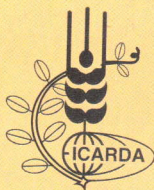


Improvement of Crop-Livestock Integration Systems in West Asia and North Africa

Editors

Nasri Haddad, Richard Tutwiler
and Euan Thomson



International Center for Agricultural Research in the Dry Areas

Improvement of Crop–Livestock Integration Systems in West Asia and North Africa

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Editors

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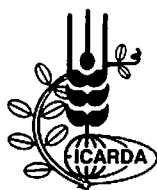
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Arabic Section

Foreword

In December 1992, agricultural scientists and researchers came together in Amman, Jordan to review research achievements and discuss strategies for increasing the productivity of barley, pastures, and sheep in the critical rainfall zones of the Mashreq countries of Iraq, Jordan, and Syria. One of the important outcomes of this meeting was a renewed call to improve crop-livestock integration in the dryland farming systems of the developing countries in the Mediterranean basin. To this end, an international symposium was held in Amman in November, 1995 with the combined support of the United Nations development Program, the Arab Fund for Economic and Social Development, the International Fund for Agricultural Development, and ICARDA. The symposium was attended by over 120 scientists and experts representing 14 countries and international research organizations. This volume presents the proceedings of the symposium and provides a state of the art review of progress being made in research and technology transfer.

During the past three decades there has been considerable interest in crop-livestock integration in the cereal-based farming systems of the developing Mediterranean countries. Research has covered a wide spectrum of topics, from straw quality improvement to fallow replacement in mixed farming to production of forage shrubs on non-arable land as a fodder reserve for increasing numbers of small ruminants. In recent years the effort has intensified, and crop-livestock interactions are now seen as a critical point of entry for improving the productivity of land in marginal agricultural environments while, at the same time, efficiently managing and conserving the natural resource base. The subject is of particular relevance given national concerns for improving the livelihoods and economic well-being of million of people living in low rainfall areas in the developing Mediterranean countries who continue to depend upon crop and livestock production for their family income.

This volume covers both the promises and the constraints for improved crop and livestock productivity, reflecting the great diversity among the dryland farming systems and agro-ecological environments concerned. A welcome trend is the increased emphasis being given to the socioeconomic aspects of the subject, including the direct participation of the farmers and livestock herders themselves. This reflects our conviction that technical feasibility and experimental results should not be the only measures of technology performance. In the final analysis, it is the land users themselves who will decide what technologies to adopt and apply, and therefore they should be active participants in the technology generation process from the beginning.



Prof. Dr. Adel El-Beltagy
Director General
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N. Haddad
R. Tutwiler
E. Thomson

Introduction

The West Asia and North Africa (WANA) region is characterized by a high population growth rate, large and rapidly increasing food deficits, highly variable income levels both within and between countries, limited arable land, and increasingly scarce water resources. In ICARDA Mashreq/Maghreb Project countries (including Iraq, Jordan, Lebanon, Syria, Algeria, Libya, Morocco, and Tunisia), the population doubled between 1960 and 1990, reaching around 100 million in 1990. Further increases are projected: another 32 million by the year 2000, 68.7 million by 2010.

Climatic features, especially low and variable rainfall, limit farmers' options. Traditionally, crop production and livestock production have been closely interrelated, in ways that have maintained the producing population while conserving the resource base. However, recent changes in production practices threaten the region's natural resource base.

Small ruminants (sheep and goats) represent the principal economic output in the region, and constitute a large proportion of the income of small farmers and nomadic or semi-nomadic herders. This income derives from the sale of live animals, dairy products, and wool. The animals also provide a valuable dietary contribution to the household. Livestock also plays an important role in reducing the risk associated with climatic variability by acting as a buffer against uncertain crop yield.

Livestock numbers have increased over the last two decades. On average, small ruminants increased by 27% from 1972 to 1992 in the Mashreq, and by 14% in the Maghreb. As a result, the livestock feed gap in the Mashreq and Maghreb countries has widened substantially. A deficit of 8.9 million metric tons was reported for the period 1988 to 1992. Future prospects are not encouraging. The deficit is being met by imported feeds, principally barley, bran, and other concentrates. The pressure on rangeland grazing has also increased, resulting in serious degradation.

Integrated, sustainable, crop–livestock systems are needed to increase the quantity of available feed, reduce the dependency on imported feed, and improve livestock productivity, while protecting and regenerating natural rangelands, halting the rapid degradation by which they are now seriously threatened.

The achievement of this goal requires the consolidation of research and development efforts in the countries concerned. Technical solutions that are acceptable to and adopted by farmers, herders, and other land users must be found and implemented. The multidisciplinary approach used in the previous ICARDA Mashreq Project is now being reinforced in the new ICARDA Mashreq/Maghreb Project.

This symposium was organized to address the need for integration between crop and livestock systems. It also promoted interaction and an exchange of experiences and research findings among scientists from West Asia and North Africa in four major areas important to sustainable dryland production systems. These include:

improvement of barley and forage crop production, improvement of small ruminant production and management, marginal land and rangeland improvement, and technology assessment and transfer. Crop–livestock integration was given special emphasis.

The symposium was a regional scientific gathering, with the participation of 120 scientists from Jordan, Syria, Iraq, Lebanon, Morocco, Tunisia, Libya, Palestine, Egypt, Cyprus, Turkey, Spain, France, and Pakistan, as well as representatives from ICARDA programs and units, and from ACSAD and ILRI.

The symposium represented a bridge between the Mashreq Project and the new ICARDA Mashreq/Maghreb Project, which now covers eight countries—four from the Mashreq and four from the Maghreb. It addressed the development of sustainable crop–livestock production systems in West Asia and North Africa.

We hope we have thus strengthened interaction and networking among scientists and countries in West Asia and North Africa, and we look forward to similar cooperative efforts in the future.

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Regional Coordinator

Crop-Livestock Integration

Crop-Livestock Integration in the Drier Areas of West Asia and North Africa

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Abstract

This paper examines integrated crop-livestock farming systems in West Asia and North Africa (WANA) from conceptual and historical points of view. Prospects for the continued existence of these systems are discussed in the light of contemporary changes, particularly in relation to population growth, agricultural intensification, and differentiation among farming household strategies. Divergent trends are suggested for North African and West Asian countries. In North Africa, considerable scope exists for intensifying the traditional crop-livestock system at the farm level. In West Asia, future integration of crop and livestock may depend upon market mechanisms operating at a higher system level than the individual farm holding.

Standard Conceptualization of Crop-Livestock Integration

Crop-livestock integration is promoted as a desirable goal by many researchers concerned with improving agriculture in WANA. It is a particularly important objective for those international, regional, and national organizations advocating a systems approach to agricultural development, the sustainable use of natural resources, and self-reliance in food production. This paper reviews crop-livestock integration as a descriptive and analytical concept, describes the traditional use of the term to characterize the dryland farming systems of WANA, examines contemporary development trends and their negative impact on crop-livestock integration in selected countries, and draws tentative conclusions concerning the location and scale of future efforts to achieve renewed crop-livestock integration.

As a convenient starting point, we set forth a simple definition of crop-livestock integration, based upon Sandford (1988):

Crop-livestock integration is a production system in which there are interactions between crop production and livestock production within a farm where both the crops and livestock are managed by the same economic unit (e.g., a household) in which part of the land is used for feed production, including grazing for animals.

Crop-livestock integration is accomplished within what is generally termed a mixed farming system (i.e., a production strategy in which both crops and livestock

are produced by the same management unit). An important feature of mixed farming systems is their association with the economic goal of economic security for the household. Crop-livestock integration represents a diversified production strategy in which a household makes the best use of its land, labor, and capital resources by producing a variety of products while consciously maintaining an internal balance among individual enterprises in order to preserve the flexibility necessary to adequately respond to demographic, environmental, and socioeconomic fluctuations.

Sandford (1988) distinguishes between *economic interactions* and *biological and physical interactions* between crops and livestock. Examples of the former include: (i) sale of livestock products to purchase crop inputs such as fertilizer and improved seed; (ii) accumulation of livestock wealth "on-the-hoof" to offset vagaries in crop production; and (iii) conversion of non-useable resources (e.g., crop residue) into useful animal products. Examples of biological and physical interactions include: (i) provision of feed to livestock from crop residues, fallows, or non-arable land; (ii) livestock contribution to soil fertility through manure; and (iii) use of animals for traction. When these linkages are maintained, the resulting system is robust and resilient in the face of uncertainty and risk. More importantly, the economic and biophysical interactions between crop and livestock enterprises strengthen the productivity of both, and enhance the natural resource base upon which both depend. Finally, integration between the two increases the marginal returns to farm labor by making the best productive use of the fruits of that labor.

The integration of crop and livestock production by resource-poor smallholders has recently become an important development goal, largely because of its potential contribution to achieving sustainable agricultural intensification in areas of the world where population pressure on a limited land base threatens economic livelihood. Defined as increasing the annual returns to land, intensification is the substitution of labor or capital for land by increasing the investment of human labor and external inputs per unit of land. Although none of the definitions of intensification require changes in agricultural technology, most emphasize the use of improved technologies in intensification efforts (Boserup 1965; Netting 1993). Acquisition of improved technologies implies possession of financial and institutional resources not easily obtainable by the majority of poor farmers in the developing world. Therefore, crop-livestock integration practices are often seen as particularly appropriate for the poor, since improved mixed farming can often be realized through more efficient use of household labor and better management of existing capacities.

Because animals have the ability to reproduce themselves, productivity gains can be accumulated and reinvested in the family herds and flocks. By increasing allocative efficiency—making better use of crops and crop by-products to increase livestock productivity—farmers should be able to intensify their production without major external inputs.

With its emphasis on allocative efficiency, crop-livestock integration is seen as imminently practicable in terms of sustainability (persistence within a variable resource environment) and reproducibility (succeeding generations can follow the same production system). Largely because of these attributes, agricultural research scientists and development experts have been strong advocates of reinforcing

existing mixed farming systems and promoting further integration between crops and livestock (Thomson et al. 1995).

Within WANA the dryland cereal and livestock farming system would appear to offer the greatest scope for productivity gains through improved crop-livestock integration. The thesis argued in this paper is that market forces increasingly dominate population pressure and intensification. Instead of encouraging crop-livestock integration, they can actually result in the disassociation of crop and livestock enterprises at the farm level, with differentiated farm types emerging based on production specialization rather than integration of farm enterprises. The disassociation is not uniformly distributed across WANA countries. It is more pronounced in situations where integration was originally maintained under conditions of extensive land use, but where present intensification tends to minimize on-farm forage production in favor of cash crops. Disassociation may be mitigated and retarded in situations where emigration has reduced pressure on the land or where farming households seek off-farm income to relieve dependence on farm income and therefore insulate their farm production decisions from market forces. However, the shift in economic reliance from on-farm to off-farm employment may have adverse effects on the improvement of the technical and allocative efficiencies of production.

Traditional Systems of Crop-Livestock Integration In WANA

Crop-livestock integration is firmly rooted in the farming systems of WANA. Mixed farming has evolved into a number of local variations and has been articulated with other production systems, most notably nomadic pastoralism. Historically, crop-livestock integration in WANA has been practiced within both intensive and extensive land-use systems. This paper is primarily concerned with the extensive, dryland cereal-livestock systems. However, intensive systems are briefly reviewed for comparison.

There are two types of intensive agricultural systems. The first is irrigated year-round. It is found primarily in river valleys and oasis settlements, where an assured source of surface or shallow groundwater is used to produce a variety of annual and perennial crops for humans and livestock. Farm size is typically quite small, but assured water guarantees high productivity per unit of land. Two or more annual crops are commonly grown on the same plot each year. The principal forage crops are feed legumes—especially clovers and alfalfa—but animals are also fed cereal, food legume, and vegetable crop residue. Large ruminants such as cattle and buffalo are pervasive, but farmers often keep small flocks of sheep and goats.

The second type is found in mountainous areas. At higher elevations along the Mediterranean coast and in southern Arabia, rainfall is sufficient to produce cereals, food legumes, and tree crops. However, the topography and soil usually demand a considerable investment in labor to create and maintain suitable cultivation. Terraces, either constructed with stone walls or carefully laid sod embankments, are common. As with irrigated agriculture, mountain farming in WANA is characterized by small, intensively cultivated farms. But unlike the irrigated valleys and oases, which are surrounded by desert or near-desert

conditions, mountain farms can make use of the extensive non-cultivated areas surrounding farming communities to graze livestock and collect native forage plants. Typically, both large and small ruminants are kept. In addition to grazing on mountain pastures, they are fed with crop residues and collected forage. Large ruminants are the primary source of traction for cultivation.

Intensive irrigated and mountain farming systems cover only a small proportion of the cultivated land in WANA. The great majority of the arable land is found on the plains and plateaus along a wide belt stretching from the Atlantic seaboard in Morocco to the Jezira plains of Syria and Iraq. These areas receive an average annual rainfall of 400–250 mm, concentrated between November and April. At the wetter end of the rainfall spectrum, wheat is the principal crop, and at the drier end barley predominates. In general, cereals constitute 60–85% of the annually cultivated land. The remainder is made up of food legumes, some vegetables, and a modest number of forage crops. Practicing annual fallow on a high percentage of arable land has always been an important aspect of the farming system. Land is often kept as weedy fallow for grazing. In the Levantine countries and Iraq, barley is produced almost exclusively as feed for sheep and goats. In the North African countries, barley supplements wheat as a human food, but also serves as the principal forage crop for small ruminants. It is common for households in the wetter areas to keep one or two cows for milk, but the drier areas are almost exclusively the preserve of sheep and goats.

Below about 300 mm rainfall, the system has little crop or animal diversification. Barley, almost the only crop grown, is used to feed the sheep upon which the household relies for economic security. Traditionally, the sustainability of the barley–livestock system in the drier areas has been dependent upon an extensive land-use pattern. Fallowing large areas has been important for maintaining soil productivity. Grazing the nearby natural rangelands in the semi-desert steppe areas has always been an important component of the livestock feeding system.

Compatibility of Agricultural Intensification and Crop–Livestock Integration

For the past half century, WANA has experienced one of the highest population growth rates in the world. The same period has witnessed a transformation of the region from a net exporter of food to the largest net importer of food in the world (Nordblom and Shomo 1995). The natural resource base for rainfed agriculture in WANA is extremely limited. Only about 7% of the land area can be classified as arable or potentially arable, and most of this has already been brought under cultivation. The growing demand for cereals, meat, and milk has fueled a steady rise in cropping intensity and livestock population, particularly small ruminants. Increases in livestock are particularly significant in the extensive rangeland areas, where high stocking rates have led to overgrazing and resulted in loss of vegetation, soil, and water resources. Most observers recommend intensification—improved production technologies and management practices designed to increase productivity and integrate food, feed, and animal production in mixed farming—as the only viable option for maintaining the economic livelihood and sustaining the natural resource base of the region's farming population (FAO 1994).

Boserup (1965, 1981) provides a useful model for understanding the dynamics of agricultural intensification. Her approach differs from others because it implicitly rejects notions of rigid environmental, technological, and economic determinism in favor of a focus on the farmer's adaptive responses to changing conditions. The central theme of Boserup's model is agricultural intensification as an adaptive response to the need to produce more food for a growing population living on a fixed land area. Intensification may take several forms. The first and most simple is increasing the exploitation of the natural resource base. Often this starts with reducing and replacing fallow with more frequent cropping, followed later by double and multiple cropping on the same field each year. Greater cropping density on the land may require higher water use, which leads to the search for sources of water for irrigation. Greater frequency of cropping and irrigation implies higher labor inputs. As soil fertility and water quality begin to deteriorate as a result of earlier intensification efforts, the farming population may seek to augment its resource base with external inputs such as chemical fertilizers, improved seed, and other forms of modern agricultural technology.

While increased land and water resource exploitation produces greater returns, Boserup acknowledges that intensification can lead to resource degradation, and thus undermine the long-term sustainability of the farming system. But she remains optimistic that the carrying capacity has great elasticity, and that it can be continuously stretched by technological advances. This is obviously a contentious point. There may, in fact, be serious environmental constraints to continuous intensification. Boserup recognizes that a continuously growing agricultural population struggling to survive in a steadily degrading environment might, at some point, have to reduce its numbers through emigration and other movement out of agriculture and into different economic pursuits.

Intensification has other drawbacks. Most notably, there is an observed tendency for intensification to result in diminishing returns to labor. While irrigated agriculture has a great capacity to absorb labor, and to respond productively to increased labor inputs, the marginal benefits in dryland agriculture decrease sharply as the intensification process proceeds. This can be substantially compensated through technological change, particularly mechanization of the principal operations, but mechanization requires financial outlays that may not be possible for many poor subsistence farmers. Livestock production, in contrast to dryland cereal crop production, is much more responsive to additional labor inputs, both in terms of total productivity and marginal returns.

The recent evolution of WANA's irrigated and mountain farming systems provides excellent, if contrasting, examples of the logic of Boserup's model. For irrigated systems such as Egypt's, intensification under population pressure has proceeded much as the model would suggest. Seasonal flood irrigation gave way to perennial irrigation with the construction of the Aswan High Dam and the extension of the country's freshwater and drainage canal systems. The agricultural sector continues to absorb more labor and external inputs per hectare, with corresponding increases in productivity. The balance between on-farm crop and livestock production has been maintained—although market prices are increasingly important for year-to-year crop production choices, particularly since recent liberalization policies were introduced (Okonjo-Iweala and Fuleiha 1993).

For terraced mountain agriculture, declining marginal returns to labor, topographical restrictions on mechanization, and off-farm employment opportunities have produced considerable emigration, the response of a farming population squeezed between its own demographic increase and a limited productive base. In some areas, notably Yemen, this has resulted in the deterioration of the traditional means of soil and water management due to lack of continued labor investments, thereby threatening the sustainability of the production system (Tutwiler 1990). In other areas, such as the mountains of Syria, Lebanon, and Jordan, emigrant remittances have been used by the people remaining in the villages to repair and even expand the terrace systems, but there has been a change in cropping patterns from subsistence cereal and livestock production toward the commercial production of tree crops, particularly fruit and nut. There is also a growing tendency for "hobby farming," in which household members become increasingly engaged in off-farm work, returning to their land for short periods to attend to the needs of the tree crops.

The intensification phenomenon is particularly relevant to the issue of continued crop-livestock integration in dryland areas. The original development of the system depended on the relative abundance of land to counter the problems of low and uncertain rainfall. Once land availability becomes constrained by increased population pressure, the issue arises of whether or not mixed farming will continue, as well as—and perhaps more importantly from the development point of view—whether or not crop-livestock integration at the farm level can serve as a useful vehicle for both intensifying production and sustaining the natural resource base.

Our thesis is argued through the presentation of country case studies. The first involves the three North African countries of Algeria, Morocco, and Tunisia, where dryland crop-livestock integration at the farm level appears to be most persistent. The second involves Iraq, where intensification in dryland areas has become a major focus of government policy. The third case is that of Jordan, a situation where de-intensification is taking place (where an already extensive system has become even more extensive in terms of land use). The final case study involves Syria, the best example in WANA of intensification along the lines of the Boserup model.

The Case for Continued Crop-Livestock Integration in North Africa

The agricultural population in Algeria has declined by 12% since 1961. There has been a corresponding increase in cropped land of 13%, accomplished mainly by the use of tractors to expand barley cultivation onto rangeland in the drier areas.¹ This means that land available per capita of agricultural population has increased from 0.93 to 1.28 ha (almost 30%, indicating decreased demographic pressure to intensify production. Off-farm employment, rather than intensification, was the

¹ Except where otherwise noted, all national statistics are derived from FAO (1995).

dominant farm household strategy in the 1970s and 1980s (Chaulet 1987). Seeking to reduce dependence on food imports, the government nevertheless promoted the goal of agricultural intensification through the use of improved and labor-intensive technologies. There were modest gains in a few areas, most notably wheat production, but agricultural employment continued to fall (Tutwiler 1995; Bouaita and Chaulet 1990a).

The predominant land-use pattern in the rainfed areas continues to be cereals and annual fallow (weedy fallow). Fodder and legume production occurs only on a very limited scale. There has been a four-fold increase in the national flock of sheep and goats, with a rise in the number of small ruminants from 0.77 to 3.53 animals per capita of agricultural population. This increase has taken place mostly in the driest areas, where the larger flocks are fed primarily through increased grazing on the rangelands, with supplementary feed brought in from farming areas (Bedrani 1992).

In their study of privately owned farms in Tiaret province (chosen because it is representative of the much larger High Plateau dry farming area), Bouaita and Chaulet (1990a) conclude that farmers have returned to traditional mixed farming after a period of specialization in cereal cultivation introduced by colonization. Land use is roughly divided between cereals and fallow, with flocks being fed primarily from on-farm resources. This is seen as economically rational under the present circumstances, because livestock are much more profitable than cereals. Although flock sizes appear to be increasing modestly, there is little intensification, either of livestock or feed production. Bouaita and Chaulet attribute the failure of Algerian mixed farmers to intensify production to a variety of factors, many of them external to the farm, such as market and credit conditions and input availability. But other factors include the perceptions and attitudes of the farmers themselves. The overall picture is one of stagnation, under-employment (for those remaining on the farm), and under-investment in improved productivity, although crop-livestock integration continues.

In Tunisia, demographics and land are similar to Algeria. The number of people involved directly in agriculture has declined by 15%, while cropped land has increased by 6%. However, Tunisia differs markedly from Algeria in that the area under permanent crops (principally olive) has increased by almost 50% since 1961. Much of the expansion of tree crops has been at the expense of rangeland. Overall, 29% of the cropped land in Tunisia is now planted to fruit trees. The combination of decline in agricultural population and modest increase in cropped area translates into a per capita increase in cropped area of 76% since 1961 (from 1.34 to 2.36 ha). Population pressure does not appear to be an inducement to intensification in Tunisia.

Recent observers of farming systems in Tunisia (Hopkins 1990; Ben Achour 1990a; Gana and Khaldi 1990a) stress the difference between large commercial farms specializing in wheat production and a smallholder sector dominated by traditional mixed farming. All observers note the importance of livestock enterprises for smallholders, and all comment on the intensive use they make of the land. Rainfed cropping densities are higher in Tunisia than in the rest of North Africa. Although the national average is 0.73, farmers with less than 10 ha (almost 70% of farms), commonly have a cropping density greater than 0.90 (Ministry of Agriculture

1989). In large part, this high figure can be attributed to the increasing trend to devote land to tree crops, intercropped with cereals and legumes in wet areas. Moreover, national figures can be misleading. While land-use intensity is certainly high in the higher rainfall zones, in the drier areas intercropping is less common, and much more of the land is planted to cereal crops if the system is left fallow in alternate years. This is particularly so in the barley producing areas in the center and south of the country. Ben Achour (1990) reports that farmers in the semi-arid northwest commonly fallow up to half their arable land. In a somewhat more humid area, Gana and Khaldi recorded a fallowing average of about 25% of the agricultural area, with trees covering only 7% of the land. Both studies report an almost universal incidence of sheep and goats on farms. Cattle are also prevalent, but rarely above about three per household.

The number of small ruminants in Tunisia increased by about 25% between 1970 and 1990, but the number of large ruminants decreased somewhat (Nordblom and Shomo 1995). Livestock are concentrated on the small farms, with about 40% on farms smaller than 10 ha and another 20% on farms between 10 and 20 ha (Ministry of Agriculture 1989). The average flock size is less than 50 head, but stocking rates are very high, and the ability of the farmers to provide adequate feed to sustain productivity from on-farm resources is questionable. Farm surveys indicate considerable use of common grazing areas, scrub forest areas, roadsides, and domestic areas. The use of purchased feed to maintain flock size may be on the increase.

On the vast majority of Tunisian farms, the general conclusion is that livestock production should not be considered a commercial enterprise. Although sales of livestock and livestock produce can occasionally be an important source of income, the keeping and management of livestock by small farmers is better understood as a risk-management strategy. Livestock play an important income-stabilizing role within the entire economic portfolio of the farm family in much the same way as conceptualized by Sandford. In fact, all indications are that off-farm employment is already a major, if not the major, source of smallholder income in the semi-arid center and south of the country, and that the same situation is rapidly becoming characteristic of the north (Hopkins 1990).

There is little differentiation among small farms in Tunisia, with some specializing in tree crops, others in field crops, and still others, for example, in commercial livestock raising. The pattern seems to be continued economic diversification among all small farms, adding new enterprises (such as olive plantation), and seeking off-farm employment whenever possible. Diversion of family labor resources into tree crops and off-farm work may even detract from the ability to invest in further crop-livestock intensification.

In contrast to Algeria and Tunisia, the agricultural population in Morocco has increased over the past 35 years by 14%. There has been an expansion of the cropped area that has more than matched the increase in agricultural population, resulting in a modest per capita increase of 0.84–0.99 ha in land available to the agricultural population. The increase in cropped area has largely been achieved through a reduction in the amount of fallow land, indicating a limited degree of intensified land use.

Faced with mounting food import costs, the Moroccan government has sought to promote agricultural intensification, mainly through the development of large-scale irrigation projects (Swearingen 1988). Considerably less public investment is being made in the dryland sector. In these less favored areas, durum wheat and barley are the major crops, with durum wheat serving as both a subsistence and cash crop, and barley as the major forage crop. Durum wheat showed substantial yield improvement between 1964 and 1988, reflecting farmer input of fertilizer, improved varieties, and improved cultivation practices (Tutwiler 1995). Barley continues to be grown under very low input conditions, and little progress has been made in increasing yield.

A nationwide study conducted in the early 1960s found that 76% of smallholders in the so-called traditional sector practiced mixed farming, with 15% raising animals and no crops, and 9% cultivating crops with no livestock (Azzam 1990).

A recent survey of Moroccan barley producers (Saade et al. 1994), in seven districts receiving various amounts of rain, demonstrates the continuing importance of mixed farming (barley is used to feed the farmer's sheep and goats). Wheat is by far the dominant cereal in the wetter zones—much of it destined for market. As rainfall decreases, barley becomes more important and livestock production increases.

In the driest areas, there is very little wheat, and barley covers 50% or more of the cultivated area. Here, much of the land is left in fallow, although fallowing is not uncommon in the wetter areas. In either case, fallow land is an important grazing resource for sheep and goats, which are owned by almost all farmers. Less than 10% of barley production is sold. The rest is used for on-farm consumption, mainly as livestock feed (60% of grain, 91% of straw), seed (23% of grain), and human consumption (7%). The principal reasons cited for not adopting improved barley varieties are low straw yield and poor grain quality for animal feed, which are important considerations for mixed farming. Farmers are also concerned with the performance of barley cultivars when used for green grazing in early spring, a practice commonly used to supplement small ruminant diets.

The data show that North Africa is not experiencing extraordinary population pressure on arable land. This is the result of the movement of people out of farming in Algeria and Tunisia, and the decreased use of fallowing along with the cultivation of vast areas of former rangeland in all three countries. Intensification of cereal and forage production to feed increasing livestock numbers is not taking place.

A tentative hypothesis, based on the evidence from the three countries, is that the traditional cereal-livestock system of North Africa remains entrenched and viable, bolstered by migration and the bringing of new land into cereal production. Crop-livestock integration continues to rely on an extensive land-use pattern. Tunisia presents a warning, however. The spectacular spread of olive plantations means that the trees are absorbing an ever-greater proportion of farm labor at a time when the agricultural labor pool is shrinking due to migration and off-farm employment. The modestly rising animal population must be fed either by intensifying cereal and forage production (which does not appear to be happening) or by increasing grazing pressure on shrinking rangeland (reduced by the spread of tree

plantations). Increased grazing pressure appears to have created serious soil erosion and degradation problems, particularly in the drier areas, thus undermining the future ecological stability of the entire system (IRA 1995).

The Special Case of Iraq

Iraq is different from other countries in West Asia because a large proportion of its agricultural land is irrigated by the Tigris-Euphrates river system. It is also different from Syria and Jordan in terms of the economic importance of petroleum production, and its political fortunes since 1980: a decade of almost continual war with its neighbors followed by the imposition of severe international trade sanctions.

In the irrigated river valleys, crop-livestock integration traditionally follows the pattern of the Nile Valley, with greater emphasis on smallholders and large ruminants. In the large rainfed areas to the north and west, the traditional pattern is akin to that of the plains of eastern Syria: an extensive system of cereal production integrated with small ruminants.

Between 1961 and 1991, the agricultural population of Iraq remained steady: between 3.8 and 3.9 million people. However, during the same period there was extensive government investment in renovating and expanding the river and canal system, and the irrigated area grew by 83%. At the same time, rainfed agriculture was allowed to languish, and the area under rainfed production declined by 16%. Indications are that the rainfed farming systems in Iraq grew more extensive, with lower cropping intensities. Sheep and goats, located primarily in the rainfed areas, declined by 25%. The number of large ruminants (cattle and buffalo) in the irrigated areas did not increase appreciably, although the number of chickens produced by capital-intensive methods in the river valleys jumped twenty-fold, from 4 to 80 million birds.

A recent survey (Shideed et al. 1995) of rainfed barley producers in northern Iraq, conducted after the imposition of international sanctions, found major changes taking place. Faced with the need to rely on domestic resources to feed its population, Iraq has taken significant steps to encourage intensification of rainfed agriculture. The survey shows a trend towards increased farm size in the drier areas, as additional land is leased by commercial barley and wheat producers. Small ruminants have been banned from cereal producing areas during the growing season, reducing crop damage from grazing. Since about 60% of the cereal farmers surveyed own sheep and goats, they must make arrangements to shepherd their flocks in nearby rangeland for a large part of the year. As the amount of natural pasture is declining due to overgrazing, flock owners have had to transport barley grain and cereal straw to the rangelands to feed their animals.

Many of the larger cereal producers show little interest in trying to maintain both crop and animal enterprises. Rather, they are focusing their efforts and investments on increasing the production of cereals for direct sale. This indicates a trend towards specialization, at least among the larger farmers.

Jordan: Specialization by De-Intensification

Compared with the other WANA countries, Jordan has a small agricultural sector. Its very limited arable land and water resources are being increasingly encroached upon by a steadily growing urban population. Between 1961 and 1991, the agricultural population fell by 50%. During the same period, more land was brought under production through the use of tractors to expand cultivation into drier areas formerly used as range. While annually cropped land increased by 30%, the irrigated area almost doubled and the area planted to tree crops tripled. Although annual fallowing is a persistent feature of Jordan's semi-arid dryland farming, there is strong evidence that the arable area devoted to fallow each year is actually increasing as entire farms are left fallow due to absenteeism and economic disincentives (Aydin 1990). There has been a sharp decline in the wheat area, while the area planted to barley remains fairly steady, with noticeable annual variations due mostly to rainfall fluctuations.

The national sheep and goat herd has grown from 1.3 to 2.2 million animals, although the number of large ruminants has declined slightly. As in Iraq, poultry production has skyrocketed from 1 to 50 million birds. Much of the national animal production is sustained with imported feed.

The Jordanian National Center for Agricultural Research and Technology Transfer (NCARTT) and ICARDA have conducted a number of studies of dryland farming systems. In 1988/89 a total of 432 randomly selected barley producers were interviewed (Tutwiler et al. 1990). The responses show considerable differences among farm types. About half the farmers reported that their farms produced 30% or less of their annual household income. Of these part-time farmers, only about a quarter owned sheep and goats, and about two-thirds of these said their crop production was sufficient to sustain their small household flocks. Wheat and barley were grown in roughly equal proportions. Just over half the farmers reported a dependency on farm income (i.e., 70% or more of household income from on-farm sources), of which 19% owned no livestock and sold their cereal production. Interestingly, those farmers specializing in cereal production for sale had the largest farm areas, and they averaged almost twice the farm size of cereal producers who relied primarily on off-farm employment for their household income.

The remaining 34% of farms fit into two categories, for which crop-livestock integration is perhaps most relevant. Both categories share a dependency on income generated from on-farm crop and livestock production. They differ (in about equal measure) in terms of ability to feed their livestock from on-farm resources. In terms of the balance between farm size (and cereal area) and flock size, the two groups are almost identical. Farms without a feed deficit had an average area of 60 ha, with an average flock of 125 head. Feed deficit farms averaged 30 ha with flocks of 340 head. There were noticeable differences between the two mixed farming systems in terms of crop mix and cropping intensity. The non-deficit farms devoted 30% of their land to barley, 28% to wheat, leaving the remaining 42% mostly fallow. Deficit farms, with less land and more sheep, planted an average 53% of their land to barley, 23% to wheat, leaving about 20% fallow.

The most recent survey of barley producers in Jordan (Tutwiler et al. 1995) shows similar differentiation. Of the 285 farmers surveyed, 42% stated that the major portion of their household income comes from off-farm employment. Of these, half sell almost all their barley production. Including all respondents regardless of proportional sources of income, 52% of farmers are producing barley for sale, not to feed their sheep. Only 7% report surplus production after feeding their sheep, leaving 41% who either keep their feed production and flock size in balance or experience on-farm feed deficits.

Flock ownership parallels barley production figures. Forty one percent of barley farmers own no sheep or goats, and a further 23% maintain only small flocks for household use. Those that expect to sell animals or animal products are distinguished by flock size. Small commercial flock owners, who more or less maintain a balance between animals and on-farm feed production, represent 15% of the sample. Larger commercial livestock producers (at least 100 head, generally many more) account for 21% of barley producers. These livestock-oriented farmers must find off-farm feed sources. They cannot produce enough barley given their land resources to maintain their commercial flocks.

The two studies reviewed above focused on barley producers. Two other recent studies sampled sheep and goat producers who may or may not also grow cereals. Nabulsi et al. (1993) interviewed 64 households across Jordan. Most of them (70%) also have land, and only a few have permanent off-farm income sources. Almost all these livestock producers were found to follow a transhumant strategy involving a home where the flock is hand fed using concentrates of barley, sorghum, and wheat bran, and seasonal movement of the flock to take advantage of grazing opportunities on rangeland and, following the harvest, on cereal residue. Purchased concentrates are estimated to constitute 55% of the variable cost of sheep and goat production, with labor and transport accounting for 14% of the cost. The average net return for livestock enterprises is 42% above variable cost. Producers generally feel that sheep and goats are quite profitable, and labor and transport costs per animal can be reduced by increasing flock size. However, the herders noted that profit margins depend on the high market value of animals and the then current government policy of subsidizing purchased feed concentrates.

A similar study of sheep production on the margins of cultivation in an area receiving less than 200 mm annual rainfall produced results similar to Nabulsi's study. In this area, barley production is intermittent and primarily designed to provide modest amounts of green grazing for animals in spring. Flocks tend to be large, often exceeding 500 head. Because there is little in the way of local cereal production, and the surrounding rangeland is heavily degraded, animal nutrition is dependent on purchased feed, mainly rough grains and bran used in combination with straw, trucked in from distribution centers. Water is also brought in on tanker trucks. Despite the fact that most livestock operations are little more than open air feedlots on heavily degraded rangeland, sheep rearing is considered very profitable. The average cost/benefit ratio for the flocks surveyed was 1.5. Sheep production combined with barley cultivation was slightly less profitable for the farmer than sheep production without barley cultivation.

The national statistics for Jordan and the various recent surveys of farming households tend to confirm a general movement by the rural population away from

economic dependence on agriculture. Roughly half the people engaged in farming no longer depend on agriculture for the bulk of their household income. More important for the thesis argued in this paper, there appears to be a growing differentiation and specialization among the remaining farmers. Those with adequate land tend to specialize either in high value tree crops or in cereals, while reducing their investment in livestock to small flocks for household use. In contrast, other farmers are effectively reducing their investments in crop production while increasing flock size, more and more by increasing purchased feed. Crop-livestock integration, to the extent that it can be said to occur beyond the 20% or so of farmers maintaining an adequate balance between crop and livestock production, takes place through market mechanisms or through government institutions (such as the Jordanian Cooperative Organization and the Ministry of Supply, which organize feed purchases and distribution on a national scale).

Syria: An Example of Agricultural Intensification

Of all the countries in WANA, Syria presents the best example of intensification under the combination of: (i) a growing agricultural population; (ii) a shrinking arable land base; and (iii) expanding market integration. Between 1961 and 1991, the number of people directly involved in agriculture in Syria grew by 15%, but the annual cropped area decreased by a staggering 22%. The fall in cropped area is somewhat mitigated by large increases in land devoted to perennial crops, particularly olives, vines, and other fruit and nut trees. Despite this, large areas of formerly productive farmland have been absorbed into Syria's burgeoning urban areas and—as economic improvement has come to rural areas—to new homes, shops, and service institutions in the villages as well.

The steep decline in arable land area per capita of agricultural population is a result of the rapid increase in livestock population, from about 4.5 to 16 million sheep and goats, i.e. from 1.8 to 5.4 head per person in the agricultural population. The decreased rainfed farming area implies decreased supplies of feed to meet rising demand. The shortage has been largely offset by several developments: (i) increased grazing pressure on rangeland; (ii) greater use of crop residue (particularly grazing cereal stubble in the higher rainfall areas); and (iii) more intensive use of by-products from irrigated areas. These developments imply a trend towards greater flock mobility in the seasonal search for grazing and feed supplies.

The farming household has responded to demographic and economic pressures in a number of ways. Perhaps the most important is off-farm employment. As in Jordan, the incidence and economic importance of off-farm employment is noticeably increasing, particularly in areas surrounding the major cities and towns. Off-farm employment opportunities, particularly in combination with the inheritance of small- to medium-sized holdings, has led to the phenomenon of part-time farming, in which adult males spend little time in crop production activities and even less in livestock rearing. Unlike field crops such as wheat and barley, livestock requires daily attention. Although part-time farmers can still maintain cereal production by arranging to be on the farm during the few peak labor and supervisory periods—such as planting and harvesting—it is difficult for them to maintain both an off-farm job and a substantial flock. It is usually possible

for the women and children who remain on the farm to tend a small flock for household use, but for them to provide for the needs of a large flock on their own is difficult. The standard practice is to reduce the flock when the men are away for prolonged periods. It is simply easier for them to continue cereal production alone, and forego integrated crop-livestock production.

In the past few years, the Syrian Directorate of Agricultural Scientific Research (DASR) and ICARDA have conducted a number of studies on the recent evolution of farming systems in agricultural areas with an average annual rainfall of 200–350 mm. These are the areas where integrated crop-livestock production has traditionally been practiced. Early diagnostic research by ICARDA characterized these zones as practicing a barley-livestock system, in which the predominant crop was barley, grown to feed the farmers' flocks of sheep and goats. The studies done in the late 1970s and early 1980s fully justified this description. Over vast areas, barley was virtually the only crop produced, and barley grain, straw, and stubble were used to feed the animals owned by almost every farmer. However, during the 1980s, changes in land use occurred. More land came into continuous production as fallows began to disappear, the numbers of sheep seemed to increase, and here and there new plantations of fruit trees appeared, along with well-irrigated wheat, vegetables, and industrial crops. In 1994, DASR and ICARDA undertook a reappraisal of the situation (Mazid et al. 1995).

Results confirm the trend of increased cropping intensity due to reduced fallowing. Continuous cereal cropping now takes place, although in some locations food legumes have increased modestly. Although it is not a qualitative change in the production system, replacing fallow with continuous cropping requires additional labor and material inputs to maintain productivity. Field crop operations have been largely mechanized, and there is a distinct preference for cereal varieties that grow tall enough, even with low rainfall, to allow combine harvesting. For food legumes, vegetables, and certain industrial crops where mechanization is difficult due to the physical nature of the crop, farmers are relying more and more on gangs of daily paid workers (many of whom are women) for weeding and harvesting. Indications are that rising market prices have more than compensated farmers for the additional cost of both mechanized cereal production and hand-harvesting of legumes (Salkini 1995).

Water resource development has proceeded in tandem with increased cropping intensity. The area under permanent irrigation in Syria is reported to have grown by 16% since 1965. Most of this official figure is due to government-installed canal systems drawing water from the Euphrates, Khabur, and Orontes river basins. However, there has been an even greater growth in the area irrigated by private small schemes utilizing groundwater with drilled wells and sprinkler systems, most often limited to single farms (Tutwiler and Mazid 1992). Well irrigation is used in winter to supplement rainfall, and in summer for full irrigation. By applying irrigation water during the critical spring months of crop growth, coupled with the use of improved high-yielding varieties, fertilizers, and other modern technologies, Syrian farmers have managed to double national wheat yield per hectare in the past ten years.

Many farmers in the drier areas report a replacement of barley by wheat, spurred by the higher value of wheat grain in the market. Once water for irrigation

becomes available, there is an inevitable shift from dryland barley to irrigated wheat. Moreover, as improved varieties of wheat become available, together with technologies to lessen risks of low yield or crop loss under rainfed conditions, farmers tend to shift from barley to wheat, especially on the more fertile fields. This tendency works against on-farm livestock production since wheat grain cannot substitute for barley as a feed crop, although it is reported that wheat straw and stubble are increasingly being used in Syria as forage for sheep (Nordblom and Shomo 1995). Although wheat is increasingly cultivated in the drier areas, either through expansion of irrigation facilities or adoption of improved technology in rainfed production, the national wheat area has not substantially increased. This is due to the fact that the wheat area in the wetter areas is declining, to be replaced by higher-value crops.

In locations where conversion to irrigated agriculture is not an option, farmers have increasingly sought to diversify and intensify land use by planting perennial crops, especially vines, and fruit and nut trees. Initially, these plantations were often placed on land only marginally useful for cereal cultivation. But, increasingly, perennial crops are replacing cereals and food legumes on more fertile land. As farmers switch their emphasis to vine and tree crops, they report a declining interest in livestock. Plantations on marginal land reduce the natural grazing area around farms and villages, and may even require protective measures against damage from casual grazing. As tree crops replace cereals and food legumes, the amount of on-farm forage production is reduced, and the cost of keeping livestock increases.

A recent survey (Tutwiler et al. 1995c) of barley producers in the drier areas confirmed the trend towards reduced fallowing in favor of continuous barley cultivation. More significantly for the future of crop-livestock integration, the results also show a trend toward commercial barley production. Fully two thirds of the farmers interviewed stated that their purpose in producing barley was sale through government and private marketing channels. The remaining one third use their barley to feed their flocks. Slightly more than a third said they expected to enjoy a surplus of barley grain and straw after they had met the requirements of their flocks, which they would sell. Twenty percent of barley producers grow the crop solely to feed their own flocks. About half this group said that they must supplement their own production with purchased feed.

The survey suggests a tendency towards specialization, either in barley production for sale, or commercial livestock raising, but not both on the same farm. Some 40% of barley growers surveyed have no sheep or goats at all, and an additional 33% keep only small flocks for household consumption. This leaves about 27% of barley producers who can be considered commercial livestock producers. These farmers have farms that are larger than average. The largest farms are about equally divided between commercial barley and commercial livestock producers.

The market has become an important factor in producer decision making. Many commercial barley producers still keep livestock, but they sell almost all of their barley harvest. The livestock is fed with feed purchased in the market at prices lower than the value of their barley production. The growing feed market has encouraged the separation of crop and livestock enterprises.

Further studies (Leybourne 1993; Wachholtz 1996) of livestock producers in Syria report on the disassociation of the two enterprises at the farm level from the point of view of those specializing in livestock production. Although commercial livestock producers appear to be increasing flock size, they are not proportionately increasing their on-farm feed production. Rather, they practice a strategy of mobility, taking their flocks to areas where excess crop residue is available at relatively low cost. Increasingly, industrial crop, vegetable, and wheat residues are substituting for traditional barley grain and straw in the small ruminant diet.

Conclusion: Divergent Locations for Future Crop-Livestock Integration

This review of the situation in selected countries of North Africa and West Asia points to certain conclusions regarding the future of crop-livestock integration in dryland farming systems under situations of rapid population growth, limited land resources, and differing degrees of agricultural intensification. Although the population has grown considerably in all the countries reviewed, the impact of population growth on agriculture has not been uniform. In some countries, demographic pressures that might otherwise lead to intensification efforts similar to those predicted by the Boserup model have been mitigated by emigration and movement into off-farm employment. This is particularly true in North Africa and Jordan. In North Africa, crop-livestock integration characteristic of a traditional extensive dryland production system has persisted despite major changes in national economies, and there is little evidence that the productivity of the system has improved. There is considerable scope for improvement and intensification through improved methods of on-farm feed production.

In West Asia, the situation is very different. There has been substantial intensification in Syria, which offers the closest approximation to the process of agricultural system evolution presented by Boserup. But intensification in Syria has produced results at odds with those sought by the proponents of crop-livestock integration. Far from being a vehicle for intensification, crop-livestock integration at the farm level in Syria becomes more tenuous as intensification proceeds. There is an emerging disassociation of crops and livestock at the farm level. In Iraq, indications are that a similar trend will develop. In Jordan, paradoxically, there has also been a disassociation of crop and livestock production at the farm level, but this is as a result of the de-intensification of land use. For all three countries, future crop-livestock integration should be pursued at system levels higher than the individual farm. The future focus for developing new and more productive agricultural technologies and management systems should be on commercialized feed production, adding value to crop by-products, and ensuring they can be made available to livestock producers through market mechanisms at reasonable cost.

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Discussion

M. Harb: You limit yourself with your definition. You did not look at sheep production under extensive systems. The integration should be done at other levels, and not according to your definition.

R. Tutwiler: We recognize that in the past, as well as perhaps now, much or most livestock production may have taken place outside the on-farm crop-livestock integrated systems. The focus of our paper was on the stability and sustainability of these systems over time.

We agree with your observation that future integration between crop production and animal production within the region, particularly in West Asia, needs to take place at a level higher than that of the farm itself.

H. Nabulsi: Where and how may integration be achieved? And do you have a development recommendation?

R. Tutwiler: Achievement of integration may actually depend on development objectives. For example, if the development goal is to reduce resources on rangelands and increase provision of feed to livestock owners, then integration may have to be at the national level, linking feed producers with livestock producers. The mechanism of integration may be the marketplace, for example. On the other hand, if the development objective is to improve arable cropping by inserting a feed legume into a cereal monocropping system, then integration should be sought at the farm level, relying on incentives within the same household to feed its flock with its own feed resources.

Agro-pastoral Systems, Feed Calendars, and Feed Resources In the Arab Countries of the Mediterranean Region

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Abstract

After centuries of equilibrium, the societies of the Arab World have recently undergone a rapid evolution. Traditionally, they survived in spite of unpredictable feed and fodder resources hinging on unreliable rainfall. They survived by migrating (nomadism and transhumance) from one range to another. They had little contact with the neighboring crop lands in wetter areas. Each group lived under an autarchy. Famines, raids, and epidemic diseases regulated natural feed and fuel resources. Stocking rates were close to 4 ha/sheep. But increasing demographic pressures and their devastating consequences on natural resources have altered the old equilibrium. Rangeland feed has dwindled, forcing nomadic groups to find other means to feed their animals—the cornerstone of their income and their problems. The isolated pastoralists have had to move towards another system, seeking alliance with the farmers.

After reviewing and describing the worsening steppe conditions, the increasing dependence of small ruminants on crop residues and the cropping zone, deciphering livestock and feed trends in the Arab countries, the authors make the case for rangeland rehabilitation, and better rangeland–cropping zone integration whereby the former is the breeding base while the later is the fattening ground.

From Bedouin Rule to Settlement

With changing political and economic systems, along with motorized transportation, the life of the nomadic Bedouin has greatly altered since the end of the Second World War. Previously, sheep and goats were the main animals herded and the main source of income. Rangelands were under Bedouin authority, with access controlled by tribal law.

Then, long-distance movements were licensed by the colonial authorities. Land was allocated to tribal leaders to force tribal settlements, as in Saudi Arabia (Shamekh 1977). Raids (*ghazu* in Saudi Arabia) and the *khuwa* system, by which villagers had to pay protection money to Bedouins, came to an end. Under forced control, Bedouins were forbidden access to cultivated lands at the better margins of the steppe (Denis 1989). With the spread of mechanized cultivation and expanding settlement, larger steppe districts came under barley cultivation (Thalen 1979).

Private entrepreneurs, in partnership with tribal leaders, provided capital for seed and machinery. Bedouin partners would receive 25–50% of the crop, and the crop residue for their flocks. Soon after, Bedouins started purchasing their own supplies to plow the steppe (Leybourne 1993). Cultivation expanded to the detriment of rangeland resources.

But in low rainfall areas, pastoralists remained nomadic. They migrated in fixed annual patterns as seasonal grazing became available in wetter areas (Kabbali and Berger 1990). In North Africa, the yearly *achaba* of Bedouins between the steppe and the cereal zone matched the farming calendar. Bedouins provided a cheap labor force in exchange for grazing rights on crop residue and weedy fallows. In the Mashreq, between 1946 and 1958, the steppe was soon classified as *mawat* (“dead” or “empty”), and by plowing it for ten years, one could claim ownership (Hamide 1959 and Thalen 1979).

Tolerance of cereal cultivation encroachment in the steppe amplified natural resource degradation. From an unlimited nomadic and pastoral system, the region underwent a change towards greater dependence on the farmers and their crop production.

Steppe Resources In the Arid Zones of the Arab Countries: a Resource under Fatal Threat

The Mediterranean arid zone stretches between the 100 and 400 mm isohyets (Le Houérou 1995). In Arab Countries, this zone covers 10–15% of a total of 974 million ha (Table 1). There is a precarious rangeland–arable land frontier. There, the probability of harvesting a cereal crop ranges from 50% in the wetter zones to 10% in the arid zones. This is the steppe, where agro-pastoral systems have developed. The 350–400 mm isohyet is considered the lowest limit for reliable rainfed cereal cultivation. Below the 150 mm isohyet, native vegetation, once destroyed or overgrazed, has little chance to recover or to be restored (Le Houérou 1969, 1991). The 100 mm isohyet is the lowest rainfall limit where permanent rangeland vegetation can be found. This is the real desert. Today, flock and water transportation by trucks to remote desert areas has slimmed down these valuable resources (Lewis 1987). As much as 50% of the arid rangeland may have lost its vegetation since World War II, as the human population has increased fourfold in North Africa and the Middle East (Le Houérou 1991). The sheep population has increased by 75% and the stocking rate jumped from 1 sheep/4 ha to 1 sheep/ha between 1950 and 1989. This came about through uncontrolled and government-subsidized supplementary feeding (Boutonnet 1991), transforming rangelands into open-air feed lots, and allowing pastoralists to maintain their flocks in spite of worsening rangeland conditions. This trend is reflected in the feeding calendars of the different livestock owners involved in agro-pastoral activities in northern Syria.

Table 1. Arid steppe zones and desert areas in WANA below the 400 mm isohyet (1,000 km²).

	100-400 mm	Less than 100 mm	Total area	% Steppe	% Desert
North Africa					
Morocco	120	303	620	19	49
Algeria	210	1,990	2391	9	84
Tunisia	55	60	164	34	37
Libya	90	1,670	1,760	5	95
Egypt	30	910	1,001	3	91
Sub-total	505	4,933	5,926		
Near East					
Egypt (Sinai)	5	55	60	8	92
Iraq	291	96	435	67	22
Palestine	5	7	21	24	33
Jordan	40	43	98	41	44
Kuwait	18	0	18	100	0
Oman	12	198	212	6	93
Qatar	0	22	22	0	100
U.A.E.	0	84	84	0	100
Saudi Arabia	200	1,940	2,150	9	90
Syria	157	10	185	85	5
Yemen	160	312	530	30	59
Sub-total	888	2,767	3,815		
Total	1,393	7,700	9,741	14.3	79.0

WANA steppe (100-400 mm/yr) = 139,000,000 ha.

WANA desert (less than 100 mm/yr) = 770,000,000 ha.

Source: After Le Hou  rou (1991).

Sheep Grazing and Feeding Calendars in Northern Syria

Agro-pastoral systems can be defined by a feeding calendar that includes feed origin and when it is utilized. Interview and data summaries for the feeding calendars developed in this study are from a 1991/92 survey of 128 flock owners in the marginal farming and rangeland districts of Aleppo and Hama Provinces (Wachholtz et al. 1993). Three major groups were identified. Group 1 is settled with permanent crops and houses. Group 2 has larger cultivated areas of barley, larger flocks of sheep, and sustains a migratory pattern of grazing and feeding in the steppe for the winter, remaining near their barley fields in the spring, and moving to available crop residues in the wetter agricultural areas for the summer and autumn. Group 3 is contains nomadic herders with no significant cultivation who spend the winter and spring months in the steppe and, like Group 2, move their flocks to the higher potential areas for summer and autumn months. Due to

their cultivation of barley, and because they depend on settled farmers' resources, these groups are called agro-pastoralists, found from Morocco to Balochistan.

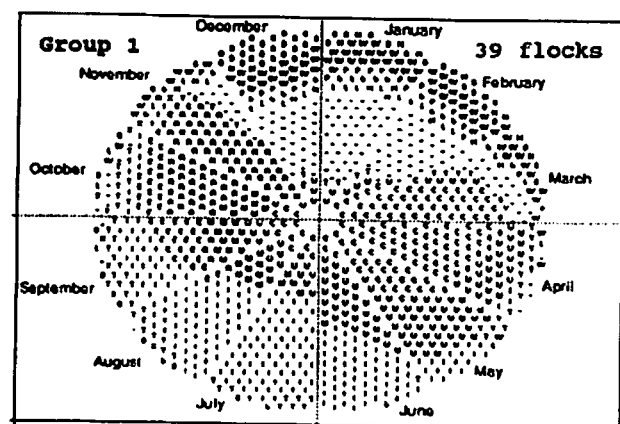
Sheep Diet Calendars In the Arid Syrian Zone

The diet calendars for the flocks of Groups 1, 2, and 3 are summarized in Figure 1. Feed reported at 1% or higher is listed separately. A strong seasonality in livestock diets is revealed by the flock owners' flexible use of a variety of cheap hand-fed feeds, including chopped cereal straw (*tibin*) and grazed materials. Expensive grains, legume straw, and concentrates are hand-fed in winter, before and during lambing and lactation. Wheat straw is not important as a feed source. In the summer months, dry ewes are able to survive on cheap cereal residue. Flock mobility makes these flexible diets possible. Only from March to May does grazing of native pastures and rangelands make up a significant portion of the sheep diet. Other minor components of the winter diet have been reported, such as sugar beet pulp, cottonseed (whole, cake, and hulls), wheat and legume straw, and bread (Thomson et al. 1989), which is consistent with reports of earlier studies (Jaubert and Oglah 1987; Thomson and Bahhady 1983; Nygaard et al. 1982; Tully 1984). Barley straw is an important ingredient in the winter diets (40%) of all three groups in the 1991/92 survey. Strict pastoralists cannot rely only on rangelands. The farmers' contribution to the small ruminant diet is increasingly important. This is confirmed by the trend towards increased rainfed and irrigated cropping in the arid zone.

Feed Calendars for Full Nomad Flocks

Wachholtz et al. (1993) provides the first quantification of year-round sheep diet calendars for fully nomadic flocks (Group 3). This is generally consistent with Bahhady (1981) and Chatty (1986). However, in the grazing of the barley crop is an important difference between nomadic flocks and those of the sedentary and semi-sedentary agro-pastoralists; it remains a very minor part of the nomadic (Group 3) flock diet, but a major feed source for flock owners (Groups 1 and 2) growing barley for their own sheep.

The grazing of standing barley in lieu of harvesting has been well documented (Nordblom 1983; Somel et al. 1984; Tully 1984). The finding that fully nomadic flocks make little use of this source is new. Grazing of marginal lands (mountain, village/site, and open steppe) was concentrated in March, April, and May of the dry 1990/91 season. This made up a minor proportion of the annual sheep diet: 12, 13, and 18% for Groups 1 and 2, and nomadic Group 3, respectively. This is the first quantitative estimate of the contribution from marginal land in recent years in Syria. It reflects the extent to which the contribution of native pastures to the sheep diet has decreased since the 1950s, when little, if any, winter supplement feed was used (Thalen 1979; Bahhady 1981; Chatty 1986; Lewis 1987; Le Houérou 1991).



KEY: each symbol is 1% of monthly diet

Hand-Fed Materials

— = cereal straws (wheat and barley)

W = wheat bran

B = barley grain

b = bread

N = cottonseed cake and cottonseed

L = lentil straw (tibn)

p = sugarbeet pulp

H = cottonseed hull and other cotton residues

X = peanut residue

Grazed Materials

U = unharvested crops (wheat, barley, legume)

| = cereal stubbles (wheat and barley)

M = maize stubble (some unharvested maize)

R = cotton residues

C = common grazing: village areas, roadsides & mountains

S = open steppe grazing

Y = weedy fallow grazing

E = melon and sunflower residues

T = other residues: sugar beet, vegetable, orchard weeds, onion, weeds of irrigated land

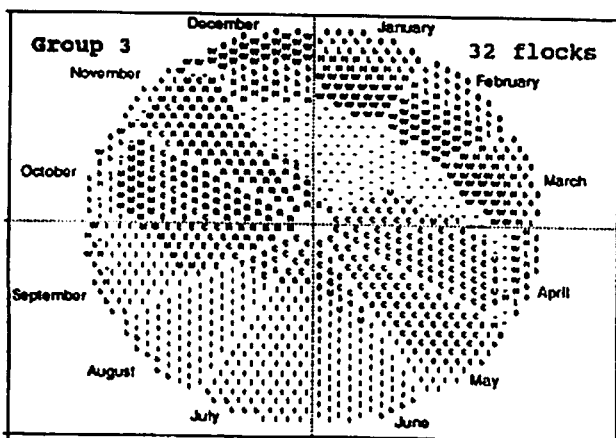
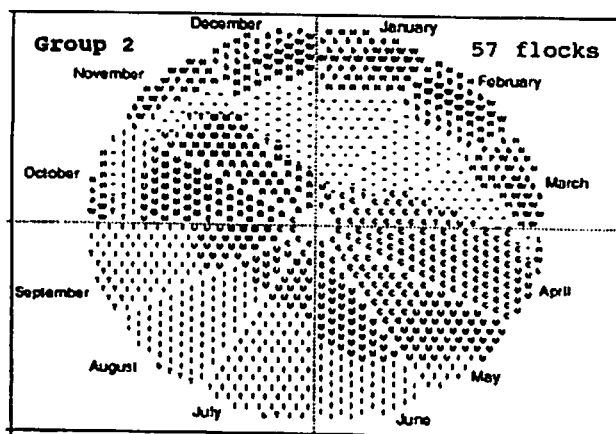


Figure 1. Sheep diet calendars for Bedouin Groups 1, 2, and 3 in Aleppo and Hama Provinces, northwest Syria (1991/92).

Decreasing Utilization of Steppe Vegetation

Open-access steppe provides less than 1% of the agro-pastoralist flock's diet, and less than 3% of full nomadic flock's diet. Of secondary importance is marginal land grazing in mountain areas with higher rainfall. More important is the village grazing area in the dry farming zones, and grazing areas in the steppe where native pastures are used in common by local households, but less by outsiders' flocks. There are indications, however, that the latter may enter these areas after the local flocks have moved away to higher rainfall zones in late spring or summer. This raises serious questions about the economic viability of rangeland improvement where access is uncontrolled throughout the year.

Open-access Grazing: a Calamity for the Steppe

There is a distinction between open-access and common grazing (Bromley and Cernea 1989). Full open-access grazing is of little importance in terms of the quantity of feed, although the land areas involved may be quite large. The best grazing lands have been taken over by barley cultivation and agro-pastoralist settlements, with little feed left over for flocks. Open-grazing practices do not allow the nomad to leave anything to spare for later. He is condemned to graze the range to the last twig and straw. This is one of the reasons for the poor condition of the rangelands in WANA.

The issue of sustainability of substitute feed sources is important, since feed and grazing sources which appear cheapest in the short run (e.g., from barley cultivation in the steppe) lead to loss of native vegetation and soil in the long run. This is seen in the decreasing share of rangeland in the small ruminant diet. But how does this relate to the feed conditions in WANA?

Livestock and Feed: a Macro-perspective on WANA Rangelands

Feeds in WANA present a challenge to anyone wishing to describe them briefly. Crop residues of all sorts are used in addition to grazing of native pastures, feed grains, and other concentrates. Quantitative estimates of crop residues are derived from crop statistics. Grazing of off-take is estimated according to pasture area (FAO 1993) and then by country-specific kg/ha assumptions (ACSAD/AOAD 1985). Feed grains and other concentrates comprise the smallest feed category for most countries in WANA, with the exception of Saudi Arabia, Jordan, and Libya, where feed imports have increased spectacularly over the past 20 years.

FAO (1993) livestock population data are summarized in five-year averages between 1970 and 1990, using a factor for conversion to a standard Livestock Unit (LU) equal to a 500 kg bovine at maintenance.

The 20-year aggregate trends, balances of all feeds (crop residues, natural grazing, and feed grains), and all livestock units (small ruminant, bovine, draft, and poultry) are plotted in millions of metric tons of dry feed matter and millions of aggregate LUs (Fig. 2). The band of annual dry matter consumption, with feeding

levels between 1.5 and 3.0% of live weight per day, covers the middle range of the region's feed and livestock balance.

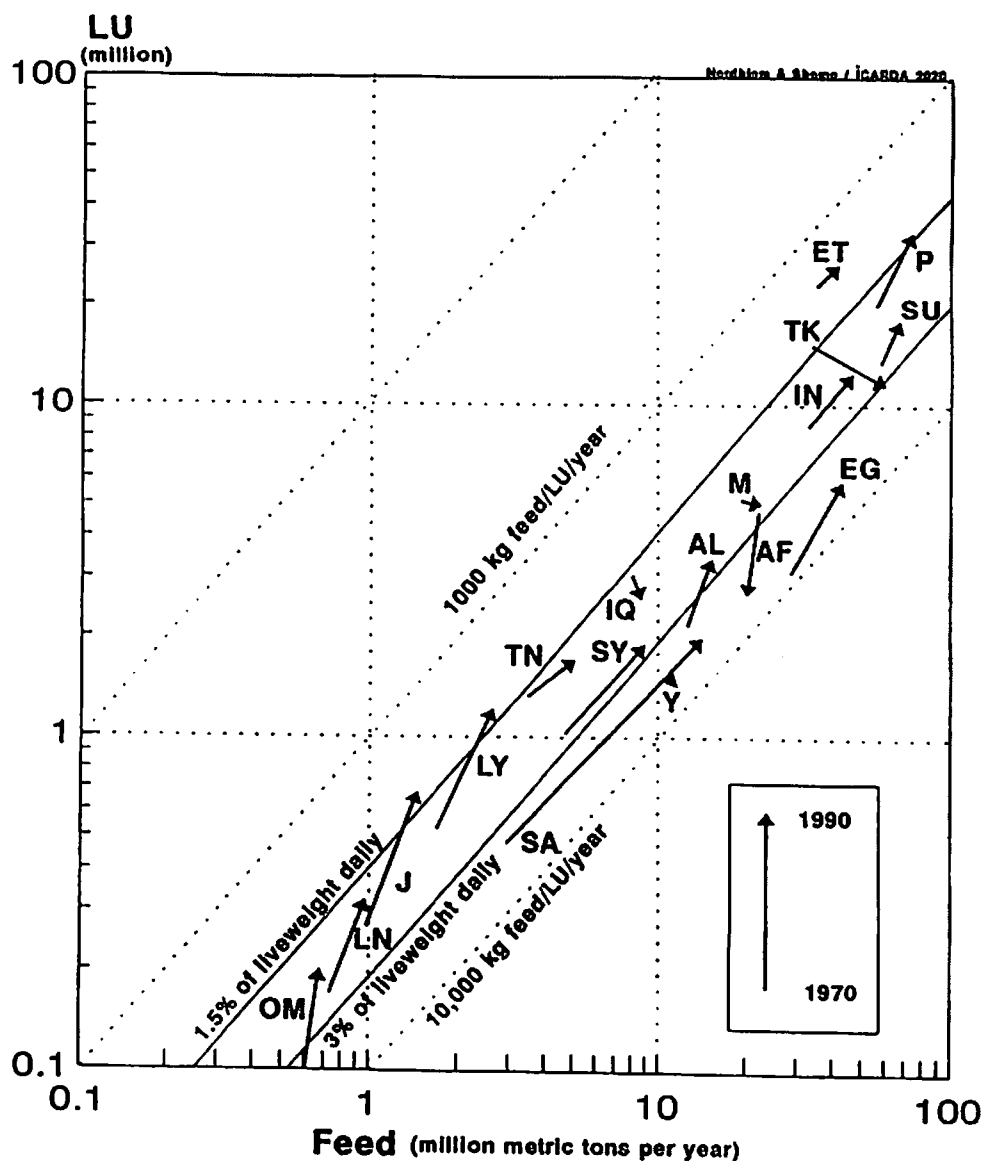


Figure 2. Livestock units and feeds in selected countries of WANA, 1970 and 1990 (log-log scale). AF=Afghanistan, AL=Algeria, EG=Egypt, ET=Ethiopia, IN=Iran, IQ=Iraq, J=Jordan, LN=Lebanon, LY=Libya, M=Morocco, OM=Oman, P=Pakistan, SA=Saudi Arabia, SU=Sudan, TN=Tunisia, TK=Turkey, Y=Yemen. 1970 and 1990 values are five-year averages for 1968-1972 and 1988-1992, respectively.

There are three feed categories: (i) crop residue and forage crops; (ii) natural pasture grazing; and (iii) feed grains and concentrates. These add up to 100% of feed use for any country at a given time. Thus, a 20-year trend is plotted for each of the countries in a composition graph (Fig. 3) similar to a soil texture chart. Contrasts in the feed resource endowments and general shifts toward greater proportions of feed grains and crop residues, away from marginal land and rangeland grazing, are apparent, most spectacularly so in Jordan, Lebanon, Libya, and Saudi Arabia. Except in Afghanistan and Yemen, all countries show rangeland as a diminishing proportion of diet without accounting for degradation of rangelands, an important factor to be considered for the future of the region.

Quantities of both domestic crop residues and feed grains should increase, as should better management of cereal crops in rotations including forage and food legume crops (Osman et al. 1990).

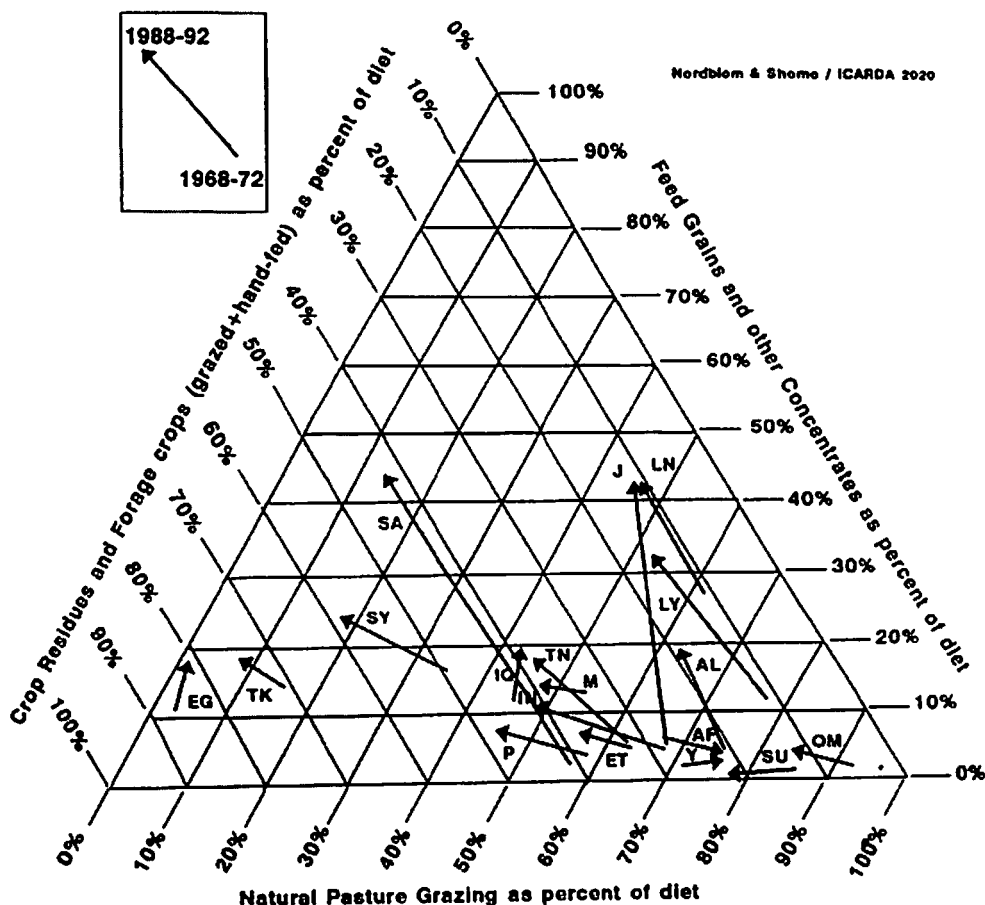


Figure 3. Composition of livestock diets by feed category: 20 year trends for selected countries of WANA (1968-1972 to 1988-1992). AF=Afghanistan, AL=Algeria, EG=Egypt, ET=Ethiopia, IN=Iran, IQ=Iraq, J=Jordan, LN=Lebanon, LY=Libya, M=Morocco, OM=Oman, P=Pakistan, SA=Saudi Arabia, SU=Sudan, TN=Tunisia, TK=Turkey, Y=Yemen.

However, domestic feed production is unlikely to keep up with demand in most WANA countries. Assuming increases in crop production are associated with increases in crop residue, forage crops, and feed grain production in equal proportions allows us to make simple projections of the number of LUs supportable by domestic feed sources in the future. Our projection of total domestic feed supplies, given 1, 2, and 3% annual rates of increase in crop production, allows us to bracket a plausible scope of possibilities for each country (Fig. 4). Subtracting feed imports from the total feed resources of each country (five-year averages around 1990 for crop residue, rangeland, and feed grain) and dividing the result by 3% of live weight per day for our 500 kg LU, gives an estimate of the number of ruminant LUs supportable by domestic feed alone. A WANA-wide median of 0.2 LU per capita for 1990 was found by Nordblom and Shomo (1993). To derive the LU and feed projections (Fig. 4), a constant demand of 0.2 LU per capita is assumed, and UN population projections (1993) are used. Some countries show surpluses well above 0.2 LU per capita (Sudan, Ethiopia, Pakistan, and Turkey).

The deficit in LUs may be satisfied either by importation of livestock products or of feed. Or such deficits may simply remain unsatisfied. Beginning with a node at 1990, branches spread out to nodes for the years 2000, 2010, and 2020 for the 1, 2, and 3% rates of increased crop production in relation to human population. The larger populations of Syria and Algeria, already showing feed deficits in 1990, may face what appear to be very large deficits by 2020 (11 and 23 million tons of feed, respectively) given a 3% rate of increase in crop production. Even such substantial increases in crop production may not, for most WANA countries, turn the tide of decline in per capita LUs supportable by domestic feed production.

Rangeland and Marginal Land Degradation: Is there Hope for Rehabilitation?

The causes, processes, and the consequences of the degradation of grazing land (rangeland and marginal land) in WANA and possible corrective measures are well documented (Le Houérou 1969, 1975, 1986, 1991; Gintzburger and Bayoumi 1977; Osman and Cocks 1992). Degradation of vegetation is often accompanied by severe soil erosion, especially wind erosion as in Tunisia (Novikoff 1983; Floret and Pontanier 1982). In addition to rangelands, marginal lands exist within the cropped lands and cover 30–40% of the land in Syria and Lebanon and 1 million ha in Jordan. They are endlessly overgrazed by village flocks, and suffer from severe soil erosion (Osman and Cocks 1992). Marginal lands are particularly important in spring, when large amounts of supplementary feed are provided. Improving productivity of these range and marginal lands may reduce supplementary needs and lessen cultivation of rangeland and marginal land.

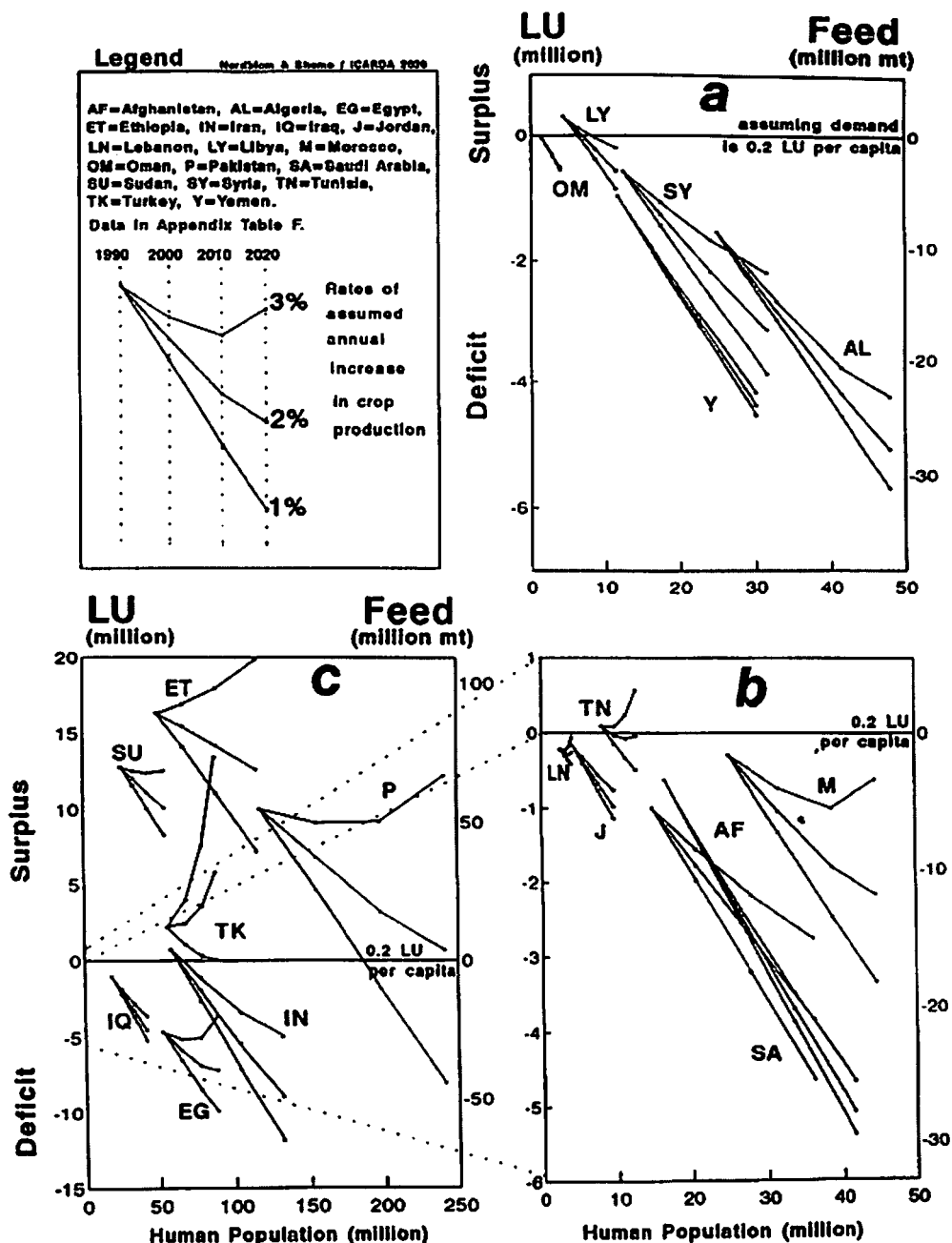


Figure 4. Projected surpluses and deficits in livestock units and feeds, assuming a constant demand of 0.2 LU per capita, with population projections for 2000, 2019, and 2020 and annual increase in crop production of 1, 2, and 3% for 18 WANA countries.

Prospects for Rangeland and Marginal Land Improvement

In almost every country of the region there is an irritated and impatient concern for natural resource conservation and rehabilitation of rangelands to halt degradation and/or to improve productivity. Energetic national and international agencies in WANA have launched large-scale shrub plantations (Le Houérou 1992). Planting of fodder shrubs and trees (*Atriplex* spp., *Salsola* spp., and *Acacia* spp.) may alleviate the pressure (Le Houérou 1980), reduce wind erosion, and secure a fodder reserve when the nutritional value of grass is low (McKell 1980). In spite of encouraging results in several WANA countries, the local agro-pastoralists have benefited little from these plantations (Leybourne et al. 1994), which require prudent management from inception to maturity. In several countries, plantations established at a high cost (US\$ 300–2,000/ha) have been damaged or totally destroyed in a few grazing seasons, or after a drought, by uncontrolled flocks. In most cases, land tenure and grazing management are the key issues (Draz 1978).

Other potential techniques are available. The work carried out around the Mediterranean basin and at ICARDA has indicated prospects for technical improvement of degraded rangelands even in extremely low rainfall zones (Gintzburger 1979). On the marginal lands in northern Syria in the 350 mm/year rainfall zone, annual applications of super-phosphate, even at 25 kg/ha, may improve pasture and sheep productivity and prove profitable (Osman et al. 1994).

Likewise, the use of small-seeded local pasture legumes and their pods is effective in enriching the seed bank of the degraded marginal land and in improving pasture productivity (Christiansen et al. 1994). Rangeland soils may become eroded or compacted so that early plant establishment is difficult or impossible unless micro water catchments are created to collect water, soil, seed, and organic material (Gintzburger 1987) to facilitate early establishment. It is of prime importance that rangeland rehabilitation techniques remain low cost, low input.

However, as we have seen, rangeland and marginal land in their present condition cannot supply the required feed. Research on forage crops to improve crop–livestock integration between the steppe and the farming zones is needed.

Improving Pasture and Forage In the Cropping System

Rangeland improvement programs on degraded lands, such as reseeding or shrub plantations, require animals to be excluded for one to three years. Therefore, more emphasis may be placed on feed supply from other sources, especially arable lands. With such forages, it should be possible to take large numbers of young animals off the range to be raised entirely on arable land (Le Houérou 1969; Huss 1978); rangelands would be used for breeding stock and croplands for fattening.

At present, livestock move to the range at the beginning of the rainy season, causing great damage to the newly emerging or sprouting vegetation. This will not be the case if feed in the form of conserved hay or medic pasture is made available

on arable land to support animals through the winter and beyond. WANA countries have varying capabilities to produce pasture and forage on arable lands. Carter (1978) assumes that 23 million ha of fallow in the WANA region could be planted with forage and pasture legumes, such as annual medics, to support the equivalent of 86 million ewes a year.

Studies at ICARDA, in the 350 mm rain zone of northern Syria, indicate that adapted medic species such as *Medicago rigidula* and *M. noeana* can produce 40–50 kg DM/ha/day during winter, easily supporting 10–12 sheep/ha. Spring productivity of the same pasture raises to 100–160 kg DM/ha/day, giving enough feed for 12 sheep/ha and at the same time allowing high seed production. The excess spring production could provide an additional 100 days of grazing in summer, thus carrying 12 sheep/ha for most of the year (Osman et al. 1990). But this system is not easily adopted by local farmers (Nordblom et al. 1994), who plant most of the fallow land available to continuous cereal or cash crops. Carter also stated that over 20 million tons of forage DM could be produced under irrigation, supporting an additional 26 million ewes or equivalent/year. But in WANA countries irrigated forages are not in favor, because of the limited water supply and better return obtained from irrigated cash and food crops.

All this can only mean that we should expect increasing pressure on the remaining rangelands of WANA. Hence there is an urgent need to invest in rangeland and marginal land rehabilitation with balanced technical and socioeconomic measures.

Conclusions

Small ruminant diets vary among agro-ecological zones according to seasonal rainfall, local feed resources, and the way resources are managed. From early summer through early winter, grazed residue of dryland and irrigated crops provides much more feed than native pastures in spring.

Rangeland grazing, a free and therefore cheap feed resource, is highly unreliable because of climatic hazards and extreme degradation. The data reviewed in this paper demonstrate the diminishing contribution of rangeland and marginal land to the small ruminant diet. The hypothesis that the presence of adequate feed on arable land would induce a deferred grazing system, whereby the range and marginal land would be allowed to set adequate seed and still be used for limited grazing, has yet to be proven. Experience in the region tends to demonstrate that feed increases on cropping land do not necessarily decrease the pressure on the rangeland. Backup research on techniques and plant development, with strong socioeconomic support and user participation, is essential, as is development of low cost and reliable methods that rangeland users can employ.

Political decisions are needed to secure tenure of grazing rights while reducing the amount of time spent grazing on the range and matching grazing pressure to carrying capacity. This a major challenge with no simple answer. The arrangement should consider both the national interests of conserving natural resources and enhancing productivity, as well as the interests of range users, who are likely to continue the migratory system to exploit crop residue in higher rainfall zones, and the free seasonal pasture on the steppe—a clear example of crop–livestock–rangeland integration by agro–pastoralists.

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Village, Farm, and Pasture Resource Assessment In Planning a Forage, Livestock, and Range Improvement Project for the Central Highlands of Turkey

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Abstract

Most of the pastures in the central highlands of Turkey have been replaced by cereals over the last 50 years. Mismanagement of the existing pastures by early grazing and overstocking has resulted in severe degradation of pasture species. This study is part of a multidisciplinary project that includes botanical and socioeconomic surveys, improvement of village-based feed resources, and realistic livestock feeding schemes that put limited feed resources to best use. The main components of the project—farmers, livestock, and common pasture—interact with each other in unpredictable and conflicting ways. Combined with objective methods to diagnose village structure and the botanical state of the rangeland, a participatory approach helps to broaden potential solutions to livestock feeding problems by including land users, extension agents, and scientists in the dialogue on natural resource use. Results of surveys and biodiversity studies in selected villages are presented as prerequisite information for the initiation of a forage, livestock, and range rehabilitation project.

Introduction

In the central highlands of Turkey cereal agronomy techniques and levels of production have significantly improved since the establishment of the Turkish Republic in 1923. The development of cereal culture displaced common pastures, a side effect of which has been increased environmental degradation. As a result, many of the permanent pastures have been converted to cropped land in the last 50 years (Bakır 1971). This may not, however, be sustainable in the long term because of severe water and wind erosion.

According to government statistics, the pasture area, which had decreased from 44.3 m ha in 1935 to 21 m ha in the 1970s, decreased still further to 12.4 m ha

in 1991. Rapid increases in human population have encouraged the conversion of pasture to cultivated land. Simultaneous increases in livestock have concentrated more animals on a smaller area. This trend is not sustainable without the development of feed resources such as forage crops to counterbalance the loss of pasture to cereal cultivation, or without the rehabilitation and improvement of marginal grazing land.

The mismanagement of pasture lands by overgrazing and overstocking has resulted in a reduction in the number of pasture species. The rangeland is grazed from early spring to winter. However, the ideal grazing season, which enables pasture species to recover, is between 15 May and 15 September (Büyükburç 1983a). As a consequence of this extended use, the grazing capacity of the common land has been dramatically depleted.

Socioeconomic constraints often restrict the sustainable use of common lands. Because of traditional and excessive use, rangelands never reach their full productive capacity, and farmers are not aware of the gains that could be obtained by adopting better management techniques. Common ownership of rangeland prevents land users from investing in improvements because there is no guarantee that they will receive the benefits from the investment.

In the past, development projects on rangeland consisted of on-farm studies and demonstrations of seeding, fertilizing, and feeding. The seeded pasture demonstrations, initially accepted by villagers with great interest, failed because of the relatively high cost of establishment and the subsequent mismanagement of the pastures (Munzur 1989). Therefore, in 1995 the Central Research Institute for Field Crops (CRIFC) of the Turkish Ministry of Agriculture and Rural Affairs (MARA) and the International Center for Agricultural Research in the Dry Areas (ICARDA) initiated a multidisciplinary research project on the management and rehabilitation of village rangeland in three districts in Ankara Province.

The project has the following objectives: (i) to identify representative villages for a participatory project; (ii) to increase feed resources through range rehabilitation and the use of forage crops and perennial legume/grass mixtures; and (iii) to develop feeding recommendations for livestock based on local resources and practical livestock management techniques that will improve flock or herd health. Highlights of this approach and the initial results obtained are presented below.

Methods

Description of the Study Area

The central highlands of Anatolia, comprising 13 provinces, contain about one third of the range in Turkey, and are characterized by severe drought combined with temperature extremes in both summer and winter, and average rainfall of 350–mm. The most important plant species are *Thymus squarrosus*, *Artemisia fragrans*, *Festuca ovina*, and *Poa bulbosa* var. *vivipara*. *Thymus* and *Artemisia* species are predominant, and grasses constitute about 40% of the vegetation (Bakir 1971). Büyükburç (1983a) reports that pastures of the Anatolian central highlands originally consisted of legume, grass, and other genera. However, due to

continuous, heavy, and early grazing, the pastures have been invaded by weed species with low nutritional value. High-quality legume species make up less than 1% of the plant cover.

Twelve million sheep and goats and approximately 2 million cattle depend on these rangeland pastures for feed.

The project study area was divided into two distinct localities—plateau and mountain. Three districts—Polatlı, Kalecik, and Çubuk—were selected as a pilot area in collaboration with the extension service of the Provincial Agriculture Directorate of Ankara. From these districts, 14 villages were identified as potential locations, two of which were finally selected for feed resource interventions: Kargalı in Polatlı County and Gököy in Kalecik County.

Description of the study

The study focuses on a descriptive diagnosis of villages, current feed practices, and the botanical composition of the rangeland.

Diagnosis of village structure

The first focus of the study was the whole village, followed by the collection of data at the farm level to identify and describe the pilot area and associated constraints.

Preliminary survey with village leaders (*muhtars*)

Surveys were conducted in the 14 villages: six in Polatlı and eight in Çubuk and Kalecik. Details included the number of households and livestock owners, a livestock inventory, the distribution of land and the area of arable and fallow, the ratio of income derived from crop and animal production, forage crop production, food and feed legume cropping, and the utilization of rangeland.

General Survey

A general survey, based on a pre-tested questionnaire, was conducted to learn more about the individual users of rangeland and interventions which are feasible for implementation at a village level. Factors such as farm structure (land size, number of parcels, rotations, etc.), land tenure, farm income, dependence on livestock, and interest in participating in fallow replacement, rangeland rehabilitation, and livestock activities in the next stage of the project were quantified.

Fifty four farmers from four villages on the plateau (Kargalı, Seyhahmetli, Yagcıoğlu, and Ömerler) and 62 farmers from seven villages in the mountains (Karaman, Sarıkoz, Hacılar, Yukarıçavundur, Deliören, Gököy, Ahmetadil, and Yeniçöte) were questioned.

Farmers were questioned about components of livestock diets for each month of the year. Feeding calendars based on the method of Goodchild et al. (1994) were constructed.

Biodiversity of Pasture Species on Range

Plants were collected in seven villages, with the location and habitat type recorded at each site. Slope was estimated by eye, location was determined with a global positioning instrument, and height above sea level with an altimeter.

The vegetation and its distribution were described for each site in a number of ways. The general habitat type (meadow, rangeland) and dominant species were recorded. Visual estimates were made of the percentage of vegetative cover and of annual legumes and grasses. Aspect, i.e., the position of the hillside with relation to the sun, was converted to a numeric value (0–7) with north=0, east=2, south=4, and west=6.

Soil pH was measured with a test kit on a bulked sample taken from several places at each site. Degradation of the land was described by assessing grazing pressure, the amount of plant debris on the soil surface, and trampling. Each site was visited twice, with approximately one month between visits. Herbarium specimens and seed of legume and grass species were collected.

SAS was used to cluster the 23 locations, with Ward's minimum variance procedure, into four groups containing 7, 5, 5, and 6 sites. Clustering variables included percentages of plant cover, annual legumes, perennial legumes, grasses, woodland, and rocky outcrops. Slope (degree), soil pH, and aspect were also included as variables. F-tests were carried out to identify variables contributing significantly to the cluster analysis.

Results

Village Survey Results

There were considerable differences between the plateau of Polatlı and the mountains of Çubuk and Kalecik in terms of the amount of arable and fallow land per household and the dependence on animal production (Table 1). There are 141 households in the plateau survey and 47 in the mountains. On the plateau, about 84% of the households own livestock that depend on rangeland pastures. In the mountains, 95% of the households surveyed depend on rangeland to graze their animals, although there is a smaller area of rangeland per household than on the plateau. The plateau villages have 21.2 ha of arable and 9.0 ha of fallow land per household, compared with 8.7 ha and 0.7 ha, respectively, in the mountains. Almost 45% of the arable land was left fallow in the plateau, compared with less than 10% in the mountains.

The major crops in the plateau are wheat, barley, and sugar beet. Melon, cumin, and onion are also important. Cereals are grown for home consumption in the mountains, but are the mainstay of agriculture on flatter lands where mechanical harvesting is easier. Food legumes are grown on 39 ha (0.3 ha/household) in the plateau villages, but no feed legumes were found. The opposite was true in the mountains, where vetch was found on 100 ha (2.1 ha/household) while only 4 ha (0.1 ha/household) was used for food legumes.

According to village leaders, livestock production contributes about three quarters of the annual income in the mountains but only one third on the plateau. There are twice as many small ruminants as cattle on the plateau and twice as many cattle as small ruminants in the mountains (Table 1).

Table 1. Mean values from 14 villages (plateau and mountains) as described by village leaders.

Characteristic	Plateau (Polatlı)	Mountains (Çubuk, Kalecik)
Number of households	141.0	47.0
Households using range	119.0	40.0
Rangeland area (ha/household)	11.0	7.7
Stocking rate (AU [†] /ha)	4.1	1.2
Arable land (ha/household)	21.2	8.6
Fallow (ha/household)	9.0	0.7
Food legume sown (ha/household)	0.3	0.1
Feed legume sown (ha/household)	0.0	2.1
Cattle/village	225.0	345
Sheep/village	2550	1011
Goats/village	93	231
Percentage annual income: livestock	35	71
Percentage annual income: crops	65	29

[†] AU = Animal Unit (500 kg live weight).

Table 2. Mean values for farm size distribution and livestock herd size in 11 villages in the plateau and mountains.

Characteristic	Plateau (Polatlı)	Mountains (Çubuk, Kalecik)
Number of households	54	62
Land distribution (% of households)		
No land	14.8	8.1
0–5 ha	0.0	35.4
5–10 ha	11.1	27.4
10–50 ha	59.3	29.1
>50 ha	9.3	0.0
Number of small ruminants		
0	29.7	50.0
1–10	1.7	4.8
11–50	24.1	16.1
51–100	16.7	6.5
101–500	26.0	17.8
>501	1.8	4.8
Number of cattle		
0	29.6	0.0
1–5	40.7	17.7
6–10	25.9	32.3
11–50	3.8	50.0

General Survey Results

According to the general survey, the field size of the farm holdings varies in the two areas. There are more landless farmers on the plateau (Table 2). More than one third of the farms in the mountains are <5 ha, while there are no farms in the 0-5 ha class on the plateau. The average farm on the plateau is much larger than in the mountains—more than two thirds of plateau farms are larger than 10 ha.

A third of the plateau households are crop farmers. Each household in the mountains has at least one cow, and half have more than two, highlighting the greater dairy potential s, although 50% have no small ruminants (Table 2).

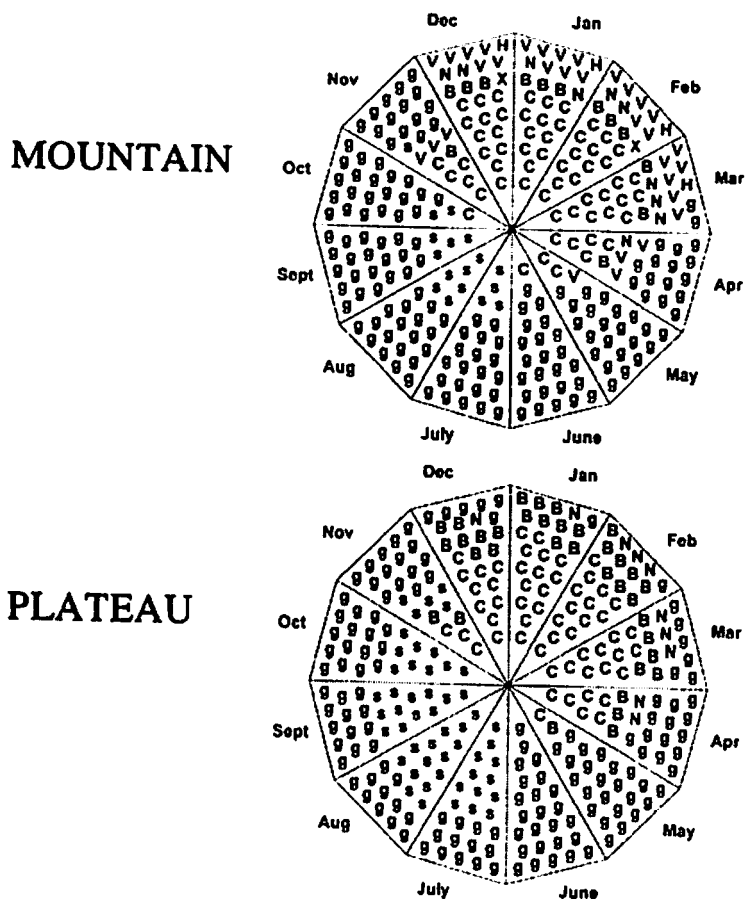


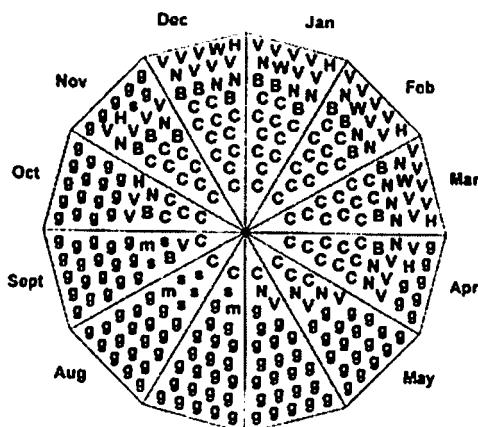
Figure 1. Grazing calendars of small ruminants in mountains and plateaus of the Turkish central highlands. Ingredients of diets are as reported by farmers: each symbol represents 4% of the diet in each month. Upper-case symbols denote hand feeding: C = cereal straw; B = barley; N = concentrates; V = vetch straw; H = hay; X = wheat grain. Lower-case symbols denote that animals were grazing: s = cereal stubble; m = meadow; g = pasture and rangeland.

Feeding Calendars

Small ruminants in the mountains are more dependent on rangeland, whereas—not surprisingly—much more cereal stubble grazing was found on the plateau. On the plateau, rangeland is grazed to some extent throughout the year, while in the mountains grazing starts in March and ends in mid-November. Vetch straw is used as a supplement in the mountains, while barley grain and concentrates are more common on the plateau (Fig. 1).

Cattle depend on rangeland more in the mountains than the plateau, but in the mountains their diet is supplemented by a more diverse feed mix, including hay, vetch straw and grain, and smaller amounts of barley grain. Cattle start grazing on rangeland at the beginning of April, one month after small ruminants (Fig. 2).

MOUNTAIN



PLATEAU

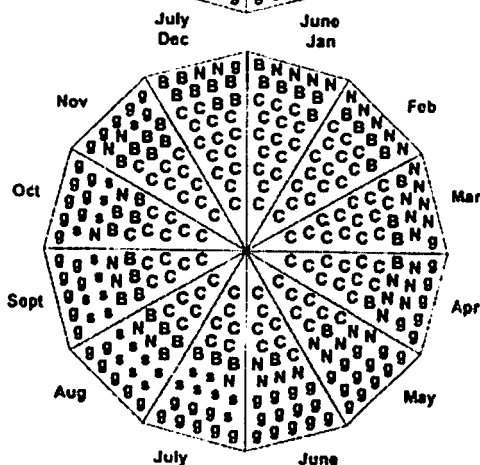


Figure 2. Grazing calendars of large ruminants in the mountains and plateaus of the Turkish central highlands. Diet ingredients are as reported by farmers: each symbol represents 4% of the diet per month. Upper-case symbols denote hand feeding: C = cereal straw; B = barley; N = concentrates; V = vetch straw; H = hay; X = wheat grain. Lower-case symbols denote that animals were grazing: s = cereal stubble; m = meadow; g = pasture and rangeland.

Pasture Species Biodiversity on Grazing Lands

Plateau

Biodiversity was estimated at 910–1,200 m alt at 11 sites—sites 3–6 in Kargall, 7–9 in Yagciloglu, and 10–13 in Seyhahmetli. Annual legume species include *Trigonella crassipes*, *T. monantha*, *T. astroides*, *T. monspeliaca*, *Medicago minima* and *Pisum sativum*. Perennial legumes such as *Astragalus creticus*, *A. vulnerariae*, *A. creticus*, and *A. lydius* spp. are frequently found. However, perennial grasses such as *Bromus* spp., *Festuca* spp., *Stipa* spp., *Dactylis glomerata*, and *Agropyron cristatum* are more common. *Artemisia*, *Euphorbia* and *Thymus* species are found at Kargall, and *Euphorbia*, *Verbascum*, and *Thymus* at Yagciloglu.

Mountains

Twelve locations were surveyed at altitudes between 1180 and 1790 m: sites 14–18 in Gököy, 20–22 in Hacilar, 23–24 in Sarlköy, and 25–26 in Karaman. Some annual legumes, *Medicago minima*, *Vicia villosa*, and *Trigonella* spp., were observed. The perennial legumes *Onobrychis armena*, *Medicago sativa*, and species of *Trifolium* and *Astragalus* were common. *Festuca*, *Bromus*, *Dactylis*, *Phleum*, *Stipa*, and *Poa* were common grasses. Associated species were *Sanguisorba* and *Euphorbia*, and, less frequently, *Lotus* and *Hedysarum* spp. Low-growing thorn bushes were also observed at site 18.

Cluster analysis

A canonical discriminant analysis was performed on the member sites within the clusters to determine which quantitative variables were significant in creating the groups (see F-tests in Table 3). In the present analysis, four clusters (Table 4) were created, using percentages of plant cover, annual legumes, grasses, and degree of slope. Cluster 4 contains the sites with the highest percentage of annual legumes, high plant cover, and greater slopes. Cluster 3 contains sites with the highest percentages of grass and plant cover. Cluster 2 includes the most degraded areas with high slopes, and Cluster 1 is intermediate with low slopes.

Table 3. Mean, standard deviation, minimum, and maximum values of parameters at sites of botanical surveys (n=23) and their statistical significance in a cluster analysis.

Variable	Mean	Std Dev	Min	Max	P>F
Plant cover (%)	53.7	15.8	30.0	80.0	<0.01
Rocky outcrops (%)	11.0	10.3	0.0	40.0	0.23
Wooded (%)	5.4	5.5	0.0	20.0	0.82
Annual legumes (%)	4.2	5.9	0.0	40.0	<0.01
Perennial legumes (%)	8.8	6.4	0.0	20.0	0.56
Grasses (%)	44.8	12.7	30.0	80.0	<0.01
Slope (degree)	25.1	15.2	0.0	50.0	<0.01
Aspect [†]	3.6	2.4	0.0	8.0	0.47
Soil pH	8.1	0.8	6.5	9.5	0.81

[†] N, E, S, and W = 0, 2, 4, and 6, respectively. Std. Dev. = Standard deviation.

Table 4. Means and significant differences for site characteristics after separation into clusters using Ward's minimum variance method.

Variable	Cluster			
	1	2	3	4
Plant cover (%)	46.6 ^b	35.6 ^c	71.7 ^a	62.0 ^a
Rocky outcrops (%)	13.0 ^a	4.0 ^a	9.0 ^a	16.1 ^a
Annual legumes (%)	1.6 ^b	1.4 ^b	3.2 ^b	10.4 ^a
Perennial legumes (%)	5.6 ^a	8.1 ^a	9.7 ^a	12.5 ^a
Grasses (%)	42.8 ^b	39.3 ^b	59.4 ^a	39.4 ^b
Slope (degree)	10.0 ^b	34.2 ^a	19.8 ^b	39.4 ^a
Aspect NSEW=0,2,4,6	2.7 ^a	4.3 ^a	2.7 ^a	4.9 ^a
Soil pH	8.0 ^a	8.2 ^a	7.9 ^a	8.4 ^a

Values within a row followed by different superscripts are significantly different ($P < 0.05$).

Since in a small project with a limited budget it is best to concentrate resources, Göküy and Kargali were chosen as representative villages because they contained sites from all four clusters. Figures 3 and 4 show a schematic representation of these villages.

KARGALI

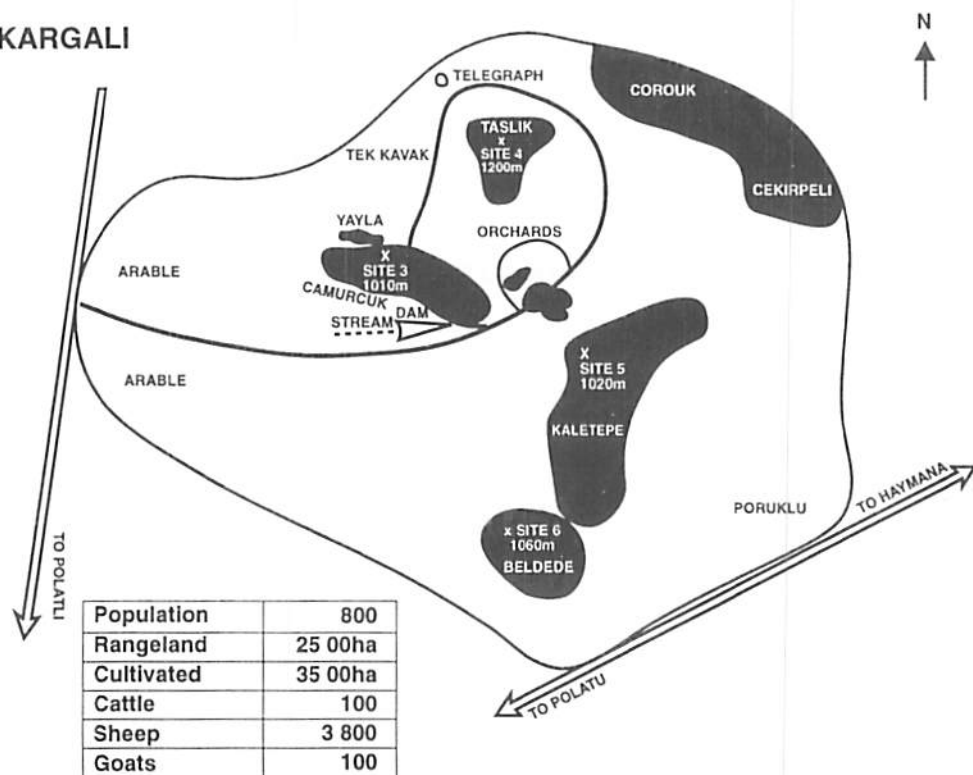


Figure 3. Schematic representation of Kargali and Polatli Counties, in the central Anatolian plateau of Turkey.

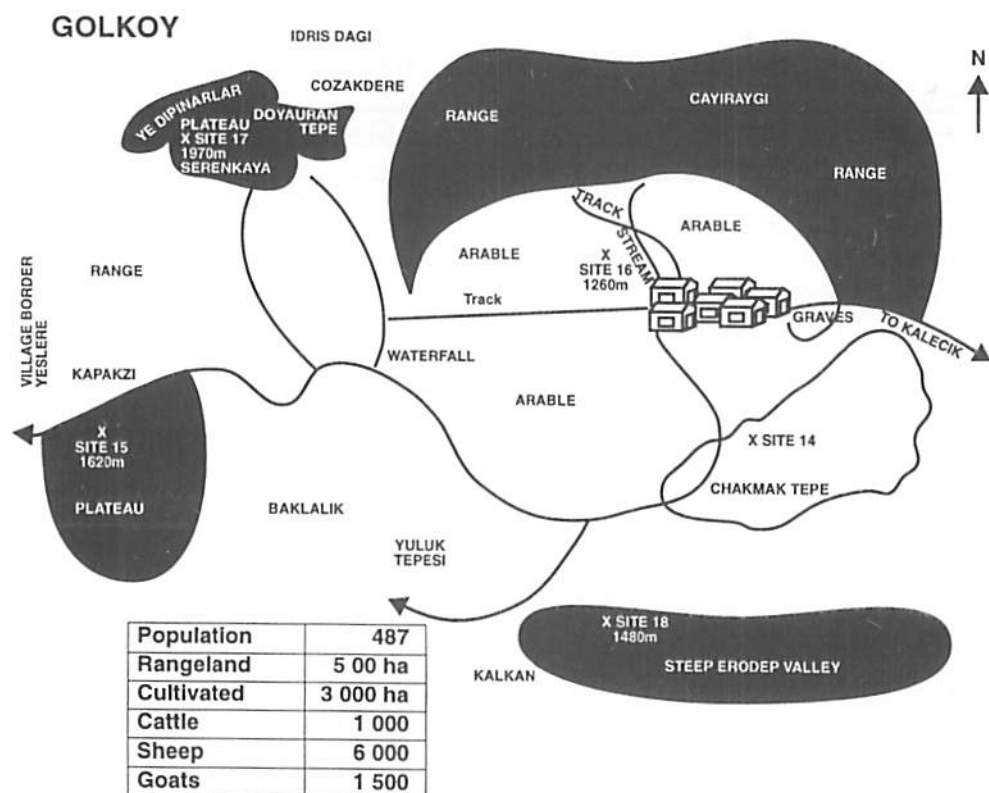


Figure 4. Schematic representation of Gököy and Kalecik Counties, in the central Anatolian mountain region of Turkey.

Discussion

Thus, there are remnants of vegetation that could form the basis of a rehabilitation program. Rehabilitation involves grazing management on sites with good plant cover and botanical composition, phosphate fertilizer to encourage annual legumes, over sowing, fertilization, and rest from grazing for the most degraded areas.

There are constraints to implementation of such programs. Livestock owners want more feed from the range, but increased grazing results in less and less off-take, degradation of the land, and a reduction in the number of plant species.

Questions remain. Is it possible to improve productivity and use of feed resources in a sustainable manner under free access management of the resource? Is it possible to conserve in a sustainable manner pasture resources that might otherwise be lost forever? Past failures suggest that a new approach is needed to rangeland rehabilitation. In the past, the full participation of farmers and integration of feed and livestock production have been lacking. This problem must be studied using an approach that combines socioeconomics and the management of livestock and feed resources, including rehabilitation of rangeland, improvement of permanent pastures, and inclusion of forage crops in rotations.

Farmers in the mountains have much less arable land, and their dependence on livestock and range is greater than farmers on the plateau. Vetch straw and grain contribute significantly to winter livestock feeding (Figs. 1 and 2). The current use of forage legumes in this farming system suggests an avenue for delivery of improved forage legume varieties that are winter sown and more productive than common vetch, such as Hungarian vetch (*V. pannonica*).

The small ruminant population is generally believed to have declined in the central highlands by 30–40% since 1991. This may explain the low grazing pressure—about 4.1 ha/AU on the plateau. In the mountains the stocking rate is 1.2 ha/AU, similar to that reported by Büyükburç (1993b). In the mountains there are shifts in population that should be monitored for their effect on livestock numbers, as young people move to cities and fewer older people are left to tend the livestock. Shepherding is becoming a difficult problem and the raising of livestock may decrease or become more specialized.

It appears that range species are less depleted in the mountains than on the plateau, which could be due to fewer small ruminants, higher altitudes, and more favorable climatic conditions. The results of the biodiversity study clearly indicate differences in the pasture species in the two areas. Bakır (1971) reports that the most predominant species of the common grazing lands of central Anatolia are *Thymus squarrosus*, *Festuca ovina*, *Poa bulbosa* var. *vivipara*, and *Artemisia fragrans*, all of which were observed. The density of annual legume species on the plateau is very low, less than 1%, similar to the figure reported by Büyükburç (1983b).

The botanical survey and classification of sites based on vegetation cover and composition in the present study confirm that range degradation is not uniform. The cluster analysis will help to classify the sites according to the degree of effort needed to rehabilitate them. Less degraded sites could be used to start rehabilitation programs.

Acknowledgments

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Discussion

M. Tahir: What are the reasons/factors responsible for reduction in livestock production in Turkey during the last few years?

H. Firincioglu: The number of small ruminants has decreased 30–40% since 1991. The main reasons for this are because prices have decreased dramatically and because farmers have shifted from small ruminants to big ruminants.

M. Saxena: Why these has been no adoption of feed legumes on the plateau?

H. Firincioglu: The farming systems are different in the two areas. The farmers on the plateau grow barley over a large area. We are trying to introduce autumn-sown vetch (narbon vetch) for fallow replacement because it is suitable for mechanical harvesting. Labor-intensive interventions are rejected on the plateau.

T. Treacher: What success have you had in starting the participatory approach to improvement of rangeland?

H. Firincioglu: So far we have conducted, as I said before, two surveys in the target area. We explained about degradation of the rangeland, forage crops, and livestock husbandry. The farmers were very interested in the ideas and we convinced them to work in participation with us. We know that there are difficulties. We acknowledge the studies conducted in the past, but we are approaching the farmers differently. It is a multi-disciplinary, systems approach consisting of farmers, researchers, and extension agents. The key point is that there must be full participation from farmers, extension personnel, and researchers.

Performance of Awassi Lambs Grazing Common Vetch In On-farm and On-station Trials

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Abstract

Lamb fattening trials on common vetch were conducted on the ICARDA research station for 13 years in two trials (the first from 1980 to 1983, the second from 1987 to the present) and on vetch and chickling in northwest Syria (from 1987 to 1992). The objective of the experiment was to assess the value of introducing legume crop rotations into wheat- or barley-based farming systems in northwest Syria, and of using forage legumes to fatten lambs. Weaned lambs were grazed in spring until the pasture was consumed. Average rainfall was 339 mm/yr at the research station. Thirty six lambs/ha were grazed for an average of 42 days, resulting in a mean daily gain of 196 g and a live-weight production of 263 kg/ha. In the farm trials, the average rainfall was 275 mm/year. Forage legumes supplied 33 days grazing at a stocking rate of 33 lambs/ha, resulting in mean daily gains of 184 g and a live-weight production of 196 kg/ha. Lamb fattening on forage legumes provides several benefits. The plants add nitrogen and organic matter to the soil, and a rotation with cereals gives farmers a solution to the problems of cereal monoculture. Grazing avoids the difficulties and expense of harvesting forage legumes and, because the plants are grazed earlier (when green), leaves more water in the soil for the subsequent cereal crop.

Introduction

Pressure on agricultural land is forcing farmers in parts of West Asia to use monoculture rather than the traditional cereal-fallow rotation (Jones and Singh 1995). Programs to encourage the growing of annual forage crops on fallow land started over 50 years ago in North Africa, and more recently in West Asia. Research shows that forage legume crops increase organic matter and total nitrogen in the soil (White *et al.* 1994), increase the production of feed for ruminants, and result in only small reductions in yield in the cereal phase of the rotation (Nordblom *et al.* 1992, 1994).

On-farm testing of forage legumes, such as common vetch (*Vicia sativa*) and chickling (*Lathyrus sativus*), is an essential step in attempts to get farmers to adopt these crops in West Asia. At the same time, it is important to confirm the

information flowing from on-station studies in on-farm trials. On-station and on-farm trials starting in the early 1980s at ICARDA have shown the potential of forage legumes grown on fallow land (Thomson and Bahhady 1995a, 1995b; Thomson *et al.* 1992, 1995), and confirmed that livestock can be integrated into such trials.

Common vetch and chickling were included in on-farm testing because of their high digestibility and high daily intake of dry matter in the green stage: reaching 2.4 and 2.1 kg/head/day in pen-fed animals (Table 1). In addition, forage legumes have dry matter digestibility values above 75% prior to flowering, and high daily live-weight gain. These gains were, however, exaggerated due to positive gut-fill adjustments (Table 1). When common vetch was fed at the green stage and compared with other vetch species, it registered higher intake and digestibility compared to the other forages (Table 2). By comparison with lambs grazing forage legumes, lambs fed on concentrate feeds averaged 0.23–0.25 kg/day gain using barley with various amounts of soybean and cottonseed meal (Thomson and Bahhady 1986).

Table 1. *Ad libitum* intake and live-weight changes of Awassi sheep offered fresh herbage of forage legumes.

	Barley	Vetch	Pea	Chickling	SED [†]
Daily intakes (g)					
Dry matter	1954	2411	506	2080	329.2
Met. energy (MJ)	19.3	25.6	4.7	22.2	3.58
Digestibility (%)					
Dry matter	68.7	76.8	63.6	76.1	2.94
Live weight change (g) [‡]	309	395	-210	383	112.9

[†] Standard error of difference.

[‡] Subject to gut-fill changes.

Adapted from Thomson (1985).

Table 2. *Ad-libitum* intake and live-weight changes of Awassi sheep offered common vetch (CV), narbon vetch (NV), and woolypod vetch (WPV) harvested at pre-flowering.

	CV	NV	WPV	SED [†]
Daily intakes				
Dry matter (g)	1599 ^a	1351 ^a	397 ^b	159.9
Met. energy (MJ)	17.8 ^a	14.7 ^a	4.1 ^b	1.83
Digestibility				
Dry matter (%)	81.3 ^a	77.2 ^{ab}	75.3 ^b	2.08
AD fiber [‡] (%)	72.8 ^a	64.6 ^b	62.7 ^b	3.74
Daily gains (g) [§]	71 ^a	24 ^a	-28 ^b	33.1

[†] Standard error of difference

[‡] Acid detergent fiber.

[§] Subject to gut-fill changes.

Means followed by different superscripts are statistically different ($P < 0.05$) within each row of means.

Source: after Thomson *et al.* (1986).

At least two distinct generations of on-farm trials have been conducted using forage legumes during the life span of ICARDA in Syria. The first effort consisted of several on-farm, scientist-managed trials over six years in Breda (Thomson et al. 1992). Critical appraisal towards the end of these trials indicated that greater farmer involvement was desirable. For this reason, a new project started in the district of El Bab.

The new project had the following objectives:

- To use on-farm trials to compare the output of grain, straw, and feed energy from a traditional barley–fallow rotation with barley–barley and barley–forage rotations.
- To compare the benefit of applying nitrogen during the barley phase of the rotation, and to determine if the response changed following legumes, fallow, or barley.
- To assess the growth of lambs grazing the forage crops.
- To monitor the opinions of farmers towards the new technology and its adoption potential.

This paper focuses on the growth of lambs grazing forage legumes.

Project Background

A baseline survey was conducted in El Bab area in 1983 (Tully 1984). It indicated that about half of the cultivable land was in a barley–fallow rotation. Moreover, almost no legumes were grown on the shallow (<40 cm) and stony soils covering roughly the southern half of El Bab district, where annual rainfall is 250–300 mm. In the northern half of the area, where there are deeper soils combined with higher rainfall, 9% of the land was sown to lentils, chickling, and vetch.

Many changes have taken place during the years since the 1983 survey, the most worrying being the widespread replacement of the barley–fallow system with continuous barley cultivation. This change is related to several factors. The first is the need to provide alternative sources of feed because of the loss of cultivable and grazing lands to olive and fruit tree plantations and land degradation. Second, the multi-purpose nature of barley makes it attractive to farmers and difficult to replace. It provides green grazing in spring; it can be conserved as grain and straw for winter use; stubble can be grazed after harvest; and in bad years the barley can be left as a standing crop for later grazing by sheep. Finally, availability of tractors and combine harvesters makes it easier to plant and harvest larger areas. Flock owners in El Bab utilized the steppe in the past, but nowadays they remain in their villages. With almost no weeds on fallow land for grazing, more sheep and goat flocks are concentrated on the remaining communal village pastures, leading to more overgrazing.

Most farmers in the area are now aware of the connection between barley monoculture and a disease in which plants develop normally but bear no grain at maturity. The farmers call this problem *Abou Alouwei*. Pathologists are working to

identify the problem, and the lack of a solution has awakened farmers to the advantages of rotation.

At the time of Tully's survey it was not anticipated that the barley-fallow system would be replaced by barley monoculture in the short span of 10 years. The survey recommended that forage legumes be grown on the fallow land to provide additional animal feed. However, the main agronomic and economic problems associated with these legumes were appreciated. These included high start-up costs due to expensive seed, and the view that high seeding rates were needed for a successful crop (180, 150, and 120 kg/ha for chickling, vetch, and lentil, respectively). Yields were generally low, approximately 0.4 t grain and 1.0 t straw/ha, and variability in yield was high. Moreover, a brief period of time was available for hand-harvesting the legumes, after which they shed both leaf and seed. Successful harvesting necessitated a concentrated mobilization of 10–15 laborers/ha at a time when the lentil crop was also being harvested.

In the earlier project in Breda, farmers preferred to use the crop as seed and straw, rather than as hay or for grazing (Thomson et al. 1992). The reasons for this were: the high cost and poor availability of seed; the need for straw to decrease winter feed deficits; the difficulty of making hay (Rihawi et al. 1987); and the lack of machinery.

A new survey was conducted in El Bab with a view to gaining an updated and comprehensive view of the farming community in general, and to compare the innovative farmers in the project with their neighbors.

Materials and Methods

On-station Lamb Grazing Trials

The first experiment on lamb growth took place on the Tel Hadya research station from 1980 to 1983. Unreplicated plots of 2 ha on shallow soils (10–20 cm) were tilled with a duckfoot cultivator and drilled at a seeding rate of 120 kg/ha. Common vetch was grazed by lambs to compare a traditional barley-fallow system to an alternative barley-vetch land-use practice (Thomson and Bahhady 1995a, 1995b; Thomson et al. 1995).

The second experiment on lamb fattening took place between 1987 and the present. In this experiment, vetch was rotated with wheat, with plot cultivation and vetch seeding rates as mentioned above. Soils were deeper (<40 cm) at the on-station location.

On-farm Project Site and Farmer Participation

The on-farm project started in October 1986 and ran through to the 1991/92 season in villages near El Bab. Farmers were selected based on their interest but also on their ability to adapt the ideas coming from the ICARDA on-station trials. Owning sheep was an obvious requirement. The experiment was replicated on six to eight farms, and the plots were located on shallow (<20 cm) soils, although

some sites had medium (20–40 cm) and deep (>40 cm) soils. Farmers were given the option to use the forage legumes as they wished. Results in this paper are based on three to five farms that used the grazing option between 1987 and 1992.

On-farm Land Preparation, Sowing, and Fertilization

Ducksfoot cultivators on tractors belonging to the farmers, or hired and farm labor, were used to prepare the land and sow the crops. If farmers wanted lambs to graze the forage, they sowed 160 kg/ha of uninoculated forage legume seed. If they chose to use forage legumes for seed and straw, they sowed 140 kg/ha. The latter option was preferred on deeper soils. Local landraces of vetch and chickling were used, sown by drill. All fertilizer was applied in the barley phase. Triple super-phosphate was hand-broadcast depending on the phosphorus status of the soils, measured at the start of the season. Soils with more than 15 ppm were not fertilized; soils with 6–10 ppm were given 14.4 kg P/ha, and soils with less than 6 ppm were given 28.8 kg P/ha.

Crop Rotations and Trial Management

The on-farm project compared fallow or barley with common vetch or chickling in rotations with barley. On each of the farms, rotations were established on about four hectares, half sown to feed legumes, continuous barley, or left fallow, and half sown to barley each year. Harvest operations were managed by the farmers in both forage and cereal phases of the trial.

On-farm Grazing Management

Vetch and chickling plots were both grazed by a single group of lambs on the farms that chose the grazing option. Forage was fenced and grazing started between mid-March and early April, depending on the season. Stocking rates were between 20 and 30 lambs/ha, depending on the farm. Lambs received a daily supplement of 300 g barley grain.

Experimental Design and Statistical Analysis

Each farm included both a cereal and non-cereal phase of the rotation in each year. Farms were considered a blocking factor. Analysis of variance and regression techniques were used to predict lamb off-take as a function of annual precipitation.

Survey of 100 Farmers in El Bab

To update our knowledge on a broader segment of the farming community of El Bab, we surveyed 100 farmers to assess the applicability of our results. The area surveyed is a 250–350 mm rainfall zone in the El Bab district in northeastern Aleppo Province, an area known to be typical of integrated barely–livestock farming systems. Households were selected by a two-stage stratified sampling process. The study area consists of 106 villages, from which 20 were randomly selected. In each of these villages, 10% of farmers, with a maximum of 10 from the large villages,

were randomly selected, using two separate lists of names based on a representative ratio of farmers having land with some supplementary irrigation versus those who had only rainfed land. The total sample included 43 farmers with some supplementary irrigation and 57 rainfed farmers. Single visits to farmers to solicit answers to a standardized questionnaire covering qualitative and quantitative information about the farming system took place in April 1995.

Results and Discussion

Results of the on-station and on-farm trials are shown in Tables 3 and 4. They are quantitatively better than what was achieved on the farmers' fields for two reasons. First, the rainfall was better, averaging 339 mm instead of 275 mm per year. Second, the deep soils of Tel Hadya have much better water-holding capacity, permitting better forage growth. In El Bab, the areas with deeper soils are usually planted to higher value crops or, if forage legumes are used, they are grown to maturity for seed and straw.

Table 3. Growth rate and feed conversion ratio of male lambs offered diets containing barley grain, and different proportions of soybean and cottonseed meal during a 70-day period.

	Soybean:Cottonseed ratio				SED [†]
	100:0	67:33	33:67	0:100	
Feed conversion ratio [‡]	4.6	4.7	4.6	4.7	0.64
Number of lambs	8	9	9	9	
Initial live weight (kg)	23.5	24.8	23.1	23	1.19
Daily gain (g)	249	228	242	229	24

[†] Standard error of difference.

[‡] kg feed DM per kg daily gain.

Source: after Thomson and Bahhady (1986).

Table 4. Performance of lambs grazing forage legumes between 1980–1983 and 1987–1995 Tel Hadya.

	1980	1981	1982	1983	1987	1988	1989
Rainfall per year	450	372	338	324	358	504	234
Grazing days	27	61	70	56	31	43	25
Number of lambs/ha	20	16	27	30	68	30	50
Daily gain (g/lamb)	255	238	151	188	144	249	200
Live weight (kg/ha)	139	232	260	310	289	322	250

	1990	1991	1992	1993	1994	1995	Mean	SD
Rainfall per year	233	287	352	277	373	299	339	75
Grazing days	28	44	42	38	35	49	42	13
Number of lambs/ha	30	30	40	39	52	36	36	14
Daily gain (g/lamb)	255	182	206	174	150	155	196	40
Live weight (kg/ha)	219	240	350	261	274	273	263	50

Data from the first four years were from unreplicated plots on shallow soil (10–20 cm). Results from 1987 to 1995 are averages of three replications, all of which were located on deep soils (>40 cm). No supplemental feed was offered to lambs.

In both on-station experiments, it was found that grazing should be initiated at an early stage of vetch growth with high lamb stocking rates of 20–30 head/ha. This practice requires common sense, a consideration of the climatic conditions in each year, and proper estimation of the necessary grazing pressure and timing of grazing. The recommendation is to begin grazing when the vetch reaches a height of about 15 cm, a stage of growth that generally occurs between mid-March and early April.

High stocking is designed to consume the vetch in an efficient manner. If grazing starts too early the leaf area of the crop is limited and maximum productivity is not achieved. If grazing starts too late the forage is trampled and wasted. These practices were later extended for use in the on-farm trials.

Table 4 shows the average lamb live-weight gains obtained while grazing forage legumes over a period of six years on three to five farms. Although the vetch and chickling were not grazed individually, farmers reported that chickling was chosen before vetch by lambs grazing in the plots.

The grazing of lambs on forage legumes fits nicely into the forage calendar in El Bab area because it provides high quality feed following weaning. Lambs averaged a growth rate of 184 g/day. By weaning lambs early and grazing them on forage legumes and having ewes on natural pasture (supplemented by straw and barley in bad years), the farmer can sell more milk products.

Regression analysis was used on the relationship and fit between lamb off-take and rainfall for on-station and on-farm results (Fig. 1). Both quadratic and linear models were used to describe the relationship between off-take and rainfall. The best results were obtained using a linear model ($R^2=75\%$). The effect of rainfall was significant ($P < 0.01$), but location (farm versus station) was not ($P = 0.08$). If the additional on-station results from 1993 to 1995 are added to the comparison, a significant difference is detected between the slopes of the line in Figure 1. Therefore, each of the predicted lines was plotted. The flatter slope of the line at Tel Hadya reflects the higher moisture-retaining ability of the deep soils on the station, in that more off-take was achieved when rainfall was lower at Tel Hadya.

One drawback to the direct comparison between on-farm and on-station results for 1987 to 1992 is that animals were fed 300 g/head/day of barley in the on-farm trial. This amount of barley contains sufficient energy to meet maintenance requirements for a 20 kg lamb and falls to 74% of maintenance requirements for a 35 kg lamb (Goodchild, personal communication). Therefore, even though lambs were supplemented in on-farm trials, the live-weight gain was supplied by the forage legumes they grazed. Conversely, vetch grazed on-station provided all the nutrients needed for both maintenance and growth.

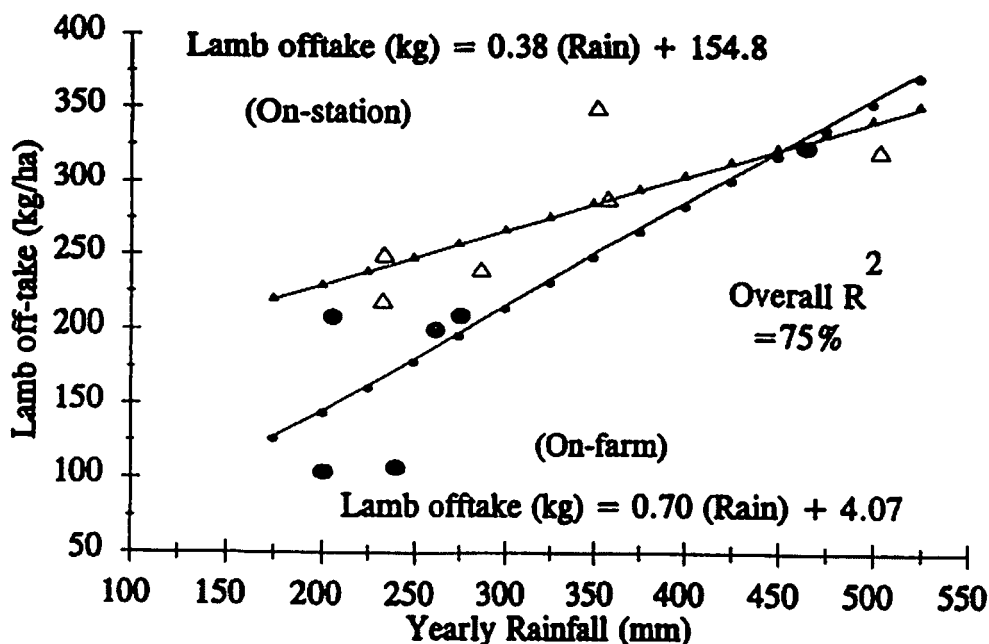


Figure 1. Relationship between lamb off-take and yearly precipitation on-station (triangles) at Tel Hadya (339 mm average annual rainfall) and on-farm (circles) in El Bab area (275 mm average annual rainfall).

Results of the 1995 Survey

The 1995 survey in El Bab district shows that the farms in this study are generally larger and have more sheep than the average for the area (Table 5). The survey also shows that 72% of El Bab farmers no longer use fallow; 61% of respondents said they stopped fallowing their land less than ten years ago. A significant proportion of the farmers (46%) said they need the land that was fallowed to grow more barley, and 30% said that fertilization makes it unnecessary to have a fallow phase. The percentages of land used for barley, forage, and fallow for the farmers in the El Bab study are shown in Figure 2. The results suggest that they are fairly typical of the broader trend toward increased barley cultivation and minimal dependence on fallow.

Table 5. Performance of lambs grazing forage legumes between 1987 and 1993.

	1987	1988	1989	1990	1991	1992	Mean	SD
Rainfall/year	262	465	201	207	275	240	275	89
Grazing days	33	48	24	31	40	21	33	9
Number of lambs/ha	30	39	29	36	37	25	33	5
Daily gain (g/lamb)	210	172	139	186	177	217	184	26
Live weight (kg/ha)	200	324	104	208	209	107	196	76

Data are averages of five farms, all of which had shallow soils (<20 cm). Lambs were supplemented with 300 g/day barley grain.

Six farms in the El Bab Area of NW Syria

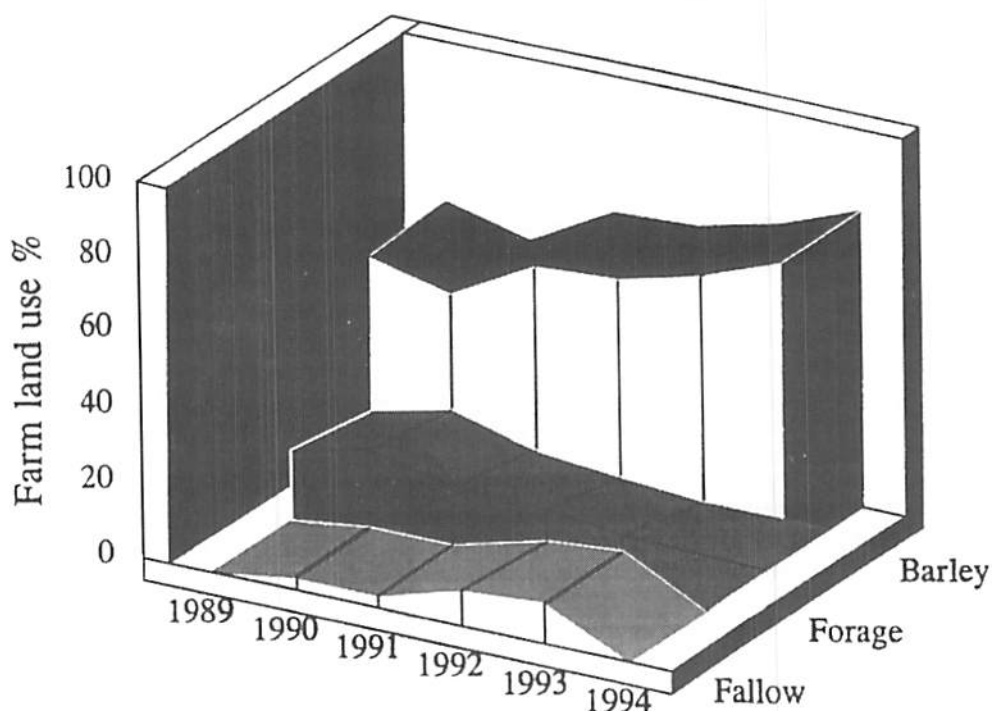


Figure 2. Percentage barely, forage, and fallow use on six farms that participated in vetch grazing trials in El Bab.

The formerly fallowed land was mostly sown with barley, and 52% of the farmers grew no legumes at all. However, 26% of farmers surveyed had started growing legumes in the past five years. For the 48 farms that did grow legumes, the three species reported were lentil, vetch, and chickpea (65, 15, and 12% of respondents, respectively). When asked if they grow less legumes now than in the past, 83% said they increased or kept the same area, while 17% said they decreased the area, the main reason being the increased labor cost for hand-harvesting.

When asked about the main problems in animal production, the three most common answers were: lack of natural grazing land (23%), high cost of purchased feed costs (22%), and inability to find shepherds (18%).

Today in El Bab, continuous barley cultivation is recognized as the cause of yield reductions due to disease and pests, and crop rotations are known to be a solution. The northern part of the area surveyed in El Bab receives >300 mm rainfall, and lentil can be grown there, but the southern half receives <275 mm and is only suitable for chickling or vetch. In this area, grazing is a suitable option because the crop is exposed to much less risk of spring drought than a crop grown to maturity. The grazing option does not necessitate rolling or mechanical harvesting; however, it does require the farmer to purchase new forage legume seed and find someone to shepherd the sheep.

The grazing option is also useful when growing legumes on shallow soil. There are several reasons for this: (i) grazing eliminates the need for weeding, and this is important in El Bab where there are no selective herbicides available for elimination of broadleaf weeds in forage legumes; (ii) grazing eliminates the need for hand-harvesting a mature crop; and (iii) grazing the legumes prior to normal maturity is less risky than the mature crop option. Extension workers could try to introduce low-cost electric fencing that can be taken to and from the field with the sheep, thereby reducing the need for a shepherd.

The use of forage legumes for seed and straw will not be widespread until inexpensive and efficient mechanized harvesting methods are available to avoid the high cost of hand labor. Farmers are now experimenting with a cutterbar mower to cut the forage legume stem close to the ground, after which the crop is gathered from windrows for threshing at a convenient location. Even mechanized harvesting, however, will face problems: in dry years plants are short, resulting in poor recovery of straw; in wet years the forage legumes tend to lodge, effectively doubling the time necessary to cut because cutting can only be done opposite the direction of lodging.

Research can contribute to the solution of some problems. Non-shattering varieties of forage legumes with drought and cold tolerance, early maturation, less leaf drop and higher harvest index contribute to increasing farmer interest in forage legumes (Abd El-Moneim et al. 1988; Abd El-Moneim 1993). In addition, scientists are now designing a box that attaches to the cutterbar, catches the forage, and drops it in piles to further simplify harvest.

As far as is known, forage legumes have not previously been grown in this area. Indeed, the trials include several non-traditional practices. For example, Tully (1984) reports that threshing is generally a problem because the owners of threshers are usually geared for the harvest of barley, and forage legumes require a different threshing calibration and speed. Now that legumes are more commonly grown, the skills and experience of the operators has risen, and the locally available machines have improved in design and efficiency.

Returning to the survey: farmers were asked if they would be interested in growing forage legumes in rotation with barley, with ICARDA's assistance. Only 30% were interested. Of all comments elicited from those who were positive, a third said their soils were too shallow for forage legume cultivation, another third said their farms were too small and they needed the area for barley, and the remainder said they would try forage legumes as an experiment if cheap seed and a cutterbar were provided.

There is a role for forage legumes in El Bab, mostly because farmers need a rotation to arrest the cereal yield decline on barley fields that are being cultivated continuously. An economic analysis of lamb grazing is not a part of this paper, but is a subject of future interest. A whole farm model from ICARDA (Nordblom et al. 1992, 1994) can be used to compare the profit of forage legumes for seed and straw versus forage legumes used for lamb fattening. We also wish to assess the economic benefits of mechanical harvesting compared to grazing the crop while green. These efforts must be evaluated over both phases of the rotation and in the context of other resource use on the farm.

Acknowledgments

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Discussion

A. Lahlow-Kassi: I am concerned about the comparison made between on-station and on-farm in terms of explaining the difference. Off-take is due mainly to rainfall. The genetics of the flocks, the disease encountered, explain the major differences.

S. Christiansen: Your concerns are pertinent. However, let me say that the Tel Hadya flock is not selected for high performance, so it should be representative of the general situation in El Bab. Perhaps you are right about diseases, because our management on-station would make a difference in the comparison. Nevertheless, the results of 13 years on-station and six years on-farm rate the regression of off-take versus rainfall at an overall $R^2=75\%$. We mentioned that barley was fed on-farm, and that this should be considered in the interpretation of results. We still feel the paper presented useful information.

A. Goodchild: What is the maximum proportion of the farm that is needed to provide vetch grazing for the lambs produced by the ewes kept on that farm?

S. Christiansen: The area will depend on the farmers' strategies. Some receive considerable income from taking lambs to market early. Vetch grazing for ewes can increase milk production. It also help ewes conceive earlier and produce more lambs.

The area depends on the farmer strategy and diversification of activities. It depends on the area of land available and the size of the flock. It depends on whether the farmer depends on livestock as a main source of income or whether he uses livestock products for family consumption. It also depends on whether the farmer has off-farm sources of income.

M. Ayyadi: Did you carry out economic analysis for this trial?

S. Christiansen: These results have not yet been subjected to Dr Thomas Nordblom's whole-farm linear programming model. However, we are in line to receive some attention from Tom's group. The LP model has been developed on the Tel Hadya station, and we would now like to validate the results on-farm. The model does easily accommodate various options for forage legume utilization, such as vetch used for hay versus vetch for seed and straw, versus vetch grazed by lambs. This is a good question and focuses on the need to put the results of this paper into the overall economic setting of farms in El Bab.

A. Al-Rawi: The regression coefficients of lamb off-take on amount of rainfall is higher for on-farm than on-station. What is the reason for that?

S. Christiansen: The main differences for the two lines shown in the figure dealing with regression of lamb off-take versus rainfall are related to greater rainfall and deeper soils at the Tel Hadya on-station location.

E. Ahmed: What were the criteria used in choosing your farms?

S. Christiansen: In 1986 the farmers were chosen because of their interest in working with ICARDA. I did not contact the farmers against the results shown in the 1995 survey because of lack of time. However, when you look at the survey

results you will find that two farms were considered small, two medium, and two large in terms of land size and sheep flock. Overall averages are distorted upwards because of the two large farmers. Our methods now attempt to be more systematic in assuring that our selected farmers adequately represent the farmers in the target zone.

Y. Sweidan: What is the reason for the gap between the live weight of lambs on-farm and on-station? Is there any new technology applied on-station?

S. Christiansen: If you recall the figure that showed the regression of lamb off-take in kg/ha versus annual rainfall (mm), you will notice that the lines tend to converge at higher values of rainfall. This is an accurate reflection of vetch growth on-farm (where the soils were shallow) and on-station (where the soils were deep). This means that when 250 mm falls at Tel Hadya, it is used more efficiently in creating forage dry matter because of the greater moisture-holding capacity on the Tel Hadya soils. Also, variability of rainfall within a season is more damaging on-farm, where the soils are shallow.

E. Thomson: It is important to highlight the term "common sense" used by Christiansen. This implies how difficult it is to define stocking rates for a particular situation. This is also true of rangeland situations.

S. Christiansen: I'd like to add that not all lambs are born and weaned by the time vetch is ready to graze. Some times we start with 20 and increase to 30 or 40 lambs, depending on the number weaned and the growth of vetch in the field.

A. Mohamed: What system of grazing did you use and when did grazing start on-station?

S. Christiansen: We started grazing between mid-March and early April, depending on the rainfall and temperature affecting growth of vetch each year. The lambs are grazed in groups of 20 to 30 head, depending on how many are already weaned in the flock.

A. Salman: Is it better to use forage legumes as hay rather than grazing directly by the animals?

S. Christiansen: Over 15 years of work at Tel Hadya in Syria, we have found that hay is often spoiled by rainfall in April and the equipment for making hay is not generally available in the region. We would say that the choice of grazing versus harvesting vetch when mature depends on the needs of the farm. It would be wise to have both options on the same farm so as to fatten lambs by weaning them early. Mature seed and straw can be saved for winter to decrease costs associated with purchase of supplemental feeds from the market.

Crop-Livestock Integration Through Better Use of Feed Resources in Tunisia

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Abstract

The growing demand for cereals, for both human and animal consumption, pushes crop cultivation into the rangelands, resulting in the plowing of more and more marginal land every year. Livestock production systems are extensive and diversified, but are fragile and suffer from feed gaps. Competition between cultivated and grazing land, farmers and livestock owners, continuously increases, bringing with it considerable friction, as well as change in the production system.

Of some 376,000 farms in Tunisia, 229,910 raise livestock. The breeder ratio increases with farm size (43% of small farms do not have livestock). More than 73% of large farms have livestock. The large breeders are located mainly in the northern part of the country. Sixty three percent of cattle are located in the north, 58% of sheep are located in the central part of the country, as are 55% of goats. The mixed (sheep and goat) flocks are located mainly in the center. In the south, flocks are more specialized: only 16.6% of flocks are mixed.

In the past it was thought that cereal and livestock production were incompatible in the Mediterranean basin. It was also supposed that pastoralists were the enemies of farmers, who were mainly cereals producers. However, under favorable climatic conditions, agreement is found between farmers and transhumants. But under unfavorable climatic conditions (drought), conflicts occur frequently.

There are two levels of crop-livestock integration. At the macro-level, the integration of livestock has not been a great success. Livestock contribution to feed resources remains below 20%. At the national level, statistics indicate that the contribution of pasture and rangelands is decreasing dramatically, while the contribution of cereal grain, straw, and crop residue is increasing.

At the farm level, success stories of livestock-crop integration are limited. Cereal producers are not livestock owners, nor are forage crop producers always livestock owners. Moreover, most small ruminants are on farms with limited forage crops. Existing integration is mainly based on the need to make better use of feed resources, especially barley cropping (green forage, grain, straw, and stubble).

For all these reasons barley-based systems are predominantly animal production systems. Dependence on barley is increasing; as fallowing is reduced, cultivation encroaches on grazing lands and the remaining rangeland is over-exploited.

Barley cultivation has increased significantly during the last 30 years (Fig. 2). This increase is not only explained by the area increase (40%), but also by increased yield (average yields were 5.6 q/ha for 1971–1977 and 11 q/ha for 1991–1993). Most of the barley produced and/or imported is used for animal feed. The amount of barley consumed by humans is in constant decline (4.3 kg/person in 1980, 2.6 kg/person in 1990). Barley is produced mainly on small farms (50% of the total barley area is on small farms, and 30% on medium farms).

In most arid and semi-arid areas where barley and sheep are in a mixed farming system, fodder by-products from cereal (stubble, fallow, and straw) represent the largest resource in quantitative terms and also have the best seasonal availability. Therefore, any future reduction of cereal area in the marginal zones will immediately diminish the feed bank for livestock.

Is there an alternative to this situation? Following as a global strategy is based on improved practices for barley production, fallow replacement with legumes, the improvement and protection of natural grazing, and efficient residue utilization.

General Description of Current Agricultural Activities

Agriculture in the Mediterranean basin is characterized, outside the irrigated areas, by dryland cereal production, orchards and vineyards, and small ruminants, based mainly on rangeland. The increase in human population has raised the demand for meat, milk, and cereals. An increase in the sheep population has resulted from favorable ratios between the prices of sheep meat and cereals, but the growing demand for cereals for both human and animal consumption has resulted in the cultivation of more and more marginal land every year (Boutonnet 1989). Major degradation has resulted from increased grazing pressure on the remaining rangelands.

Until the end of the last century, well-defined territories were assigned to different tribes. More recently, marginal lands have been under pressure from a number of social and economic developments, including growth in the agricultural population, changing definitions of cultivated and grazing land, and friction between farmers and livestock owners.

Livestock Production Systems

Livestock production systems are extensive and are based largely on marginal lands. Productivity is low and the systems are not very profitable, partly because of the use of breeds which are less productive but well adapted to the environment, which have persisted for many centuries. A large variety of feed resources is used, including grassland, shrubland, forest, pasture, stubble, fallow, wetland, lowland, and upland. The resources are more limited in arid areas. Farm income in semi-arid Mediterranean areas is derived from cereals, vines, fruit, and livestock, making the system very adaptable to changing environmental and economic conditions.

There are two major forage gaps due the Mediterranean climate. One is in winter for about 2–4 months, when plant growth is inhibited by low temperatures, and the other in summer for about 3–6 months, when high temperatures and lack of moisture result in the drying out of herbaceous plants (Papanastasis 1993). The systems are now fragile because of the increasing use of animal supplements, leading to increased production costs. The majority of these systems collapse, and farmers move to urban centers, thus depopulating the rural areas.

The Livestock Sector in Tunisia

Table 1 summarizes the general characteristics of the livestock sector. There are 376,000 farms, of which 229,910 (61%) have livestock. Forty three percent of small farms (<5 ha) have no livestock, whereas more than 73% of large farms (>50 ha) have livestock, with an average of 76 livestock units (LSU).

Table 1. General characteristics of livestock in Tunisia (1986).

Farm size	Small (0–20 ha)	Medium (20–100 ha)	Large (> 100 ha)
Number of farmer/breeders (1000)	191	35.4	3.5
Total arable land (1000 ha)	1165	1400	862
Available rangelands (1000)	1180	1609	576
Livestock (1000 and % of total)			
Cattle	415.4 (66.5)	113.7 (18.2)	95.2 (15.3)
Sheep	2797 (51.7)	1753 (32.4)	859 (15.9)
Goat	618 (59)	364 (34.8)	64.8 (6.2)
Average size/farm			
Arable land	6.1	39.6	244
Rangelands	6.2	45.5	163
Cattle	2.2	3.2	27
Sheep	14.6	49.5	243
Goat	3.2	10.3	18
Livestock percentage (SBU)	54.9	27.6	17.5
ha/SBU ratio	2.8	7.1	5.3
Average size (SBU)	4.4	11.9	76

Table 2 shows that 63% of cattle are located in northern Tunisia; 58% of sheep and 55% of goats and mixed flocks are located in the center of the country. Flocks in the south are usually of one type, with only 17% mixed.

Table 2. Number of livestock owners by livestock and region.

	North	Center	South	Total
Cattle	57950	32740	790	91490
Sheep	53240	113380	28500	195300
Goat	17700	51310	24330	93340
Mixed livestock	28070	79430	7620	115120
Mixed livestock (%)	28	67.3	16.6	43.3

Source: Sarniguet et al. (1994).

It is generally assumed that the number of small sheep flocks has decreased because of a shortage of feed resources. In fact, a survey in 1993 shows that the number of sheep on small farms is increasing (Table 3).

Table 3. Percentage of sheep according to farm size.

Farm size (ha)	0-20	20-50	> 50
Percentage of sheep (1980)	49.9	22.4	27.7
Percentage of sheep (1993)	54	19.9	26.1

Source: Sarniguet et al. (1994).

Livestock-Cereal Crop Relationship

It has often been suggested that cereal production and livestock are incompatible in the Mediterranean basin (Kayser 1992). In reality, the situation is more complicated, as the farmer is often a livestock owner, and animals play a key role in the farming system.

Crop farmers and livestock owners compete for space (Kayser 1992). If climatic conditions are favorable, there is no problem, as livestock provide organic fertilizer for poor soil, and income by renting fallow. During drought, conflicts occur frequently as feed becomes scarce and animals cause damage to crops and compete with the farmers' livestock for the meager grass.

Integration of Crops and Livestock

Integration at the regional level has had limited success for several reasons. Rainfed forage crop production has not succeeded. The cultivated area has remained constant in the last 15 years. Its contribution to animal feed is about 10% (Fig. 2, Table 4). Increasing forage production from irrigated areas is only practiced on state farms and by some a few farmers for summer forage crops of sorghum and maize. Although irrigation has been extended to increase fodder production, farmers have opted for tree crop production for economic reasons.

National statistics show that the contribution of pasture and rangelands to the feed calendar is decreasing dramatically (<30% during the 1990s), while the cereal grain, straw, and crop residue contribution in general is increasing (Table 4).

Successful integration of crops and livestock is rare in Tunisia. Production systems where cereals predominate are complex, and even if both crops and livestock belong to the same farmer, the production objectives are different. Integration is limited for a number of reasons. On the large farms of Beja and Kef, the cereal producers are not livestock owners. Forage crops are often grown by farmers without livestock to produce hay for sale, and most livestock is on small farms with limited forage crop resources. Existing interactions are mainly dictated by the need for better use of feed resources, especially barley used as green forage, grain, straw, stubble, or alley cropping in association with atriplex, acacia, or even cactus.

Table 4: Contribution of feed resources to ruminant requirements in a wet year (1992) and a dry year (1994).

Feed resource	1992/wet year (%)	1994 /dry year (%)
Rainfed forage crops	14.7	6.0
Irrigated forage crops	7.0	11.3
Straw and stubble	15.0	8.4
Fallow	7.7	5.0
Rangelands	20.5	13.9
Shrubs and fodder trees	1.3	3.5
Bran	6.6	8.9
Concentrates	6.6	12.1
Olive tree twigs	5.1	6.9
Agro-industrial by-products	0.8	1.6
Barley	14.7	19.9
Dehydrated	0.0	2.5

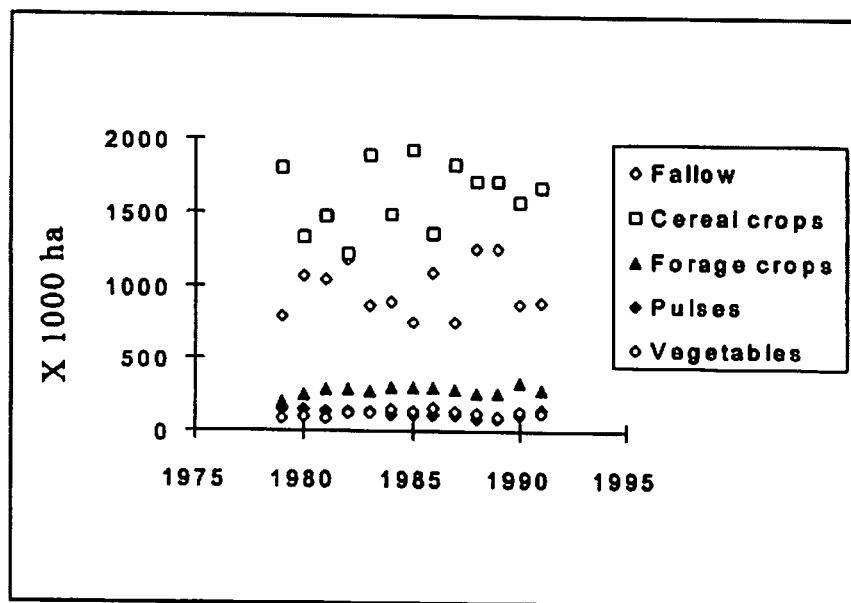


Figure 1. Areas (1,000 ha) of fallow, cereal crops, forage crops, pulses, and vegetables.

Animal Production Systems are Predominantly Barley-based

According to Jones (1992), sheep and goat flocks traditionally grazed hillsides, steppe, and stubble. Today, although this occurs, it is much less important. Increases in income have boosted the demand for animal products and resulted in the development of more and more intensive livestock production units, including peri-urban feedlots and the widespread use of supplementation. These production

systems consume large quantities of cereal and cereal by-products (grain, straw, and stubble). Rising imports of feed such as maize, barley, and soya bean meal, etc., have an adverse effect on the country's balance of payments and, in order to limit this, more feed must be produced internally.

Jones (1992) discusses the dangers of increasing feed production internally at the expense of food crops, especially wheat. The greater profitability of the livestock sector encourages the cultivation of more and more marginal land, resulting in the destruction of natural vegetation and soil.

Wheat and barley are the predominant winter cereals in the rainfed systems in Tunisia and North Africa. Broadly speaking, wheat is more productive in wetter areas, and less productive in drier areas, and the distinction between wheat-based systems in wetter areas and barley-based systems in drier areas appears to be valid. Although animals are found in both systems, their contribution to farm incomes generally increases as rainfall decreases. Barley systems are therefore predominantly animal production systems, where barley is used as green pasture, stubble, and stored grain and straw. Dependence on barley rises as the area of fallow is reduced, cultivation encroaches on grazing land and the remaining grazing is over-exploited.

Eighty percent of barley is produced on small to medium-sized farms. In spite of relative decreases in barley prices, barley production (Fig. 2) has increased by 30% in the last 30 years as a result of a 40% increase in the cultivated area and better yields. Average yields were 5.6 q/ha in 1971–1977 and 11 q/ha in 1991–1993. Sarniguet et al. (1994) attribute this increase to subsidies on fertilizers and machinery, etc., and to the ease of barley production, harvesting, transportation, and storage techniques, in comparison with forage production. Human consumption of barley decreased from 4.3 kg/person in 1980 to 2.6 kg/person in 1990.

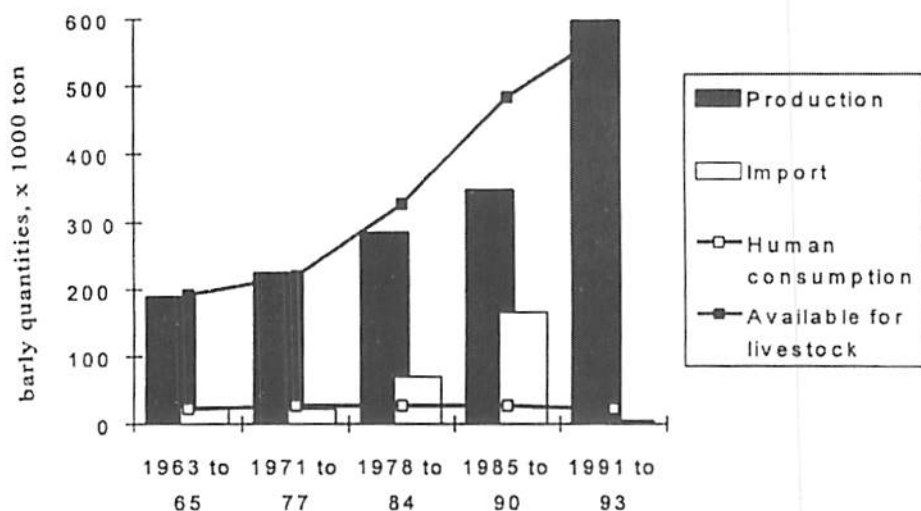


Figure 2: Amount (1,000 ton) of barley produced, imported, and used for human consumption and available for livestock feeding (adapted from INS and Minagri 1994).

Cereal By-products

In most arid and semi-arid areas, by-products from cereals, stubble, fallow, and straw are the largest feed resource and represent about 20% of the total available feed units. Their feed value and seasonal availability are also important (Table 4). Any reduction in the cereal area in marginal lands will immediately affect the amount of feed available for livestock, an alternative unacceptable to livestock owners.

For example, a typical small farmer will produce, on poor soil, 600–800 kg of barley per ha, of which only 30–40 kg will be for human consumption. The remaining 560–760 feed units from grain and 120–180 from straw will be used to feed the flock. This will supply 25% of the requirements for about 20 sheep or goats.

Agro-pastoralism and silvo-pastoralism can help mitigate land degradation (Boyazoglu et al. 1988), but certainly cannot solve the problem (Le Houérou 1990). Boyazoglu et al. (1988) discuss two scenarios. First, faced with the difficulty of improving the productivity of ecologically fragile marginal lands, intensive, specialized meat and milk production units can be developed (Flamant and Cocks 1989). Alternatively, the productivity of existing sedentary mixed cereal-livestock systems can be increased by altering the traditional grazing of fallow by introducing annual legumes and thus increasing grain and straw yield. Both scenarios should be part of a global strategy for reducing the pressure on rangelands.

Jones (1992) suggests that the following strategies be considered:

- **Improved practices for barley production.** The use of fertilizer, particularly phosphate, was shown to be effective even where rainfall is the main limiting factor (Cooper et al. 1987).
- **Replacement of fallow with legumes.** Some annual feed legumes, including vicia, lathyrus, and pea show potential (Abd El Moneim et al. 1988). Local varieties of medicago could play a key role in dry areas if seed production is increased to reduce their cost.
- **Improvement of natural grazing.** Phosphate fertilizer applied annually at 11 kg/ha greatly increases the yield of herbage, especially of legumes (Osman et al. 1990). Regeneration of degraded rangelands by planting shrubs such as *Atriplex* and *Acacia* species is being attempted in some areas, but establishment is expensive. Regeneration of large areas using low-cost seeding techniques is promising, but more trials are necessary.
- **The efficient utilization of residues.**
- **Integration of fodder trees and shrubs with cereal production and the use of alley cropping.**

Efficient Utilization of Residue

Utilization of tree crop residues (two examples from olive by-products)

Example 1: Survival diet for extreme dry years. Barbarine ewes fed 35% olive cake *ad libitum* with 300 g/day straw from mating to lambing had similar performances to those on a diet based on bran (Table 5). Replacement of bran by olive cake, supplemented with molasses and urea, resulted in the survival of the ewes, with reductions in live weight and birth weight.

Example 2: Replacement of oat/vetch hay with olive leaves and twigs in yearling diets resulted in similar performance (Table 6). This alternative is suggested for central and southern Tunisia, where forage production is low, in the pruning season from January to March, or in summer and autumn, after air-drying the leaves.

Table 5. Use of olive cakes to feed Barbarine ewes.

Diet composition	Olive cake in the diet (%)		
	0	35	70
Bran	70	35	0
Molasses	26	26	26
Urea	2	2	2
Mineral mixture	2	2	2
Intake, g DM/kg LW ^{0.75}	76	105	85
Initial LW (kg)	52.3	52.2	52.5
Final LW (kg)	57.3	57.3	42.8
Lamb birth weight (kg)	3.5	3.3	2.6

Source: Nefzaoui and Ben Dhia (1978).

Table 6. Performance of yearling Barbarine sheep fed oat/vetch hay or olive leaves and twigs.

	Oat/vetch hay + concentrate	Leaves and twigs + concentrate
Intake (g/day)	761-829 680	786-859 660
Initial LW (kg)	25	25
Final LW (kg)	40.7	42.4
ADG (g/day)	171	188

Ben Rouina (1986).

Cereal crop residue

Cereal straw. Extensive research has been carried out on the use of straw in small ruminant feeding and on methods of improving its nutritive value, using NaOH initially and ammonia gas or urea later. Two examples are presented:

- Heifer diets, based on oat/vetch hay or straw treated with 3% ammonia, gave similar results (Table 7). Long-treated straw reduced feeding costs by 30%.

- Table 8 shows that covering stacks of urea-treated straw with plastic or mud results in material with similar intake and performance characteristics. Covering stacks with mud may be a suitable technique for small farmers. In addition, it reduces pollution by utilizing waste plastic sheeting.

Stubble. In the mixed crop-livestock systems of North Africa, stubble is a key feed resource, particularly for small ruminants. Stubble is available in summer, when other natural resources are limited. In Morocco, Guessous (1992) found an average stubble biomass of 4–6 tons/ha immediately after harvesting, with 100–120 kg of grain. Grain was consumed during the first four weeks of grazing. The sheep selected a high value diet in the first weeks of grazing, but this gradually decreased. Live weight increased during the first month of grazing, but then decreased, especially at higher stocking rates. It was necessary, therefore, to supplement diets with a protein source initially and with both energy and protein later. Wheat stubble grown with supplementary irrigation in areas with 250 mm rainfall maintained 20 sheep/ha for 80 days, and Guessous (1992) concludes that the stubble supplied 700 feed units (UFL)/ha.

Table 7: Intake and performance of heifers fed diets based on ammonia-treated straw or oat/vetch hay.

Diet	3% Ammonia-treated straw		Oat/vetch hay [†]
	Unchopped	Chopped	
Intake (kg DM/day):			
Concentrate	2.18	2.18	2.18
Straw	3.86	3.64	4.89
Initial live weight (kg)	173.6	174.7	187.0
Final live weight (kg)	312.1	286.9	324.2
ADG (g/day)	657	532	650

[†] CP of concentrate, hay, and treated straw were 19.7, 10.3 and 6.9% of DM, respectively.

Source: Rokbani and Nefzaoui (1993)

Table 8: Intakes and mean daily gains of untreated, ammonia-treated and urea-treated straw, with plastic or mud covered stacks (Ben Salem et al. 1995).

US	ATS	UTSp	UTSm
CP (g/kg DM)31	78	76	78
Straw DM intake (g/day)720	910	816	829
ADG (g/day)57	96	92	93

US = untreated straw; ATS = ammonia (3% NH₃) treated straw; UTSp = urea (5.6%) treated straw covered with plastic; UTSm = urea (5.6%) treated straw covered with mud.

These results indicate the value of stubble and the need to prevent plowing of stubble soon after harvest. A better utilization of stubble may occur when cereals are planted between widely-spaced rows of atriplex bushes. This is quite frequent in the semi-arid areas of Tunisia, where atriplex has been planted to control erosion on slopes. This may be a sustainable way of establishing shrub plantations. Use of atriplex as a protein supplement is discussed below.

Integration of Fodder Trees and Shrubs with Cereal Production and the Potential of Alley Cropping

Correal (1993) recommends the following strategies for the use of fodder shrubs plantations in low rainfall areas.

- In rangeland, fodder shrub plantations could be used to reduce the grazing pressure on degraded areas where plant cover is very poor. If rest periods between grazing are sufficiently long, vegetation may recover, increasing plant density, species diversity and biomass production.
- In semi-arid areas, where cereals occupy a large proportion of the land, atriplex plantations could be used as a protein supplement for cereal stubble during summer. If the cultivated soils are prone to erosion, saltbushes can be planted in widely-spaced rows along the contour to reduce erosion.
- In the rangeland, where the currently available species are very poor (e.g. *Stipa tenacissima*, *Artemisia* sp., *Rosmarinus officinalis*, *Thymus* sp.) fodder shrubs can be used as a supplement to increase intake of native resources by the sheep. Plantations can also be used to defer grazing of native rangeland until after the opening rains, thus permitting greater production on the native rangeland in autumn and winter.

Although fodder shrub plantations already occupy several thousand hectares in Tunisia, they have many problems:

- They cover a small area compared to the native rangeland.
- Most plantations have been established on marginal areas where poor plant cover, soil erosion, and severe grazing are common problems.
- Foresters, more interested in soil conservation, often prevent grazing of the plantations, while in other areas, uncontrolled communal grazing leads to degradation.
- Plantations showing most persistence are those harvested by cutting rather than grazing.
- Research has concentrated on agronomic studies to evaluate primary productivity and persistence of shrubs, and has ignored their utilization by animals. These screening procedures have resulted in recommendations to plant species which are unpalatable or do not recover well after grazing.
- The nutritive value of fodder shrubs is frequently measured by chemical analysis of parameters, such as crude protein, fiber, and *in vitro* digestibility. Antinutritional factors, essential oils, saponins, phenolics, etc., which can cause low intake, have generally been ignored.

Examples of the use of fodder shrubs:

1. Figure 3 shows the value of atriplex shrubs as a source of protein to increase intake by ewe lambs.

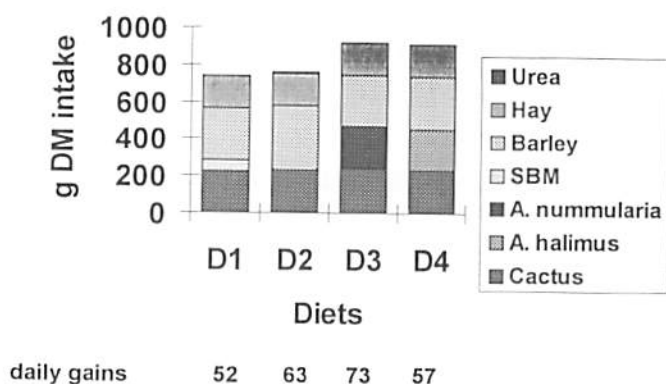
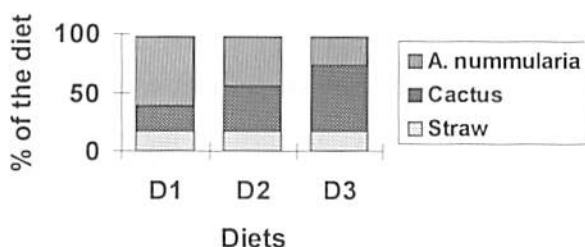


Figure 3: Intake of diets based on atriplex or cactus and restricted amounts of hay. Daily gains: 52, 63, 73, 57. Nefzaoui et al. (1995).

2. Figure 4 shows that cactus and atriplex fed *ad libitum* with 200 g/day of straw provide 1.5 times the maintenance energy requirements of sheep.



Digestible organic matter intake and digestible crude protein intake

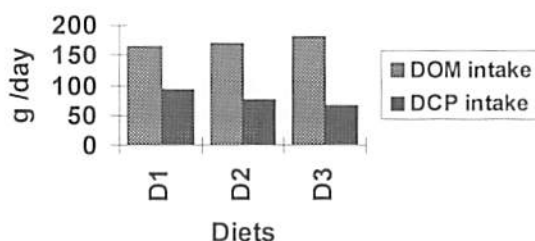


Figure 4. Diet composition and intake of digestible organic matter and digestible crude protein (Nefzaoui, 1995)

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Discussion

B. Al-Rawi: Regarding crop–livestock integration, I would like to see our researchers take into account government policy and the educational level of the farmer. Using fodder legumes becomes a problem in the following season if not properly managed. As a result, farmers lose their barley crop in the next season. As for atriplex, it has to be well managed. Otherwise it will spread as a weed in land that is not intended for grazing.

M. Juneidi: What subspecies of atriplex is used in Tunisia for range improvement?

A. Nefzaoui: *Atriplex halimus* and *Atriplex nummularia* are used in most cases.

M. Tahir: The increase in barley area is more than in marginal lands. Therefore, to ensure sustainable livestock production we need to work out the right balance in barley and livestock production to avoid uncertainties and to increase livestock production.

A. Nefzaoui: Indeed, the system is highly unstable. We have not worked out the right balance between barley and livestock. Nevertheless, environmental conditions (rainfall) do regulate this balance. When there is drought or feed shortages, breeders sell part of their flock. This is a natural regulation.

Constraints on the Adoption of Integrated Farming Systems

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Abstract

The area of Syria is 18.15 million ha, of which 6 million ha is cultivable. There are 4.7 million ha under rainfed agriculture, while 10 million ha are in the steppe. Small ruminant production and cereals are the main farm enterprises in the dry areas, where rainfall is 200–350 mm. With increasing demand for meat and milk, there has been a significant increase in livestock population, especially sheep, of which there were 15 million in 1993. This increase is leading to the degradation of the rangeland, an expansion in cereal cultivation and the elimination of the fallow system. This paper discusses the problems of introducing integrated crop and forage systems.

Introduction

The cultivable area in Syria is 6.13 million ha. Steppe and pasture account for 8.06 million ha, and forests 0.66 million ha. Of the cultivated land, 18% is irrigated and the remainder rainfed. There are five agricultural stability zones designated according to average annual rainfall (Table 1).

Table 1. Agricultural stability zones.

Zones	Rainfall (mm)	Area (× 1000 ha)	Percent of total area
1A	> 600		
1B	350–600	2,701	14.5
2	250–350	2,470	13.3
3	250	1,306	7.0
4	200–250	1,832	9.8
5	< 200	10,207	55.1

Source: Ministry of Agriculture, Statistical Directorate.

Land Use

There are 10.2 million ha of rangeland in Syria, where annual rainfall is less than 200 mm. The rangeland is unsuitable for cultivation, but provides a native pasture that is grazed by increasing numbers of livestock. As a result of degradation, the percentage of feed supplied to flocks by grazing could now be as low as 20%, which leads to an increasing need for cultivated crops, especially barley. The area sown to barley increased from 177,000 ha in 1980 to 507,000 ha in 1990. In the

same period, yield decreased from 860 kg/ha to 31 kg/ha (SMAAR 1990). Where barley cultivation has expanded into the rangeland, it is often not harvested. The expansion of cultivation with tractor-drawn implements into the steppe has removed pasture and shrub species and accelerated erosion. According to an ACSAD report (Elaiwi 1990), the soil affected by wind erosion in Syria is about 2 million ha, or 20% of the steppe.

Marginal lands make up 10% of the area and receive 200–250 mm annual rainfall. Barley is now grown continuously in this area to feed livestock. In years of normal rainfall, straw, grain, and stubble are all used to feed sheep after a normal harvest. In dry years, when the crop is too short to be combine-harvested, it is usually grazed as a standing crop. Occasionally, when the price of straw is very high, it may be hand harvested. In good years, barley is often grazed for a short time in winter.

Barley monoculture results in declining soil fertility, fluctuations in yield—especially in very dry seasons—and a high incidence of disease and pests.

The major agricultural aim in the better areas is to grow crops, some of which are kept for household use and some sold (Jones 1988). Table 2 shows the crop areas under rainfed farming in 1980 and 1990. Wheat is grown in the wetter areas (Zones 1 and 2) and barley in the drier areas (Zone 3). In the wetter areas, a three-year rotation of wheat, grain legumes, and summer crops, is commonly practiced (Table 3). Tables 4 and 5 show the yield of barley grain and straw in different rotations in trials at sites in Zone 2, in northern Syria. Similar results are shown in Table 6 for wheat grain and straw in different rotations in 1992/3 at the Hemo Station in northeastern Syria.

As a result of cereal price subsidies and the input supply, the fallow system has almost been eliminated, and continuous cereal cultivation is prevalent. The area sown to wheat and barley has increased to 3.79 million ha, 80% of the total cultivated rainfed area in 1990 compared to 73% in 1980. Food legumes declined from 5% to 1.2%, and forage crops 1.2% to 1% (Table 1).

In conclusion, there is an urgent need to improve forage and pasture legumes, well-adapted to this area, to break up the continuous barley cultivation.

Table 2. Area of main crops in Syria, and percentage of rainfed land (1980 and 1990).

Crop	1980		1990	
	Area (× 1000 ha)	Percentage of rainfed cultivated land	Area (× 1000 ha)	Percentage of rainfed cultivated land
Wheat	1,275	38	1,066	22.3
Barley	1,193	35	2,725	57
Chickpea	91	2.7	70	1.4
Lentil	8.2	2.4	130	2.7
Grain vetch	8	0.23	12	0.24
Grazed vetch	2	0.04	12	0.24

Statistics from SMAAR (1980, 1990).

Table 3. Planned and applied rotation in the different stability zones in 1993.

Zone	Planned Rotation (%)	Intensification (%)	Applied Rotation (%)
1	Wheat 58.2, Barley 5.7, Lentil 17, Chickpea 4.5, Summer Crop 14.5	100	Wheat 38, Barley 9, Chickpea 3.2, Lentil 5.7, Forage legume 1.05
2	Wheat 36, Barley 42.3, Lentil 4.2, Chickpea 3.9, Summer crop 13.9	100	Wheat 24, Barley 53, Chickpea 3.2, Lentil 2.7, Forage legume 1.06
3	Wheat 10.2, Barley 73, Lentil 0.1, Forage legume 1	85	Wheat 9, Barley 80, Chickpea 0.29, Lentil 0.68, Forage legume 0.3
4	Wheat 1.1, Barley 61	60	Wheat 3, Barley 67, Chickpea 0.002, Lentil 0.17
5	Wheat 5, Barley 95	50	Wheat 6, Barley 92.

SMAAR, Directorate of Statistics.

Table 4. Barley yield (kg/ha) in different rotations in trials in El Bab (Zone 2) from 1986 to 1993.

	After fallow	Barley	Lathyrus	Vetch
Grain	1,162	877	1,272	1,189
Straw	1,803	1373	1837	1,874

Scientific Cooperation Program Report, 1992-1993, ICARDA-DASR.

Table 5. Barley yield (%) in different rotations in Zone 2.

After	Tel Hadya/Aleppo		Breda/Aleppo	
	Grain	Straw	Grain	Straw
Fallow	100	100	100	100
Lathyrus	80	82	81	95
Vetch	84	83	84	96
Barley	69	66	64	67

Sheep

There are an estimated 15 million Awassi sheep in Syria, of which 80% are in flocks that spend a major part of the year in the steppe. The Government Office for Feed (GOF) distributes forage rations to sheep for 4-6 months a year. In good seasons, grazing lasts until the barley harvest, when the flocks move to the agricultural areas to graze cereal stubble. At the end of October, grazing on the residue of irrigated crops such as sugar beet and cotton begins. In dry seasons, flocks move to the marginal lands to graze barley.

About 20% of the sheep are raised in agricultural areas and are more integrated with the farming system. Forage legumes, such as vetch and lathyrus, have been introduced in rotations with cereals and wheat, and barley may be sown to be

grazed at the green stage. Marginal lands in agricultural areas which cannot be cultivated because of shallow or stony soils, or steep slopes, provide natural grazing in spring, particularly in March and April.

Find Alternative Feed Resources

This paper focuses on the integration of livestock, forage, pasture, and cereal production as a solution to the increasing shortage of feed and the need for a sustainable system. An integrated system improves soil fertility, enables weeds and diseases to be controlled more easily, and increases livestock and crop production (Cocks 1991).

Research has been conducted in cooperation with ICARDA to study the possibility of applying the integrated system, including forage legumes and annual medic. In spite of the success achieved in some locations, the application of the integrated system is still very rare because of a number of constraints, including:

- The small size of holdings. The legislative decree of 1980 restricts the size of land holdings to 55 ha in areas with rainfall above 500 mm/year, 85 ha in areas with 350–500 mm, and 140 ha in areas with less than 350 mm. The inheritance laws also lead to smaller and fragmented holdings, which lead to difficulties in applying an integrated system and in the transfer of technology.
- Flock size. The main reason for early and overgrazing, especially in dry seasons, is the large size of the flocks and the unwillingness of farmers to divide them because shepherding is expensive unless family labor is used.
- Poor grazing management. The lack of management experience has contributed to the failure of integrated systems. Proper grazing management, particularly of medic, is considered the key to the success of the integrated farming system. Poor grazing management leads to the degradation of the seed bank, low productivity, and the growth of weeds, which all limit stocking rates or the number of grazing days.
- Marketing. The lack of centers for the collection, processing, and marketing of livestock products leads to low prices and fluctuations in production, particularly of milk. The low price for sheep during dry seasons makes farmers more dependent on growing crops, especially cereals, and flock sizes are reduced to the needs of the family.
- Lack of qualified extension staff. The first attempt to introduce an integrated farming system was made by an FAO project in 1967, followed by projects run by ICARDA in collaboration with SADR. Some of these projects achieved technical success in both station and on-farm trials, but the lack of qualified extension staff has prevented their expansion to farms.
- Government policy. As a result of cereal price subsidies and the supplying of inputs in an attempt to achieve self-sufficiency, farmers were encouraged to increase cereal production and eliminate food and forage legumes whose prices fluctuate from one season to another while production costs, particularly those of hand-harvesting these crops, increase annually.

- The technical and economic advantages of the integrated system can only be seen in the long term. This contrasts with technology transfer in crop production, particularly cereals, where transfer of new practices such as new seed varieties, seeding rates, or fertilizer application, can be achieved in one season. The adoption of integrated systems is also limited by traditionally accepted grazing rights. Some farmers have started to use integrated systems, but have quickly abandoned them for this reason. For example, one farmer gave up a successful, established area of medic because he thought it was not profitable, as it was regularly grazed by other flocks.

Table 6. Wheat grain and straw yield in different rotations at Hemo station (1992/93).

Rotation	Grain (kg/ha)	Straw (kg/ha)
Wheat/fallow	4,555	7,068
Wheat/lentil	4,345	6,325
Wheat/vetch	4,208	6,108
Wheat/medic (low S.R)	4,195	5,988
Wheat/medic (medium SR)	3,740	6,078
Wheat/medic (high SR)	3,735	5,830
Wheat/wheat	1,526	2,475

Scientific Cooperation Program Report ICARDA-DASR (1992/93).

SR = stocking rate of sheep grazing annual medic pasture

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Discussion

A. Goodchild: In response to Dr. Ababneh's comment "let us graze forage legumes only," we need the output of forage legume crops all year round. It is a valuable source of nutrients.

B. Mawlawi: I agree with you, and this is why we are conducting the on-farm trials. But we need qualified extension staff to disseminate and apply the integrated farming system.

A. Al-Rawi: You mentioned that one of the constraints to the integrated system is government policy. What is the proper policy you suggest to improve the integrated system?

B. Mawlawi: As a result of cereal price subsidies, farmers were encouraged to

increase the cereal areas and eliminate the food and forage legume area, whose prices fluctuate from one season to another while the production costs rise. I believe that changing and modifying the pricing and subsidy policy, and improving marketing facilities, would improve the integrated system.

E. Thomson: Which is needed, more technology work on annual forages, or more work on policy?

B. Mawlawi: We need both. As researchers we should identify improved forage and pasture legumes that are well adapted to dry areas to break up the barley rotation. As you know, ICARDA's efforts have focused on the high rainfall area in the last decade. Also, the policy should be changed to encourage farmers to grow forages.

M. Ababneh: Why don't we encourage the cultivation of forage legumes to break the continuous barley rotation, and use it for direct sheep grazing?

B. Mawlawi: This is what we prefer when we work with farmers at Al-Bab, east of Aleppo. However, there are still some constraints that limit the adoption of this system.

Production Technology and Systems

Preliminary Economic Analysis of Medic Pasture and Other Dryland Crops In Two-year Rotations with Wheat In Northeast Syria

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Abstract

The economic role of annual medic (*Medicago* spp.) pasture in rotation with wheat is compared with other crop rotations (wheat-fallow, wheat-entil, wheat-wheat, and wheat-vetch), based on an eight-year study in Hassakeh Province, in the dryland area of northeastern Syria. A whole-farm linear programming model was designed to assess interactions between crop, pasture, and livestock activities, prices, and household requirements and resources. Results indicate a minor but positive role for annual medic pastures on good farmland in northeastern Syria, particularly where access to hired labor is limited and fallow-wheat rotations play a major role. Where there is unlimited access to hired labor for harvest, the labor-intensive lentil-wheat rotation is more profitable.

Introduction

The introduction of self-regenerating annual medic pastures into rainfed farming systems in West Asia and North Africa has been one of the major research goals of ICARDA's Pasture, Forage, and Livestock Program. The objective of this paper is to demonstrate under what conditions the medic-wheat rotation is economic.

Hassakeh Province has a rainfed area of about one million hectares, 24% of the country's total. Crop rotations are predominantly cereal-cereal (75%), or mixed cereal-legume, cereal-summer crops and cereal-fallow (25%). In 1993 the province's animal population was estimated at 1.7 million sheep, 0.2 million goats, and 90,000 cattle, 13, 17, and 12% of the national animal population, respectively (SMAAR 1992).

Data from the long-term crop rotation trial at the Hemo experimental station and from farm and market surveys were used in the model. Precedents for this sort of multidisciplinary modeling are the MIDAS modeling in Western Australia

(Kingwell and Pannell 1987) and the whole-farm modeling work of Nordblom et al. (1994).

The long-term crop rotation trial (L34) begun in 1986 at the Hemo experimental station, near Kamishly, was set up to:

1. Assess the productivity of the wheat/medic rotation, compared with typical local wheat rotations with vetch, lentil, and fallow, and with continuous wheat production.
2. Monitor the effect of three stocking rates on medic and sheep production.
3. Provide a basis for determining the profitability and economic risk of the rotations.

Results from eight seasons (1986/87–1993/94) were used. Farmer surveys were used to specify costs and returns (Nordblom et al. 1993)

For wider distribution of locally proven cultivars of medic to farmers, it is important to prove that medic can play a significant role in increasing farmer income. In addition to the local physical conditions, the socioeconomic conditions must be appropriate for the medic/wheat rotation to compete with other rotations (Springborg 1990). Among the socioeconomic conditions considered to play an important role in the success of a farming system on a given farm are:

- Family labor available.
- Cost of family and hired labor.
- Availability of hired labor.
- Prices for farm outputs and inputs.
- Farm size and inherent productivity.
- Farmers' attitudes towards risk.

The effects of various combinations of these factors on yield were quantified using a whole-farm linear programming (LP) model. It was assumed that farmers had, or could develop, skills for managing medic pastures in the rotation.

Feed, sheep product, and crop prices over the eight-year period were collected from the Kamishly markets and adjusted to the value of the Syrian lira in 1992 (Table 1) using the wholesale price index from the Central Bureau of Statistics, Syrian Arab Republic (CBS 1994).

Assessment of the availability of family labor, and the labor requirement for managing and milking shepherded flocks, was based on survey results and previous experience. Labor costs and opportunities for off-farm work are important variables in the economic analysis. A typical farm (16 ha) and a large one (64 ha) were examined. The model optimizes sheep numbers at a constant level across the eight years, assuming that the production of milk and lambs is constant.

Table 1. Eight-year means and coefficients of variation of prices of inputs and outputs, deflated to 1992 levels.

	Mean (SL/kg)	CV (%)
Barley grain purchase	8.70	18
Cottonseed cake	13.05	24
Wheat grain sale	7.28	13
Wheat straw sale	1.45	114
Wheat stubble sale	0.24	114
Vetch hay sale	1.77	86
Vetch grain sale	10.11	14
Vetch straw sale	2.95	86
Lentil grain sale	14.12	26
Lentil straw sale	1.47	33
Milk sale	18.93	20
Lamb sale (Spring)	82.29	21
Cull ewe sale	54.34	11
Lamb sale (Early Summer)	65.77	20
Hired labor	125.00 per day	

SL = Syrian lira.

SL 42 = US\$ 1.00.

CV = coefficient of variation.

Cost of Different Rotations

Details of the crop budgets are given in Shomo et al. (1995). It was assumed that the cost of establishing and growing wheat was the same in all the rotations. It included the purchase and application of seed, fertilizer, and herbicide. Labor requirements were considered separately. Costs of combine harvesting and labor requirements were adjusted for yield recorded for each year and rotation.

Fallow–Wheat

Wheat is alternated with clean fallow. It was assumed that maintaining a clean fallow required cultivation in autumn, winter, spring, and summer, each at the same cost and labor requirement.

Wheat–Wheat

Wheat is grown every year in this “rotation.” The cost of establishment of 2 ha is twice that of 1 ha.

Vetch–Wheat

Costs and labor requirements for cultivating vetch were calculated for 1 ha. These were combined with wheat costs and labor requirements for a 2 ha rotation. Farmers have three options for use of vetch after establishment: harvesting it for

hay and grazing the stubble, harvesting by hand for seed and straw, or grazing it as spring pasture. The three options are considered in the model.

Lentil-Wheat

This rotation was established in 1991. Lentil yield for the previous four years was estimated by multiplying vetch yield by the ratio of lentil and vetch yield from 1991 to 1994.

Medic-Wheat

Since medic pasture self-regenerates from the seed bank in alternate years in rotation, its establishment costs and labor demands are spread over a number of years. It was assumed that pasture survives for 10, 8, and 6 years at low, medium, and high stocking rates, respectively, and costs were calculated accordingly.

Yield

Wheat

Wheat straw plays an important role as fodder in the sheep diet, and stubble is the main grazing source. Mean wheat grain and straw yields in the rotations are presented in Table 2.

Table 2. Eight-year means and coefficients of variation of wheat grain and straw biomass yields.

Rotation	Grain		Straw	
	Mean (kg DM/ha)	CV (%)	Mean (kg DM/ha)	CV (%)
Fallow-wheat	1,896	44	3,585	31
Wheat-wheat	1,647	55	3,814	34
Vetch-wheat	1,359	67	3,075	32
Lentil-wheat	1,392	70	3,098	34
Medic(low)-wheat	1,349	74	2,785	38
Medic(med)-wheat	1,338	76	2,708	43
Medic(high)-wheat	1,354	77	2,823	36

CV = coefficient of variation.

Vetch and Lentil

Hand-harvested vetch seed and straw, and lentil yields are summarized in Table 3.

Medic Pasture

Medic pasture off-take was estimated from the number of ewes and lambs grazing in each period. Adjusted ewe grazing day equivalents were calculated and

converted to pasture off-take (Table 3), using Nordblom et al. (1992) assumptions of daily dry matter intake for each season and stage of the ewe's annual production cycle.

Table 3. Eight-year means and coefficients of variation (CV) of estimated pasture offtake and other crop yields.

		Mean (kg DM/ha)	CV (%)
Medic pasture, low stocking:	Spring	906	55
	Summer	558	54
Medic pasture, medium stocking:	Spring	1,067	40
	Summer	600	56
Medic pasture, high stocking:	Spring	1,198	42
	Summer	533	30
Other crops grown in rotation with wheat			
	Vetch hay	1,018	3
	and Vetch stubble	424	33
	or Vetch seed	928	51
	and Vetch straw	2,071	55
	or Vetch pasture	2,071	55
	Lentil grain	1,099	48
	and Lentil straw	2,089	68

Sheep Nutrition

Several types of information were used to quantify the nutritional parameters in this analysis: (i) ewe weight and weight change over the year; (ii) the production phase in each season, assuming late pregnancy in autumn, lambing and early lactation in winter, milking in spring, and dry and mating periods in summer; (iii) typical ewe diet; and (iv) published nutritive requirements of sheep. Three nutritive parameters were used as constraints that needed to be satisfied to maintain given sheep performance levels (Nordblom et al. 1994): (i) maximum dry matter intake; (ii) minimum requirements for metabolizable energy (MJ); and (iii) minimum requirements for crude protein (CP).

The model allows for the purchase of concentrate feeds, barley grain, and cottonseed cake. These, together with the other feed sources available on the farm, are used to supply the estimated energy and protein requirements of the flock at minimum cost while optimizing ewe numbers.

The Whole-farm Model

The analysis is based on a whole-farm linear programming model, using a discrete joint-probability distribution of yields and prices. The model was designed to identify combinations of farming practices, rotation, and flock size which provide the optimal balance of activities to maximize household income, using variations in prices and production shown in Tables 1, 2, and 3. It also allows for consideration of labor constraints and costs, and cash flow.

The main activities in the model are:

1. Rotation. All rotations are two year, with wheat alternating with fallow, wheat, lentil, vetch, or medic.
2. Feeding in each season. Feed includes crop residue, grain, pasture, hay, and straw from the farm, and purchased barley grain and cotton seed cake.
3. Product sale.
4. Sheep. The number of sheep and flock labor requirements.
5. Labor market. Labor may be hired to meet seasonal shortages, and family labor hired out during times of excess labor availability.
6. Cash-flow.

The main constraints in the model are:

1. The objective. Finding a farm plan which maximizes total net return in relation to family resources of land, labor, and capital, and management is met as the LP solver works towards maximizing the sum value of this row.
2. Land. Farm sizes of 16 and 64 ha are used, since most farms in the area are less than 64 ha. A unit of one ha is used in the model, representing 0.5 ha of wheat and 0.5 ha of the other phase of the rotation. Combinations of crop rotations are possible in the model.
3. Labor. There is a constraint on the availability of family labor in each of five periods of the year (autumn, winter, spring, early summer, and late summer). This may be supplemented with hired labor at times of peak need in some solutions of the model.
4. Income accounting. One for each year.
5. Crop product. Sale and uses of the various crop products are tied to production activities by transfer rows.
6. Feed quantity and quality for sheep. Limits on maximum dry matter intake and minimum metabolizable energy and crude protein levels are defined on a per ewe basis, per season.
7. Consumption of cottonseed cake. This cannot exceed 10% of the diet.
8. Livestock product transfer. The flock is assumed to have four marketable products: milk, weaned lambs, fattening lambs, and culled ewes. Sales activities in each year are linked to the EWE activity by transfer rows.
9. Flock labor requirement. A constraint sets the flock labor requirement to appropriate levels, or to zero if sheep are excluded from a model solution.
10. One family. The family's minimum cash needs for essential purchases are specified in the family activity, which is constrained to exactly one unit. This constraint also provides quantities of family labor.

Results and Discussion

The results for each crop rotation, assuming unlimited access to hired labor, are presented in Table 4. Figure 1 shows the relationship between annual income and standard deviation for the crop rotations with and without sheep.

Most dryland crop rotations in the Kamishly area include wheat, with lentil and vetch found in some areas. Continuous wheat cultivation, the least profitable option in the model (Table 4), is widespread because farmers are required by law to grow wheat on two thirds of their land, and fallows, which give a more profitable rotation in the model, are not allowed.

Predicted income from fallow-wheat and vetch-wheat rotations is lower than from lentil-wheat, but the fallow-wheat rotation is more stable.

Where vetch pasture cannot be sold for use by other flocks, vetch-wheat with sheep is more profitable than without sheep. Only vetch hay, seed, and straw can be sold in this model. There is flexibility to choose among the options for using vetch.

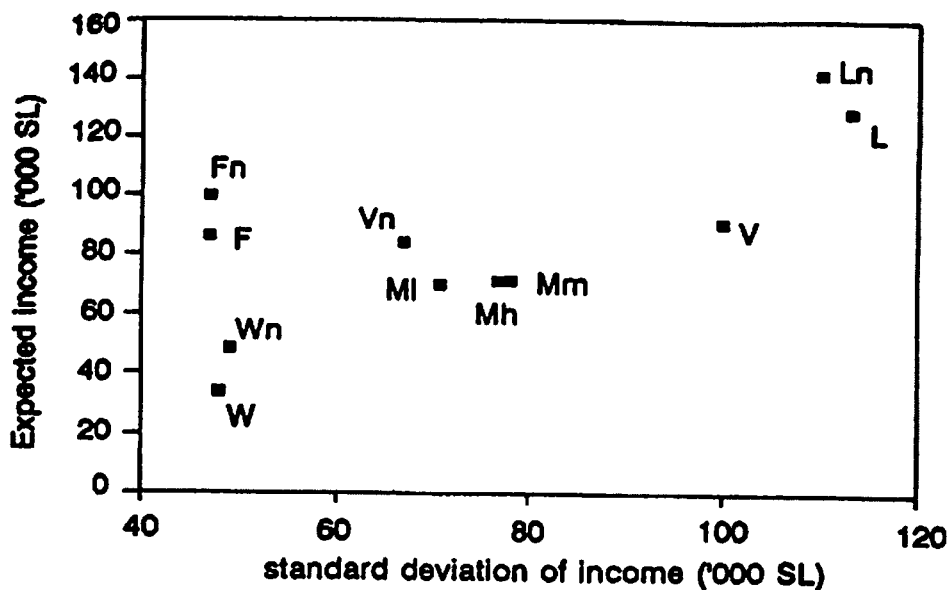
The medic-wheat rotation is less profitable than fallow-wheat on both 16 and 64 ha farms.

Although a lentil-wheat rotation appears, from the model, to be more profitable, in practice it is less common than other rotations because it requires high labor input. Labor availability and the impact of machine harvesting of lentils, which is just starting in the area, require examination in a district-level model.

Table 4. Mean and standard deviations of whole-farm income and optimal ewe numbers for 16 and 64 ha farms (with and without sheep) for crop rotations with wheat (Kamishly area, NE Syria).

Rotation	Whole-farm income (with sheep)		Optimal constant no. of ewes	Whole-farm income (no sheep)	
	Mean 000 SL	SD		Mean 000 SL	SD
16 ha					
Lentil-Wheat	129	113	12.1	142	110
Vetch-Wheat	91	100	51.5	84	67
Fallow-Wheat	86	47	0	100	47
Wheat-Wheat	34	48	0	48	49
Medic-W(heatL)	70	71	36.6		
Medic-Wheat(M)	71	78	41.6		
Medic-Wheat(H)	71	77	42.0		
64 ha					
Lentil-Wheat	428	444	48.3	437	430
Vetch-Wheat	280	392	207.2	201	257
Fallow-Wheat	283	181	0	299	181
Wheat-Wheat	70	184	0	88	185
Medic-Wheat(L)	224	278	146.2		
Medic-Wheat(M)	224	306	166.6		
Medic-Wheat(H)	226	301	169.3		

a. for a 16 ha farm



b. for a 64 ha farm

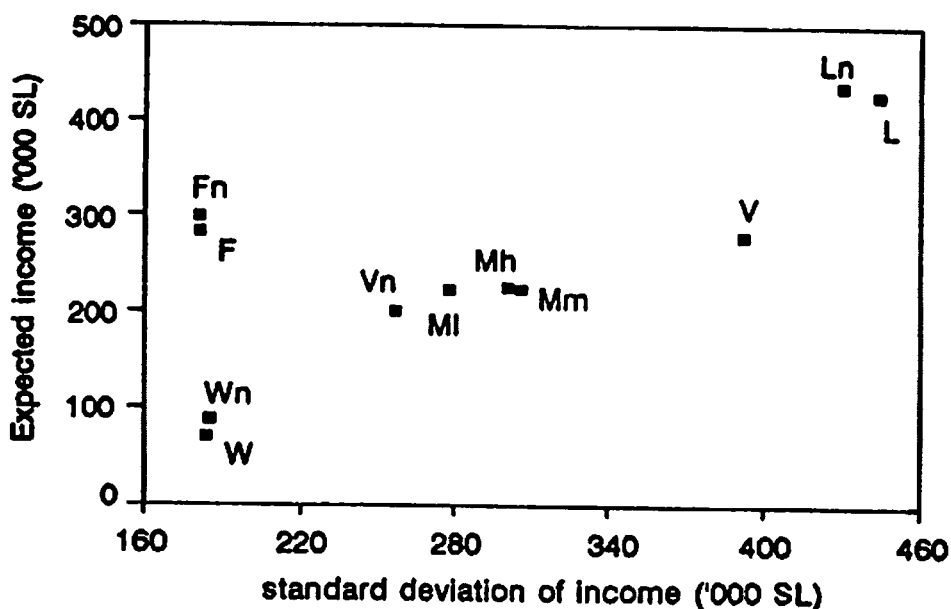


Figure 1. Eight-year means and standard deviations in the whole-farm income. L=lentil-wheat; V=vetch-wheat; W=wheat-wheat; F=fallow-wheat; MI, Mm, Mh=medic-wheat with low, medium and high stocking; n=no shepherd or sheep allowed in plan.

Table 5 shows the results of the model when a combination of crops in the rotation are permitted, with and without access to hired labor. Without hired labor, the lentil area is much smaller and largely replaced by fallow. Plans for farms without sheep or hired labor have a large area of fallow, but include some lentil. Optimal plans for farmers with a flock and no hired labor are more diversified, with fallow, medic, and smaller areas of lentil and vetch.

Table 5. Optimal allocation of land to crop rotations on 16 and 64 ha farms with and without sheep, and with and without access to hired labor.

	Optimal allocation of land				No. of ewes	Annual income	
	(ha)					(000 SL)	
	F	V	L	Mh		Mean	SD
Unlimited hired labor							
16 ha + sheep		0.7	15.3		11.53	129	134
No sheep			16.0			142	110
64 ha + sheep		1.2	58.1	4.7	46.95	430	498
No sheep			64.0			437	430
No access to hired labor							
16 ha + sheep	4.6	1.2	4.9	5.2	40.03	101	86
No sheep	11.3		4.7			112	59
64 ha + sheep	44.7	0.2	3.1	15.8	76.64	218	161
No sheep	60.3		3.7			244	130

F= fallow-wheat; V= vetch-wheat; L= lentil-wheat; Mh = medic-wheat, high stocking rate.

When hired labor is unavailable, mean annual incomes are reduced by about 27% on 16 ha farms, and 50% on 64 ha farms. On the 16 ha farm family labor alone is sufficient. On the 64 ha farm, when no hired labor is available, most of the farm is fallow. Where hired labor is available, both small and large farms allocate larger proportions of their land to lentils (Table 5).

Sheep/No Sheep

But what of the effects of sheep on whole-farm income? Lower mean incomes, with higher variations, are found when shepherd and sheep are included in the farm plan. Sheep numbers are optimized at a constant level across the eight years in each run of the model when their performance (milk and lamb production) is also constant over time. Thus, the lower mean incomes are due to lost opportunities for sale of crops and family labor which are "consumed" along with purchased feed. The greater variations in income with sheep are due to the effect of having to feed a constant number of sheep through the poor years (when feed prices are highest) and through the abundant years when not all home grown feed can be used, and any amounts sold fetch only their lowest price. This is an artifact of the model; farmers in real life are free to adjust their flock size according to changes in the feed situation.

Sheep in the model are internally financed by the farm in the sense that all ewes are recruited from unsold female lambs; they are in, in a sense, "purchased" at the

cost of lost opportunities for the sale of female lambs in addition to the cost of feeding the replacement animals and shepherding time. With all these costs, sheep have the important benefit of being a store of wealth with real value, the minimum of which is their value at liquidation. If we add this internally-generated store of wealth to the mean annual income values, the negative gaps between the sheep/no-sheep options are closed. Until the flock is liquidated, it holds the potential to be sold off by the farmer at any time.

Conclusions

This model captures the complex interactions within the crop-livestock economy. It reveals a limited role for medic pasture in northeastern Syria, particularly where access to hired labor is limited.

We have not exhausted the usefulness of the model with this short paper. Hopefully, we have provoked interest in exploring further questions at the farm and district levels. The model summarizes a considerable data base and the organic links among the variables and constants of the study area and will be of direct use in quantitative policy analyses.

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Nearly Three Decades of Using Medics to Introduce Ley Farming in Tunisia

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Abstract

Annual medics have been used for nearly three decades in largely unsuccessful attempts to introduce ley farming in Tunisia. The main constraints are inadequate grazing management, the poor performance and high price of medic cultivars imported from Australia, inappropriate tillage methods and implements, and lack of weed control. Although ley farming is economically feasible and can be adapted to some areas in Tunisia, the low adoption rate raises the question of technology transfer and the need to modify the system to suit Tunisian conditions. Successful ley farming requires the management of medic-cereal rotations as a farming system that integrates cereals and livestock rather than using medics to replace fallow.

Introduction

Since the 1960s, the number of small ruminants in Tunisia has increased, resulting in imports of large quantities of feed, such as barley grain, corn, and soybean. The shortage of livestock feed, particularly for small ruminants, has also put great pressure on rangeland. Environmental degradation in most semi-arid areas through overgrazing, deforestation, and erosion, is leading to desertification. In addition, the increase in cereal yields has not been sufficient to satisfy the increased demand for wheat and barley grain.

Ley farming was first introduced in Tunisia in 1970 with the start of the Tunisian/Australian Agriculture Development Project in the semi-arid region, making use of Australian experience with cereal-medic rotation.

Annual *Medicago* species (usually called medics, or *nefla* in Arabic) were proposed as an alternative to improve the cropping system in Tunisia, which is traditionally based on fallow-cereal (Haddad 1982). The new system integrated livestock in farming systems in areas with average annual rainfall of 300–500 mm. An analogy was made with the deliberate introduction of annual medics in Australia, starting in the early 1940s with screening and improvement (Halila et al. 1990), followed by the adoption in the 1950s of cultivars in ley farming systems which were particularly successful on large farms in southern Australia where cereal and livestock production were integrated (Doolette 1975). As early as 1970 attempts were made to transfer ley farming to Tunisia and other Mediterranean countries (Gachet and Elmir 1972).

Main Agricultural Areas In Tunisia

Rainfed agriculture in Tunisia occupies a major part of the cultivated area, which can be divided into the following major agro-ecological zones:

- Northern zone: a mountainous area with forests, with mean rainfall over 500 mm/year, suitable for improved crop production and yield. Most cattle are raised here.
- Semi-arid zone: more than 60% of cultivated land is in semi-arid areas, with a mean rainfall of 300–500 mm/year. Crop production and yield are determined by the amount and distribution of rainfall during the season.
- Arid zone: mainly in central and south Tunisia, with a mean rainfall of 100–300 mm. Crop production potential is limited because of low rainfall and hot summers.

Climatic and Edaphic Conditions

Tunisia has a Mediterranean climate with mild winters and hot, dry, summers. Rainfall is poorly distributed and yield is unpredictable. There are wide variations in temperature, ranging from mild winters in the coastal areas to continental conditions in many inland areas, where most of the semi-arid regions are. Frost occurs in many areas and low winter temperatures are a limiting factor for the growth of many forage legumes, including clovers and medics. Temperatures rise in early June, and July and August are very hot and dry (Rouz 1994).

Most Tunisian soils are clay loams (Dahmane 1984), which are neutral to slightly acid in the northern zone and alkaline and infertile in the semi-arid zone.

Land Occupation In Tunisia

Tillable land represents 30% and rangeland 21% of the total area (Table 1). More than 60% of small ruminants graze the rangeland, but the potential is very low because of environmental degradation as a result of overgrazing (Seklani 1981).

Table 1. Land occupation in Tunisia.

Land occupation	Area (ha)
Total area	16,273,000
Tillable land	4,856,000
Rangeland	3,430,000
Forest and alfa	1,115,000

Ministère de l'Agriculture, Annuaire des Statistiques Agricoles (1975–1992).

Table 2 shows that cereals are the main rainfed crop. There is about as much fallow every year as the area used for grain legumes and forage crops combined. This indicates a problem of crop sequence and rotation, which limits increases in yield.

Table 2. Average areas of important rainfed crops in Tunisia.

Land use	Cultivated area (ha)
Cereals	1,600,000
Forage crops	260,000
Grain legumes	130,000
Fallow	360,000

Ministère de l'Agriculture. Annuaire des Statistiques Agricoles. 1975–1992.

Assessment of the Livestock Situation

Table 3 shows that small ruminants are the most important livestock in Tunisia. There are five times as many sheep as goats. Cattle are mainly raised in the northern areas, while small ruminants are located in the central-southern part of the country where feed resources are limited for most of the year owing to low and poorly distributed rainfall.

Table 3. Cattle, sheep, and goat populations in Tunisia.

Livestock	Females	Total number
Cattle	348,000	670,000
Sheep	3,312,000	6,290,000
Goats	692,000	1,313,000

Office de l'Elevage et des pâturages.

The large livestock population is increasing land degradation with obvious changes in the botanical composition. Legumes are scarce and weed species are more frequent. Soil fertility has not been maintained in many cultivated areas. Mismanagement and overgrazing have led to severe degradation of natural resources and to desertification in many areas.

Table 4 shows serious shortages in milk and meat, and large quantities are imported every year. Deficits in milk and meat production are reported as 38% and 10%, respectively. However, the true deficit is the percent increase in milk or meat production required to meet the demand. True deficits are estimated as 60% and 11% for milk and meat, respectively.

Table 4. Milk and meat production, consumption, and deficits in Tunisia.

Product	Production (tons)	Consumption (tons)	Reported deficit (%)	True deficit (%)
Milk	450,000	720,000	38	60
Meat	148,000	164,000	10	11

Ministère de l'Agriculture. Annuaire des Statistiques Agricoles (1975–1992).

The 1991 World Bank report and Nordblom (1993) project that Maghreb countries will face substantial food deficits in the coming three decades due to the steady increase in population and demand for food. The major constraint preventing substantial increases in meat and dairy products has been the shortage and poor quality of feed. The period from May to early October is critical, as it coincides with

mating and pregnancy of small ruminants. Unfortunately, during this period small ruminants feed only on cereal stubble.

The second critical period in feeding small ruminants is October to February, when no annual forage or grassland is available for lambing ewes. Shortages and poor quality of grazing also affect cattle. Irrigated areas of forage crops are limited, since farmers prefer high return vegetable crops to forages, if irrigation is possible. The only time when feed is sufficient for livestock is in spring in favorable years.

Tunisian Experience with Medics

Considerable extension efforts were made to introduce the Australian ley farming system in Tunisia as early as 1970 (Dahmane 1984) by a number of institutions, including the Office des Cereales, the Office de l'Elevage et des Paturages (OEP), GRAFOUPAST, the Extension Service (CRDA), and teaching and research institutions (INRAT, INAT and ESAK).

Achievements

Soil Fertility

Ley farming in Tunisia has been found to improve soil fertility. Dahmane found that in addition to the increase in organic matter, annual medics increase soil nitrogen from 77 to 311 kg/ha, depending on annual rainfall (Table 5).

Table 5. Estimated biological nitrogen fixed by annual medics.

Rainfall (mm)	Nitrogen (kg/ha)
124	77
248	203
353	311

Source: After Dahmane (1985).

Forage Production

Trials conducted at INRAT research stations using medic-wheat rotations yielded quantities of forage equal to mixtures of vetch-oat, which continues to be the main source of hay production in Tunisia (Nefzaoui and Chermisti 1984). Annual medics are nutritious, palatable, and high yielding when appropriately managed. Medic forage is well accepted by animals and highly digestible (Table 6). It has a total nitrogen content ranging from 20 to 25%, depending on the stage of growth. The fiber content is low and similar to that of alfalfa.

Table 6. Yield and forage quality of annual medics.

Fresh weight (ton/ha)	Dry matter (ton/ha)	Dry matter (%)	Total N content (%)	Crude fiber (%)	Digest- ibility (%)
15	4	27	20-25	20-25	70

Direction de l'Enseignement de la recherche et de la Vulgarisation (1985).
Nefzaoui and Chermisti (1989).

Medic and Livestock Performance

Grazing trials conducted in 1975 by INRAT at its Bou Rabia research station indicate the importance of annual medics. Average daily gain for grazing lambs ranged from 94 to 160 g/lamb. The grazing period lasts between 94 and 139 days per year (DERV and OEP). When appropriately managed, the estimated return of using medics for grazing is equivalent to a yield of 15–34 Qx/ha of wheat (Table 7).

Table 7. Livestock performance and estimated economic return of annual medics.

Livestock performance	Recorded level
Stocking rates (lambs/ha)	6–20
Average daily gain/lamb (g)	94–160
Days of Grazing	94–139
Estimated return (dinar/ha)	260–590
Equivalent return of wheat: (Qx/ha)	15–34

Cereal Yield after Medics

Comparison of wheat yield after medics and after fallow, made by the Office des Cereales, indicated better yield after medics (Table 8).

Table 8. Comparative effect of medic ley and clean fallow on wheat yield in various locations with different nitrogen fertilizer applications.

Rotation	Nitrogen fertilizer (kg/ha)					
	1982/83 [†]			1984/85 [‡]		
	0	33	66	0	33	66
Medics–cereals	1.67	1.86	1.53	2.75	2.06	3.25
Fallow–Cereals	1.38	1.53	1.58	2.32	2.63	3.10

[†] Average of seven sites with annual rainfall 350–500 mm.

[‡] Average of two sites with annual rainfall 400–500 mm.

Table 9 shows how areas sown to annual medics have evolved since the introduction of ley farming in the early 1970s. The area sown to medics did not exceed 2–6% of planted acreage—far below expected levels. There were significant fluctuations each year, with a maximum of 7,574 ha in the 1985/86 season. Most of these areas were on state-controlled farms, and private farmers remained reluctant to use medics in rotation with cereals or for pasture improvement.

Table 9. Areas sown to medics since 1970 in Tunisia.

Season	Medic/cereal rotation	Pasture improvement	Regenerated medics	Total
1971/72	15			15
1972/73	468			468
1973/74	492			492
1974/75	2,665	115		2,770
1975/76	2,525	603		3,128
1976/77	2,200	2,350	550	5,105
1977/78	2,691	400	1,366	4,457
1978/79	1,780	1,641	896	4,317
1979/80	1,563	641	1,234	3,438
1980/81	905	508	2,215	3,628
1981/82	954	271	2,227	3,452
1982/83	1,243	211	215	1,669
1983/84	1,030	400	1,445	2,875
1984/85	1,050	1,671	2,693	5,414
1985/86	6,665 [†]	4,802 [†]		11,467 [†]
1986/87	4,368	2,119	500	6,987
1987/88	2,568	640	4,680	7,574
1988/89	2,350			
1989/90	2,513			
1990/91	2,150			
1991/92	2,270			
1992/93	2,300	1,600		3,900
1993/94	1,897	383		2,280
1994/95	1,820	300		2,120

[†] Over-estimated.

DERV and OEP (1985).

Office des Cereales.

Office de l'Elevage et des Pâturages.

Ley Farming Setbacks In Tunisia

The transfer of Australian ley farming to Tunisia has encountered a number of different constraints at the farm level:

- Climatic and edaphic. A comparison of climatic and edaphic conditions in semi-arid areas in southern Australia and Tunisia reveals that altitudes in Tunisia are higher, temperatures are lower in winter with more frequent frosts, and summers are hotter. Soils in semi-arid areas of Tunisia are clay loam alkaline, similar to those in southern Australia.
- Australian medic cultivars. Medic cultivars, selected and developed for the milder conditions of southern Australia, performed badly in Tunisia (Halila et al. 1990). Frost is frequent in a number of areas in the semi-arid zone as a result of high elevation. Research is needed to select adapted, productive cultivars for Tunisian conditions. Australian (Jemalong and Harbinger)

cultivars of *Medicago truncatula* also have spiny pods that stick to the sheep and reduce wool prices.

- **Management.** Inadequate grazing management limits seed production of annual medics and, therefore, regeneration. The establishment of medic pastures during the first year was poor, due to inadequate seedbed preparation and insufficient phosphate.

There was a lack of appropriate tillage implements such as plows and cultivators. Farmers continued to use traditional deep soil preparation for cereal crops after medics, using a moldboard and disk plow, burying seed too deep and limiting regeneration.

Weeds were rarely controlled and reduced medic growth. Bloat occurred in small ruminants grazing medic pastures, causing death in some cases.

- **Socioeconomic.** Ley farming was difficult for many Tunisian farmers because of the careful management needed for medics, cereals, and livestock on the same farm. Farmers' concerns and perception of these three components were different from those of farmers in Australia. Farmers were not involved fully in projects to introduce ley farming and the system was not clearly presented to them. There was insufficient emphasis on the need to integrate livestock in the cropping system to optimize the use of medics in ley farming. Land ownership and subdivision of inherited farms of a few hectares also limited the use of ley farming, which was successful on large farms in Australia.

Medic seed is imported from Australia and is expensive: \$2.3/kg, 8–10 times the price of barley. The germination rate is often low because of storage and delays in shipment. In addition, the production of medic seed in Tunisia has not been developed because of the lack of suitable equipment.

Farmers in many areas found reductions in cereal yield after medics, compared to yield after fallow (Table 10). They were, therefore, reluctant to use the medic–cereal rotation and raised questions about the relevance of medics in rotation with cereals.

- **Extension:** Extension workers need training in the use and management of annual medics in the ley farming system. Extension is needed to improve and fine tune the system. There was no follow-up of ley farming projects at the farm level after the introductory phase.

Table 10. Yield comparison of wheat and barley cultivars grown after medic and fallow at several sites in Kef province, Tunisia.

Locations	Wheat				Barley	
	cv Ben Bachir		cv D58-25		cv Martin	
	Medic	Fallow	Medic	Fallow	Medic	Fallow
Nebbeur	13.5	14.0	7.5	14.0		
Dahmani	5.0	6.0	6.0	7.0	7.0	22.5
Sers	8.0	15.0	10.0	13.0	8.0	20.0
Tajerouine	9.0	10.5	9.0	12.0	6.0	11.0

Ministère de l'Agriculture. Annuaire des Statistiques Agricoles. 1975–1992.

Summary and Conclusions

Annual medic species have become an important component of an efficient cropping system in many semi-arid regions of the world because of their value in producing palatable, nutritious and high quality feed. Medics are a good alternative to fallow and suitable for biennial rotation with cereals. They also improve soil fertility and help to control soil erosion.

Annual medics have also become an important issue in Tunisia. Reports indicate the possibility of converting about 300,000 ha of fallow each year into forage legumes and improving more than 500,000 ha of rangeland with annual medics (Gachet 1979). This would reduce the need for milk and meat imports. Medic species deserve more attention and care to improve the cropping system in these areas of Tunisia.

Experience with annual medics on state farms indicates that ley farming is economically feasible and can be adopted in areas with appropriate climate, soil, and farm structure. Some modification of the Australian system, however, is necessary before it can be adopted by Tunisian farmers:

- Better extension is needed of management techniques for annual medics in a biennial rotation with cereals that integrates livestock and optimizes the use of annual medics.
- Weed control must be carefully considered, since annual medics are poor competitors with weeds in Tunisia.
- Medic seed production in the country must be developed to provide an adequate and cheaper supply of seed.
- Breeding programs must be developed to select productive species and cultivars of medic adapted to Tunisian climatic and edaphic conditions.
- Efforts must be focused on range and marginal land improvement where medic pasture improvement, soil and water conservation, and livestock production are easier and more successful.

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Discussion

U. Optiz: You have been trying to introduce ley farming in Tunisia for the past 25 years. Imported Australian cultivars proved to be expensive and not adapted to local conditions. Why did you not try to utilize endemic, adapted species?

M. Ben Younes: When the ley farming project started in Tunisia, medic seeds were 100% subsidized by the government to encourage and help farmers to adopt ley farming. Farmers had no problem or complaints about seed prices.

Ley farming projects were Australian/Tunisian, and obviously Australian experts wanted to export their medic seed production.

Seed production equipment is expensive, dusty, and heavy. Farmer cooperatives can't afford them. The Australian/Tunisian extension people pushed for medic self-regeneration rather than its production every year.

Research institutions and their staff are mostly trained. There was a lag phase in research programs in forages in general and particularly forage germplasm collection and evaluation.

Investigation of Forage Alternatives Following Wheat Harvest Under the Rainfed Conditions of Central Anatolia

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Abstract

A two year wheat-fallow rotation system has been used in Central Anatolia to overcome the water deficit in the wheat year. However, past research indicates that fallow could be replaced with legumes, particularly with those annual forage crops that are grown for hay. Since forage crops have low hay yield when grown alone, cereal/forage mixtures need to be tested to improve dry matter production. The present study was conducted to determine hay and crude protein yield of cereal/vetch mixtures under the rainfed conditions of Central Anatolia. Barley (*Hordeum vulgare* L.), rye (*Secale cereale* L.), Hungarian vetch (*Vicia pannonica* Crantz.) and hairy vetch (*Vicia villosa* Roth.) were grown alone and as mixtures with each other in different seed compositions following barley harvest. Overall, hay yields for all treatments in 1979/80 were higher than in 1980/81. Cereals grown alone produced 20% less hay and 46% lower crude protein, and vetches 52% less hay and 28% lower crude protein than the mixtures. Increasing the ratio of cereals in the mixture increased hay yield but not crude protein.

Cereal and vetch mixtures for hay seem to be a better alternative feed source than vetches grown alone. Higher crude protein content and hay yield from mixtures can be explained by a positive association between vetches and cereals, and by the amount of N fixed by vetches for cereal use.

Introduction

Wheat-fallow is the major two year rotation system practiced in Central Anatolia, covering almost 5 million ha. Since precipitation in Central Anatolia is low (350–425 mm/year) and sporadic, farmers use this rotation in order to provide more moisture to wheat by storing the fallow year precipitation. However, fallow efficiency is low because of improper husbandry and shallow soil depth. Most of the time fallow lands are used as a feed resource for sheep, particularly in early spring. Consequently, first soil cultivation is deliberately postponed or eliminated to allow weed growth and stubble for utilization by animals. Grazing of the fallow land causes insufficient moisture storage and inadequate seedbed preparation. Therefore, in many cases in the region, fallowing does not serve the farmers'

needs. Moreover, the increase in the small ruminant population and decreasing yield from the rangelands due to heavy grazing compel farmers to find new feed resources. Presently only about 3% of the arable land is devoted to forage crops, and total forage production is far below feed demand.

Replacing the fallow year with legume crops, particularly annual winter forage crops, is a promising practice in terms of profitability and better land use. The time to harvest winter forage legumes for hay is much earlier than the time to harvest the seed of spring food legumes. Vacating fields earlier permits higher soil moisture storage and better seedbed preparation for the subsequent wheat crop.

Research indicates that even where annual precipitation is less than 400 mm, vetches could be grown for hay in the fallow year without any wheat yield reduction in the subsequent year (Durutan et al. 1988; Kurt et al. 1989). In particular, cold-resistant vetches provide early winter and spring soil coverage that increases water-use efficiency via reduced run-off. However, growing vetches alone puts the crop at risk of late spring drought, which usually causes lower hay yield. Vetch and cereal mixtures seem to provide a way to overcome this low hay production (Elçi et al. 1976; Kurt and Tan 1984). Since the feeding value of cereal/hay is lower than legume/hay, rates of the components need to be investigated to bring quality up to acceptable levels. Therefore, the objective of this study was to study replacement of fallow with winter forage legumes mixed with cereals in a two year cereal-fallow rotation. This new alternative should also increase hay yield as well as crude protein, without restricting subsequent cereal production.

Materials and Methods

Field trials were conducted in 1979/80 and 1980/81 after barley harvest at Lodumlu, Ankara, which has a typical continental climate. The soil is fine-textured with a high lime content. Average organic matter content is 1.3 and pH is 7.8.

Average annual precipitation in the region is 375–400 mm. Precipitation received during trial growing periods is shown in Figure 1. The total precipitation received during the first year was higher than the second year. Furthermore, most of the rain fell in April and May in 1979/80, a period when vegetative grow in normal years is prone to drought. In 1980/81, most of the precipitation fell from November to March.

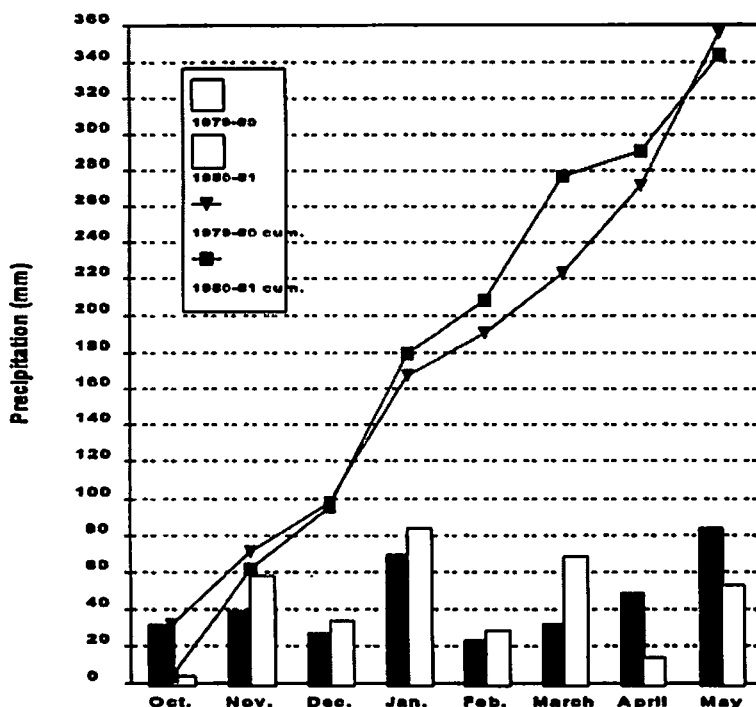


Figure 1. Monthly and cumulative precipitation received during field trials in 1979/80 and 1980/81.

After barley harvesting, seed bed preparation was done twice, using a duckfoot cultivator. Seeding took place in early October. Vetch and cereal mixtures were sown with a seeder in cross rows 35 cm apart for vetch species and 17.5 cm apart for cereals. Diammonium phosphate (18% N, 46% P) at a rate of 80 kg/ha was applied during seeding.

Treatments and seed rates used are given in Table 1. The amount of seed used was based on previous research concerning sole crop hay yields.

All of the treatments were harvested in late May, and samples were taken from each plot to measure crude protein (CP) and dry matter (DM). Treatments were laid out in a complete block design with three replications and results were analyzed for one and two years. Treatment means were grouped using LSD.

Results and Discussion

Hay Yield

Hay yields for each treatment are summarized in Table 1. The first year was better in terms of hay production than the second. This is probably because of high precipitation during the vegetative period of April and May in the first year. The amount of precipitation in that period during the second year was only half as high. This indicates that late spring rains are important, especially for dry matter

production. In other words, moisture deficit during the vegetative stage shortens the vegetative period and lowers hay production.

Mixing vetches with cereals increased hay production above vetches and cereals alone. Although N utilization was not studied, high mixture hay yields probably result from the N fixed by vetches for cereal use. Thus plots where cereals were grown alone produced lower hay yields than plots where vetch and cereal were grown as mixtures. It was also observed that post-harvest losses were lower in the plots where crops were grown in mixtures. When vetches were grown alone, lodging was the main problem, particularly with mechanized cutting. Vetches are climbers, and the cereals prevent lodging and may also enforce vegetative growth and consequently enhance DM production.

Table 1. Seed rate and average dry matter yield from different treatments.

Treatment	Seed rate (seed/m ²)	Average dry matter yield (t/ha)		
		1979/80	1980/81	Average
1. Rye/Hungarian vetch (20:80)	80+160	6.22 a	3.29 bc	4.76 a
2. Rye/Hungarian vetch (40:60)	160+120	6.41 a	3.20 bc	4.80 a
3. Rye/Hairy vetch (20:80)	80+160	5.42 ab	3.93 ab	4.68 a
4. Rye/Hairy vetch (40:60)	160+120	3.79 de	3.47 abc	3.63 abc
5. Barley/Hungarian vetch (20:80)	60+160	5.48 ab	3.15 bc	4.32 a
6. Barley/Hungarian vetch (40:60)	120+120	5.00 bc	3.95 ab	4.48 a
7. Barley/Hairy vetch (20:80)	60+160	4.82 bcd	3.55 abc	4.19 ab
8. Barley/Hairy vetch (40:60)	120+120	4.54 bcd	4.16 a	4.35 a
9. Hungarian vetch 100	200	2.65 f	1.46 d	2.06 c
10. Hairy vetch 100	200	2.73 ef	1.53 d	2.13 c
11. Rye 100	400	4.17 cd	3.34 abc	3.76 abc
12. Barley 100	300	3.82 d	2.94 c	3.38 abc
LSD (0.05)		0.107	0.087	0.292

In the dry year (1980/81) barley in the mixture (Treatment 8) produced the highest dry matter yield, whereas rye (Treatments 1 and 2) was best in the wet year (1979/80). Barley is probably able to tolerate late spring drought better than rye because of earlier completion of the vegetative stage (Table 1).

Crude Protein Content

The CP content of each treatment was determined to investigate the nutritional value of the hay (Table 2). As was expected, vetches grown alone had a higher CP content than the other treatments. Overall, the CP content of the barley mixtures were higher than the rye mixtures. Slightly higher CP measurements were found with mixtures containing Hungarian vetch.

Table 2. Crude protein content of different treatments.

Treatment	Crude protein content (%)		
	1979/80	1980/81	Average
1. Rye/Hungarian vetch (20:80)	0.078 c	0.092 de	0.085 e
2. Rye/Hungarian vetch (40:60)	0.081 a	0.100 cde	0.090 de
3. Rye/Hairy vetch (20:80)	0.098 bc	0.107 bcd	0.103 bcd
4. Rye/Hairy vetch (40:60)	0.080 c	0.102 cd	0.091 cde
5. Barley/Hungarian vetch (20:80)	0.103 b	0.114 bc	0.109 b
6. Barley/Hungarian vetch (40:60)	0.098 bc	0.111 bc	0.104 b
7. Barley/Hairy vetch (20:80)	0.086 bc	0.120 b	0.103 bc
8. Barley/Hairy vetch (40:60)	0.083 bc	0.109 bc	0.096 bcde
9. Hungarian vetch 100	0.144 a	0.153 a	0.149 a
10. Hairy vetch 100	0.135 a	0.159 a	0.147 a
11. Rye 100	0.054 d	0.061 f	0.058 g
12. Barley 100	0.056 d	0.085 e	0.070 f
LSD (0.05)	0.021	0.015	0.012

Crude Protein Yield

The amount of protein harvested per unit area is also important when considering the nutritional value of hay. Although there is no extra payment for higher protein in hay mixtures, it is important for the farmers to know about it. Crude protein yields were calculated by multiplying the values in Table 1 by Table 2, and are expressed as t/ha (Table 3). In general, higher CP was found in the barley/vetch and rye/vetch mixtures than in the sole crops. Twice as much CP was found in the barley/Hungarian vetch mixture than in the sole cereals, and 34% more than sole vetches. CP of rye mixtures was similar irrespective of mixture components and vetch species, and was about 10% less than the barley/Hungarian vetch mixtures (Table 3).

Table 3. Mean crude protein yields of different treatments.

Treatment	Crude protein yield (t/ha)		
	1979/80	1980/81	Average
1. Rye/Hungarian vetch (20:80)	0.48 abcd	0.29 de	0.39 bc
2. Rye/Hungarian vetch (40:60)	0.52 abc	0.32 cd	0.42 ab
3. Rye/Hairy vetch (20:80)	0.52 ab	0.41 ab	0.47 a
4. Rye/Hairy vetch (40:60)	0.30 ef	0.35 bcd	0.33 cd
5. Barley/Hungarian vetch (20:80)	0.58 a	0.36 bc	0.47 a
6. Barley/Hungarian vetch (40:60)	0.49 abcd	0.43 a	0.46 a
7. Barley/Hairy vetch (20:80)	0.42 bcde	0.42 a	0.42 ab
8. Barley/Hairy vetch (40:60)	0.38 cde	0.45 a	0.41 ab
9. Hungarian vetch 100	0.38 bcde	0.22 f	0.30 de
10. Hairy vetch 100	0.37 de	0.24 ef	0.31 de
11. Rye 100	0.23 f	0.20 f	0.22 f
12. Barley 100	0.21 f	0.25 ef	0.23 ef
LSD (0.05)	0.14	0.06	0.11

Conclusion

Growing vetches alone is a good alternative to the fallow year in a two year cereal-fallow rotation. However, problems such as low hay yield due to early spring drought and high post-harvest losses due to lodging still need to be solved. Growing vetches with cereals as a mixture is a promising way to address these problems. Specifically, the low seeding ratio of barley in a mixture with Hungarian vetch showed that hay as well as crude protein production can be increased over sole vetches and cereals. However, rainfall during the vegetative period determines the performance of the mixtures.

Although inserting vetch into the cereal-fallow rotational system does not reduce subsequent cereal production, the effect of various mixtures on subsequent cereal production should be approached with caution.

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Discussion

A. Osman: Are the seed rates used in your experiments comparable with those used by neighboring farmers? It seems to me that the CP percentages are too low, probably the authors have missed some decimals!

M. Munzur: Farmers prefer high seed rates because of the seed bed preparation and seeding equipment. In some locations seed mortality is high due to cold. But you are right, we have missed some decimals after pointing out the percentage.

Barley Improvement

Cloning of Barley Genomic DNA Fragments Into the Hind III Site of the Plasmid pGEM-7Zf(-)

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Abstract

A molecular biology program was established with the aim of detecting naturally occurring polymorphism at the DNA level in six barley varieties/lines grown under natural saline conditions.

A number of barley genomic DNA clones were prepared, which form the basis of this work. To achieve this, barley genomic DNA was isolated and completely digested with the Hind III restriction enzyme. The mainly single-copy barley genomic DNA fragments were inserted into the bacterial plasmid pGEM-7Zf(-) prepared and cleaved with the same enzyme. The work also included the reintroduction of recombinant plasmid molecules into bacterial host *Escherichia coli* strain XL1-blue, via a transformation system. An average efficiency of about 10^6 CFU for normal plasmid and 10^3 CFU for recombinant plasmid was obtained. Recombinant colonies were easily identified by means of two selectable markers (ampicillin resistance and colony color) encoded by the plasmid vector.

Introduction

Naturally occurring variations in salinity tolerance have been observed in many plant genotypes, including barley (Aspinall et al. 1981). The molecular basis for this is not well understood. Thus, any molecular investigations related to differences in salinity tolerance in barley are useful. For instance, Ramagopal (1987) reports that salinity stress induces specific protein changes in both roots and shoots of one barley genotype, California Mariout (CM 72), as a salt-tolerant and salt-sensitive barley genotype ratio.

Differences at the DNA level, called restriction fragment length polymorphisms (RFLPs), have been demonstrated in a large number of plants since first described by Botstein et al. (1980). In barley, RFLPs have been used by different authors (Graner et al. 1991) for construction of linkage maps. The unavailability of such linkage maps and markers in our laboratories encouraged us to start this project.

A number of probes (normally radioactively labelled DNA fragments) are required (Wu et al. 1983) for this experiment.. These probes are able to detect differences between individuals in the length of a particular restriction fragment.

The first aim of this investigation was to prepare single-copy barley DNA fragments by restricting barley genomic DNA to completion with the Hind III hexa-nucleotide restriction enzyme (Gill et al. 1991). These fragments were inserted into the plasmid vector pGEM-7Zf(-) cleaved with the same restriction enzyme via a ligation experiment using a T4 DNA ligase enzyme (Fig. 1). The recombinant plasmids were introduced into the bacterial host cell, *E. coli* strain XLI-blue, via a bacterial transformation system, using a heat shock method (Cohen et al. 1972; Hanahan 1983). The recombinant colonies were selected by planting transformants onto LB agar containing ampicillin, X-gal and IPTG substrates.

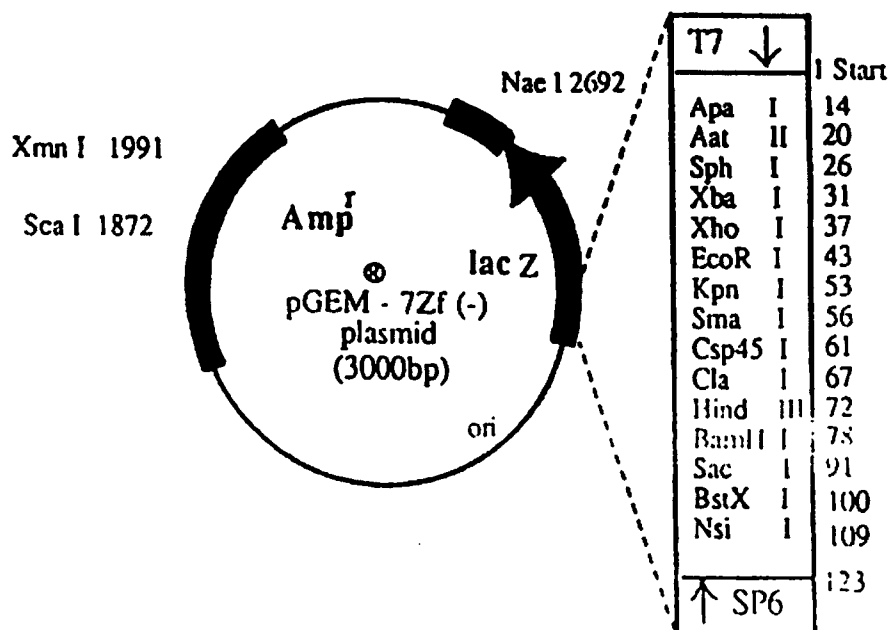


Figure 1. Restriction map of the plasmid pGEM-7Zf(-) cloning vector, showing the polylinker sequence within the lac Z gene, ampicillin resistance gene. From Promega catalogue (1987/88).

Materials and Methods

Leaves of six different barley varieties (California Mariout, Numar, IPA-2, IPA-7, IPA-99, and IPA-265) were collected at the IPA experimental station at Fudheilia.

DNA Isolation and Restriction Enzyme Analysis

Total genomic DNA was isolated from barley samples separately, following the protocol described in the CIMMYT Applied Molecular Genetics Laboratory Manual (Hosington 1992). Fresh leaves (4–5 g) were ground in liquid nitrogen. Then DNA was extracted using CTAB extraction buffer. The DNA preparations were further purified by phenol/chloroform after RNase treatment. Following Sambrook et al. (1989), DNA was precipitated with two volumes of cold 96% ethanol in the

presence of 0.3 M sodium acetate. The DNA samples were quantified and qualified spectrophotometrically at 260 nm and 280 nm wavelengths, then checked on 1% agarose gel under ultraviolet light after electrophoresis in 1x TBE buffer at 3-5V/cm, and stained with ethidium bromide.

Plasmid DNA was isolated from a 25 ml culture of *E. coli* strain XL1-blue grown overnight using the mini-preparation (STET) method according to Sambrook et al. (1989). A 20 µg sample of California Mariout DNA and vector DNA were separately digested to completion with Hind III restriction enzyme according to the supplier's recommendations, followed by agarose gel electrophoresis analysis.

Preparation of Barley Clones

A sample of California Mariout DNA digested with Hind III enzyme was ligated to the plasmid pGEM-7Zf(-) cloning vector, cleaved with the same enzyme and treated with calf intestine alkaline phosphatase CIP (Boehringer; Mannheim). The ligation ratio (4 inserts:1 vector), the enzyme T4 DNA ligase, and reaction setup were carried out according to Maniatis et al. (1982). Competent cells of *E. coli* strain XL1-blue were prepared according to Cohen et al. (1972) and Hanahan (1983), with minor modifications. Twenty five ml of exponentially-grown bacterial cells were pelleted and re-suspended in 10 ml of cold TF1 solution (10 mM CaCl₂ and 10 mM Mops pH 6.8). Bacterial cells were then repelleted and resuspended in 1 ml of TF2 solution (75 mM CaCl₂ and 10 mM Mops pH 6.0). To enhance transformation efficiency, the cells were kept for 24 hours at 4° C (Dagert and Ebrlich 1979). Each 100 µl of competent cell was mixed with 10 µl (120 ng) of recombinant plasmid molecules and 90 µl of TF3 (75 mM CaCl₂, 50 mM Mops pH 7.5, 1 mM EDTA, 100 mM KCl, 5% glycerol). After incubation of this mixture on ice for 45 minutes, it was heat-shock treated at exactly 42° C for five minutes. One ml of LB media was added to each tube and then incubated at 37° C for one hour to allow for expression of encoded, resistance ampicillin. One hundred µl of each sample was plated on LA agar containing ampicillin, X-gal and IPTG (Sambrook et al. 1989). Three control experiments were set up, the first containing normal pGEM-7Zf(-) plasmid. The second was the religated plasmid after digestion and CIP treatment, and the third control experiment was a sample of competent cells.

Results and Discussion

Results were positive. An average yield of 200–350 µg DNA was isolated from fresh barley leaves with a purity of 1.8–1.9, according to the 260/280 nm wavelengths. Results of digestion experiments of both barley genomic DNA and the plasmid DNA are shown in Figure 2 (lane b), which represents a mixture of both DNA. The long smear shows that the barley DNA was successfully digested, whereas the single band (3kb) shows that the multiple circular plasmid bands (lane a) were linearized due to cleavage by the Hind III restriction enzyme.

The results of the ligation experiment are shown in Figure 2 (lane c), which again shows reasonable efficiency. This is indicated by the intensity disappearance of both vector band and barley DNA smear and the faint bands.

These results are somewhat similar to those obtained by Rodriguez and Tait (1983)

in their ligation experiment between the plasmid pBR 329 and *E. coli* bacterial chromosome cleaved by PstI restriction enzyme. However, since ligation between two DNA sources is generally inefficient (Dahl et al. 1981), this may explain why a faint residual of the plasmid band may still be seen in Figure 2 (lane c).

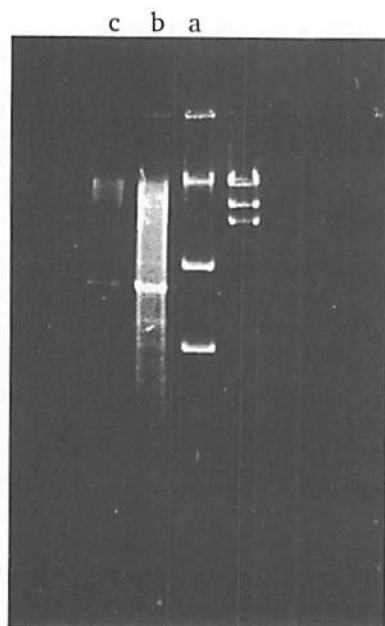


Figure 2. Agarose gel electrophoresis of DNA samples using 1x TBE running buffer and run at 3–5vcm. a = represents the undigested plasmid DNA bands. b = a mixture of digested barley and plasmid DNA with Hind III restriction enzyme (without ligase enzyme); c = one result of ligation experiments between barley and plasmid DNA.

The average efficiency of the transformation was calculated according to Mohan (1991) and was found to be in the range of 6×10^3 CFU/per μg of recombinant plasmid DNA and 10^6 CFU for normal plasmid. These transformation efficiencies agree with the expected average suggested by Dahl et al. (1981) for the well-known plasmid pBR322. Although the former transformation efficiency is lower than in the first control experiment, this is to be expected due to a number of factors reported by Dahl et al. (1981). These factors include the inefficient ligation between vector and target DNA (barley), which resulted in less efficient transformation. Another factor is the size of the vector molecules containing an insert (DNA fragment) larger than its normal size and therefore with lower transformation efficiency. Nevertheless, the numbers obtained were sufficient for the purpose of the following investigations.

The recombinant colonies were distinguished according to their color by plating a sample of transformants on to X-gal ampicillin agar (Fig. 3). The colony color is attributed to the fact that the plasmid pGEM-7Zf(-) carries a copy of the lac Z gene. Normal colonies thus appeared blue (the first control experiment), whereas recombinants formed clear colonies due to inactivation of the lac Z gene by insertion of barley DNA fragments.

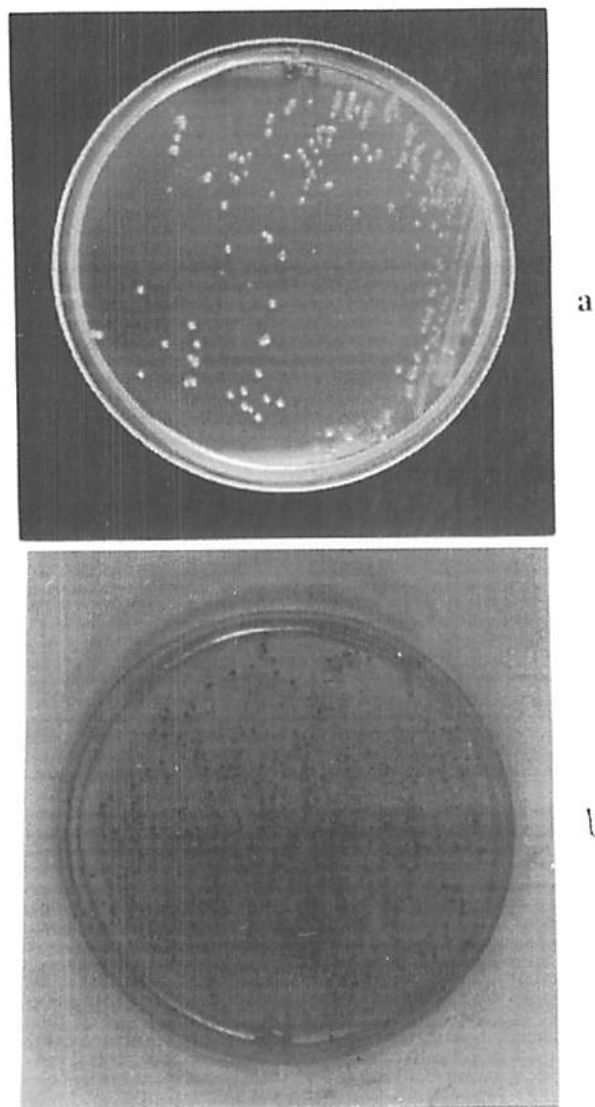


Figure 3. One result of the bacteria transformation experiments plated on LB agar containing ampicillin, X-gal and IPTG. a = recombinant colonies with clear appearance; b = the transformation experiment using normal plasmid (first control) sowing blue colonies.

The results of the second control experiment, which formed the plasmid pGEM-7Zf(-) digested with Hind III and alkaline phosphatase, did not (as expected) form any colonies. This may have be due to the efficient removal of the five phosphate groups which impeded the recerculization (Chanchos 1971) of plasmid DNA and may not, therefore, be functional. This may explain why no blue colonies appeared within recombinant colonies (clear).

The third control experiment, which represented competent cells only, did not form any colony on ampicillin X-gal plates, as was expected. To this end, a sufficient number of barley clones have successfully been prepared for use in further experiments involving the detection of DNA polymorphism between barley varieties.

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Discussion

B.A. Al-Rawi: Would you go a step further to select the *E. coli* that carry the different plasmid to screen them for salt tolerance, for instance, if your aim is to breed salt-tolerant varieties?

J. Jubrael: The *E. Coli* bacteria used in these investigations are genetically engineered as host cells and are not salt-tolerant.

B. de Hoop: Why don't you use randomly amplified polymorphic DNA instead of RFLP? This avoids the use of a probe.

J. Jubrael: Unfortunately we have neither a thermo-cycler nor the required chemicals (primers, DNA polymerase enzymes, etc.). Also, the RAPD markers may be difficult to use with cereals.

Bram de Hoop: Using molecular biology is it possible to: (i) cross barriers between species using gene transfer; and (ii) support conventional breeding of crops using genetic markers for diagnostic purposes?

J. Jubrael: Yes, this is what is known about such techniques, and was touched on briefly in my previous answer.

M. El-Shazly: Do you think we really need to spend a lot of money working in this high technology field, instead of concentrating on the classical methods?

J. Jubrael: Both types of work should go hand in hand, and the new technique can be used side by side with the classical methods.

Classical breeding has been and still is successful. However, these methodologies need time, labor, and large areas for cultivation. Molecular marker technology will be very helpful in assisting selection, thus reducing the time and labor involved. Plus the fact that introducing such techniques in our countries is necessary to familiarize us with new and sophisticated techniques applied in the developed countries. Moreover, these techniques have many advantages over classical breeding methods, such as the possibility of overcoming the genetic barriers between species, the introduction of individual genes, etc. But this is to say that molecular biology techniques would replace classical breeding methodology.

Screening Barley (*Hordeum vulgare* L.) Genotypes for Salinity Tolerance under Naturally Salinized Field Conditions

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Abstract

An experiment was conducted at Fudheilia (30 km southeast of Baghdad) and Dalmaj, Wasit Province (180 km south of Baghdad) over two growing seasons (1984/85 and 1985/86). The aim of the experiment was to devise a screening methodology to test barley genotypes for salinity tolerance in naturally salinized fields. The screening test was based on planting frequent checks alternated with the cultivar under study. Six barley cultivars—CM-67, Numar, Prior, Clipper, Weeah, and Arivat—were used, and a check cultivar, California Mariout. Plot size was 3.2×4 meters. The seeding rate was 100 kg/ha in rows spaced 20 cm apart. Fertilizer (NPK 18:18:18) was applied at a rate of 100 kg/ha. The setup of the experiment was a randomized complete block design with three replications.

Results show non-significant differences between the check cultivar and cvs CM-67 and Numar in terms of grain yield and other characteristics at both locations in both seasons. On the other hand, differences between the check cultivar and the rest of the cultivars were significant with respect to all studied characteristics in most environments. The reduction in yield under saline environment appears to be due mainly to the decreased number of kernels per head. Relationships among the various characteristics and their consistency under salinity are discussed.

Introduction

Although barley (*Hordeum vulgare* L.) shows considerable tolerance to salinity when compared with other cereal crops, efforts have been underway to develop new lines with improved yield and quality under saline conditions. Variability of tolerance to salinity among barley lines is widely reported and therefore provides a prerequisite element for initiating a proper breeding program to develop highly salt-tolerant lines of barley. In general, the detection of variability for physiological traits requires accuracy in both the selection and the utilization of the test scheme. The identification of a cultivar or genotype with a potential to tolerate a given stress requires that all lines be subjected equally to the stress, otherwise breeding efforts may prove unsuccessful.

Workers in this field often rely on testing genotypes under controlled environments using, in particular, salinized nutrient solutions. These have proved to be more

reliable than other types of media (Al-Shamma and Sabir 1986). However, the response of a given cultivar or genotype to salinity may vary from one environment to another. This may be due to the fact that plant salt tolerance is largely affected by the environment. Environmental factors such as temperature (Francois and Goodin 1972), relative humidity (Hoffman and Jobes 1978), soil fertility (Bernstein et al. 1974), soil moisture (Wagnet et al. 1980), oxygen level around the plant (Aubertin et al. 1968), and light (Nieman and Poulsen 1971) have all been reported to alter plant response to salinity. Therefore it would seem logical to have genotypes tested on naturally salinized fields to ensure that all plants are subjected to salinity under variable and changing environmental conditions. After all, the final destination of any recommended cultivar is the farmer's field.

There is, however, one major obstacle to accurate identification of truly tolerant cultivars or genotypes, and that is the lack of uniform distribution of salt ions in the soil. In fact, this has been the breeders' excuse for using screening techniques which provide fairly uniform ion distribution in the media such as those which rely on salinized nutrient solution.

This work proposes a screening methodology for the identification of salt tolerant genotypes in naturally salinized fields. It also discusses the inter-relationships among yield components under these conditions.

Materials and Methods

The experiment was conducted at two locations in Iraq's central irrigated zone over two consecutive seasons (1984/85 and 1985/86). The two locations were Fudheila Experimental Station (30 km southeast of Baghdad) and Dalmaj Experiment Station (180 km south of Baghdad). At both locations, experiment sites were selected in fields with soil electrical conductivity ranging from 15 to 25 Ds/m. The test scheme is based on planting frequent check rows alternated with the cultivar under study. This provides an opportunity for taking more readings in a single plot. The idea is to minimize the experimental error which may arise from the lack of uniformity of salt concentration in the soil. Seven spring barley cultivars were used in this study—California Mariout (CI 1455), CM-67 (CI 13782), Numar (CI 13683), Arivat (CI 6573), Clipper (WI 2095/10), Prior, and Weeah.

The first four cultivars originate in the United States, while the rest come from Australia. California Mariout was used as a rotating check, since it is known to be tolerant to salinity throughout its life cycle. Two rows of each cultivar alternating with two rows of the check cultivar were planted. A total of eight rows of each cultivar and its check were planted in 3.2×4 meters plots. Seeding rate was 100 kg/ha and rows were spaced 20 cm apart. A chemical NPK fertilizer (18:18:18) was applied at a rate of 100 kg/ha. The setup of the experiment was a randomized complete block design with three replications.

Experimental fields received 420 mm of irrigation water in each of the two growing seasons, which lasted from 1 November to 15 April. At harvest, one meter long samples were taken from each cultivar and from its adjacent check at two sites within the plot. Readings were recorded for grain yield, biological yield, number of heads/one meter length, number of kernels/head, and 1,000 kernel weight. Data on every cultivar were individually and statistically analyzed as unpaired

observations with the data of the check cultivar following the procedure devised by Steel and Torrie (1960). Coefficients of correlation among the various characteristics were calculated using different data sets (whole data set, location data set, data on cultivars, and data on check cultivar).

Results

The performance of the six cultivars varied when compared with their corresponding check cultivar California across the four environments (location and season). Tables 1 and 2 show that cvs CM-67 and Numar performed as well as the check cultivar in terms of all studied characteristics in the four environments. Arivat, a widely grown cultivar in Iraq, showed a sensitive reaction in contrast with the check in all environments except in Dalmaj in 1984/85, when no difference in grain yield was found between the cultivar and the check. The rest of the cultivars—Clipper, Prior, and Weeah—showed sensitive reactions to natural salinization when compared with their corresponding checks in terms of most of the studied characteristics ($P < 0.05$ or $P < 0.01$). In general, the reduction in yield among these cultivars appears to be due mainly to a decrease in the number of kernels per head. Differences between most of the cultivars and their checks were significant ($P < 0.05$ or $P < 0.01$) in the four environments. The other two yield components, number of heads per meter and 1,000 kernel weight, showed better stability with few exceptions, especially in the sensitive cultivars.

In this study, coefficients of correlation among the various characteristics were calculated to show whether relationships differ under changing environmental conditions (Table 3).

Eleven groups of data were analyzed, with degrees of freedom ranging from $n-2 = 70$ to $n-2 = 286$. The interrelationships among yield components represent the final products of all biological processes under such conditions. Harvest index is also considered, since it reflects the ability to transport and accumulate photoassimilates in the grains.

We assumed that the correlation coefficients calculated from data Group 1 were more realistic than those calculated from other data groups, since Group 1 has the highest degree of freedom ($n-2 = 286$). It was accordingly used as the base for comparison. Table 1 shows that the harvest index is positively correlated with all other characteristics ($P < 0.01$). When data Group 1 is considered, however, and when other data groups are taken into account, the picture changes, especially with the 1,000 kernel weight, since only five out of 10 data groups show significant correlation ($P < 0.05$ and $P < 0.01$). Correlation coefficients between number of heads/m and grain yield are highly and positively significant in all data groups ($P < 0.01$). However, no significant correlation is found between number of heads/m and 1,000 kernel weight and number of kernels/head in most of the data groups, including those calculated from data Group 1.

Table 1. Performance of six barley cultivars and corresponding check cultivar California Mariout, grown on naturally salinized fields in Dalmaj in 1984/85 and 1985/86.

Cultivar /check	1984/85						1985/86					
	HI	BY(gm)	GY(gm)	Hds/m	Knls/hd	1000kwt (gm)	HI	BY(gm)	GY(gm)	Hds/m	Knls/hd	1000 kwt(gm)
CM-67	0.40	210.0	84.65	82.0	40.33	39.80	0.35	150.17	52.48	50.17	41.10	36.16
CM	0.39	165.17	63.83	72.33	37.50	40.80	0.37	142.0	52.47	48.67	44.85	36.64
Numar	0.34	216.0	73.40	96.5	39.49	37.00	0.38	172.17	66.12	58.67	44.83	37.10
CM	0.40	191.83	77.93	85.17	41.07	40.33	0.38	196.5	74.89	57.50	42.03	37.44
Arivat	0.44	245.17	107.82	115.83	37.83	38.60	0.33	141.83	46.86	48.17	47.17	35.78
						**		**	**			
CM	0.40	262.83	104.32	119.67	36.32	43.47	0.37	206.67	76.05	64.15	50.55	36.50
ClipperC	0.14	251.67	40.82	104.75	34.80	40.45	0.17	144.83	24.32	52.33	20.28	35.52
	**		**				**	**	**			
M	0.43	236.0	102.22	108.50	37.70	38.13	0.37	208.0	76.63	67.0	44.20	37.54
Prior	0.24	171.67	40.47	82.50	22.03	36.13	0.16	99.67	16.33	36.40	21.93	34.03
	**	**	**		**	**	**	*	**		**	
CM	0.39	227.67	88.27	95.17	40.80	44.53	0.31	166.83	51.71	54.33	46.02	35.65
Weeah	0.33	206.33	68.10	96.33	18.67	41.33	0.25	121.17	29.97	36.83	42.39	36.59
	**				**		**	*	*	*		
CM	0.45	147.83	67.00	68.17	36.10	44.07	0.37	183.10	68.44	58.83	42.88	37.57

HI = harvest index; BY = biological yield; GY = grain yield; Hds/m = number of heads per meter long; Knls/hd = number of kernels per head, 1000 kwt. = 1000 kernel weight.

* P < 0.05

** P < 0.01

Table 2. Performance of six barley cultivars and corresponding check cultivar, California Mariout, grown on naturally salinized fields in Fudheilia in 1984/85 and 1985/86.

Cultivar /check	1984/85						1985/86					
	HI	BY (g)	GY (g)	Hds/ m	Knls/h d	1000 kwt (g)	HI	BY (g)	GY (g)	Hds/m	Knls/hd	1000 kwt (g)
CM-67	0.33	222.7	73.52	62.60	43.83	40.60	0.23	17.017	39.50	42.33	37.34	40.87
CM	0.36	216.17	77.53	63.00	43.20	41.97	0.20	155.17	30.74	32.80	39.00	39.59
Numar	0.34	209.0	70.60	60.25	42.23	37.78	0.28	149.5	41.14	48.00	40.77	37.5
CM	0.30	201.83	60.72	47.50	41.68	42.80	0.30	180.0	54.86	55.83	43.85	39.59
Arivat	0.21	135.33	28.92	27.67	38.30	37.80	0.22	143.17	31.40	42.83	39.85	35.44
	**	**	**	**	*			**	*			**
CM	0.38	208.67	79.60	62.58	44.13	39.80	0.31	203.83	62.50	57.80	41.90	38.81
Clipper	0.22	118.17	26.10	32.00	33.53	36.80	0.16	116.5	18.32	46.17	16.83	33.58
	**	**	**	**	*		**	**	*		**	**
CM	0.37	257.5	96.15	75.33	48.07	38.13	0.28	204.67	56.71	56.17	43.10	39.41
Prior	0.20	165.0	33.60	55.00	20.83	38.67	0.21	114.67	24.52	49.33	19.72	34.33
	**	**	**		**			**	*		**	
CM	0.39	242.67	94.48	69.17	44.33	38.43	0.25	220.17	54.78	52.17	42.50	38.89
Weeah	0.25	141.5	35.10	48.00	22.02	38.60	0.24	182.67	43.26	46.00	46.70	33.95
	**		*		**			**				
CM	0.39	182.67	70.62	58.00	38.73	39.73	0.27	280.58	75.4	65.00	48.85	38.58

HI = harvest index; BY = biological yield; GY = grain yield; Hds/m = number of heads per meter long; Knls/hd = number of kernels per head, 1000 kwt. = 1000 kernel weight.

* P < 0.05

** P < 0.01

Table 3. Coefficients of correlation among certain characteristics in 11 groups of data on barley extracted from four different environments.

Characteristic	Group	Harvest Index	Heads/m	Kernels/head	1000 kwt
Heads/m	1	0.40**			
	2	0.39**			
	3	0.39**			
	4	0.63**			
	5	0.21**			
	6	0.26*			
	7	0.53**			
	8	-0.05			
	9	0.38**			
	10	0.55**			
	11	0.72**			
Kernels/head	1	0.41**	0.0		
	2	0.41**	-0.6		
	3	0.05	-0.7		
	4	0.47	0.27**		
	5	0.41**	-0.14		
	6	0.34**	-0.06		
	7	0.60**	0.27**		
	8	0.29*	-0.08		
	9	0.69**	0.22		
	10	0.49**	0.26*		
	11	0.51**	0.29*		
1000 kwt	1	0.26**	0.10	0.10	
	2	0.21**	0.04	0.07	
	3	0.09	0.09	-0.29**	
	4	0.16	0.07	0.26*	
	5	0.38**	0.13	-0.05	
	6	0.24*	-0.10	0.11	
	7	0.18	0.06	0.23*	
	8	0.32*	-0.31*	-0.02	
	9	0.34*	0.21	0.28*	
	10	0.12	0.09	0.30*	
	11	0.03	-0.03	0.24*	

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Characteristic	Group	Harvest Index	Heads/m	Kernels/head	1000 kwt
Grain yield	1	0.75**	0.75**	0.40**	0.25**
	2	0.78**	0.72**0.0	0.63**	0.20*
	3	0.61**	83**	0.14	0.09
	4	0.83**	0.80**	0.60**	0.28**
	5	0.66**	0.75**	0.24**	0.25**
	6	0.69**	0.72**	0.36**	0.10
	7	0.78**	0.75**	0.63**	0.21*
	8	0.54**	0.74**	0.21	-0.02
	9	0.77**	0.68**	0.59**	0.34**
	10	0.83**	0.79**	0.62**	0.23
	11	0.79**	0.83**	0.67*8	0.19

Group 1: Overall data n-2 = 286.

Group 2: cultivars only n-2 = 14.2.

Group 3: checks only n-2 = 142

Group 4: Dalmaj location n-2 = 142.

Group 5: Fudheilila location n-2 = 142.

Group 6: 1985 data n-2 = 142.

Group 7: 1986 data n-2 = 142.

Group 8: Dalmaj 1985 n-2 = 70

Group 9: Dalmaj 1986 n-2 = 70.

Group 10: Fudheilila 1985 n-2 = 70.

Group 11: Fudheilila 1986 n-2 = 70.

* P < 0.05; ** P < 0.01.

The number of kernels/head is positively correlated with grain yield ($P < 0.01$) in all data groups except Groups 3 and 8. Significant correlation between number of kernels per head and 1,000 kernel weight was not detected in Groups 1, 2, 5, and 6. However, they are positive and significant in the rest of the data groups ($P < 0.05$ and $P < 0.01$), except in Group 3 (checks), which is significantly negative ($P < 0.01$). Finally, 1,000 kernel weight and grain yield are positively correlated ($P < 0.05$ and $P < 0.01$) in data groups 1, 2, 4, 5, 7, and 9, while no correlation was detected in the data of other groups. To indicate whether correlation coefficients computed from data from Groups 2-11 are different from those computed from Group 1 (overall correlation), a test of homogeneity of correlation coefficients was conducted. The results are shown in Table 4. Significance in the differences between correlation coefficients varies with data groups. None of the correlation coefficients estimated from Groups 2 and 6 differ from those of Group 1. Data Group 3, which represents those of the check cultivar (n-2 = 142) shows the least consistency with those of Group 1, since only three out of 10 correlation coefficients do not differ from those of Group 1.

The three relationships involved are harvest index with number of heads per meter, number of heads per meter with number of kernels per head, and number of heads per meter with 1,000 kernel weight. The consistency of relationships in other data groups with data Group 1 is variable, and no systematic pattern can be detected as regards data source.

Table 4. Statistical differences between correlation coefficients of certain characteristics estimated from different data groups (overall correlation, Group 1 vs. Groups 2-11).

Correlated characteristics [†]	Levels of significance between data groups [‡]									
	1-2	1-3	1-4	1-5	1-6	1-7	1-8	1-9	1-10	1-11
HI										
Hds.m ⁻¹	ns	ns	**	*	ns	ns	**	ns	ns	**
Knls/hd	ns	**	ns	ns	ns	**	ns	**	ns	ns
Kwt.	ns	*	ns	ns	ns	*	ns	ns	ns	*
GY	ns	**	*	*	ns	ns	**	ns	ns	ns
HDS.M ⁻¹										
KnLs/d	ns	ns	**	ns	ns	**	ns	ns	*	*
Kwt.	ns	ns	ns	ns	ns	ns	*	ns	ns	ns
GY	ns	*	ns	ns	ns	ns	ns	ns	ns	ns
KnLs/hd										
Kwt.	ns	*	*	ns	ns	ns	ns	ns	ns	ns
GY	ns	**	**	*	ns	**	ns	*	*	**
Kwt.										
GY	ns	*	ns	ns	ns	ns	*	ns	ns	ns

[†] HI = harvest index, Hds.m⁻¹ = number of heads per meter long, knls/hd = number of kernels per head, kwt = 1000 kernel weight, gy = grain yield.

[‡] For data groups, see footnotes of Table 3.

* P < 0.05

** P < 0.01

ns = non-significant.

Discussion

A salt-tolerant line must maintain a stable performance across and within environments. The screening method discussed here provides information on the ability of a given cultivar to withstand and perform under variable and changing environmental conditions in salinized fields. The check cultivar California Mariout is registered in the United States as an introduction from Egypt, and has been widely used by researchers as a check, since it is well known for its superior tolerance to salinity among other barley genotypes.

The fact that the two cultivars CM-67 and Numar performed as well as California Mariout in this study was not surprising, since both cultivars were bred from crosses involving California Mariout (Arias et al. 1983). In addition, Numar, a cultivar released in Iraq in the early 1970s, is well known among farmers for its considerable tolerance to salinity. This has been confirmed experimentally elsewhere (Al-Shamma and Sabir 1986). Arivat, another released cultivar, responded sensitively to salinity in this study, although an earlier report (Al-Shamma and Sabir 1986) indicated that it had a moderate response compared with cv Numar when grown in salinized nutrient solution in a controlled environment. This discrepancy may explain the belief that reaction of plants to salinity, per se (where all other factors are fixed) differs from their reaction to salinity when grown under variable and changing environmental conditions, i.e. in a naturally salinized field.

In general, the reduction in grain yield among the sensitive cultivars (Arivat, Clipper, Prior, and Weeah) appears to be due mainly to a reduction in the number of kernels per head. Previous study found that salt stress caused a decrease in the duration of the reproductive phase of apex development and a decrease in the number of spikelet primordia on the main spike of durum and bread wheat (Mass and Greive 1990). This may contribute to the development of shorter spikes with fewer spikelets (Grieve et al. 1992) and eventually result in fewer kernels. The other two yield components, number of heads per unit area and 1,000 kernel weight, seem to be more stable. Such findings suggest that the number of kernels per head could be considered an indicator of saline sensitivity.

Stoy (1975) states that in barley, as in other cereal crops, the flow of assimilates to the grain may be subject to limitations in the source, the sink, or the assimilate transport system, depending on the particular combination of genotype and environment. He provides evidence that modern varieties of barley represent types which Evans (1975) considers as "likely to have their photosynthetic capacity and their storage capacity fairly closely balanced in the environments to which they are adapted." In saline environments, however, source limitation seems to be absent, especially in the sensitive cultivars, as indicated by the lower harvest index values. Similar results were demonstrated by Stoy (1975) for primitive types of barley and for modern barley cultivars grown under sub-optimal incident radiation.

The flow of assimilates from the source to the sink (the grain in this case) seems to be the limiting factor in maintaining high grain yield under salinity. Soil salinity is known to exert osmotic effects on plants. For a plant to grow under such conditions, it must make certain adjustments to maintain a proper potential gradient with the external solution. In glycophytes (among which are cereals), the major osmotic components are potassium salts of organic acids and sugars (Hellebust 1976). However, these groups of plants, unlike halophytes, cannot tolerate and accumulate high levels of salts in their cells as a major part of the osmotic adjustment (Greenway 1973). At moderate salinity levels, tolerant barley cultivars (e.g., California Mariout) are better able to exclude sodium as well as chloride ions from the shoot than are sensitive cultivars (Storey and Wyn Jones 1978). The system is probably more complex than one can imagine. Plants grown under salt stress are expected to expend much energy to compensate for the accumulation of salts and the maintenance of higher osmotic pressures (Nieman 1962). Under these circumstances all metabolic processes must proceed with, most likely, lower efficiency, leading to decreased grain yield.

Yield component compensation occurs in plants, which leads to negative correlation. Adams (1967) considers this negative correlation to arise primarily from developmentally-induced relationships, i.e. developing structures of a plant body competing for a common, possibly limited nutrient supply. He concludes that plant yield systems show what he calls "developmental flexibility" in the sense that components develop sequentially with an overlapping pattern. The first component to develop (number of tillers in cereals) draws upon the resources it needs, but by the time the next component (number of kernels per head) begins to develop, the resources may not be available for optimum development.

But do these interrelationships hold true under salinity? There are only two cases where component compensation is cited in this work. One is between the number

of kernels per head and the 1,000 kernel weight in Group 3 (representing data on the check cultivar, $n-2 = 142$) and the other is between the number of heads per meter and the 1,000 kernel weight in data Group 8 (data from Dalmaj location 1985, $n-2 = 70$).

In general, two types of response seem to dominate: (i) where components behave independently (zero or no significant correlation), as in the case of the number of heads per meter and the 1,000 kernel weight; and (ii) where there is a tendency for positive correlation, as with the number of kernels per head and the 1,000 kernel weight. Interestingly, we found similar results in another work (Table 5). Even in a non-saline environment, compensation among components was not evident, rather, behavior was independent, except for the number of kernels per head and the 1,000 kernel weight, where correlation was high and positive ($P < 0.01$). Lack of correlation among the three components in a non-saline environment has also been reported (Al-Shamma et al. 1989). In the Mediterranean, the growing season of cereal crops is rather long, especially in the irrigated areas and rainfall areas with supplemental irrigation where planting begins in early November and the crop matures in mid to late April. Development of the apical meristem proceeds at a slower rate and may require at least 100 days before anthesis takes place for spring cultivars. This suggests that each of the yield components has enough time to develop at a pace that does not create competition high enough to cause compensation among them. As to why compensation among yield components was absent in saline environments, the information obtained from this work cannot provide answers and further work should be carried out to clarify this matter.

Table 5. Coefficients of correlation among yield components in barley under saline and non-saline conditions.

Type of field	1,000 Kernel wt.	Kernels/head
Non-saline heads/m	0.05	0.02
Kernels/head	0.63*	
Saline heads/m	0.34	0.41*
Kernels/head	0.44*	

* $P < 0.05$.

Unpublished data of Al-Shamma and Al-Rawi, 1989.

Finally, consistency of relationships among the various characteristics under salinity may vary with data group (location, year, cultivar, check). From Table 4 one can classify these relationships according to their stability as follows:

- **Highly stable.** These include relationships between number of heads per meter and 1,000 kernel weight and grain yield, between number of kernels per head and 1,000 kernel weight, and between 1,000 kernel weight and grain yield.
- **Moderately stable** This includes the relationship between harvest index and grain yield and its components, in addition to number of heads per meter and number of kernels per head.
- **Unstable.** This involves the relationship between number of kernels per head and grain yield, where only two data Groups (6 and 8) were consistent with data Group 1.

Such results may help plant breeders to come up with improvement strategies for the development of salt-tolerant barley lines. Breeders consider those components which have a highly stable and positive relationship with grain yield, such as number of heads per unit area and 1,000 kernel weight, as dependable criteria for selection in a saline environment. Number of kernels per head seems to have a weak relationship with grain yield under such conditions and breeders may choose not to utilize this yield component as a selection criterion.

Conclusions

Screening genotypes for salinity tolerance must be carried out in naturally salinized fields (in at least two locations and probably over two seasons). Under such conditions, genotypes are exposed to salinity effects as well as the interactive effects between salinity and other variable and changing environmental factors. Only those genotypes which make it through these conditions are truly salt tolerant. This screening methodology can also be used for selection using segregating populations.

In general, reduction in grain yield in a saline environment appears to be due to a decrease in the number of kernels per head.

Yield component compensation under salinity is not evident. There are two types of relationship: (i) zero correlation, where components behave independently, as with number of heads per meter and 1,000 kernel weight; and (ii) a tendency for positive correlation, such as number of kernels per head and 1,000 kernel weight.

Consistency of relationships among the studied characteristics varies across location, year, cultivar, check, etc. Among the highly stable relationships is that between number of heads per meter and 1,000 kernel weight and grain yield. A fragile relationship exists between grain yield and number of kernels per head.

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Discussion

Y. Sweidan: Did you measure the degree of salinity before planting? How high was the salinity and did you measure it during the growing season? Was there any change in the degree of salinity throughout the growth season?

A. Al-Shamma: Yes, it ranged from 15 to 20 Ds/m. Throughout the season salinity fluctuates. It goes down after irrigation, and as the soil dries out it goes up. By the end of the season it maintains a similar range.

N. Hrimat: What was the design of the experiment and the type of analysis?

A. Al-Shamma: The layout was according to randomized complete block design

N. Hrimat: Was the reduction, due to salinity, in number of kernels per head a result of the existence of unfertilized florits or abnormal kernels?

A. Al-Shamma: The decreased number of kernels was due to less developed spikes, and sterility was due to salinity effects.

M. Tahir: What should the level of salinity be so that major salinity areas are covered? What should the composition of saline soil be?

A. Al-Shamma: The salinity barley can tolerate is 15-25 Ds/m. Saline soils in Iraq contain sodium, calcium, potassium, chlorides, carbonates, and bicarbonates. The composition of saline soil (although important) may not be critical. The main factor is to achieve osmotic levels at which cultivars can be differentiated for tolerance. We do not want levels where toxic effects predominate.

Breeding Barley for Hay

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Abstract

Hay is becoming increasingly important as intensive management of ruminants and improved breeds are introduced into dryland farming systems. Improved barley varieties for hay production are a major objective in increasing hay yield in the low rainfall areas of WANA.

An improved hay variety must have high palatability, high digestibility, and high crude protein content, but also high grain yield to secure low seed cost. Thus, in breeding for hay, all selection criteria used in breeding for grain, plus additional criteria for hay, must be employed.

Only limited work on breeding for hay has been done world-wide, especially in the WANA region. Special hay varieties, including hooded types, are grown in certain countries, including Cyprus. This paper outlines a breeding procedure for breeding hay barley, starting from evaluation of local germplasm, introduction of improved material, and hybridization. Special emphasis is given to the genetics of the hooded gene, a trait which increases hay palatability. Hay made of smooth-awned barley is more palatable than that of rough-awned barley. A simple technique is suggested to distinguish lines giving high hay and grain yield from those giving only high hay or grain yield. The paper then goes on to summarize the results of the long-term breeding effort in Cyprus. The authors emphasize that it is possible, though difficult, to breed for hay barley in the driest areas of WANA and the Mediterranean countries.

Introduction

Scientists are paying increasing attention to barley breeding. The objectives vary according to ultimate use. Barley is one of the few crops which satisfies a variety of needs and is adaptable to a wide range of environmental conditions. It is grown in the dry and hot climates of West Asia and North Africa (WANA) for its grain (used as livestock feed, human food, and malt for beer), forage (fed green or conserved as hay and, rarely, as silage), and for grazing. Grazing takes place at the tillering stage, either continually after regeneration or in a dual-purpose farming system (Sprague 1963; Hadjichristodoulou 1983; Yau et al. 1989).

Recently, breeders have engaged in "reverse evolution," aimed at establishing barley as a permanent pasture crop. This has been attempted by using the wild barley gene of brittle rachis in crosses with subsp. *vulgare* barley and by selecting for wild seed to enable self-regeneration of the pasture (Hadjichristodoulou 1995).

Hay making receives special attention in WANA countries because the surplus spring forage production is easily conserved as hay for use in late summer and early winter, when there is a severe scarcity of forage. During this period sheep and goats are at the critical stages of pregnancy and lambing.

In some cases, varieties normally grown for grain are harvested at an early stage of growth for hay. However, these varieties may not produce the highest hay yield. Therefore, special hay varieties must be developed. A good hay variety must have a high yield in dry matter, be rich in protein, and be high in digestibility. Furthermore, it must be palatable (to reduce losses during feeding) and produce satisfactory grain yield for low cost seed supply. A high percentage of disease-free leafage increases the quality of forage, and the replacement of awns by hoods increases the palatability of hay (Hadjichristodoulou 1979, 1985, 1994a). Smooth-awned varieties are more palatable than rough-awned ones.

Only limited work appears to have been done on breeding barley varieties for hay production under dryland conditions. Recent work in Cyprus is reported by Hadjichristodoulou (1994b). Hooded hay varieties have been released recently in the USA (Day et al. 1974; Hockett et al. 1990). There is considerable literature on improved management techniques of barley for hay, such as optimum cutting stage, seed rate, etc. (Hadjichristodoulou 1976a; Droushiotis and Wilman 1987).

In this report, the information on breeding barley for hay in drylands will be reviewed and breeding strategies will be suggested for increasing the availability of hay in WANA.

Materials and Methods

The studies included in this report were conducted in Cyprus under rainfed conditions from 1970 to 1995. During this period long-term annual precipitation was around 300 mm, but with significant fluctuations from year to year, ranging from 200 to 500 mm. Detailed methodologies are described elsewhere (Hadjichristodoulou 1976a, 1976b, 1994a, 1994b). Results are presented on the following topics:

- Evaluation of local landraces and wild genetic resources.
- Evaluation of introduced barley germplasm for hay.
- Selection criteria when breeding for hay.
- Studies on the effects of the hooded gene in breeding for yield.
- A crossing program aimed at developing high yielding hay varieties.
- Maintenance of high grain yield potential in improved hay lines, with the aim of reducing the cost of seed production.

Both published and unpublished data are included in this report.

The screening procedure followed was generally the same in all studies. At the initial stages, leafy, tall, and disease-resistant lines were visually selected. Special

attention was given to optimum heading date to secure the adaptation of the lines to the dryland environment of Cyprus. The selected material was then evaluated for grain and hay yield. Researchers also recorded heading date, plant height, tiller number per m², disease resistance, total biological yield, crude protein content, and digestibility of dry organic matter. Material for hay evaluation was harvested at the milk-to-dough stage of the grain, which earlier studies have shown is the optimum harvesting stage (Hadjichristodoulou 1976a).

Results and Discussion

Evaluation of Landraces

Barley landraces were compared for grain yield with the improved grain varieties Athenais and Kantara. One, Exadjio (ARI-22), gave yields approaching those of the improved varieties (Hadjichristodoulou 1995). Two of the landraces were evaluated for hay production with the commercially grown hay variety Morocco 628 and the promising hooded line, Sanokrithi 80-79 (Table 1). Landraces gave slightly lower hay and crude protein yields than Morocco 628. Total biological yield (grain plus straw) of the landraces was 11–12 t/ha and straw yield was 5.5–6.0 t/ha, similar to those of the commercially grown variety Athenais.

Table 1. Hay, grain yield, and other traits of landraces compared with hay varieties (means of two locations, 1992/93).

	Grain yield (t/ha)	Hay			Heading date (1=1st March)	Plant height (cm)	Lodging (%)
		Dry matter	Crude protein				
		(kg/ha)	(%)	(t/ha)			
Morocco 628	7.03	18.76	8.7	1.60	35	128	8.4
Sanokrithi 80-79 [†]	6.43	14.70	11.0	1.76	27	121	24.7
Exadjio (LR)	7.07	16.79	8.4	1.50	24	124	15.6
Paphitico (LR)	6.40	13.98	9.3	1.36	35	122	30.1
Mean (25 lines)	6.95	14.52	9.3	1.41	29	119	16.1

[†] Hooded variety.

Introduced Germplasm

When hay barley improvement began in Cyprus in 1968, the variety Athenais was used for both grain and hay production. When barley material was evaluated for grain yield, some lines were found to be leafy, and produced large quantities of forage, though their grain yield was not among the highest. It was decided to evaluate all these lines, most introduced from other countries, in a special trial, and harvest them for hay production at the milk-to-dough grain stage.

Two varieties were subsequently selected, Morocco 628 and 48 Alger, introduced from Morocco and Algeria, respectively (Hadjichristodoulou 1976b). Morocco 628 outyielded Athenais in dry forage matter yield by 17% (Table 2). In 1975, Morocco 628, which is leafy and disease resistant, was released as a hay variety. No variety has since then been superior to it. The grain yield of Athenais (7.5 t/ha) was 20% higher than Morocco 628's grain yield.

Table 2. Yield and other data of Athenais compared with forage barley during 1970-75.

	Dry matter yield (t/ha)	Crude protein yield (kg/ha)	Heading date (1=1st March)
Athenais	5.72	666	23
48 Alger	6.22	644	35
Morocco 628	6.69	688	34
Beecher	4.78	640	27

Data obtained from Hadjichristodoulou (1976b).

It is evident that at the initial stages of a varietal improvement program for hay, leafy varieties rich in vegetative growth should be evaluated for hay. The chances of success are limited, because of WANA's specific and fluctuating climatic conditions. Such varieties may not give satisfactory grain yields, and will thus increase the cost of seed and ultimately the cost of hay production. However, this is a step in the whole strategy, which should be pursued before, or simultaneously with, the more expensive hybridization program.

Selection Criteria

Criteria must be identified before selection program, especially a hybridization program, begins. Certain traits are considered important in breeding for hay, namely, dry matter yield, digestibility of organic dry matter, and palatability.

Hay made from smooth-awned and hooded barley is more palatable than from rough-awned barley (Sprague 1962; Hadjipanayiotou et al. 1981). Likewise, leafiness (higher fraction of leaves over stems) and high crude protein content are desirable, as they increase nutritive value. Disease susceptibility affects both yield and hay quality. Breeding must therefore aim at disease resistance. Hay barley is not grown for its high grain yield, but selected hay varieties must have a high grain yield to produce low-cost seed.

The difficulties in breeding varieties which give both high hay and high grain yield are discussed by Hadjichristodoulou (1994b). Because of the unpredictable fluctuation of the dryland environment, it is very difficult to breed barley for consistently high grain yield (Hadjichristodoulou 1990, 1992, 1994c; Ceccarelli et al. 1991). The situation becomes even more difficult when including selection criteria for hay production.

The "hooded" barley gene

The hooded trait, which is controlled by a single dominant gene, is very useful in breeding barley for hay. Day et al. (1974) emphasizes this point, stating that awns are undesirable in forage breeding. Other studies, however, point out the positive effects of awns in assimilating in a hot, dry climate such as is found in WANA (Grundbacher 1963; Blum 1985). The negative effects of the hooded gene have been studied in California and in Cyprus (Hadjichristodoulou 1994a). These studies show that the magnitude of the negative effects of the hooded gene varies with environment. In Cyprus, hooded barley performs better in the central plain (Athlassa) than in a coastal area (Dromolaxia).

Table 3. Comparison of ten awned and hooded selections at two sites in 1992/93 (means of six crosses).

	Dromolaxia		Athlassa		Means	
	Hooded	Awned	Hooded	Awned	Hooded	Awned
Grain yield (kg/ha)	5262	6360	6140	6982	5701	6671
Heading date (1=1st March)	23.6	25.3	30.4	30.9	27.0	28.1
Plant height (cm)	110.2	112.7	134.8	132.4	122.5	122.5
1000 grain weight (g)	37.9	42.0	36.0	40.4	36.9	41.2
Volume weight (kg/hl)	56.6	58.6	58.2	59.3	57.4	58.9

After Hadjichristodoulou (1994a).

The studies in Cyprus show that the choice of parents may also produce hooded genotypes giving yields close to the awned genotypes from the same cross. In the six crosses, the mean yield differences between hooded and awned genotypes varied from 13 to 30% (Hadjichristodoulou 1994). The best awned selection outyielded the best hooded selection by 4% in cross No. 2 and by 26% in cross No. 5 and by 41% in cross No. 4 (Table 4). For the other traits (total biological yield, harvest index, and 1,000 grain weight) the best awned selection was superior to the best hooded selection in all six crosses.

The mean grain yield (four trials) of the 10 awned selections from the cross CYB 87-4725 was 37% higher than the 10 hooded selections from the same cross. Awned selections were shorter (by 7 cm), had higher weight by volume (by 4 kg/hl), higher 1,000 kernel weight (by 4 g), but earliness was similar to the hooded lines.

Four hooded lines selected from the cross CYB 87-4725 outyielded their hooded parent by 2–10%, and their 1,000 kernel weight was higher by 3–5 g (Table 5). However, the awned selections had higher grain yield than the hooded lines.

Table 4. Comparison of best hooded and awned selections from six crosses in two trials (1993/94).

	Best lines	GY (kg/ha)	TBY (kg/ha)	HI (%)	TN (per m ²)	HD (1 = 1st March)	PH (cm)	VW (kg/hl)	TKW (g)	NGPSP (No)
Cross No. 1	H	4,218	10,938	38	317	19	105	59	32	43
	A	4,991	13,198	41	361	21	106	59	42	34
Cross No. 2	H	4,704	12,255	39	317	14	109	58	35	44
	A	4,907	14,756	39	321	19	110	53	34	47
Cross No. 3	H	4,002	11,278	35	347	21	109	52	33	36
	A	4,446	11,450	42	321	17	113	58	43	33
Cross No. 4	H	4,167	11,396	39	300	18	112	54	35	41
	A	5,890	14,725	44	352	20	105	58	42	41
Cross No. 5	H	,3895	10,291	39	331	19	107	50	32	40
	A	4,904	12,317	41	328	20	113	57	48	34
Cross No. 6	H	3,960	11,130	36	291	25	113	55	35	40
	A	4,837	13,648	40	323	14	108	58	45	35

H = hooded; A = awned; GY = grain yield; TBY = total biological yield; HI = harvest index; TN = tiller number HD = heading date; PH = plant height; VW = volume weight; TKW = 1000-kernel weight; NGPSP = number of grains per spike.

Table 5. Agronomic performance of five hooded and five awned selections from the cross Mari/Aths//BC/3/ Sanokrithi 80-79, CYB 87-4725 (means of four trials, 1992-94).

Selection	Grain yield (kg/ha)	Heading date 1=1st March	Plant height (cm)	Volume weight (kg/hl)	1000 grain weight (g)
Hooded					
4725-3A-0A	4,776	20	118	54	38
4725-7A-0A	5,122	21	128	57	36
4725-4A-0A	5,372	22	119	58	38
4725-20A-0A	5,239	22	122	54	38
4725-23A-0A	5,001	19	115	54	36
Awned					
4725-85A-0A	6,901	22	116	63	47
4725-67A-0A	6,731	17	107	58	41
4725-78A-0A	7,021	17	110	65	44
4725-72A-0A	6,821	20	121	61	46
4725-54A-0A	6,240	21	116	63	39
Parents					
Mari/Aths//BC (A)	7,100	21	119	61	49
Sanokrithi 80-79 (H)	4,884	22	111	60	33

In spite of the negative effects of the hooded gene, a hooded variety, Sanokrithi-94, was released in Cyprus between 1980 and 94. This variety gives the same or slightly higher hay and grain yields than the awned Morocco 628 (Hadjichristodoulou 1994b). The steady progress in breeding of hooded forage lines which also have a higher grain yield is shown in Figure 1. Selected hooded genotypes give lower yields than Morocco 628, but hooded genotypes give equal hay yield and higher grain and crude protein yields than Morocco 628. Today, with the exception of Cyprus, very few WANA countries are using hooded genes in their crossing programs. With more input in this field, it is expected that the hooded gene will be incorporated into WANA breeder programs.

Hybridization

A crossing program is the most efficient way to develop high-yielding hay varieties with desirable traits. However, this requires special knowledge of the genetics of the selected traits. Also, an important prerequisite for the crossing program is the existence of useful genetic variability on which breeders can build.

There has been very little experience in breeding technologies for hay barley. Likewise, there is a shortage of improved germplasm when breeding for grain yield. However, experience gained in breeding grain barley in WANA countries can be exploited in breeding barley for hay. Ceccarelli (1994) and Hadjichristodoulou (1994c) presented such information at the 1992 Amman workshop.

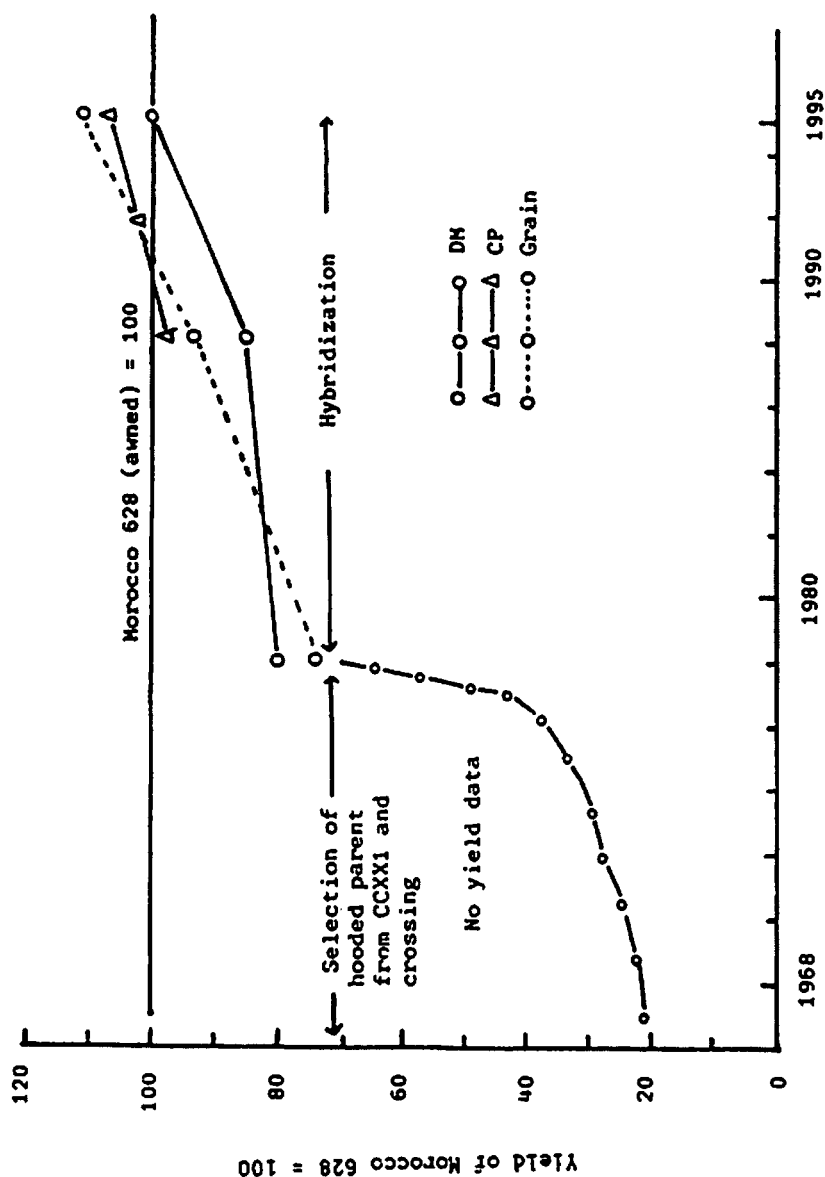


Figure 1. Relative performance of the best hooded lines compared to best awned hay variety from 1968 to 1995 (Grain = grain yield; DM = dry matter yield; CP = crude protein yield).

A hybridization program has been underway in Cyprus since the early 1980s, aiming at developing hay varieties for the dryland conditions of Cyprus. The most common parents were the high yielding varieties Morocco 628 and other leafy varieties with high biological yield, and hooded genotypes obtained from the Composite Crosses CCXX1 developed in California. Smooth-awned, disease-resistant, leafy, tall, and lodging-resistant genotypes were also used as parents.

The highest yielding lines selected through this program are:

1. **Sanokrithi 94.** Pedigree Mor 628*2/Sanokrithi 80-50, CYB85-4019-OD Sel A. This line was released in Cyprus because of its high grain, hay, and crude protein yields. It is a hooded, six-rowed variety.
2. **Lysi.** Pedigree Mor 628/Att CYB85-4012-OD-Sel B. Lysi was released in Cyprus in 1994 and is a smooth awned, six-rowed variety.

The following lines were found very promising and will be used in future crosses:

1. **Assia.** Pedigree Kantara/Sanokrithi 79-No2 CYB81-1726-3D-3D-1D-2D-0D. Assia is a two-rowed hooded line with a long, very strong stem. It has the highest hay yield among all the material developed in Cyprus, but its grain yield is very low. Thus the cost of seed for this variety is high and the line will be used in crossing programs to increase grain yield.
2. **Vatili.** PedigreeSanokrithi-80-26/48 Alger CYB 82-3153-2D-1D-2D-0D. Vatili is a six-rowed awned line with very high grain yield and high hay yield. It has great potential as a parent in crosses.

In a breeding program aimed at high hay yield, it is necessary to select at the same time for high grain yields. A variety with very low grain yield is unlikely to succeed on the open market. The implications in breeding for both hay and grain yield are discussed by Hadjichristodoulou (1994b).

The results of a trial conducted at two sites in 1994/95 illustrate the procedure followed in such a program (Fig. 2). Two lines, passing through the means and parallel to the X or Y axis, divide the 25 lines into four groups. Lines in group G are high-grain but low-hay yielding; lines in group H are high-hay but low-grain yielding; lines in group G + H are high in both grain and hay yield; lines in group -G-H are low in both grain and hay yield. Line 2 is Morocco 628, the commercial hay variety. Line 3 is the recently released hooded line Sanokrithi-94. Both lines are between hay and hay + grain types. Thus, they need further improvement of their grain yield potential. Line 1 is the commercially grown grain variety, Athenais. Line 16 combines both high grain and hay yield and was included in this trial after two years of testing for grain yield. Line 12 gave the highest grain yield and will be promoted to grain yield trials. However, Line 22, a high-hay-yielding line selected from a cross involving four parents (including Morocco 628 and Athenais) is not suitable for release, but only as a parent to improve grain yield.

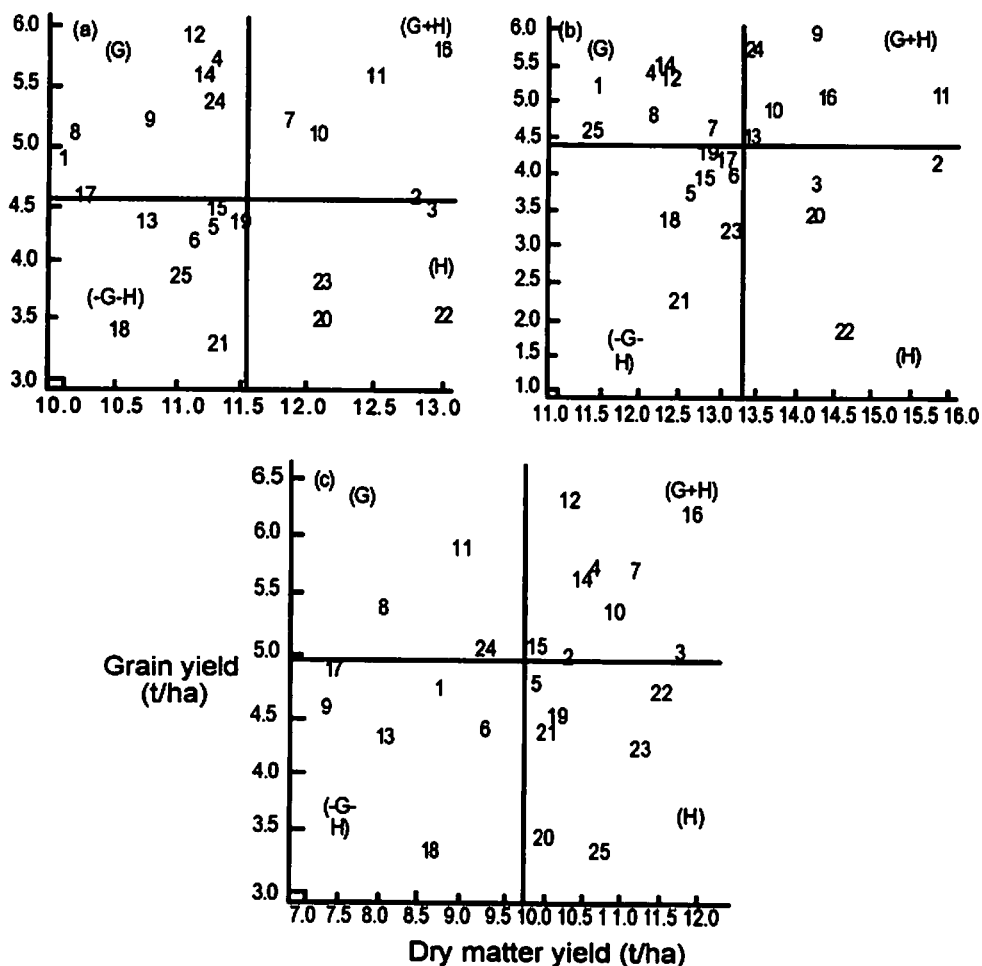


Figure 2. Forage grain and dry matter yield of 25 barley varieties in 1994/95. G = grain type; H = hay type; G+H = grain + hay type; -G-H = low in grain and hay yield; a = means of two locations; b = Dromolaxia; c = Athalassa.

The data in Figure 2a are the means of two locations. However, by comparing the data in Figures 2b and 2c, it can be seen that the relative position of the 25 lines is not necessarily the same at Dromolaxia and Athalassa. This is the result of a genotype $\times$ environment interaction, which affects the efficiency of selection in drylands. Ways to alleviate these effects are recommended by Hadjichristodoulou (1987, 1990, 1992) and Ceccarelli et al. (1991).

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Discussion

M. Al-Ayadi: How can you make hay from barley and vetch more palatable for sheep, and what seeding rate do you recommend for hay production.

A. Hadjichristodoulou: Breeding barley for high hay palatability is necessary. Growing hay barley in mixture is another way of increasing palatability, but long-term studies in Cyprus showed that barley grows fast and suppresses the vetch, which has slow growth in the center. The result is to harvest mainly barley with little contribution from the vetch even if the seed rate of the mixture is 20% barley and 80% vetch. Triticale is a more suitable companion species to grow in combination with vetch. When barley is grown in a pure stand for hay, the seeding rate is 150 kg/ha, and it is harvested at the mild-to-dough stage of grain.

Genetic Nature of the Principle Yield Components in Barley

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Abstract

A diallel set, including eight genetically diverse barley varieties, was used to estimate the type and magnitude of gene action involved in the inheritance of barley's principle yield components. The results underscore the importance of both additive and non-additive genetic effects in controlling these traits, except for number of spikes per plant, which is mainly controlled by the dominance effect. The proportion of positive and negative alleles was unequally distributed among the parental populations for the studied traits, except for number of spikes per plant and number of kernels per spike, which were equally distributed among the studied parents. The dominance effect of inheritance with asymmetrical gene distribution in the genetic background of the parents was detected for most characters. The additive variance percentage appreciably exceeded dominance percentage for number of spikes per plant and number of kernels per spike, particularly in the F_2 generation. Consequently, successful selection for those two characters among early generations is feasible. Estimates of heritability were moderate for all characters except for number of spikes per plant and grain yield, which were low. Completely recessive parents were higher than completely dominant parents for number of spikes per plant, number of kernels per spike, 1,000 kernel weight, and grain yield per plant.

Introduction

The area planted with barley in Egypt decreased from 192,000 fed (1 feddan = 0.42 hectare) in 1990 to 115,000 fed in 1993. Average yield increased from 0.77 t/ha to 1.04 t/ha during the same period. The barley crop in Egypt ranks twelfth in priority in the Old Lands (Delta and Nile Valley). However, barley is considered the main cereal crop in rainfed areas, which are scattered along the northern coast and the Sinai Peninsula. Barley is the best-adapted field crop for drought, salinity, and low soil fertility in the New Lands (newly reclaimed areas).

Several researchers have studied the genetic nature and the relative magnitude of each possible source of genetic variability for the polygenic traits of barley. However, most analyses found in the literature were conducted on a fixed model basis. Their conclusions apply to those populations as constituted by their plant materials. This study involves genetic analysis of principle yield components in

barley using the diallel approach (Hayman 1954). The aim was to understand the genetic behavior of polygenic traits help formulate breeding procedures to achieve maximum genetic improvement within a set of barley varieties.

Materials and Methods

The breeding materials in this study comprised eight barley genotypes. These were: (i) Aramir; (ii) Bonus; (iii) Tyra; (iv) Impala; (v) Rupal; (vi) Georgia; (vii) Bomi; and (viii) Proviners. The first two were imported from Holland, while the others come from Denmark. All are two-rowed *Hordeum distichum* L., except for Proviners, which is a six-rowed *H. vulgare*. The eight genotypes were crossed in all possible combinations (excluding reciprocals). The eight parents and the 28 F₁ and F₂ populations were planted in a randomized complete block design with four replications. In each replicate, every cross was represented by one row for each parent and F₁ generation, and by two rows for each F₂. Rows were three meters long and 30 cm apart. Plants were spaced 20 cm apart within rows.

Number of spikes per plant, number of kernels per spike (on the main stem), 1,000 grain weight (gm), biological yield (gm), and grain yield per plant (gm) were recorded for each plant. Before proceeding with the biometrical analysis, significant differences among genotypes were tested by carrying out regular variance analysis of the randomized complete block design. The diallel cross procedure developed by Hayman (1954) and Mather and Jinks (1971) was used to detect the relative magnitude of the genetic components and to provide information on the genetic mechanism by which traits are inherited.

Table 1. Mean performance of the eight barley genotypes used in diallel crosses.

Parents	No. spikes per plant	No. kernels per spike	1,000 kernel wt. (g)	Biological yield (g)	Grain yield per plant
Aramir	42.00	28.50	40.20	143.00	26.30
Bonus	45.70	31.20	45.44	191.00	46.04
Tyra	54.90	32.30	44.50	143.00	43.05
Impala	46.80	29.30	41.49	135.00	29.17
Rupal	60.80	34.90	31.19	163.50	43.94
Georgia	46.20	31.30	37.02	144.50	37.16
Bomi	60.80	33.50	50.41	190.00	57.83
Proviners	37.60	72.00	30.08	268.00	97.95
Sign.	**	**	**	**	**
L.S.D (0.05)	9.79	0.95	0.47	33.59	12.23
L.S.D (0.01)	14.47	1.41	0.70	49.69	19.21

** Significant at 0.01 level of probability.

Results and Discussion

The present investigation endeavored to study the genetic behavior of the principle yield components in barley, and the impact on barley breeding programs. Therefore, genetic nature will be discussed separately for each component.

Table 2. Mean squares for principle yield components in F₁ and F₂ diallel crosses and test of validity.

Source of variance	Generation	Spikes/Plant	Kernels/Spike	1,000 kernel wt.	Biological yield	Grain yield/plant
Replicants	F1	2.723	3.923	0.034	2901.620	8.657
	F2	42.426	0.560	0.253	616.433	10.737
Genotypes	F1	599.790**	183.275**	0.882**	6407.180**	861.887**
	F2	547.905**	648.414**	0.707**	5005.476**	1112.700**
Error	F1	62.070	1.678	0.543	878.665	87.232
	F2	83.823	12.107	0.354	525.772	83.610
t ²	F1	2.815	1.760	0.054	0.999	0.334
	F2	54.996**	1.046	1.040	0.031	0.072
b -/+ SE	F1	0.550±0.161	0.953±0.0186*	0.110±0.475	0.213±0.266	0.757±0.370**
	F2	0.0175±0.210	* 0.554±0.203	0.104±0.020	0.066±0.438	0.873±0.173**
Ha: b = 0	F1	3.416	51.236**	1.007	0.801	2.043
	F2	0.083	2.526*	20.400**	0.151	5.046
Ho: b = 1	F1	2.795	2.729*	1.407	2.958*	0.621
	F2	4.678	2.198	25.300**	2.135	0.734

* Significant at 0.05 level of probability.

** Significant at 0.01 level of probability.

Number of Spikes per Plant

Parental genotypes differed significantly in terms of number of spikes per plant, as shown in Table 1. The two-rowed variety Bomi gave the highest number of spikes per plant (60.80), while the six-rowed variety Proviners had the lowest number (37.60). Highly significant differences in the number of spikes per plant were recorded among the F_1 and F_2 genotypes (Table 2). The significant value of mean square due to genotype revealed the presence of genetic variability among the materials under investigation. However, the t^2 estimates were non-significant, indicating the correctness of the assumption underlying the diallel analysis. The insignificant value of the regression coefficient (b) may support the presence of non-allelic interaction among the studied parents.

Additive and dominance gene effects for number of spikes per plant are shown in Table 3. Additive gene effect (D) is non-significant in both F_1 and F_2 , whereas H1 and H2 components (due to dominance) are highly significant in both generations. These results reflect the lower magnitude of additive effects compared with dominance action in controlling the number of spikes per plant.

Positive estimates of F values, which measure the relation between dominant and recessive alleles, indicate that the dominant alleles are more frequent than the recessive ones at most loci.

For better comparison between variance components, partitioning of variance to its main components, additive (DR), dominance (HR) and environmental (E) were considered. These values illustrate the high contribution of dominant gene effects in F_1 , whilst in F_2 additive effects are more important. Popescu (1985) finds that dominance genes predominate in controlling the inheritance of number of spikes per plant. However, Asaad (1983), El-Sherif (1991), and El-Shazly et al. (1992) state that the additive gene is the major factor in controlling that trait.

Estimates of dominance degree (3.322 and 2.492 for F_1 and F_2 , respectively) suggest over-dominance, and hence preponderance of non-additive gene effects. The same conclusion was previously mentioned for partitioning of variance (Table 3).

Estimates of the average frequency of positive versus negative alleles U:V at all loci show that they are not distributed equally among parents. Estimates of the ratio of dominant and recessive alleles in the parents, KD/KR, are greater than the unity in both generations. This implies an excess of dominant genes in the parents for number of spikes per plant.

Number of Kernels per Spike on Main Stem

Highly significant differences among the genotypes, including F_1 and F_2 , in number of kernels per spikes were found (Tables 1 and 2). The six-rowed variety Proviners significantly surpassed the other parents in number of kernels per spike (72.00). However, the test of validity (t-value) confirms the validity of the assumptions of diallel analysis (Table 2).

Estimate of gene action and the genetic mechanism for number of kernels per spike found that values of D and H1 were highly significant in both generations, showing the importance of both additive and non-additive types in conditioning this trait. The component of variation due to dominance effects correlated with gene distribution (H2) was highly significant in both generations, showing the effect of dominance genes with asymmetrical gene distribution in the genetic background of the parents. Frequency of dominant alleles was higher than recessive alleles in the parents, since F values were positive and highly significant in both generations. This finding is supported by the increasing proportion of dominant to recessive genes in the parents, KD/KR, as shown in Table 3.

Regarding partitioning of variance to its main components, the results reflect the low contribution of additive effects (DR=23.80) in comparison to dominance gene effects (HR=74.75) in the F₁ generation, whereas in F₂ there was a higher magnitude of additive effects (DR=78.45). The remarkable role of additive genetic effects in F₂ may help in successfully isolating promising lines during early generations.

Thousand Kernel Weight

Highly significant differences between genotypes, including parents and their respective crosses, were detected in 1,000 kernel weight. Except for the Rupal variety, the other two-rowed varieties significantly surpassed the six-rowed variety Provincers in 1,000 kernel weight (Tables 1 and 2). However, a test of validity for F₁ and F₂ was non-significant, confirming the validity of the assumptions of diallel analysis. The genetic components of variation in F₁ and F₂ show that D and H values were highly significant in both generations. These results indicate that genetic variation is caused mainly by additive and non-additive gene effects. The estimates of average value of dominance effect in loci with unequal positive and negative allelic frequency were highly significant in F₁ and F₂, suggesting dominance with symmetrical gene distribution in the parents. The number of dominant and recessive genes was more or less the same in the parents, as indicated by the highly significant values of F in both generations. This agrees with the KD/KR scale shown in Table 3. These results agree with those reported by Yadav et al. (1986). The estimates of h² were highly significant and positive in both generations, suggesting the prevalence of positive genes in governing the inheritance of 1,000 kernel weight.

Table 3. Genetic components and ratios between components in F₁ and F₂ generations for the principle yield components in barley.

	Spikes/Plant		Kernels/Spike		1000 Kernels Wt.	
	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂
Variance components						
E	15.106±.495	20.668±23.163	0.435±1.877	3.382±17.859	0.0133±1.465	0.02±3.327
D	53.229±28.799	47.667±69.180	501.288±5.608**	498.341±53.338**	35.936±4.374**	35.930±9.935**
F	48.764±67.303	2.955±164.194	899.649±13.310**	559.521±126.596**	42.313±10.381**	38.442±23.581**
H1	587.479±65.480**	429.887±159.742**	502.770±12.949**	519.538±123.163**	58.914±10.100**	64.358±22.942**
H2	489.648±56.969**	354.778±138.979**	90.072±11.266**	459.204±107.154**	38.56±8.787**	43.316±19.96**
h ²	31.977±38.206	162.167±93.207*	25.504±7.556**	103.920±71.864	70.394±5.893**	278.947±3.386**
Variance percent						
E	8.006	27.348	1.450	2.273	0.079	0.100
DR	27.111	43.125	23.800	78.455	42.160	46.062
HR	64.883	29.437	74.750	19.272	57.671	53.838
Other genetic ratios						
Dom.						
degree	3.322	2.492	1.001	1.021	1.280	1.338
Dom.						
deviation	0.338	0.025	0.989	1.613	0.782	0.699
U:V	0.208	0.2063	0.045	0.221	0.1636	0.1682
KD/KR	1.302	1.0173	18.233	3.443	2.726	2.331
YD	-40.015	45.725	37.765	-84.523	44.768	20.386
YR	11.434	47.300	991.868	455.708	43.788	40.781

* Significant at 0.05 level of probability.

** Significant at 0.01 level of probability.

(Continued next page)

(Table 3. Continued)

	Biological yield		Grain yield/Plant	
	F ₁	F ₂	F ₁	F ₂
Variance Components				
E	233.010±272.585	132.073±292.627	21.256±29.265	20.396±16.222
D	1738.850±814.113*	1840.497±876.958	489.973±88.766**	490.833±48.450**
F	1519.722±1932.243	2878.751±2081.402*	738.606±207.450**	393.716±114.992**
H1	6401.438±1879.850**	6201.438±1879.850**	921.295±201.825**	754.656±111.875**
H2	5612.744±1635.515**	4588.380±1761.764**	595.524±175.592**	621.096±97.333**
h ²	2452.853±1635.515**	22.881±18.153	156.364±17.762	55.916±5.277*
Variance %				
E	10.899	8.432	10.185	7.009
DR	23.543	18.345	18.479	39.634
HR	65.558	73.223	71.335	53.357
Other genetic ratios:				
Dom. degree	1.919	1.835	1.371	1.24
Dom. deviation	0.6488	0.8353	0.924	0.768
U:V	0.2192	0.1849	0.1614	0.2057
KD/KR	1.598	2.484	1.443	1.956
YD	43.880	189.197	-37.552	-529.201
YR	-48.660	143.520	434.117	132.040

* Significant at 0.05 level of probability.

** Significant at 0.01 level of probability.

For a better comparison between variance components, the relative magnitude of both additive and dominance effects were considered. The relative importance of additive effects in terms of heritability was clear.

The average degree of dominance at each locus was 1.28 in F_1 and 1.33 in F_2 , indicating that 1,000 kernel weight behaved as a dominant character. Dominance deviation values were 0.782 in F_1 and 0.699 in F_2 (Table 3). These low values may stem from the existence of dominance at some loci, although not the majority. This provides further proof of the unequal distribution of alleles over loci (U:V ratio). U:V estimates were 0.1636 in F_1 and 0.1682 in F_2 (Table 3). These values were less than the maximum value of 0.25, which arises when $U = V = 0.5$. The low estimates indicate that the positive and negative alleles at the loci exhibiting dominance are not present in equal proportion.

Biological Yield

Biological yield (total plant weight excluding roots) was significantly different among the studied genotypes (Tables 1 and 2). The components of variation suggest that both additive and non-additive effects are significant. This illustrates the importance of both additive and non-additive gene effects, with non-additive effects prevailing in the inheritance of biological yield (Table 3). The component of variation due to dominance gene effects in correlation with gene distribution was highly significant in F_1 and F_2 , indicating asymmetrical distribution of dominant genes in the genetic background of the parents. Thus it may be difficult to get the best allelic combinations in early generations.

However, DR heritability values were 23.543 and 18.345% in F_1 and F_2 , respectively. These values suggest that selection from these populations is generally low. Low values of heritability were also reported by Khalifa (1980), Osman (1985), and Ismail (1986).

Grain Yield per Plant

Grain yield per plant is a metric character which is highly susceptible to environmental conditions. Breeding high-yielding genotypes requires information on the nature and magnitude of genetic variation. Significant differences were detected between genotypes, indicating the presence of variability (Tables 1 and 2). A test of the validity of diallel assumptions proves the validity of this type of analysis.

Estimates of the genetic variation component in F_1 and F_2 show that D and H1 values are highly significant in both generations (Table 3). This shows the importance of both additive and non-additive gene effects in governing the inheritance of grain yield per plant. The estimate of average value of dominance effect in loci having unequal positive and negative allelic frequency was highly significant in both generations, indicating the dominance of asymmetrical gene distribution in the genetic background of the parents.

Estimates of DR and HR suggest only a small contribution by additive effects when compared with dominance effects in F_1 . However, the study detected an important

role for additive effects in parallel with dominant effects as a result of new segregates in F_2 . Khalifa (1980), Ismail (1986), and El-Shazly et al. (1992) report that both additive and non-additive gene action are important in controlling grain yield. Thus, the small amount of additive effects in both generations makes isolation from early generations of promising lines unfeasible.

The distribution of alleles over loci was unequal. The recessive parents were present in greater proportion than the dominant parents. This indicates that selection among the generations for this character is not efficient because the best combinations might be found in heterozygotic forms. If selection is practiced in later generations, a large population to recover the desirable recombinations will be needed.

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Discussion

A.M. Al-Shamma: What are the heritability figures obtained on yield components? What are your recommendations for selection in terms of components and generation?

M. El-Shazly: Estimates of heritability were moderate for all characters except for number of spikes per plant and grain yield, which were low. Therefore, selection for grain yield per plant and number of spikes per plant in early generations is not recommended.

Barley Improvement for Feed and Forage Use In Continental Mediterranean Environments to Increase Livestock Production

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Abstract

In the continental Mediterranean environments of West/Central Asia and North Africa the predominant farming system is cereal-livestock-pastoralism. During the last 15 years the population of this region has increased from 302 to 426 million (41%). Yet the number of milk and meat producing animals has increased by only 4.9%. This has resulted in a shortage of milk and meat. Immediate steps are thus needed to increase livestock production.

Barley as feed and forage plays a major role in livestock production in this region. Barley is grown on 18.2 million ha, with an average yield of 1,225 kg/ha. Therefore, ICARDA has placed special emphasis on barley improvement for feed and forage. At Tel Hadya, it is possible to select lines that are superior for both traits, i.e., total biomass and grain yield in facultative and spring barley.

The new barley lines, with grain yield of 3.7–4.7 t/ha and protein content of 10–13.8% in dry areas, have been identified by several national agricultural research stations (NARS). With the adoption of new cultivars, yield per hectare can be increased by at least 50%, and grain production could jump from 22.9 to 34.4 million tons. Straw production could increase to 68.7 million tons. The availability of a larger quantity of high-quality feed could support the equivalent of another 41.3 million ewes.

Introduction

The cultivation of barley is an essential and integral component of the cereal-livestock-pastoralism farming system in the highlands of WANA and central Asia, where a continental Mediterranean climate prevails. Barley is the biggest source of animal feed, especially during winter, when no other feed source is available and the land surface is covered with snow for several months.

During the last 15 years the human population in this region has increased by 41%, i.e., from 302 to 426 million (FAO 1994). The livestock (milk and meat animals) population has registered a nominal increase of 4.9% during the same

period (Table 7). These figures indicate a shortage of milk and meat in the region. Immediate steps are needed to correct this situation. However, this requires increased availability of animal feed.

Barley, which plays a major role in livestock production, registered a production increase of 10.3%, i.e., from 20.8 to 22.9 million tons, between 1980 and 1994 (Table 1). This increase is largely the result of an expansion in the area planted with this crop (+13.6%). Barley production in this region fluctuates enormously due to severe abiotic (thermal, moisture deficiency, and problematic soils) and biotic (disease and insect) stresses, in addition to several other factors which reduce production drastically in certain years. Stable barley production is necessary to assure resource-poor farmers a stable income and livestock production.

The areas with continental Mediterranean climates are however, highly diverse and agro-climatically variable. Therefore, to enhance sustainable barley production, a well-defined strategy has been developed in close cooperation with scientists in the national programs to develop germplasm of feed and forage barley with high yield potential and quality.

The process of introduction of desirable genes and their subsequent identification, selection, and performance is intensively carried out. Once the material has gone through careful genetic manipulation, the best-performing lines are provided to collaborating NARSs in the form of nurseries for evaluation, testing and selection under specific environments. Some of the results of work on the improvement of grain and forage yield and quality, and implications for livestock production in the region, are presented in this paper.

Performance of Improved Feed-barley Germplasm

Newman and Newman (1992) states that is not practical to define a single ideotype of barley which will be ideal for feeding various animals and fowls for different production requirements. Therefore, they conclude that feed-barley improvement should focus on increasing the available energy, which can be accomplished by selecting for high starch plus free sugars (>65%), high fat (4–5%) and low non-starch polysaccharides (<12%). However, in areas of the world, such as WANA, where protein is deficient, high protein barley should receive due consideration. The average yield of barley in the countries of North Africa and West/Central Asia is 1,225 kg/ha, compared to the world average yield of 2,188 kg/ha. This low productivity is often attributed to lack of suitable varieties. Therefore, one of the major objectives is to supply the NARSs with improved winter and facultative (W&F) germplasm which can better withstand abiotic and biotic stresses and give stable high grain yield and better grain protein. The improved germplasm is supplied in the form of international nurseries for local testing, evaluation, and selection by NARS scientists. The results of some of these nurseries for 1993/94 are summarized below.

Table 1. Area and production of barley in North Africa and West/Central Asia.

Country	Area (000 ha)			Production (000 tons)			
	1980	1994	Percent change	1980	1994	Percent change	Yield kg/ha
Algeria	875	1,100	+25.7	592	800	+35.1	727
Morocco	2,190	2,582	+17.9	1,712	3,720	+117.3	1,440
Tunisia	457	512 [†]	+12.0	279	478 [†]	+71.3	933
Afghanistan	296	170	-42.6	313	180	-42.5	1,059
Azerbaijan	175 [†]	158	-9.7	371 [†]	238	-35.8	1,506
Iran	1,727	2,100	+21.6	1,558	3,100	+98.9	1,476
Iraq	858	1,400	+63.2	726	1,002	+38.0	716
Kazakhstan	5,718 [†]	6,044	+5.7	8,511 [†]	5,497	-35.4	909
Kyrgyzstan	263 [†]	170	-35.4	582 [†]	300	-48.5	1,765
Pakistan	199	151	-24.1	141	146	+3.5	967
Tajikistan	55 [†]	40	-27.2	42 [†]	34	-19.0	850
Turkey	2,846	3,400	+19.5	5,480	7,000	+27.7	2,059
Turkmenistan	61 [†]	52	-14.8	124 [†]	108	-12.9	2,063
Uzbekistan	280 [†]	292	+4.3	361 [†]	340	-5.8	1,164
Total	16,000	18,171	+13.6	20,792	22,943	+10.3	

[†] Figures for 1992.

[†] Figures for 1993.

Source : FAO Statistics Year Book (1994).

International Winter and Facultative Barley Observation Nursery

This nursery (IWFBON) comprises 150 entries of the most advanced material. It has gone through several cycles of selection at key locations in the highlands of WANA. Characteristics of entries selected five times or more at 16 locations are presented in Table 2. The yield of the most frequently selected entries ranged from 3,496 to 4,656 kg/ha. The protein content of these high-yielding lines was 9.9–13.7%, compared to 10% (Tokak) and 9.2% (Zarjou) for the most widely grown cultivars in Turkey and Iran, respectively. A great majority of the crosses at ICARDA are made using cultivars from WANA countries with very diverse germplasm originating from other ecological regions but possessing one or more desirable traits. From these data it is obvious that the selected lines, except entry Nos. 71, 61, and 47, contain locally adapted germplasm in the recombination of desirable genes. These data clearly indicate the tremendous scope for increasing the present yield level.

International Winter and Facultative Barley Yield Trial

This replicated trial (IWFBYT) comprises 24 of the best, most widely tested entries. Like IWFBON, this trial is also distributed globally on request. The results of three highland sites of Iran are summarized in Table 3.

Table 2. Characteristics of IWFBON entries selected five times or more at 16 locations in 1993.

Entry No.	Name/Cross	Sum Sel.	Avg. Yield (kg/ha)	DH	DM	PH(cm)	PM	Lodging (%)	Protein (%)
4	Rihane/Lignee 640//ICB 102854	7	4,389	153	203	78	4	40	10.7
108	Bkf/Magnelone 1604//Aloutte	6	3,899	160	204	61	3	0	11.4
54	Lignee 131/Soufara-02	6	3,771	157	203	76	2	22	11.5
33	Kitchen/Mullers Heydla/Salmas	6	4,588	155	203	74	3	26	12.3
58	YEA455-25//4679/105	6	3,782	158	204	83	3	6	11.9
76	GB3433/TOK II	5	4,076	164	206	88	3	58	10.5
71	Alpha/Quinn	5	3,948	164	205	85	4	44	13.3
51	Lignee131/5/Cq/Cm//Apm/3/12 410/Giza 134	5	4,584	155	204	75	4	20	9.9
98	26106	5	4,088	159	205	81	3	16	11.2
61	Kitchen/Mullers Heydla	5	3,496	158	204	82	3	6	11.6
47	Victoria	5	4,356	160	204	79	3	19	10.9
14	CWB22-6-13/ICB-102893	5	4,441	162	206	79	3	53	13.7
12	Roho/MazurB-103020ka//IC	5	4,518	157	202	79	2	60	12.5
48	Roho/Mazurka	5	4,656	159	205	77	2	0	11.4
126	ICB103515/80-5144	5	3,954	156	202	71	3	38	13.1
84	Roho/Alger/Ceres 362-1	5	4,458	159	201	79	3	38	10.4

PM = powdery mildew (scale = 1 resistant, 10 susceptible); protein for Zarjan was 9.2%; DH = days to heading; DM = days to maturity; PH = plant height.

Table 3. Characteristics of top yielding winter barley lines in Iran (1993/94).

Variety/cross	DH	DM	PH (cm)	TKW (g)	Yield (t/ha)	Check (%)
Ardabil						
YEA 1276/132TH//5053 YEA...	209	248	69	41	2.73	108
Hj 33-81/Malta/YEA 196-3...	201	247	75	42	2.85	110
YEA 422.1/YEA 455.25//...	205	246	70	41	3.83	148
Boyer/Ij-126/6/Cm14,F1/3/...	202	247	83	45	3.41	132
Zarjow (check)	205	249	59	34	2.21	87
Star (Improved check)	205	250	71	36	2.58	100
CV					25.05	
LSD at 5%					0.87	
Zanjan						
1246/78//1246/105	223	254	56		1.23	185
Tokak	221	248	58		1.68	253
Bulbul	221	252	61		2.05	308
132 TH/Tokak	220	250	63		1.55	233
YEA 560.2//Luther/BK259	222	251	61		1.75	263
Gorgan-4 (check)	217	248	50		0.66	100
CV					13.53	
LSD at 5%					0.31	
Karmanshah						
Lignee 131/5/Cq/Cm//Apm...	173	215	75	34	6.04	123
CWB117-77-9-7/ICB 104073	173	213	85	37	6.27	127
Robur/J-126//OWB						
753431D/S13	173	221	85	41	5.94	121
Roho/Mazurka//ICB 103020	173	215	85	44	6.6	135
YEA 560.2//Luther/BK 259	187	221	105	35	5.68	115
National Check	182	221	110	40	4.92	100
CV					15.61	
LSD at 5%					1.32	

DH = days to head; DM = days to mature; PH = plant height.

The three sites represent different ecological regions. Ardabil is very cold and moderately dry, whereas Zanjan is a very cold and moisture-stressed site with a short rainfall season. Karmanshah is not very cold and enjoys adequate rainfall and good distribution and relatively high production. At each location the check was a local improved variety.

The yield at Ardabil ranged from 1.76 to 3.83 t/ha. Two lines—YEA 422.1/YEA 455.25//..., and Boyer/Ij-126/6/cm 14, F1/3—gave significantly higher yields, 3.83 and 3.41 t/ha, respectively, than the two checks—Zarjou and Star— at 2.21 and 2.58 t/ha, respectively (Table 3). The high-yielding lines have a higher 1,000 kernel weight and are more cold tolerant than the local checks. The other agronomic characteristics, such as days to heading, maturity, and plant height are similar to the improved check cv Star.

At Zanjan all the entries outyielded the local check cv Gorgan-4. The yield of the top five lines ranged from 185 to 308% of the check cultivar (Table 3). The better performance is due to the high level of cold and drought tolerance. Variety Gorgan-4 is highly susceptible to cold and does not seem to be adapted to moisture stress.

The agronomic data for top yielding lines at Karmanshah are presented in Table 3. Though there was an increase of 115–135% over the national check, only two entries, CWB 117-77-9-7/ICB 104073 and Roho/Mazurk//ICB 103020 ICB 103020, gave significantly higher yields (6.27 and 6.6 t/ha, respectively) than the check cultivar (4.92 t/ha).

These data confirm that the three sites are very different from each other. None of the best performing lines was among the top yielders across all sites. All the selected lines have been included in the national trials for wide-scale testing.

From these results, it is evident that the strategy of multi-locational testing, and the use of locally adapted germplasm to introduce desirable genes, is the best course of action for rapid germplasm improvement for grain production.

Grain Protein and Thousand Kernel Weight

In view of the feed and food value of barley in the highlands, the emphasis is on developing germplasm not only with high grain yield but also of better quality than the varieties most widely cultivated in the region.

All the material supplied to the NARSs—in the form of various nurseries (IWFBON, IFBON), yield trials (IWBYT, IFBYT) and the advanced elite winter barley lines (EWBL)—is tested for 1,000 kernel weight (TKW), which is an important yield component, and protein content. In total, 1,851 lines/cultivars from various nurseries, along with three checks (Tokak, Bulbul, and Arabic Abiad), were evaluated during 1993/94. The data on protein and TKW distribution are presented in Figures 1 and 2. The majority of the tested material had higher protein and TKW than the checks. Line 1233 was selected on the basis of high protein, and 1087 on the basis of high TKW. A great majority of these lines also gave significantly higher grain yield than the local check varieties. The amount of genetic variability observed in the tested material clearly shows the scope for improvement in these traits in combination with high grain yield.

Performance of Forage Barley Germplasm

Before evaluation for forage and grain production, forage barley germplasm, like feed barley, is categorized into spring, facultative, and winter types, based on response to vernalization. In the continental Mediterranean, predominant cultivars are either winter or facultative. Therefore two separate experiments, with 44 entries each, including checks, were carried out to evaluate forage and grain yield potential at Tel Hadya. Forage yield was determined by clipping just before heading. The ratoon crop was also harvested to identify dual-purpose lines (forage cum grain). The data on growth habit (scale 1 spring–5 winter type), days to heading and maturity, green forage yield, crude protein (%), total dry biomass, grain yield (unclipped), and grain yield of the ratoon crop are described below.

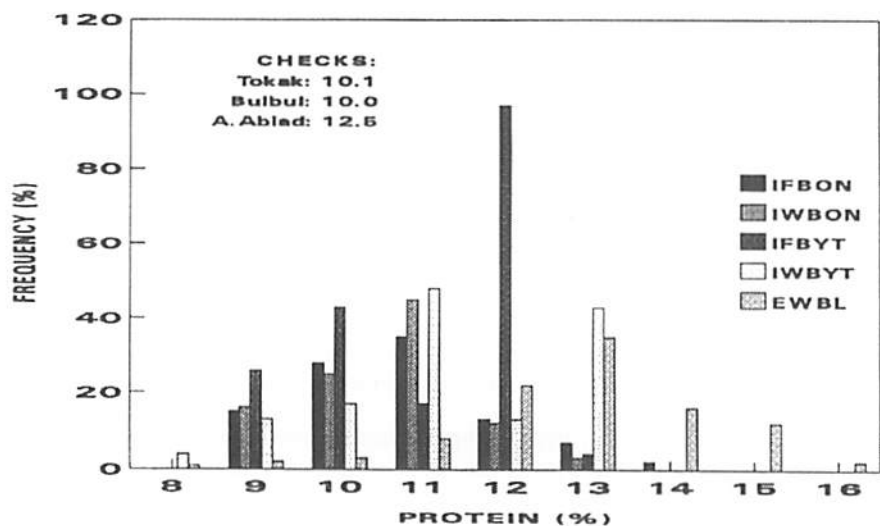


Figure 1. Protein content in winter and facultative barley.

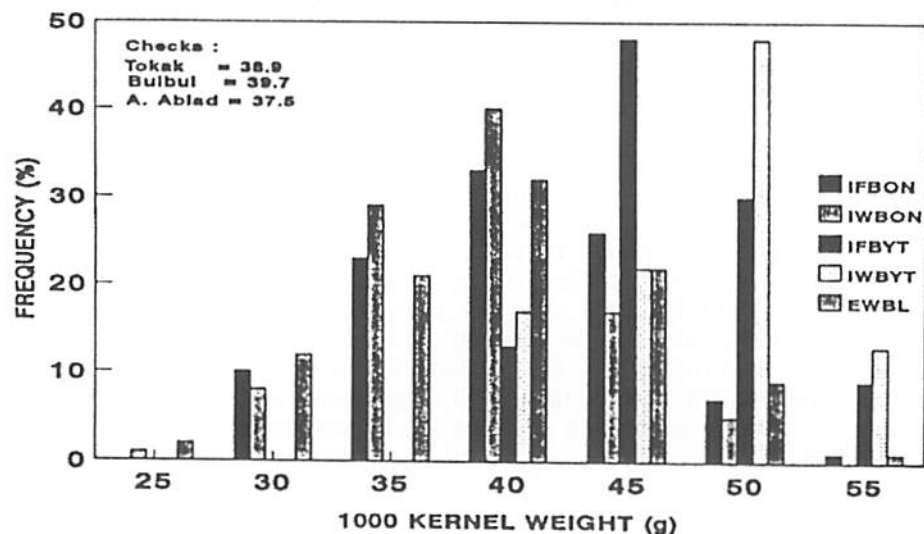


Figure 2. Thousand kernel weight in winter and facultative barley.

Facultative Barley

The data on the top 10 forage yielding lines out of the 44 tested entries, along with two check cultivars (Tokak and Arta), are presented in Table 4. All top forage yielding lines except two were significantly earlier in days to heading and maturity than the winter type check variety Tokak, whereas only one line was later in maturity than local check cv Arta. Though no significant differences in plant height were observed in these lines compared to Tokak (except line Rihane 3/Rihane 08, which was significantly taller than all the entries) all lines had significantly higher

forage yield than the check varieties Tokak and Arta. Forage yield ranged from 11,595 kg/ha to 15,840 kg/ha, indicating major genetic differences in forage production. Seven out of the 10 lines gave significantly higher grain yield than cv Tokak. Generally, all these high forage producing lines also had high total biomass, except one line, ICB 100709/Rihane 03.

In the evaluation of wheat and barley germplasm from Ladakh, Kashmir, Misri (1989) found major differences in fodder and grain production. Similarly, Kang and Kang (1991) observed significant differences in forage and grain production. They emphasize that higher production is obtained in early fall sowing than in late planting.

In all these high forage producing lines the grain yield from the ratoon crop was very small. In earlier studies, Hadjichristodoulou (1991) and Khaldoun (1989) found reductions in yield and yield components after grazing and clipping during winter. Purushotham et al. (1991) also reports variable responses of different genotypes in ratoon crop after clipping, whereas Kang (1987) and Kang et al. (1989) conclude that winter defoliation does not affect grain yield but reduces lodging. These conflicting results are due to differences in environment, sowing date, and cultural practices. The response of a defoliated crop is highly dependent on the stage of the crop at the time of clipping. Late clipping reduces ratoon yield, crop soil fertility, and availability of moisture in spring.

Crude protein (CP) content ranged from 9.4 to 22.5% in all 44 entries. However, in the top forage yielding lines, CP ranged from 13.6 to 21.3%, compared to 19.6% in the check cultivars (Table 4). Crude protein is highly influenced by soil fertility, stage of the crop at the time of harvest, and genotype, as reported by Varma et al. (1990), DiRienzo et al. (1991), and Pahl (1990).

Based on these studies we have classified the lines into three groups: grain, fodder, and dual purpose types. From these studies it is obvious that early maturing lines give higher forage yield when clipped in early spring than late maturity types. However, the grain yield from the ratoon crop drops drastically at final harvest.

Winter Barley

The data on agronomic traits, and forage and grain yield for the nine top-yielding lines, along with three check cultivars (Arta, Tokak, and Zarjau) are presented in Table 5. There are major differences in forage production and crude protein, which is in conformity with earlier studies (Kang et al. 1989; Kang 1987). The majority of the lines included in this trial have a relatively high vernalization requirement and are responsive to long day length. Though significant differences in days to heading were observed, they all matured at almost the same time.

Table 4. Characteristics of top-yielding, facultative-type forage barley lines.

Variety/Line	GH	DH	DM	PH (cm)	Forage yield [†] (kg/ha)	CP (%)	Grain yield (kg/ha)	Total dry biomass
Rihane 03/Rihane 08	3	120	159	120	15,840 (510)	16.2	4,814	15,150
ICB100709/Rihane 03	3	115	155	80	15,350 (645)	18.1	3,154	8,830
ICB105932/Marageh	3	120	161	100	13,485 (925)	13.6	3,486	11,566
ICB102998/3/Roho/Alger/Ceres 362	3	120	159	90	12,750 (1,190)	21.3	4,233	13,620
Salamas	3	117	160	90	12,540 (570)	18.2	3,735	11,080
KV/Alt/Arr/Esp/Alger/Ceres 362	2	112	156	80	12,540 (860)	13.6	5,229	12,790
Deir Alla 106/Cel=ICBH88-0134	2	119	155	95	12,510 (470)	14.8	3,901	12,240
Salamas/3/KV/Alger/Ceres 362	3	124	170	90	12,138 (770)	17.9	4,814	10,806
Rihane/Lignee 640//ICB102854	4	120	160	95	12,138 (990)	14.3	4,233	14,200
CWB 117-77-9-7/ICB102411	3	126	159	90	11,595 (570)	17.1	4,150	11,510
Tokak (winter type check)	4	130	172	90	8,388 (1,105)	19.6	3,154	10,240
Arta, local check	3	115	151	80	10,388 (750)	19.6	2,158	10,720
LSD at 5%		9	11	10	1,132 (231)		745	1,252

[†]Total biomass yield of the ratoon crop at maturity.

Table 5. Agronomic traits of top forage yielding winter barley lines.

Variety / Line	GH	DH	DM	PH (cm)	Forage yield [†] (kg/ha)	CP (%)	Total dry biomass (kg/ha)	Grain yield (kg/ha)
Roho/Mazurka// ICB 10320	3	131	178	80	16,345 (300)	13.5	11,160	4,690
Salmas	3	130	178	65	16,110 (240)	19.5	8,350	3,030
Roho/Mazurka// ICB 102411	3	129	178	65	14,160 (400)	18.7	7,650	3,154
Arta-Check	2	132	172	75	13,955 (265)	11.8	7,940	2,935
BMG-86	3	138	172	75	13,425 (235)	10.5	8,540	3,569
K247/2401- 10//Vavilon	4	137	178	75	13,000 (205)	13.1	8,500	2,573
Kitchen/Muller Heydla/Salmas	4	144	178	80	12,995 (685)	13.2	10,020	3,818
K247/2401//Vavil on LF7	3	132	178	80	12,960 (280)	10.2	9,960	4,150
Torrent	4	142	180	70	12,900 (560)	10.3	10,620	3,528
CWB117-77//ICB 104078	4	137	178	75	11,580 (990)	10.9	11,610	4,565
Tokak - Check	5	159	180	65	6,505 (850)	11.6	10,350	3,192
Zarjou - Check	3	130	178	80	8,270 (330)	13.2	8,760	3,818
LSD at 05%		11	NS	12	1,245 (85)		1,156	731

[†] Figures in parenthesis are total biomass yield of ratoon crop at maturity.

CP = Crude Protein (N x 6.25).

Table 6: Correlation between total biomass yield and agronomic characteristics in different types of barley.

Traits	Total biomass		
	Spring	Facultative	Winter
Grain yield	0.57**	0.62**	0.41*
Days to maturity	0.55**	0.57**	-0.47*
Days to heading	0.62**	0.53**	-0.40*
Plant height	0.31	0.28	0.22
Harvest Index	0.22	0.17	-0.42*

* P < 0.05.

** P < 0.01.

Interaction between Barley and Livestock Production

In West Asia and North Africa the crop often suffers due to terminal moisture stress and high temperature, which forces the crop to mature rapidly. In this experiment the winter types, which otherwise would have taken longer to mature, had forced maturity due to moisture and high temperature stress.

From the forage yield results it appears that under the Tel Hadya environment, the lines with moderate vernalization perform better than lines with strong vernalization requirements, which suffer more from receding available moisture and high temperature.

However, the yield data on the ratoon crop show that facultative types give higher forage yield and lower grain yield than lines with strong vernalization requirements.

The correlation between total biomass yield and agronomic characteristics in different groups of barley shows that in the spring and facultative types, grain yield, days to maturity, and heading are significantly correlated with total biomass yield. No strong correlation was found between plant height, harvest index, and total biomass yield. In winter types, only grain yield was positively correlated with total biomass, whereas a negative correlation was found between days to heading/maturity and harvest index with total biomass yield (Table 6). Jedel and Helm (1992) also found a highly significant positive correlation between total biomass yield and grain yield. However, they found a highly significant negative correlation between days to anthesis/maturity and total biomass. In the present study, a highly significant correlation was found between total biomass and days to heading/maturity in spring and facultative types, contrary to Jedel and Helm. In winter types, significant negative correlation was found between these traits. From these studies it appears that spring and facultative types can make best use of the available moisture. Therefore it should be possible to select lines that are superior for both traits. However, under Tel Hadya conditions, the winter types are not suitable because of their long growing season. They also suffer badly in spring and early summer due to moisture stress coupled with high temperature. However, they seem to provide a big genetic resource for the development of superior dual-purpose barley varieties.

In North Africa and West/Central Asia, a major portion of barley (grain + straw) is utilized to feed livestock, and a small portion is used for malt and human consumption. In WANA countries the natural pastures currently have low productivity due to overgrazing during the last several years. Therefore sheep and goats depend on grazing barley during winter, and barley fields after harvesting provide excellent grazing ground. In the highlands of WANA, when the ground is covered with snow, the livestock is largely stock fed on barley straw and grain. Therefore, barley is an extremely important crop in these countries.

Due to rapidly increasing population and improvement in living standards, the demand for food (bread, milk, and meat) is growing. To meet this increasing demand, two-way efforts (i.e. expansion in area and per unit increase in production) are being attempted. However, the expansion in cultivated area is taking place at the cost of pastoral land. Since barley gives higher production under moisture stress and low soil fertility, it is being pushed further to marginal areas. During the last 15 years (1980–1994) the area under barley has increased by 13.6%, but the production increase was only 10.3%, i.e. from 20.8 to 22.9 million tons (Table 1), with an average yield of 1,225 kg/ha. The average barley yield for the world is 2,188 kg/ha. The production figures in Table 1 show that none of these countries are getting yield equal to the world average, and 50% of the countries are not even obtaining one half the world average.

During this period, the population in these countries increased by 41%, from 302.1 to 426 million (FAO, 1994). However, livestock (milk and meat animals) production registered only a nominal increase of 5.5%, from 390.2 to 411.6 million head (Table 7). Eight countries had negative growth for livestock production. These figures clearly indicate a seriously aggravated situation. The gap between demand—which can only be met by increasing local production and by imports from other parts of the world—and supply is widening.

To increase local production, Tahir (1993) notes the possibility of increasing cereal production vertically, and the introduction of ley farming (cereal-legume) instead of the cereal-fallow system. There is a significant possibility of both of these options in this region. The experimental results on the performance of new high-yielding lines (Tables 2 and 3) show an average yield of 3.5–4.7 t/ha across environments, compared to 1,225 kg/ha for this region. There is a big yield gap between the experimental farm and farmers' fields. If the present available technology is transferred to farmers, barley production can easily be increased by 50%. From the present area, 22.9 million tons of grain and 45.8 million tons of straw could be obtained on the basis of a 33.3% harvest index. If we succeed in increasing production by 50%, grain and straw production would increase to 34.5 and 68.7 million tons. If we use the calculation basis of Carter (1978), this additional 11.5 million tons of grain, plus 34.5 million tons of straw, would be sufficient to feed 41.3 million ewes or equivalent.

In addition to the above option, the introduction of forage legumes in the cropping pattern will not only increase the availability of feed but also greatly benefit the following cereal crops by increasing soil fertility.

Therefore, it is not a matter of choosing either cereal or livestock production in a given area (Tahir, 1993); rather it is the integration of the two, i.e. cereals

(especially barley) with livestock, which will contribute to the economy of dryland farming in North Africa and West/Central Asia.

Table 7. Status of livestock production (000 head) in North Africa and Central/West Asia.

Country	Draft animals [†]			Milk and meat animals [‡]		
	1980	1994	% Change	1980	1994	% Change
Algeria	1,037	633	-39.0	17,234	22,046	+28.0
Morocco	1,857	1,591	-14.3	24,370	22,466	-7.8
Tunisia	498	598	+20.1	6,060	10,957	+80.8
Afghanistan	2,003	1,748	-12.7	25,268	17,850	-29.4
Azerbaijan	70 [§]	65	-7.1	7,166 [§]	6,285	-12.3
Iran	2,747	2428	-11.6	54,753	76,300	+39.4
Iraq	592	211	-64.4	17,784	8,570	-51.8
Kazakhstan	1,615 [§]	1495	-7.4	46,598 [§]	46,105	-1.1
Kyrgyzstan	375 [§]	360	-4.0	10,894 [§]	85,22	-21.8
Pakistan	3,816	5,456	+43.0	75,638	10,7348	+41.9
Tajikistan	134 [§]	135	-0.7	4,290 [§]	4,135	-3.6
Turkey	1,661	1465	-11.8	81,465	59,909	-26.5
Turkmenistan	86 [§]	85	-1.2	6,650 [§]	7,577	+13.9
Uzbekistan	279 [§]	290	+3.9	15,055 [§]	15,263	+1.4
Total	17,901	1,656 [§]	-7.5	390,225	411,634	+5.5

[†] Horses, mules, asses, and camels.

[‡] Cattle, buffaloes, pig, sheep, and goats.

[§] Figures for 1992.

Source: FAO Year Book (1994).

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Discussion

Bram de Hoop: Is there no risk of loss of biodiversity due to barley being expelled from its original crop lands to marginal lands?

M. Tahir: The straight answer is “yes,” unless it is conserved.

M. Ben Younes: Since the 1980s, barley yield has not increased very much in many WANA countries. My understanding is that we have no doubt about the performance of the new varieties developed by plant breeders in the region, but that we need vertical yield increases through the use of better agronomic practices to increase barley yields. What do you think?

M. Tahir: There is no doubt that better production technology is the basic requirement to increase production. In the production package, new varieties are just one—albeit very important—component. Therefore, if a new variety is released with better production technology, the production will increase significantly. The shift in barley cultivation in more marginal and stressed area is primarily responsible for low and unstable production. Therefore we should raise this issue at a higher level to draw lines demarcating where it is economical to cultivate barley.

A. Osman: How can the feed gap be closed by introducing or growing new barley varieties at a time when no control or check is imposed on livestock numbers?

M. Tahir: The feed gap cannot be reduced without some form of control to restrict the increase in livestock numbers. However, by increasing feed availability, and by introducing high yielding, better quality barley varieties, this rapidly widening gap can be narrowed to a certain degree, which will be proportional to the increase in area under new variety production technology on the one hand, and livestock number on the other hand. Unrestricted increases in livestock number will undoubtedly result in a bigger feed supply-demand gap.

The Future of Landraces

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Abstract

The barley grown in most of the semi-arid regions (SARs) of Tunisia is almost exclusively local cultivars. The productivity of these cultivars is very low, hence there is a need to select for improved agronomic types and better yielders within these populations. A serious limitation to barley production in the SARs is the narrow genetic base of the new cultivars and their lack of adaptability to harsh environmental conditions. The exploitation of existing genetic variability within the landraces will allow researchers to develop stable and adapted varieties that can survive the SARs' harsh environmental conditions. The low productivity of the landrace cultivars can be improved by extracting individual cultivars or by crossing them with high-yielding lines. Improved landrace cultivars have been tested at different locations in Tunisia's SARs. A number of selected lines and populations outyielded the local check, Rihane, during favorable and unfavorable crop seasons.

Use of Landraces In Breeding Programs

Semi-arid regions cover large parts of northwest, central, and southern Tunisia. The SAR area currently under cereal production represents 71% of the country's total production area (Ministry of Agriculture 1992). In these regions, barley is the most adapted crop, representing about 40% of the cereal area in the SARs. The cultivated barley in the center and south is almost exclusively local cultivars that have become, over time, adapted to local growing conditions. The productivity of these landrace cultivars is very low, therefore selection for improved agronomic types, for better yield, is needed to improve barley production in these areas.

In the SARs, stable varieties are needed, cultivated under traditional management, which are also responsive to whatever improved management farmers can afford. National and international programs have developed varieties that perform well under optimal growing conditions, particularly in the north, where improved soil, water, and crop management techniques have increased production (Hepworth et al. 1975). But the genetic potential of the newly developed germplasm cannot be realized in the SARs due to the lack of good management practices.

Another serious limitation to increasing yield under the harsh environment of the SARs is the narrow germplasm base of many high-yielding varieties. Narrowing the genetic base is a common trend in many plant breeding programs, and is accompanied by heterogenicity (Simmons 1983). There is a need to recover and maintain genetic variability and to exploit this variability to stabilize and increase production in the marginal areas. In the SARs, this genetic variability gives the landrace an adaptive advantage over pure line varieties. The landrace is a

heterogeneous mixture of different genotypes, giving the cultivar the flexibility to produce grain under adverse environmental conditions.

Certain authors recognize that landraces will consistently yield at least something, despite stress factors. They have an excellent general fitness for local conditions and a wide spectrum of resistance to disease (Harlan 1976). Barley landraces from many collection sites in Syria and Jordan have been evaluated for agronomic characteristics (Ceccarelli et al. 1987) and for disease resistance (Van Leur et al. 1989). High diversity for all characteristics studied was found among and within collection sites. Landrace cultivars collected in Tunisia show high variability in maturity (Fig. 1) and adequate resistance to scald and powdery mildew (Fig. 2).

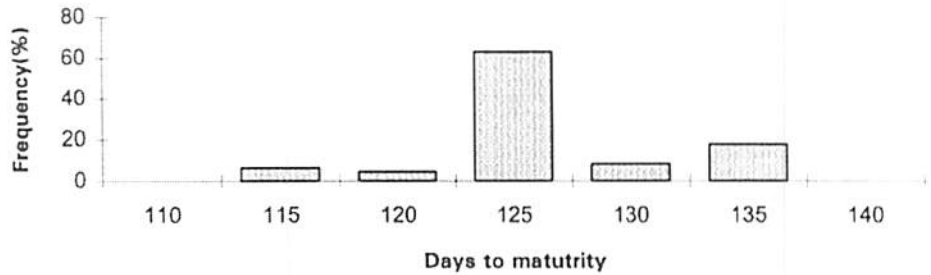


Figure 1. Frequency distribution of maturity range for 157 landraces.

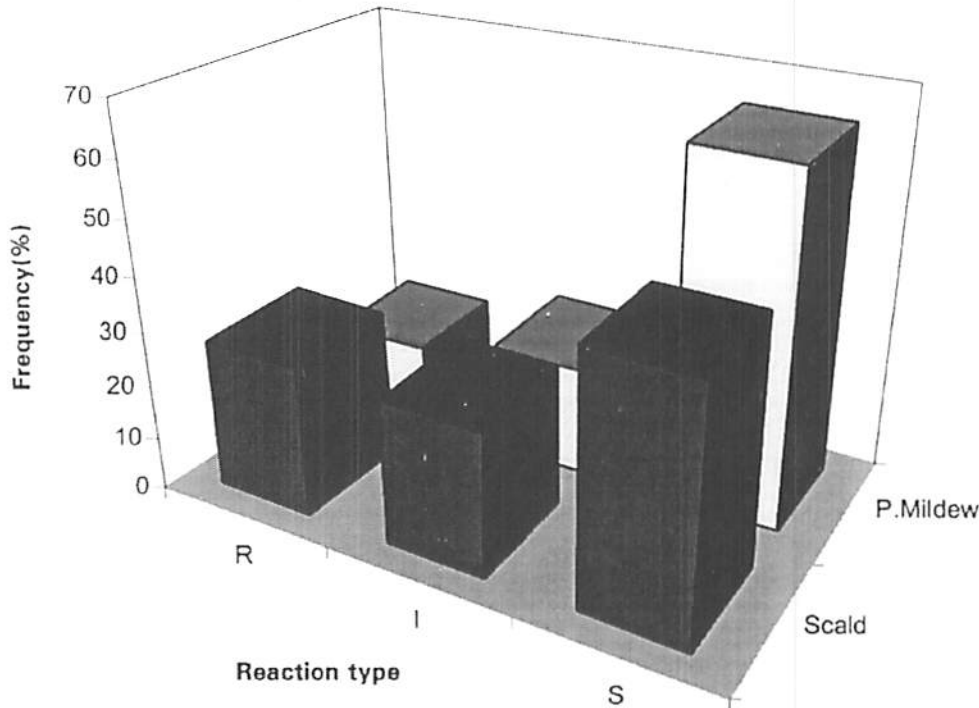


Figure 2. Reaction of 157 landraces to scald and powdery mildew.

Locally adapted germplasm has low yield potential and is quite often susceptible to disease, particularly when evaluated as a population and grown under favorable climatic conditions. This can change when individual genotypes from landraces are evaluated (Ceccarelli et al. 1987; Van Leur et al. 1989; Weltzien 1982).

Figure 3 shows the yield performance of barley lines extracted from landrace populations and pure selected barley lines. The average yield of the local check variety Rihane was 1m006 kg/ha at Krib and 737 kg/ha at Kef.

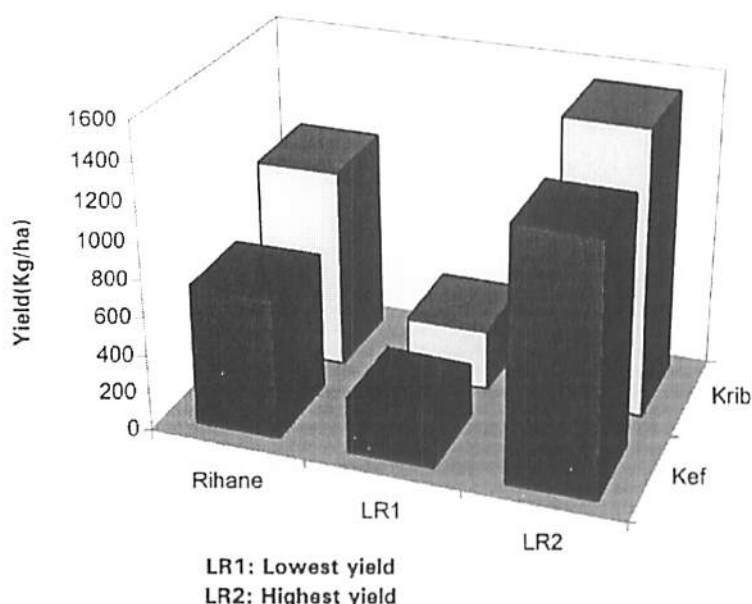


Figure 3. Yield performance, improved barley landraces at Kef and Krib (1995).

The productivity of landrace cultivars can be improved by crossing them with high-yielding lines. Figure 4 shows the yield performance of 16 accessions from landrace $\times$ high-yielding variety crosses; 11 lines outyielded Rihane at the Kef station. Improved landrace genotypes were tested, together with both commercial barley varieties and advanced pure lines, over four years in regional on-farm trials at five locations in areas of Tunisia receiving less than 350 mm annual rainfall (Fig. 5). Varietal improvement based on the use of landraces as parents is impressive (Fig. 4). Landraces contribute to yield increase by transferring the gene(s) for disease resistance (Yahyaoui 1986) and through drought tolerance and some genetic components for adaptation (Chang 1985).

Landraces have a substantial amount of variability within the population for a variety of traits (Grando and McGee 1990). Adaptation and stability performance under adverse and variable conditions are both likely to be associated with genetic heterogeneity. An adequate level of heterogeneity has to be maintained in the landrace populations. This can be accomplished by creating mixtures of superior lines extracted from landraces. The efficiency of selection is high when direct selection is applied on lines extracted from landraces grown in the target environment (Ceccarelli and Grando 1989), and where adapted germplasm can fully show its advantage.

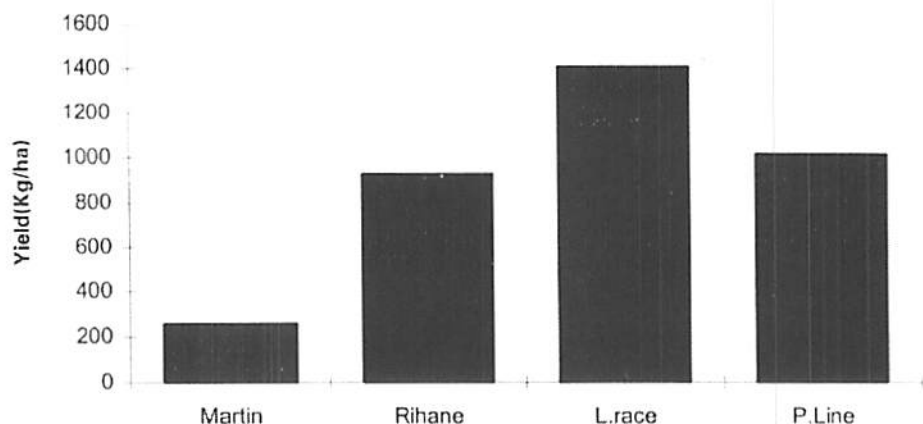


Figure 4. Yield performance of landraces and pure lines at Kef (1995).

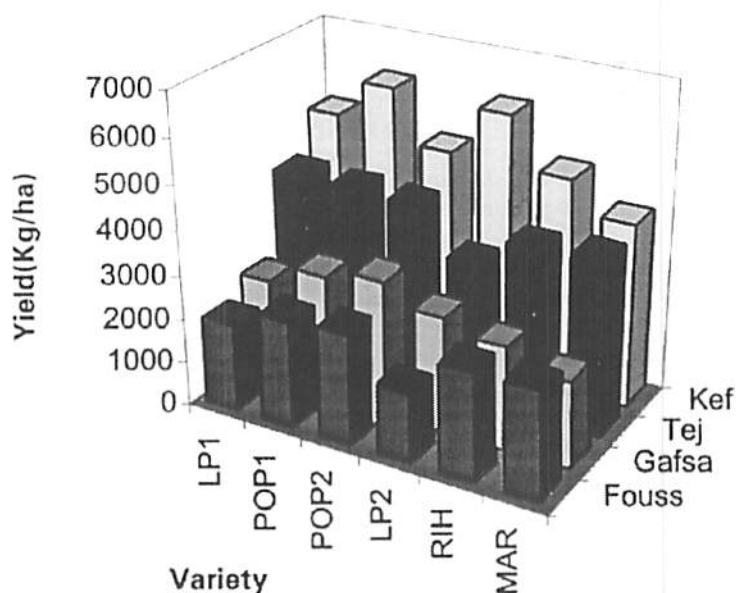


Figure 5. Average grain yield (kg/ha) over four years (1990–1994) in the SARs.

Figures 3, 4, and 5 show the relative yield variability within Tunisian landraces and improved cultivars. Landraces are recognizable morphologically. They differ in optimal seeding date, date of maturity (Fig. 2), and height. Farmers have designated names for the cultivated landrace in their area. Variability within the population allows it to tune itself and respond to the unpredictable and variable environmental conditions it may encounter during the crop cycle. The yield performance of landraces during the 1994/1995 season is encouraging (Fig. 4). The average yield of the lines tested was higher than the check cultivar Rihane. Eleven out of the 16 lines tested for yield outyielded Rihane.

Conclusions

Landraces are genetically diverse and have a certain genetic integrity (Harlan 1975). The genetic variability of landraces provides an insurance against possible hazards in a plant's environment. Their ability to adapt to a fluctuating environment underlies the long-term nature of their stability and dependability.

Growing locally-adapted material in stressful environments is extremely important. International centers need to put more emphasis on producing advanced breeding stocks rather than finished varieties for national programs to use in their own research programs. In conclusion, it is appropriate to quote from the work by Harlan and Martini, originally published in 1936:

"In the great laboratory of Asia, Europe, and Africa, unguided barley breeding has been going on for thousands of years. Types without number have arisen over an enormous area. The better ones have survived in the hinterlands of Asia where there were probably barley fields when man was young. The progenies of these fields with all their surviving variation constitute the world's priceless reservoir of germplasm. Unfortunately, from the breeder's standpoint, it is now being imperiled. When new barleys replace those grown by the farmers of Ethiopia or Tibet, the world will have lost something irreplaceable."

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Discussion

Baha A. Al-Rawi: Regarding development of pure lines from landraces, we have tried this method and developed about 720 lines from three different landraces in Iraq. Nonetheless, we ended up with lines that are not as productive as the landraces from which these lines were extracted.

A. Al-Shamma: When crossing local lines with improved cultivars, do you expect to widen the adaptation capacity and, if so, will that have an effect on yield under stress environments?

A. Yahyaoui: It possible to widen the adaptation capacity of the improved cultivar, which would allow it to perform better under stress environments. Crosses of landrace $\times$ Rihane, F_6 (fixed selection) have given better yield than Rihane in the semi-arid area for the past four cropping seasons, including bad years (1993/94 and 1994/95). They have given better yields than the landrace parents during the good, average years, but slightly less than the original improved population.

B. Jamal: Don't you think that using two-rowed barley genotypes will provide more drought tolerance genes for low rainfall areas than the six-row material? In Syria, we have succeeded in selecting high-yielding barley cultivars from the two-row landraces.

A. Yahyaoui: Your statement is correct for the approach in using local adopted material in breeding programs. To my knowledge the landrace cultivars lose their adaptive advantage if you grow them under different climatic conditions. Selection must be made under new environments.

The use of the Syrian landraces in our areas would be possible, but I would not assume that they will have a yield advantage over our local barley. It is not always true that two-row barley outyields six-row barley. On the other hand, farmers in our region prefer six-row barley, and even reject the idea of trying to grow two-row barley.

Introduction and Spread of Rihane 03 In Northern Iraq

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Abstract

The Rihane 03 barley cultivar was introduced into Iraq in 1985 in cooperation with ICARDA. During the initial replicated yield tests (1986–1989) at Hammam Al-Alile (250–350 mm average annual rainfall) it exceeded the local Aswad barley by 33% the first year, 124% the second year, and 54% the third year.

In 1991 implementation began on a plan to spread this cultivar in the limited and moderate rainfall regions of northern Iraq. The cultivar was planted at seven locations (22 ha) in farmers' fields. It exceeded the local variety by 14% in straw yield and 31% in grain yield. Total production in 1992/93 was 129 tons. The area was expanded to 494 ha in 1994, with total production of 761 tons and an average yield of 1,544 kg/ha (the range was 600–2,597 kg/ha). During 1994/95 the area was expanded to 5,000 ha with 78 farmers. Production was over 4,000 tons and the range of grain yield was 528 to 2,572 kg/ha. Rihane 03 exceeded the local average by 13–206% at different locations and with different farmers. The plan calls for expansion onto 250,000 ha by 1997. The cultivar was favored by the farmers for its lodging resistance, high potential yield (up to 4,000 kg/ha under good rainfall and fertilization), good protein content (13%), and suitability for breadmaking (a 50% mix with wheat flour or even baked alone). Also, it is a dual-purpose barley that can be grazed and still give good grain yield.

Introduction

Barley (*Hordeum vulgare* L.) is considered the second largest cereal crop after wheat, in both area and production, in the rainfed areas of Iraq. In 1994, it was planted on 0.776 million ha and produced 0.132 million tons. It is more highly adapted to the limited rainfall zone (200–350 mm) than wheat (Al-Fakhry 1981; Ceccarelli 1984). The local Aswad (LA) is the principle barley variety planted across the different rainfall zones. It is a landrace with different grain colors (ranging from white to black), and is highly susceptible to lodging and powdery mildew. Its yield potential rarely exceeds 600 kg/ha.

Rihane 03's main use is for grazing and sheep feeding. It is not suitable for breadmaking in the area. The limited barley cultivars in the region justify introduction and breeding of new barley cultivars with wide adaptation to the local environmental. Breeding efforts also produced Mosul 72 (Tamimi et al. 1975). Gezire 1, Gezire 2 (1992), and Tuwiatha (1992) are not yet widespread enough to affect production levels for various reasons.

Method of Introduction and Study of Rihane 03

During 1985 an observation nursery for barley was obtained from ICARDA. The nursery included 90 lines, which were planted at the Hammam Al-Alil station of the College of Agriculture and Forestry, University of Mosul (25 km south of Mosul). Rihane 03 was one of the best lines selected. It produced 1,830 kg/ha. The variety was tested in replicated yield trials from 1986 to 1989 (Adary 1989). The rainfall at the station was 252, 204, 540, and 250 mm annually during the four years of the experiment. The local two-rowed black barley was used as a check variety. Rihane 03's performance, together with Harmal and the LA, was evaluated using fertilization (NP) and supplementary irrigation during 1988 and 1989 (Adary et al. 1991).

In 1991/92, Rihane 03 was planted on large-scale on-farm demonstrations in seven locations throughout the Mashreq Project, with Gezira 1 (six-rowed black) and LA as checks. The plots were 2–5 ha, planted using modern equipment to drill the seed (120 kg/ha), and fertilized by 160 kg/ha of a compound NPK fertilizer (27:27:0). The area was expanded during 1992/93 to 107 ha at various locations in Al-Gezira, including two irrigated sites at Baghdad and Al-Wota (on the Euphrates Bank near Ana). Table 5 presents the number of farmers, areas, and production for Rihane during 1991–1995. The target of the project is to reach 60,000 ha by 1997. The Rihane 03 cultivar was officially certified for release in 1993. During the 1992/93 season, heavy rain led to widespread lodging in the local variety throughout Al-Jezira, whereas Rihane 03 fared well.

A list of over 200 farmers willing to plant Rihane 03 in 1995/96 was prepared. The project purchased the total production during 1995 in order to redistribute it to a large number of farmers in the region. A variety maintenance program was initiated in 1995 to get high-quality seed to maintain the purity of the cultivar.

Results and Discussion

Productivity of Rihane 03 in 1986–1989 at Hammam Al-Alil station is presented in Table 1. Yield ranged from 700 to 2,127 kg/ha, significantly exceeding the LA.

Table 1. Productivity of Rihane 03 compared to the LA and percentage increase over LA at Hammam Al-Alil (1986–1989).

Season	Rihane 03	LA	Increase (%)	Remarks
1986/87	1,344	1,008	33	no fertilizer
1987/88	700	308	124	no fertilizer
1988/89	2,124	1,360	54	with fertilizer

Source: Adary (1989).

Table 2 shows the response of Rihane 03 to supplementary irrigation and NP fertilization in comparison with LA. Rihane 03 had a higher response to good environment and reached 4,440 kg/ha with 80 kg/ha of NP and one supplementary irrigation. LA had a much lower response to fertilization or irrigation. This result is very significant to northern Iraq, where supplementary irrigation facilities have been undertaken and could be utilized.

Table 2. Response of Rihane 03 to fertilization and supplementary irrigation at Hammam Al-Alil (1986/87).

Variety	NP kg/ha	Rainfed + one supplementary irr.	Rainfed
Rihane 03	0	1,804	1,891
	40	2,772	1,753
	80	4,440	3,736
Average		3,005	2,460
LA	0	1,720	2,412
	40	2,656	1,696
	80	2,296	2,679
Average		2,224	2,353

Source: Adary et al. (1990).

In large-scale demonstrations during 1991/92 (Table 3), Rihane 03 production ranged from 1,200 to 3,400 kg/ha, proving its high production potential in the farmers' fields.

Table 3. Farmers, area planted with Rihane 03, and total production (1991/92).

Farmer	Location	Area (ha)	Total production	Average yield
M. Abdul Rahman	Fasta	2.0	2.828	1,414
N. Jalood	Hukna	2.0	4.083	2,041
J. Hasani	Kahriz	2.5	3.100	1,240
A. Zugair	Ain Husan	2.0	3.850	1,925
M. Sadoon	Tel-Morak	1.5	3.180	2,120
Kirkuk Station	Kirkuk	12.5	25.000	2,000
Mosul Station	Rashidia	0.250 m ²	0.085	3,400

Source: Mashreq Project Annual Report (1992).

Rihane 03 was superior to LA both in grain (31%) and straw yield (14%) at most locations. It also exceeded Gezira 1 (improved six-rowed black variety) by 19% in grain yield and 42% in straw yield (Table 4).

Table 4. Straw and grain yield (kg/ha) for Rihane 03 compared to Gezira 1 and LA (1991/92).

Location	Rihane		Gezira 1		LA		Increase over LA (%)	
	GY	Str	GY	Str	GY	Str.	GY	Str.
Fasta	2,828	2,504	1,624	1,888	1,510	2,246	87	11
Hukna	2,832	2,790	2,274	2,052	1,862	1,908	52	46
Ain Husan	1,814	4,362	2,468	2,692	2,120	3,850	4*	13
Kahriz	2,580	3,238	2,068	2,474	2,168	3,296	19	-1
Mean	2,513	3,223	2,108	2,276	1,919	2,850	31	14

Source: Mashreq Project Annual Report (1992).

The spread of Rihane 03 in northern Iraq grew from seven farmers in 1991 to more than 120 farmers in 1995 (Table 5). The expansion in area was from 22 ha in 1991 to 5,000 ha of harvested area in 1995. There was enough seed available to plant about 30,000 ha in 1995/96.

Table 5. Number of farmers, areas, total seed production and average yield of Rihane 03 (1991–1997).

Year	No. of farmers	Area (ha)	Total seed received	Average kg/ha	Range (kg/ha)
1991/92	7	22	40	2,020	1,240–3,400
1992/93	12	107	120	2,086	832–3,840
1993/94	27	494	761	1,544	600–2,597
1994/95	78	5,000	4,040	1,223	528–2,568
1995/96	7,120	30,000			
1996/97		60,000		Target	

Productivity In 1995

In 1995 Rihane 03 was planted on 78 farmers' fields and stations under three environmental conditions: low-yielding (250–350 mm average annual rainfall), moderately-yielding (350–400 mm average annual rainfall), and high-yielding (>450 mm). The combined grain yield means are presented in Table 6.

Table 6. Means and range of grain yield (kg/ha) for Rihane 03 in three environments (1995).

Environment	No. of farmers	Grain yield kg/ha	Range over LA	Increase (%)
LYE	23	1,038	528–2,004	101.0
MYE	17	1,351	924–2,168	84.6
HYE	6	1,803	1,156–2,572	92.6

LYE = low-yielding environment; MYE = moderately yielding environment; HYE = high yielding environment.

The results show consistently higher averages than LA in all environments. This indicates the stability of performance, compared to LA, across the Gezira region.

Marketed production of Rihane 03 barley was 4,040 tons, at an average of 1,223 kg/ha (528–2,564 kg/ha). The increase over the local check (official number) was 19–289%. Table 7 presents a partial list of distinguished farmers who achieved yields above the average (>1,223 kg/ha). There are pronounced differences from the local average for each region. Rihane 03 outperformed the local variety in lodging resistance and lower infestation with weeds and nematodes. There is a long waiting list of farmers willing to plant Rihane 03 next season. One unexpected result was the willingness of farmers to use the barley in breadmaking, with wheat flour (50:50) or alone. It has an acceptable taste, and was extensively used at Shuwarate and Telafer. The protein content of Rihane is 13%.

Table 7. Productivity of Rihane 03 for selected farmers in 1994/95 (partial list).

Farmer	Location	Area (ha)	Grain yield (kg/ha)	Location mean (LA)	Percent increase (kg/ha)
1. Y. Hamed	Mukhazaka	250	2,252	704	220
2. M.Wahab	Mahalabya	50	1,668	596	180
3. H. Barakat	Zumar	125	1,228	872	41
4. A. Ghulami	Hamdanya	125	1,852	732	153
5. A.F. Salim	Nemrud	375	1,900	756	151
6. U.A. Najafi	Nemrud	250	1,332	756	76
7. A.Y. Abdalla	Hamdanya	125	1,340	732	83
8. T.S. Abdulaziz	Alkana	15	2,240	936	139
9. H.M. Hassan	Hamdanya	25	1,248	732	70
10. K.M. Ali	Shoora	7.5	1,320	556	137
11. S.M. Azawi	Shuwarat	5	1,272	556	129
12. K.H. Kanaan		2.5	1,760	556	216
13. A.S. Sulabi	Rabea	7.5	1,792	936	88
14. S.I. Abas	Eiathya	15	1,564	724	116
15. A.H. Habel	Shuwarat	7.5	1,580	556	184
16. M. N. Fatah		7.5	2,010	556	262
17. A.K. Ali	Rabea	32	1,596	936	71
18. K.A. Hussain	Hamdanya	7.5	2,168	704	208
19. Hamedate st.	Hamedate	20	2,152	712	201
20. Rabea st.	Rabea	8	2,564	936	174

Certification of Rihane 03

The Rihane 03 cultivar was officially accepted for release to the farmers in northern Iraq during 1993. It is a dual-purpose barley suitable for grazing and gives good grain yield after suitable management. It is adopted to the dry local conditions, is lodging-resistant, and is a high yielding cultivar with good response to fertilizer and moisture. A variety maintenance program is underway to maintain the purity of the Rihane 03 cultivar.

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Discussion

A. Osman: To reach your target acreage with Rihane 03, are you providing seed to the farmers or are the farmers providing their own seeds?

A. Adary: We provided the seed to the farmers in 1993/94. In 1994/95 we bought seed from the farmers and redistributed it to a larger number of farmers.

F. Nassif: Was the Rihane 03 seed provided to farmer free of charge?

A. Adary: No, they always paid for it. They never got the seed free.

Bram de Hoop: Are you not afraid of the loss of valuable landraces by encouraging Rihane 03?

A. Adary: Yes, we are afraid of this and therefore no more than the 250,000 targeted hectares will be allocated to Rihane 03.

F. Nassif: How were farmers selected?

A. Adary: Farmers were chosen among those who had the desire to cooperate with us, who wanted to grow improved varieties and compare them with their landrace. Later on some of those farmers became involved in Rihane seed production.

A. Yassin: Neither Rihane 03 nor LA yields were better than the yields when no fertilizer was applied and one irrigation supplied.

A. Adary: The area had good rainfall in some years, and Rihane 03 had a better response to fertilizer because of its lodging resistance. We need to increase barley production through both variety and fertilization.

A. Al-Shamma: Rihane 03 is a six-rowed barley and one cannot expect it to segregate to two-row types, because six-rowed is recessive to two-row.

B. Jamal: By studying Rihaan 03 in Syria, we observed that it requires high moisture, and also a small amount of segregation. Did you observe this in Iraq?

A. Adary: We experimented with Rihane 03 at different rainfed zones, from 200 mm to over 400 mm. We found it to be better than the local variety. However, it is true that it responded better to good environment, higher rainfall, and supplementary irrigation.

Accurate Timing of Nitrogen can Increase Barley Grain Yield

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Abstract

In Iraq, traditional top-dressing of nitrogen is based on calendar date, i.e. 45 days from sowing. However, this is not the most effective use of nitrogen, because the development stage of the crop at that time is ignored. The objective of this study was to investigate the importance of timing the recommended rate of nitrogen fertilizer according to certain developmental stages of the apex. A two-year field study using widely grown cultivars, Arivate (*Hordeum vulgare* L.—six-rowed barley) and Clipper (*Hordeum distichum* L.—two-rowed barley), was conducted during 1992/1993 and 1993/94 at the experimental farm of the College of Agriculture at Abu Ghraib, Iraq. Applications were timed to coincide with double ridge, maximum spikelet number, and booting stages.

In general, nitrogen application split, two or three times, resulted in a significant increase of grain yield for both cultivars in both seasons compared with the traditional method of application. This increase in grain yield was associated with significant increases in ear number/m², 1,000 kernel weight (g), total biomass (g/m²), and, more interestingly, the harvest index, especially for the three-time application. However, late single application at booting stage tended to reduce grain yield of both cultivars due to decreased ear number and total biomass. For the cultivars studied, Arivate outyielded Clipper in both seasons due to higher 1,000 kernel weight, total biomass, and harvest index.

In conclusion, this study suggests nitrogen should be applied at certain critical development stages when the crop's demand for nitrogen is high.

Introduction

Nitrogen is a major requirement for high barley yield, and nitrogen fertilization is usually essential for soil low in organic matter or when recropping after non-legume crops. The timing of the application is equally if not more important than the amount of nitrogen used. In Iraq, traditional top-dressing of nitrogen for cereals, including barley, is based on calendar date, i.e. 45 days from sowing. However, in developed countries, cereal growers and advisors recognize the need to develop more precise management strategies in order to produce high-yield crops. This requires an understanding of cereal growth and development in the field. The development of the cereal apex (spike) has been described by several authors (Bonnet 1966; Kirby 1974 1977; Thomson and Mathews 1984) and can be followed using the dissection technique illustrated by Kirby and Appleyard

(1984). The idea of shifting from calendar date to apex development is based on the fact that barley grain yield can be divided into several components. These components are dependent upon processes controlling apical development and grain filling (Ma and Smith 1991). Moreover, throughout the life cycle of barley there are marked changes in development and growth patterns. It is therefore not surprising that the plant responds differently to various treatments at different stages. Accordingly, nitrogen fertilizer can be used more efficiently by splitting the applications to minimize volatilization, immobilization, leaching, and denitrification losses (Hocking et al. 1984), and probably further improved if the applications are synchronized with the needs of the crops, as shown for wheat (Appleton and Haggard 1985).

The objective of this study was to emphasize the importance of timing the recommended rate of nitrogen fertilizer according to a particular spike development stage, and its influence on the grain yield and yield components of two barley cultivars widely grown in Iraq.

Materials and Methods

A field experiment was conducted at the experimental farm, College of Agriculture, Abu Ghraib, during 1992/93 and 1993/94 on silty clay loam (Table 1).

Table 1. Analysis of soil.

	Soil depth (cm)			
	0-15	15-30	30-45	0-45
Lime (meq/100 g soil)	16.7	17.75	17.75	10.26
Gypsum (%)	nil	nil	nil	nil
Organic matter (%)	1.47	1.37	0.63	1.29
P (ppm)	24	24	12	17.65
N (%)	1.4	3.5	2.8	4.10
K (meq/100 g soil)	0.40	0.38	0.33	0.36
CEC	21.5	19.5	22.7	19.75
EC	3.2	3.9	3.8	3.7
pH	7.7			
Soil texture	Clay loam	Silty clay loam	Silty clay loam	Silty clay loam
Clay (%)	34	36	31	37
Silt (%)	22	15	27	25
Sand (%)	44	49	42	28
Ca ⁺² (meq/L)	22	15	17	8
Mg ⁺² (meq/L)	30	25	22	31
Cl ⁻ (meq/L)	25	36	20	31
HCO ⁻³ (meq/L)	23	20	18	26

Two barley cultivars were used: Arivate (six rows) and Clipper (two rows). The experimental design used was a split plot with three replicates, where cultivars occupied the main plots and nitrogen timings the sub-plots. Plot dimensions were

2m × 3m. Rows were spaced 20 cm apart. Seeding rate was 100 kg/ha, at a depth of 5 cm. The recommended rate of fertilizer was 200 kg/ha of super phosphate (46% P₂O₅) applied as basic fertilizer at seed bed preparation and 200 kg/ha of urea (46% N). Details of the nitrogen treatments were as follows:

- A (control) 1/2 at seedbed preparation + 1/2 at 45 days from sowing (traditional method).
- B 1/4 at seedbed preparation + 1/4 at double ridges + 1/4 at maximum spikelet number + 1/4 at booting.
- C 1/3 at seedbed preparation + 1/3 at maximum spikelet number + 1/3 at booting stage.
- D 1/3 at seedbed preparation + 1/3 at double ridges + 1/3 at booting.
- E 1/3 at seedbed preparation + 1/3 at double ridges + 1/3 at maximum spikelet number.
- F 1/2 at seedbed preparation + 1/2 at double ridges.
- G 1/2 at seedbed preparation + 1/2 at maximum spikelet number.
- H 1/2 at seedbed preparation + 1/2 at booting.

Dates of sowing and times of nitrogen application were:

Growing season	Sowing date	45 days	Double ridges	Maximum spikelet number	Booting stage
1992/93	8/11/1992	23/12/1992	10/2/92	31/1/93	28/2/93
1993/94	2/12/1993	18/1/1994	10/1/94	11/2/94	9/3/94

To identify the stages of double ridges and maximum spikelet number for nitrogen application, the following steps were followed (Jaddoa 1985):

1. Ten plants were randomly chosen from each replicate for dissection of apex at each time of monitoring.
2. Plants were carefully examined, main stems picked out, and tillers discarded.
3. The roots of the stems were carefully removed using a scalpel.
4. The outer leaves were gently peeled away from the main stems. Leaves were separated and peeled back down to the youngest leaves.
5. The last (youngest) leaf was gently removed to expose the main stem's apices. Apice development was assessed with the aid of a hand lens or, preferably, a low-power stereo microscope, according to Kirby and Appleyard (1984).

For measurement of grain yield components, one square meter was identified in each plot at early tillering and was left without disturbance until maturity. The data obtained for each measured trait were subjected to variance analysis (ANOVA).

Results

Ear Number/m²

Table 2 shows the effect of application timing on ear number/m² of both cultivars in both seasons. No significant differences were found in 1992/93. In 1993/94, Clipper significantly gave more ears (317 ear/m²) than Arivate (223 ear/m²). Splitting the application two or three times (treatments B, C, D, and E) gave the highest increases in ear number, an effect more marked in the B treatment in both seasons. Treatment H (late single application) tended to decrease this character. Although the interaction between cultivar and timing was not significant, it is clear from Table 2 that Clipper responded more than Arivate, especially in 1992/93.

Table 2. Effect of time of nitrogen application on ear number/m² of two barley cultivars in two seasons.

		Nitrogen treatments	Arivate	Clipper	Mean
1992/93		A	259.0	224.0	239.8
		B	299.0	323.0	311.3
		C	270.0	299.0	284.6
		D	278.0	303.0	290.6
		E	292.0	308.0	300.5
		F	263.0	280.0	272.0
		G	265.0	246.0	256.0
		H	240.0	223.0	231.6
		mean	270.5	276.1	
LSD	(.05)				
C	ns				
N	22.3				
C × N	ns				
1993/94		A	204.0	297.0	250.8
		B	284.0	357.0	329.8
		C	223.0	315.0	269.3
		D	230.0	348.0	289.1
		E	250.0	369.0	309.5
		F	208.0	286.0	247.1
		G	197.0	279.0	238.1
		H	187.0	267.0	227.1
		mean	223.1	317.1	
LSD	(.05)				
C	31.2				
N	25.9				
C × N	ns				

Thousand Kernel Weight

The effect of time of application on this character is given in Table 3. Arivate significantly surpassed Clipper in 1,000 kernel weight in both seasons. In 1992/93 all nitrogen treatments significantly increased 1,000 kernel weight compared with the A treatment, with the highest increase from the H treatment. In 1993/94, a similar response was found, except for the treatment, where 1,000 kernel weight was less (42.9 g) than in 1992/93 (50.4 g). In 1992/93, Arivate responded to the H treatment by giving highest 1,000 grain weight (54 g), while Clipper benefited from the E treatment. However, in 1993/94 both cultivars responded similarly to the B treatment.

Table 3. Effect of time of nitrogen application on 1,000 kernel weight (g) of two barley cultivars in two seasons.

		Nitrogen treatments	Arivate	Clipper	Mean
1992/93		A	42.9	43.7	43.1
		B	47.9	47.5	47.7
		C	47.8	44.4	46.1
		D	49.1	45.8	47.4
		E	46.2	47.7	46.9
		F	44.4	46.5	45.4
		G	49.0	47.1	48.3
		H	54.0	46.9	50.4
		mean	47.6	46.2	
LSD	(.05)				
C	0.78				
N	2.9				
C × N	4.2				
1993/94		A	43.3	41.2	42.3
		B	48.2	43.0	45.6
		C	46.0	41.5	43.7
		D	47.7	42.0	44.8
		E	43.6	42.8	43.2
		F	44.0	41.7	42.8
		G	41.4	41.3	41.3
		H	45.4	40.3	42.9
		mean	44.9	41.7	
LSD	(.05)				
C	2.59				
N	1.5				
C × N	2.2				

Grain Yield g/m²

The effect of timing on grain yield of both cultivars in both seasons is illustrated in Table 4. Significant differences between cultivars were obtained in 1992/93, during which Arivate outyielded Clipper (41%). In 1993/94, the same trend was found, but was not significant. It is clear from Table 4 that splitting the nitrogen application two or three times resulted in significant increases in grain yield in both seasons, following the pattern for ear number (Table 2). In 1992/93, Arivate and Clipper responded similarly to treatment B (grain increases of 40 and 38%, respectively). In 1993/94, the interaction between cultivar and application timing was not significant.

Table 4. Effect of time of nitrogen application on grain yield (g/m²) for two barley cultivars in two seasons.

		Nitrogen treatments	Arivate	Clipper	Mean
1992/93		A	292.0	201.2	246.6
		B	407.7	277.9	342.8
		C	358.1	38.4	298.2
		D	385.4	256.9	321.1
		F	305.9	235.2	270.5
		G	278.1	220.2	249.2
		H	235.4	181.2	209.7
		Mean	331.0	234.5	
LSD	(.05)				
C	13.72				
N	21.8				
C × N	30.9				
1993/94		A	256.3	195.6	226.0
		B	337.3	247.0	292.1
		C	302.6	243.0	272.8
		D	290.3	244.6	267.5
		E	328.6	260.0	294.3
		F	268.3	215.0	242.0
		G	268.3	208.0	238.1
		H	259.6	201.6	230.6
		Mean	288.9	226.9	
LSD	(.05)				
C	ns				
N	25.8				
C × N	ns				

Total Biomass g/m²

No significant differences between cultivars were found in 1992/93, while in 1993/94 Arivate gave more biomass than Clipper (Table 5). Only treatments B, D, and E gave significant increases in response to timing of nitrogen application, compared with the A treatment in the 1992/93 season. Treatment B gave the highest response in the 1993/94 season. However, treatments G and H significantly decreased this character in both seasons. It is clear from Table 5 that Arivate was more responsive to nitrogen timing than Clipper, while means of biomass were higher than Clipper in both seasons. In 1992/93 Arivate responded to the D and E treatments, while in 1993/94 the response was to the B and C treatments. However, treatments G and H significantly decreased this character in both seasons for both cultivars.

Table 5. Effect of time of nitrogen application on total biomass (g/m²) for two barley cultivars in two seasons.

		Nitrogen treatments	Arivate	Clipper	Mean
1992/93		A	1093.0	1050.0	1071.6
		B	1122.0	1236.0	1179.5
		C	1133.0	1050.0	1091.6
		D	1410.0	1217.0	1313.5
		E	1583.0	903	1243.3
		F	1096.0	1046	1071.6
		G	880.0	953.0	916.6
		H	806.0	873.0	840.0
		Mean	1140.7	1041.2	
LSD	(.05)				
C	ns				
N	63.0				
C × N	89.1				
1993/94		A	892.0	799.0	845.6
		B	1031.0	937.0	984.0
		C	1015.0	712.0	863.1
		D	913.0	909.0	893.6
		E	956.0	711.0	833.5
		F	777.0	795.0	785.8
		G	862.0	684.0	772.8
		H	707.0	592.0	649.6
		mean	889.8	767.2	
LSD	(.05)				
C	82.6				
N	68.5				
C × N	96.9				

Harvest Index

Table 6 illustrates the effect of time of fertilizer application on the harvest index. No significant differences between cultivars were found in the first season, while in the second season Arivate gave a higher harvest index (0.37) than Clipper (0.30). Splitting the application resulted in higher harvest index than the control (the A treatment) in both seasons. The effect was more marked in treatment H (1992/93) and treatment E (1993/94). The interaction was significant in both seasons. Only treatments B and C with a split application (1992/93) and treatments G and H with a single application significantly increased the harvest index of Arivate, while in Clipper all split (B, C, D, and E) and single applications (G and H) increased this character. For Arivate, split applications of B, D, and E and single application F significantly increased the harvest index in 1993/94. For Clipper, all treatments, either split or single, increased the character over the control.

Table 6. Effect of time of nitrogen application on harvest index of two barley cultivars in two seasons.

		Nitrogen treatments	Arivate	Clipper	Mean
1992/93		A	0.22	0.18	0.20
		B	0.30	0.20	0.25
		C	0.26	0.23	0.24
		D	0.21	0.20	0.20
		E	0.21	0.29	0.25
		F	0.24	0.20	0.22
		G	0.30	0.22	0.26
		H	0.32	0.23	0.27
		Mean	0.25	0.22	
LSD	(.05)				
C	ns				
N	0.02				
C × N	0.04				
1993/94		A	0.33	0.25	0.29
		B	0.40	0.30	0.35
		C	0.35	0.33	0.34
		D	0.44	0.28	0.36
		E	0.40	0.37	0.38
		F	0.39	0.29	0.34
		G	0.32	0.32	0.32
		H	0.34	0.31	0.32
		mean	0.37	0.30	
LSD	(.05)				
C	0.04				
N	0.03				
C × N	0.05				

Discussion

The importance of applying nitrogen fertilization at a particular developmental stage in barley has been shown. This accords with recent studies recognizing optimal developmental stages for nitrogen fertilizer application for winter wheat (Appleton and Hagger 1985), and others as "safe" for hormone-based herbicide treatments (Tottman et al. 1985) and for the application of plant growth regulators to barley (Jaddoa 1986; Ma and Smith 1991).

Three developmental stages were identified: double ridge, maximum spikelet number, and booting. The features of each stage are related to events that are responsible for the determination of grain yield components. The appearance of double ridges is considered an important stage in the plant life cycle (Kirby and Appleyard 1984). At this stage the spikelet primordia can be seen clearly, and this event is often referred to as "floral initiation," although about half the total number of spikelet primordia have already been initiated by this time (Kirby 1977). The apex is about 1 mm long and has an elongated cylindrical shape. This stage coincides with early tillering in barley, i.e. plants at this stage generally have 3–4 leaves on the main shoot and 2–3 tillers, depending on sowing date and variety (Cartwright et al. 1985). Therefore, the first nitrogen top-dressing at this stage increases spikelet and tiller numbers. In fact, Millner (1983) states that in barley, early nitrogen boosted tiller number and ear size, but subsequent tiller death took ear number back down again once the availability of the added nitrogen had decreased. This supports the need for split nitrogen applications instead of one single application.

At the maximum spikelet number stage, the embryo ear has its full complement of spikelet primordia, and the initiation of all structures within the median spikelet is complete (Kirby and Appleyard 1984). At the tip of the ear the meristematic dome has ceased activity and is relatively small. This stage coincides approximately with the end of tillering and the beginning of stem elongation, i.e. two nodes are detectable on the main stem (Cartwright et al. 1985). Nitrogen top-dressing at this stage may increase tiller survival, and may also improve spikelet survival (Thomson and Stokes 1985). In the booting stage, as the stem grows rapidly, the developing ear is pushed further inside the protecting leaf-sheaths. During this time, the ear increases weight rapidly, therefore there is considerable demand for nitrogen within the plant as both ear and stem are growing quickly.

The results presented in this study show that increases in grain yield of both cultivars in both seasons due to split nitrogen were associated with almost equivalent increases in ear number. The increases in 1992/93 following B, C, D, and E applications were: 32, 21, 30, and 31%, respectively, for grain yield, and 30, 19, 21, and 25, respectively, for ear number. In 1993/94 they were: 29, 21, 18, and 30%, respectively, for grain yield, and 31, 7, 15, and 23%, respectively, for ear number. This indicates a high correlation between grain yield and ear number. As most nitrogen responses result in increases in ear number, Greenwood and Mcleod (1980) conclude that nitrogen application timed to coincide with tillering gives the greatest increase in wheat grain yield. This means that tillering in cereals may be the most important determinant of grain yield.

The increased grain yield seen in treatments B, C, D, and E was also associated with an increases in 1,000 kernel weight. The increases in both seasons were: 11, 7, 10, and 9% for B, C, D, and E, respectively in 1992/93, and 8, 3, 6, and 2% in 1993/94. This result is of interest because two components, ear number and 1,000 kernel weight, were simultaneously increased despite the compensation in cereals. A possible explanation for this is that nitrogen was made available for barley plants when the demand for it was high. Treatments G and H (late single application) also increased 1,000 kernel weight, especially in the 1992/93 season. This increase was not enough to increase grain yield, however. In 1993/94, 1,000 kernel weight was not affected by the G and H treatments, despite the decreased ear number (Table 2). The possible reason for this is that the 1993/94 season was a bit shorter than the 1992/93 season due to warmer temperatures (Table 7), especially during grain filling. The availability of nitrogen due to the G and H treatments near grain filling did not increase 1,000 kernel weight.

Table 7. Means of temperature (°C) for three months in 1992/93 and 1993/94.

	1992/1993	1993/1994
March	15.3	16.5
April	19.7	23.7
May	24.5	27.6

The increase in grain yield as a consequence of increased ear number and 1,000 kernel weight, i.e. sink capacity, was associated with higher harvest indices, but a more unusual and potentially more important finding was increased total biomass at maturity. Indeed, these results indicate that dry matter production was not only increased, but also more efficiently deployed. This is in agreement with the expected trend of the relationship between biomass yield and grain yield (Donald and Hamblin 1983). Yield gains appear possible through increased biomass yield, harvest index, or both (Wych et al. 1985). However, with treatments G and H (late single application) the increased harvest index was not associated with increased biomass. In fact, total biomass was reduced due to reduced ear number.

Conclusions

For accurate timing of nitrogen fertilization in barley, three critical development apex stages were identified. All split treatments (urea, 46% nitrogen) increased barley grain yield. Three applications showed the highest increase, 39.6%. The increased grain yield was due to two increased components, ear number and 1,000 kernel weight and, more interestingly, improved harvest index.

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Discussion

M. El-Shazly: How can you make your recommendations applicable to ordinary farmers?

K. Jaddoa: The dissection of a spike requires experience, and I agree that the ordinary farmer can't do this job unless he is experienced. Nonetheless, the good returns from using this method should encourage farmers to consult the experts. Short training with simple instruments, for example a hand lens with an illustrated sheet, would certainly help the farmer.

A. Adary: You use two diverse cultivars of barley. Why do they coincide in their developmental stages? How can your work coincide with plant analysis for N requirements?

K. Jaddoa: Although these cultivars were different in their growth aspects, they reached developmental stages at almost the same time.

In my study I have a soil analysis, but I haven't done plant analysis to follow up the movement of nitrogen in the plant organs because nitrogen is rapid in its uptake and translocation.

A. Mohamed: Did you calculate the number of grains per spike? The previous paper found that N increased the number of spike primordia.

K. Jaddoa: I counted the number of grains per spike in the first season of my study, but unfortunately I didn't do it in the second season. Therefore, I decided not to include this data in my study. However, I agree that nitrogen increases the number of spike primordia.

Effect of the Delay of the Second Round of Clipping on the Performance of some Dual-purpose Barley Lines

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Abstract

Dual-purpose barley genotypes usually lend themselves to two consecutive rounds of clipping (once-over per round) when the stand is 32–36 cm high (based on extended leaf). A delay in the second round of clipping frequently occurs, especially when sheep grazing is practiced. The effect of such delays on green forage production, recovered grain yield, aftermath biomass, and tolerance to clipping was investigated. A split plot with a randomized complete block design was replicated three times in 1992/93 and 1993/94. Five dual-purpose barley lines (main treatments) were tested. Second rounds were delayed 4, 8, 12, and 16 days from the recommended height of the second round (sub-treatments). For both seasons delays ≥ 4 days resulted in a significant increase ($P < 0.05$) in green forage yield. Recovered grain yield after a ≥ 4 day delay was significantly reduced for all genotypes in both seasons, except for line IPA 99, which tolerated up to 4 days of delay in 1993/94.

Mean forages for all genotypes in 1992/93 were more than double 1993/94. Average grain in 1992/93 was 0.47% of 1993/94. Such inconsistencies could be attributed to seasonal differences and to different management practices.

The aftermath biomass was significantly ($P < 0.05$) reduced when the second round of clipping was taken ≥ 4 days from the recommended date. Seasonal changes and different management practices played a lesser role in stand re-establishment after the second round of clipping. Genotype mean performance in 1992/93 was 0.74% of 1993/94. Genetic makeup of the line thus plays an important role in re-establishment. Tolerance of clipping for a majority of genotypes was lost when clipping was practiced at or after the recommended height. Such results suggest a re-evaluation of the stand height at which the second round of clipping is practiced.

Introduction

Dual-purpose barley varieties and lines are becoming more popular in Iraq's irrigated central plains. Their popularity stems from two factors. First, the ability of

such varieties to survive the short freezing bouts that occasionally cover the region during the growing period. Second, they are able to tolerate two or sometimes three consecutive rounds of direct sheep grazing at the pre-stem elongation stage. After such grazing the stand will fully recover and produce an amount of grain, comparable to that produced from an ungrazed stand of the same variety. This will happen under optimal management (Morey 1961).

Despite this, grain production on the grazed fields of the newly recommended dual-purpose barley variety IPA 99 was found to be highly variable even under optimal conditions. Such behavior was not unexpected. Tolerance to grazing in small grains, barley in particular, was found to be a function of genotype, climatic conditions throughout the growing season, and grazing management as reported by Al-Rawi et al. (1989), Al-Shamma et al. (1989), and Al-Rawi and Al-Shamma (1991). Hadjichristodoulou (1983) and Morey (1961) report that genetically different lines and cultivars of barley differ in their tolerance to clipping or direct grazing. Hubbard and Harper (1949), Washko (1947), and Thakur and Shands (1954) attribute grain losses, which ranged from 23.2 to 80% in grazed oats, barley, rye, and wheat, to differences among these species, differences between lines of each species, and management practices.

Sprague (1954), on the other hand, observed losses in grain yield on grazed fields only under unfavorable growing conditions. The literature, however, does not report the duration of either the first or the second round of grazing, nor does it report the growing stage of the grazed stand at which the grazing animals were removed from the fields. Such factors play a major role in the tolerance of small grain crops, barley in particular, to grazing. The objective of this study was to evaluate the effect of the delay or duration of the second round of clipping or grazing on green forage yield, grain yield, total aftermath biomass production. The degree of tolerance to clipping treatments of one proved and four other dual-purpose barley lines was also evaluated.

Materials and Methods

Two experiments were carried out in 1992/93 and 1993/94 at the Fudhalia Field Crops Research Station of the IPA Agriculture Research Center, Baghdad, Iraq (soil type silty clay, pH 7.9, and organic matter content 0.64%). The design of these experiments was a split plot arrangement in a randomized complete block design with three replications. Variety IPA 99 dual-purpose barley (pedigree sel 7L-4A-OAP) and the dual-purpose barley lines 265, 267, 270, and 116 (whose pedigrees are ICB 79-0335-4AP-2AP-OAP, L108-2AP-O54-5AP-OAP, ICB79-0105-5AP-3AP-OAP and ICB-1097-1AP-5AP-OAP, respectively) were used. These genotypes were entered as main plots treatments. The sub-treatment was the second round of clipping (simulated sheep grazing), split into five levels in 1992/93 and four levels in the 1993/94 season. The levels were spaced at four-day interval.

The sequence was as follows:

- Level 0. Second round of clipping begins when stand height is 32–36 cm on an extended leaf basis (0d).

- Level 1. Four days after level 0 (4d).
- Level 2. Eight days after level 0 (8d).
- Level 3. Twelve days after level 0 (12d).
- Level 4. Sixteen days after level 0 (16d).

Sub-plot size was 1.5×4 m.

Clipping procedures were as follows:

- In 1992/93 the first round of clipping was carried out on 31 January, 1993 at a stand height of 32–36 cm. The five levels of the second round were carried out on 20 February, 24 February, 1 March, 5 March, and 9 March, 1993.
- In 1993/94 the first round of clipping was on 8 January 1994. The four levels of the second round were carried out on 4 February, 8 February, 12 February, and 16 February, 1994. Clipping was done at soil line through the use of the usual farmer's hand sickle.
- The 1992/93 experiment was seeded on 26 November 1992, and on 16 November 1993 for 1993/94. The seeding rate for all entries was 140 kg/ha. Plots were carefully hand-seeded in rows spaced at 30 cm. apart. Fertilizer in the form of N:P:K (27:27:00) was applied at a rate of 480 kg/ha at seeding. Nitrogen fertilizer in the form of urea (46% N) was applied at a rate of 140 kg/ha after the first round of clipping and repeated after the second round.

Irrigation was carried out on regular basis and plots received approximately 450 mm during the 1993/94 growing season. However, the heavy rains that hit the area in January 1993 supplied the equivalent of 580 mm during that growing season. Such extra moisture retarded the growth and development of the stand. As a result, additional fertilizer was added (320 kg/ha N:P:K 27:27:00) to stimulate stand growth and development. The application date was 20 January 1993. Data on green forage yield, grain yield, and aftermath biomass for both seasons were collected and statistically analyzed following procedures set by Steel and Torrie (1960).

Results and Discussion

Forage yield data for the second clipping for the five genotypes included in the study are presented in Tables 1A and 1B, respectively. Mean green forage yield for the 1992/93 season ranged from 17.980 t/ha for entry IPA 267 to 21.772 t/ha for entry IPA 116. Mean performances of the five genotypes were similar to each other, except for IPA 116, which significantly ($P < 0.05$) outperformed entry IPA 267 in green forage yield.

The effect of the delay of the second round of clipping on green forage yield is shown in Table 1A. The delay caused an increase in green forage yield for all entries. Delays of 8, 12, and 16 days resulted in significant ($P < 0.05$) increases in green forage yield when results are compared with clipping upon reaching the suggested stand height. Such results were valid for all entries. However, IPA 99

and IPA 116 can be singled out for their "better than most" performance, both in mean performance and in performance at delayed removal of foliage, especially at 12 or 16 days. Removal contributed to a 2–4-fold increase in green forage yield contrasted with the Od treatment. Lines IPA 265, IPA 99, and IPA 116 fit this pattern.

Data on green forage yield for the 1993/94 season are presented in Table 1B. The five different genotypes were divided into two groups according to their mean performance. IPA 265, IPA 99, and IPA 116 were similar in their mean performance, averaging 12.243, 11.290, and 12.723 t/ha green forage, respectively. These lines, as a group, significantly ($P < 0.05$) outperformed lines IPA 267 and IPA 270, which averaged 8.080 and 7.693 t/ha green forage, respectively. As in 1992/93, a delay of 8 or 12 days for the second round resulted in a significant ($P < 0.05$) increase in green forage yield. Once again, lines IPA 265, IPA 99, and IPA 116 were similar in their performance. However, these lines outperformed IPA 267 and IPA 270 at all levels of the second round.

There was a marked difference in the mean performance of the five genotypes over the two seasons. Table 1c shows the relative performance of each genotype (mean performance in 1992/93 /mean performance in 1993/94). For green forage production, all genotypes performed better in 1992/93. Their performance ranged from 1.624 to 2.225. Such results reflect the better-than-maximum growing conditions that prevailed in 1992/93, which in turn contributed to continuous vegetative growth and development throughout the season. Similar results were obtained in a study of fodder barley landraces, and dual-purpose and early spring barley lines (Al-Shamma et al. 1992). On the other hand, the more balanced green forage production in 1993/94 may be explained by referring to Morris and Gardner (1958), Burton and Prine (1958), Morey (1961), Thakur and Shands (1974), and Al-Rawi et al. (1989), all of whom assert that higher nitrogen fertilization and regular moisture supply contribute to high forage yield and small grain crop output under simulated grazing. Moreover, a daytime temperature of around 18° C must prevail during the growing period (Frank et al. 1992) to make full use of higher rates of nitrogen application (200 kg/ha). Such temperatures did prevail throughout the 1992/93 and 1993/94 growing seasons.

Data on grain yield recovered after the second round of clipping for both seasons are presented in Tables 2a and 2b, respectively. In the 1992/93 season, means of grain yield for the different genotypes over the five dates of the second round ranged from 1.591 t/ha for IPA 270 to 1.817 t/ha for IPA 116. However, differences among the means were not statistically significant ($P > 0.05$). The delay of the second round of clipping caused a sharp and significant decline in grain yield for all lines. In fact, the decline in grain yield was observed at four days and continued as time progressed. The sharpest decline in grain yield occurred when the second round of clipping took place 12 or 16 days from the recommended date.

Data for recovered grain yield for the second round of clipping for 1993/94 are presented in Table 2b. Mean performances of the different lines ranged from 3.477 t/ha for IPA 267 to 4.423 t/ha for IPA 99. However, there were no significant differences among the means of different genotypes ($P > 0.05$).

Table 1. Effect of the delay of the second round of clipping on green forage yield (t/ha) for five barley genotypes grown at the Fudhalia Experiment station, Baghdad, Iraq (1992/93 and 1993/94).

Entry	a: 1992/93						b: 1993/94					c Relative performance of entry means 1992/93; 1993/94
	Second round						Second round					
	Od	4d	8d	12d	16d	Mean	Od	4d	8d	12d	Mean	
IPA 265	10.678	15.815	17.891	23.466	31.568	19.884	6.722	8.545	15.944	17.759	12.243	1.624
IPA 267	10.616	14.733	17.078	20.414	27.018	17.980	5.404	5.294	9.344	12.277	8.080	2.255
IPA 99	7.653	15.452	19.531	28.355	33.355	20.869	6.592	8.489	13.732	16.347	11.290	1.848
IPA 270	12.261	15.461	19.146	22.778	31.000	20.129	4.534	4.637	9.114	12.487	7.693	2.616
IPA 116	11.913	17.319	21.610	24.149	33.870	21.772	6.872	8.188	15.569	20.264	12.723	1.711

LSD 5%; Entry means = 3.016; Entry means = 2.988; Mean=2.0; LSD 5%; Within entry = 5.085; Within entry = 2.462.

Table 2. Effect of the delay of the second round of clipping on grain yield (t/ha) for five barley genotypes grown at the Fudhalia Experiment Station, Baghdad, Iraq (1992/93 and 1993/94).

Entry	a: 1992/93						b: 1993/94 b					c
	Second round						Second round					Relative performances of entry means 1992/93 ; 1993/94
	Od	4d	8d	12d	16d	Mean	Od	4d	8d	12d	Mean	
IPA 265	3.990	2.057	1.569	1.334	0.077	1.805	4.085	3.381	3.244	3.205	3.479	0.52
IPA 267	3.804	2.179	1.365	0.596	0.536	1.696	4.327	3.725	3.104	2.751	3.477	0.49
IPA 99	3.246	1.949	1.418	1.208	0.255	1.615	5.698	5.179	3.821	2.994	4.423	0.37
IPA 270	3.401	1.901	1.505	0.969	0.180	1.591	4.069	3.641	2.918	3.864	3.373	0.47
IPA 116	4.385	2.240	1.262	0.932	0.267	1.817	4.339	3.596	3.331	2.932	3.550	0.51

LSD 5%; Entries means = 0.673; Entries means = 1.43; Mean=0.47; L.S.D 5%; Within entry = 0.889; Within entry = 0.827.

Table 3. Effect of the delay of the second round of clipping on aftermath biomass (t/ha) of five barley genotypes grown at Fudhalia Experiment Station, Baghdad, Iraq (1992/93 and 1993/94).

Entry	a: 1992/93						b: 1993/94					c	
	Second round clipping						Second round clipping					Relative performance of entry mean	
	Od	4d	8d	12d	16d	Mean	Od	4d	8d	12d	Mean	1992-1993 / 1993-1994	
IPA 265	13.237	9.100	5.928	6.004	0.361	6.926	9.950	8.108	7.197	7.120	8.094	0.86	
IPA 267	10.959	8.332	6.525	3.486	2.010	6.262	12.707	10.438	8.582	7.694	9.855	0.64	
IPA 99	10.588	7.427	6.127	4.811	1.469	6.084	13.052	11.947	8.833	6.934	10.192	0.60	
IPA 270	10.605	6.872	7.133	4.953	1.057	6.124	12.076	9.770	7.805	7.092	9.186	0.67	
IPA 116	13.576	10.283	6.757	6.384	1.535	7.707	10.58	8.486	8.038	6.853	8.490	0.91	

LSD 5%; Entry means = 1.960; Entry means = 2.624' Mean = 0.74; L.S.D 5%; Within entry = 2.605; Within entry = 1.340.

Table 4. Effect of the delay of the second round of clipping on grain yield (t/ha) and the nature of tolerance to clipping at Fudhalia Experiment Station, Baghdad, Iraq (1992/93 and 1993/94).

Entry	a: 1992/93							b: 1993/94						
	Second round clipping							Second round clipping						
	NC	Od	4d	8d	12d	16d	L.S.D 5%	N.C	Od	4d	8d	12d	LSD 5%	
IPA 265	5.752	3.990	2.057	1.569	1.344	0.077	1.228	6.343	4.085	3.381	3.244	3.205	1.067	
IPA 267	5.049	3.804	2.179	1.389	0.596	0.536	1.049	5.825	4.327	3.725	3.104	2.751	0.553	
IPA 99	4.305	3.246	1.949	1.418	1.097	0.255	1.056	5.931	5.698	5.179	3.821	2.994	0.822	
IPA 270	5.015	3.401	1.901	1.505	0.969	0.180	1.107	6.265	4.069	3.641	2.918	2.864	0.517	
IPA 116	3.615	4.385	2.240	1.262	1.099	0.267	1.015	6.519	4.339	3.596	3.331	2.931	1.690	

NC = No clipping.

Delay of the second round of clipping caused an insignificant ($P > 0.05$) decline in grain yield when green cover removal was carried out four days after the designated date of clipping (0d). However the reduction in grain yield was statistically significant for all genotypes when the second round was carried out at 8 or 12 days. A delay of 12 days for the second round of clipping in this particular season caused a reduction in the recovered grain yield. However, grain yield ranged from 2.751 t/ha for IPA 267 to 3.205 for IPA 265, which was enough to justify the delay. Genotypes gave different recovered grain yields over 1992/93 and 1993/94. Table 2c shows the relative performances of the different genotypes (mean performance of 1992/93 divided by mean performance of 1993/94), which ranged from 0.37 for IPA 99 to 0.52 for IPA 265, with an average relative performance of 0.47. Such results are inversely related to green forage yield for the two seasons. Pumphrey (1970), Dumphy et al. (1983), and Anderson (1985) assert that the more green fodder removed, the larger the reduction in grain yield. This is supported by our findings, where a two-fold increase in green forage production in the 1992/93 season resulted in only 0.47 of the expected grain yield under balanced optimal conditions.

Data on biomass yield for the different levels of the second round for 1992/93 and 1993/94 are presented in Tables 3a and 3b, respectively. In 1992/93, mean performance of the five genotypes ranged from 6.084 t/ha for IPA 99 to 7.707 t/ha for IPA 116. There were no statistical differences ($P > 0.05$) between the biomass means of the different genotypes. However, there was a significant reduction in biomass yield associated with every delay in the second round of clipping, and for all genotypes included in this study.

Table 3b shows that in 1993/94 mean performances of the genotypes ranged from 8.094 t/ha (IPA 265) to 10.192 t/ha (IPA 99). Once again there were no significant differences among the mean biomass yields of the different genotypes. However, clipping carried out at delays of 4, 8, and 12 days resulted in a significant reduction in biomass yield when compared with the designated date of the second round of clipping. Results of the 1992/93 season numerically differed from those of the 1993/94 season. The relative performances of the genotypes (mean performance of 1992/93 divided by mean performance of 1993/94 for every genotype) are presented in Table 3c. The relative performance of these genotypes ranged from 0.60 for IPA 99 to 0.91 for IPA 116, with a mean of 0.74. From such results it appears that stand re-establishment after the termination of the second round of clipping is not related to the amount of green forage removed. A case in point is the behavior of IPA 99 and IPA 116, whose mean green yields were the highest in 1992/93 and 1993/94. However, the relative performance of the aftermath biomass for the two seasons for these two genotypes differed widely: 0.60 for IPA 99 and 0.91 for IPA 116. Stand regrowth after green cover removal in dual-purpose barley may be closely related to the theory advanced by Perry and Chapman (1974), who attribute lack of tolerance to clipping in basin wild rye (*Elymus cineris*) to the rapid depletion of the carbohydrate reserves in the crown and roots of this grass. Everson (1966), on the other hand, suggests that regrowth after continuous clipping of western wheat grass (*Agropyron smithii*) is related to the extra reserves and the slow depletion of the reserved nonstructural carbohydrate. Based on this argument it is suggested that the five genotypes differed in speed of depletion of their reserved carbohydrates, although the process was not as rapid as with some of their distantly related grasses.

To measure the degree of tolerance to the second round of clipping (0d) and to delayed clipping (4d, 8d, 12d, and 16d), data on grain yield was compared with the mean grain yield of the unclipped stands for each entry. Grain yield means and LSDs for both seasons are presented in Tables 4A and 4B.

Results for 1992/93 show that, with the exception of IPA 116, all entries lost their tolerance to clipping after the second round (0d). Delayed clipping treatment contributed to a significant loss of grain yield.

Results for 1993/94 season show that IPA 99, the previously recommended dual-purpose barley line (Al-Rawi et al. 1989), tolerated the second round of clipping and delay up to four days. However, all other entries showed no tolerance to either timely second round of clipping or delayed second round, despite the fact that their grain yield after 0d ranged from 4.069 t/ha (IPA 270) to 4.339 t/ha (IPA 116). This would appear to prove that a real dual-purpose barley—such as IPA 99—could lose its tolerance to clipping according to management and prevailing seasonal conditions.

Conclusions

From the above results and discussions, we can conclude that:

- A real dual-purpose barley could be used for green forage supply after two rounds of clipping with insignificant loss in recovered grain yield under well-balanced, optimal conditions. However, an excessive supply of fertilizer and moisture will transform dual-purpose barley into fodder barley under the climatic conditions of Iraq's central plains.
- A delay in the second round of grazing or clipping will enhance green forage production at the expense of recovered grain yield production.
- Productivity of dual-purpose barley is region-specific and can be easily manipulated through proper management to serve the different needs of the farmer, sheep, and livestock owner. Studies should be conducted to determine the ideal stand height at which clipping or grazing is needed to attain the full potential of the lines.

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Discussion

M. Al-Shazly: What do you think of the stability of such genotypes of dual-purpose varieties over years and locations?

B.A. Al-Rawi: As I mentioned in my concluding remarks, dual-purpose barley varieties are region-specific. Over the years, we have discovered that their performance is stable. However, I have my doubts regarding their stable performance at different locations.

A. Hadjichristodoulou: I noticed that you compare varieties and cutting time using green matter data. Was this done on purpose or out of necessity? We know that evaluation on the basis of dry matter is more reliable.

B. Al-Rawi: Yes, I agree with you that we should compare dry matter yield instead of green forage yield. However, certain circumstances necessitated green forage yield comparison. I may add, as you already know, that green forage data might not reflect the actual efficiency of the performance of the variety.

M. Tahir: I suggest in terms of grazing, sheep or cattle should be determined separately, because sheep can graze almost to the ground level and cause a marked reduction in the crop if grazed late, but cattle normally graze 2–3 cm above ground and cause less damage to the growing tip. Secondly, if you intend to breed for dual-purpose (forage plus grain), then genetic buffering is essential to provide plasticity which can be better achieved by incorporating the degree of synchronization in tillering. Highly synchronized tillering is not suitable for dual purposes. During the past several years the breeding programs have been geared towards increasing grain production by increasing harvest index. With dual-purpose barley this is not a very desirable trait.

Forage Legume Improvement

Developing Cultivated Forage Legumes for Improved Yield and Quality to Feed Livestock in the Dry Areas

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Abstract

The West Asia and North Africa (WANA) region is experiencing increasing pressure on its agricultural resource base due to rapidly growing livestock and human populations (FAO 1987; Alexandratos 1988). The shortage of animal feed is imposing a heavy burden on the rangelands, which are deteriorating. The severe feed and food deficit has also triggered replacement of the fallow-barley rotation with continuous barley in dry land agriculture, and increased cropping on marginal lands with attendant degradation of the soil resource base (Jubert 1985; Oram 1988).

Expansion of cultivation of such legumes as vetches (*Vicia* spp.) and chicklings (*Lathyrus* spp.), which are indigenous to the Mediterranean basin, can augment the feed and food supply when sown either to interrupt barley monoculture or to replace fallow in a fallow-barley rotation (Abd El Moneim et al. 1988, 1990). These species are sown and harvested in a single year and can be used for grazing during winter, harvested for hay in spring, or carried to maturity for seed and straw. Their introduction into the rotation increases the productivity of food and feed and, therefore, sustainable animal carrying capacity of the land (Cocks 1988; Harris et al. 1991; Papastylianou 1991). This is because of better maintenance of organic matter and soil nitrogen (Peter White, personal communication), improved soil physical conditions, and better control of diseases and pests than in continuous cereal rotations.

Introduction

Although there is a huge diversity of *Vicia* and *Lathyrus* species in the Mediterranean basin, only a few have been used as feed crops, and these have received little attention in the past by agronomists and plant breeders. Kernick (1978) reports that three species of *Lathyrus* and nine of *Vicia* are potentially important. ICARDA focuses only on such annual species of these two legumes which can adapt to areas where rainfall is between 250 and 400 mm. Table 1 summarizes the use and environmental adaptation of the species of interest. In areas where rainfall is less than 300 mm, *Lathyrus* spp. are common, whereas in higher rainfall areas, vetches are better adapted. *Vicia narbonensis* is adapted to

drier sites, whereas *V. sativa* and *V. ervilia* perform better with more assured moisture. *Vicia ervilia* and *V. villosa* subsp. *dasycarpa* are better adapted to the cold environments of the highlands than other *Vicia* and *Lathyrus* species. Subterranean species of *Vicia* and *Lathyrus* are adapted to areas with marginal lands and low rainfall.

Table 1. Use and environmental adaptation of different species of *Lathyrus* and *Vicia* in West Asia and North Africa and priority research objectives for these crops at ICARDA.

Species	Use	Adaptation	Priority research objectives
<i>L. sativus</i> (common chickling)	GZ, G, S	<300 mm rain	Resistance to <i>Orobanche</i> and moderate cold foliar diseases
<i>L. cicera</i> (dwarf chickling)	G, S	<300 mm rain	Resistance to <i>Orobanche</i> and foliar diseases; high HI; low BOAA content
<i>L. ochrus</i> (ochrus chickling)	G, S	300 mm rain, mild winters	Improved cold tolerance
<i>L. cillolatus</i> (subterranean chickling) areas, hard seededness	GZ	300 mm rain	Adaptation to low rainfall, cold, marginal lands, barley
<i>V. sativa</i> subsp. <i>amphicarpa</i>	GZ	"	"
<i>V. sativa</i> (common vetch) diseases, and cyst nematode	G, H	>300 mm rain, moderate cold	Leafiness, non-shattering pods; resistance to foliar
<i>V. narbonensis</i> (narbon vetch)	G, S	< 00 mm rain, moderate cold	Earliness, improved HI, botrytis, resistance, low tannin content
<i>V. villosa</i> subsp. <i>dasycarpa</i> (woolly-pod vetch)	GZ	~350 mm rain, high elevation, severe cold	Earliness, increased leaf retention and seed yield
<i>V. ervilla</i> (bitter vetch)	G, S	350 mm rain cold	Reduced pod shattering
<i>V. panonica</i> (Hungarian vetch)	GZ, G, S	~350 mm rain, high elevation, severe cold	Improved HI, ascochyta blight resistance

G = grain; GZ = grazing; H = hay; S = straw.

Area, Production, and Yield

Unfortunately, precise estimates of recent area, production, and yield of these legumes are unavailable. FAO (1987) found that nearly 1.30 million hectares were sown to vetches globally in 1985, with a yield of 1.69 t/ha and total production of 2.2 million tonnes. The estimates for WANA were an area of 0.34 million ha, 0.739 t/ha yield, and 0.25 million tonnes production. Some recent reports suggest

that the current area in WANA under vetches may be nearly 0.6 million hectares, mainly in Turkey, Syria, Ethiopia, Morocco, and Algeria, but also in Iraq, Jordan, Cyprus, Lebanon, and Tunisia. *Lathyrus sativus* is grown as a food legume on nearly 1 million ha globally, with a production of about 0.6 million tonnes. The major production is in India, Bangladesh, Nepal, and Pakistan in South Asia, and in Ethiopia in WANA. Afghanistan, Greece, Portugal, and France also produce this crop. *Lathyrus cicera* is common in Cyprus, Greece, Iran, Iraq, Spain, and Syria, and *Lathyrus ochrus* in Cyprus and Greece, used mainly for feed and forage. Precise area and production estimates are not known.

Germplasm Collection and Evaluation

ICARDA's total collection of *Vicia* spp. stands at 4,572 accessions, with 2,280 (49.9%) from WANA, 1,083 (23.7%) from other countries, and 1,209 (26.4%) from unknown sources. The collection of *Lathyrus* spp. is smaller—1,374 accessions—of which 83.6% originates from WANA, 16.2% from other countries, and 0.1% from unknown sources. Only part of the germplasm collection of the species listed in Table 1 has been evaluated for various agronomic traits and for reaction to common biotic and abiotic stresses.

Germplasm Enhancement

Two approaches are adopted to develop improved lines of *Vicia* and *Lathyrus* spp. (Fig. 1). In one, selection is affected in the wild accessions to develop improved cultivated types. In the second, hybridization is done to introgress desirable traits using selections from the wild accessions. The work is carried out by a multidisciplinary team including a breeder, physiologist, pathologist, entomologist, and animal nutritionist.

The major objectives for improvement in the *Vicia* and *Lathyrus* species are given in Table 1. While attempting to improve yield and adaptation to environment, the emphasis is on ensuring acceptable palatability, intake, and nutritive value of herbage, hay, grain, and straw.

As an international center with major responsibility for WANA, ICARDA aims to serve the national feed legumes improvement programs through: (i) assembling, classifying, evaluating, maintaining, and distributing germplasm; (ii) developing and supplying breeding populations with adequate diversity to be used in different environments; and (iii) coordinating international trials to facilitate multilocation testing and identification of widely adapted cultivars.

Vetches

Promising selections from *V. sativa*, *V. ervilia*, and *V. villosa* subsp. *dasycarpa* (25 from each) were evaluated over a period of three seasons (1986/87–1988/89). Rainfall ranged from 233 to 504 mm, and minimum temperatures -5.8°–9.9° C. Considerable inter- and intra-specific variations in phenology, quantitative traits, and productivity were revealed (Table 2).

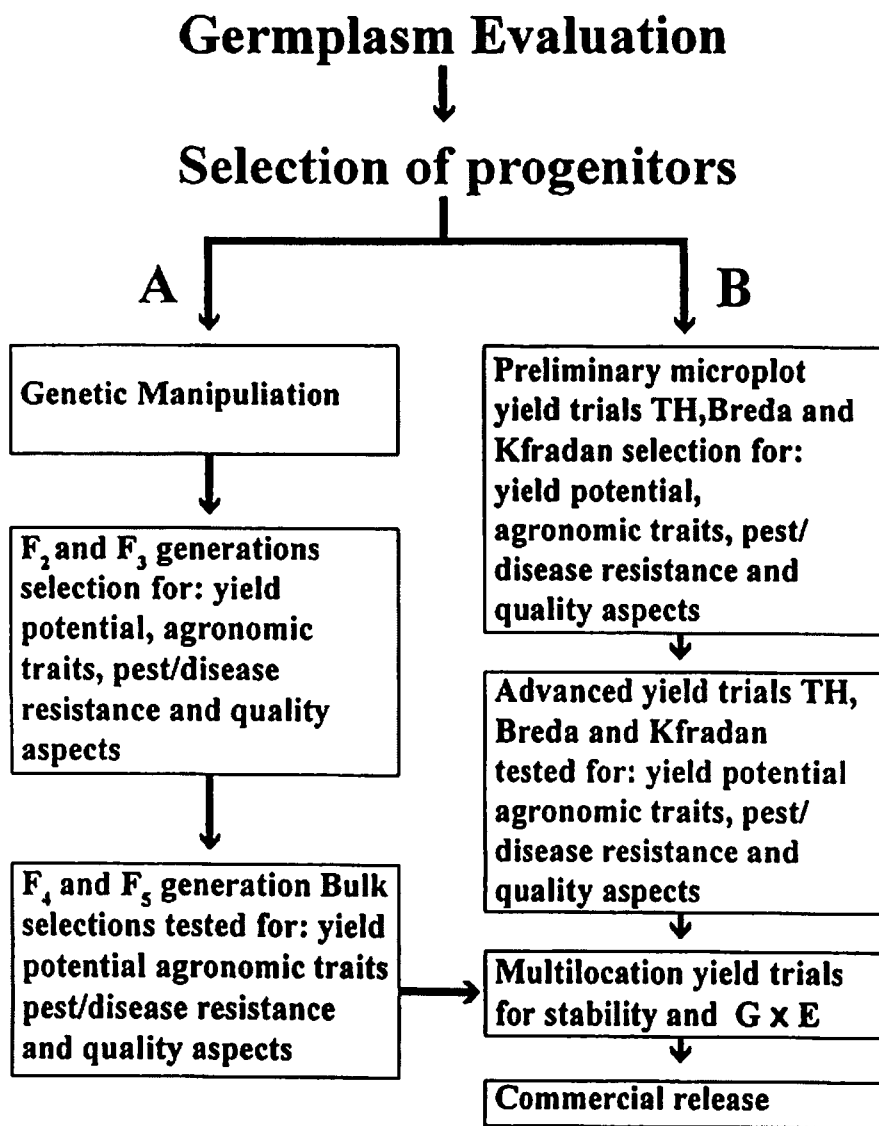


Figure 1. Structure of forage legumes breeding program. A = hybridization; B = selection.

Table 2. Variability of phenological and quantitative traits in *Vicia* spp. accessions at ICARDA.

Traits	<i>V. sativa</i>		<i>V. ervilia</i>		<i>V. v. subsp. dasycarpa</i>	
	Range	+ Sem	Range	+ Sem	Range	+ Sem
Days to start of flowering	105-115	1.03	95-109	1.02	114-136	1.10
Days to 100% flowering	134-160	1.10	115-130	0.95	140-168	1.20
Days to maturity	170-189	1.18	122-140	1.09	162-196	1.28
Seedling vigour†	2.5-4.5	0.30	1.9-3.5	0.30	1.1-3.2	0.20
Winter growth†	3.0-5.0	0.40	2.5-5.0	0.46	0.9-1.0	0.13
Cold effect‡	2.1-4.5	0.31	0.5-2.0	0.10	0.5-1.5	0.09
Spring growth†	4.3-5.0	0.37	2.1-5.0	0.30	0.6-5.0	0.26
Leafiness†	3.5-5.0	0.40	2.0-5.0	0.28	1.0-4.0	0.30
Herbage yield (t/ha)§	2.29-4.20	0.51	2.02-2.71	0.14	5.79-11.2	0.82
Grain yield (t/ha)	0.80-2.64	0.15	0.73-1.27	0.10	0.28-0.9	0.07
Straw yield (t/ha)	2.80-7.90	0.38	2.10-3.50	0.15	5.82-7.58	0.61
Harvest index (%)	18-32	1.6	26-39	2.1	14-19	1.30

† Visual score on 0-5 scale where 0 = poor; 5 = very good.

‡ 0 = no damage; 5 = all killed.

§ at 50-100% flowering.

Vicia sativa was most affected by frost, while *V. villosa* subsp. *dasycarpa* was most cold tolerant. The latter, although producing high herbage yield in spring, had low grain yield and reduced harvest index because of excessive flower drop. *Vicia ervilia* and *V. sativa* (Table 2), as well as *V. narbonensis* (Table 3) had high seed yield and high harvest index. Large variations in phenology and other quantitative traits make it possible to identify lines suitable for different production niches and for different uses in various farming systems in WANA (Abd El Moneim 1992b). For example, the rapid winter and spring growth of *V. sativa* make it promising for early grazing in mild winter areas at a time when feed shortage is acute. It could also be used for hay making and for seed and straw production. Combined with barley, *V. sativa* is widely used in Tunisia (Halila et al. 1990). In areas where winters are severe, *V. villosa* subsp. *dasycarpa* has proved most promising because of its high cold tolerance (Keatinge et al. 1991). Because of its prolonged flowering period and low harvest index, it is quite suitable for grazing. *Vicia narbonensis*, with its high grain yield and harvest index and erect growth habit, is ideal for the production of grain and straw (Abd El Moneim 1992a), particularly in areas of low seasonal rainfall and moderate cold (Table 3). In *Orobanche* spp. infested areas, early maturing selections of *V. sativa* are less damaged, and *V. villosa* subsp. *dasycarpa* is not damaged at all as it resists the parasite (Linke et al. 1992).

Table 3. Mean performance of 25 lines of *Vicia narbonensis* and 12 lines of *Lathyrus sativus* in eight different environments.

Site	Season	Seasonal rainfall (mm)	<i>Vicia narbonensis</i>		<i>Lathyrus sativus</i>	
			Seed yield (t/ha)	HI (%)	Seed yield (t/ha)	Herbage yield ¹ (t/ha)
1. Tel Hadya	1985/86	316	1.55	38	0.85	2.68
2. Tel Hadya	1986/87	358	1.90	40	1.36	2.81
3. Tel Hadya	1987/88	504	1.10	34	0.91	2.58
4. Tel Hadya	1988/89	233	0.90	32	0.50	1.98
5. Breda	1985/86	218	1.29	36	0.37	1.22
6. Breda	1986/87	245	1.40	36	0.39	1.33
7. Breda	1987/88	415	1.61	38	1.25	3.28
8. Breda	1988/89	195	0.47	30	0.55	1.46
Mean			1.28	35	0.772	2.42

¹ Cut at 50–100% flowering.

Inter and intra-specific variation in the selections of *Vicia* spp. has been adequate for major biotic and abiotic stresses as well (Table 4). Sources of resistance have been identified for ascochyta blight (*Ascochyta pisi* f.sp. *viciae*), downy mildew (*Pernospora viciae*), powdery mildew (*Erysiphe pisi* f.sp. *viciae*), botrytis blight (*Botrytis cineria*), cyst nematode (*Heterodera ciceri*), root-knot nematode (*Meloidogyne artiellia*), broomrape (*Orobancha crenata*) and cold. These are being used in the breeding program.

Table 4. Number of selections of *Vicia* and *Lathyrus* spp. with resistance to different biotic and abiotic stresses at Tel Hadya.

Stress	Vetch			Chickling		
	Common	Narbon	Woolly-pod	Common	Dwarf	Ochrus
Ascochyta blight	7	1	12	5	3	5
Botrytis blight	0	3	10	4	3	2
Downy mildew	5	3	8	13	7	6
Powdery mildew	4	7	8	11	4	4
Cyst nematode	11	5	11	9	3	5
Root-knot nematode	10	10	11	6	3	4
Broomrape	6	1	23	0	0	18
Cold	32	42	99	0	50	1

Pod shattering has been a major constraint to the use of *V. sativa* as a grain crop. Incorporation of non-shattering genes into agronomically promising lines resulted in recombinants with 95–97% non-shattering pods with good agronomic backgrounds, compared with only 40–45% in the original, otherwise improved, parents. This has agronomic advantages as well: (i) harvest can be delayed and mechanized to permit better compatibility with other crop enterprises of the farmer; (ii) the problem of vetch weeds is reduced in the rotation. With these improvements, introduction of *V. sativa* to replace fallow has become an economical and agronomically feasible proposition.

Subterranean vetch (*V. sativa* subsp. *amphicarpa*), a typical Mediterranean species commonly found on poor lands in WANA, could prove to be an excellent component of ley-farming systems in habitats that are too dry and marginal for other vetches and medics. Because of its underground cleistogamous flowers, subterranean vetch produces nearly 50% of its pods underground. It is drought resistant and has high persistence under heavy grazing. Studies at ICARDA, initiated in 1989/90, investigated the potential of one of the selections of this vetch, with very promising results (Table 5). The agronomic advantage of introduction of subterranean vetch is that it can withstand tillage during the cereal phase. Improvement work has concentrated on incorporating increased herbage yield by crossing promising selections of subterranean vetch with the superior *V. sativa* lines, with positive results.

Table 5. Effect of grazing management of subterranean vetch on dry herbage yield in the year of establishment (1989/90), yield of succeeding barley (as compared to barley after barley), vetch seed bank at the start and the end of barley phase, and dry herbage yield of self-regeneration vetch (1991/92, Tel Hadya).

Yield/seed bank (kg/ha)	Subterranean vetch grazing				Barley	Sem (+)
	February	March	April	No grazing		
Herbage yield [†] 1989/90	830	730	860	2,020	-	57
Barley seed 1990/91	1,966	2,035	1,925	1,909	1,599	98
Barley total shoot 1990/91	4,347	4,193	3,947	3,877	3,143	215
Starting seed bank 1990/91	50	130	160	240		27
End-season seed bank 1990/91	32	95	141	218		34
Herbage yield [†] 1991/92	3,258	3,879	3,708	3,900		320

[†] At 50% flowering.

Chickling

As mentioned earlier, *Lathyrus* spp. are particularly promising in low rainfall areas because of their ability to grow under drought conditions. *Lathyrus sativus* and *L. cicera* are particularly adapted to cool, dry environments (Table 3). The crop improvement objectives for the *Lathyrus* species of interest to ICARDA are listed in Table 1. The diseases that constrain production include ascochyta blight (*Ascochyta pisi* f.sp. *lathyr*), downy mildew (*Pernospora trifoliorum*), powdery mildew (*Erysiphe martii* f.sp. *lathyr*) and botrytis blight (*Botrytis cineria*). Root-knot nematode and cyst nematode also damage the crop. *L. sativus* and *L. cicera* are parasitized by broomrape, and *L. sativus* and *L. ochrus* are susceptible to cold. Sources of resistance to common biotic and abiotic stresses have been identified (Table 4). These are being used in the breeding program.

Although the seeds of *Lathyrus* are rich in crude protein (29 g 100g⁻¹ of edible seed), and have high lysine content, they also possess the neurotoxin, β -N-oxalyl-L, β -diaminopropionic acid (ODAP, syn. BOAA), which is implicated in causing lathyrism in humans and domestic animals (Briggs et al. 1983; Roy and Kisby

1989) by affecting the central nervous system. ICARDA endeavors to develop promising *Lathyrus* lines with low or zero BOAA content. Screening of 81 pure lines of *L. sativus*, 19 lines of *L. cicera*, and 22 lines of *L. ochrus* for BOAA content revealed a wide range in the concentration of the neurotoxin. It ranged from 18 to 316 $\mu\text{g g}^{-1}$ of seeds in *L. sativus*, 405–560 μg in *L. cicera*, and 20 to 266 μg in *L. ochrus*. The lowest value recorded in *L. sativus* is lower than that ever reported for any cultivar in the past. Using the low BOAA content lines, a breeding program for genetic detoxification of *L. sativus* has been initiated. Development of cultivars with low or zero levels of BOAA and high yield potential in dry areas would prevent the development of lathyrism and provide a safe food for humans and feed for animals in regions where drought is frequent.

Emphasis has been placed on enhancing the cold tolerance in *L. ochrus*, which has great potential for production of herbage and seed, particularly in areas infested with broomrape and thus unfit for production of *L. sativus*. *Lathyrus ciliolatus* (subterranean chickling) is being improved for its productivity.

International Cooperation

Improved genetic material is currently distributed to national programs in WANA in the form of two international yield trials, each containing 20 entries. Demand for these nurseries is increasing. Cooperators in the national programs are encouraged to send their local selections for entry in these nurseries to obtain valuable information on their adaptability to a wide range of environments.

Collaboration is also being developed with institutions in industrialized countries, particularly to identify rapid and reliable methods for the evaluation of genetic material for antinutritional factors.

ICARDA is eager to cooperate with other institutions interested in exploiting the potential of *Vicia* and *Lathyrus* species for augmenting food and feed production in the dry areas and promoting sustainable agriculture.

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Improving Feed Legumes for the Central Highlands of Turkey

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Abstract

The central highlands of Turkey are characterized by cold winters and dry summers. Under these extreme weather conditions, forage crops are still underexploited as a part of crop rotations. There is a shortage of good quality feed, especially during winter supplementary feeding. Half of the total vetch in Turkey is located in the central highlands, and farmers still use local cultivars, which have good adaptability but low yield potential. Therefore, with the aim of identifying and improving annual forage legume species for the cold and dry environment of the central highlands, work was conducted under a collaborative Turkey/ICARDA project during the 1992/93, 1993/94, and 1994/95 seasons. Autumn-sown forage legume species showed more potential than the spring-sown ones. Hungarian vetch (*Vicia pannonica*) and woolly-pod vetch (*V. villosa* subsp. *dasycarpa*) showed promise for autumn sowing and utilization for grazing and/or hay. Narbon vetch (*V. narbonensis*) performed better when autumn sown than when spring sown. Chicklings (*Lathyrus* spp.) were also promising alternatives to spring sown vetches. Accession 751 of Hungarian vetch, 694/1 of woolly-pod vetch, 793/A of narbon vetch, 1033 of bitter vetch (*V. ervilia*), 794 of common chickling (*L. sativus*), and 812 of dwarf chickling (*L. cicera*) were considered superior.

Introduction

In the central highlands of Turkey (CHT), the major feed resources are common pastures, forage crops, and crop residues. Most of the common grazing area has been replaced by cereal production over the last 50 years (Bakir 1971). Moreover, mismanagement, in the form of early and over-grazing, has led to the destruction of rangeland vegetation and resulted in soil erosion. Although forage crop production has increased in the last 20 years, forage crops are still underexploited as a part of crop rotations, and shortage of good-quality forage is particularly acute during winter supplementary feeding. In general, feeding of livestock is mainly dependent on common pasture, cereal straw, barley seed, vetch straw (in mountainous areas only), and supplementary feed.

In Turkey, only 2–3% of the total cultivated area (515,000 ha) is devoted to forage crops (Table 1). Of this, about 180,000 ha (35%) is in the CHT, where the

cultivated species are common vetch (*Vicia sativa*), alfalfa (*Medicago sativa*), and sainfoin (*Onobrychis sativa*). Fifty percent of the total vetches grown in the CHT are used for seed and straw. Among vetches, common vetch is the most popular, grown as a spring crop because of the cold sensitivity of the currently cultivated vetches—which are also subject to terminal drought. In the CHT most farmers still use local landraces, which are very adaptive but poor in both seed and straw yields.

Table 1. Area under forage crops in Turkey.

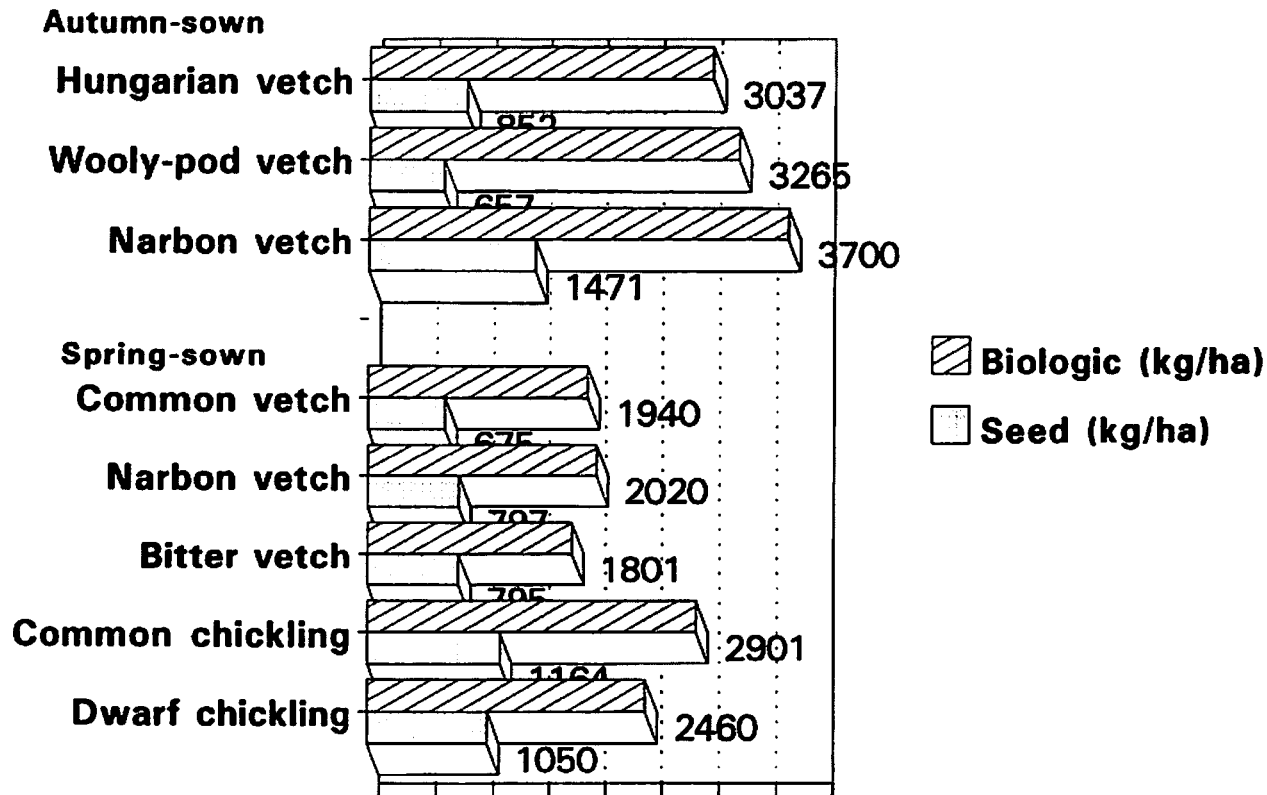
Crops	Turkey (ha)	The CHT	
		Area (ha)	% of total
Vetch	257,000	130,230	50.6
Alfalfa	172,625	38,190	22
Sainfoin	85,637	15,253	17.8
Total	515,262	183,673	35.5
Field crops			
Cultivated land	14,590,000	4,159,000	28.5
Fallow land	3,655,000	1,697,000	46.4

Agricultural Production, State Statistics Institute (1992).

The area under Hungarian vetch (*V. pannonica*), which has reasonable cold tolerance, has been increasing over the last three years. Winter planting, if successful, results in higher seed, straw, and hay production in the CHT's drier conditions. Therefore, it has great potential as a feed legume crop in this region. The other annual forage species with cold tolerance are woolly-pod vetch (*V. villosa* subsp. *dasycarpa*) and narbon vetch (*V. narbonensis*). Presently, chicklings (*Lathyrus spp.*) are not grown by farmers in the CHT.

Research on the introduction, adaptation, and improvement of annual forage legumes was needed to identify better varieties for specific regions (Elçi 1971). Thus, work on the improvement of the annual forage legume species was intensified at the Central Research Institute of Field Crops (CRIFC) in collaboration with ICARDA to identify productive forage legume species with sufficient cold tolerance for winter or early spring planting and desirable agronomic traits for the highland environments of CHT.

Figure 1. Biological and seed yield of autumn and spring-sown species over locations and years.



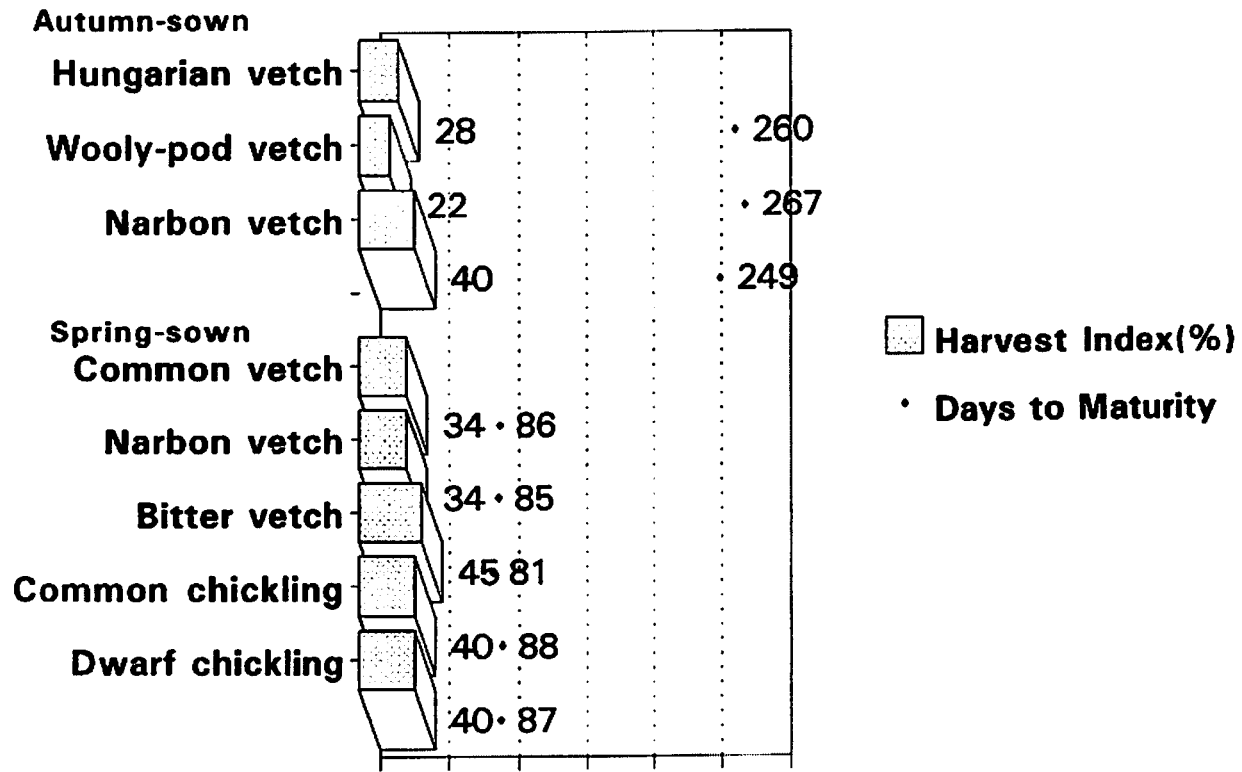


Figure 2. Harvest index and days to maturity of autumn and spring-sown species over years and locations.

Materials and Methods

Annual forage legume species obtained from ICARDA and IPGRI, and landraces collected from the CHT were evaluated during the 1992/93, 1993/94 and 1994/95 seasons. Hungarian vetch (*V. pannonica*), woolly-pod vetch (*V. villosa* spp. *dasycarpa*), narbon vetch (*V. narbonensis*), common vetch (*V. sativa*) and bitter vetch (*V. ervilia*), and two species of chickling: common chickling (*Lathyrus sativus*) and dwarf chickling (*L. cicera*) were included.

The Hungarian and woolly-pod vetches were evaluated for autumn (October) sowing, narbon vetch for both autumn and spring (March/April) sowing, and common vetch, bitter vetch, and chicklings for spring sowing only. In 1992/93, one nursery set of each species was planted at the Haymana Research Farm (HRF) of the CRIFC, located 35 km southwest of Ankara at an altitude 1,055 m and 350 mm annual rainfall. A total of 26, 30, and 15 lines of Hungarian vetch, woolly-pod vetch, and narbon vetch, respectively, were sown in four-row, 4.8 m² plots in three replications. The fertilizer DAP (46% P, 18% N) was applied at a rate of 100 kg/ha. These lines were seeded in October 1992—the farmer's normal planting time—into dry soil. For early spring planting, 15, 7, 12, 10, and 11 promising lines of *V. sativa*, *V. narbonensis*, *L. sativus*, *L. cicera*, and *V. ervilia*, respectively, were sown in six-row, 9 m² plots in three replications.

In the 1993/94 season, the winter nurseries and trials were planted at two locations, HRF, and Çankiri, 160 km north of Ankara at an altitude of 800 m with 399 mm annual rainfall. Twenty seven, 16, and 19 lines were sown of *V. pannonica*, *V. villosa* spp. *dasycarpa*, and *V. narbonensis*, respectively. The spring nurseries and trials were planted at HRF, and at the Kazan Research Farm (KRF), 30 km west of Ankara. Twenty, 9, 14, 15, and 15 lines were sown of *V. sativa*, *V. narbonensis*, *L. sativus*, *L. cicera*, and *V. ervilia*, respectively. *L. cicera* and *V. ervilia* were not planted at KRF.

In 1994/95, the seeding times and species of both winter and spring species were the same as in the previous two seasons. However, the germplasm material was not the same, as additional lines were included in autumn planting trials.

Observations were made on emergence, plant height, maturity, crop phenology, resistance to abiotic and biotic stresses, seed yield, and harvest index. Comparison of lines between and within species was carried out. The cumulative rainfall and monthly average temperature at HRF and Çankiri are summarized in Figures 3, 4, 5, and 6.

Figure 3. Cumulative rainfall at HRF.

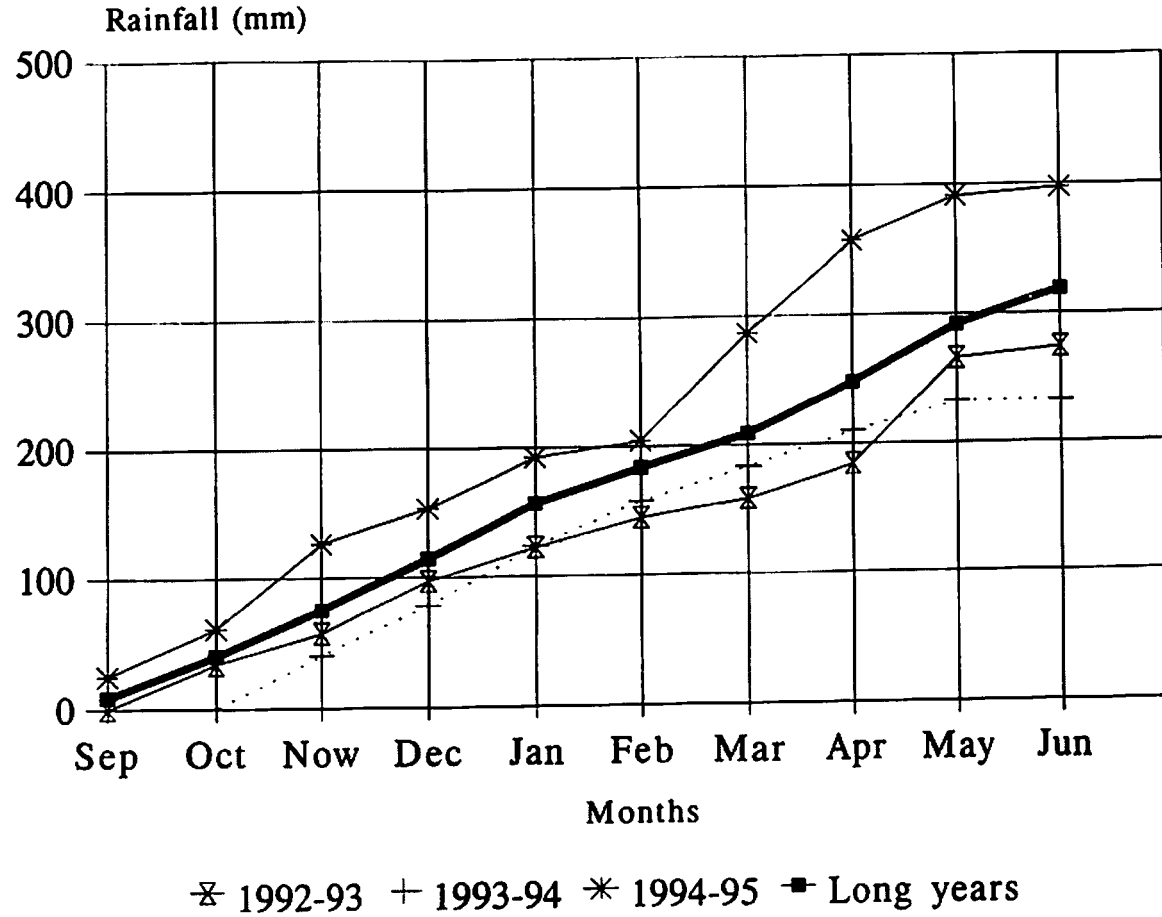


Figure 4. Cululative rainfall at Çankırı.

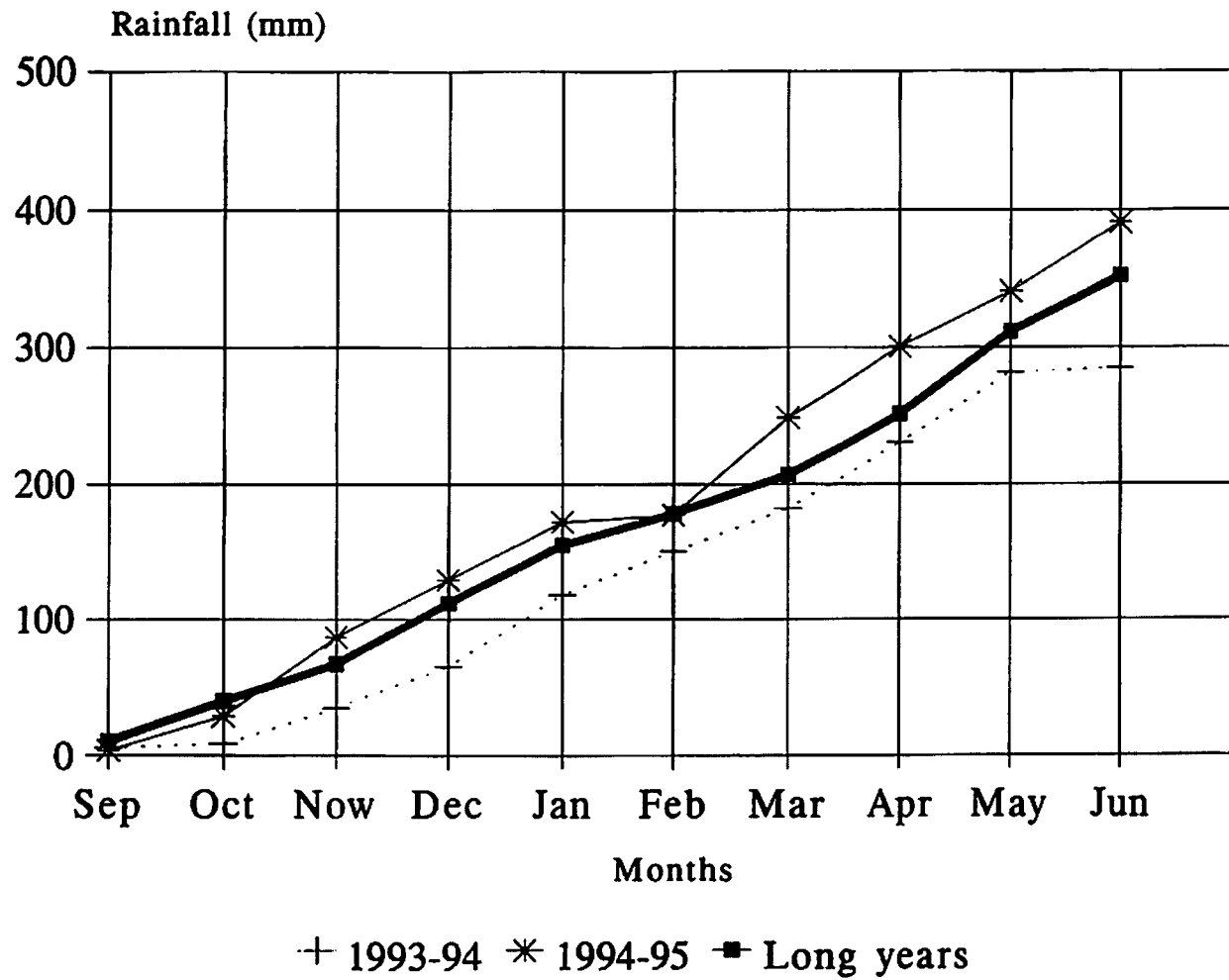


Figure 5. Monthly average temperature at HRF.

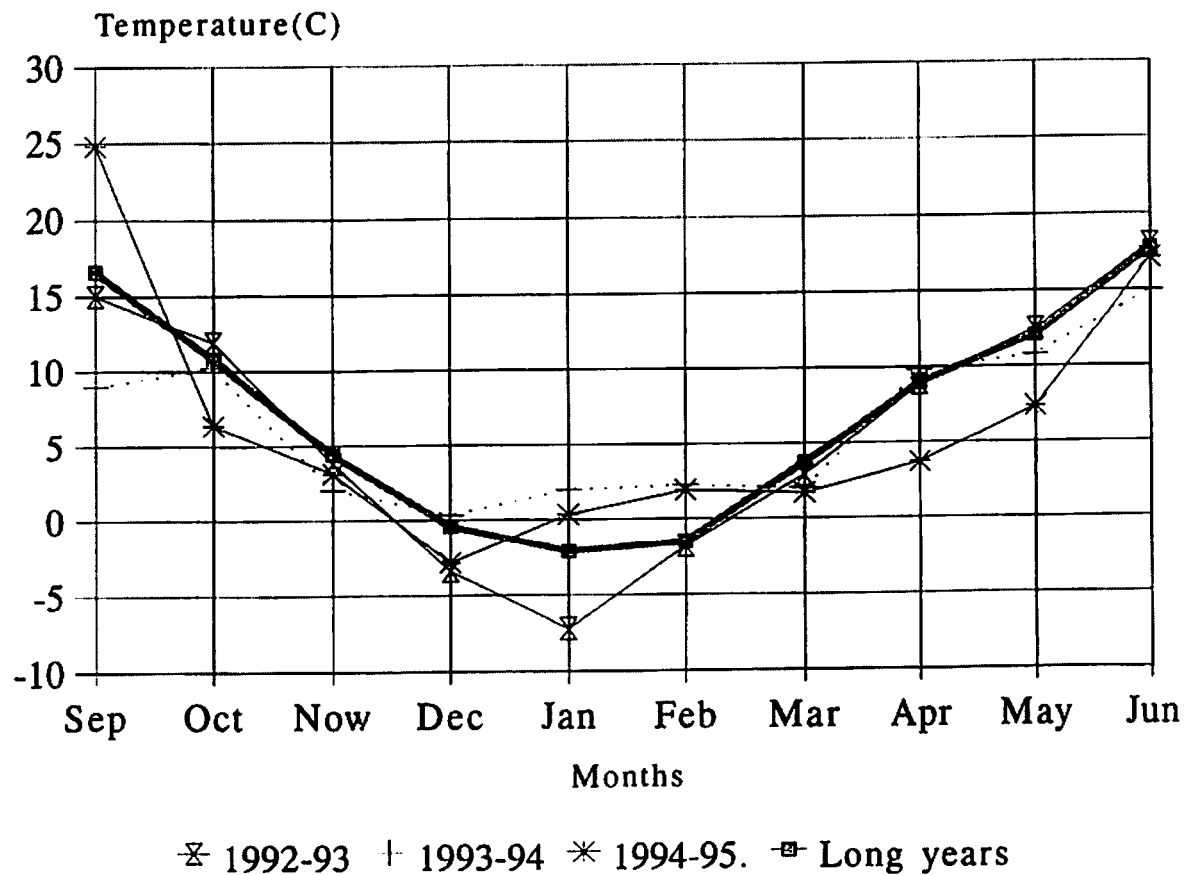
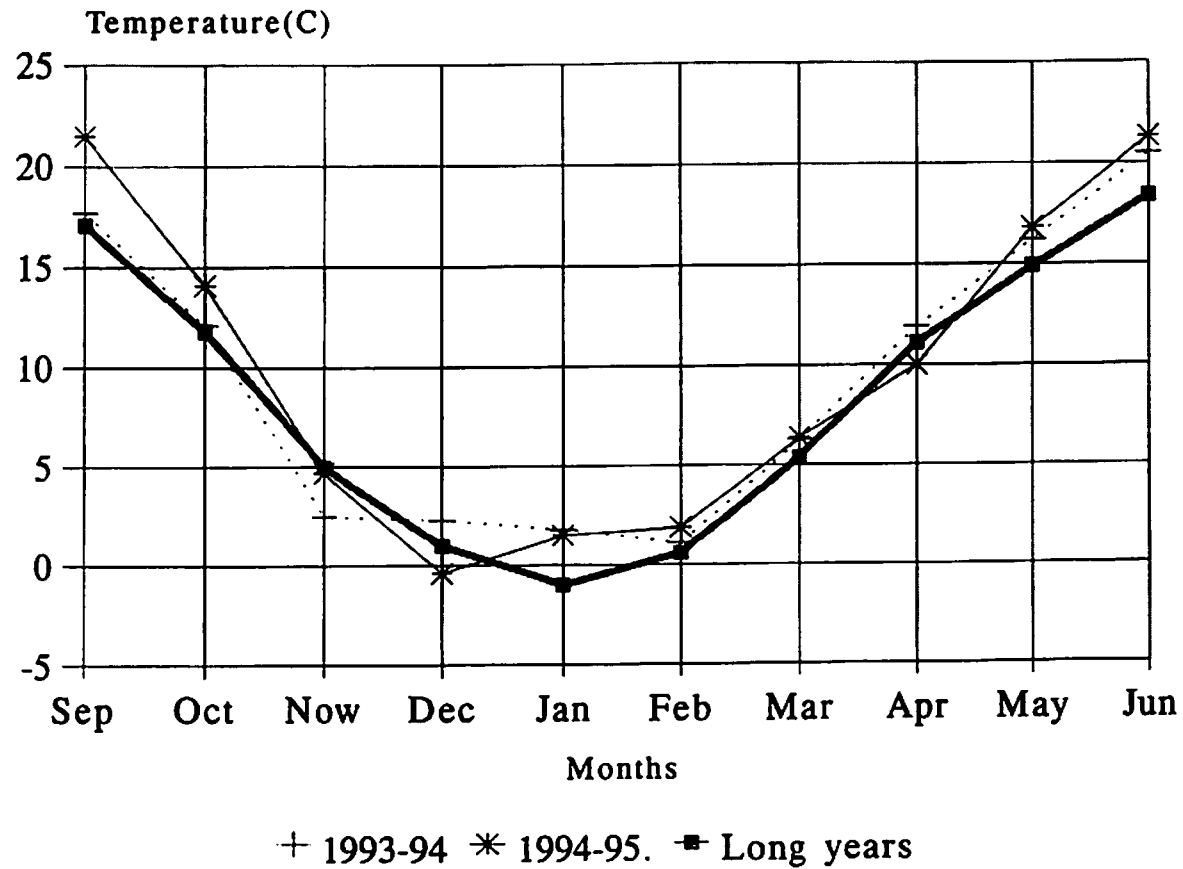


Figure 6. Monthly average temperature at Çankırı.



Results

The 1992/93 Season

The 1992/93 season was characterized by a cold winter with an average temperature of about -7° C in January (nearly 5° C lower than the long-term average, Fig. 5), and insufficient rainfall (Fig. 3). The latter prohibited a good plant stand at the beginning of winter and thus screening for cold tolerance. As a result, biological and seed yield of the tested lines were poor (Table 2). Among the three autumn-planted species, *V. pannonica* produced the highest average biological yield (1292 kg/ha), followed by narbon vetch (1007 kg/ha). *Vicia villosa* subsp. *dasycarpa* produced the lowest, at 692 kg/ha. For seed yield, *V. narbonensis* was the best yielder (435 kg/ha), and also had the best harvest index (0.43).

The spring-planted species had good plant emergence and stand because of sufficient rainfall after sowing (Fig. 5). Among the three vetch and two chickling species (Table 2), common chickling produced the highest biological and seed yield (3,810 and 1,682 kg/ha), followed by dwarf chickling (3,087 and 1,507 kg/ha). Common vetch produced the lowest biological and seed yield (2,266 and 867 kg/ha, respectively). The highest harvest index (0.48) was obtained from dwarf chickling, followed by bitter and common chickling (both 0.44).

The four best-yielding lines are presented in Table 6. Among the autumn-planted species the best accessions were Hungarian vetch 997, woolly-pod vetch 642/2, and narbon vetch 629. In the spring planting, the best accessions were common vetch 784, narbon vetch 628, bitter vetch 1033, common vetch 803, and dwarf chickling 812, producing biological yields of 2833, 3201, 2822, 4296, and 3305 kg/ha, respectively.

The 1993/94 Season

The winter was relatively mild (Figs. 5 and 6) and did not favor screening for cold tolerance. However, as a result of good plant growth in early spring, biological and seed yields were much higher than those expected at HRF (Table 3), where average yields of the species were almost twice those at Çankırı. Narbon vetch produced the highest biological and seed yield (6,371 and 2,528 kg/ha) at HRF, and woolly-pod vetch the lowest (5,510 and 966 kg/ha). However, at Çankırı, narbon vetch produced the highest biological yield (3,710 kg/ha), and Hungarian vetch produced the highest seed yield (917 kg/ha), followed by narbon vetch (867 kg/ha). Across locations, narbon vetch produced the highest biological yield (5,041 kg/ha), seed yield (1,698 kg/ha), and harvest index (0.32). The number of days to maturity was lowest (247 days) for narbon vetch, and highest (280 days) for woolly-pod vetch, because of its long flowering period.

Table 2. The mean, minimum, maximum values of biological (BY) and seed (SY) yield (kg/ha) and harvest index (HI) of autumn- and spring-sown species at Haymana Research Farm (1992-93).

Species		HRF		
		BY	SY	HI
Autumn Sown				
<i>V. pannonica</i>	Mean	1,292	317	0.25
	Minimum	322	41	
	Maximum	2,530	798	
	SEM($\pm$)			
	CV(%)			
<i>V. villosa</i> spp. <i>dasycarpa</i>	Mean	692	173	0.25
	Minimum	36	10	
	Maximum	1,638	530	
	SEM($\pm$)			
	CV(%)			
<i>V. narbonensis</i>	Mean	1,007	435	0.43
	Minimum	125	31	
	Maximum	19,679	895	
	SEM($\pm$)			
	CV(%)			
Spring Sown				
<i>V. sativa</i>	Mean	2,266	867	0.38
	Minimum	1,957	664	0.35
	Maximum	2,833	1,276	0.45
	SEM($\pm$)	45	30	0.6
	CV(%)	11	19	10
<i>V. narbonensis</i>	Mean	3,033	1,186	0.38
	Minimum	2,548	929	0.35
	Maximum	3,392	1,392	0.43
	SEM($\pm$)	87	44	0.77
	CV(%)	7.4	7.4	5.49
<i>L. sativus</i>	Mean	3,810	1,682	0.44
	Minimum	3,437	1,411	0.39
	Maximum	4,296	1,922	0.47
	SEM($\pm$)	64	32	0.56
	CV(%)	8.2	7.8	5.18
<i>L. cicera</i>	Mean	3,087	1,507	0.48
	Minimum	2,871	1,298	0.46
	Maximum	3,305	1,656	0.51
	SEM($\pm$)	57	31	0.39
	CV(%)	7.1	6.1	2.7
<i>V. ervilia</i>	Mean	2,588	1,134	0.44
	Minimum	2,355	933	0.37
	Maximum	2,822	1,288	0.46
	SEM($\pm$)	79	40	0.87
	CV(%)	14	15	11.8

Table 3. The mean, minimum, and maximum values of biological and seed yield (kg/ha) and harvest index of autumn and spring-sown species at HRF, Çankiri, and KRF (1993/94).

Sown species at HRF, Çankiri, and KRF (1998/99):										
Species		HRF			Çankiri (Autumn)/ KRF (Spring)			Over locations		
		BY	SY	HI	BY	SY	HI	BY	SY	HI
Autumn Sown										
<i>V. pannonica</i>	Mean	3,814	1,168	0.31	2,995	917	0.32	3,404	1,403	0.25
	Minimum	1,517	533	0.24	2,377	563	0.25			
	Maximum	6,577	1,673	0.36	3,920	1223	0.36			
	SEM(±)	149	83	0.4	86	32	0.63			
	CV(%)	19	21	11	16	20	15			
<i>V. villosa</i> spp. <i>dasycarpa</i>	Mean	5,510	966	0.18	2,552	584	0.22	4,031	775	0.20
	Minimum	3,143	367	0.11	1,750	276	0.16			
	Maximum	6,371	1,257	0.24	170	933	0.27			
	SEM(±)	4,590	32	0.6	19	52	0.9			
	CV(%)	7,603	14	13	3,710	23	16			
<i>V. narbonensis</i>	Mean	190	2,528	0.40	1,710	867	0.24	5,041	1,698	0.32
	Minimum	17	1,650	0.31	4,937	356	0.13			
	Maximum		3,167	0.47	177	1167	0.34			
	SEM(±)	1,391	71	0.8	22	40	1.06			
	CV(%)	1,069	14	16		20	21			
Spring Sown										
<i>V. sativa</i>	Mean	1,660			1,499					
	Mean	29	415	0.30	1,194	276	0.18	1,445	346	0.24
	Minimum	15	271	0.21	1,896	167	0.14			
	Maximum	1,445	611	0.38	54	469	0.24			
	SEM(±)	1,339	15	0.9	23	18	0.8			
<i>V. narbonensis</i>	CV(%)	1,569	23	20	1,571	38	25			
	Mean	31	392	0.27	1,454	179	0.11	1,508	286	0.19
	Minimum	11	193	0.14	1,745	74	0.4			
	Maximum	1,697	587	0.39		287	0.18			
	SEM(±)	1,276	29	1.7	18					
<i>L. sativus</i>	CV(%)	1,983	23	9.6	1,675	35	26			
	Mean	29	626	0.37	1,181	534	0.30	1,686	580	0.34
	Minimum	14	271	0.32	1,886	236	0.16			
	Maximum	1,614	611	0.41	78	775	0.42			
	SEM(±)	1,073	15	0.9	22	47	1.9			
<i>L. cicera</i>	CV(%)	1,847	17	10		29	16			
	Mean	36	454	0.28				1,614	454	0.28
	Minimum	13	635	0.16						
	Maximum	1,103	173	0.35						
	SEM(±)	778	24	1.1						
<i>V. ervilia</i>	CV(%)	1,398	28	21						
	Mean	36	523	0.47				1,103	523	0.47
	Minimum	14	347	0.38						
	Maximum		685	0.54						-
	SEM(±)		20	1						-
	CV(%)		20	14						-

BY = biological yield; SY = seed yield; HI = harvest index.

For spring-planting trials, good plant stand was obtained at both Haymana and Kazan. However, a severe drought during the vegetative growth period resulted in yield reduction. At both locations, common chickling produced the highest biological and seed yield, 1,697 and 626 kg/ha at HRF, and 1,675 and 534 kg/ha at KRF, respectively. Bitter vetch produced the highest harvest index (0.47), but the lowest biological yield (1103 kg/ha). Narbon vetch produced the lowest seed yield at both locations (392 at HRF and 1,79kg/ha at KRF). Across locations, common chickling produced the highest biological and seed yields (1,686 kg/ha at HRF and 580 kg/ha at KRF), whereas narbon vetch had the lowest seed yield (286 kg/ha) and harvest index (0.19). Dwarf chickling was late in maturity (92 days), whereas bitter vetch was the earliest (80 days).

In the autumn-planted trials (Table 6), the best yielding lines of Hungarian, woolly-pod, and narbon vetches were accessions 1107, 642/1, and 757/1, producing biological yields of 6,047, 6,887, and 5,807 kg/ha, respectively. The seed yields of these lines were 1,673, 1,027, and 2,039 kg/ha, respectively. In the spring-planted trials, the best-yielding lines were accession 777 of common vetch, accession 793/A of narbon vetch, accession 1138 of bitter vetch, accession 795 of common chickling, and accession 1055 of dwarf chickling, producing 1,695, 1,530, 1,398, 1,935, and 1,847 kg/ha, respectively.

The 1994/95 Season

This was another mild winter, although the rainfall was much higher than the long-term average at both locations (Figs. 5 and 6). For the autumn-planted trials, the average yields of all species were higher than those of the previous two seasons (Table 4). Woolly-pod vetch produced the highest biological yield (5,567 kg/ha) at HRF, whereas narbon vetch produced 5,105 kg/ha at Çankiri. Narbon vetch produced the highest seed yield (2,285 at HRF and 2,277 kg/ha at Çankiri) and harvest index (0.47 at HRF and 0.45 at Çankiri), whereas woolly-pod vetch produced the lowest seed yield (1,105 at HRF and 943 kg/ha at Çankiri) and harvest index (0.20 at HRF and 0.21 at Çankiri). However, across both locations, woolly-pod vetch produced the highest biological yield (5,071 kg/ha), and the lowest seed yield (1,024 kg/ha) and harvest index (0.21). Narbon vetch produced the highest seed yield (2,281 kg/ha) and harvest index (0.46). The number of days to maturity of narbon vetch was lowest with 243 days, followed by woolly-pod vetch (246 days) and Hungarian vetch (248 days).

For the spring-planted species, the heavy rain permitted the establishment of only one set of trials for each species at HRF. The trials consisted of promising lines of three species of vetches—*V. sativa*, *V. narbonensis*, and *V. ervilia*—and the two species of chickling—*L. sativus*, *L. cicera*. Sufficient rainfall after planting resulted in a good plant stand in the experimental plots. Common chickling produced the highest biological and seed yield (3,027 and 1,230 kg/ha, respectively), whereas bitter vetch the produced the lowest (1,713 and 729 kg/ha, respectively). Narbon vetch yielded the highest harvest index (0.44), and common vetch the lowest (0.39). The number of days to maturity was 79 for dwarf chickling and 83 for common chickling. The best yielding autumn-sown species were: accessions 1101 of Hungarian vetch, 1006 of woolly-pod vetch, and 1023 of narbon vetch,

producing biological yields of 4,987, 5,574, and 8,609 kg/ha, respectively. In the spring-sown species, common vetch 784, narbon vetch 628, bitter vetch 1138, common chickling 796, and dwarf chickling 811 had the best biological yields, at 2,725, 2,400, 1,937, 3,347, and 3,006 kg/ha, respectively.

Across the Three Seasons

Over the three years, narbon vetch produced the highest biological yield (3,700 kg/ha) followed by woolly-pod vetch (3,266 kg/ha) and Hungarian vetch (3,037 kg/ha) among the autumn-sown species. Narbon vetch also had the best seed yield, at 1,471 kg/ha, followed by Hungarian vetch (852 kg/ha) and woolly-pod vetch (667 kg/ha). Narbon vetch also had the best harvest index (0.40) followed by Hungarian vetch (0.28) and woolly-pod vetch (0.22). Narbon vetch matured earliest (240 days), followed by Hungarian vetch, which matured 260 days from planting.

Since the number of lines included in the trials progressively increased over the years, and the weather varied over seasons, the best yielding lines did not remain constant (Table 6). Nevertheless, some of the lines were more stable and stayed in the best group for biological and seed yield in more than two seasons. Among the autumn-sown vetches, accession 694/1 of woolly-pod vetch was in the best yielding group during all three years. Accession 1023 of narbon vetch was in the best yielding group in 1992/93 and 1994/95. Among the spring-sown species, accessions 784 and 772 of the common vetch were in the best yielding group in 1992/93 and 1994/95, along with accessions 628 and 793/A of narbon vetch. Among the bitter vetch lines, accession 1033 ranked in the best-yielding group in all three years. Accession 800 of common chickling was in the best-yielding group in 1992/93 and 1993/94. Accession 812 of dwarf chickling was in the top-yielding group during all three years.

Table 4. The mean, minimum, and maximum values of biological (BY) and seed (SY) yield (kg/ha) and harvest index (HI) of autumn- and spring-sown species at HRF and Çankırı (1994/95).

		HRF			Çankırı			Mean over locations		
Species		BY	SY	HI	BY	SY	HI	BY	SY	HI
Autumn Sown										
<i>V. pannonica</i>	Mean	4561	1269	0.28	4268	1124	0.26	4415	1197	0.27
	Minimum	3336	836	0.14	2324	286	0.12			
	Maximum	6432	2026	0.40	6391	2067	0.37			
	SEM(±)	70	27	0.6	99	46	0.8			
	CV(%)	13	13	13	15	22	16			
<i>V. villosa</i> spp. <i>dasycarpa</i>	Mean	5567	1105	0.20	4574	943	0.21	5071	1024	0.21
	Minimum	2918	482	0.7	3038	514	0.8			
	Maximum	7976	1700	0.30	7257	1562	0.31			
	SEM(±)	133	39	0.6	108	37	0.73			
	CV(%)	12	22	21	17	27	22			
<i>V. narbonensis</i>	Mean	5001	2285	0.47	5105	2277	0.45	5053	2281	0.46
	Minimum	1576	808	0.33	3219	1410	0.35			
	Maximum	9038	3400	0.57	7610	3229	0.53			
	SEM(±)	183	71	0.6	131	58	0.6			
	CV(%)	13	14	7	17	16	6			
Spring Sown										
<i>V. sativa</i>	Mean	2110	813	0.39						
	Minimum	967	267	0.21						
	Maximum	4378	1356	0.50						
	SEM(±)	33	15	0.5						
	CV(%)	13	13	11						
<i>V. narbonensis</i>	Mean	2120	920	0.44						
	Minimum	1408	608	0.30						
	Maximum	2758	1208	0.50						
	SEM(±)	80	38	1						
	CV(%)	14	14	6						
<i>L. sativus</i>	Mean	3027	1230	0.41						
	Minimum	2358	667	0.28						
	Maximum	3700	1642	0.49						
	SEM(±)	65	34	0.7						
	CV(%)	12	14	7						
<i>L. cicera</i>	Mean	2679	1188	0.45						
	Minimum	1722	780	0.33						
	Maximum	3533	1467	0.51						
	SEM(±)	74	32	0.8						
	CV(%)	15	15	10						
<i>V. ervilia</i>	Mean	1713	729	0.43						
	Minimum	1238	457	0.22						
	Maximum	2524	1143	0.55						
	SEM(±)	39	17	0.9						
	CV(%)	8	15	12						

BY = biological yield; SY = Seed yield; HI = Harvest index.

Table 5. The mean, minimum, and maximum values of days from planting to harvest of autumn and spring-sown species at Haymana Research Farm (1992/93, 1993/94 and 1994/95).

Species		1992/93	1993/94	1995/96	Mean over years
Autumn Sown					
<i>Vicia pannonica</i>	Mean	273	260	248	260
	Minimum	260	253	240	
	Maximum	281	262	251	
	SEM($\pm$)		0.2	0.29	
	CV(%)		0.3	0.43	
<i>V. villosa</i> spp. <i>dasycarpa</i>	Mean	275	280	246	267
	Minimum	269	274	241	
	Maximum	277	282	256	
	SEM($\pm$)		0.5	0.48	
	CV(%)		0.37	0.73	
<i>V. narbonensis</i>	Mean	256	247	243	249
	Minimum	256	247	239	
	Maximum	256	247	244	
	SEM($\pm$)			0.15	
	CV(%)			0.45	
Spring Sown					
<i>V. sativa</i>	Mean	89	88	81	86
	Minimum	83	83	77	
	Maximum	95	96	103	
	SEM($\pm$)	0.4	0.5	0.37	
	CV(%)	3.6	2	1.27	
<i>V. narbonensis</i>	Mean	87	88	80	85
	Minimum	82	83	78	
	Maximum	92	96	84	
	SEM($\pm$)	0.5	0.95	0.6	
	CV(%)	1.6	2.4	0	
<i>Lathyrus sativus</i>	Mean	94	87	83	88
	Minimum	-	81	77	
	Maximum	-	88	96	
	SEM($\pm$)	-	0.3	0.72	
	CV(%)	-	0.2	3.9	
<i>L. cicera</i>	Mean	91	92	79	87
	Minimum	88	89	77	
	Maximum	93	97	84	
	SEM($\pm$)	0.41	0.2	0.58	
	CV(%)	3.5	0.25	2.23	
<i>V. ervilia</i>	Mean	82	80	80	81
	Minimum	80	78	78	
	Maximum	84	89	83	
	SEM($\pm$)	0.36	0.5	0.5	
	CV(%)	2.46	3	3	

Table 6. Best yielding lines of *Vicia* and *Lathyrus* species (1992/93, 1993/94 and 1994/95).

Species	1992/93			1993/94			1994/95		
	Acq	BY	SY	Acq	BY	SY	Acq	BY	SY
Autumn Sown									
<i>Vicia pannonica</i>	997	2530	749	1107	6047	1673	1001	4987	1378
	995	1944	586	751	5249	1400	752	4794	1187
	1002	1850	503	723/3	4057	1118	751	4790	852
	738/3	1496	409	750	3949	1167	1026	4667	1383
<i>V. villosa</i> spp. <i>dasycarpa</i>	642/2	1984	494	642/1	6887	1027	1006	5557	1291
	694/1	1638	530	700/1	5307	1095	1012	5544	1124
	653/2	1546	296	694/1	4847	1029	694/1	5424	1273
	627	1498	411	636/4	4837	834	700/1	5242	1203
<i>V. narbonensis</i>	629	1979	895	757/1	5807	2039	1023	8609	2678
	792	1628	777	788	4965	1969	628	6292	2758
	757/1	1482	673	1025	5465	1954	629	6495	2711
	1023	1413	657	1019	5629	1752	1016	6099	2651
Spring Sown									
<i>V. sativa</i>	784	2833	1276	777	1695	441	784	2725	1086
	777	2290	926	775	1664	475	782	2528	1006
	782	2284	895	776	1656	457	772	2467	1014
	772	2280	740	774	1550	478	932	2358	1078
<i>V. narbonensis</i>	628	3201	1392	793/A	1530	359	628	2400	1028
	793/A	3379	1345	792	1468	368	793/A	2317	1056
	788	3392	1215	788	1500	328	1017	2228	1014
	629	3198	1374	628	1582	183	788	1935	925
<i>V. ervilia</i>	1033	2822	1288	1138	1398	634	1138	1937	832
	1034	2800	1266	1038	1292	685	1033	1762	746
	1032	2700	1200	1033	1241	625	1032	1816	844
	1037	2655	1212	1036	1269	625	1035	1632	787
<i>Lathyrus sativus</i>	803	4296	1776	795	1935	584	796	3347	1333
	800	4062	1922	794	1752	518	798	3342	1378
	802	4042	1687	805	1816	516	804	3186	1325
	796	3895	1804	800	1489	543	794	3056	1319
<i>L. cicera</i>	812	3305	1607	1055	1847	635	811	3006	1256
	814	3173	1576	1053	1703	578	813	3114	1319
	811	3073	1562	812	1524	538	812	2742	1253
	816	3066	1416	816	1712	389	814	2917	1197

BY = biological yield; SY = seed yield; Acq = acquisition.

Discussion

The success or failure of growing annual forage legume species in harsh environments is largely dependent on the degree of resistance to abiotic stresses. In environments like the CHT, the major constraints are low winter air temperatures and variable drought in the growing season. It is hard for a single species to produce stable yields under unstable conditions. This requires identification of adapted species and lines for a given place and time (Keatinge et al. 1991).

Despite the fact that the availability of good-quality hay decreases the dependence on costly concentrates for livestock feeding, farmers in the CHT grow common vetch only for its seed and straw. This might be due to local traditions and climatic conditions. The introduction of additional annual forage legumes into the farming system would provide alternatives to farmers. These crops are versatile or multipurpose, some are suitable for haymaking in spring and others are suitable for grazing and straw production at full maturity. Targeting suitable crops for a certain environment and a specific use is necessary.

The experiences gained through this initial study show that autumn-sown species have more yield potential in the CHT than spring-sown species. Over the three years, the performances of Hungarian vetch and woolly-pod vetch, both of which produced high crop biomass for hay and grazing, were very promising, although they have a relatively low harvest index. Both can be cut or grazed during the spring when herbage quality is still high and forage is badly needed, as emphasized by Abd El Moneim et al. (1990). On the other hand, narbon vetch produced the highest biological and seed yield and harvest index when grown as an autumn-sown crop. The high seed yield of narbon vetch makes this species a good grain legume crop in the semi-arid regions of West Asia (Abd El Moneim et al. 1988). In the CHT, this forage legume species has good potential as an important crop for seed and straw.

Although the autumn-sown species are likely to be preferred by farmers in the CHT, due to the risk of failure or to variations in use patterns, the spring-sown species should be considered as alternatives. Açıkgöz (1988) reports promising annual forage legumes, principally *Vicia* and *Lathyrus* spp., in the highlands of Turkey. In our evaluation, common chickling (*L. sativus*) was the most promising when spring sown, followed by dwarf chickling (*L. cicera*). This makes them good alternatives to common vetch. Bitter vetch matured earliest, enabling this species to avoid terminal drought in 1993/94.

Despite more lines in later seasons, some lines were identified as best yielding and most stable over time and place. These included accessions 694/1 of woolly-pod vetch, 793/A of narbon vetch, 1033 of bitter vetch, and 812 of dwarf chickling.

Further study is indicated on: (i) further screening of new potential species and lines from genus *Vicia* and *Pisum*; (ii) screening of the selected lines for feed quality and toxic elements; (iii) screening for the competitive ability of the lines in a mixture with cereals, e.g., barley and oat, and for grazing or hay.

Compared with other economically important crops, limited work on germplasm evaluation of annual forage legumes in the CHT has been carried out. This might

be partly because of the nature of these crops and/or their lower attractiveness to researchers. However, we believe that an increased demand for livestock feed supplies and existing low yielding landraces and non-tangibility of alternative forages make this work on forage legume germplasm evaluation and selection very important.

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Discussion

Y. Sweidan: Do you think that narbon vetch is suitable for sheep feeding as green fodder? My understanding is that is not suitable, and is less palatable than wild vetch or lathyrus.

H. Firincioglu: Narbon vetch has the highest total biomass, seed yield, and harvest index. Furthermore, the high seed yield makes it a good grain crop. Therefore, it should be utilized as a grain crop.

M. Al-Ayadi: What about using *Vicia amphicarpa* in this trial and about production of common vetch by farmers for lamb fattening or for seed production?

H. Firincioglu: I tried, but because it has seed hardness it is difficult to get a good plant stand, and it produces very low biomass. Therefore it is not suitable to grow under field conditions. It might be utilized for rangeland rehabilitation because of its seed hardness.

M. Tahir: Does *Vicia panonica* require vernalization? If yes, what is the level of vernalization requirement? Secondly, does this species respond to photoperiodism?

H. Firincioglu: At present we don't have any information on its vernalization and photoperiod requirement.

Forage and Seed Production of Vetches (*Vicia* spp.) at Different Seeding Rates under Rainfed Conditions

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Abstract

Field experiments were conducted at the farm of the College of Agricultural and Forestry at Hammam Al-Alil for two successive seasons (1992/93 and 1993/94), and at Telafar and Rabiaa research stations in 1993/94 under rainfed conditions, to study forage and seed production at different seeding rates (40, 80, 120, 160, and 200 kg/ha) for two vetches (*Vicia sativa* and *V. dasycarpa*).

Results show that *V. sativa* produced greater forage and seed yields than *V. dasycarpa* and had a higher harvest index. *Vicia dasycarpa* produced the longest branch length. There were no significant differences in the number of branches per plant between the two species. Maximum forage production was 120 kg/ha, and maximum seed production was 80 kg/ha. Branch length increased with increasing seeding rates, but the number of branches per plant decreased.

There were no clear differences in forage and seed yield among the three locations, except for 1992/93 at Hammam Al-Alil, where greater forage and seed yields were produced.

Introduction

Since 1989 the Mashreq Project has played a major role in the development of a low-rainfall area (250–350 mm) in northern Iraq (1.750 million ha) by introducing forage legumes as vetches, including *V. sativa* and *V. dasycarpa*. The purpose is to increase farm productivity in two ways: to increase pasture productivity and therefore sheep grazing productivity in the marginal areas of the northern Jazirah, and to increase productivity of cereals, mainly barley. Total farm productivity in the traditional cereal-growing areas, where the current farming system is a cereal–fallow rotation, must also be increased.

Fallowing involves leaving half the land without cultivation for a growing season, while continuous cultivation leads to depletion of soil fertility, the build-up of soil-borne diseases and nematode, and consequently low cereal yield. Iraq and other countries in the area are aiming to change the current farming system by introducing forage legumes like vetches and medics instead of fallow or continuous cropping (Bakhtri 1979; Al-Fakhry 1981; Papasytyliaous 1990). The new rotation

will be cereal-forage legumes. Very few studies on forage legumes in general and vetches in particular exist. The aim of this study is to seek information on vetches in respect to forage and seed production and other characters at different seeding rates.

Materials and Methods

This study was carried out at the farm of the College of Agriculture and Forestry at Hammam Al-Alil, 30 km southeast of Mosul (1992/93 and 1993/94), and at the Rabiaa and Telafar Agricultural Research Stations (1993/94), 90 and 65 km northeast and west of Mosul, respectively. Forage and seed production at different seeding rates (40, 80, 120, 160, and 200 kg/ha) for two vetches, *V. sativa* and *V. dasycarpa* were studied.

At Hammam Al-Alil, the soil is silty clay loam, with a pH of 7.9. At Rabiaa and Telafar, the soil is clay loam with a pH of 7.1.

At Hammam Al-Alil, experimental plots were seeded on November 19 in 1992/93 and November 22 in 1993/94. Plots were seeded on November 26 at Rabiaa and November 28 at Telafar, in 1993/94. Each plot consisted of six rows, 4 m long, planted 30 cm apart.

A randomized complete block design (RCBD) was set up with three replications, as outlined by Steel and Torrie (1960). Duncon's new multiple range test was used to identify the significant differences between treatment means. Means followed by the same alphabetical letters are not statistically significant.

Weed control was by hand from germination to flowering.

Table 1: Amount of rainfall (mm) and its monthly distribution at Hammam Al-Alil (1992/93 and 1993/94) and at Rabiaa and Telafar (1993/94).

Months	Hammam 92/93	Al-Alil 93/94	Rabiaa 93/94	Telafar 93/94
October		8.9	2.8	9.2
November	49.9	57.4	44.5	72.6
December	107.2	103.0	49.2	49.5
January	44.7	87.2	89.7	104.0
February	104.0	30.5	29.4	32.0
March	24.2	32.7	79.3	84.0
April	130.0	74.2	43.3	35.0
May	110.6			
June				
Total	570.6	393.9	338.2	386.3

Ten plants were randomly taken from each plot at flowering to determine longest branch length and number of branches per plant. Dry forage yield was determined at 50% flowering by cutting the second and third lines of each plot and then dried at 90° C for 48 hours, and then weighted. Seed yield was determined by harvesting the fourth and fifth lines of each plot, threshing and weighting. Seed yield (HI) is calculated as:

$$\text{Harvest index} = \frac{\text{economic yield}}{\text{biological yield}} \times 100\%$$

Results and Discussion

Hammam Al-Alil

Vegetative characteristics

Effect of species. *Vicia dasycarpa* gave significantly longer branch length than *V. sativa* in 1992/93 and 1993/94 (Table 2). In 1992/93, *V. dasycarpa* produced a branch length of 80 cm compared with 58 cm for *V. sativa*. Corresponding values were 63 and 47 cm in 1993/94. This is probably because *V. dasycarpa* matures about 10 days later than *V. sativa*, which gives it more time for growth. *Vicia dasycarpa* surpassed *V. sativa* in branch length in 1992/93 compared with 1993/94. This superiority is due to the amount of rainfall.

The number of branches per plant showed no significant differences between the two species for 1992/93 and 1993/94 (Table 2).

Table 2: Mean values of the branch length (cm) and number of branches per plant of *Vicia sativa* and *Vicia dasycarpa* for Hammam Al-Alil (1992/93 and 1993/94).

	1992/93		1993/94	
	<i>V.sativa</i>	<i>V. dasycarpa</i>	<i>V. sativa</i>	<i>V. dasycarpa</i>
Longest branch length	58.0b	80.0a	47.0b	63.0a
Number of branches/plant	4.8	4.7	4.5	4.4

Effect of seeding rate. The longest branch length was significantly increased by increasing the seeding rate from 40 kg/ha to 200 kg/ha in 1992/93 and 1993/94 (Table 3). The seeding rate of 40 kg/ha produced shorter branches: 43 cm in 1992/93 and 46 cm in 1993/94, whereas the highest seeding rate, 200 kg/ha, produced longer branches: 86 cm in the first year and 63 cm in the second (Table 3). Data presented in Table 3 show that the number of branches per plant decreased with increasing seeding rates in both years (Table 3).

Table 3: Effect of vetch seeding rate on the longest branch length (cm.) and the number of branches per plant of *Vicia sativa* and *Vicia dasycarpa* at Hammam Al-Alil (1992/93 and 1993/94).

Seeding rates (kg/ha)	1992/94		1993/94	
	Longest branch length	No. of branches per plant	Longest branch length	No. of branches per plant
40	43 c	5.6 ab	46 b	5.3 a
80	57 b	5.6 ab	52 c	5.2 a
120	78 a	4.9 b	53 bc	4.6 b
160	80 a	4.2 c	60 ab	3.8 b
200	86 a	3.5 d	63 a	3.1 c

Forage, seed and biological yields and harvest Index

Effect of species. There were significant differences in forage and seed yield between the two species in both seasons (Table 4). Yields of *V. sativa* were greater than that of *V. dasycarpa* in both seasons, 15% and 26% for forage yield, and 59% and 51% for seed yield in 1992/93 and 1993/94, respectively. Dry matter yield showed similar differences between the two species in both years (Table 4). Where *V. sativa* had a higher harvest index (46% and 45% in 1992/93 and 1993/94, respectively) than *V. dasycarpa* (32% and 31%). (Table 4). The decrease in HI of *V. dasycarpa* was due to lower seed production, as there were no significant differences in biological yield between the two species in both seasons (Table 4).

Table 4: Mean values of forage, seed and biological yield (kg/ha), and harvest index of *Vicia sativa* and *Vicia dasycarpa* at Hammam Al-Alil (1992/93 and 1993/94).

Characters	1992/93		1993/94	
	<i>V. sativa</i>	<i>V. dasycarpa</i>	<i>V. sativa</i>	<i>V. dasycarpa</i>
Forage yield	1708 a	1480 b	1091 a	866 b
Seed yield	1140 a	716 b	1016 a	672 b
Biological yield	1196	1088	1084	1056
Harvest index %	46 a	32 b	45 a	31 b

Effect of vetch seeding rate. Seeding rate had a great effect on forage yield in both years (Table 5). The highest forage yield was produced at 120 kg/ha and the lowest at 40 kg/ha in both seasons. There were no significant differences in forage yield among seeding rates of 120, 160, and 200 kg/ha. Forage yield at a seeding rate of 120 kg/ha were 1,852 and 1,098 kg/ha in 1992/93 and 1993/94, respectively. Corresponding values at 40 kg/ha were 924 and 725 kg/ha. A seeding rate of 40 kg/ha produced significantly lower seed yield in both seasons (Table 4). The highest results were produced at 80 kg/ha (1060 kg/ha) and the lowest was at 40 kg/ha (612 kg/ha) in 1992/93, and were 984 and 516 kg/ha in 1993/94 (Table 5).

Table 5: Effect of seeding rate on forage, seed and biological yield (kg/ha), and harvest index of *Vicia sativa* and *Vicia dasycarpa* at Hammam Al-Alil (1992/93 and 1993/94).

Seeding rates (kg/ha)	1992/93				1993/94			
	Forage yield	Seed yield	Biological yield	Harvest index %	Forage yield	Seed yield	Biological yield	Harvest index %
40	924 c	612 b	1525 b	39 a	725 c	516 c	1148 b	38 a
80	1532 b	1060 a	2625 a	40 a	933 b	984 a	2508 a	39 a
120	1852 a	1032 a	2583 a	40 a	1098 a	960 ab	2452 a	39 a
160	1840 a	992 a	2550 a	39 a	1081 a	908 ab	2416 a	38 a
200	1832 a	952 a	2633 a	36 b	1066 a	860 b	2464	35 b

Biological yield showed significant differences according to seeding rate in both seasons (Table 5). A seeding rate of 40 kg/ha gave by far the lowest biological yield (Table 5). Partitioning of dry matter between the economic yield and the biological yield showed significant differences among seeding rates (Table 5). Harvest index followed a similar pattern in both seasons (Table 5).

The highest seeding rate, 200 kg/ha, produced by far the lowest harvest index, 36% and 35%.

Rablaa and Telafar

Vegetative characteristics

Effect of vetch species. *Vicia dasycarpa* produced by far the longest branch length both locations (Table 6). The longest branch length of *V. dasycarpa* was 68 cm at Rablaa and 64 cm at Telafar (Table 6). *Vicia sativa* lengths were 49 and 47 cm. The number of branches per plant showed no significant differences between the two species (Table 6).

Table 6. Mean values of the longest branch length (cm) and number of branches per plant of *Vicia sativa* and *Vicia dasycarpa* at Rablaa and Telafar (1993/94).

Character	Rablaa		Telafar	
	<i>V. sativa</i>	<i>V. dasycarpa</i>	<i>V. sativa</i>	<i>V. dasycarpa</i>
Longest branch length	49 b	68 a	47 b	64 a
No. of branches/plant	4.6	4.5	4.7	4.8

Effect of seeding rate. The longest branch length increased along with the seeding rate at both locations (Table 7). The lowest values were 48 and 46 cm for Rablaa and Telafar, respectively, at a seeding rate of 40 kg/ha. Highest values were 70 and 70 cm at a seeding rate of 200 kg/ha (Table 7).

The number of branches per plant decreased with increasing seeding rate (Table 7). Lowest value was recorded at the highest seeding rate (200 kg/ha) and highest value was recorded at the lowest seeding rate (40 kg/ha). (Table 7)

Table 7: Effect of seeding rate on the longest branch length (cm) and number of branches per plant of *Vicia sativa* and *Vicia dasycarpa* at Rabiaa and Telafar (1993/94).

Seeding rate (kg/ha)	Rabiaa		Telafar	
	Longest branch length	No. of branches plant	Longest branch length	No. of branches plant
40	48 d	5.5 a	46 c	5.7 a
80	53 c	5.4 ab	50 c	5.5 a
120	58 b	4.8 b	52 c	4.9 b
160	63 b	4.0 c	62 b	4.2 c
200	70 a	3.3 d	70 a	3.5 d

Forage, seed and biological yield, and harvest index

Effect of vetch species. Data presented in Table 8 show significant differences in forage yield between the vetch species. *Vicia sativa* was surpassed by *V. dasycarpa* in forage yield by 16% at Rabiaa and 18% at Telafar. Seed yield showed the significant superiority of *V. sativa* over *V. dasycarpa* at both locations. This superiority is probably due to the fact that *V. sativa* matures about 10 days earlier than *V. dasycarpa* and therefore encounters favorable conditions for fertilization and seed formation. There were no significant differences in biological yield between the vetch species at both locations.

Vicia sativa had a significantly higher harvest index than *V. dasycarpa* at both locations (Table 8). *Vicia sativa* produced the highest harvest index, 46% at Telafar and 47% at Rabiaa. *Vicia dasycarpa* produced the lowest harvest index, 31%. The superiority of *V. sativa* means that more dry matter or photosynthate is allocated to seed formation than the rest of the plant (leaves, stems, and roots). This is because, either *V. sativa* is more efficient at directing dry matter towards seed formation than *V. dasycarpa* or, as mentioned above, *V. sativa* matures 10 days earlier than *V. dasycarpa*.

Table 8: Mean values of forage, seed and biological yield (kg/ha), and harvest index of *Vicia sativa* and *Vicia dasycarpa* at Rabiaa and Telafar (93/94).

Characters	Rabiaa		Telafar	
	<i>V. sativa</i>	<i>V. dasycarpa</i>	<i>V. sativa</i>	<i>V. dasycarpa</i>
Forage yield	900 a	775 b	992 a	842
Seed yield	952 a	608 b	793 a	642 b
Bio. yield	2017	1950	2125	2067
Harvest yield %	47 a	31 b	46 a	31 b

Effect of seeding rate. Table 9 illustrates significant differences in forage yield between the seeding rates at both locations. A seeding rate of 120 kg/ha produced greater forage yield than other rates, while a rate of 40 kg/ha produced the lowest forage yield (Table 9). The rate of 120 kg/ha surpassed the rate of 40 kg/ha by 57% and 63% at Rabiaa and Telafar, respectively. There were no significant differences in forage yield among seeding rates of 120, 160, and 200 kg/ha.

Seed yield followed a similar pattern at both locations (Table 9). At a seeding rate of 40 kg/ha, seed yield significantly decreased in comparison with other seeding rates, while a rate of 80 kg/ha produced the greatest seed yield (Table 9). Biological yield followed a similar pattern at both locations (Table 9). A seeding rate of 40 kg/ha produced by far the lowest biological yield. Partitioning of dry matter between economic yield and biological yield showed significant differences among seeding rates (Table 9). Seeding rates of 80 and 120 kg/ha had the highest harvest index values.

Table 9: Effect of seeding rate on forage, seed and biological yield (kg/ha). and harvest index of *Vicia sativa* and *Vicia dasycarpa* at Rabiaa and Telafar (1993/94).

Seeding rates (kg/ha)	Rabiaa				Telafar			
	Forage yield	Seed yield	Biological yield	Harvest index %	Forage yield	Seed yield	Biological yield	Harvest index %
40	625 b	450 b	1,133 b	39 bc	648 c	475 b	1,208 b	38 bc
80	725 b	900 a	2,233 a	40 ab	833 b	942 a	2,383 a	40 ab
120	983 a	867 a	2,075 a	42 a	1,058 a	917 a	2,242 a	41 a
160	942 a	850 a	2,208 a	38 c	1,042 a	883 a	2,292 a	38 bc
200	925 a	833 a	2,250 a	37 c	983 a	866 a	2,367 a	37 c

Conclusion

Vicia sativa has a higher forage yield than *V. dasycarpa* (at 50% flowering) and higher seed production. A seeding rate of 120 kg/ha is recommended for forage production and 80 kg/ha for seed production. More dry matter is allocated for seed production in *V. sativa* than *V. dasycarpa*. Consequently *V. dasycarpa* has a lower harvest index.

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Discussion

Y. Sweidan: Did you take samples to estimate the yields from *V. sativa* and *V. dasycarpa* at the same time or at different times? Also, what is your recommendation: to produce seed or hay, and what seed rate do you recommend?

K. Kasim: Sampling depended on flowering time (50% flowering). I would recommend 80 kg/ha for seed production, 120 kg/ha for forage production.

N. Hrimat: Farmers sow seed by broadcasting, so the recommended seeding rates must be increased. What was the method used for sowing the seeds, driller or broadcasting?

K. Kasim: The seed was sowed by hand inside the line, not broadcast.

Effect of Seeding Rates and Barley Harvesting on Forage and Seed Production in some Forage Legumes

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Abstract

The benefits of including forage legumes in the farming systems of the Mediterranean region are well known, but more research is needed on the effect of management factors on forage and seed production. A field trial was carried out in 1992/93 and 1993/94 to study the effect of three seeding rates (40, 80, and 120 kg/ha) and three harvesting treatments, on forage and seed production and yield components in four forage legumes (*Vicia sativa* sel. 2541, *V. ervilla*, *V. villosa* subsp. *dasycarpa*, and *Lathyrus sativus* sel. 311). The species were sown in November in both years and harvested on the first in March. The regrowth was left for seed production. The second harvest was conducted at pod formation and the third at maturity. Average dry matter and seed yield were increased by increasing the seeding rates in both seasons. *Lathyrus sativus* was the lowest yielding species at early harvest, while *V. sativa* was the highest yielding at late harvest. Harvesting legume species early in March and leaving the regrowth for seed production caused a considerable reduction in seed yield.

This reduction was most marked in *V. ervilla*. Other seed components were affected only slightly by seeding rate. The relationship between their adaptation to the prevailing environmental conditions and their possible uses are discussed.

Introduction

The benefits of including forage and pasture legumes in the farming systems of the Mediterranean countries is well known (Osman et al. 1990). Seed supply is considered one of the constraints to extending the area under forage crops in most of these countries. Though there is relatively little published information concerning the effect of management factors on forage and seed production from these crops, at least in Iraq, most of the work has focused on forage production from mixtures of vetches with small cereals (Tubaileh 1977; El-Tekriti and Altif 1986) and rarely on vetches sown alone (Mohamed and Tawfiq 1993).

Production of forage legume seed requires knowledge and technology. The factors that affect it must be studied and can be manipulated by agronomic and breeding programs. This investigation was conducted to study the effect of early harvesting

and seeding rate on forage and seed production in four forage legumes, bearing in mind that these two factors can influence the prostrate growth habit, which is a general drawback in the mechanical harvesting of most *Vicia* and *Lathyrus* species.

Materials and Methods

The study was carried out at the Experimental Research Station of the College of Agriculture and Forestry at Hammam Al-Alil (6 10 N, 43 16 E) 25 km southeast of Mosul in northern Iraq. The soil at the site was silty loam, with low phosphorus. Rainfall and mean temperatures for the experiment are shown in Table 1.

Four *Vicia* and *Lathyrus* species were used: common vetch (*V. sativa* selection 2541); woolly-pod vetch (*V. villosa* subsp. *dasycarpa*); bitter vetch (*V. ervilla*) and common chickling (*L. sativus* selection 311), sown at three seeding rates (40, 80, and 120 kg/ha) in late November, 1992 and 1993, in rows 30 cm apart, with four rows in each plot. Triple superphosphate (46% P205) was applied at a rate of 90 kg/ha. A split-split-plot design was used with three replicates. Forage legumes were laid out in main plots and seeding rates in sub-plots. Each sub-plot was subdivided into three 2 × 1.2 m sub-sub-plots. In both years three harvests were made, the first on 5 and 22 March in the first and second years, respectively, with regrowth left for seed production. The second harvest was taken on 20 and 13 May in the first and second years, respectively (at 100% pod formation), with the exception of bitter vetch, which was harvested on 14 May in the first year. The third harvest was taken from the two subplots of each treatment at maturity for seed yield. At the first and second harvests, fresh material was weighed and samples of approximately 200 g dried for 48 hours at 80–90° C for dry matter determination. Weed percentage was determined for the first harvest of the second year only. Before the third harvest, ten plants were taken randomly from each sub-plot to calculate the number of pods/plant and the number of seeds/pod. Harvest index was calculated by dividing the seed yield by the total biological yield. The 1,000 seed weight was also determined. Data of each harvest were subjected to statistical analysis according to the design, using the least Significant Differences Test at a 5% level of significance (Steel and Torrie 1960).

Table 1. Meteorological data from the College of Agriculture and Forestry, Hammam Al Alil.

Month	1992/93			1993/94		
	Air temp (C)		Rainfall	Air temp (C)		Rainfall
	Max.	Min.		Max.	Min.	
October	33.8	13.8		34.0	14.1	8.9
November	26.1	12.8	94.9	91.1	6.2	57.4
December	11.7	3.1	107.2	15.2	5.7	103.0
January	11.7	1.3	44.7	15.6	5.8	87.2
February	15.4	1.5	104.0	17.5	4.8	30.5
March	17.4	2.4	24.2	19.6	7.0	32.7
April	23.6	10.4	130.0	27.5	12.1	74.2
May	28.1	15.0	110.6	31.6	15.8	
Total			615.6			393.9

Results and Discussion

Table 1 shows the forage and seed production of various forage legumes. It can be seen from this table that the dry matter yields of the vetch species at the first harvest was not significantly different from each other, but higher than common chickling. The low yield of common chickling may be due to the slow winter growth (ICARDA 1991; Davies et al. 1993) and to prostrate growth habit, as has been observed in this study. The dry matter yield of the first harvest in the second year was higher than that of the first year. This can be partly attributed to the difference in harvest date and partly to the warmer months of the second year (Table 1). In the second harvest the differences between the legume species were more marked. Common vetch was the highest producing species and woolly-pod the lowest.

The dry matter yield of bitter vetch and common chickling was intermediate. In the second year common vetch outyielded other species, which did not differ significantly. The better performance of common vetch in this trial, particularly in the first year, may be due to favorable weather conditions. The relatively low yield of woolly-pod vetch could be due to lodging and fungal diseases, exacerbated by high rainfall, which caused a great reduction in the crop's leafiness. However, it should be noted that this crop produced a great mass of vegetative growth during the spring flowering stage, and therefore it is suitable for grazing.

The dry matter yield of legume species was increased by increasing seeding rate in both harvests in both years (Table 3). The increase is attributable to the increase in the number of plants per unit area and plant height. This is similar to results reported by Siddique and Walton (1992) in south Australia. They found that yield was increased by increasing seeding rates up to 200 kg/ha. For lentil, Haddad (1993) also found that biological yield increased with increasing plant population.

Table 2. Forage, seed yield, and components: legume species.

	Common	Bitter	Woolly-pod	Chickling	LSD
1992/93 Dry matter yield (t/ha)					
First harvest	0.256	0.276	0.264	0.135	0.098
Second harvest	10.11	7.79	5.32	6.97	2.03
Seed yield (t/ha)	1.56	1.82	0.37	1.35	0.549
Harvest index (%)	24.9	31.5	10.5	23.5	8.5
No. of pods per plant	11.4	33.3	6.2	19.4	6.30
No. of seeds per pod	5.0	3.4	2.9	2.8	0.09
1,000 seed wt. (gm)	50.33	52.92	41.83	72.67	3.31
1993/94 Dry matter yield (t/ha)					
First harvest	2.04	2.96	2.40	1.33	0.87
Second harvest	6.94	4.24	4.66	5.28	1.12
Weed proportion (%)	29.8	22.6	11.6	39.2	8.3
Seed yield (t/ha)	1.2	0.81	0.75	1.55	0.42
Harvest index (%)	21.7	26.1	19.3	34.7	6.89
No. of pods per plant	9.2	31.6	9.2	15.7	7.1
No. of seeds per pod	4.9	3.4	3.2	3.3	0.29
1,000 seed wt. (gm)	56.93	40.00	42.82	76.60	1.82

Weed proportion in the second year is shown in Table 2. It was highest with common chickling and lowest with woolly-pod vetch. Wall et al. (1988) found that common chickling was a poor competitor with annual weeds, perhaps due to slow winter growth. On the other hand, the dense canopy of woolly-pod vetch seems to smother weeds, resulting in a low weed proportion. Common and bitter vetches had vigorous early growth and thus can be considered good weed competitors.

Increasing seed rate markedly reduced the weed proportion (Table 3). This reduction was more pronounced at higher seeding rates. This result is to be expected, since a higher seeding rate increases the number of plants per unit area. This is considered one of the advantages of increasing seeding rate. Table 1 shows the average seed yield and some yield components of legume species. The mean seed yields achieved in this experiment are comparable to seed yields obtained by other adapted legumes such as lentil. In the first year, bitter and common vetches outyielded common chickling and woolly-pod vetch. In fact, woolly-pod was the lowest seed producer and also had the lower harvest index. There may be several reasons for the low seed yield and harvest index of this species, among them prostrate growth habit, lodging, fungal disease, long flowering period, and excessive flower drop (Saxena et al. 1992). On the other hand, bitter vetch, with a more erect growth habit than other legume species, had a high harvest index and high seed yield, and was also the easiest crop to harvest. It is thus considered an ideal crop for grain production in areas of good rainfall.

In fact, bitter vetch, which was not harvested, gave an even higher seed yield (Table 5). In the second year, common chickling outyielded bitter and woolly-pod vetches, while common vetch was intermediate. In general, the seed yield of vetches and chickling was similar to the seed yield range reported by Saxena et al. (1992) and Abd El Moneim et al. (1990), taking into consideration the differences in the environmental conditions. No doubt the variation in seed and forage yield between these species reflects their responses to the environment and management factors, and the potential for adaptation in the environment of northern Iraq.

Mean seed yield was increased by increasing seeding rate. This increase reached significant levels in the second year. These results agree with the results reported by Mohamed and Abdullah (1993) and Haddad (1983) with lentil. This increase in the mean seed yield as a result of increasing seeding rates is mainly due to an increase in the number of plants per unit area. The harvest index was also increased slightly, but not significantly, by increasing seeding rate.

Table 4 shows the effect of early harvest on the seed production of various legume species. It can be seen that the general mean of the seed yield was reduced considerably in both years. This reduction is due to the decrease in some seed components, e.g., the number of pods per plant, number of seeds per pod, and to some extent the 1,000 seed weight. It seems that forage legumes, unlike pasture legumes or cereals, are not adapted to frequent harvesting. Therefore, early grazing or harvesting is not recommended. Seed yield components can strongly influence seed yield. Bitter vetch had more pods per plant than other legume species, followed by common chickling. Woolly-pod vetch gave the lowest number of pods, especially in the first season (Table 2). The number of pods per plant was inversely related to seeding rate (Table 3). The low seeding rate gave more pods per plant than other seeding rates. Similar results were obtained by Mohamed and

Abdulla (1993) and Sharma and Singh (1986) with lentil. Early harvest (Table 4) reduced the number of pods per plant greatly in both years.

Table 3. Effect of seeding rate on forage and seed yield and some components of legume species.

	Seeding rate (kg/ha)			
	40	80	120	LSD
1992/93 Dry matter yield (t/ha)				
First harvest	0.137	0.216	0.347	0.089
Second harvest	6.59	7.75	8.44	0.66
Seed yield (t/ha)	1.09	1.42	1.32	0.36
Harvest index (%)	22.2	21.1	23.5	3.18
No. of pods per plant	23.2	16.5	12.6	3.02
No. of seeds per pod	3.5	3.5	3.5	0.28
1,000 seed wt. (gm)	56.81	55.38	53.13	2.88
1993-94 Dry matter yield (t/ha)				
First harvest	1.52	2.03	2.42	0.52
Second harvest	4.19	4.89	6.77	0.63
Weed proportion (%)	37.1	25.4	14.9	7.2
Seed yield (t/ha)	0.85	1.16	1.23	0.23
Harvest index (%)	25.1	23.8	27.2	3.64
No. of pods per plant	21.0	15.8	12.4	1.08
No. of seeds per pod	3.8	3.7	3.6	0.54
1,000 seed wt. (gm)	54.13	54.00	54.14	1.02

Table 4. Effect of early harvest on seed yield and some seed components.

	H	HO	Mean	LSD
1992/93				
Seed yield (t/ha)	0.63	1.92	1.28	0.195
Harvest index (%)	20.4	24.6	22.5	1.48
No. of pods per plant	13.5	21.4	17.4	2.11
No. of seeds per pod	3.3	3.7	3.5	0.16
1000 seed wt. (gm)	53.21	55.67	54.44	0.78
1993/94				
Seed yield (t/ha)	0.56	1.60	1.08	0.210
Harvest index (%)	24.8	25.9	25.4	1.34
No. of pods per plant	12.5	20.3	16.4	2.61
No. of seeds per pod	3.5	3.9	3.7	0.23
1000 seed wt. (gm)	53.87	54.29	54.09	0.47

H = harvested early in March

HO = without early harvest

This could be due to a reduction in the number of branches and in flower formation due to the short time allowed to the plants, after which they were harvested in March. The number of seeds per pod differs significantly among the

legume species, being highest with common vetch and lowest with common chickling. Woolly-pod vetch was not significantly different, particularly in the second year. In fact, common vetch has longer pods than any of the other legume species in this trial, so naturally it has more seeds per pod. Seeding rate (Table 3) seems to have had no significant effect on the number of seeds per pod in either years. These findings were also noticed by Mohamed and Tawfiq (1993) with narbon vetch and by Mohamed and Abdullah (1993) with lentil. However, early harvesting caused little reduction in the number of seeds per pod. The crops which were unharvested probably had good conditions for growth and flowering. Crops harvested early produced weak regrowth due to high temperatures (Table 1). Table 2 shows that the mean 1,000 seed weight differs between legume species. The seed size of common chickling was higher than those of other species and that of woolly-pod vetch was the lowest. The 1000 seed weight was reduced significantly by increasing seed rate from 40 to 120 kg/ha in the first year, but this effect was not apparent in the second year. One possible explanation is that the plants resulting from the higher seed rate had a low number of pods and hence less competition for the substrata between them. Barley harvest reduced the 1,000 seed weight significantly in first year (Table 4).

This reduction was not enough in the second year to reach a significant level. The depressive effect of early harvest on seed size could be attributed to the short period allowed for regrowth and filling of seeds in raising air temperature.

In comparing the two seasons (Table 4), seed yield and most of the seed components were higher in the first than in the second season. This was clear with bitter vetch, where seed yield declined on average, by about one t/ha, while the seed yield of unharvested woolly-pod vetch doubled in the second season. This variation in seed yield was mainly due to the difference in the amount of rainfall. Table 5 presents the interactions between seeding rates and harvesting treatments on the seed yield of four forage legumes. The most striking feature of this table is the severe reduction in the seed yield of bitter vetch due to early harvesting in both seasons. This reduction is expected, since this species matured early. If cut or grazed the regrowth does not have enough time to flower and produce reliable seed yield, particularly when rainfall is low. Another reason for the weak regrowth of this species may be low leaf residue after cutting, due to its erect growth habit.

The species least negatively effected by early harvest were common chickling and common vetch, especially in the second season. The reaction of unharvested species to increasing seeding rates differs between seasons. For example, bitter vetch in the first season, when rainfall was high, responded significantly to an increase in the seed rate from 40 to 80 or 120 kg/ha, while in the second season, when rainfall was lower, the increase in seed yield due to increasing seeding rate was not significant. The increase in common chickling seed caused by increasing seeding rate in both seasons may be due to its ability to grow under drought conditions (Saxena et al. 1992). Common vetch seed was also increased significantly by increasing seeding rate, though only in the second season. Generally, the differences between 80 and 120 kg/ha were not significant, so it is not advisable to use a seeding rate higher than 100 kg/ha, since the increase in seed yield is not enough to justify the higher price of legume seeds. The highest seed yield was obtained from unharvested bitter vetch (3.96 t/ha) in the first season and the lowest from harvested woolly-pod vetch in both seasons.

Table 5. Effect of seeding ratios and early harvesting on seed yield of legume species.

		Seeding rate			
	Treatment	40	80	120	Average
1992/93					
Common vetch	Ho	1.99	2.07	2.23	2.10
	H	1.14	1.33	0.64	1.03
Bitter vetch	Ho	2.12	3.59	3.96	3.22
	H	0.64	0.23	0.37	0.43
Woolly-pod vetch	Ho	0.59	0.68	0.40	0.56
	H	0.12	0.32	0.12	0.19
Common chickling	Ho	1.20	2.06	2.17	1.81
	H	0.70	1.06	0.90	0.89
1993/94					
Common Vetch	Ho	1.26	1.71	1.98	1.65
	H	0.56	0.94	0.72	0.74
Bitter Vetch	Ho	1.21	1.43	1.47	1.37
	H	0.18	0.22	0.39	0.26
Woolly-pod vetch	Ho	1.09	1.19	1.52	1.27
	H	0.16	0.26	0.31	0.24
Common chickling	Ho	1.68	2.48	2.19	2.12
	Ho	0.65	1.02	1.29	0.99

Ho = without early harvest; H = harvested early in March.

LSD for Ho and H for each legume species as a mean of 1993: (0.391), 1994 (0.416) seeding rates.

LSD for the interaction between forage species, seeding rates and harvesting treatments: 1.753 and 0.8568.

Conclusions

Early harvest has a negative effect on seed yield. When forage legumes are grown for seed production they must be not grazed or harvested before seed maturation. Although increasing seed rate above 80 kg/ha increased forage and seed yield, using seed rates higher than 100 kg/ha is not recommended.

This study agrees with other studies (Saxena et al. 1992) that the high forage and seed production of common vetch make it suitable for haymaking and seed production. Bitter vetch with early winter growth and high seed production can be used for early grazing and seed production.

Woolly-pod vetch, with high vegetative growth, can be used for grazing and haymaking. Common chickling, with relatively good drought tolerance but slow winter growth, can be used for haymaking and seed production. But care should be taken when animals are fed the seed since it contains a neurotoxin which causes paralysis in humans and animals.

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Discussion

M. Khniefs: What is the relationship between the different factors?

M. Mohamed: There is a relation between seeding rate and early harvest. Using a high seeding rate causes excessive growth, which reduces seed production, while harvesting could encourage the appearance of new strong branches able to give good production of flower and seed.

A. Shehadeh: Does time of grazing effect the main crop?

M. Mohamed: Grazing can affect the main crop by increasing soil fertility.

Sheep Breeding, Nutrition, and Management

Environmental and Genetic Factors Influencing Milk and Growth Traits of Awassi Sheep In Cyprus

I. Estimates of Genetic Parameters

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Abstract

Data on 1,213 ewes and 1,382 lambs born between 1978 and 1991 at the Orites livestock unit were used to study environmental factors affecting ewe productivity and lamb growth in the Awassi breed. Genetic and phenotypic parameters were estimated for production and reproductive traits in ewes and for growth traits in lambs. The results show that year and season of lambing significantly affect all production and reproductive traits of the ewes and growth traits of lambs. Lamb birth weight was not affected by season of lambing. Parity (lactation number) had a significant quadratic effect on all ewe and lamb traits, except post-weaning lamb growth rate, which was probably free of maternal effects. Type of birth and sex were the most important sources of variation for lamb growth, with the exception of post-weaning daily gain, which was not influenced by type of birth. Estimated heritability for ewe production and reproductive characters was modest, but generally high enough to justify selection procedures for improvement. In particular, estimates for prolificacy (0.30 ± 0.08) and part- (0.58 ± 0.12) or total- (0.56 ± 0.11) lactation milk yield indicated that both traits can be improved, particularly prolificacy, which is one of the breed's weaknesses. Response to selection for post-weaning growth rate is probably the best selection criterion to use for improving lamb performance. The absence of genetic antagonism among ewe or lamb traits indicates that correlated responses in other traits from selection on milk production or post-weaning growth are not negative.

Introduction

Awassi is the most common sheep breed in Syria, Lebanon, Israel, and Jordan, the dominant breed (60%) in Iraq and an important breed in southern Turkey (Mason 1967). It is characterized by considerable resistance to disease and heat, and is a good walker. It is variably used as a milking breed (Israel), meat breed (mostly in the Arab World), and occasionally as a dual purpose breed. Its coarse wool is generally used for weaving coarse cloth, blankets, and carpets. Because of its ability to graze for long hours under semi-arid conditions, the breed has been widely used in improvement programs (Finci 1957).

One of the first objectives in livestock improvement is to determine the mode and degree of inheritance of the various traits of economic importance, since that will determine to a great extent the methods and procedures for genetic improvement.

Awassis have been used to upgrade local populations, and have been central in systematic crossbreeding systems aiming at the utilization of general and specific combining ability (Lawlor et al. 1974; Mavrogenis and Louca 1979; Mavrogenis 1981). Despite the breed's extensive use in improvement programs, both in purebred and crossbreeding systems, there is very little available information about estimated genetic and environmental factors influencing milk and growth traits. The purpose of the present study was to investigate some environmental factors influencing milk and growth traits and estimate genetic parameters for these traits.

Materials and Methods

Animals, Management, and Feeding

The study utilized data on 1,213 ewes and 1,382 lambs born between 1978 and 1991 at the Orites government farm (380 m above sea level, 560 mm average annual precipitation). All lambs were classified by sex and type of birth. They were weighed at birth, at weaning (42 ± 3 days), and at 105 ± 3 days post partum. They were allowed free suckling until 28 ± 3 days post partum, followed by restricted suckling, during which they had free access to a pelleted creep feed (18% CP) and lucerne hay. Following weaning they were fed on hay (alfalfa and cereal) and a barley/grain-based diet (14–16% CP) until the age of 105 days. Ewes in heat were detected using vasectomized teaser rams and were mated individually. Feeding during pregnancy was based on pregnancy requirements for single bearing animals (NRC 1985). In the last six weeks of pregnancy feeding was improved, and following parturition they were on an *ad libitum* feeding regime (concentrate and cereal hay) until weaning. Milk production was individually recorded at monthly intervals, the first test performed 7 ± 3 days after weaning. Total milk production was estimated using the A4 method adopted by the international regulations for milk recording in sheep (ICAR 1992) and reflects the production of milk following weaning. Ewes were considered dry when test-day yield dropped below 0.2 kg.

Statistical Procedures

Ewes classified as "abortion" were excluded from analyses. The data were analyzed using the least squares procedure (Harvey 1975). A separate mathematical model was used to describe an individual observation for the ewe and lamb data. Both models accounted for the variation due to year and season of birth (lambs) or lambing (ewes) and lactation number of the dam or ewe. In addition, effects due to sex and type of birth were included in the model used for the lamb data. All the above effects were considered fixed for purposes of analysis. Sires of lambs and ewes were the only effects considered random, in addition to the error term with variances σ_e and σ_{e_s} , respectively.

Lambs were the progeny of 76 sires, and the average half-sib family size was 15 lambs. Ewes were the progeny of 68 sires and the half-sib family size was 16.3 females per sire. With very few exceptions, sires were used for a single breeding season and replaced at the end of the second mating period. Sire components of variance and covariance were used to estimate heritability and genetic correlation from the expressions

$$h^2 = 4\sigma_s / (\sigma_s + \sigma_e)$$

$$r_g = \sigma_{sij} / \sigma_{sj} \sigma_{si}$$

where σ_s is the sire component of variance, σ_e is the environmental variance, σ_{sij} is the sire component of covariance between traits i and j , and σ_{si} and σ_{sj} are the sire components of variance for traits i and j , respectively.

Since twinning rate for the Awassi breed is very low, the few twin sets in lamb and ewe data were discarded and the dam component was not used in the genetic analyses of either data set.

Results and Discussion

Ewe Traits

Environmental effects

Mean squares and tests of significance for all traits studied are given in Table 1. Year differences were significant for all traits studied and accounted for a considerable amount of variation. Seasonal effects, which described the period in which ewes gave birth (September–October, November–December, January–February, and March–May), were important only for total weight of lambs at weaning, milk production, and lactation length following weaning (Table 1). This can be explained by the fact that most ewes lambing in the last two periods (January–May) were yearlings and, in addition to lower milk production during the suckling period, they had lower milk production than adult ewes that lambed from September to December.

Age of ewe (or lactation number) significantly affected milk production. Similar results have been reported for a number of other breeds, including Chios (Mavrogenis and Louca 1980; Mavrogenis 1982). It was also evident (Tables 1 and 2) that these effects were quadratic, showing peak productivity at an age of 40–50 months (third to fourth lactation). Prolificacy in the Awassi breed was considerably lower than in Chios, but was characteristic of the breed (Mavrogenis 1982). All reproductive traits (litter size at birth and at weaning) were significantly influenced by year and season of lambing, and lactation number had a quadratic effect on litter size and weight at birth and at weaning. Similar effects have been observed in most meat or milk breeds (Carter et al. 1971; Mavrogenis, 1982).

Genetic effects

Estimates of heritability, along with standard errors for all traits studied, are presented in Table 3. Variance components were estimated by equating the appropriate mean squares to each variance component. Estimated heritabilities for reproductive traits ranged from 0.17 ± 0.07 for litter size at birth and at weaning to 0.35 ± 0.09 for litter weight at weaning. The higher heritability estimate for number of lambs born (dead+live) probably better reflects the reproductive capacity of the breed. Similar findings were observed in the Chios breed

(Mavrogenis 1985). These results strongly suggest that genetic progress for prolificacy (twinning) is attainable, provided that better selection criteria can be devised to measure the trait. An estimate of heritability for ovulation rate in Finn sheep was similar to the heritability estimate for litter size obtained in the present study (Hanrahan 1976), and Turner (1978) has demonstrated a direct response to selection for multiple births in Merino sheep.

Estimated heritabilities for partial (90 day) and total lactation milk yield were moderately high (Table 3), indicating that genetic progress for either trait is possible. A previous yield estimate for the same breed (Soller et al. 1966) is similar to that reported here. Similar values have been reported for the Sardinian (Casu et al. 1977) and the Chios breed (Mavrogenis 1982).

The genetic correlation between partial and total lactation milk yield was positive and high. Both traits were also highly associated with lactation length. Hence, selection for partial lactation production is correlated with responses to total production and longer lactation. Phenotypic correlation among the above traits was also high, ranging from 0.5 to 0.92 (Table 3).

Genetic associations between reproductive traits and milk production were virtually zero, considering the associated standard errors. The only significant genetic association was between litter weight at weaning and partial lactation production. The negative sign associated with the moderately low estimate (-0.21 ± 0.18) indicates that ewes that wean heavy lambs may not necessarily be high milk yielders. Phenotypic correlations between litter weight at weaning and part or total lactation milk yield support the above hypothesis, since they were insignificant.

Lamb Traits

Environmental effects

Mean squares and tests of significance for all traits studied are presented in Table 4. Year and seasonal effects were significant for all traits studied. Parity effects (Table 5) were important for all weights and pre-weaning daily gain, but did not affect post-weaning growth rate. Similar findings were reported by Mavrogenis et al. (1980) for Chios sheep. As expected, pre-weaning growth is affected by maternal influence, whereas the maternal environment no longer influences post-weaning growth (Mavrogenis 1982; Mavrogenis and Constantinou 1990). Type of birth effects were also highly significant for all traits studied, except post-weaning growth rate (Tables 4 and 6). The results of this study agree with other studies on Chios sheep (Mavrogenis et al. 1980) and confirm the hypothesis that post-weaning growth rate reflects the genetic potential of the lamb for growth. Moreover, this trait is the least affected by maternal effects that do not persist beyond weaning. Male lambs were heavier at birth, at weaning and at 105 days of age. They also grew faster both before and after weaning (Table 6). Similar results have been reported for the Chios breed by Lawlor et al. (1974) and Mavrogenis and Louca (1979). Live weight and gain at different periods of growth may be representative of the improved milking Awassi (Epstein 1985), although higher weight and gain have been reported (Folman et al. 1966).

Table 1. Mean squares and tests of significance for some production and reproductive traits of Awassi ewes.

Source	df	LSB	LSBL	LWTB	LSWN	LWTWN	Milk 90	Days	Milk
Sires	67	0.188**	0.132**	3.53**	0.109**	56.7**	6,559**	5207**	17,374**
Years	15	0.180*	0.131*	3.99**	0.186**	101.8**	6,330**	10,277**	22,677**
Seasons	3	0.068	0.119	0.78	0.108	156.0**	2,634	135,843**	86,907**
Lactation no.	5	0.224*	0.187*	4.23*	0.233**	107.0**	11,588**	2,273	27,518**
Linear	1	0.755**	0.625**	4.54*	0.555**	21.5	10,740**	1,786	22,241*
Quadratic	1	0.312*	0.242*	14.74**	0.333*	469.3**	45,698**	6,044*	113,973**
Residual	3	0.018	0.022	1.62	0.091	14.7	501	1,177	459
Error	1,122	0.080	0.076	1.42	0.064	22.2	1,496	1,944	4,773

LSB = total lambs born; LSBL = lambs born live; LWTB = litter weight at birth; LSWN = lambs weaned; LWTWN = litter weight at weaning; Milk 90 = 90-day milk yield; Days = lactation length; Milk = total milk yield.

Table 2. Least squares means and standard errors for lactation number effects on production and reproduction traits of Awassi ewes.

Lactation No.	No. of observations	LSB	LSBL	LWTB (kg)	LSWN	LWTWN (kg)	Milk 90 (kg)	Days	Milk (kg)
1	380	1.03±0.05	1.02±0.04	5.2±0.2	1.01±0.04	16.6±0.8	109±7	144±8	145±13
2	303	1.05±0.04	1.04±0.03	5.5±0.2	1.03±0.03	18.0±0.7	124±7	145±6	164±11
3	226	1.10±0.04	1.09±0.03	5.6±0.2	1.07±0.03	18.1±0.6	133±6	152±6	178±11
4	136	1.19±0.04	1.17±0.03	5.8±0.2	1.17±0.03	18.5±0.7	131±6	154±6	180±11
5	83	1.21±0.05	1.18±0.04	5.6±0.2	1.15±0.04	17.2±0.8	131±7	150±8	175±13
>6	85	1.21±0.06	1.20±0.06	5.5±0.3	1.15±0.05	16.5±1.0	122±9	146±10	155±16

For explanation of abbreviations see Table 1.

Table 3. Estimates of heritability (on diagonal), genetic (above diagonal) and phenotypic (below diagonal) correlations and standard errors for production and reproductive traits of Awassi ewes.

Trait	LSB	LSBL	LWTB	LSWN	LWTWN	Milk 90	Days	Milk
LSB	0.30±0.08	1.01±0.02	0.72±0.10	1.03±0.04	0.42±0.17	-0.01±0.19	0.11±0.20	0.07±0.19
LSBL	0.94	0.17±0.07	0.67±0.13	1.03±0.03	0.43±0.19	0.00±0.24	0.12±0.24	0.07±0.20
LWTB	0.71	0.72	0.34±0.09	0.73±0.12	0.65±0.12	-0.07±0.15	-0.00±0.20	0.01±0.19
LSWN	0.84	0.89	0.67	0.17±0.07	0.53±0.17	0.01±0.22	0.10±0.24	0.07±0.22
LWTWN	0.50	0.55	0.60	0.62	0.35±0.09	-0.21±0.18	-0.10±0.20	-0.12±0.18
Milk 90	0.11	0.13	0.13	0.10	0.18	0.58±0.12	0.77±0.09	0.97±0.02
Days	-0.00	-0.00	0.03	-0.01	0.06	0.50	0.37±0.09	0.92±0.04
Milk	0.06	0.08	0.10	0.07	0.17	0.88	0.76	0.56±0.11

For explanation of abbreviations see Table 1.

Table 4. Mean squares and tests of significance for pre- and post-weaning growth in Awassi lambs.

Source	df	BWT	WWT	WT105	AD61	AD62
Sires	75	1.222**	16.94**	67.03**	6300**	10202**
Years	13	1.479**	52.85**	252.62**	13830**	41042**
Seasons	3	0.285	90.87**	761.57**	33707**	86696**
Lactation No.	5	3.742**	68.33**	132.30**	21238**	7282
Linear	1	7.606**	11.50	45.56	127	7918
Quadratic	1	8.086**	185.70**	323.36**	44779**	4986
Residual	3	1.005	12.16	51.53	4967	7803
Type of birth	1	108.706**	834.57**	672.91**	165754**	6804
Sex	1	59.465**	817.86**	11053.75**	228418**	1534766**
Error	1283	0.544	8.62	29.51	3476	4249

BWT = Birth weight; WWT = Weaning weight; WT105 = 105-day weight; ADG1 = Pre-weaning daily gain; ADG2 = Post-weaning daily gain.

Table 5. Least squares means and standard errors for dam lactation number effects on growth traits of Awassi lambs.

Lactation No.	No. of observations	Birth weight (kg)	Weaning weight (kg)	105-day weight (kg)	Pre-weaning growth (g/day)	Post-weaning growth (g/day)
1	372	4.2±0.1	14.1±0.3	28.4±0.6	235±6	230±8
2	279	4.5±0.1	15.6±0.3	30.3±0.6	261±6	240±8
3	250	4.6±0.1	15.4±0.3	30.4±0.7	252±6	245±8
4	212	4.5±0.1	15.1±0.3	29.4±0.7	247±7	243±8
5	168	4.5±0.1	14.7±0.4	29.5±0.7	240±8	243±9
>6	101	4.5±0.1	14.8±0.4	29.5±0.8	240±8	242±10

Table 6. Least squares means and standard errors for type of birth and sex effects on growth of Awassi lambs.

Main affect	Subclass	No. of observations	Birth weight (kg)	Weaning weight (kg)	105-day weight (kg)	Pre-weaning growth (g/day)	Post-weaning growth (g/day)
Type of birth	singles	1,156	4.9±0.1	16.2±0.3	30.7±0.6	263±5	235±7
	twins	226	4.0±0.1	13.7±0.3	28.5±0.7	229±6	242±8
Sex	males	676	4.7±0.1	15.8±0.3	32.6±0.6	260±6	273±7
	females	706	4.3±0.1	14.2±0.3	26.6±0.6	233±6	204±7

Table 7. Estimates of heritability (on diagonal), genetic (above diagonal) and phenotypic (below diagonal) correlations and standard errors for growth traits of Awassi lambs.

Trait	BWT	WWT	WT105	ADG1	ADG2
BWT	0.31±0.08	0.51±0.17	0.46±0.17	0.24±0.22	0.31±0.19
WWT	0.42	0.24±0.08	0.78±0.09	0.89±0.05	0.45±0.18
WT105	0.33	0.73	0.31±0.08	0.66±0.13	0.89±0.05
ADG1	0.18	0.94	0.68	0.21±0.07	0.29±0.21
ADG2	0.14	0.30	0.85	0.25	0.34±0.08

For explanation of abbreviations see Table 5.

Genetic effects

Estimates of heritability and of genetic and environmental correlations among traits are given in Table 7. Estimated heritability for birth, weaning, and 105-day weight were moderately high. Estimated heritability for birth weight was higher than that previously reported for the Chios breed (Mavrogenis et al. 1980), but similar to that for the Rambouillet and Targhee breeds (Vesely and Robinson 1970; Ercanbrack and Price 1972). The heritability estimate for weaning weight was lower than that for birth or 105-day weight. Pre-weaning growth rate was less heritable than post-weaning growth rate and reflects the higher total phenotypic variation observed during the pre-weaning period, when factors such as mothering ability, maternal environment, and other uncountable sources of variation, may have a negative association with direct genetic effects for growth.

Genetic correlations among weights at different ages were moderately high and positive. The correlation between birth weight and pre-weaning growth were moderately low. Positive and high genetic correlations were found between weaning weight and 105-day weight, pre-weaning growth rate and weaning weight, and post-weaning growth rate and 105-day weight. Similar findings have been reported by Gjedrem (1967) for Norwegian sheep at different ages. On the other hand, low genetic correlations between birth weight and pre-weaning growth rate were reported for the Rambouillet, Targhee, and Columbia breeds (Ercanbrack and Price 1972). Higher estimates have been reported by Thrift et al. (1973). Phenotypic correlations approximately followed the pattern of the corresponding genetic correlations both in size and in magnitude.

It is evident that correlated responses from selection can be expected, especially if selection is based on post-weaning growth or 105-day weight. The moderately high genetic association between 105-day weight and birth weight may cause concern regarding increased lamb birth weights and possible lambing difficulties.

The results suggest that post-weaning growth rate is the best criterion of selection. Either this criterion or 105-day weight should be superior to weaning weight or pre-weaning growth rate, since they are probably much less influenced by maternal effects that mask the genetic potential of the lamb for fast growth. The absence of genetic antagonisms among body weights and gains indicates that there should not be any serious impairment through correlated responses. Some problems may arise from the relatively high association of the selection criterion with birth weight.

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Environmental and Genetic Factors Influencing Milk and Growth Traits of Awassi Sheep in Cyprus

II. Heterosis and Maternal Effects

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Abstract

Data on 5,234 purebred and crossbred ewes and 6,457 purebred and crossbred lambs, born between 1978 and 1986 at two government farms (Athalassa and Orites) were used to study environmental factors that affect ewe productivity, milk production, and lamb growth. Breed and heterosis effects (individual and maternal) were also estimated. Most of the environmental factors examined were significant sources of variation for the reproductive and production traits of ewes and the growth traits of lambs. Chios ewes were significantly more prolific than Awassi and crossbred ewes. They also produced heavier litters at birth and at weaning than Awassi ewes. On the other hand, Awassi ewes had higher milk production than all other breed groups. Awassi lambs were heavier at birth, at weaning, and at 105 days of age and had a faster growth rate than Chios lambs. Crossbred lambs were mostly heavier and faster-growing, both before and after weaning, than either purebred group. All estimates of individual heterosis for ewe reproductive and production traits were negative except for total lamb weight at weaning. On the other hand, estimates for maternal heterosis were positive, although those for milk production were close to zero. All lamb traits exhibited positive heterosis effects of crossbreeding. In addition, individual heterosis was more important than maternal heterosis.

Introduction

Crossbreeding to improve market lamb production is a common practice. Chios and Awassi sheep are being widely used in improvement and intensification programs in a number of Mediterranean and Near East countries.

Positive effects of crossbreeding on lamb growth traits have been reported by Terril (1958), Donald et al. (1963), Sidwell et al. (1964), Sidwell and Miller (1971), Mavrogenis and Louca (1979), and Mavrogenis (1981). Nitter (1978) concludes that individual heterosis is generally higher for lamb survival and that maternal heterosis is much more important for fertility traits.

The purpose of the present study was to determine the effects of some environmental factors and estimate breed and heterosis effects on ewe productivity, and production traits and lamb growth traits in purebred and crossbred sheep.

Materials and Methods

Animals, Management, and Feeding

The study utilized data on 5,234 purebred and crossbred ewes and 6,457 purebred and crossbred lambs, collected between 1978 and 1986 at two government farms (Athalassa and Orites). All lambs were classified by sex and type of birth and their weights were recorded at birth (within 48 hours post partum), at weaning (43 ± 3 days), and at 105 days of age. Free suckling was allowed to only two lambs per ewe until 28 ± 3 days post partum, followed by restricted suckling until full weaning. During the partial suckling period all lambs had free access to pelleted creep feed (18% CP) and alfalfa hay. Following weaning, they were fed on hay (alfalfa or cereal) and a concentrate mixture based on barley (16% CP).

Management and feeding practices were similar on both farms. All ewes, regardless of breed, were kept under a semi-intensive, minimum grazing, stall-feeding system. Ewes in heat were detected using vasectomized teaser rams and were mated individually. Feeding during pregnancy was based on requirements for single-bearing animals (NRC 1985). In the last six weeks of gestation feeding was improved and following lambing ewes were fed *ad libitum* on concentrates and cereal hay until weaning.

All breed groups, with few exceptions, had contemporary records in all year/season classes. The bulk of information, however, came from the purebred classes that were represented by larger numbers in all year/seasons.

In addition to reproductive data that were recorded concurrently for lambs and ewes at birth and at weaning, milk production was individually recorded at monthly intervals. The first milk control was performed 7 ± 3 days following complete weaning. Total milk production was estimated using the A4 method adopted by ICAR (ICAR 1992) and reflects the production of milk following weaning. Ewes were considered dry when individual daily milk yield dropped below 0.2 kg. Lamb growth before and after weaning was estimated using live weight at different stages of growth as daily gain.

Statistical Analysis

The data were analyzed by least squares procedures (Harvey 1975). A separate linear model was used to describe the individual observation in the ewe and lamb data set. Both models accounted for variation due to flock, year and season of lambing (ewes) or birth (lambs), lactation number, and breed group effects. In addition, the effects of sex, type of birth, and interaction with lamb traits were accounted for in the lamb model. All lactations beyond the sixth were grouped into lactation six, because of the small number of observations in those subclasses. The linear models used to describe individual observations were:

A: Ewe model

$$Y_{ijklm} = \mu + a_i + c_j + f_k + p_l + b_m + e_{ijklm}$$

B: Lamb model

$$Y_{ijklmnq} = \mu + a_i + c_j + f_k + p_l + b_m + s_n + t_q + e_{ijklmnq}$$

where Y_{ijklm} and $Y_{ijklmnq}$ are individual observations that describe the ewe or lamb record for a particular trait, a_i is the i^{th} year of lambing (ewes) or birth (lambs), c_j is the j^{th} season of lambing (ewes) or birth (lambs), f_k is the k^{th} flock, p_l is the l^{th} parity of the ewe (ewes) or dam (lambs), b_m is the m^{th} breed group (Chios, Awassi, reciprocal F_1 s and first backcrosses to Chios) of ewes or lambs, s_n is the n^{th} sex of lamb (males, females), and t_q is the q^{th} type of birth of lamb (single, twin or multiple).

Observations in both data sets were considered normally and independently distributed with zero mean and variance σ^2 .

Results and Discussion

Ewe Traits

Mean squares and tests of significance for all factors studied on ewe productivity and production traits are given in Table 1. Year and season of lambing had a significant effect on all traits studied except for total number of lambs weaned. Similar findings have been reported for both meat and dairy breeds of sheep (Carter et al. 1971; Mavrogenis 1982). Flock effects were also a significant source of variation for most traits studied. Total lambs weaned and total milk yield were not significantly influenced by flock effects. Parity effects were always a significant source of variation and had a quadratic nature (Table 2). Primiparous ewes were less productive than multiparous ewes. Similar findings have been reported by Mavrogenis (1992). Best performance for reproductive characters was displayed by ewes in the fourth parity, and for milk production in the third. Ewe productivity declined thereafter in both trait categories, nearing that of primiparous ewes (Table 2). Similar findings have been reported by Mavrogenis and Louca (1980), Whiteman and Dzakuma (1981), Mavrogenis (1982), and Wilson (1987).

Breed effects were significant for all traits studied (Table 1). Chios ewes were significantly more prolific than Awassi or any other crossbred group at birth and at weaning (Louca et al. 1974; Mavrogenis 1992). They also had significantly heavier litter weights (total lambs born or weaned) than Awassi ewes and reciprocal F_1 crossbreds, but lower than that of first backcrosses to Chios (Table 3). Mavrogenis (1982) reports similar results. F_1 crossbred ewes had higher litter sizes and litter weight at birth and at weaning than purebred Awassi ewes. Increases in prolificacy were further accentuated in the first backcrosses to Chios rams, indicating that the Chios breed can successfully be used to improve these traits in non-prolific breeds, such as Awassi. These findings were supported by similar conclusions from Carrol et al. (1976) and Guney (1990).

Awassi ewes had higher part and total milk production than Chios or crossbred ewes, although they were also milked for a longer period.

Table 1. Mean squares and tests of significance for production and reproductive traits of ewes.

Source	Df	LSB	LSBL	LWTB	LSWN	LWTWN	Milk 90	Days	Milk
Flocks	1	7.47**	4.55**	125.1**	0.62	15.8	83,473**	35,3528**	2115
Years	8	0.71*	0.73*	17.2**	0.52	1,048.5**	43,047**	9,1443**	104146**
Seasons	3	2.02**	1.22**	12.9*	0.81*	965.7**	9,587**	35,5538**	159697**
Lact. linear	1	9.06**	3.13**	225.7**	5.31**	2,257.5**	5,201	26,234**	25988*
Quadratic	1	10.49**	11.93**	466.4**	11.63**	7,245.3**	200,408**	45,462**	503780**
Residual	3	0.06	0.02	4.1	0.02	79.7	2,717	1,032	8637
Breed group	5	59.35**	44.45**	220.0**	34.04**	2,104.3**	1,2717	18,425**	59486**
Error	5,211	0.36	0.32	3.5	0.28	49.1	1,748	2,871	5093

LSB = total lambs born; LSBL = lambs born live; LWTB = litter weight at birth; LSWN = lambs weaned; LWTWN = litter weight at weaning; Milk 90 = 90-day milk yield; Days = lactation length; Milk = total milk yield.

Table 2. Least squares means and standard errors for lactation number effects on production and reproduction traits of ewes.

Lact. No.	No. of observ,	LSB	LSBL	LWTB (kg)	LSWN	LWTWN (kg)	Milk 90 (kg)	Days	Milk (kg)
1	1,614	1.31±0.02	1.30±0.02	5.70±0.07	1.24±0.02	18.6±0.3	97.4±1.6	133±2	128.3±2.7
2	1,362	1.41±0.02	1.39±0.02	6.46±0.08	1.35±0.02	21.7±0.3	114.0±1.7	142±2	151.2±2.9
3	940	1.47±0.03	1.44±0.03	6.72±0.08	1.39±0.02	22.3±0.3	116.3±2.1	144±2	157.6±3.2
4	617	1.51±0.03	1.46±0.03	6.78±0.10	1.42±0.03	22.3±0.4	110.0±2.1	144±3	151.0±3.6
5	374	1.47±0.04	1.42±0.03	6.60±0.11	1.38±0.03	22.0±0.4	106.9±2.5	144±3	145.5±4.3
±6	327	1.40±0.04	1.32±0.04	6.21±0.12	1.30±0.03	19.9±1.5	100.0±2.7	139±4	130.3±4.7

For explanation of abbreviations see Table 1.

Table 3. Least squares means and standard errors for breed group effects on production and reproduction traits of ewes.

Breed group	No. of observ.	LSB	LSBL	LWTB (kg)	LSWN	LWTWN (kg)	Milk 90 (kg)	Days	Milk (kg)
2	3,305	1.72±0.01	1.63±0.01	6.81±0.04	1.54±0.01	21.4±0.2	105.4±1.0	142±1	140.0±1.7
3	1,252	1.15±0.02	1.12±0.02	5.65±0.07	1.09±0.02	17.8±0.3	114.3±1.5	152±2	160.0±2.6
12	200	1.23±0.05	1.21±0.04	5.95±0.14	1.21±0.04	19.9±0.5	102.6±3.2	130±4	136.0±5.4
14	116	1.67±0.06	1.62±0.06	7.01±0.18	1.52±0.05	23.6±0.7	103.0±4.1	141±5	139.5±7.0
19	234	1.34±0.04	1.32±0.04	6.32±0.13	1.31±0.04	20.9±0.5	109.6±3.0	139±4	144.3±5.0
41	127	1.45±0.06	1.43±0.05	6.73±0.18	1.41±0.05	23.2±0.7	109.7±3.9	143±5	144.4±6.7

For explanation of abbreviations see Table 1.

2 = Chios (C); 3 = Awassi (A); 12 = A × C; 14 = C(A × C); 19 = C × A; 41 = C(C × A).

Table 4. Mean genotypic values and estimates of individual and maternal heterosis for ewe production and reproductive traits.

Trait	A	B	C	H _i	H _M
LSB	1.345	1.285	1.560	-10.45	21.4
LSBL	1.375	1.265	1.525	-8.00	20.6
LWTB	6.23	6.14	6.87	-1.44	10.4
LSWN	1.315	1.260	1.465	-4.18	16.3
LWTWN	19.6	20.4	23.4	4.08	14.7
Milk 90	109.6	106.1	106.4	-3.46	0.3
Milk	150.0	140.2	142.0	-6.53	1.3

For explanation of abbreviations see Table 1.

$A = (\text{Chios} + \text{Awassi})/2$; $B = [(C \times A) + (A \times C)]/2$; $C = [C(C \times A) + C(A \times C)]/2$; H_i : Individual heterosis = $100(B-A)/A$; H_M : Maternal heterosis = $100(C - B)/B$.

Although non-additive genetic variation and increased heterozygosity was expected to influence the traits considered as reproductive (litter size and litter weight), all but one estimate for individual heterosis were negative. It would appear that additive rather than non-additive genetic variation was more important. The only reproductive trait that exhibited positive individual heterosis (4.1%) was total weight of lamb at weaning. This trait may be considered a composite trait, since it is confounded with maternal ability and survival of the lamb. Indeed, lamb survival has been shown to exhibit positive heterosis of similar magnitude by a number of investigators (Wiener and Hayter 1974; Dickerson et al. 1975; Hohenboken et al. 1976). Positive effects for number of lambs born and weaned have, however, been reported by Donald et al. (1963) for Scottish Blackface crosses with Swaledale. Maternal heterosis, on the other hand, was much more important, especially for litter size at birth and weaning. Similar results have been reported by Land et al. (1974). These findings suggest that commercial breeders should seriously consider the use of crossbred mothers in their breeding programs.

Lamb Traits

Mean squares and tests of significance for all traits studied are presented in Table 5. All effects were significant sources of variation for lamb growth indicators, except flock effects on post-weaning growth.

Parity effects on lamb weight and gain were significant and quadratic (Table 6). Lambs born to primiparous ewes were the lightest at birth, at weaning, and at 105 days of age. In addition, lambs born to ewes older than six years of age had lower weights and gains than those from ewes in their third or fourth lactation. Similar findings have been reported by Gjedrem (1967), Mavrogenis and Louca (1979), and Mavrogenis and Constantinou (1986).

Table 5. Mean squares and tests of significance for pre-weaning and post-weaning growth traits of lambs.

Source	df	BWT	WWT	WT105	AD61	AD62
Flocks	2	31.0**	97.6**	107.0*	0.086**	0.005
Years	8	3.0**	527.8**	940.0**	0.030**	0.202**
Seasons	3	4.2**	195.0**	3,798.6**	0.158**	0.545**
Lact. linear	1	23.2**	66.1**	527.5**	0.007	0.062**
quadratic	1	48.2**	726.2**	1,691.6**	0.161**	0.070**
residual	3	0.5	5.7	27.4	0.004	0.005
Breed group	5	30.0**	522.6**	1,339.7**	0.128**	0.085**
Type of birth	2	1,648.8**	5,464.1**	9,606.8**	1.140**	0.157**
Sex	1	163.4**	1,638.5**	19,253.8**	0.473**	2.757**
Type × sex	2	5.6**	70.9**	343.7**	0.026**	0.037**
Error	6,428	0.5	7.6	28.9	0.003	0.004

BWT = birth weight; WWT = weaning weight; WT105 = 105-day weight; ADG1 = pre-weaning daily gain; ADG2 = post-weaning daily gain.

Table 6. Least squares means and standard errors for dam lactation number effects on growth traits of lambs.

Lact. No.	No. of observ.	BWT (kg)	WWT (kg)	WT105 (kg)	ADG1 (g/day)	ADG2 (g/day)
1	1,771	3.89±0.03	14.2±0.1	27.4±0.3	232±3	218±3
2	1,558	4.09±0.03	15.2±0.1	29.2±0.3	248±2	232±3
3	1,157	4.22±0.03	15.2±0.1	29.4±0.3	248±3	234±3
4	783	4.20±0.04	15.3±0.1	29.3±0.3	246±3	234±3
5	863	4.15±0.03	14.7±0.1	28.4±0.2	238±2	230±3
≥6	325	4.03±0.05	14.6±0.2	28.3±0.4	237±4	229±4

For explanation of abbreviations see Table 5.

Male lambs were significantly heavier than female lambs at all ages (Table 7). They also had a faster growth than females both before and after weaning. Such differences have been well documented by a number of other investigators (Richard and Cooper 1966; Gjerdem 1967; Mavrogenis and Constantinou 1986).

Table 7. Least squares means and standard errors for type of birth and sex effects on growth of lambs.

Main effect	Subclass	No. of observ.	BWT (kg)	WWT (kg)	WT105 (kg)	ADG1 (g/day)	ADG2 (g/day)
Type of birth	singles	2,673	4.95±0.03	17.1±0.1	31.8±0.2	274±2	241±2
	twins	3,070	4.06±0.03	14.5±0.1	28.6±0.2	236±2	233±3
	multiples	744	3.29±0.04	12.9±0.1	25.9±0.3	216±3	216±4
Sex	males	3,257	4.23±0.03	15.5±0.1	30.9±0.2	252±2	255±3
	females	3,200	3.97±0.03	14.2±0.1	26.7±0.2	232±2	205±3

For explanation of abbreviations see Table 5.

Differences in type of birth conformed with the literature regarding live weights and pre-weaning growth rate. Single lambs were heavier and had a faster growth than twins or other multiples, except after weaning, when twins had a similar growth rate to single lambs. This concurs with the results by Mavrogenis and Louca (1979), who report similar growth rates for single and twin lambs in Chios sheep.

Awassi lambs were significantly heavier at all ages and had a faster pre-weaning growth than Chios lambs. The post-weaning growth rate was, however, similar for the two purebreds (Table 8). Crossbred lambs were generally heavier and grew faster both before and after weaning than either purebred group. Furthermore, there were significant differences in lamb weight and gain both between F_1 reciprocals and the two backcrosses that resulted when F_1 dams were backcrossed to Chios rams.

Table 8. Least squares means and standard errors for breed group effects on lamb growth traits.

Breed group	No. of observ.	BWT	WWT	WT105 (kg)	ADG1 (g/day)	ADG2 (g/day)
2	4,089	3.78±0.02	13.5±0.1	26.7±0.2	221±2	217±2
3	1,117	4.13±0.03	14.6±0.1	27.2±0.3	236±3	217±3
12	387	4.13±0.04	15.1±0.2	29.9±0.3	244±3	246±4
14	273	4.15±0.05	15.1±0.2	29.1±0.4	247±4	230±5
19	274	3.30±0.05	15.7±0.2	30.3±0.4	256±4	242±5
41	317	4.10±0.05	15.1±0.2	28.8±0.4	248±3	227±4

For explanation of abbreviations see Table 5.

2 = Chios (C); 3 = Awassi (A); 12 = $A \times C$; 14 = $C(A \times C)$; 19 = $C \times A$; 41 = $C(C \times A)$.

Estimates of individual and maternal heterosis are presented in Table 9. The values for individual heterosis were small, ranging between 6.4% (birth weight) to 12.4% (post-weaning growth rate). Consistent with previously published results (Mavrogenis 1981; Mavrogenis and Constantinou 1986), heterosis effects were positive for all traits studied. Positive heterosis effects have also been reported by Singh et al. (1967) and Sidwell and Miller (1971) for birth and weaning weight, Dickerson et al. (1975) and Teehan et al. (1979) for post-weaning gain, and Hohenboken et al. (1976) for weaning weight.

Table 9. Mean genotypic values and estimates of individual and maternal heterosis for lamb growth traits.

Trait	A	B	C	H_i	H_m
BWT	3.96	4.22	4.13	6.44	4.29
WWT	14.1	15.4	15.1	9.61	7.09
WT105	27.2	30.2	29.0	11.03	6.62
ADG1	229	250	248	9.18	8.30
ADG2	217	244	229	12.44	5.53

For explanation of abbreviations see Table 5.

$A = (\text{Chios} + \text{Awassi})/2$; $B = [(C \times A) + (A \times C)]/2$; $C = [C(C \times A) + C(A \times C)]/2$; H_i : Individual heterosis = $100(B - A)/A$; H_m : Maternal heterosis = $100(C - B)/B$.

Estimates of maternal heterosis were lower than those for individual heterosis, but positive for all traits studied. Vesely and Peters (1972) found that three-breed crossbred lambs from crossbred dams exceeded the mean of the two-breed crossbred lambs (from straight-bred dams) by 10% in weaning weight, which was only slightly higher than the estimates obtained from backcrosses in the present study. However, Rastogi et al. (1982) found small and mostly negative estimates of maternal heterosis for lamb weights and gains.

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Genetic Analysis of Crosses Between Local Awassi, Assaf, and Turkish Awassi Sheep

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Abstract

A total of 4,701 lambs were studied to assess the complementarity of crossings between the Assaf breed (A) and the Turkish Awassi (T) with the local Iraqi (L) strains of Awassi sheep. Heterosis, deviation from the mean of the local Awassi, additive values of the breed combinations, and the non-additive contribution of the crossbreds were estimated. Linear and quadratic regression analyses were carried out to evaluate the effectiveness of Assaf or Turkish Awassi gene substitution into the local Awassi.

No heterosis was observed in birth weight. Heterosis for weight at six months ranged from -2.1 to 9.3 for 3/4A and 1/4T, respectively. An increase in the proportion of Assaf or Turkish in the crossbreds resulted in an increase in weight at weaning, and at 6, 9, and 12 months of age. Additive effects were higher than non-additive effects in the crossbreds, indicating that further improvement can be made by selection within genetic groups.

Introduction

Traditionally, sheep production in Iraq takes place on extensive rangeland, using local Awassi sheep, which are well adapted to arid and semi-arid environments. Productivity is low, and with a rapidly increasing human population, there is an urgent need to increase production of meat, milk and wool.

Owen (1987) suggests that the use of exotic genotypes can be a short cut for genetic improvement. This paper summarizes the results since 1990 of a crossing program to introduce Assaf (A) and Turkish Awassi (T) genes into the local Awassi (L) breed to increase body weight at weaning, 6, and 9 months, and milk production (Al-Salman et al. 1995). Elzo (1994) reports that additive and non-additive genetic effects are important when comparing crossbreds. Evaluation of the crossbreds includes an estimation of heterosis, and the additive and non-additive values in the breed combinations for weight at different ages.

Materials and Methods

The data presented in this study were obtained from the Awassi sheep breeding program initiated by the IPA Agricultural Research Center in 1990 and conducted

at the Al-Radwaniya Station, Baghdad. The breeds, management and measurements have been previously described by Al-Rawi et al. (1992) and Al-Salman et al. (1995). Nine genetic groups were evaluated, three purebreeds: local Awassi (L), Turkish Awassi (T) and Assaf (A), and six crossbreeds: 1/4T 3/4L (1/4T), 1/2T 1/2L (1/2T), 3/4T 1/4L (3/4T), 1/4A 3/4L (1/4A), 1/2A 1/2L (1/2A), and 3/4A 1/4L (3/4A).

The number of lambs in each group is shown in Table 1. The deviation of the mean of each weight for the crossbreeds from the mean of the local Awassi was expressed as a percentage. Additive effects of breed combination and non-additive contributions in crossbreeds were calculated as described by Van Vleck et al. (1987).

Table 1. Number of lambs produced across genetic groups.

Genetic group	BWT	WWT	WT6	WT9	WT12
T	501	501	426	332	367
A	157	157	137	117	105
L	661	661	510	404	229
1/4T	190	190	160	148	139
1/2T	1,376	1,376	1,114	993	881
3/4T	240	240	192	176	176
1/4A	174	174	158	145	131
1/2A	1,353	1,353	1,150	718	805
3/4A	49	49	43	41	30
Total	4,701	4,701	3,890	3,074	2,863

The effectiveness of Assaf or Turkish Awassi gene substitution was assessed by linear and polynomial regression coefficients, in which weight at birth, weaning, 6, 9, and 12 months was expressed as a function of the percentage of Assaf or Turkish Awassi genes, as follows:

$$Y = b_0 + b_1 X \quad \text{linear}$$

$$Y = b_0 + b_1 X + b_2 X^2 \quad \text{polynomial}$$

where Y = the weight at birth, weaning, 6, 9, or 12 months; and X = percent of Assaf or Turkish Awassi genes

Heterosis was calculated, using the formula given by Van Vleck et al., (1987):

$$\text{Percentage heterosis} = \frac{\text{mean of offspring} - \text{mean of parents}}{\text{mean of parents}}$$

Results and Discussion

The mean values (kg) for birth weight (BWT), weaning weight (WWT), and weights at 6 (WT6), 9 (WT9), and 12 (WT12) months for the three purebreeds and six crossbreeds are presented in Table 2. Crossbreeds were generally heavier than local Awassi.

Table 2. Weights at birth, weaning, and 6, 9, and 12 months for local Awassi, Turkish Awassi, Assaf and crosses.

Weight at	Local	1/4T [†]	1/2T	3/4T	1T	1/4A [‡]	1/2A	3/4A	1A
Birth	4.01	3.98	4.03	3.96	3.95	4.00	4.01	3.70	4.02
Weaning	17.79	17.79	18.31	17.85	18.64	18.57	18.85	19.21	19.85
6 months	23.35	26.38	24.94	26.84	25.87	27.55	27.96	28.66	30.60
9 months	32.09	33.70	32.30	33.35	33.56	34.36	36.54	33.66	41.00
12 months	35.17	37.92	36.47	36.68	36.60	36.49	38.47	36.43	44.72

[†] proportion of Turkish Awassi

[‡] proportion of Assaf

No heterosis was found for birth weight in Assaf or Turkish crossbreds (Table 2). Values for heterosis were negative for the crossbreds 3/4T, 1/4A, 1/2A, and 3/4A, indicating that mean birth weights were less than the mid-parent means. This may be due to maternal effects in the small local Awassi. Deviation of mean BWT of the crossbreds from the mean for the local Awassi ranged from -7.7 to 0.5% for 3/4A and 1/2T, respectively (Table 3).

Table 3. Heterosis and relative weight gain.

Genetic group	BWT		WWT		WT6		WT9		WT12	
	H	D	H	D	H	D	H	D	H	D
1/4T	0.0	-0.7	-1.4	0.0	9.3	13.0	4.7	5.0	5.8	7.8
1/2T	1.3	0.5	0.5	10.8	1.3	6.8	-1.6	0.7	1.6	3.7
3/4T	-0.8	-1.2	-3.4	0.3	5.6	14.9	1.3	3.9	0.4	4.3
1/4A	-0.3	-0.3	1.4	5.6	7.4	18.0	0.1	7.1	-0.9	3.8
1/2A	-0.1	0.0	1.2	6.0	3.7	19.7	0.0	13.9	-3	9.4
3/4A	-7.8	-7.7	0.3	7.6	-2.1	22.7	-13.2	4.9	-12.4	3.6

H = percentage of heterosis.

D = percentage of deviation in the mean for the crossbred from the mean for the local Awassi.

Neither linear nor quadratic polynomial regression coefficients of birth weight on the proportion of Assaf or Turkish Awassi gene substitution were significant (Table 4). The non-additive components, representing dominance and epistasis for birth weight, were not important and ranged from -0.315 to 0.05 kg for 3/4A and 1/2T, respectively (Table 5). On the other hand, the additive effects were large, ranging from 3.98 in 1/2T to 4.02 kg in 1/2A and 3/4A.

The highest weaning weights were 19.45 kg in pure Assaf and 19.21 kg in 3/4A. Heterosis occurred in WWT in all crossbreds, except 1/4T and 3/4T. The deviation of the crossbred means from the local Awassi mean ranged from 0% in 1/4T to 10.8% in 1/2T. The increases in WWT were mainly due to additive effects and ranged from 18.05 kg in 1/4T to 19.15 in 3/4A (Table 5). The linear coefficient (b_1) of WWT on percentage of Assaf genes was 15.8 ($P < 0.01$), but the coefficient for Turkish genes was not significant (Table 4).

Table 4. The intercept (b_0), linear (b_1) and quadratic (b_2) coefficients of the regressions of the various weights on the percentage of Assaf or Turkish genes.

		BWT	WWT	WT6	WT9	WT12
Assaf						
Linear	b_0	4,004	17,982	24,502	32,106	34,448
	b_1	-1.1	+15.8**	+62.4*	+68.5	+76.2
Polynomial	b_0	4,053	17,839	23,898	32,832	35,865
	b_1	-5.0	+27.3*	+110.7	+10.4	-37.2
	b_2	+0.04	-0.11	-0.48	+0.58	+1.13
Turkish Awassi						
Linear	b_0	4,014	17,724	24,376	32,482	36,244
	b_1	-0.5	+7.0	+22.0	+10.4	+6.5
Polynomial	b_0	4,002	17,809	23,710	32,432	35,673
	b_1	+0.4	+0.1	+75.3	+14.4	+52.2
	b_2	0.00	0.07	-0.05	-0.04	-0.045

* ($P < 0.05$)

** ($P < 0.01$)

Table 5. Additive and non-additive values of crossbred weights (kg).

		1/4T	1/2T	3/4T	1/4A	1/2A	3/4A
BWT	M	3.98	4.03	3.96	4.0	4.01	3.7
	A	4.02	3.98	3.99	4.01	4.02	4.02
	N	-0.04	0.05	-0.03	-0.01	-0.01	-0.32
WWT	M	17.79	18.31	17.85	18.57	18.85	19.21
	A	18.05	18.22	18.48	18.32	18.62	19.15
	N	-0.26	0.10	-0.62	0.25	0.23	0.06
WT6	M	26.38	24.94	26.84	27.55	27.96	28.66
	A	24.14	24.61	25.40	25.66	26.105	29.28
	N	2.24	0.33	1.44	1.90	0.98	-0.62
WT9	M	33.7	32.3	33.35	34.36	36.54	33.66
	A	32.20	32.82	32.93	34.32	36.54	38.77
	N	1.50	0.52	0.42	0.04	-0.01	-5.11
WT12	M	37.92	36.47	36.68	36.49	38.47	36.43
	A	35.82	35.88	36.535	36.82	39.94	41.60
	N	2.10	0.58	0.14	-0.33	-1.47	-5.16

M = Mean; A = Additive value; N = Non-additive value.

The highest estimates of heterosis and deviation from the local Awassi in this breeding program occurred in weights at 6 months (Table 3). The highest values were 9.3 and 7.4% in the 1/4T and 1/4A crosses, respectively. The highest deviation from the local Awassi in WT6 was +22.7% in 3/4A. The non-additive effects were higher for WT6 than for BWT and WWT, with the highest values in the 1/4T and the 1/4A crosses. As WT6 is a common slaughter age, these results suggest that it may be advantageous in commercial flocks of local Awassi ewes to produce slaughter lambs using 1/2T or 1/2A rams. The linear regression

coefficients of WT6 on the proportion of genes substituted was significant ($P < 0.05$) for Assaf, but not for Turkish Awassi.

Heterosis was found for WT9 in 1/3T, 3/4T, and 1/4A (Table 3). The percentage deviation of WT in crossbreds was lower than that recorded for WT6, with a maximum of 13.9% in 1/2A. The lower difference between crossbreds and the well-adapted local Awassi may be due to a gene/environment interaction, as the ambient temperatures were high (40–45° C) when the lambs were approximately nine months old. The contribution of the non-additive component to WT9 was less than to WT6, with a maximum of 1.50 kg in 1/4T (Table 5). Neither the linear nor the quadratic regression coefficients of WT9 on Assaf or Turkish Awassi gene substitution were significant. The reason for the non-significant coefficients may also be gene/environment interactions.

Heterosis for WT12 was estimated to be 5.8, 1.6, and 0.4% for 1/4T, 1/2T, and 3/4T, respectively (Table 3). In contrast, the Assaf crossbreds did not show heterosis. Deviations of the crossbred weights at WT12 ranged from +3.6% in 3/4A to +9.4% in 1/2A. At WT12 the additive effects of breed combination were important. Linear regression coefficients of WT12 on the proportion of Assaf or Turkish Awassi genes were 76.2 and 6.5, respectively, but were not significant.

These results agree with those reported by Bradford and Berger (1987), Owen (1987), and Davis et al. (1994), indicating that genetic variation among breeds can be used to exploit heterosis and additive effects to improve sheep production. The results of this study are generally similar to crossings of the Awassi with other breeds as reported by Epstein (1985) and Mavrogenis (1992).

Variations in the extent of heterosis were observed in weights at different ages. This suggests the existence of gene/environment interaction. Additive effects occurred frequently, indicating a highly heritable portion of the superiority of the crossbreds. Thus the backcrosses of both 1/2A or 1/2T to obtain 1/4 or 3/4 inheritance of the exotic breed maintained the superiority over the local Awassi. Selection within each genetic group will produce animals with still higher growth rates. Further assessment of the crosses in different locations is necessary before genotypes suitable for different environments can be recommended.

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Discussion

H. Nabulsi: Crossing local Awassi with Turkish Awassi and Assaf is not going far, because Turkish Awassi is an Awassi with some selection and Assaf is 5/8 Awassi.

A. Al-Rawi: Out-crossing is one of the tools used by breeders to introduce new genes. Assaf or Turkish Awassi are genetic groups produced either by crossing or by selection within populations, which is what happened to Turkish Awassi. Crossing these genotypes with local Awassi should either change the gene frequency of certain traits toward the required target or introduce new genes (usually required for improving a specific trait or traits). I agree that if we had selected within our local Awassi population we would come up with the same result but over a longer period of time. That is why we selected Assaf or Turkish Awassi, because we believe that both of these genotypes have local Awassi genes and are relatively more adaptable than other breeds.

A. Goodchild: If we need Assaf in the rest of Mashreq, from where could we obtain them?

A. Al-Rawi: We are multiplying our Assaf flock through interbreeding the flock, i.e. male Assaf mated to female Assaf. Now we have more than 200 head of Assaf, while we imported 100 head.

M. Harb: Don't you think that you are mixing up your aims—milk, meat, reproduction—when the commercial side should be your aim?

A. Al-Rawi: Yes, our main aim should be the farmer, from a commercial side. We are introducing a new semi-intensive system to Iraq. We have distributed 400 rams to improve Turkish Awassi and have crossbred Turkish rams. We now have three multiplier flocks, and can exchange rams with IPA to let those multipliers produce improved rams. Regarding Assaf crossbreeds, we distributed the rams to sheep owners in central Iraq to be raised in a semi-intensive system. The breeding plan simultaneously concentrates on milk production and growth rate.

Genetic Parameters of Some Economic Traits in Sheep

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Abstract

In 1990, the IPA Agricultural Research Center initiated a breeding project to develop genotypes suitable for dry land, extensive, and semi-intensive systems in West Asia by crossings Assaf, Turkish Awassi, and local Awassi. Weights were recorded at birth (BWT), weaning (WWT), 6 months (WT6), 9 months (WT9), and 12 months (WT12) of age. Purebreds and their crosses were evaluated using general least squares and maximum likelihood techniques.

A mixed model was used to determine the influence of some non-genetic factors (fixed effects) and to estimate variance/covariance components of the random variables. Heritabilities of 0.56, 0.33, 0.33, 0.26, and 0.32 were estimated for BWT, WWT, WT6, WT9, and WT12, respectively. Genetic correlation between different weights ranged from 0.001 for BWT and WWT to 0.91 for WT6 and WT9, whereas phenotypic correlation ranged from 0.005 for BWT and WT6 to 0.98 for WT9 and WT12. The presence of additive effects suggests that selection for heavier weights could be effective, especially at 6 months.

Introduction

The fat-tailed Awassi is one of the native breeds of sheep in Iraq. It is a triple-purpose animal, providing milk, meat, and wool. In 1990, a project to improve the local Awassi was initiated by the IPA Agricultural Research Center at Al Radwan, 20 km west of Baghdad.

The objectives were to develop genetic groups through selection within the local Awassi and to introduce genes from some other breeds to obtain more productive animals suitable for different environmental conditions. The genetic parameters of different weights for Awassi sheep have been reported by Al-Rawi et al. (1982).

This paper presents results on the effects of genetic and environmental factors on weights of sheep at different ages.

Materials and Methods

Data were obtained over four years (1991–1994) for nine genetic groups, three purebreds: local Iraqi Awassi (L), Turkish Awassi (T), and Assaf (A), and six crossbreds: 1/4A 3/4L (1/4A), 1/2A 1/2L (1/2A), 3/4A 1/4L (3/4A), 1/4T 3/4L (1/4T), 1/2T 1/2L (1/2T), and 3/4T 1/4L (3/4T). Pedigree, date of birth, and

litter size (birth type) were recorded. The breeding season was from April to July. The history and management of the flock have been described by Al Rawi et al. (1992).

The data were analyzed following SAS (1987). The number of lambs for each breed and cross in the statistical analysis is shown in Table 1. The statistical model includes genetic group, year, age of ewe, sex, and birth type. Heritabilities and genetic correlations were calculated from data for paternal half-sibs, using a restricted maximum likelihood procedure (REML).

Table 1. Number of records for different groups and weights.

Genetic group	BWT, WWT	WT6	WT9	WT12
Local	661	510	404	229
1/4T	190	160	148	139
1/2T	1,376	1,114	993	881
3/4T	240	192	176	176
T	501	426	332	367
1/4A	174	158	145	131
1/2A	1,353	1,150	718	805
3/4A	49	43	41	30
A	157	137	117	105

Results and Discussion

Genetic group, year, sex, and birth type significantly ($P < 0.01$) affected BWT, WWT, WT6, WT9, and WT12 (Table 2). The age of the ewe affected BWT, WWT, WT6 ($P < 0.01$), and WT9 ($P < 0.05$), but not WT12. The overall means and their standard deviations are presented in Table 2.

Birth weights in this study were similar to those reported by Yalcin (1986), and Al-Salman (1995), with an overall mean of 4.0 ± 0.7 kg. The birth weight of 3/4A was significantly lower than that of all other breeds and crossbreds, which did not differ significantly.

The weaning weight of the Turkish crossbreds was not significantly different from that of the local Awassi, while the purebred Assaf was significantly different from both Turkish and Assaf crossbreds.

Weight at WT6 ranged from 23.35 kg for L to 30.60 kg for A. L was significantly lower than A, T, and all crossbreds. WT6 for A was significantly higher than for all other groups.

WT9 and WT12 showed similar trends, with L having the lowest weight, but not significantly so, for WT9. The Assaf purebred was significantly heavier than all other groups, and 1/2A was significantly heavier than 3/4A. The weights of local Awassi were similar to those in unpublished doctoral studies by Kazzal (1973), Kermiz (1988), and Al-Nidawi (1991).

Table 2. Means at birth, weaning, 6, 9, and 12 months of weights for genetic group, year, age of ewe, sex and birth type.

	BWT	WWT	WT6	WT9	WT12
Overall mean	4.0+0.7	18.44+3.68	26.23+5.59	33.97+7.59	37.33+6.42
Genetic group					
Local	4.01 a [†]	17.79 e	23.35 g	32.09 d	35.17d
1/4T	3.98 a	17.79 e	26.38 de	33.70 cd	37.92bc
1/2T	4.03 a	18.31 cde	24.94 f	32.30 d	36.47cd
3/4T	3.96 a	17.85 de	26.84 cde	33.35 cd	36.68cd
T	3.95 a	18.64 bcd	25.87 ef	33.56 cd	36.60cd
1/4A	4.00 a	18.57 bcde	27.55 bcd	34.36 c	36.49cd
1/2A	4.01 a	18.85 abc	27.96 bc	36.54 b	38.47b
3/4A	3.70 b	19.21 ab	28.66 b	33.66 cd	36.43cd
A	4.02 a	19.45 a	30.60 a	41.00 a	44.72a
Year					
1991	3.99 b	16.72 d	2.040 d	28.73 c	33.16c
1992	3.92 a	18.44 a	24.72 a	32.50 a	38.86a
1993	4.08 a	19.90 a	29.03 a	35.24 a	37.13a
1994	3.92 ac	17.60 a	26.76 a	34.63 a	37.65a
Age of ewe					
2	3.95 a	18.26 ac	24.94 a	32.79 a	36.97ac
3	3.97 ac	19.15 a	27.74 a	35.22 a	38.08a
4	4.08 a	18.52 a	26.65 a	33.91 a	37.03ac
5	4.10 a	18.10 ad	26.89 a	34.31 ab	37.59ab
6	4.05 ab	17.81 a	25.97 a	34.32 ab	36.62a
Lamb sex					
Male	4.10 a	18.82 a	27.56 a	35.50 a	39.14a
Female	3.90	18.04 a	24.94 a	32.57 a	35.65a
Birth type					
Single	4.29a	18.94a	26.76 a	34.37 a	37.69a
Twins	3.42a	17.44a	25.21 a	33.21 a	36.67a

[†] Within each main effect and column, means with different letters are significantly different ($P < 0.05$).

Weight at birth, weaning, 6 months, and 9 months of age, of 4.08, 19.90, 29.03, and 35.24 kg, respectively, was recorded for lambs born in 1993. Lambs born in 1991 and 1992 were lighter ($P < 0.05$) than in other years. Year significantly affected weights in a study by Martin et al. (1980).

Lamb birth weight was significantly higher in lambs born to ewes aged 4–6 years than in those born to ewes aged 2–3 years. Ram lambs and single lambs were significantly heavier than ewe and twin lambs.

The heritability estimates and genetic and phenotypic correlations are presented in Table 3.

Table 3. Genetic parameters of weights at birth, weaning, 6, 9, and 12 months.

	BWT	WWT	WT6	WT9	WT12
BWT	0.56	0.001	0.003	0.004	0.001
WWT	0.001	0.330	0.102	0.125	0.105
WT6	0.005	0.126	0.330	0.910	0.530
WT9	0.013	0.226	0.039	0.260	0.280
WT12	0.007	0.167	0.478	0.978	0.320

Estimates on the diagonal are heritabilities. Estimates above the diagonal are genetic correlations. Estimates below the diagonal are phenotypic correlations.

Heritabilities of BWT, WWT, WT6, WT9, and WT12 were estimated as 0.56, 0.33, 0.33, 0.26, and 0.32, respectively. The genetic correlation between various weights ranged from 0.001 for BWT and WWT to 0.914 for WT6 and WT9. The genetic correlation between different weights was generally similar to that reported by Martin et al. (1980), Al-Rawi et al. (1982), and Al-Hillali et al. (1993). Phenotypic correlations ranged from 0.001 for BWT and WWT to 0.978 for WT9 and WT12. The heritability estimates found in this study were similar to those reported by Al-Rawi et al. (1982), but lower than those of Mavrogenis (1992) for weaning weight and weight at 105 days. These estimates of heritability suggest that an appreciable rate of genetic response in lamb weight could be achieved through selection.

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Discussion

Question: Why are the post-weaning growth differences between local Awassi, Turkish Awassi, and Assaf greater than pre-weaning differences?

M. Al-Salman: I think pre-weaning growth is almost the same between Turkish Awassi and Assaf, but the local Awassi have a lower pre-weaning growth than others. This is due to genetic ability and milk production. The post-weaning growth shows that both local and Turkish Awassi had the same growth, about 18 kg from weaning to WT12, but the Assaf weigh about 25 kg at the same period. I think it depends on the genetic make-up of each breed, especially the Assaf, which is a bigger animal and thus may have better feed conversion.

Relationship Between Body Weight and Dimension Traits in Awassi Sheep

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IPA Journal of Agricultural Research

Abstract

A study was conducted on 584 lambs born in 1991 and 1992 to investigate environmental factors affecting weight at birth, weaning, 6, and 9 months of age, weight gain, and different body dimensions (body length, heart girth, height and width at withers and hips, chest depth, barrel, and fat tail dimensions including length, width, and circumference). Year of birth, breed or crossbreed, sex, and size of litter (birth type) generally affected the traits studied. The crossbred lambs were larger than the purebred lambs at weaning, 6 months, and 9 months, but the fat tail of the crossbreds was shorter and narrower than that of the Turkish and local Awassi lambs at weaning. At 6 and 9 months, however, fat tail length and width in crossbred lambs were superior to the local Awassi. The adjusted data were used to estimate a correlation of weight or weight gain with body dimensions. Prediction equations were calculated to estimate weight at weaning, 6 months, and 9 months from body measurements.

Introduction

Many studies have reported that live weight is correlated with different body dimensions (Juma et al. 1969; Eliya and Juma 1970; El-Tawil et al. 1970; Aboul-Naga et al. 1972; Aziz et al. 1981; and Abdul Rahman et al. 1986). Aboul-Naga et al. (1972) show that factors such as year of birth, sex, and birth type have a significant effect on weight at weaning and one year of age.

This study was conducted to determine the factors affecting live weight at birth, weaning, 6 months, 9 months, weight gain between these periods, and average daily gain for local Iraqi Awassi, Turkish Awassi, and their crosses. A multiple stepwise regression process was used to develop equations to predict live weight from body dimensions at each age. Correlations between live weight and gains with various body dimensions were calculated at each age.

Materials and Methods

A breeding project was initiated by IPA Agricultural Research Center at Al-Radwan Sheep Improvement Station, 20 km west of Baghdad. One hundred and seventy Turkish Awassi sheep (T)—33 rams and 137 ewes—and 1,500 local Iraqi

Awassi (L) ewes were brought to the station in 1990. Flock management and mating and feeding systems are described by Al-Rawi et al. (1992).

Weight at birth (BWT) and weaning (WWT) was recorded in 584 lambs born in 1991 and 1992, and weight at 6 (WT6) and 9 (WT9) months was recorded in 575 and 314 lambs, respectively. Weight gain from birth to weaning (GAINW), weaning to 6 months (GAIN6), from 6 to 9 months (GAIN9), and mean daily gain from birth to weaning (ADG) were recorded. Body dimensions, body length (BL), heart girth (HG), height at withers (HW) and hip (HH), width at withers (WW) and hip (WH), chest depth (CD), barrel (BD), fat tail length (FL), fat tail width (FW), and fat tail circumference (FC), were recorded at weaning, 6 months, and 9 months.

A least square analysis for the main factors, using the SAS package program (1989), was carried out, using the following model:

$$Y_{ijklm} = M + Y_i + L_j + S_k + T_l + E_{ijklm}$$

where M = overall mean; Y = effect of the year (1991, 1992); L = effect of lamb genetic group; j = T, L, TL (Turkish, local and crossbred, respectively); S = effect of sex; k = male, female; T = effect of type of birth; l = single, twins; E = random error effects. Duncan's multiple range test was used to compare class means.

A multiple stepwise regression was used to develop equations to predict live weight from body dimensions at each age. The coefficient of determination (R^2) was used to determine the efficiency of the predictive equations. Correlation between live weight or weight gain and body dimensions was estimated at each age.

Results and Discussion

Year, genetic group, and sex had significant ($P < 0.01$) effects on WWT and GAINW (Table 1). The WWT, GAINW, and ADG of the crossbred lambs exceeded that of the purebred (18.17, 16.59, and 16.99 kg, 14.05, 12.53, and 11.98 kg, and 114, 112, and 104 gm, for crossbreds, T, and L, respectively. These results are similar to those reported by El-Tawil et al. (1970); Al-Rawi et al. (1992); Abdul Rahman et al. (1984); and Juma et al. (1985), and lower than those of Bhat et al. (1981), Abdul Rahman et al. (1986), and Yalcin (1986). There was a significant difference ($P < 0.05$) in BWT between male and female lambs with means of 4.17 and 3.91 kg, respectively. Means for WWT, GAINW, and ADG were 17.16 and 16.03 kg, 12.99 and 12.11 kg and 111 and 102 g for male and female, respectively.

These results are within the range reported by Bhat et al. (1981), Al-Rawi et al. (1992), and Juma et al. (1985), and lower than those of Abdul Rahman (1986). Birth type significantly ($P < 0.01$) affected BWT, but not WWT, GAINW, or ADG. Al-Rawi et al. (1992) and Abdul Rahman (1984, 1986) found a similar effect on BWT, but the lack of effect of birth type on WWT and GAINW differs from the results of Aziz et al. (1981), Bhat et al. (1981), Al-Rawi et al. (1992), and Abdul Rahman (1986). Single lambs were heavier at weaning.

Table 1. The mean of live body weights and gains at different ages.

	No.	Bwt	Wwt	Gain	ADG	Wt 6	Gain 6	Wt 9	Gain 9
Year									
1991	349	4.02	16.18	12.15	106	18.86	2.86	28.13	8.67
1992	235	4.06	17.14	13.09	108	22.12	4.59	27.05	5.11
Genetic group									
Turkish (T)	64	4.07	16.59	12.53	112	19.60	2.70	30.26	10.36
Local (L)	382	4.01	16.99	11.98	104	19.39	3.56	27.58	8.01
Cross (TL)	138	4.09	18.14	14.05	114	22.32	3.73	31.32	11.77
Sex									
Male (M)	276	4.17	17.16	12.99	111	20.88	3.62	31.47	10.93
Female (F)	308	3.91	16.03	12.11	102	19.37	3.40	25.50	6.59
Type of birth									
Single (S)	550	4.07	16.60	12.53	107	20.12	3.51	28.14	8.42
Twins (T)	34	3.56	16.06	12.51	102	19.27	3.43	27.13	8.83

Year significantly ($P < 0.01$) affected WT6, GAIN6, and GAIN9, but not WT9 (Table 2). Genetic group and sex significantly ($P < 0.01$) affected WT9 and GAIN9. Crossbred lambs were heavier and gained more weight than the purebreds between 6 and 9 months (Table 1).

Year significantly ($P < 0.01$) affected body dimensions at weaning (with the exception of WW and HW), and 6 months (with the exception of HG, HW, CD, and FC), but not at 9 months of age (Tables 2, 3, and 4). Most values were greater in 1992 than in 1991.

Genetic group significantly affected ($P < 0.01$) BL, HG, WW, HW, and ($P < 0.05$) BD at weaning (Table 2), ($P < 0.01$) HG, WW, and HW at 6 months (Table 3), and FL and FW at 9 months (Table 4). The crossbred lambs exceeded ($P < 0.05$) the purebreds for BL, HG, HH, WW, and HW, but not for FL or FW, at weaning (Table 2), for BL, HG, WH, HH, HW, or FL at 6 months (Table 3), fat tail length FL or FW at 9 months (Table 4).

Sex significantly ($P < 0.01$) affected WH and HH at weaning, WH, HH, BD, ($P < 0.05$) BL, HW, CD, and FL at 6 months, and BL, HG, WH, HH, CD, FL, FW, and FC at 9 months (Tables 2, 3, and 4). In general, body dimensions of male and single lambs exceeded those of females and twins at each age.

The correlation of body dimensions with weight and gain at weaning and 6 and 9 months of age is presented in Table 5. The values were adjusted for significant factors at each age. Weaning weight and gain to weaning were significantly correlated with body dimensions BD, BL, and CD ($P < 0.001$) and GH, WW, HW, FL, and FW ($P < 0.01$). Similarly, weight at 6 months was significantly correlated ($P < 0.001$) with most body dimensions. Correlation of gain with dimensions was, in general, higher for GAIN9 than for GAIN6.

Table 2. The means of various body dimension traits at weaning.

	No.	BL	HG	WH	HH	WW	HW	CD	BD	FL	FW	FC
Year												
1991	349	44.79	40.02	43.44	43.44	12.37	11.49	19.05	18.96	12.54	13.66	22.44
1992	235	46.78	58.33	44.20	44.52	12.03	11.49	17.91	17.91	11.25	12.23	20.79
Genetic group												
Turkish (T)	64	44.75	54.91	43.39	43.50	12.44	11.53	18.95	18.81	12.17	13.60	22.08
Local (L)	382	44.90	41.57	43.51	43.58	12.01	11.25	18.60	18.50	12.30	13.28	21.70
Cross (TL)	138	47.88	59.99	44.28	44.86	12.75	12.12	18.41	18.53	11.20	12.33	21.86
Sex												
Male (M)	276	45.82	47.91	43.39	44.54	12.41	11.63	18.71	18.74	12.08	13.04	21.95
Female (F)	308	45.38	46.92	41.27	43.27	12.07	11.36	18.48	18.36	11.96	13.13	21.62
Type of birth												
Single (S)	550	44.64	47.72	43.91	43.94	12.25	11.50	18.60	18.56	12.04	13.11	21.82
Twins (T)	34	44.77	42.06	42.71	42.71	11.97	11.27	18.44	18.21	11.82	12.77	21.12

Table 3. The means of various body dimension traits at 6 months of age.

	No.	BL6	HG6	WH6	HH6	WW6	HW6	CD6	BD6	FL6	FW6	FC6
Year												
1991	361	48.86	62.70	46.14	46.42	13.86	13.04	19.78	19.54	11.96	13.26	23.92
1992	214	50.52	63.42	48.53	48.53	13.24	12.80	19.72	18.96	13.85	14.47	24.09
Genetic group												
Turkish (T)	63	49.46	62.33	46.37	46.59	14.00	13.38	19.60	19.33	11.94	13.10	23.89
Local(L)	383	49.08	62.42	46.77	46.99	13.44	12.70	19.69	19.30	12.60	13.73	23.95
Cross (C)	129	50.67	64.91	48.10	48.14	14.04	13.49	20.05	19.39	13.23	13.95	24.15
Sex												
Male (M)	267	49.99	63.32	47.76	47.95	13.90	13.23	20.01	19.72	12.33	13.69	24.17
Female (F)	308	49.04	62.66	46.39	46.56	13.41	12.71	19.54	18.98	12.96	13.73	23.83
Type of birth												
Single (S)	545	49.57	63.03	47.12	47.30	13.65	12.96	19.76	19.33	12.64	13.68	23.97
Twins (T)	30	47.90	61.80	45.27	45.47	13.37	12.87	19.77	19.23	13.20	14.20	24.33

Table 4. The means of various body dimension traits at 9 months of age.

	No.	BL9	HG9	WH9	HH9	WW9	HW9	CD9	BD9	FL9	FW9	FC9
Year												
1991	295	55.84	70.58	52.01	52.38	15.77	14.97	22.65	21.87	14.97	16.81	30.52
1992	19	54.74	64.21	51.47	51.47	15.05	14.63	21.47	20.84	14.68	16.47	30.32
Genetic group												
Turkish (T)	42	56.14	70.45	52.74	53.29	15.31	14.59	23.10	21.69	16.95	18.12	30.67
Local (L)	261	55.63	70.49	51.81	52.09	15.74	14.98	22.46	21.84	14.46	16.42	30.40
Cross (C)	11	57.82	70.73	53.27	54.27	16.91	15.64	23.27	21.46	18.91	20.36	32.27
Sex												
Male (M)	135	56.50	71.35	53.79	53.87	15.42	14.99	23.20	22.13	16.93	19.20	33.38
Female (F)	179	55.22	69.86	50.62	51.16	15.96	14.92	22.11	21.56	13.46	14.97	28.34
Type of birth												
Single (S)	290	55.83	70.71	52.06	52.44	15.72	14.93	22.59	21.79	15.07	16.87	30.66
Twins (T)	24	55.13	70.48	51.04	50.92	15.79	15.13	22.42	22.04	13.54	15.83	28.67

Table 5. The correlation between live body weight with different body dimension traits at various age.

Trait	BL	HG	WH	HH	WW	HW	CD	BD	FL	FW	FC
WWT	.77+.02	.31+.04	.70+.02	.71+.02	.46+.03	.50+.03	.52+.03	.51+.03	.28+.04	.34+.04	.53+.03
WT6	.67+.02	.65+.02	.73+.02	.75+.02	.37+.04	.44+.03	.62+.03	.49+.03	.59+.03	.63+.03	.60+.03
WT9	.27+.05	.20+.05	.43+.05	.39+.05	.02+.06	.06+.06	.22+.05	.09+.06	.53+.04	.58+.04	.47+.04
GAINW	.77+.02	.31+.04	.67+.02	.69+.02	.44+.03	.49+.03	.50+.03	.50+.03	.30+.04	.35+.04	.53+.03
GAIN6	.40+.04	.40+.04	.41+.03	.40+.04	.28+.04	.32+.04	.37+.04	.27+.04	.31+.04	.32+.04	.32+.04
GAIN9	.67+.03	.52+.04	.75+.02	.73+.03	.21+.05	.29+.05	.54+.04	.41+.05	.56+.04	.67+.03	.73+.03

All the values are significant ($P < 0.01$).

The equations with the best fit to predict live weight from body dimensions were:

R ²	WWT	= -9.64 + 0.58 BL	0.595
		= -16.41 + 0.41 BL + 0.32 FH	0.645
		= -15.10 + 0.38 BL + 0.28 FH + 0.10 FC	0.664
		= -14.34 + 0.36 BL + 0.28 HH + 0.11 FC	0.665
	WT6	= -19.41 + 0.84 HH	0.569
		= -16.46 + 0.65 HH + 0.34 FW	0.637
		= -16.96 + 0.51 HH + 0.46 HW + 0.51 FC	0.670
	WT9	= -27.79 + 1.07 WH	0.561
		= -21.59 + 0.71 WH + 0.41 FC	0.699
		= -23.82 + 0.73 HH + 0.45 FC	0.715
		= -31.29 + 0.30 BL + 0.58 HH + 0.39 FC	0.745

Including additional traits in the equations improved the predicted body weight at each age. Juma et al. (1969) developed equations for predicting weight at weaning and 12 months with accuracy from WH, BL, and HG.

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Discussion

E. Thomson: Don't you think the average daily gain of all purebreds or crosses is rather low, about 100-200 g until weaning? Would it not be better to feed high-producing lines according to the genetic potential of the breed, to allow them to achieve their genetic potential?

W. Al-Azzawi: I think the ADG of the pure and crossbred is within the range of this station, and I agree with you, it is low, but this is what happens with these animals. Also, it depends on the nutritional value of the feeding systems.

M. Tabbaa: Why didn't you consider the effect of lactation or age of ewe, given that they were considered significant in the previous two papers of your colleagues?

A. Al-Azzawi: I did not use it because I considered it unimportant. Maternal effect may not have an effect after weaning. The ewe age at the beginning of the project was not available, especially for the local Awassi, and thus it was not included in the statistical analysis model.

Reproductive Performance of Awassi Ewes Artificially Inseminated Using Fresh Semen

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Abstract

Distribution of oestrus, lambing rates, and distribution were recorded for 1,786 Awassi female yearlings (18 months) and 367 ewes following cervical insemination using 0.2 ml of fresh semen from 17 Turkish (Ceylanpinar) and four Israeli Awassi rams. Seventy percent of the yearlings and 85% of the ewes showed oestrus within 20 days of the start of the mating season. The majority of lambing occurred over a period of three weeks. Lambing rates from the first insemination were 61.0% for yearlings and 70.3% for ewes. Lambing rates from two inseminations were 71.2% and 82.8%, respectively. These results are higher than in most previous studies.

In another study, four different fresh semen doses were tested. Lambing rates, following insemination with 0.2, 0.3, 0.4, and 0.5 ml of semen, were found to be 68%, 88%, 64%, and 66%, respectively. Under field conditions, where semen quality is assessed subjectively, 0.3 ml of fresh semen via cervical insemination may improve lambing rates significantly.

Introduction

In the Middle East, natural mating is used almost exclusively, and artificial insemination is used only in research projects. Artificial insemination, in addition to requiring high levels of technical skill and organization, generally gives low conception rates in ewes. Artificial insemination using fresh semen gives conception rates of about 60% (Maxwell and Hewitt 1986; Epstein 1985; El-Gaafary et al. 1987). Conception rates can be increased appreciably by inseminating into the uterus or oviduct (Maxwell 1986b; Maxwell and Hewitt 1986; Jabbour and Evans 1991; Maxwell et al. 1993).

The efficiency of progeny testing programs in milking sheep is often low, because of the small numbers of lambs born to each ram. Rarely does the number of daughters per ram exceed 20, and, with subsequent losses, the number of full lactation records may drop to 5–8, making precise estimation of breeding values impossible. Dependable breeding values and faster genetic gains can be achieved by increasing the number of daughters per ram, using artificial insemination.

The Awassi breed is raised extensively at the Ceylanpinar State Farm in southeastern Turkey. Except in cold, wet weather between December and

February, grazing depends entirely on poor and unproductive grassland, stubble, fallow, and the residues of cash crops in the irrigated agriculture areas. Grazing is supplemented in the last month of pregnancy and early lactation.

The objective of this study, which was carried out at Ceylanpinar State Farm, was to investigate the distribution of oestrus and conception rates in Awassi ewes, following artificial insemination using fresh semen. Approximately 2,500 yearlings and ewes were used to assess oestrus activity in July and August, and conception rates, when inseminated once with 0.2 ml of fresh semen. A further 200 ewes were used to assess the effect of semen dose rate on conception rates.

Materials and Methods

The study was carried out on 2,160 female Ceylanpinar Awassi yearlings (approximately 18 months old), inseminated with semen from 17 Ceylanpinar yearling rams (approximately 18 months old) and on 450 Ceylanpinar Awassi ewes of varying ages, inseminated with semen from four Israeli Awassi rams (3.5 and 4.5 years). Thirty six marker rams were used to detect oestrus.

The study of semen dose rate was carried out on 200 yearlings, with five rams selected at random from the flock. Groups of 50 ewes were inseminated with 0.2, 0.3, 0.4, or 0.5 ml of fresh semen.

The rams were fed 2 kg of concentrate mixture, consisting of 55–60% wheat screenings, 25–30% cracked lentil, and 10–20% chopped alfalfa, together with alfalfa hay *ad libitum*.

The rams were trained for collecting semen using an artificial vagina and the semen was examined under the microscope. Rams with semen that was abnormal or of low motility were replaced. Depending on the number of ewes in heat each day, a maximum of two ejaculates per day were collected from each ram.

Each morning and evening, oestrus was detected with marker rams either vasectomized or carefully aproned (Chemineau et al. 1991). Females showing standing heat between 05.00 and 07.00 hours were penned and inseminated between 17.00 and 19.00 hours, and those showing oestrus in the evening were inseminated in the morning (Evans and Maxwell 1987; Berg 1989; Chemineau et al. 1991; Ryan et al. 1992; Maxwell et al. 1993). The ewes were not inseminated twice because Berg (1989) showed that a second insemination does not significantly increase conception.

Mating took place over a period of 32 days, between 22 July and 22 August, 1993. Inseminations were made vaginally in the cervix, using 0.2 ml fresh semen. From 14 days after the first insemination, the ewes were tested twice a day, using marker rams, for those that had failed to conceive. The conception rates from artificial insemination were determined as the ratio between ewes inseminated and ewes lambing.

Results and Discussion

Distribution of Oestrus In the Mating Season

In an efficient AI program, it is very important to detect oestrus accurately. Missing ewes in heat will reduce reproductive efficiency. Figure 1 shows the distribution of oestrus detected by marker rams in Awassi yearlings and ewes. The yearlings and the ewes exhibited slightly different frequencies. The yearlings had peaks on days 2–4, 17–19, and 24–27, whereas the ewes had a wider peak on days 9–11 and a sharp peak on days 15–17. Epstein (1985) shows that, with Awassi ewes, oestrus occurs in two peaks, on days 18 and 25, following the introduction of teaser rams.

Seventy-two percent of the yearlings and 86% of the ewes showed standing oestrus in the first 20 days after testing started on 22 July. This may be the stimulating effect of the ram, resulting from teasing with marker rams twice daily for 30 minutes (Schinkel 1954; and Chemineau et al. 1991).

A higher percentage of the yearlings showed oestrus in the morning (56%) than the evening (44%). In the ewes, morning and evening frequencies were found to be almost equal. Schindler and Amir (1972), and Barr (1968) report frequencies of morning and evening oestrus in Awassi ewes of 48% and 67%, and 52% and 33%, respectively.

Seventeen percent of the yearlings and 18% of the ewes did not show standing heat between 22 July and 22 August. Awassi ewes show a wide range in date of the start of the mating season. Some animals remain anoestrus until September or even October. Epstein (1985) reports similar figures; 84% of first oestrus in Awassi ewes occurred in July and August and approximately 15% in September and October. The relatively wide distribution of the first oestrus of the season may result from differences in body condition at the start of the mating season. Finci (1957), Asker (1964), and Epstein (1985) report that ewes with better body condition show oestrus earlier and with higher ovulation rates and, consequently, more twins in ewes lambing in the early season.

Of the 1,786 yearlings and 367 ewes initially inseminated, 300 yearlings and 96 ewes showed return oestrus.

Distribution of Lambing In Awassi Yearlings and Ewes

Figure 2 shows the lambing distribution between 15 December and 5 February. In the 1,272 yearlings the peak was between 4 and 8 January. The ewes, however, showed two peaks, between 21 December and 1 January, and between 3 and 13 January.

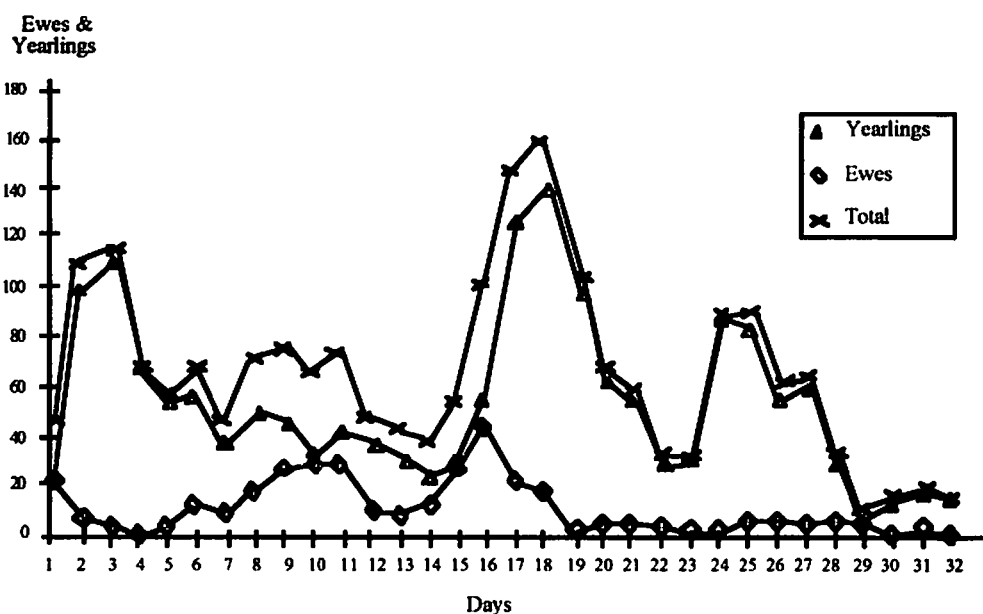


Figure 1. Distribution of first oestrus in Awassi ewes and yearlings (1993).

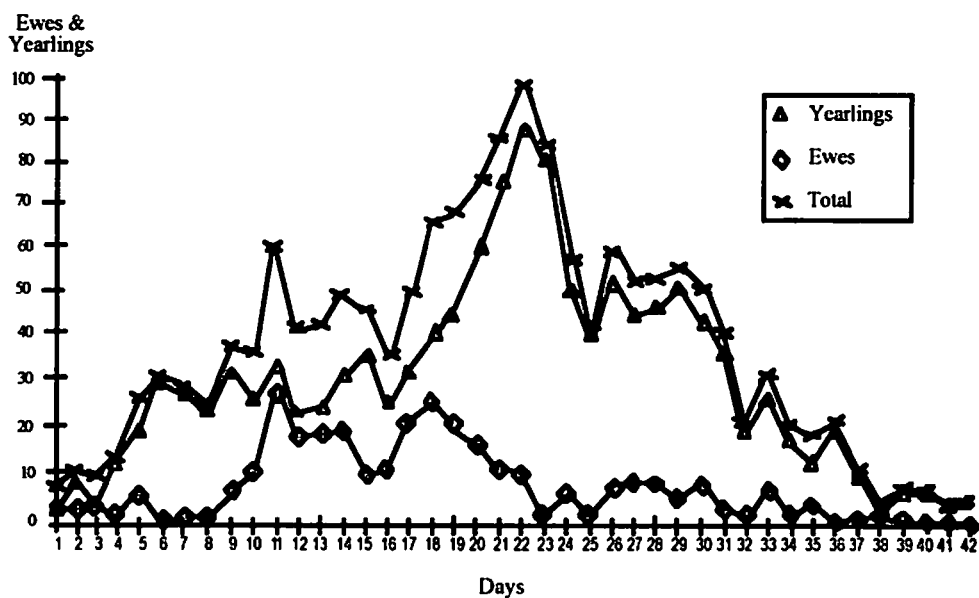


Figure 2. Distribution of lambing in Awassi ewes and yearlings (1993).

Artificial Insemination Results

In the Awassi ewes that were inseminated with semen from four mature rams, 49% of first inseminations were in the morning. Conception rates from the first insemination were 65% in the morning and 75% in the evening. In ewes that failed to conceive at the first insemination and showed a second oestrus, 44% and 56% were inseminated for a second time, in the morning and evening, respectively, with conception rates of 57 and 41%. Conception rates, using semen from the four rams, varied from 86 to 54% and from 64 to 32% from the first and second inseminations, respectively. The ranking of the rams differed at the two inseminations.

In the yearling ewes that were inseminated with semen from yearling rams, 44% of first inseminations were in the morning. Conception rates from the first insemination were 59 and 63%, for morning and evening, respectively. In ewes that failed to conceive at the first insemination and showed a second oestrus, 39 and 61% were inseminated for a second time, in the morning and evening, respectively, with conception rates of 57 and 64%. Conception rates using semen from 17 rams varied from 73 to 55%, and from 93 to 29%, from the first and second inseminations, respectively. As with the mature rams, the ranking of the rams differed for the two inseminations.

These results are higher than most of the conception rates reported for insemination with fresh semen at the entrance of the cervix. These range from 48–50% by Maxwell (1986a), and 54–82% by Fernandez et al. (1992a) to 81–88% by Özcan (personal communication) using undiluted semen.

Effect of Semen Dose on Lambing Percentage

Table 1 presents conception rates following insemination of groups of yearlings with 0.2, 0.3, 0.4, or 0.5 ml of fresh semen. The conception rate was higher with 0.3 ml, but there was no explanation for the lower rates using 0.4 and 0.5 ml.

Table 1. Effect of quantity of fresh semen on conception rate.

Semen dose (ml)	1st Oestrus			2nd Oestrus			Mean conception rate (%)
	Ewes inseminated	Ewes lambed	Conception rate (%)	Ewes inseminated	Ewes lambed	Conception rate (%)	
0.2	50	33	66	3	1	33	68
0.3	50	40	80	4	4	100	88
0.4	50	29	58	4	3	75	64
0.5	50	32	64	4	1	25	66
Total	200	134	67	9	9	60	71.5

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Discussion

M. Awad: You say that the age of the rams in your study was 18 months. From your experience, do you feel that the age of the ram affects the quality or the quantity of the semen, or the lambing rate? If the answer is yes, how old should the rams be?

O. Gursoy: Yes, it is true that it is a fact that both semen quality and quantity decrease along with the age of the ram. To counter this, we have hit upon the strategy of using rams for two years and then culling them or selling them. In our progeny testing project, it is our policy to test the rams when they are 18 months old.

A. Al-Haboby: We see that you got a good natural synchronization rate by using a sudden ram introduction regime. Can you tell us for how long you kept the rams separated from the flocks, and under what conditions this separation was carried out?

O. Gursoy: It is our policy to use the marker rams on the first day we start the insemination, and the yearlings and ewes on the 18th and 19th days. In fact, the ram effect should be used by introducing aproned or vasectomized rams two weeks before mating. This will have the effect of shortening the mating and lambing seasons.

Regarding your second question, we separate rams and ewes all year round and only introduce rams during the mating season.

S. Al Hussein: How long can you use fresh semen after acylation?

O. Gursoy: We use fresh semen immediately, but according to the literature fresh semen can be used within three days at room temperature.

J. Gresham: Is there a correlation between sperm count and other factors? Was sperm count done on semen?

O. Gursoy: Semen of the rams was assessed subjectively for motility (turbulence), color, volume, odor, and also for motility and live cells under the microscope. After that rams having abnormal semen were discarded from the program. However, we have to accept the variation in semen quality among the rams as seen in the semen dose study. Rams were found to have a lambing variation between 62.5 and 87.5%.

Question: Was the comparison between 0.2 and 0.3 ml semen for the same ram or for all rams together? Did you find that there was any difference in lambing between those inseminated in the morning and those inseminated in the afternoon?

O. Gursoy: For the purposes of this study, the comparison was made on an AM ram dose basis. Semen of a ram was tested on groups of 10 yearlings using 0.2, 0.3, 0.4, and 0.5 ml of semen. To eliminate the ram effect discussed above, 5 rams were used.

Regarding your second question, yes, there are differences. In the yearlings lambing rate from the morning and evening inseminations were 58.7 and 62.7% in the first insemination. In the second insemination 56.8% lambed from the morning insemination and the evening insemination resulted in 63.7%. In the ewes, morning and evening inseminations resulted in 65.2 and 75.3%, in the second insemination 57.1 and 85.2 for morning and evening inseminations.

Effect of Vitamin A on the Reproductive Performance of Awassi Sheep

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Abstract

Three experiments were conducted to investigate the effect of vitamin A treatment during the mating season on the reproductive performance of ewes and rams. In Experiment 1, groups of five ram lambs were treated monthly for 16 weeks with 50,000 IU or 100,000 IU vitamin A or left as control (C) to assess the effect of vitamin A on spermatogenesis. In Experiment 2, 12 rams were evenly divided to be treated monthly for 20 weeks with either 100,000 IU or 200,000 IU vitamin A or left as control to study semen quality. Experiment 3 used 300 ewes in three flocks which were divided into two groups each. One group was treated with double doses of 150,000 IU vitamin A during the mating season and the other was left as a control to evaluate the treatment effect on some reproductive traits. After vitamin A treatment, spermatogenic cell relative weight (Experiment 1) was greater by 72% and 141% than group C. In rams (Experiment 2), there was a drop in ejaculate volume sperm concentration and total sperm/ejaculate. There was an increase ($P < 0.05$) in dead and abnormal sperms in group C with advancing time. The farm trial (Experiment 3) showed that vitamin A treatment improved the lambing rate by 8% and the twinning rate by 1.6%.

Introduction

Vitamin A plays an essential role in reproductive performance in both males and females. Vitamin A affects ovarian activity, reproductive hormone secretion and fertilization rate in females (Ghannam and Younis 1976; and Bittner 1986). In the male, vitamin A deficiency was claimed to influence spermatogenesis (Haq and Chytil 1988; Unni and Rao 1986), testosterone secretion (Coward et al. 1966), and accessory sex gland secretory activity (Thompson 1969). Sheep in Iraq are characterized by low reproductive performance (Younis 1977), especially those raised extensively in the dry lands. Preliminary results of a fertility survey (Al-Haboby et al. 1995, unpublished data) show that sheep in the northern Al-Jezira region of Iraq have low lambing and twinning rates. The sheep mating season in the dry lands is long, lasting for five months (May–October). During that period, at harvesting and post-harvest, sheep are grazed only on loose grain and straw. It is believed that sheep may suffer a vitamin A deficiency due to the shortage of green roughage. Low reproductive performance may in part be due to a reduction of vitamin A reserves in the body. This may affect the reproductive performance of both males and females and the effect may be more progressively pronounced

during the mating season. Therefore, a study of three experiments was conducted to explore the effect of vitamin A on testicular development and spermatogenesis, on ram semen quality and quantity, and on lambing and twinning in Awassi ewes.

Materials and Methods

Experiment 1

Fourteen ram lambs, 3–3.5 months old weighing an average of 32.2 kg, were fed on straw and barley grain as recommended (NRC 1975). A group of five ram lambs was treated monthly for 16 weeks with either 50,000 IU (T1) or 100,000 IU of vitamin A (T2) or left as control (C, 4 lambs). Vitamin A (retinol palmitate) in gelatin capsules was administered orally to lambs in T1 and T2. Single blood samples were taken from each lamb at weeks 0 and 16 of the experiment to determine plasma vitamin A. Another five serial blood samples were taken from each ram lamb at week 16 for plasma testosterone measurement. On week 16 the testes were surgically removed, weighed, and a small piece of testicular paranchyma prepared for morphometric histological analysis. The morphometry of the testes was examined using the Weible grid (Weible 1979) to calculate relative weight (g/kg) (RW) of testicular components. Seminiferous tubule and lumen diameters as well as epithelial cell height were determined using a visopan screen microscope.

Experiment 2

Twelve Awassi rams (2–2.5 years-old weighing on average 57.2 kg) were observed for 20 weeks and offered barley grain and straw as recommended (NRC 1975). Rams were evenly divided to be treated monthly with either 100,000 IU or 200000 IU vitamin A or left as control to study semen quality and quantity. Semen was collected weekly via an artificial vagina using teaser ewes brought into oestrus by an oestradiol benzoate injection. Physical semen properties (ejaculate volume, mass and individual motility, dead and abnormal sperm percentages, sperm concentration, and total sperm per ejaculate) as well as chemical properties (pH; Glutamic Oxaloacetic Transaminase, GOT; Glutamic Pyruvic Transaminase, GPT ; Alkaline phosphate, ALP) were determined. At weeks 0, 10, and 20, blood samples were collected to determine plasma vitamin A. Testosterone was measured in blood samples collected at week 20 only.

Experiment 3

During the 1994 season, three flocks in the northern Al-Jezira were observed. In each flock, 50 ewes were injected twice with 150,000 IU vitamin A (as AD3E compound) and another group (50 ewes) served as control. First injections were done in mid-June (flock 1), the first of July (flock 2) and mid-July (flock 3). The second injection was given two months later to all ewes. All rams in the three flocks were injected with 100,000 IU vitamin A at the time of first injection. At lambing season, lambing and twinning percentages, percentage of dead lambs, lamb birth weight and weight of ewes prior to lambing were recorded.

Vitamin A Determination

Plasma vitamin A concentration was determined using trifluoroacetic acid as an indicator (Neeld and Pearson 1963). The standard curve of vitamin A was prepared using 50 mg of vitamin A alcohol, which contained 95% all-trans retinol. For complete vitamin A extraction, all blood samples were treated with ethanol and petroleum ether. A Beckman spectrophotometer (wave length of 620 nm) was used.

Testosterone Analysis

Plasma testosterone was measured using RIA procedure, double antibody technique (Gamma B- testosterone, IDS, UK). The testosterone standard curve used concentrations of 0.1–12 ng/ml. The tracer contained a radioactive iodine (3 uci). Sensitivity was about 0.1 ng/ml. The assay has a cross reactivity of 100% for testosterone, 3–4% for 5- α -dihydrotestosterone and 5.56% for androstenedione.

Statistical Analysis

This was done using the general linear model procedure of the SAS system. Relative weights, vitamin A, and testosterone concentrations were analyzed as a complete randomized design. Physical and chemical semen properties were analyzed as a randomized complete block design.

Results

Experiment 1

Concentration did not differ among the three groups at week 0 (8.9–10.38 $\mu\text{g}/100\text{ ml}$). By week 16 it had decreased by up to $4.17 \pm 1.22\ \mu\text{g}/100\text{ ml}$ (C) (Fig. 1) and increased to 16.75 ± 1.07 (T1) and $20.58 \pm 2.32\ \mu\text{g}/100\text{ ml}$ (T2). Vitamin A in both T1 and T2 was significantly higher ($P < 0.01$) than group C. Plasma testosterone did not differ among the three groups at week 16, despite an increase by 52% (T1) and 67% (T2) compared to C.

Treatment with vitamin A had no effect on total seminiferous tubules RW. There was a trend toward increase in the RW of Sertoli cells and the basement membrane in T1 and T2 compared to C. Vitamin A treatment had a significant ($P < 0.05$) effect on the RW of spermatogenic cells, which was $0.55 \pm 0.11\ \text{g/kg}$ (T1) and $0.77 \pm 0.14\ \text{g/kg}$ (T2). Among all spermatogenic cells, only the RW of sperms was higher ($P < 0.01$) in T1 ($0.09 \pm 0.03\ \text{g/kg}$) and in T2 ($0.11 \pm 0.01\ \text{g/kg}$) than C ($0.01 \pm 0.0\ \text{g/kg}$). There was no effect of vitamin A treatment on the RW of the spermatogonia, spermatocytes, and spermatids, and all tended to be higher in treatment groups. Among all interstitial components, the RW of only the myoid cells was different, with a tendency of the Leydig cells RW to be higher in the treatment groups. Vitamin A had no influence on seminiferous tubule diameter (Fig. 2), but caused an increase ($P < 0.01$) in epithelial cell height in T1 (+54%) and T2 (+99%) compared to C. A decrease ($P < 0.01$) in lumen diameter was noticed in T1 ($61 \pm 1.84\ \mu$) and T2 ($45 \pm 2.61\ \mu$) compared to C ($115.3 \pm 6.67\ \mu$) (Fig. 2).

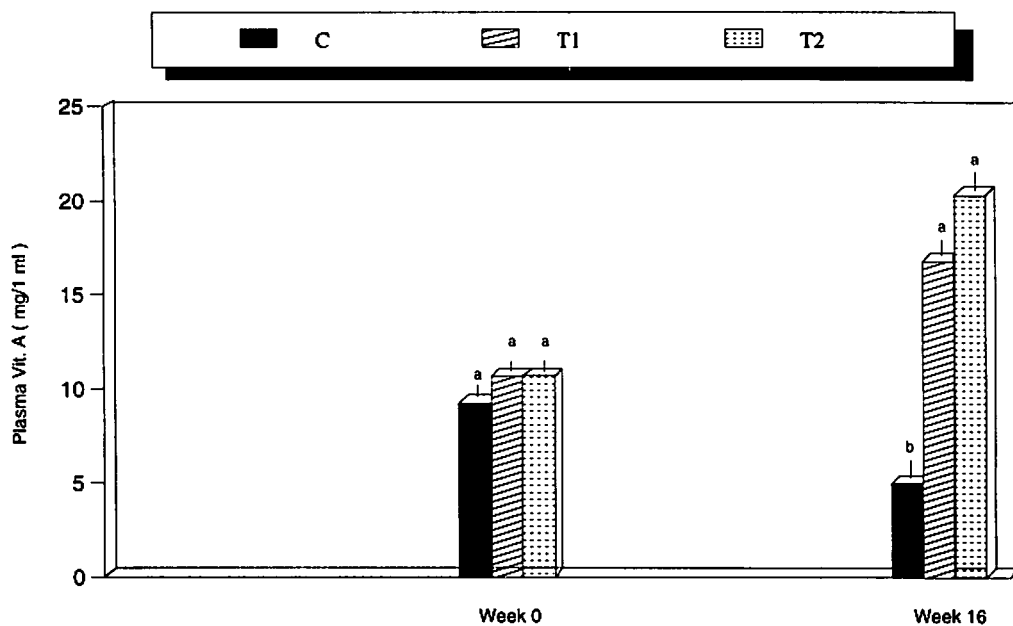


Figure 1. Plasma Vitamin A (X±SE) in ram lambs prior to treatment and at week 16 in Control (C), Treatment 1 (T1), and Treatment 2 (T2). Different superscripts within each trait are significantly different (P <0.05)

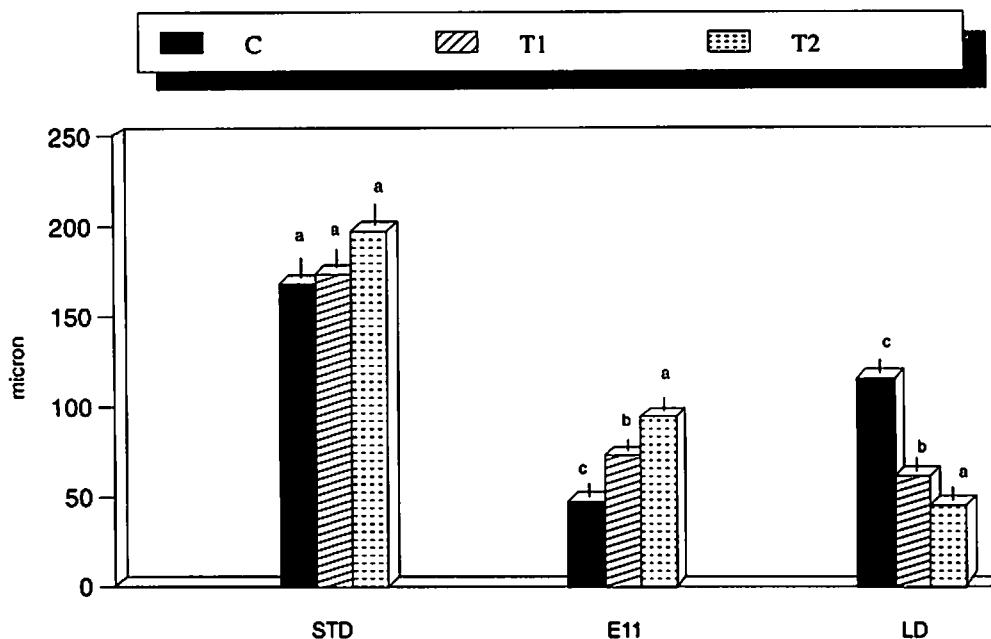


Figure 2. Seminiferous tubule (STD) and Lumen (LD) diameter and epithelial cell height (EH, $X \pm SE$) of ram lambs in Control, (C), Treatment 1 (T1), and Treatment 2 (T2). Different superscripts within each trait are significantly different ($P < 0.05$).

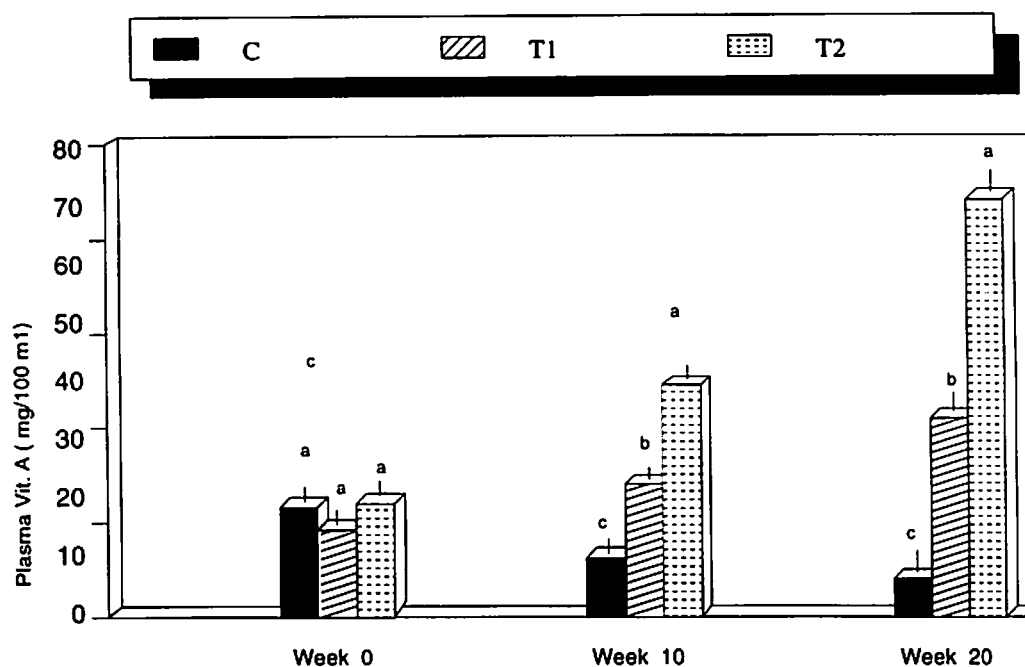


Figure 3. Plasma Vitamin A ($\bar{X} \pm \text{SE}$) in rams prior to treatment and at weeks 0, 10, and 20 in Control (C), Treatment 1 (T1), and Treatment 2 (T2). Different superscripts within each trait are significantly different ($P < .05$).

Experiment 2

All groups had similar plasma vitamin A concentration prior to vitamin A treatment (Fig. 3). Plasma vitamin A dramatically increased ($P < 0.01$) in T1 and T2 over group C at weeks 10 and 20. The concentration was 8.61 ± 1.81 , 20.92 ± 3.64 , 37.66 ± 4.06 $\mu\text{g}/100$ ml (week 10) and 4.02 ± 0.7 , 31.92 ± 1.2 , 69.75 ± 3.5 $\mu\text{g}/100$ ml (week 20) in C, T1, and T2 respectively. Plasma testosterone was not different among treatment groups, being 3.75 ± 2.6 , 3.85 ± 2.9 , and 4.78 ± 2.7 ng/ml in C, T1, and T2, respectively, at week 20.

Vitamin A had influenced ejaculate volume, which was higher ($P < 0.05$) in T1 and T2 than C from week 14 of treatment. Spermatozoa mass activity, as well as individual forward motility (Fig. 4) were higher ($P < 0.01$) from week 13 (mass activity) and week 9 (individual motility) in T1 and T2 than in C. Low individual motility in group C was accompanied by a high dead spermatozoa percentage (Fig. 5), evident from week 9. At week 20, the percentage of dead spermatozoa was similar in T1 ($2.6 \pm 0.12\%$) and in T2 (3 ± 0.57), and both were much lower ($P < 0.01$) than that of group C ($20 \pm 1.9\%$). Low vitamin A in group C also resulted in higher ($P < 0.01$) total abnormal sperms than T1 and T2, starting from week 6. At week 20, sperm abnormalities were $21 \pm 2.33\%$ (C), $2.7 \pm 0.25\%$ (T1), and $2.5 \pm 0.5\%$ (T2) (Fig. 6).

Treatment with vitamin A caused an increase ($P < 0.05$) in sperm concentration ($\times 10^9$)/ml T1 (5.11 ± 0.7) and T2 (5.32 ± 0.66) compared to C (3.69 ± 0.6) on average. The number of sperms per ejaculate ($\times 10^9$) was also higher ($P < 0.05$) in T1 by 52% and in T2 by 62% over C at week 20 (Fig. 7).

Treatment with vitamin A had no clear effect on the chemical properties of semen studied. PH, GOT, GPT, and ALP were affected throughout the experiment, but differences among treatment groups were only significant in certain separated weeks.

Experiment 3

Treatment with vitamin A (AD3E) slightly improved lambing by 8%, twinning by 1.6%, and reduced lamb mortality by 0.8%. There was no difference in the weight of the ewes prior to lambing and lamb birth weight between the control and vitamin A treated groups (Table 1). A comparison between control and treated groups among different flocks at different treatment times showed that reproductive traits such as lambing and twinning percentage were better in flock 2 (injection at 1 July and September) than those of flocks 1 and 3.

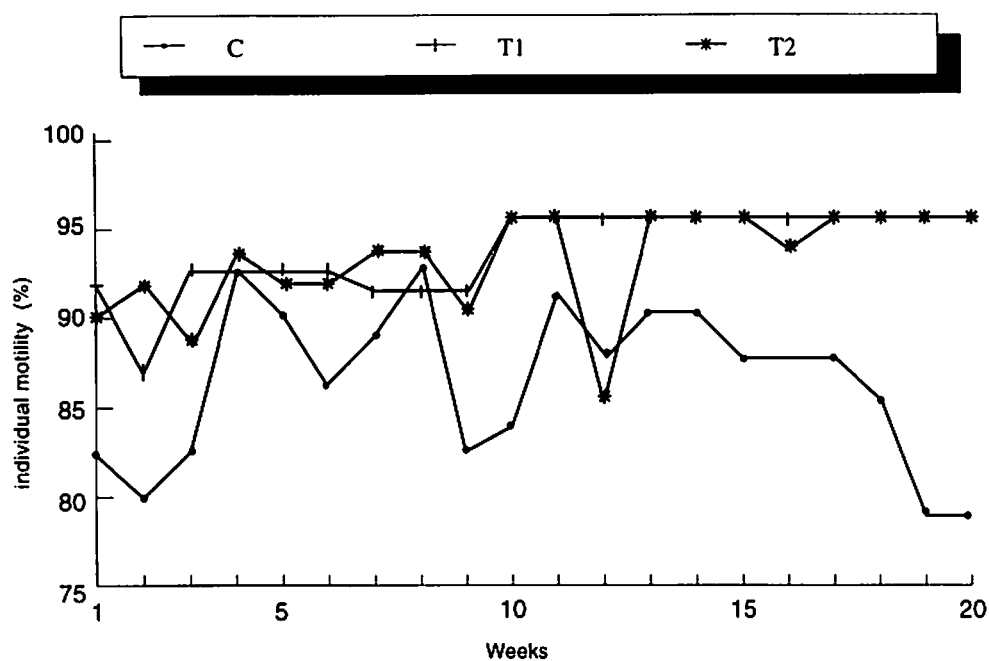


Figure 4. Average individual motility (%) of rams in Control (C), Treatment 1 (T1), and Treatment 2 (T2) over 20 weeks.

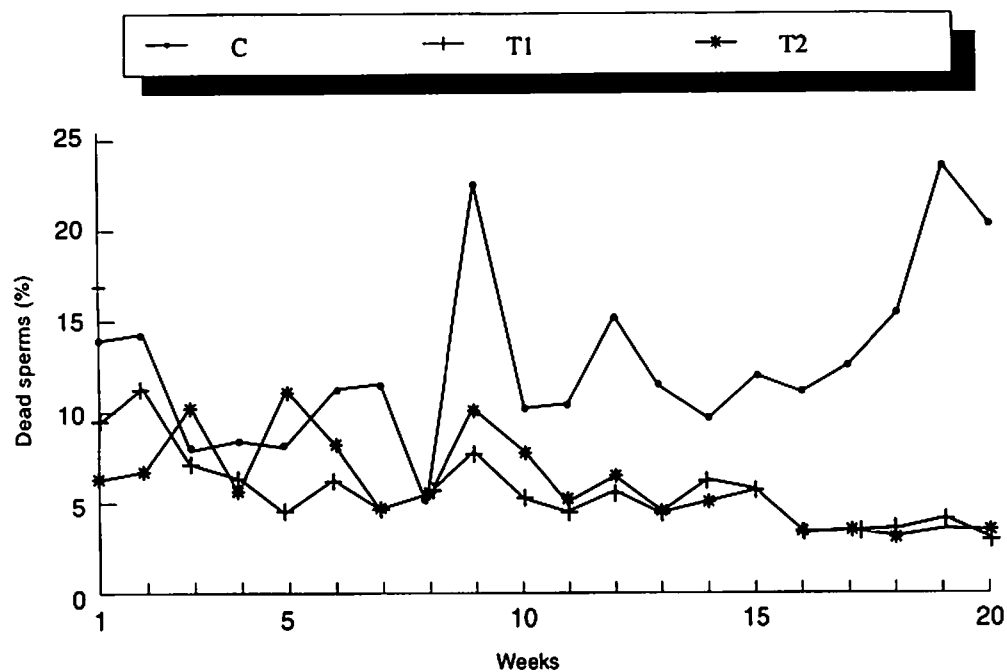


Figure 5. Average dead sperm (%) of rams in Control (C), Treatment 1 (T1), and Treatment 2 (T2) over 20 weeks.

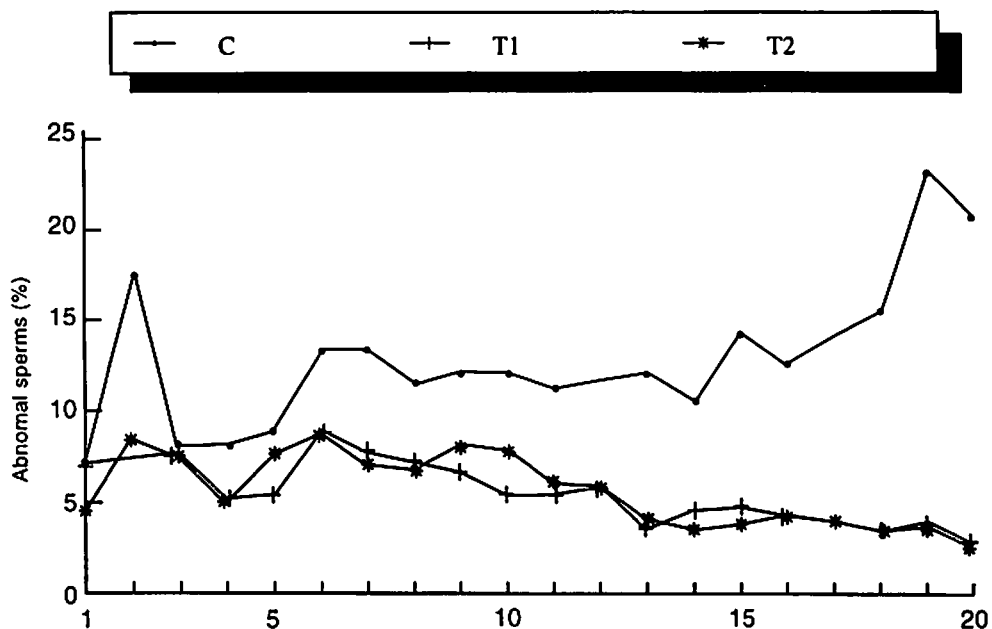


Figure 6. Average abnormal sperm (%) of rams in Control (C), Treatment 1 (T1), and Treatment 2 (T2) over 20 weeks.

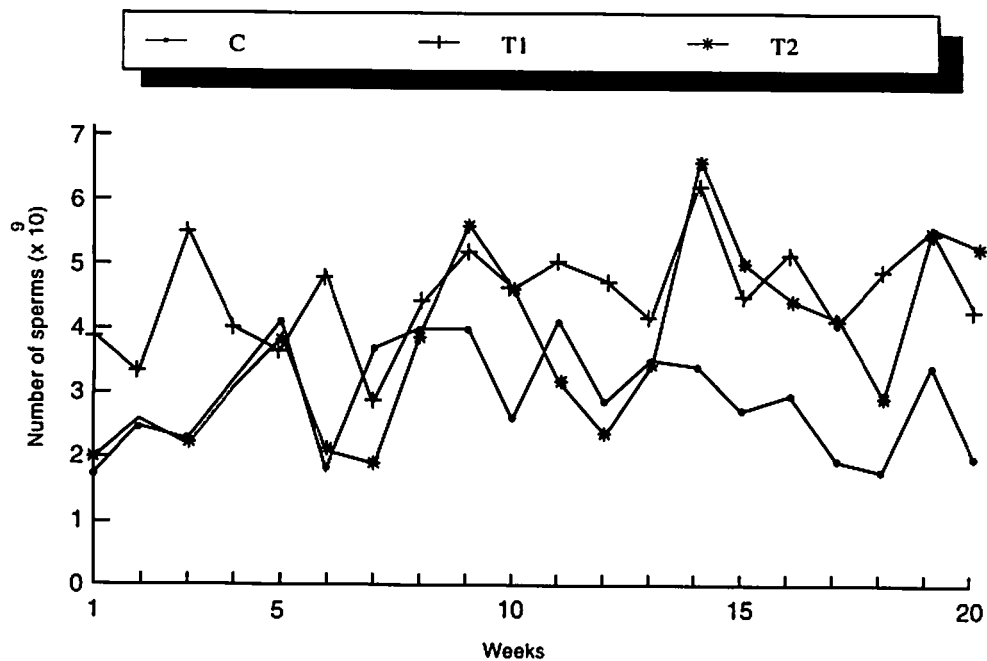


Figure 7. Average number of sperm/ejaculate (X10) of rams in Control (C) Treatment 1 (T1), and Treatment 2 (T2) over 20 weeks.

Table 1. Reproductive traits of sheep flocks treated with Vitamin AD3E.

Flock No.	Control						Treatment					
	No. of ewes	Lambing (%)	Twining (%)	Lamb mortality (%)	Lamb Wt. at birth (kg)	Ewe wt. prior lambing (kg)	No. of ewes	Lambing (%)	Twining (%)	Lamb mortality %	Lamb Wt. at birth (kg)	Ewe wt. prior lambing (kg)
1	50	38	0.0	10.5	3.5	36.9	50	46	0.0	4.3	3.3	37.8
2	50	78	7.7	2.4	3.7	48.3	50	88	11.4	6.1	3.8	47.8
3	50	54	0.0	7.4	3.1	38.9	50	60	0.0	6.7	3.3	37.5
Total or average	150	56.7	2.5	6.7	3.4	41.4	150	64.7	3.8	5.7	3.5	41.0

Injection time: Flock 1, mid June; flock 2, 1st of July; and flock 3, mid July.

Discussion

Results indicate a clear effect of vitamin A on spermatogenesis in ram lambs. The absence of differences in Sertoli cell RW among treatment groups may be due to type and level of vitamin A used. Different vitamin A types have different binding sites on Sertoli cells (Huang et al. 1989). Leydig cell RW was also not different after vitamin A treatment, and this could be a result of the absence of vitamin A binding sites (Rajguru et al. 1982) or the exposure time required to stimulate LH secretion. The increase in spermatogenic cells RW in T1 and T2 indicates the effect of vitamin A on spermatogenesis. The increase in sperm cell RW is supported first by the increase in germinal epithelium cell height as an indication of active spermatogenesis, and by a relatively greater Sertoli cell RW in T1 and T2, whose role in regulating the process of spermatogenesis should not be neglected (Berndtson et al. 1987). Sertoli cells play a role in the synthesis of retinol binding protein, which carries retinol to spermatid and sperm cells (David and Ong 1992).

Vitamin A in germ cells increases gene expression of male germ cell-associated kinase and therefore division rate and sperm production (Wang and Kim 1993). Vitamin A also increases the concentration of mRNA of testis-lipid binding protein at the level of pachytene spermatocyte and spermatid (Schmitt et al. 1994). It is clear, therefore, that a shortage of vitamin A in ram lamb rations for 16 weeks drastically influenced spermatogenesis and the rate of sperm production. Long-term vitamin A shortage in Al-Jezira may influence age at puberty and testicular development of these lambs. A shortage in vitamin A effected semen characteristics drastically in rams. Treatment with vitamin A increased ejaculate volume over that of C starting at week 14. The number of sperms per ejaculate was 53% (T1) and 50% (T2) higher group C. Treatment with vitamin A increased transfer into the epididymal epithelial tissue and then played a role in sperm maturation (Pappas et al. 1993).

Materials added to the sperm in the epididymis are necessary to prevent changes in DNA and chromatin and change the plasma membrane to make the sperm more efficient in using external energy for motility (Amann 1993). This is in line with the finding that sperm-mass activity and forward motility were better in T1 and T2 than in C. The increase in total sperm abnormalities in C affected sperm fertilization ability, especially with advancing time and with the reduction of vitamin A reserves. Erdinc et al. (1987) noticed an increase in abnormal sperm content after short-term deficiencies of vitamin A in both bulls and rams. Changes in the epididymal fluid quality as a result of a vitamin A deficiency would affect sperm DNA transcription and then increase head abnormalities and the percentage of dead sperm (Pappas et al. 1993). An overall increase in dead (59%) and abnormal sperm (64%) in C could result in a lower fertilization rate. Irregular changes in chemical properties of semen may not be a good indicator for vitamin A deficiency in rams. Semen characteristics, such as percentage of normal sperm, deteriorated in C, within only two months after vitamin A shortage in the ration. Lowered ram fertility with advancing time is expected. This is probably the case in Al-Jezira flocks during long and dry periods in the mating season. Vitamin A supplementation could play a role in improving semen quality, quantity, and therefore increasing ram fertility. Since T1 and T2 had similar semen quality; there is no need to use a high level of vitamin A; only 100,000 IU/month is sufficient to improve semen characteristics.

Overall improvement of reproductive traits of ewes raised extensively in dryland areas requires increased use of vitamin A during the mating season. Since information concerning the level of vitamin A in ewes throughout the mating season is not available. Experiment 3 examined the effect of vitamin A administered at different times. Results indicate that using vitamin A supplements at the beginning of July and September gives higher lambing and twinning rates. In fact, this depends on the pasture available prior to the mating season and the amount of vitamin A stored in the liver. However, it is clear from the results that vitamin A improves some reproductive traits, at least slightly. Improvement gained may result in a higher fertilization rate, and a reduction in embryonic mortality and abortion. Reproductive performance can also be improved through the use of vitamin E. Vitamin E is known to improve semen quality and reduce sperm abnormalities in rams (Gokcen and Asti 1985). It also improves fertilization rates and reduces dystocia in ewes (Risimbetov and Amirbekov 1987). Since Experiment 3 used only one level of vitamin A as AD3E, it may be worthwhile to use higher doses to see if there are any additional benefits to lambing and twinning rates.

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Discussion

N. Hassan: Why did you use vitamin A periodically, when it is stored in the liver and one dose at the beginning of the dry season is enough for the whole dry season?

A. Al-Haboby: Vitamin A is usually stored in the liver for about three to four months if sheep are provided with good green pasture prior to the mating season. Under the conditions in Iraq, vitamin A shortages are to be expected, since good green pasture is not available prior to the mating season. Furthermore, vitamin A stored in the liver may be not enough. Therefore, vitamin A treatment is needed not at the beginning of mating season but probably toward the end, at a time when the level of vitamin A is expected to drop.

O. Gursoy: In southeastern Turkey, Awassi do not eat green forage in the mating season. Do you think vitamin A is the only factor affecting low fertility? Also, what is the effect of frequency of semen collection on semen quantity? What is the optimum number of daily collections?

A. Al-Haboby: Regarding your first question, vitamin A is not the only factor influencing fertility. It is one of many factors but under Iraqi conditions we believe that vitamin A treatment could improve the fertility rate. In answer to your second question, we did not measure the effect of semen collection on semen quantity, but it is expected that semen quality would be depressed under a more vigorous

collection regime. Good rams could serve six ewes a day.

H. Nabulsi: Can we use vitamin A in drinking water? And how many days are necessary for vitamin A to have an effect, and how long does that effect last?

A. Al-Haboby: Regarding your first question, it really depends on the system—whether it is extensive or intensive. In the extensive system, such as exists in the drylands of Iraq, during mating season flocks do not return to the barn, so putting vitamin A in the drinking water may be difficult. If farmers understand the procedure and have the facilities, yes, it could be used in the drinking water. Otherwise, injection would be an easy method of treatment.

Drug companies have indicated that vitamin A needs to be administered prior to the mating season. When injected into the muscle, vitamin A goes directly to the blood and is carried to the tissues. Therefore, vitamin A would improve physiological traits and other traits relatively soon after administration. In the doses recommended, vitamin A could last from 2 to 2.5 months.

Question: When you initiated this experiment you assumed there is no shortage of vitamin A. Did you measure the level of vitamin A at the beginning of the experiment?

By injecting vitamin A you increase the fertility of rams. You should have used a higher male/female ratio in your experiment.

A. Al-Haboby: No, vitamin A was not measured prior to the experiment, but the assumption was made on the basis of the low fertility rate of sheep in the dryland areas of Iraq and also on the basis of our experience in the drylands looking at feeding calendars and the kind of grazing available during the mating season. Data presented in Experiment 1 and 2 support the assumption that the level of vitamin A decreased progressively during the mating season.

Vitamin A in Experiments 1 and 2 improved semen quality. Experiment 3 witnessed relatively higher twinning and lambing rates. One of the reasons for the only slight difference may be due the injection of rams, both in control and treated groups (for practical reasons, both are running in the same flock). I believe the conception rate probably improved also in the control group due to the effect of the rams.

Utilization of Barley Stubble by Awassi Sheep

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Abstract

Three experiments were carried out to study the effect of stocking rate and supplementation on removal patterns of head, leaf, and stem and on intake of metabolizable energy and crude protein for sheep grazing stubble for 28 days. Removal of stubble fraction was estimated by cutting samples to ground level on days 0, 2, 4, 6, 8, 13, 23, and 28 using a quadrat (4.25 × 0.47 m). Before grazing there was approximately 1.1 t DM/ha (5% heads, 50% leaf, and 45% stem). Heads were always selected in the early days on a new area. Total intake decreased rapidly throughout the period. In experiment 1, stocking rates of 20, 40, and 60 wethers/ha resulted in mean metabolizable energy intakes of 10.3, 7.8, and 5.6 MJ/day and live weight changes over 30 days of +0.3, -2.1, and -3.2 kg. Experiment 2 compared supplements of 0 and 200 g/day of barley or cotton seed. Experiment 3 compared supplements of 0, 150, and 300 g/day of barley or 160 or 320 g/day of a 65:35 mixture of barley and cotton seed at stocking rates of 20 and 40 ewes/ha. Supplements of barley depressed intake of stubble, especially in the first week on a new area. Supplements—particularly cotton seed and barley/cotton seed mixture—increased weight gain, especially at lower stocking rates.

Introduction

In the Mediterranean basin, livestock production and crop farming have always been integrated. Cereal stubble and straw are important feed resources, not only for animals based in the areas where crops are grown, but also for the very large numbers of animals, mainly small ruminants, that utilize the natural pastures of the drier steppe. In the last 40 years, degradation of steppe vegetation in most parts of the Mediterranean basin has increased dependence of livestock production on feeds produced in cropping zones (for Algerian examples, see Boutonnet 1989).

In most small ruminant systems in the Mediterranean basin, the period in summer when stubble is available for grazing coincides with mating and/or pregnancy in the flocks. As nutrition before mating and in the first month of pregnancy can have a major effect on the fertility and prolificacy of the flock, it is possible that nutrition during stubble grazing has an important effect on flock performance during the whole year. The start of stubble grazing generally results in a major improvement in nutrition, leading to an increase in oestrus activity in breeds that, although not inherently seasonally anoestrus, often have a period of anoestrus in spring and early summer as a result of lactation, poor nutrition, or low body weight.

In spite of the long tradition of grazing stubble, and its importance as a source of nutrients at a critical time of year, very little research has been carried out to examine the practice or to measure the response to supplementation. This contrasts with the enormous number of studies on all aspects of the intake of harvested straw. Most of the research relates to the grazing of wheat stubble, and only three references, by Valderrábano (1991) and Caballero et al. (1992) in Spain, and Mulholland et al. (1976) in Australia, relate to barley stubble.

Area of Stubble

Table 1 details the harvested area of all cereal crops and barley in 1992 in the countries of the Mediterranean basin and West Asia (FAO 1993). Barley is grown in these countries almost exclusively under dryland cultivation. It comprises 35% of the cereal area in North Africa, 23% in West Asia, and 25% in the European countries to the north of the Mediterranean, and more than 50% of the cereal area in Libya (66%), Jordan (55%), Syria (61%), and Spain (55%).

Table 1. Area (000 ha) of cereal crops and barley harvested in 1992 in the Mediterranean Basin and west Asia (FAO 1993).

North Africa	Total cereals	Barley	West Asia	Total cereals	Barley	Europe	Total cereals	Barley
Algeria	3,182	1,300	Iran	9,898	2,650	Albania	215	10
Egypt	2,505	104	Iraq	2,050	900	France	9,273	1,799
Libya	453	300	Jordan	159	88	Greece	1,407	171
Morocco	5,022	2,233	Pakistan	11,521	152	Italy	4,216	450
Tunisia	1,442	477	Syria	3,724	2,266	Portugal	854	71
			Turkey	13,493	3,400	Spain	7,366	4,021
						ex-Yugoslavia	3,624	234
Total	12,604	4,414	Total	40,845	9,456	Total	26,955	6,756

Estimates of the Quantity and Quality of Barley Stubble

Variations in the amount and quality of stubble before grazing result from the effects of many factors that occur in the cereal crop before and during harvesting, and in the period between harvesting and grazing. These factors include:

Pre-harvest

- Soil fertility and fertilizer use.
- Seed rate/plant density.
- Rainfall.
- Herbicides, which have a major effect on weed content.
- Timing of harvest can have a major effect on the grain content of the stubble if delayed or if rainstorms occur when the crop is ripe.

Harvesting process

- Cutting height has a major effect, as it can vary from 0 (hand pulled) to >45 cm if only the heads are harvested
- Removal of cut straw for winter feed or other uses.
- Efficiency of the harvester.
- With combine harvesting the skill of the driver and the adjustment of the machine have a major impact on the amount of grain returned to the stubble

After harvest

- Rainfall affects the growth of weeds and germination of grain; movement of machinery or of animals causes breaking of stems, resulting in straw being trodden into the soil or blown away.

Table 2 gives published post harvest quantities for straw, grain, and green or weed material in barley, wheat, and oat stubble. Information on digestibility, crude protein (CP) and ash (Table 3) is available from Caballero et al. (1992) for straw and grain of barley and wheat stubble. Total biomass of barley, oat, and wheat stubble in the third year is available from Mulholland et al. (1976). These very limited data indicate small differences in initial composition between stubble of different cereal species. Caballero et al. (1992) found slightly higher protein and ash content in barley straw, but digestibility was slightly higher in wheat straw. Mulholland et al. (1976) also show a higher protein content, higher digestibility, and lower ash in barley stubble than in wheat stubble. Oat stubble was similar to barley in protein content, but had higher ash content and digestibility.

Table 2. Biomass of barley stubble before grazing in Spain and Australia.

Reference	Species	Height (cm)	Straw (kg DM/ha)	Grain (kg DM/ha)	Green (kg DM/ha)
Valderrábano (1991) Spain	Barley	14–18	11,830	1300	11,240
	6 rowed		D 1,260	D 155	D 40
	Barley	14–18	11,525	185	1235
	2 rowed		D 985	D 105	D 115
	Wheat	14–18	12,340	135	1160
Caballero et al. (1992) Spain			D 890	D 20	D 25
	Barley	16	2,100 ²	110	
		?	2,400	360	
Mulholland et al. (1976) Australia	Wheat	14	1,640	160	
	Wheat	c. 45	3,200 ¹		1,500
			4,250		1,500
	Barley	c. 45	3,500		900
			5,000		650
	Oats	c. 45	4,800		400
			5,000		500
			5,500		250

I = irrigated; D = dryland.

¹ Data for different years.

Table 3. Composition of barley stubble before grazing.

	Crude Protein g/kg DM	Ash g/kg DM	Digestibility g/kg
Caballero et al. (1992)			
Barley straw	65	126	261 [†]
Barley grain	131	33	902
Wheat straw	58	107	313
Wheat grain	112	31	912
Mulholland et al. (1976)			
Barley	70	150	332 [‡]
Oats	70	189	342
Wheat	61	161	291

[†] Digestible dry matter.

[‡] Digestible organic matter

Selection of Diet Components

Most experiments show that at the start of grazing a new stubble area, sheep select either green or weed material, or grain. Mulholland et al. (1976) found very intense selection for green material in all three years on oat, barley, and wheat stubble. When there is more than 40 kg DM/ha of green material in the stubble, the diet consists of 80% green material. Even when there is a lower amount of green material, the diet had a mean of 40% (80–85%) green material. Valderrábano (1991) found almost all the heads are removed in the initial period of grazing (1–3 weeks). There is also selection of green material, except where unpalatable or toxic weeds were present, and, initially, complete rejection of straw.

Intake by Sheep Grazing Barley Stubble

The intake of unsupplemented sheep on wheat stubble varied widely, and there appears to be little relation between intake and stubble characteristics. Some of these differences almost certainly result from inaccuracies in the method used to estimate intake.

Mulholland et al. (1976) found no effect of cereal species on intake with 5–17 month-old sheep initially weighing 24–36 kg, as intake was largely green material. Mean intakes were 405, 440, and 435 g DOM/day on oat, barley, and wheat stubble, respectively. There were significant differences in intake between stocking rates of 26–30 and 13–15 sheep/ha (355 vs 500g DOM/day) and between treatments on weedy and clean stubble in the third experiment (470 vs 400 g DOM/day). Cabellero et al. (1992) found a mean intake of 1,110 g DM/day by Manchega ewes weighing 57 kg at lambing, based on six samplings at the start and finish of grazing barley, wheat, and barley/vetch stubble, from which oesophageal fistula samples with a mean DDM of 542 g/kg DM had been collected.

Effects of Supplementation

Experiments have examined the response of sheep grazing stubble, mainly wheat, to two types of supplement: conventional feed, such as cereals, legume grains, hay,

etc., and mineral blocks, urea blocks, urea/molasses licks, etc. In general, where the effect of supplements on stubble intake was measured, the results were difficult to interpret. Only the live weight response will be considered here.

Conventional feed

Butler (1981) found that 40 kg 4 year old wethers grazing weed-free wheat stubble for three months supplemented with lupin seed (100 g/day), a urea/molasses block, or with urea and sulfur in the drinking water, lost weight: 0.5 kg on the lupin supplement, 1 kg on the urea/molasses block, which was not initially eaten, and approximately 4 kg in the control and urea/sulfur groups. In a comparison of lupin seed, oat, and barley, fed twice weekly at five levels in 150 g/day increments between 150 and 750 g/day to 29 kg wethers grazing wheat stubble, Rowe et al. (1989) reports a loss of 1.5 kg by the control group, and small gains or losses by the supplemented groups in the first six weeks. Thereafter, gains in supplemented groups were greatly affected by the level offered, with predicted daily gains of 260, 175, and 235 g per kg of supplement/day for the lupin, oat, and barley supplements, respectively. Predicted gains of 390, 310, and 135 g per kg of supplement/day for the lupin, pea, and wheat supplements, respectively, were found for 29 kg sheep on wheat stubble by Morecombe and Ferguson (1990)

In Morocco, Guessous et al. (1991) examined the response to supplements of 200 g/day of sunflower meal (S) in weeks 5–8 and 200 g/day of S or 200 g/day of S plus 200 g/day of barley (S+B) in weeks 9–12. In weeks 1–4 the sheep gained approximately 1 kg, in weeks 5–8 unsupplemented controls lost 2.1 kg and the supplemented group maintained weight, although the differences were not significant. In weeks 9–12 the weight changes were -1.5, 1.2, and 2.3 kg for C, S, and S+B, respectively. Outmani et al. (1991) found that in weeks 4–10 at 24 ewes/ha, supplementation with approximately 250 g/day of alfalfa hay at night resulted in a small gain of 0.4 kg compared to a loss of 2.1 kg in unsupplemented ewes.

Response to urea, minerals, and molasses blocks and licks

All investigations of blocks and licks containing urea, minerals, and molasses found that low intake or complete rejection occurred in the first 4–6 weeks of feeding, and that coefficients of variation of intake were high, ranging from 40 to 100% (Mulholland and Coombe 1979; Coombe and Mulholland 1983). Blocks were generally more readily accepted. This problem obviously makes interpretation of the effect of these supplements on stubble intake difficult.

Mulholland and Coombe (1979) found significant differences in final weights between unsupplemented sheep and those offered a mineral/urea block and a molasses lick, as a result of reductions in the rate of weight loss after the first six weeks of grazing. Urea/molasses blocks, after low initial intake, reduced the loss of weight to 1 kg compared to 4 kg in ewes without supplement or with urea and minerals in drinking water (Butler 1981). Coombe and Mulholland (1983) found that various urea and molasses supplements had little effect on stubble intake. Using a urea/molasses lick resulted in maintenance rather than losses of 6, 2, and 4 kg in sheep without supplement, or offered a molasses lick or a urea/mineral block, respectively.

Studies of Stubble Grazing at ICARDA

In 1991 a new program of research on grazing of barley stubble was started in ICARDA. The program consisted of:

- A small survey of the practice of stubble grazing on farms in northern Syria.
- Studies of a quadrat technique to estimate intake over short periods.
- Experiments in three successive years.

Field study of stubble grazing

Thirty nine farmers in northern and eastern Syria were interviewed to discover how they grazed stubble to help define some of the management decisions in subsequent experimentation (ICARDA, 1992). The main results were:

- Farmers who had a mean flock size of 170 ewes grazed stubble for a mean of 97 days (15–160 days).
- They preferred to graze barley stubble, although 13% of farmers stated that some varieties of wheat were palatable and could be grazed successfully by sheep.
- The mean duration of grazing was 12.5 h/day (8–16 h/day)
- Supplementation with other feeds was very rare, as stubble grazing was considered a period of plentiful feed.
- The combine harvester cutting height varied from 10 to 20 cm.

Method of estimating intake

It was clear from previous observations of stubble grazing that the sheep would initially select the head and leaf fractions, and that these fractions would rapidly change in mass if the stocking rates were high. These factors made the experiment unsuitable for estimating intake based on measurements of fecal output, using the chromic oxide dilution technique or total collection, and on digestibility of the diet, using oesophageal fistulated sheep or hand plucked samples. This method requires stable intake for a period of at least 10 days to give accurate estimates.

As rain rarely occurs in Syria before the end of October, it was highly unlikely that the composition of stubble would alter during the grazing period, except as a result of removal of material by the sheep. It was, therefore, decided to use a quadrat sampling technique to estimate the removal rate of particular fractions and the intake of nutrients.

Examination of the stubble suggested that a quadrat of the same size as the cutting width of the combine harvester (4.25 m) placed at right angles to the direction of the combine cut would result in a systematic sampling of all stubble fractions. A comparison among 30 samples, cut using quadrats of 1.0 × 1.0 m (S), used in earlier studies, and 4.25 × 0.47 m (R) showed a large reduction in coefficient of variation from 23% with S to 9% with R. The total biomass means were 1.88 ± 0.80 (range 1.20–2.81) and 1.22 ± 0.20 (1.06–1.54) t/ha for S and R, respectively.

Removal of head, leaf, and stem during grazing was estimated by cutting 10 (reduced to 5 in experiments 2 and 3) quadrats to ground level on days 0, 3, 5, 7, 9, 14, 19, 24, and 29 of each grazing period. The material was separated into head, leaf, and stem. Intake was estimated by analyzing the three fractions for *in vitro* digestibility and crude protein. Metabolizable energy (ME) was calculated as $0.15 \times \text{DOMD percent}$. Daily intake of ME and CP was calculated for successive periods as the difference between successive samplings divided by the number of days and the number of sheep.

Experimentation

Three experiments involving the local landrace Arabi abiad were carried out on barley stubble cut by combine at a height of approximately 10 cm. Mean biomass before grazing was 1,110, 1,215, and 1,140 kg in Experiments 1, 2 and 3, respectively. All sheep were given adequate mineral supplementation.

Experiment 1: Effect of Stocking Rate on the Intake of Stubble Fractions

Objectives

- To record the pattern of removal of head, leaf, and stem from stubble.
- To measure ME and CP intake as a stubble is grazed down.

Design

- Stocking rates (SR) of 20, 40, and 60 sheep/ha applied in three successive periods of 28 days.

Material and methods

- Two-year-old Awassi wethers, initial weight 55 kg.
- Grazed from 06:30 to 11:30, returned to yards for watering and then grazed again from 13:30 until 18:00.

Results

- There was a clear effect of SR on the removal of stubble fractions (Fig. 1).

Heads were removed in the first 6–8 days on a new area of stubble, and contributed 4–6%, 6–8%, and 12–14% of the 28 day intake of DM, ME, and CP, respectively (Table 4). Leaves were then preferred until the amount of leaf present on the stubble was low. Leaf comprised 68% of the total DM intake at SR 20 and approximately 55% at SRs 40 and 60. Total intake of ME declined from 2–2.5 times maintenance (M) in days 1–4 to approximately 0.5, 0.25, and 0.13 M in days 23–28 at SRs 20, 40, and 60, respectively. The stubble was almost completely utilized. The wethers maintained weight at SR 20 (mean of +0.3 kg in 28 days) and made substantial losses at SRs 40 and 60 (-2.1 and -3.2 kg).

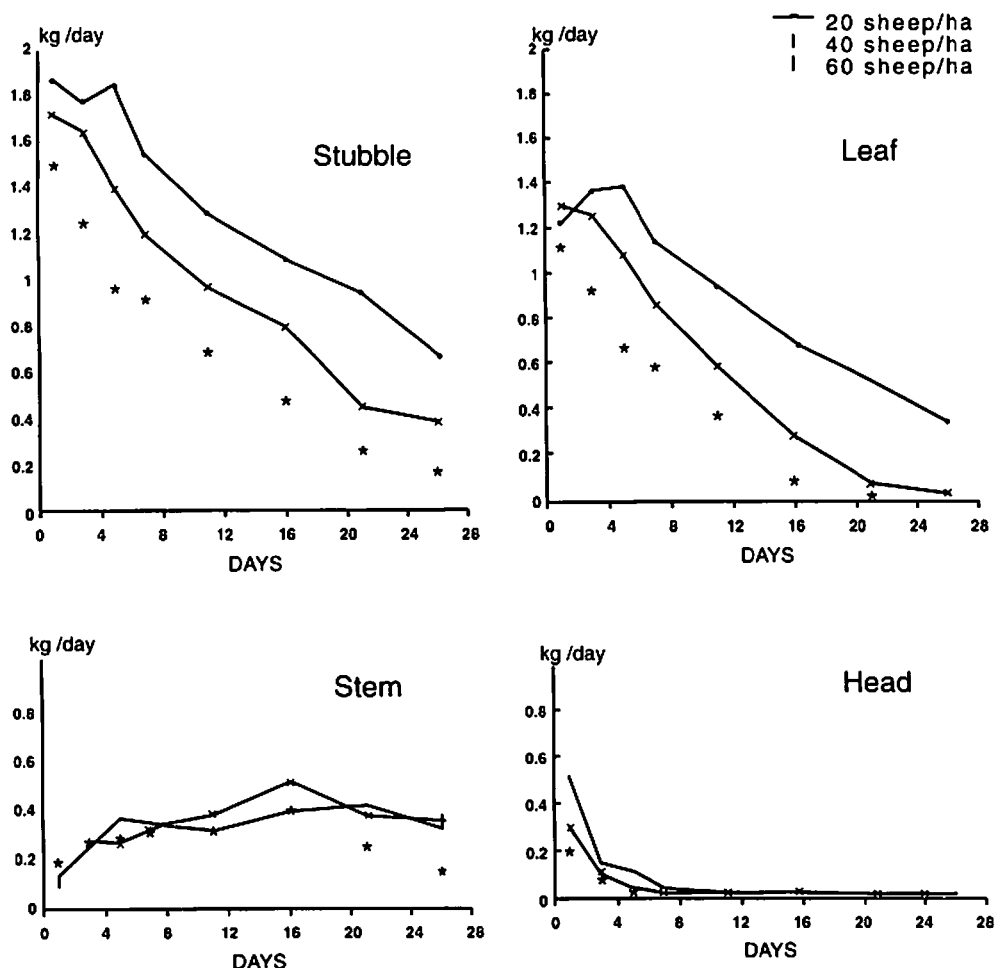


Figure 1. Daily removal (kg/sheep) of barley stubble and of head, leaf, and stem fractions.

Table 4. Experiment 1: Mean daily intakes of stubble DM, ME and CP and initial weight and weight change.

Stocking rate (ewes/ha)	20	40	60	Signif- icance
Mean intake of DM (kg)	1.06 (6:68:24) [†]	0.79 (4:56:40)	0.55 (4:53:43)	***
Intake of ME (MJ)				
Mean	8.7 (8:68:24)	6.0 (6:62:32)	4.1 (6:59:35)	***
Days 1-4	15.2	15.0	11.9	ns
Days 23-28	4.6	1.7	0.7	***
Intake of CP (g)	43 (14:75:11)	26 (12:73:15)	17 (12:71:17)	***
Initial weight (kg)	54.8	53.9	55.0	ns
Mean weight change (kg)	0.3	-2.1	-3.2	***

[†]Proportion of total intake from heads, leaf, and stem.

Experiment 2: Effect of Stocking Rate and Supplementation on Intake of Stubble Fractions

Objectives

To assess the effect of stocking rate and supplementation on:

- The pattern of removal of head, leaf and stem.
- ME and CP intake.
- The live weight changes of ewes during mating and early pregnancy

Design

- 2×3 factorial .
- Stocking rates of 20 and 40 ewes/ha applied in three successive periods of 28 days.
- Supplementation, fed to individually yoked sheep in the evening.
- No supplement.
- 200 g/day of cotton seed meal (CSM), estimated to provide 2.2 MJ of ME and 67 g CP.
- 200 g/day of barley (B), estimated to provide 2.7 MJ of ME and 20 g CP.

Material and methods

- 1.5 year old Awassi ewes, initial weight 42 kg.
- Grazing from 6:45 to 12:30, removed to a paddock for watering and then grazed again from 13:30 until 18:00.
- From the start of the second grazing period, two rams were kept with the ewes during the night.

Results

Supplementation with barley significantly reduced the intake of heads until day 13, and of total stubble in days 1–4, but not over the whole 28 days, as the total intake was higher later in the period. Supplementation with CSM increased the stem intake, but the effect was only significant when expressed as ME with mean stem ME intakes in 28 days of 2.71, 2.02, and 2.03 MJ/day for CSM, B, and none, respectively. Over the whole 28 days mean intakes of DM, ME, and CP were not affected by supplementation (Table 5). In spite of the small difference in nutrient intake from stubble, supplementation had large and significant effects on live-weight gain. The barley supplement increased weight by approximately 3kg from 0.1 to 2.9 kg and from -1.7 to 1.5 at SRs 20 and 40, respectively. The CSM supplement further increased gains to 4.4 and 2.2 kg at SRs 20 and 40.

Table 5. Experiment 2: Mean daily stubble intake of DM, ME, and CP and initial weight and weight change.

Stocking rate (ewes/ha)	20			40			Significance	
Supplement	CSM	B	None	CSM	B	None	SR	Supp
Mean intake of DM (kg)	1.19 (5:58:37) [†]	1.14 (6:59:35)	1.09 (7:61:32)	0.93 (4:56:40)	0.85 (6:61:33)	0.82 (4:67:29)	***	ns
Intake of ME (MJ)								
Mean	10.0 (8:64:28)	9.2 (10:64:26)	9.3 (9:67:24)	6.4 (7:63:30)	5.9 (7:67:25)	6.2 (8:70:23)	***	ns
Days 1-4	16.9	8.9	14.8	11.7	10.1	13.4	*	**
Days 23-28	4.9	5.0	3.1	1.7	2.0	1.8	***	ns
Mean intake of CP (g)	46 (16:69:15)	48 (18:69:13)	49 (18:69:13)	31 (13:71:16)	28 (16:71:13)	31 (14:75:12)	***	ns
Initial weight (kg)	43.0	41.8	40.9	43.0	42.0	43.5	ns	ns
Weight change (kg)	4.4	2.9	0.1	2.2	1.5	-1.7	***	***
Days to become pregnant	30.1	40.5	36.0	42.2	28.8	66.4 [‡]	***	**

[†] Proportion of total intake from heads, leaf and stem.[‡] Mean of 6 ewes, as 2 ewes failed to become pregnant.

As in the previous experiment, stocking rate had a significant effect on intakes DM, ME, and CP, and on live weight change. Nutrient intake and live weight change for unsupplemented sheep were similar to those in the previous experiment.

Both SR and supplementation affected the mean number of days that the ewes took to become pregnant. This was very much delayed in the unsupplemented ewes at the higher SR, which included two ewes that failed to get in lamb.

Experiment 3: Effects of Stocking Rate and of Level and Type of Supplement on the Removal of Different Stubble Fractions

Objectives

To assess the effect of stocking rate and supplementation on:

- The pattern of removal of head, leaf, and stem.
- ME and CP intake.
- The live weight changes of ewes during mating and early pregnancy.

Design

- $2 \times 3 \times 2$ factorial with two replications.
- Stocking rates of 20 and 40 sheep/ha in two successive periods of 28 days.
- Supplementation with two diets at two levels of intake, fed to individually yoked sheep in the evening.
- No supplement.
- 300 and 150 g/day of barley (300B and 150B), estimated to provide 3.6 and 1.8 MJ of ME and 27.0 and 13.5 g CP, respectively.
- 320 and 160 g/day of a mixture of 65% barley and 35% cotton seed meal (320M and 160M), estimated to provide 3.6 and 1.8 MJ of ME and 54 and 27 g CP, respectively.

Material and Methods

- 1.5 year-old Awassi ewes, initial weight 40 kg
- Grazed from 6:30 to 11:30, returned to yards for watering until 13:30 and then grazed until 18:00.

Results

Supplementation had significant effects on the intake of stubble in all periods, but as intake was initially depressed in days 1–6 and subsequently increased by feed

supplements, the mean intake over 28 days was not significantly different between treatments. Stem intake was affected by supplementation but, in contrast to Experiment 2, intake was higher with the barley supplement. In spite of the lack of significant effects of supplements on the total intake of stubble DM, ME, or CP, supplementation had a large effect on weight change (Table 6). As in the previous experiments, there were significant effects of SR on intake of stubble and live weight change. The mean number of days for the ewes to become pregnant was affected by both SR and supplementation.

Table 6. Experiment 3. Mean daily intakes of stubble DM, ME and CP and initial weight and weight change.

Stocking rate (ewes/ha)		20				
Supplement	M320	M160	B300	B150	None	
Mean intake of DM (kg)	1.09 (7:61:32) [†]	1.09 (7:59:34)	1.19 (6:55:39)	1.14 (7:54:39)	1.15 (7:62:31)	
Intake of ME (MJ)						
Mean	11.2 (9:62:29)	11.1 (9:62:29)	11.6 (8:58:34)	11.4 (7:63:30)	10.9 (8:63:29)	
Days 1-4	21.3	23.2	15.1	22.3	17.4	
Days 23-28	6.8	6.4	6.6	5.9	5.8	
Mean intake of CP (g)	42 (18:68:14)	40 (19:66:15)	42 (18:64:18)	41 (21:61:18)	48 (17:68:15)	
Initial weight (kg)	40.1	39.8	39.9	38.5	38.4	
Mean weight change (kg)	8.1	6.1	4.9	2.6	0.6	
Days to become pregnant	12	17	23	35	42	

Stocking rate (ewes/ha)		40					Significance	
Supplement	M320	M160	B300	B150	None		SR	Supp
Mean intake of DM (kg)	0.85 (4:62:34)	0.85 (5:60:35)	0.93 (3:56:41)	0.92 (5:59:36)	0.87 (5:61:34)		***	ns
Intake of ME (MJ)								
Mean	6.8 (7:66:27)	6.8 (7:67:26)	7.6 (6:63:31)	7.6 (6:65:29)	7.3 (6:65:29)		***	ns
Days 1-4	13.7	13.4	11.9	16.3	16.4		*	ns
Days 23-28	2.3	2.6	3.4	2.6	2.8		***	ns
Mean intake of CP (g)	25 (14:69:17)	25 (15:69:16)	28 (14:67:19)	30 (15:70:15)	27 (14:70:16)		***	ns
Initial weight (kg)	40.6	41.1	40.6	40.3	40.1		ns	ns
Mean weight change (kg)	4.1	1.9	0.9	0.3	-1.2		***	***
Days to become pregnant	27	33	42	48	46		***	***

[†] Proportion of total intake from heads, leaf and stem.

Conclusions

The results of these experiments show that, where there is no rain in the grazing period, the patterns of removal of the different stubble fractions can be described using frequent sampling with a quadrat the same length as the combine cutting width, which allows systematic sampling of all material on the stubble.

The experiments show clear patterns in the removal of different fractions from the stubble by the grazing sheep. Heads were selected first and removed in the first 4–8 days of grazing. Intake of stem increases when most of the leaf has been removed. The mean contributions of head, leaf, and stem to total DM intake on the unsupplemented treatments in the three experiments were 7, 64, and 29% at SR 20 and 5, 61, and 34% at SR 40.

Supplementation with barley decreased intake in the first 4–6 days on a new area of stubble but, as intake was subsequently higher, total intake of stubble DM in 28 days was not significantly affected. Intake of stem was increased by supplementation with CSM in Experiment 2, but not by the supplement with a higher protein content in Experiment 3. Supplements, especially those with higher protein content, had a large effect on live weight change and on the number of days taken for the ewes to become pregnant. More experimentation is needed to obtain a clear understanding of the effect of different types and levels of supplementation on stubble intake by sheep, and on their performance.

In view of the importance of stubble as a source of feed in small ruminant systems in west Asia, there is a clear need not only for more research on the grazing of barley stubble but also for similar work on wheat stubble under dryland farming conditions.

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Discussion

A. Al-Haboby, M. Hadjipanayiotou: Based on your experience, experimental work and on the limited literature available, are you in a position to prepare guidelines for when to start supplementation, stocking rates, and type and levels of supplements? And if not, is it worthwhile to conduct further work?

T. Treacher: When analysis of the data is completed, we should have a clear idea of how much leaf and stem is present on the stubble when intake is severely limited. This will give a good indication of the point at which supplementation should be used to prevent major weight losses. More information is needed on the response to supplementation with non-protein sources in feed blocks. However, more work is needed on all aspects of stubble grazing in view of the importance of this feed source in the region for three to five months of the year.

A. Salman: What is the best time to feed supplement to ewes during stubble grazing?

T. Treacher: There can be no universal answer. The results of these three experiments suggest there is little value in supplementing in the first few days on a new area of stubble when intake of energy is more than twice that of maintenance. After that, the time at which to supplement will depend on the stocking rate.

A. Lahloh-Kassi: You observed a strong effect of supplementation on number of days open, and especially a very short-term effect. This short-term effect would be due to the nature and quality of the energy you have used as a supplement.

T. Treacher: The results show the effect of barley and supplement with higher protein contents on weight change and number of days to conceive. The response was greater with supplements containing higher levels of protein.

Browse Foliage and Annual Legume Pods as Supplements to Wheat Straw for Sheep

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Abstract

Cereal stubble and straw are widely used as animal feed for sheep in arid areas of Morocco. Their low protein concentration limits their intake and, therefore, their production potential. A 15-week feeding trial was conducted to investigate the effect of supplementation with browse foliage or medic pods (*Medicago* spp.) on wheat straw (*Triticum aestivum*) intake and ewe lamb live weight. Diets were wheat straw (WS), WS plus alfalfa (*Medicago sativa*) hay (AH), WS plus oldman saltbush (*Atriplex nummularia*) foliage (AN), WS plus blue wattle (*Acacia cyanophylla*) foliage (AC), and WS plus medic pods (MP). Alfalfa and urea feeding levels were set to provide a crude protein concentration of 90 g/kg DM in the diet. Shrub foliage and medic pods were offered *ad libitum*. Atriplex and acacia foliage supplementation resulted in the highest and lowest increases in straw intake, respectively. Animals supplemented with atriplex maintained weight and those supplemented with medic showed a slight weight loss.

These results show that foliage from palatable shrubs and medic pods can be effective protein supplements for livestock consuming wheat straw. Implementing such strategies requires farmers to plant saltbush shrubs and manage medic pasture to produce enough pods to be grazed in summer.

Introduction

In Morocco, there is approximately 8 million ha of arable land, half of which is used for the cultivation of cereals. About 25% of the total arable land is left fallow or uncultivated, and is used for grazing. Rangeland makes up about 20% of the 71 million ha total land area of Morocco.

Wheat (*Triticum aestivum*) and barley (*Hordeum vulgare*) are the major cereal crops grown in the rainfed farming areas, where sheep are an important component of the mixed crop-livestock system. Seventy percent of the 16.3 million head (MAMVA 1994) are in rainfed cereal producing zones, with half in the arid and semi-arid areas (400 mm rainfall year). The mating season usually coincides with the grain harvest. After the harvest, in May and June, sheep graze cereal stubble until the start of the rainy season in October or November. This usually

coincides with the gestation period of ewes. During late gestation and until the start of the grazing season, cereal straw is the major component of the diet. Low birth weight, high lamb mortality, and slow lamb growth are very common now (Ismaili 1983; Bouhafra 1987; Guessous et al. 1987; Outmani et al. 1991; Guessous et al. 1991). Low animal performance in these areas is mainly due to the protein and energy deficiencies in available forages.

Moroccan cereal straws are deficient in soluble N, minerals, and lipids (Benata 1977; McCann 1985). There is a considerable amount of literature on the nutritive value of cereal straw and its fluctuations with the level and nature of supplementation (O'Donovan 1983). It is important, therefore, to maximize this nutritional value. This can be achieved by adding protein-rich feedstuffs to the diet or by chemical treatment (Preston and Leng 1984).

Annual medics (*Medicago* spp.), which are self-seeding annual forage legumes and need no water beyond normal rainfall, have been introduced to fallow areas in rotation with cereal crops to provide forage of high nutritive value and to provide the subsequent cereal crop with residual N. When properly managed, the medic pasture provides good quality forage during the growing season and can also be grazed in the summer after the plants have produced seed and died. The available forage at this time is dominated by medic pods of high N concentration which could be used to supplement cereal stubble. This practice could potentially improve the body condition, fertility, and lambing percentage of ewes (Thomson and Bahhady 1988). Depending on species, CP concentration of the pod ranges from 150 to 240 g/kg DM (Franklin and Powning 1942; Denney et al. 1979). The establishment of pastures containing herbaceous legumes, however, was not a success in the arid and semi-arid regions of Morocco (Christiansen and Boulanouar 1993).

Forage shrubs such as oldman saltbush and blue wattle have been shown to be adaptable and ecologically more appropriate for these areas (Arif 1992). The foliage of these fast-growing browse species has a similar composition to herbaceous legumes and can be expected to have a similar supplementary role.

Compared with dry grass and forbs at an advanced stage of maturity, browse species have the highest concentrations of CP, P, and carotene and are just marginally below the digestible energy requirement of gestating ewes (Cook 1972). Throughout Morocco, about 30,000 ha of communal rangeland has been planted to oldman saltbush. What makes this shrub especially interesting is its ability to be used in autumn and winter when other forage resources are scarce or of low quality. Several grazing studies conducted in Morocco have shown that the introduction of oldman saltbush shrub as a means of range improvement has increased live weight gain (LWG) of sheep or goats compared to those grazing on unimproved range (ORMVAT 1991; ORMVASM 1992).

One confined feeding study with oldman saltbush as a supplement for sheep in Morocco demonstrated that it is palatable to sheep and results in substantial improvements in LWG (ORMVAT 1991). Le Hou  rou (1980) found that a herd of cattle that was allowed to browse shrubs as well as graze annual grasses maintained live weight during the entire dry season, while another herd that was allowed only grass lost condition in the second half of the dry season. The nutritive value of atriplex and acacia foliage and medicago pods has been investigated

mainly as sole diets (Bhattacharya 1989; Denney et al. 1979; Vercoe and Pearce 1960; Wilson 1966, 1977). Fewer studies have been reported with shrub foliage or medic pods evaluated as a supplement to low quality roughage (Franklin et al. 1964; Boutouba et al. 1990; Arthun et al., 1992).

The objectives of this study were: (i) to compare the supplementary feeding value of oldman saltbush foliage, blue wattle foliage, and medic pods for sheep receiving wheat straw as a basal diet; and (ii) to study the effect of different sources of supplementary N on performance of ewe lambs receiving wheat straw as a basal diet.

Materials and Methods

Thirty Timahdite ewe lambs weighing 30–36 kg at the start of the experiment were used in this trial. The lambs were vaccinated against enterotoxemia, drenched for internal parasites (Panacur, Roussel-Diamant, Casablanca, Morocco), and given an A-D3-E vitamin drench every four weeks during the trial. The lambs were kept in a ventilated animal house.

The treatments were: (1) wheat straw alone, later supplemented with urea, and wheat straw supplemented with (2) saltbush foliage, (3) blue wattle foliage, (4) medic pods, or (5) alfalfa hay. The treatments were allocated to six replicates according to a randomized complete block design. The blocking criterion was the live weight of the animals. Wheat straw and alfalfa hay were milled in a large-capacity mill with a coarse (38 mm) screen before being fed. The saltbush and blue wattle foliage were harvested weekly from a two-year old and three-year old plantation, respectively. Only leaves and tender twigs were fed to the animals. Both plantations were closed to grazing.

Medic pods were collected from seed production plots using a large vacuum cleaner. Stones and other foreign matter were removed by soaking the harvested material in water. It was then sun-dried, thoroughly mixed, and stored. Six different species were present in the mixture: *Medicago polymorpha* cv Serena, *M. rotata*, *M. truncatula*, *M. polymorpha* local, *M. entertexta*, and *M. scutellata*. Two-thirds of the mixture consisted of pods and the remainder stems and leaves.

Alfalfa hay and urea (46% N) were fed at different levels to provide 90 g CP/kg DM in the diet. Straw and the other supplements were fed *ad libitum*. The quantity offered was adjusted daily on the basis of 1.15 times the previous day's intake. Straw was fed at 08:00 in the morning and supplements at 17:00, and the animals had free access to water. In addition to urea, the wheat straw diet was supplemented with 0.13% sodium sulfate on a DM basis, to ensure that the N:S ratio of the diet was approximately 10:1, which was assumed to be the optimum value for the efficient utilization of feed nutrients (Moir et al. 1967).

Refusals were weighed in the morning and air-dry matter intake calculated. A sample of straw and each supplement was taken each day and bulked weekly. A sample was taken to represent the forage fed during the previous week. All samples were dried at 55° C for 48 hours, ground in a Wiley mill with a 1 mm screen, and stored. At intervals of 15 days, the sheep were weighed in the morning on two successive days after overnight starvation.

Samples of wheat straw, alfalfa, saltbush, blue wattle, and medic pods were analyzed for DM, ash, CP, and acid detergent insoluble nitrogen (ADIN; AOAC 1984), neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL; Robertson and Van Soest 1981). The IVDMD and *in vitro* organic matter disappearance (IVOMD) were determined by the Tilley and Terry assay (1963). Tannin concentration was assessed using the technique of Burns (1963).

Variables (animal weight and DM intake) collected periodically were analyzed using the repeated measures technique (SAS 1988). The main effects of treatment and sampling period, and their possible interactions, were investigated. Chemical composition and IVDMD were analyzed following a completely random design, assuming no forage/week interaction. Significant differences were examined with the LSD test (Steel and Torrie 1980).

Results and Discussion

Average chemical composition and IVDMD are reported in Table 1. The CP concentration of wheat straw was 52g/kg DM, lower than the 69 g/kg DM required for adequate rumen microbial activity (ARC 1980; Milford and Minson 1965).

The proportion of ADIN varied from 3.5% for alfalfa hay to 13.5% for medic pods (Table 1). ADIN represents the N which is tightly bound to the ADF fraction and thus unavailable for the microorganisms in the rumen. The ADIN content seemed to be more related to the ADL than the ADF concentration, except for alfalfa hay. Alfalfa and saltbush are therefore considered more efficient sources of N for the rumen microbes.

Table 1. Chemical composition and *in vitro* digestibility (g kg⁻¹ DM) of wheat straw and supplementary forages.

	Wheat straw	Alfalfa hay	Oldman saltbush	Blue wattle	Medic pods	SEM
CP [†]	52 ^c	136 ^a	137 ^a	109 ^b	108 ^b	3.9
Ash	85 ^e	106 ^d	308 ^a	129 ^c	156 ^b	9.7
NDF	703 ^a	466 ^c	348 ^d	342 ^d	557 ^b	16.7
ADF	421 ^a	307 ^b	152 ^d	209 ^c	419 ^a	13.4
ADL	69 ^c	92 ^b	80 ^c	132 ^a	125 ^a	3.4
IVDMD	447 ^c	586 ^a	622 ^a	488 ^b	507 ^b	9.5
Tannins [‡]		0.13 ^b	0.07 ^b	11.20 ^a	0.07 ^b	0.3
Total N % DM	0.83 ^c	2.18 ^a	2.19 ^a	1.74 ^b	1.73 ^b	0.04
ADIN [§] %N	9.99 ^b	3.52 ^d	7.30 ^c	11.54 ^b	13.45 ^a	0.78

[†] Crude protein; neutral detergent fiber; acid detergent fiber; acid Detergent lignin, *in vitro* dry matter disappearance.

[‡] In catechin equivalent.

[§] ADIN = Acid detergent insoluble nitrogen.

^{a,b,c,d,e} Means within rows followed by different symbols are different (P < 0.05).

Mineral Concentration

Of the five forages, alfalfa and medic pod had adequate concentrations of P in terms of sheep requirements (0.16–0.37%). (Table 2) All forages, however, had levels of Ca well above the minimum requirement. Only blue wattle had a K level below the minimum requirement. The concentration of Cl was highest in saltbush, which indicates the high salt concentration of this forage.

Silicon concentration was highest in wheat straw, which partially explains its low IVDMD. Sulfur concentration varied from 0.18% DM for medic pods to 0.71% DM for blue wattle. None of the forages had a S:N ratio lower than 0.10, which is considered adequate for rumen microorganisms.

Table 2. Mineral concentration of wheat straw (WS), alfalfa hay (AH), oldman saltbush foliage (SB), blue wattle foliage (BW), and medic pods (MP).

Mineral	WS	AH	SB	BW	MP	SEM
Mg (g/kg)	1.3 ^d	2.6 ^b	2.1 ^a	5.3 ^a	2.9 ^b	0.15
Al	0.7 ^d	0.9 ^d	2.7 ^b	1.6 ^a	5.9 ^a	0.2
Si	30.0 ^a	5.2 ^c	5.2 ^c	4.4 ^c	17.0 ^b	1.1
P	1.0 ^c	2.0 ^b	0.5 ^a	0.7 ^d	2.2 ^a	0.07
S	1.9 ^d	2.7 ^c	4.3 ^b	7.1 ^a	1.8 ^d	0.2
Cl	8.7 ^b	7.5 ^b	56.6 ^a	7.4 ^b	3.6 ^c	2.1
K	7.4 ^c	19.5 ^a	11.1 ^b	4.6 ^a	6.0 ^d	0.57
Ca	5.5 ^a	14.8 ^c	6.9 ^d	30.1 ^a	18.8 ^b	0.9
Mn (mg/kg)	43.8 ^c	37.1 ^c	65.2 ^b	63.2 ^b	75.2 ^a	1.8
Fe	783.7 ^a	540.9 ^{bc}	602.1 ^b	432.9 ^c	-	27.3
Cu	4.8 ^c	8.0 ^a	4.8 ^c	5.1 ^c	6.3 ^b	0.18
Z	12.6	22.4	27.8	19.8	106.9	17.87

^{a,b,c,d} Means within rows followed by different symbols are different ($P < 0.05$).

Intake of Wheat Straw and Supplementary Foliage

Total (Table 3) and straw (Table 4) intakes varied significantly according to time for all the treatments. There were also significant differences among supplements. Throughout the trial, total and straw intake increased for all treatments. The increase in total intake during the first seven weeks was greatest for the saltbush treatment, followed by alfalfa and medic pods. Intake of straw alone and of blue wattle did not increase during the first period. The proportion of straw in this increase was highest for the saltbush treatment followed by those supplemented with alfalfa and blue wattle. Animals supplemented with medic pods showed a small decrease in straw intake during the same period, indicating that the increase in total intake was the result of an increase in the intake of medic pods.

During the last seven weeks of the trial, total intake increased with all supplements except for alfalfa. The highest increase occurred with the medic pod supplement followed closely by urea. Saltbush was ranked third. Straw intake during the same period increased for all supplements. The highest increase occurred on the urea-supplemented straw treatment, followed by the saltbush treatment.

Over the whole trial, the greatest increase in total intake was recorded for the treatment in which wheat straw was supplemented with saltbush foliage. Straw represented about 55% of that increase. Saltbush increased the intake of straw consumed by the animals from 420 to about 600 g DM. The most likely reason for this increase was that it corrected the protein deficiency of the straw, as the CP concentration of the total diet was increased from 52 to 74 g/kg DM (Table 5). In a study where barley straw was supplemented with *A. halimus* foliage (150 g CP/kg DM), Goodchild et al. (1992) reports similar results. For each kg of saltbush DM fed, voluntary barley straw intake increased between 340 and 630 g DM. Wilson (1966), working with oldman saltbush as a supplement to straw, reports that browse foliage increased the intake of straw in proportion to the amount offered to the animal.

Table 3. Daily total intake of dry matter ($\text{g kg}^{-0.75}$) on ewe lambs fed wheat straw alone or with a supplementary forage.

Supplement	Dry matter intake		
	October	November	January
Wheat straw [†]	38.3 ^b	40.0 ^{b,f}	47.7 ^{a,f}
Alfalfa hay	43.4 ^b	50.0 ^{a,c}	53.5 ^{a,ef}
Saltbush	41.2 ^c	59.0 ^{b,d}	64.3 ^{a,d}
Blue wattle	42.9 ^c	44.9 ^{b,ef}	48.5 ^{a,f}
Medic pods	43.3 ^{b,e}	49.3 ^{b,e}	58.6 ^{a,de}
SEM	0.83	1.50	1.60

[†]Straw as a sole diet was supplemented with urea and sodium sulfate at 1.35 and 0.13% dry matter, respectively, starting in late November.

^{a,b,c} Means within rows followed by different symbols are different ($P < 0.05$).

^{d,e,f} Means within columns followed by different letters are different ($P < 0.05$).

Table 4. Daily intake of straw dry matter ($\text{g kg}^{-0.75}$) by ewe lambs fed wheat straw alone or with a supplementary forage.

Supplement	Straw dry matter intake					
	October		November		January	
	Straw	% Tot [†]	Straw	% Tot [†]	Straw	% Tot [†]
Wheat straw [†]	38.3 ^b	100.0	40.0 ^{b,d}	100.0	47.7 ^{a,d}	99.0
Alfalfa	28.1 ^{b,e}	64.7	31.8 ^{b,f}	63.6	36.1 ^{a,f}	67.5
Saltbush	30.6 ^{c,e}	74.3	36.5 ^{b,e}	61.9	43.5 ^{a,e}	67.6
Blue wattle	29.9 ^{c,e}	69.7	33.2 ^{b,ef}	73.9	35.5 ^{a,f}	73.2
Medic pods	30.4 ^{b,e}	70.2	29.2 ^{b,f}	59.2	33.9 ^{a,f}	57.8
SEM	0.88		0.94		1.30	

[†]% Total intake.

[†]Straw as a sole diet was supplemented with urea and sodium sulfate at 1.35 and 0.13% dry matter, respectively, starting in late November.

^{a,b,c} Means within rows followed by different symbols are different ($P < 0.05$).

^{d,e,f} Means within columns followed by different letters are different ($P < 0.05$).

Medic pods ranked second in increasing total intake over the whole feeding period. The proportion of medic pods in the total intake increased from 30 to 42% between the first and third periods. This suggests that animals offered medic pods

require a longer adaptation period. The CP concentration of the total diet increased from 67 g/kg DM at the beginning of the trial to 76 g/kg DM at the end (Table 5), which was equivalent to the saltbush diet. Franklin et al. (1964) found increases in the intake of wheat straw of 100% and 250% during the first and second months of the trial, when it was supplemented with 113 g of medic seed.

Table 5. Crude protein concentration (g kg⁻¹ DM) of total intake of ewe lambs fed wheat straw alone or with supplementary forage.

Bi-weekly interval	Diet				
	WS	AH	SB	BW	MP
W2	52 ^c	87 ^a	71 ^c	74 ^b	67 ^d
W4	52 ^c	89 ^a	70 ^b	69b ^b	69 ^b
W6	52 ^d	89 ^a	76 ^b	65 ^c	73 ^b
W8	52 ^d	90 ^a	78 ^b	67 ^c	75 ^b
W10 [†]	91 ^a	92 ^a	74 ^b	64 ^c	75 ^b
W12	91 ^a	88 ^a	75 ^b	66 ^c	74 ^b
W14	91 ^a	87 ^b	74 ^c	67 ^d	76 ^c

WS = wheat straw; AH = Alfalfa hay; SB = Oldman saltbush foliage; BW = Blue wattle foliage; MP = medic pods.

[†] Straw as a sole diet was supplemented with urea and sodium sulfate at 1.35 and 0.13% DM, respectively, starting on the eighth week of the trial.

^{a,b,c,d} Means within rows followed by different symbols are different ($P < 0.05$).

The alfalfa hay treatment ranked third, based on the increase in total intake throughout the trial. Because the amount of alfalfa hay consumed was relatively constant, all increases were represented by straw. The CP concentration of the total diet averaged 89 g/kg DM, which was significantly higher than diets supplemented with saltbush, blue wattle, and medic pods.

Urea supplementation increased ($P < 0.05$) wheat straw intake by 19% and made it equivalent to the total DMI of animals receiving blue wattle and alfalfa supplements (Table 3). This was probably due to the supply of N, the most limiting nutrient in straw-based diets. The CP concentration of the straw diet was thus increased from 52 to 91 g/kg DM, making it equivalent to that of the alfalfa diet (Table 5). These results might have been better if the trial had continued for longer, as it is generally agreed that rumen microflora require an adaptation period of two to three weeks to efficiently utilize urea (Wolter 1978). Cloete and Kritzing (1984) and Termanini et al. (1993) report that urea supplementation increases voluntary intake of wheat straw by approximately 35%.

The blue wattle supplement was least effective in increasing total intake over the whole period of the trial. The increase was entirely in straw, indicating that blue wattle was not very palatable to the animals, owing perhaps to the existence of anti-nutritional factors, such as condensed tannins, in the foliage (Table 1). Reed et al. (1990) and Reed and Soller (1987) report negative effects of tannin in blue wattle on feed intake, N digestibility, and weight gain.

As with all pen-feeding work, the relevance of previous intake and digestibility recordings to intake in the field may be questioned because of selectivity by sheep

during grazing, but it may be assumed that in no circumstances would they be lower than those recorded in this experiment. The effect of supplement on straw intake can be explained by the increased rate of digestion following enhanced microbial activity (Cheeson and Orskov 1984). The effectiveness, however, of additional N depends on the availability of digestible material in the diet for rumen microbes (Johnson 1976). Straw contains high levels of indigestible material inaccessible to cellulolytic organisms (Cheeson 1981). The resistance of the roughage to ruminal digestion has a major influence on the response to supplementation; the more indigestible the diet, the lower the intake response after elevation of rumen ammonia concentration (Hunter and Siebert 1985). Fodders with a high proportion of digestible DM show a higher intake response to urea supplementation than those that are indigestible (Hunter and Vercoe 1984).

Substitution Ratio

Changes in straw intake as a result of supplementation with the different forages at a rate of inclusion of 36% or less of total DMI are summarized in Table 6. The substitution ratio, defined as the decrease of intake of basal roughage DM per unit of supplement fed, averaged 0.26, 0.57, 0.62, and 0.65 for saltbush, alfalfa, medic pods, and blue wattle, respectively. Saltbush, however, had negative substitution ratios in the last three weeks, indicating that the intake of wheat straw increased and that saltbush can act as a true supplement.

Table 6. Changes in straw intake resulting from supplementation with forage (rate of inclusion is 36% or less of total DMI).

Supplement	Dry matter intake of			Inclusion level	Substitution ratio [†]	
	Unsupplem- ented straw	Supplement- ed straw	Supple- ment		Ave.	Range
Alfalfa hay	41.4	31.7	16.9	0.35	0.57	0.35–0.68
Saltbush	41.4	36.8	18.0	0.32	0.26	0.27–1.09
Blue wattle	41.4	33.2	12.6	0.27	0.65	0.43–0.99
Medic pods	41.4	30.4	17.7	0.36	0.62	0.40–1.52

[†] Substitution ratio is the decrease of intake of basal roughage DM per unit of supplement fed.

Animal Performance

Animals on all treatments lost weight during the first seven weeks of the trial (Table 7). Those receiving straw alone and straw supplemented with blue wattle or saltbush had the largest losses, 75, 50, and 43 g/day, respectively. Animals fed alfalfa and medic pod supplements lost only 25 and 28 g/day, respectively. During the following seven weeks, animals given saltbush gained weight, and the remaining treatments, except for blue wattle, reduced live weight losses relative to the control. Animals given saltbush were the only ones to gain weight over the whole period of the trial.

In general, the results of this experiment are similar to other studies of saltbush and blue wattle supplementation. Wilson (1966) found that the intakes of oldman saltbush and bladder saltbush were sufficient to allow maintenance or a small gain in weight when sheep were fed a basal diet of oat straw and natural grass hay.

Alfalfa, medic pod, and blue wattle supplements resulted in losses of 15, 18, and 50 g/d, respectively. Dumancic and Le Hou  rou (1980) and Le Hou  rou (1987), conclude that supplementation with blue wattle resulted in intake that meets energy, but not protein, requirements for maintenance.

Table 7. Average daily gains (g d⁻¹) of ewe lambs fed wheat straw alone or with supplementary forage.

Period	Supplement					SE
	WS [†]	AH	SB	BW	MP	
Average daily gain						
7-0 wk	-133 ^c	-52 ^a	-50 ^a	-92 ^b	-45 ^a	13.0
14-7 wk	-18 ^c	8 ^b	57 ^a	-52 ^d	5 ^c	10.4
14-0 wk	-76 ^c	-22 ^b	4 ^a	-72 ^c	-25 ^b	7.1
Total weight gain as % of initial weight	-16 ^c	-5 ^b	1 ^a	-16 ^c	-6 ^b	1.4

WS = Wheat straw; AH = Alfalfa hay; SB = Oldman saltbush foliage; BW = Blue wattle foliage; MP = Medic pods.

[†] Starting late November wheat straw as a sole diet was supplemented with urea and sodium sulfate at 1.35 and 0.13% DM, respectively.

^{a,b,c,d} Means within rows followed by different symbols are different (P < 0.05).

Conclusions

Results from the feeding trial indicate that saltbush is the most efficient supplement for maintaining the live weight of ewe lambs fed a basal diet of wheat straw, common in the arid and semi-arid areas of Morocco during autumn and early winter. To benefit from these results farmers should reserve a proportion of their land for planting oldman saltbush. This planting could be done on land of low agricultural potential, usually left uncultivated. Use of an alley-cropping system could also be adopted on land planted with barley. Shrubs could also be planted as windbreaks, to release the land for other crops and to protect the soil from wind erosion. The government, through the Ministry of Agriculture, in addition to planting communal rangelands, should encourage farmers to plant shrubs on their own land by providing plants and advising on management.

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Discussion

N. Hassan: What is the practicability of the browse system in the low rainfed areas of 150 mm or less where *A. nummalaria* is affected severely by frost and snow?

A. Chriyaa: In the areas planted to atriplex in Morocco, frost and snow are not a problem.

A. Nefzaoui: I agree with your conclusion on the opportunity of planting atriplex on private land. It was not necessary to think about *Acacia cyanoplaylla* as a protein supplement. Finally, it is not useful to determine nitrogen balance on adult animals.

Guidelines for the Management of the Nutrition of Flocks in West Asia during the Dry and Mating Periods: What Information Do We Have and What Do We Need?

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Abstract

Lambing percentages of less than 80% are common in Awassi flocks in west Asia. Although the Awassi breed is inherently aseasonal in its oestrus activity, surveys show great seasonality of lambing with a peak in winter, apparently related to the increase in oestrus activity that occurs when nutrition improves in summer and autumn, when stubble and residue of irrigated crops are grazed. This offers the prospect that improved management of nutrition could lead to increased lambing percentages. Increasing fertility, without any change in ewe fecundity, from 80% to 95%, would result in a 19% increase in potential flock performance. This paper reviews recent work on effects of body condition and nutrition at mating on ovulation rate, stocking rate and supplementation on the performance of ewes grazing stubble, and mineral and vitamin deficiencies, which offer tentative guidelines for managing Awassi ewes in dry and mating periods.

Introduction

Degradation of the steppe and marginal land around villages in most of west Asia in the last 40 years has resulted in a pasture that contributes only a small part of the nutrient requirements of sheep. Natural pasture generally provides a significant contribution from March to May in years with normal or above average rainfall. For most of the year flock nutrition is based on other feed resources: cereal stubble and field crop residue (cotton, maize, vegetables, etc.) in summer and early autumn and large amounts of straw, grain, and crop by-products (cotton seed, bran, etc.) in autumn and winter. In spite of the movement away from dependence on natural pastures with highly variable production, both within and between seasons, lambing percentages (lambs reared/100 ewes put with rams) of less than 80% are still common in west Asia. An important proportion of ewes, which incur the full cost of rented grazing and purchased feed, only produces a fleece, which is of negligible value, and possibly milk. Increasing lambing percentage from 80% to 95% would not only increase sales of lambs and milk by approximately 20%, but also allow more choice in selecting replacement ewes or more rapid increases in flock size.

This paper discusses the factors causing the low lambing percentages in Awassi flocks in west Asia and considers how they might be overcome.

Current Fertility, Prolificacy and Mating Patterns

A number of ICARDA surveys give a clear picture of the lambing percentages and mating patterns in the region.

A 1978–1981 survey of 43 flocks in northwest Syria by Thomson, Bahhady and Martin (1989) shows that although some births occurred in all months (except July and August) lambing is concentrated between late November and March, with more than 60% of births in December and January. The mean lambing percentage was 87%, and ranged from 57 to 107% in individual flocks and from 82 to 90% over the three years. Lamb deaths resulted in a percentage of lambs reared of 69, 79, and 74 in the three years. Mean mortality was 14.0, 8.4, 6.5, and 2.5% for lambs, ewes, rams, and female yearlings, respectively.

Lambing performance was also recorded in a survey of flocks in three systems—designated sedentary, semi-sedentary, and nomadic—along a transect from the cultivated area southeast of Aleppo, Syria into the steppe near Palmyra (ICARDA 1993a). Mean fertility (ewes lambing per 100 ewes in the flock), prolificacy (lambs per ewe lambing) and lambing percentage (lambs weaned per 100 ewes in the flock) were 86%, 1.1, and 70%; 78%, 1.0, and 72%; and 77%, 1.1 and 70% for flocks in the sedentary, semi-sedentary and nomadic systems, respectively (Wachholtz, personal communication).

A 1993 survey in Lebanon of mixed flocks of sheep and goats (ICARDA 1994) provides data for three clusters of flocks separated on the basis of the importance of rangeland as a source of nutrients for the flocks. In cluster 1 (with the smallest use of rangeland) lambing, estimated from the data on work patterns, occurred between November and March, with 72% of births in December and January. In cluster 2 (highest use of range) lambing occurred between December and April, with 60% in December and January. In cluster 3 (intermediate use of range) lambing occurred between November and March, with 61% in January and February. Cluster 1, which had the highest concentration of lambing in December and January, made the greatest use of grazed stubble and other crop residue in July–September, when mating occurred.

Kidding occurred a month or more later than with sheep in each cluster, possibly because lactation was approximately a month longer in goats than in ewes. percentages of lambs born alive and lambs reared per 100 ewes in the flock were 89 and 80, 69 and 60, and 79 and 68% for clusters 1 to 3, respectively. Lamb deaths were 10, 13, and 14% per cluster, respectively. Goats had a slightly higher numbers of kids born per 100 goats in the flock, but kid mortality was much higher than in lambs: 21, 31, and 22% for clusters 1 to 3, respectively. Kids weaned per 100 goats put with bucks were, therefore, lower than for lambs, except in cluster 1.

Table 1 summarizes data from Mashreq trials on the use of synchronization with sponges and injection of PMSG at sponge withdrawal, supplementary feeding or multivitamin injections to increase lambing percentage. The fertility of the control, untreated groups ranged from 60 to 90%, with an overall mean, weighted for

group size, of 70%. Synchronization and use of PMSG increased fertility, but the lambing percentage was still approximately 100%, despite a much greater proportion of twins.

The information from these surveys provides a clear indication of the present level of reproductive performance of Awassi flocks in part of west Asia.

The Awassi breed is inherently aseasonal in oestrus activity, with oestrus occurring in all months except May to June, although there is some decline in activity between January and April (Epstein 1985). It is, however, clear that in commercial flocks fertile oestrus activity occurs in a more restricted period, even though the rams generally remain with the ewes throughout the year. Lambing is generally restricted to a maximum of five months (November to March), with 80% of lambing occurring in three months. This indicates that fertile mating occurs mainly in July–September, when milking of the majority of ewes has finished, eliminating effects of lactation anoestrus, and after most flocks have been grazing stubble for a minimum of 4–6 weeks.

The proportion of Awassi ewes producing twins is low: 5–9%. The proportion of live lambs born per 100 ewes put with rams is a good index of fertility, i.e., the number of ewes lambing per 100 ewes put with rams. Mean figures for this index range from 82 to 87% in Thomson et al. (1989), and from 89 to 69% in the survey in Lebanon survey. Direct records of fertility percentages are similar—86 to 77% (Walchholtz, personal communication)—and a mean of 70% in the Mashreq trials (Table 1). These figures show that a significant proportion of ewes either does not become pregnant or aborts during pregnancy. Flock owners in the Lebanon survey did not state that abortion was a major disease problem, which may indicate that infertility is the more important cause of the low proportion of ewes lambing.

Table 1. Fertility and lambing percentages in control and treatment groups in Mashreq Project trials.

Site and Year	Treatment	No. of flocks	No. of ewes	Fertility (%)	Lambing (%)
Hama, Syria 1992	Control	3	151	73	71
	PMSG	3	154	75	97
	Supplemented	3	152	71	70
Hama, Syria 1993	Control	4	185	60	61
	PMSG	4	190	77	96
Jordan 1992	Control	3	100	76	80
	PMSG	3	109	90	108
	Supplemented	3	105	78	83
Jordan 1993	Control	2	75	64	65
	PMSG	2	75	88	85
	Supplemented	2	75	83	115
Jordan 1992	Control	2	56	75	79
	Vitamins	2	55	87	87
Jordan 1993	Control	2	74	85	92
	Vitamins	2	65	88	105

These surveys also show high mortality of lambs before weaning. In view of the high level of concentrate feeds used in early lactation (e.g. Thomson 1987; Jaubert and Oglah 1993) and the close shepherding of the flocks, it would appear unlikely that a major proportion of these lamb losses are due to lack of milk, as the amount of milk required for survival is small, probably not more than 500 g/day. This suggests that disease is the major cause of these losses. The farmers in the Lebanese survey said enterotoxemia and parasites were major disease problems.

Effects of Body Condition and Nutrition at Mating on Lambing Percentage

Body weight or body fatness, generally termed body condition, has been shown to affect lambing percentage in many sheep breeds by affecting the number of ova shed at ovulation. This effect, termed the static nutritional effect by Coop (1962), is generally more important than the short-term, or dynamic, effect of nutrition immediately before mating. High feeding for a short time before mating, termed flushing, only increases ovulation within a limited range of body condition. At body conditions above and below this range, ovulation is not affected by high or low levels of current nutrition (Gunn 1983). Some experiments, however, indicate that very high levels of nutrition in the first 2–3 weeks of pregnancy can interfere with implantation of embryos and reduce prolificacy (e.g. Parr et al. 1987).

A few studies show that the lambing percentage of Awassi ewes is affected by body weight at mating. Kassem et al. (1989) found a slight positive correlation between lambs born per ewe mated and weight in May, 6–8 weeks before mating. The fertility of ewes was not affected by weight in May, a finding which contrasts with results of Thompson and Bahhady (1988) showing that fertility increases with weight at mating. In that study, fertility increased rapidly with weight to 43 kg and was 100% at 51 kg and above.

Neither of these studies was specifically designed to investigate effects of body weight, condition, or nutrition before mating on the reproductive performance of Awassi ewes. The results of two experiments at ICARDA's Tel Hadya Sheep Unit that specifically examined these factors are outlined below. In these experiments body condition was assessed using the system of palpation of the lumbar region used in Australasia and Europe, and the fatness of the tail was not considered. In this scoring system the region on and around the backbone immediately behind the last rib is palpated to give ewes a score on a scale from 1 (very thin) to 5 (very fat) according to the clearly described amounts of fat over the spinous and transverse processes of the backbone, the amount of fat and muscle below the transverse processes, and finally the depth of eye muscle and its degree of cover (Russel et al. 1969). The experiments show that the system could be applied successfully in the study of Awassi ewes. The maximum score found in Awassi ewes was approximately 3.5. During the work, ewes were slaughtered and their fat depots weighed and analyzed to assess the relationships between fat reserves at condition score in the Awassi breed (preliminary results in Treacher and Filo 1995).

The first experiment had a 3×2 factorial design with three levels of nutrition in the four weeks before mating, and two body condition scores at mating (ICARDA 1993b). The design necessitated six groups of ewes four weeks before mating with

mean scores at 0.5 intervals between scores of 3.5 and 1.0. Although these scores were not achieved, it was decided to maintain the groups as allocated and apply nutrient intakes of 0.25 maintenance (M), M, and 1.75 M in the four weeks before mating to a synchronized oestrus. At lambing, the number of lambs born and their date of birth were recorded. Body condition at mating in between 1.5 and 2.3 had no effect on lambing performance. Chi-square analyze was made on the results for the ewes lambing to the first oestrus, grouped according to the change in body condition that occurred in the four weeks before mating irrespective of score at mating (Table 2). Although the results must be interpreted with caution, they indicated a general trend, with change in condition score in the mean number of lambs born per ewe. The proportion of barren ewes was quite large in all groups, but was generally lower in groups maintaining or gaining condition. Similarly the proportion of ewes with twins was greater in the groups gaining more than 0.25 of a condition score.

Table 2. Mean number and proportion of ewes producing 0, 1, or 2 lambs and mean lambs per ewe after mating at first oestrus following synchronization.

Change in condition score	Number of ewes producing			Mean no. of lambs/ewes
	0	1 lamb	2 lambs	
> -0.5	10 (0.31) [†]	22 (0.69)	0	0.69
-0.5 to -0.25	23 (0.50)	22 (0.48)	1 (0.02)	0.52
0	11 (0.20)	42 (0.78)	1 (0.02)	0.81
+0.25 to +0.5	9 (0.25)	23 (0.64)	3 (0.11)	0.86
> +0.5	3 (0.15)	15 (0.75)	2 (0.10)	0.95

[†] Proportion of total

Mantel-Haensel Chi-square test significant at $P < 0.03$.

In the second experiment a 3×3 factorial design was used to investigate the effect of body condition five weeks before mating, and the effect of change in condition during the five weeks before mating, on reproductive performance. The condition scores were 1.5 (treatment C_1), 2.0 (C_2), and 2.5 (C_3). Levels of nutrition were 0.5 M (treatment L_1), M (L_2), and 3M (L_3). The experiment was carried out on two groups of ewes: 89 cull ewes (group S) that were slaughtered approximately 60 days after mating, and 145 ewes (group L) that were allowed to lamb. The number of corpora lutea and fetuses were recorded after slaughter in group S and lambs born in group L.

The results (Table 3) for 69 ewes mated at the first oestrus indicate that, although the designated condition scores were not quite achieved for treatments C_2 and C_3 , there was a trend in both the number of corpora lutea and of fetuses with increasing body condition ($P < 0.08$). The nutritional treatments resulted in body condition changes of -0.30, +0.05, and +0.59 on treatments L_1 , L_2 , and L_3 , respectively. These changes significantly affected both number of corpora lutea and fetuses but not the losses of embryos.

In group L the treatments had no significant effect on lambing percentage. Assuming that losses of fetuses after 60 days of pregnancy (except as a result of disease) are negligible, the data from the S and L groups were combined. The

combined data show (Table 3) the significant effect of both initial body condition and level of nutrition before mating on the number of fetuses. The treatment means for number of fetuses per ewe put with rams were 0.77, 0.85, 1.08, 0.96, 1.00, 1.15, 0.96, 1.46, and 1.08 for treatments C₁L₁, C₁L₂, C₁L₃, C₂L₁, C₂L₂, C₂L₃, C₃L₁, C₃L₂, and C₃L₃, respectively. There was a significant ($P < 0.05$) interaction between the treatments, with number of fetuses decreasing in ewes in the highest body condition fed at 3M.

Table 3. Means for initial and final body condition score and number per ewe of corpora lutea and fetuses in the slaughtered group (n=69) and combined groups (n=182).

		Initial body condition			Sign	Level of nutrition			Sign
		C ₁	C ₂	C ₃		L ₁	L ₂	L ₃	
Slaughter groups									
n		28	20	21		20	24	25	
Condition	initial	1.47	1.76	2.29	***	1.72	1.84	1.83	ns
	final	1.66	1.88	2.38	***	1.42	1.89	2.42	***
Weight (kg)	initial	44.1	49.6	55.7	***	47.8	49.8	49.8	ns
	final	46.1	51.0	56.1	***	43.4	50.0	56.9	***
No. of corpora lutea		1.10	1.30	1.38	ns	0.90	1.29	1.48	**
No. of fetuses		0.86	1.15	1.19	ns	0.70	1.12	1.24	*
Combined groups									
n		62	55	65		55	62	65	
Condition	initial	1.51	1.95	2.46	***	1.98	1.98	2.00	ns
	final	1.73	2.08	2.50	***	1.62	2.03	2.60	***
Weight (kg)	initial	44.3	50.4	56.0	***	49.4	50.1	51.3	ns
	final	46.7	51.9	55.8	***	44.2	50.8	58.3	***
No. of fetuses		0.90	1.04	1.15	*	0.87	1.06	1.14	*

These two experiments clearly indicate that the fertility and prolificacy of the Awassi breed, like many other breeds, is affected by body condition and feeding level before mating. Awassi ewes in good condition, with a score of more than 2.0, and maintaining or gaining condition before mating, can have a significant proportion of twins. More research is needed to more exactly define the minimum conditions for eliminating barren ewes. On the basis of these results, it is suggested that a tentative guideline for achieving a minimum fertility of 100% in Awassi ewes is a minimum body condition score four weeks before lambing of 1.75 (approximately 48 kg live weight) and a minimum feeding level of maintenance for 2–3 weeks before mating. Better condition and/or higher levels of feeding, (i.e., flushing), may result in a higher proportion of twin pregnancies.

A strong indication that this guideline is likely to be effective comes from the performance of the sheep in the long-term experiment on marginal land at Tel Hadya. Ewes at the higher stocking rate whose diets are supplemented whenever their weight falls below 46 kg consistently have a fertility of 97% and percentage of lambs born alive of 108.

Improving Nutrition In the Mating Period

The majority of mating takes place while the flocks are grazing stubble or other crop residue. Flock owners surveyed in northern Syria (ICARDA 1992) regard this period as a time of plentiful feed supply. Yet it is clear that a significant proportion of ewes do not become pregnant in this period. Failure to recover to an adequate body condition contributes to the low fertility.

There is little published research on stubble grazing, particularly of barley. Treacher, Rihawi, and Owen (1995) review the existing information and the results of three recent experiments on Awassi sheep grazing barley stubble.

Intake of energy and protein from stubble grazed at different stocking rates with and without supplementation were estimated in these experiments. Intake of metabolizable energy and crude protein were high in the first few days on a new area of stubble. Initially, they were more than twice maintenance but fell rapidly as the heads and leaves were removed from the stubble. If, as is common in the region, a high level of utilization of stubble is achieved, intake falls to very low levels, 0.5–0.25 M or even lower. Low levels of supplementation, 150–320 g/head/day for a month, had little effect on intake of stubble but greatly increased the weight gain of ewes and reduced the time taken for the ewes to become pregnant (Table 4). These results indicate that supplementation with a total of 5–9 kg/ewe for a month will greatly increase the rates at which ewes regain body condition after lactation.

Table 4. Effect of supplementation on weight change (kg) in 33 days and number of days to become pregnant after introduction of the rams.

Total supplement in 28 days	Weight change	Days to become pregnant	Weight change	Days to become pregnant
0	0.1	36	-1.7	66
5.6 kg B	2.9	40	1.5	29
5.6 kg CSM ¹	4.4	30	2.2	42
0	0.6	42	-1.2	46
4.2 kg B	2.6	35	0.3	48
8.2 kg B	4.9	23	0.9	42
2.9 kg B & 1.5 kg CSM	6.1	12	1.9	33
5.8 kg B & 3.1 kg CSM	8.1	17	4.1	27

B = barley and CSM = cotton seed meal.

Data from Treacher, Rihawi, and Owen (1995)

Macro- and Micronutrients

Farmers in west Asia generally do not feed supplements of macro- and micronutrients to sheep flocks. In the past this was probably because flocks grazed natural pastures and, at the relatively low levels of performance of the flocks, there were no evident deficiency problems. Similarly, feeding of salt is rare, probably because leaves of atriplex bushes, with a high sodium content, were an important component of the diet at some times of the year. In recent years, however, with

most of the nutrition of the flocks provided by straw and cereals, and grazing predominantly made up of stubble and crop residue, there have been a number of indications of problems with deficiencies of macro- and micronutrients (Bahhady, personal communication).

A survey commissioned by ICARDA in 1994 found a range of both clinical and marginal mineral and vitamin deficiencies in 18 flocks in Syria, Jordan, and Turkey (White et al. 1995). The deficiencies identified were:

- Sodium: deficiency was found in 10 of the 13 diets examined. Sodium deficiency causes lowered feed intake and reduced growth. In extreme cases there are clinical manifestations that include pica, which was found in flocks in Konya, Turkey.
- Vitamin E: deficiency was identified from blood analysis in four flocks, and all but two of the remaining flocks were at the low end of the range. Vitamin E deficiency causes white muscle disease in lambs, which has been identified in Konya and in northern Syria.
- Selenium: deficiency was found in two of the five flocks in Turkey. Selenium deficiency is linked with vitamin E in causing white muscle disease.
- Copper: deficiency was found at one irrigated site in Syria. Copper deficiency causes swayback in lambs.
- Zinc: five flocks were deficient and a further five marginal on the basis of blood analyses, although the calculated intake of zinc was adequate. The deficiency may result from reduced absorption caused by high intake of calcium. Zinc deficiency causes reduced growth and lowered reproductive performance in both ewes and rams.

This small survey indicates that mineral and vitamin deficiencies are probably widespread in west Asia. Deficiencies will have an impact on reproduction through:

- General reductions in performance and health, which may affect reproduction by reducing body condition or recovery of body condition in the dry period.
- Deficiencies that have specific effects on reproduction, e.g. selenium and zinc.
- Deficiencies causing disease and increased mortality in lambs, e.g. vitamin E, selenium and copper.

More work is needed to identify the specific areas (soil type, etc.) and/or feeding systems in which there are economically important macro- and micronutrient deficiencies in the flocks. In the short term, however, it appears very probable that there are benefits in both performance and health from offering flocks salt and a balanced mineral and vitamin supplement.

Conclusions

What Do We Know?

Below is a summary of what we know about the problems of nutrition in the dry and mating periods and their effects on reproductive performance:

1. Lambing percentages in commercial Awassi flocks are low: usually a minimum of 20% of ewes do not produce a live lamb.
2. The great seasonality of lambing in the Awassi breed, which is inherently aseasonal in oestrus activity, has always been a strong indication that nutrition has important effects on reproduction in commercial flocks. Now it has been experimentally demonstrated that body condition and level of feeding before mating affect fertility and the number of fetuses.
3. Large losses of lambs after birth greatly reduce weaning percentages.
4. Mineral and vitamin deficiencies are widespread. Some affect reproduction directly and others indirectly, through reduced performance of the sheep.

Tentative Guidelines for Management of Nutrition at Mating

1. A body condition score of 1.75 (equivalent to approximately 48 kg) and energy intake of maintenance or above in the 3–4 weeks before mating is necessary to achieve a lambing percentage of 100%.
2. Feeding of small quantities of supplements when the ewes are grazing stubble will increase weight gains and reduce the time taken to get in lamb where high levels of utilization of stubble are required.
3. Feeding of salt and a balanced supplement of minerals and vitamins will eliminate the majority of effect of macro- and micronutrient deficiencies on flock performance.

What Do We Need to Know?

1. More precise definition is required about the minimum body condition and minimum level of feeding before mating to achieve 100% lambing in Awassi. The same information is required for any other breed being used.
2. Information is needed on the responses of ewes in commercial flocks to different management and supplementation during grazing of stubble and other common crop residues. In particular, the response to supplementation with blocks containing non-protein nitrogen sources needs careful research.
3. Surveys are required of infectious diseases of ewes causing infertility, abortion, and neonatal losses of lambs and of the causes of lamb losses after birth to enable effective prevention strategies to be developed.

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Discussion

H. Al-Haboby: The relationship between trace elements and reproduction in sheep is a very interesting subject. There is good information concerning this subject here and there. Is there any information on this subject in the dry lands? Working in this field may really improve reproductive traits in both ewes and rams under dryland conditions.

T. Treacher: No, there does not seem to be good local information, but it is important to investigate this problem.

M. Harb: I do not believe that there is sodium deficiency. We have to be careful about experts coming in for two to three months and mentioning sodium deficiency.

T. Treacher: Sodium deficiency was clearly demonstration in the Konya region in Turkey. Great care must be used in these matters. Feeding systems are constantly changing. Deficiencies may start to occur if the sheep have very limited access to grazing. For example, vitamin E deficiency and muscular dystrophy in lambs have appeared since 1990 in a number of places in northern Syria. Unless local research workers are in constant contact with farmers, they may not note the changes that are occurring on farms.

A. Al-Haboby: Fertility rates or lambing rates are usually calculated during three oestrus cycles. In Iraq, rams are never separated from ewes. Therefore calculations of fertility rates in the farm flocks could be a bit complicated. Would you please comment on that?

T. Treacher: The figures I quoted are from surveys and only give an indication of the level of fertility based on the number of ewes lambing in a year in relation to the flock's total ewe number. They are not precise, but give an indication of the problem.

N. Hassan: One body scoring system cannot be generalized to the Arab countries, where we have thin-tailed, fat-tailed, and fat-rump sheep breeds? I suggest a scoring system for sheep groups of similar conformation.

T. Treacher: I think this is incorrect. Body scoring is a language, and the levels of body condition needed at particular stages will differ among breeds or breed types. The system of scoring should only be modified with extreme caution and after a lot of thought.

A. Al-Rawi: You indicate that feeding level of M was better than 3M for lambing percentage. Should we think about diets with low heat increment, especially in high temperature environs?

T. Treacher: The three time maintenance feeding treatment was exceptionally high and was only used to achieve an extreme range. There are indications that very high energy intakes after mating can reduce conception, so in a natural mating situation with a spread of lambing, it would be undesirable to use such a high level. I doubt if there was sufficient heat stress in Aleppo to affect the performance, but it might be a problem elsewhere.

A. Salman: Have you looked into the embryonic mortality? What is the possibility of using a body condition score to detect nutrition states of ewes?

T. Treacher: In the slaughter group in Experiment 2 we estimated embryonic mortality as the difference between numbers of corpora lutea and numbers of fetuses. I think body scoring, using the European system, has value in defining guidelines for management and in providing a language for communicating information between researchers, extension worker, farmers, and shepherds.

Improvement of Small Ruminant Production and Management

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Abstract

A shortage of feed is considered the main constraint to small ruminant production in the dry areas of West Asia and North Africa. Rangeland productivity is low. Production of roughage is low, and varies considerably from year to year. Indigenous breeds of sheep in the region are hardy and well adapted to the harsh environment, but their productivity is low because of poor genetic potential, nutrition, reproduction, and the high incidence of disease and mortality.

Further efforts are needed to increase small ruminant production by improving feed resources, nutrition, and management, and by implementing appropriate health control and preventive measures. Since the rangelands are already overgrazed, there is little scope for increasing the number of small ruminants to meet the demand for animal products. Increase in small ruminant production must therefore come from intensification, the integration of crop and rangeland production, and higher production per animal. Small ruminant production may be increased by reducing the age of first lambing, early weaning, fattening of lambs and kids on balanced diets, and by improving nutrition and management before and during mating, in late pregnancy, and in early lactation.

Introduction

Resources, particularly feed, for small ruminant production in the northeastern region, are limited. Average small ruminant productivity in the region has not changed significantly during the last 10 years, despite the large quantities of barley grain fed to sheep and goats in many countries of the region, mainly because of the degradation of the rangeland and the increased use of supplementary feed to increase the number of animals. There is no efficient system for the transfer of technology from research stations and research laboratories to the pastoralists, and socioeconomic difficulties hinder the implementation of such technical changes.

The current system of small ruminant production does not satisfy local demand for meat and milk. Large increases in production will be needed in the future to keep pace with the increased demand which results from population growth and per capita income increase. As the carrying capacity of the rangelands is already exceeded, there is little scope for increasing the size of the small ruminant population. Any increase, therefore, in small ruminant production must come from increasing productivity per animal, by increasing local feed resources, by more efficient utilization of these feed resources and of imported grains, and by proper

management and feeding of breeding and young animals. There will have to be improvements in disease and control measures, in reproductive rate and genetic potential, and in the development of integrated crop-livestock production systems using more external inputs. The objective of this paper is to emphasize the effects of nutrition and management on increasing small ruminant production.

Improving the Efficiency of Utilization of Feed

Efficiency of Utilization of Local Feedstuffs

Stubble, straw, and other low quality feed

When sheep are grazing stubble or dry pasture, or are fed straw and other low quality feed, the main nutrient deficiencies likely to occur are in energy intake, because of low voluntary feed intake, and in protein, vitamin A, and phosphorus. The performance of ruminants can be improved markedly by feeding practices that ensure an efficient rumen function, by improving the environment of the rumen micro-organisms for the efficient fermentative digestion of low quality feeds, and by optimizing nutrient availability in the rumen through supplementation, the feeding of multinutrient blocks, straw treatment or other chemical means. The nutritive value of cereal stubble during the first month after cereal harvesting is satisfactory, but later on the quality of straw is low and supplementation with a vitamin-trace element mixture and a small quantity of grain and/or a nitrogen source or feed blocks is necessary (Economides et al. 1981; ICARDA 1994).

Efficiency of Utilization of Imported Grains

Until the late 1960s, most of the feed for livestock came from grazing arid and semi-arid rangelands (FAO 1972). The contribution of rangelands to the total feed requirements of sheep and goats is declining. Recent estimates in the region are 2.5–10% in Syria (Leybourne 1993), 25% in Algeria (Boutonnet 1989), 20% in Saudi Arabia (Sidahmed 1991), 8–36% in Morocco (Guessous 1994), 15–20% in Tunisia in 1988 (Salah 1994) and 30% in Jordan (Gaddess et al. 1991). On the other hand, in many countries of the region sheep and goats diets are heavily supplemented with barley grain, particularly in late autumn, winter, and early spring. This period coincides with late pregnancy and early lactation, when nutrient demands are highest. Therefore, feeding balanced concentrate diets at appropriate levels during critical periods will increase animal performance, reduce feed costs, improve the efficiency of production, and reduce imports of grains.

Improving Management and Feeding

Management and Feeding of Breeding Animals

Maintenance

Energy for maintenance is the largest single factor in the annual nutrient requirements of sheep and goats (58–62% for single and 54–58% for ewes with two lambs). Table 1 shows that ewes giving birth to twin lambs require only 30 kg dry matter more than ewes producing one lamb.

Table 1. Annual metabolizable energy requirements and dry matter intake of ewes with single or twin lambs (Economides 1994).

Live weight (kg)	Energy Requirements (MJ of ME/ewe/year)		Dry matter intake (kg/ewe/year)	
	Singles	Twins	Singles	Twins
40	3,348	3,597	397	426
45	3,553	3,846	422	453
50	3,752	4,049	448	478
55	3951	4,253	473	504

Walking

The energy cost of walking is high, 8–9% of total annual requirements. Substantial savings in feed could be made by eliminating grazing on rangeland in winter and early spring when vegetation is sparse, and by feeding balanced diets which include minerals and vitamins. This would also lead to a beneficial resting of rangeland.

Mating

Nutrition before and during mating can affect the proportion of barren ewes and of ewes producing twins. (Treacher 1993; Thomson and Bahhady 1988). A higher level of feeding during mating is recommended when body condition of ewes is poor. Culling unproductive animals before mating, including infertile rams, will increase fertility. Prolificacy in experimental flocks of Awassi, Sardi, D'Man and Barbary ewes was improved by increasing the level of feeding prior to mating and/or selecting for twins within the breed (Younis 1977; Lahlou-Kassi 1987; Khaldi 1989). During mating, ewes usually graze stubble, and energy and protein intake declines substantially as intake of heads and leaves declines and intake of stems increases. Therefore, without supplementation, both fertility and prolificacy decline.

Early pregnancy (1–3 mo.)

Early embryonic losses in mated ewes may occur as a result of high temperatures and fluctuating nutrient intake, if ewes graze only stubble.

Late pregnancy (4–5 mo.)

During the last two months of pregnancy, growth of the fetus is rapid and nutrient requirements of ewes increases rapidly. In the two weeks before lambing, energy requirements are 40 and 65% higher in ewes with single and twin fetuses, respectively, than in the middle of pregnancy. Protein requirements are high: 10 g CP/MJ for single and 12.7 CP/MJ for twin ewes, respectively. Underfeeding during late pregnancy affects the deposition of secretory tissue of the udder, reduces the production of colostrum and results in weak lambs with lower viability and higher risk of starvation. Toxemia is common in underfed ewes carrying twins.

During late pregnancy, if ewes graze cereal stubble or are fed straw, supplementary feeding is necessary either in the form of feed blocks or concentrate mixtures (ICARDA 1994). In Australia, good quality range is left for pregnant ewes and, during the last stages of pregnancy, they are grazed on specially reserved rangeland until the lambs are weaned (Williams 1985). In the highlands of Scotland, forage produced on the best land is often maintained as a reserve, and sheep are allowed to graze it in late pregnancy and early lactation (HFRO 1979).

Waterhouse et al. (1994) compares the performance of ewes in an extensive system, supplemented with 5 kg of feed per ewe during late pregnancy and unattended at lambing on the hill, with another flock of ewes supplemented with 25 kg/ewe during mid- and late-pregnancy and supervised during lambing. In the extensive system, the number of lambs weaned and sold was reduced, because of a reduction in the number of lambs born and higher mortality between birth and weaning (Table 2). The reduced output per ewe, however, was offset by reduced feed costs. Although there was a reduction in gross margin, this was offset by a greater reduction in labor costs, which resulted in a slight increase in profitability.

Table 2. Comparison of flock performance and labor use in two systems of management (Waterhouse et al. 1994).

	Control	Extensive
Average no. of ewes	940	630
Ewes/ha	1.02	0.57
Lambs weaned/100 ewes mated	98	59
Lambs available for sale	600	245
Annual labor hours	2,550	780
Reduction in gross margin		£6,000
Labor saving		£6,800

Lactation and Suckling Lambs

Nutrient intake in early lactation, particularly of energy and protein, is 60% higher than in late pregnancy. When the level of feeding in early lactation is adequate, nutrition in pregnancy has only a small effect on milk production. Supplementary feeding is usually provided to lactating ewes grazing poor pasture or on a straw diet. Lactating ewes in Australia and Scotland are often grazed on specially reserved rangeland until the lambs are weaned (HFRO 1979; Williams 1985).

Perinatal mortality of lambs may be very high. The main causes of death are related to inadequate nutrition of the mother, resulting in the birth of weak lambs, and to inadequate colostrum intake immediately after birth.

The survival of lambs at birth depends on the mothering ability of the dam, early consumption of colostrum and an adequate lambing environment. Proper supervision reduces mortality due to dystocia, reduced colostrum intake, and starvation (Ducker and Fraser 1973). Early consumption of colostrum will protect lambs against infection, but its effectiveness depends on the concentration of antibodies in the colostrum (yearlings have lower concentrations), the level of colostrum intake, and the time of consumption, as absorption declines over the 24 hours after birth. Lambs should be vaccinated against clostridial and other

prevalent diseases. If muscular dystrophy has occurred in the past, vitamin E and Selenium should be injected.

Management and Feeding of Young Animals

Relationship Between Weight Gain of Suckling Lambs and Milk Yield of the Ewe

Weight gain in suckling lambs is closely associated with the level of milk consumption during the early stages of lactation. If sufficient, high quality, solid feed is not available for the lambs, growth rates may decline as the milk production of the ewe decreases. For example, Khaldi (1989) found that the growth rate of suckling lambs in Tunisia declined between the first and the third month of suckling, as low feed availability affected the milk production of the ewes.

Early Weaning of Lambs

Many benefits result from the early weaning of lambs. In countries where sheep are kept mainly for meat production, early weaning reduces grazing pressure on the rangeland because lambs are removed earlier from the range and ewes need less feed. In addition, lambs fattened on balanced concentrate diets at a younger age gain weight more efficiently than older lambs. In areas where milk fetches a high price, early weaning makes more milk available for sale, thus increasing income.

In areas where lambs are weaned late or allowed to graze on the range until they are sold, this period of grazing contributes to overstocking and, therefore, degradation of the rangeland. If lambs are weaned early and fattened away from the range, a considerable quantity of roughage can be saved. For example, if lambs remain on the range from weaning (at 20 kg), and are fed 50 or 100 g daily, they will reach a live weight of 30 kg in 200 or 100 days, respectively. During this period, they will consume 115 or 180 kg dry matter. If they are removed from the range at weaning and fattened on a minimum of 100 g of hay/day, they will reach 30 kg live weight in 50 days, consuming 5 kg hay. There is a saving, therefore, of 110 or 185 kg dry matter, respectively.

Reducing Age of Ewes at First Lambing

The age at first lambing of indigenous breeds can be reduced from 2 years to 18 months with better feeding and management (Bahhady 1987; Epstein 1987; Lahlou-Kassi 1987). The advantages are:

- The unproductive period of ewe lambs, from birth to lambing, and cost of production, are reduced.
- The productive life of ewes increases.
- There is a large savings of roughage between weaning and lambing.

- Feeding a better quality feed (10 MJ of ME/Kg DM) after weaning at 80 days, to achieve a mating weight of 40 kg at 18 months of age, compared with feeding a lower quality feed to reach the same mating weight at 2 years, reduces dry matter intake from weaning to mating by 40% (Economides 1994).

Lamb Fattening from Weaning to Slaughter

High energy intake in association with adequate protein intake from weaning to slaughter will give maximum performance. Therefore, intensive lamb fattening is based on *ad libitum* feeding of diets high in energy concentration and of adequate nitrogen content (16–14% CP as fed). The heavier lamb is generally more profitable, unless there is price discrimination or high cost feed is used to obtain part of the gain (Terrill 1985). The increase in rate of gain, better feed efficiency and decrease in feed and other costs will increase the efficiency of meat production, but improved management will generally have a greater effect than the cost of purchased feed (Terrill 1985). In Cyprus, with early weaning of lambs, fattening on balanced concentrate diets and slaughter at high live weights, meat production doubled with an extra energy intake of 18% by the lamb (Economides 1983, 1992).

Effect of Increasing Live Weight at Slaughter on Feed Intake, Feed Efficiency, Carcass Weight, and Carcass Composition

Economides and Koumas (unpublished) found that increasing live weight at slaughter from 16.25 kg to 45 kg increased carcass weight from 7.94 to 20.70 kg (Table 3). The percentage of lean meat decreased and fat increased with increasing carcass weight in a sample joint. Feed efficiency declined rapidly when weight at slaughter was increased.

Effect of Additives and Supplementation on the Performance of Lambs

Feed intake, live weight gain and feed conversion efficiency of lambs were not influenced when the concentrate mixture was supplemented with lasalocid sodium or flavomycin (Economides et al. 1988), but the performance of male lambs was considerably improved when the basic concentrate diet was supplemented with vitamins A, D₃, E, and a trace element mixture (Economides 1987b: Table 4). Economides et al. (1987) shows that Naimi lambs offered balanced concentrate diets consume more feed, grow faster, and convert feed more efficiently than lambs offered barley grain and a mineral plus vitamin block. Although the balanced diet is more expensive, these lambs are more profitable. Lambs weaned at two months of age perform better than four month old lambs.

Table 3. Effect of live weight at slaughter on the performance and carcass composition of male lambs (Economides and Koumas, unpublished).

Live weight (kg)	16.2 [†]	24.8	30.0	35.3	40.3	45.8
Age (days)	39	71	87	102	122	131
Carcass weight (kg)	7.94	10.85	13.02	14.71	18.23	20.70
Feed intake (kg)	63 [‡]	28	54	74	111	135
Feed/gain ratio (g/g)	(5.4) [‡]	2.91	3.67	3.73	4.31	4.69
Best end of neck joint						
Lean (%)	44.6	47.1	45.5	43.0	40.7	41.5
Fat (%)	33.4	33.6	34.4	37.2	37.6	40.4
Ribeye area (cm ²)	8.20	9.09	9.89	9.93	10.39	10.00
Fat thickness (mm)		3.20	3.73	3.87	5.20	6.06

[†] Weaning.

[‡] Intake of milk and ratio of milk : gain.

Table 4. Effect of diet supplementation with trace elements and vitamins on performance of male lambs (Economides 1987).

	Basic diet	Basic diet + trace elements [†]	Basic diet + vitamins [‡]	Basic diet + trace elements [†] + vitamins [‡]
Initial weight (kg)	17.4	17.0	17.0	16.8
Final weight (kg)	32.1	33.6	37.0	38.7
Daily gain (kg)	0.233	0.264	0.315	0.348

[†] Supplying 25 mg Mn, 1.75 mg I, 45 mg Zn, 30 mg Fe, 2 mg Co and 60 mg Mg.

[‡] Supplying 6,000 I.U. vit. A, 1,000 I.U. vit. D. and 8.5 I.U. vit. E.

Substitution of Soybean Meal by Leguminous Seed or Sunflower meal

Growth rate, feed intake, and feed conversion efficiency were similar when soybean meal was replaced partly or completely by common vetch seed (*Vicia sativa*), broad bean (*V. faba*), pea (*Pisum sativum*), and sunflower meal in concentrate diets of fattening lambs from weaning to slaughter. It was concluded that the substitution of soybean meal by common vetch, broadbean, pea, and sunflower meal is possible, and that their use in lamb feeding depends on the price relationship between these feedstuffs and barley grain (Koumas and Economides 1987; Koumas and Economides, unpublished).

Effect of Nitrogen Source on Lamb Performance

Although final live weight and growth rate were significantly higher, and feed-to-gain ratio was better with male lambs on the soybean diet containing no urea, the cost per kg live weight gain was lower with the urea diets. The performance of female lambs was similar on the three diets, and feed costs were also lower on the urea diets. In addition, the performance of male and female lambs was similar on either soybean or urea diets from 84 to 140 days. (Economides 1987a).

In other studies in the region lamb performance was improved when a basic barley grain diet was supplemented with urea feed blocks, urea premix or a protein source such as cottonseed (ICARDA 1994). Under intensive fattening, feeding of urea blocks was inferior to urea premix, cottonseed cake, or concentrate mixture.

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Survey of Small Ruminant Systems in Lebanon

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Abstract

A 1993 survey of small ruminant flocks in Lebanon's Bekaa Valley found three small ruminant systems: sedentary village flocks, migratory flocks, and semi-sedentary flocks. A follow-up survey was conducted in 1994/95 on 16 flock owners to monitor the impact of a disease control program. All three systems had low productivity and high abortion and mortality rates. The disease control program improved birth and 90 day weight in both sheep and goats in all three systems, but not milk production, except in goats in migratory flocks. Costs and income were recorded and profits calculated. Flocks with more sheep than goats and those of moderate size were more profitable. Small ruminants were still a reserve of capital for when money is needed.

Introduction

Small ruminants play an important role in Lebanese agriculture (FAO 1980). Sheep and goats are still raised traditionally, and thus small ruminant production is one of the least-developed sectors of Lebanese agriculture. Several projects for the improvement of the small ruminant sector are now being planned or implemented in Lebanon's Bekaa Valley, home to around 50% of the country's sheep and goats. Little information on small ruminant production in Lebanon is available. A survey conducted by Hamadeh et al. (1993) in the Bekaa Valley identified three main small ruminant systems or clusters: sedentary, migratory/semi-nomadic, and semi-sedentary. A second study was launched in 1994 (Hammad 1995) to examine in greater detail the production and management of flocks to make an economic analysis of the systems and to assess the results of a program of disease control.

Materials and Methods

Survey Region

This study was conducted in the Bekaa Valley, Lebanon's largest province and main agricultural area. Annual rainfall ranges from 410 mm in the valley to 1,200 mm on the mountain top.

The sample of farmers in this study was drawn from that of the 1993 survey by Hamadeh et al., in which farmers were grouped in three different systems or clusters. One cluster had sedentary village flocks composed mainly of sheep and fed mainly crop residues. The second, with more goats than sheep, was a migratory system with major use of native pastures. The third cluster was of semi-sedentary flocks with more goats than sheep and moderate use of native pastures.

Six farmers from each cluster agreed to take part in the study. The 18 flocks were made up of 1,900 sheep (of the indigenous fat-tail Awassi breed) and 3,380 goats (of the rustic Baladi breed). Two farmers later left and data for their flocks were eliminated from the study. The 16 remaining flocks were monitored monthly for one year starting in May 1994.

Field Survey Method

A detailed questionnaire was used to obtain information on the composition of the sheep and goat flocks, feeding, management practices, productivity, main inputs, breeding, crop yields, and economic costs and return.

The questionnaire was also designed to determine the feeding/grazing calendar (Nordblom et al. 1993) of the flocks.

Disease Control Program

A sub-sample of 20 ewes or 20 goats was selected at random from each flock (depending on which was the major species) and ear-tagged. Ten of the animals in each group were treated while the others were kept as untreated controls. Both groups remained in the flock under the same management. The treated animals were vaccinated against sheep or goat pox, foot and mouth disease (Aftovax[®], Rhone Merieux, Lyon, France), and enterotoxemia (Imotoxan[®], Rhone Merieux, Lyon, France). They were also treated with Albendazole (manufactured by Veterin S.A., Attica, Greece) in May and November, to prevent internal parasites. Treatment for external parasites was by dipping or spraying (Neocidol[®] 600EC, CIBA Geigy, Basel, Switzerland) directly after shearing and whenever the presence of external parasites was noticed.

During the study, the following diseases occurred: pleuropneumonia, sheep pox, and enterotoxemia, each in one flock; mastitis, in two flocks; and foot and mouth disease, in three flocks. Neonatal diarrhea occurred in most flocks.

Production Data

Production data were recorded for 320 ewes and goats. The lambs and kids were weighed at birth or within five days and at 90 days, the approximate time of weaning. Weights recorded in the five days after birth were adjusted to give an estimated birth weight. Milk yield was recorded volumetrically from a selected group of animals in each flock in mid-lactation. Total monthly milk production for the flock was estimated by the farmers. Details of reproduction, mortality, and sale were recorded.

Statistical Analysis

The effect of treatment for disease and parasites on birth and 90-day weights and milk yield was analyzed, using a split plot analysis of variance technique (SPSS 1987).

Economic Analysis

Data for economic analysis by flock and cluster were obtained every month. Income was calculated from data on milk production and sale of lambs, kids, culled animals, manure, wool, and crops, where applicable. Costs were calculated for veterinary supplies, mixed concentrates and roughage, and for machinery, seed, fertilizer, and chemicals for crop production. Other expenses included renting land, labor, and water.

Costs and return for the flock and for each cluster were compared for the periods June–August, September–November, December–February, and March–May.

Results and Discussion

The general characteristics of the sample of farmers in the three clusters are listed in Table 1. Goats were the main species in the migratory and semi-sedentary systems, and sheep were the main species in the sedentary system.

Table 1. Characteristics of the three clusters.

Cluster [†]	No. of farmers	Farm size (ha)	Mean flock size (head)	Majority species	Ratio sheep/goats	Rangeland Use [‡]
1	6	7.8	235	sheep	5.5:1.0	Moderate
2	5	12.2	527	goats	1.0:6.4	Heavy
3	5	17.8	247	goats	1.0:20	Heavy

[†] Cluster 1, sedentary village; cluster 2, migratory; cluster 3, semi-sedentary flocks.

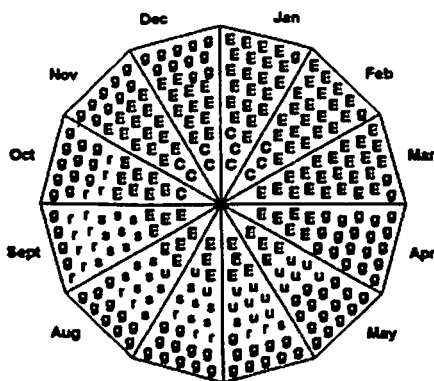
[‡] Determined from estimated contribution to diet (%): moderate <40% and heavy >45%.

Land use by the three clusters is shown in Table 2. Flocks in the sedentary system stayed near the village throughout the year and usually grazed the common and village-controlled rangelands. The other clusters left the base village for several months during the dry season to graze leased agricultural land and distant rangeland. In general, all three systems were highly dependent on rented grazing.

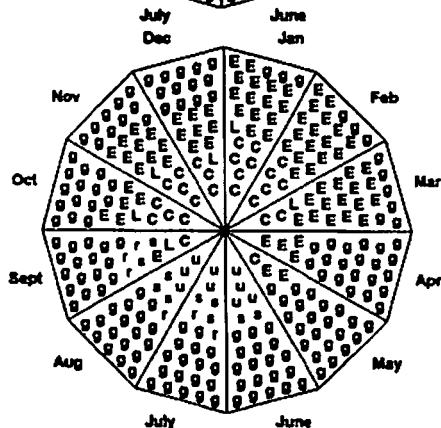
Table 2. Area (%) grazed by flocks in the three clusters.

	Cluster		
	1	2	3
Rangeland open for all	20	27	8
Rangeland controlled by village	20	13	23
Fallow land rented for grazing	13	6	0
Rangeland owned by farmer	7	7	8
Agriculture private land	13	27	38
Agricultural land rented from others	27	20	23

cluster 1



cluster 2



cluster 3

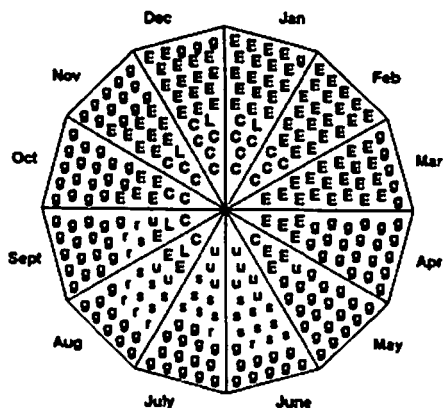


Figure 1. Ingredients of small ruminant diets by clusters of farmers in Lebanon (1994–1995, monthly interview technique). Each symbol represents 4% of the diet. Upper case symbols denote hand feeding: C = cereal straw; L = legume straw; E = energy feeds. Lower case symbols denote that animals were grazing: c = cereal stubble; r = higher-nitrogen crop residues (e.g. sugar beet); u = unharvested crops; g = pasture and rangeland grazing.

Management Practices

Nutrition

Figure 1 presents the mean feeding/grazing calendars for the three clusters. Hand feeding as a percentage of the diet ranged from 14 to 96%, 0 to 90%, and 0 to 98% in clusters 1, 2 and 3, respectively. Hand feeding was highest from December to March, coinciding with late pregnancy and the lambing and kidding season. There was no hand feeding from June to August, when unharvested cereals and vegetable residue were the source of feed.

Mean total hand-feeding was 270, 90, and 130 kg/head in clusters 1, 2, and 3, respectively. These figures were higher than those reported previously by Hamadeh et al. (1993). Wheat bran and barley grain were the major energy feeds. Sugar beet pulp was used, especially in cluster 1. This is associated with increased availability in the Bekaa valley.

Grazing resources provided most of the diet from April to December. In cluster 1, common native pastures were grazed from April to June with some use of unharvested cereal crops in May. In June, crop residues, cereal stubbles, and unharvested crops comprised 44% of the diet and were the main feed resources from July to October. In clusters 2 and 3, native pastures provided most of the grazing from April to November, with a high use of cereal stubbles from June to August.

Mating and Parturition

Rams and bucks were kept in the flocks throughout the year, resulting in haphazard mating with peaks from June to August (30–45 days) in sheep, and from late July to early November (30–40 days) in goats. As a result, the lambing and kidding season spreads over four to five months in ewes, with a peak from December to January, and four to nine months in does, with a peak from February to March.

In general, no supplementary feed was given during the mating period. Age at first mating was 24 months in goats and 12–18 months in ewes. Ewes and does were culled at 7–8 years of age or whenever they failed to give birth for two consecutive seasons, and males generally at four to five years. Superior males, however, were kept.

Lambs and kids were kept in confinement for two to three months and milk was the only source of feed, with some concentrate supplementation at weaning. Lambs and kids were allowed to suckle their mothers only twice a day, since farmers believe that more frequent suckling causes diarrhea. After weaning, they were allowed to graze with the rest of the flock.

Milking and Shearing

Milking of ewes and does in all three clusters began at weaning, with some farmers

starting a little earlier, and continued for 5–10 months in sheep flocks and 8–11 months in goat flocks. Milking was done by hand by the women.

The annual shearing took place in May and June, with clusters 1 and 2 shearing earlier than sedentary flocks. All wool produced was sold to carpet makers.

Performance

The number of kids and lambs born alive and weaned per pregnant female was 0.86 and 0.95, and 0.74 and 0.88, respectively (Table 3). The figures were higher in cluster 1 than in clusters 2 and 3, where abortion and mortality rates were higher.

Table 3. Performance of sheep and goats in the three clusters.

	Cluster		
	1	2	3
Lambs born/ewe	0.95	0.73	0.78
Lambs weaned/ewe	0.88	0.68	0.72
Kids born/doe	0.86	0.82	0.79
Kids weaned/doe	0.74	0.64	0.68
Lamb mortality rate	0.07	0.08	0.09
Kid mortality rate	0.15	0.22	0.14
Adult mortality rate	0.04	0.06	0.05
Abortion rate	0.12	0.27	0.25
Twining rate (sheep and goat combined)	0.06	0.11	0.05

The higher abortion rates in clusters 2 and 3 may have been due to brucellosis, which was reported in the region, but no confirmed diagnosis was made.

Milk production was lower in clusters 2 and 3 than in cluster 1 (Table 4), with the exception of goat milk production in cluster 3. The level of milk production was lower than reported by Battacharya and Harb (1973).

Table 4. Mean milk production for the three clusters.

	Clusters (kg/head/season)		
	1	2	3
Ewe	58.7	36.5	46.9
Goat	59.7	43.6	82.5

Birth weight, weaning weight, and weight at sale are shown in Table 5. Mean birth weight of lambs was similar (3.2–3.6 kg) across the three clusters. This weight, however, was lower than that reported for Awassi sheep by Epstein (1985), with means of 4.3 and 4.1 kg for male and females, respectively. Variations in weaning and sale weights were due to differences in management and age. Average fleece weight was similar to that reported by Rottensten and Ampy (1971) for Awassi ewes (2.1 kg) and did not differ between clusters.

Table 5. Birth weight, weight (kg), and age (months) at weaning and sale in the three clusters.

	Cluster		
	1	2	3
Sheep			
Birth weight	3.20	3.6	3.2
Weaning weight	27.8(3) [†]	30.0(3)	24.5(3)
Weight at sale	35.5(3-5)	33.0(3-4)	35.5(3-5)
Goats			
Birth weight	2.25	2.1	2.3
Weaning weight	18.8(3-5)	17.6(3-5)	18.293-4)
Weight at sale	27.5(3-8)	39.6(3-12)	22.6(3-6)

[†] Age in months at weaning or sale

Impact of the Program to Control Diseases and Parasites

The effect of this program on milk yield, and weights at birth and 90 days was evaluated within clusters. There was no significant effect on milk production in goats (Table 6) and a small, but significant ($P < 0.05$) increase in ewes (Table 7).

The program of disease control significantly increased birth and 90 day weight of both lambs and kids (Table 8).

Table 6. Effect of disease and parasite control program on goat milk production (ml) in clusters 2 and 3.

Cluster		Dose No	Mean $\pm$ SE
2	Treated	30	562 ^a $\pm$ 5.76
	Control	30	552 ^a $\pm$ 5.76
3	Treated	30	459 ^b $\pm$ 5.76
	Control	30	481 ^b $\pm$ 5.76

a, b Means with different superscripts differ significantly ($P < 0.05$).

Table 7. Effect of disease and parasite control program on sheep milk production (ml).

Cluster	No. of ewes	Mean $\pm$ SE
1	120	616 $\pm$ 47.6
2	20	591 $\pm$ 116.5
3	60	463 $\pm$ 67.3
Treated	100	570 ^a $\pm$ 6.4
Control	100	544 ^b $\pm$ 6.4

a, b Means with different superscripts differ significantly ($P < 0.05$).

Table 8. Effect of disease and parasite control program on weight (kg) at birth and 90 days for lambs and kids.

Cluster	Sheep			Goats		
	n	Birth weight	90 day weight	n	Birth weight	90 day weight
1	120	4.1±0.1	226.6±0.48	NA		
2	20	4.4±0.22	24.7±1.18	60	2.3±0.17	13.0±0.25
3	60	4.1±0.17	25.8±0.68	60	2.6±0.17	13.7±0.25
Treated	100	4.5±0.19	26.9±0.31	60	2.6±0.06	13.8±0.13
Control	100	3.9±0.19	24.6±0.31	60	2.3±0.06	12.9±0.13

* P < 0.1; ** P < 0.01.

Economic Analysis

Income and expenditure were calculated to evaluate the net benefits farmers gained over the year of the study. The information was used to develop a simple cost-benefit assessment of the surveyed flocks. The gross margin for each farmer in the three clusters was calculated by subtracting the total cost of production from total income (Table 9). Feed was the major input in the three clusters, comprised of purchased concentrates (barley, wheat and maize grain, wheat bran, beet pulp, and cereal and legume straw). Feed accounted for 60, 38, and 49% of the total cost of inputs in clusters 1, 2, and 3, respectively. The cost of grazing was 20, 31, and 13% of the total cost in clusters 1, 2, and 3, respectively.

Table 9. Total cost, income, and profit per flock and per animal, and ratio of sheep to goats in the three clusters.

Flock	No. s&g	Total costs	Cost/ animal	Total income	Income/ animal	Total profit	Profit/ animal	No. sheep	No. goats	Ratio s:g
Cluster 1 (1.000 LL)										
1	105	8.258	79	13.439	128	518	49	79	26	3:1
2	449	10.161	23	31.271	70	21.110	47	374	75	5:1
3	59	7.803	132	11.111	188	3.308	56	59	0	
4	394	38.578	98	43.780	111	5.202	13	330	64	5:1
5	196	23.296	119	20.375	104	-2.921	-15	146	50	3:1
6	208	17.794	86	30.404	146	12.610	61	208	0	
Mean	235	17.648	89	25.063	125	7.415	35	199	36	5.6:1
Cluster 2 (1.000 LL)										
1	957	32.836	34	17.832	19	-15.004	-16	57	900	1:16
2	500	19.666	39	11.893	24	-7.773	-16	0	500	
3	700	13.031	19	10.947	16	-2.084	-3	100	700	1:7
4	160	17.185	107	17.210	108	25	0.16	0	160	
5	320	21.659	68	58.444	183	36.785	115	200	120	2:1
Mean	527	20.875	53	23.265	70	2.390	16	71	476	1:6.7
Cluster 3 (1.000 LL)										
1	215	7.974	37	28.805	134	2.0831	97	0	215	
2	250	14.860	59	8.962	36	-5.898	-24	18	232	1:13
3	86	8.705	101	8.550	99	-156	-2	0	86	
4	314	8.315	26	43.935	140	3.5621	113	0	314	
5	370	16.299	44	17.791	48	1.492	4	330	40	8:1

Income from the sale of lambs or kids accounted for 34, 44, and 20% of total income, and from milk, 20, 46, and 25% in clusters 1, 2, and 3, respectively.

Veterinary costs, mainly vaccines and drugs to control parasites, were less than 5% of total cost in all clusters. Other costs, including water (usually brought by tankers) fertilizer, pesticide, seed, machinery, animal death, and labor, accounted for about 20%, 29%, and 46% of total costs for clusters 1, 2, and 3, respectively.

Table 9 presents the costs, income, and profits per animal, flock size, and ratio of sheep and goats. In general, farmers with medium-sized flocks did better than those with small or large flocks. Profits per animal in clusters 1 and 3 were much higher than in cluster 2. Flocks two and four in cluster 1 (Table 9), which had the same ratio of sheep to goats, generated different profits/animal, probably because farmer four considered small ruminant production a secondary activity on his farm. All the farmers considered small ruminants to be a store of capital for when cash was needed. The program of disease control was uneconomical, as the increase in the output of meat and milk did not cover the cost of vaccines and drugs.

Conclusions

The study shows low productivity in all three systems. Inadequate feeding may be a limiting factor to productivity. On-farm trials are needed on feeding practices, feed requirements, and evaluation of common feeds.

The program of disease control measures was not economic, in spite of improving birth and 90 day weights of both lambs and kids. A full screening of diseases will help in the development of a more adequate and cost-effective program of disease control. Economic analysis reveals that small ruminant production was profitable in some of the flocks in the survey, but the economics of production and marketing should be studied in more detail, and the factors limiting returns identified.

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Discussion

M. Harb: Milk production is very low (58 kg). In the 1970s we were receiving 120 kg/ewe.

S. Hamadeh: Health was well managed then. Governmental services were very active. Values reported by farmers involved the whole flock, including ewes that did not have lambs or had aborted. On-farm monitoring of milk production shows higher production: 0.6 kg/head/day and as much as 90–100 kg/ewe/season.

The Role of Crop Residues and Agro-Industrial By-products In Filling the Deficit of Animal Feedstuffs In the Middle East

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Abstract

In spite of its potential, livestock productivity in the Middle East is low because of a shortage of feed and forage. Many countries rely on importing cereal grains to feed livestock. Efforts are, however, now being directed toward the establishment of permanent research and development programs aimed at increasing animal productivity, using local resources. Crop residues, agro-industrial by-products, and animal wastes that are not at present widely utilized can fill at least part of the gap between supply of and demand for conventional feed resources. This paper provides information on by-products available in the region, reviews experience gained inside and outside the region on the use of non-conventional feedstuffs, describes methods for improving their nutritional, storage, and handling qualities, and discusses the use of urea blocks to meet the deficit of animal feedstuffs in the Middle East.

Introduction

Livestock owners throughout the Middle East have been subject to severe climatic conditions marked by long dry periods. This has occurred at a time of rapid human population growth, resulting in the expansion of cultivation into areas formerly used for grazing. This growth in human population has been accompanied in most countries by a simultaneous increase in animal population, resulting in a deterioration in grazing areas, with adverse effects on animal performance. Efforts to increase the output of animal products to meet increased requirements have greatly boosted the demand for conventional feed resources, leading to an increase in imported concentrates and a considerable expenditure of foreign currency (FAO 1993).

Governments in the region have become aware of the situation and recognize that they can reduce imports of concentrates by using agricultural residues and some animal wastes specifically suited to ruminant livestock feeding.

This paper discusses:

- By-products available in the region.

- A methodology for estimating available quantities.
- Experiences both in and out of the region on the use of non-conventional feedstuffs.
- Methods for upgrading nutritional, storage, and handling qualities of by-products.
- The use of urea blocks made from by-products.

The Utilization of By-products

To achieve greater and improved use of by-products, information is needed on their quantity, type, seasonal availability, alternative uses, relative costs, and feeding value. Information on their location and that of the animals, and the identification of any anti-nutritional constraints associated with their use are also necessary. The amount of crop residues and animal wastes may be estimated from the main product (Tables 1, 2, and 3).

Table 1. Ratio of by-product to main product for major by-products in the Middle East.

By-product	Ratio by-product/main product
Almond hulls	1.7:1
Citrus pulp (juice : pulp)	0.4-0.55:0.6-0.45
Grape marc	0.06:0.94
Groundnut hulls	0.32:0.68
Olive cake (OC)	0.37:0.63
Solvent extracted OC (SEOC)	0.29:0.71
Sorghum, maize, millet stover	2.00:1.00
Sugar cane tops	1.00:4.00
Sugar beet pulp	0.25-0.33:0.75-0.67
Tomato pulp	0.07:0.93
Wheat, barley, rice, oat straw	1:1

Crop By-products

Small grain cereal by-products are widely available in arable areas and are used to feed ruminants in different forms. Sheep and goats are either put onto the stubble after harvest, or are fed chopped/long straw as part of the diet during the winter. The major drawback to feeding straw is its inherent low intake based on its low digestibility. This low digestibility can be considerably improved by treatment with chemicals (NaOH, urea, ammonia gas, NH_4OH , etc.). In studies carried out at the Cyprus Agricultural Research Institute, straw treated with 10% urea solution at a rate of 400 ml/kg had higher voluntary intake, metabolizable energy intake, as well as crude fiber and dry matter digestibility, by 47, 77, 40, and 26%, respectively, than untreated straw. When urea-treated straw was given to high-yielding dairy and growing animals on an overall good quality diet, the response was small, but when it was given to animals on a poor diet the response was significant (Hadjipanayiotou 1989).

Supplementary feeding can improve straw intake and utilization. The supplementation of straw with soybean meal (150 g/head/day), or a molasses-urea mixture *ad libitum*, resulted in increased straw intake (Hadjipanayiotou et al. 1975). Similarly, straw intake by mature Chios ewes increased by 31, 22, and 19% when straw was supplemented daily with 80 g soybean meal plus 170 g barley grain, 240 g barley grain plus 10 g urea, or 250 g barley grain, respectively (Economides et al. 1981). ICARDA studies (ICARDA 1986) show that the addition of 170 g DM/head/day of barley grain changes live weight losses on unsupplemented straw into modest live weight gains, with no significant increase in the supply of dietary energy from straw. The provision of 130 g/head/day of cottonseed cake significantly improves the organic matter intake from straw, as well as live weight gain.

In studies carried out in Mashreq Project countries, urea blocks made from a variety of agricultural by-products (olive cake, poultry manure, molasses, fresh sugarbeet pulp, etc.), resulted in a significant improvement in the performance of sheep fed on cereal straw (Table 2). The wider use of urea blocks over the dry season (May–November) is strongly recommended, not only because of the positive effects on animal performance, but also because it increases the use of agricultural by-products and animal wastes (Hadjipanayiotou et al. 1993a).

Table 2. Performance of sheep grazing cereal stubble with and without urea blocks (UB).

Country Treatment	Iraq		Jordan		Syria	
	None	UB	None	UB	None	UB
No. of animals	30	30	11	12	99	100
Initial LWT (kg)	48.4	49.4	29.7	31.8	45.8	44.8
Final LWT (kg)	50.8	53.6	31.5	33.9	41.5	43.0
LWT change (g/d)	57	115	61	83	-101	-41

With increased maize production in some countries in the region, maize residues are becoming available for animal feeding. In other parts of the world, maize stover, after being chopped into 2–6 cm lengths, is ensiled either alone or with poultry litter, molasses, etc. Snyman (1991) gave an IVDMD of 50.7–57.8% for maize residue, which is much greater than wheat (36%), barley (40%), or oat straw (45%). Collection of residue as soon as possible after grain harvest is desirable in order to obtain better quality silage.

Food Legume Straw

The contribution of food legume straw to ruminant livestock requirements is limited compared to cereal straws, but it can be important on a local or seasonal basis. An example is the use of lentil straw fed to sheep during winter in Syria. Compared with barley and wheat straw, food legume straw is more digestible and contains more crude protein (Hadjipanayiotou and Economides 1985). Countries where food legume straw is potentially important in relation to total feed requirements are Morocco (3.6%), Egypt (2.7%), Turkey (3.8%) and Syria (2.4%). Lentil and faba bean straw, fed *ad libitum*, can meet the requirements of ewes in late lactation. Similarly, lambs of 25 to 30 kg, if fed these straws, grow at around 50 g per day.

Peanut Crop By-products

Peanut hay, hulls, and skins (testa) are by-products of peanut production. Hadjichristodoulou (1987) reports mean pod yield of 4.1 t/ha, with an average shelling percentage of 61%, and 7.8 t/ha of leaves and stems, with approximately 37% DM. Hadjipanayiotou (1988) demonstrates that peanut hay, with 9.4% CP and an *in vitro* OM digestibility of 68%, is a medium-quality roughage.

Although peanut hulls have low CP and digestibility, up to 20% have been included in steer finishing diets without adverse effects on performance (Hill and Utley 1987). Peanut skins, with 15.5–17.7% CP, 21–23.8% ether extract, and 20.5–23.8% tannin, appear to be a desirable feed ingredient, but they affect protein metabolism and should be limited to approximately 16% of the diet, which should exceed the recommended minimum CP content (West et al. 1993).

Sugarcane By-products

Cane tops and bagasse are the main by-products of sugarcane production. Bagasse production equals about 12% of sugarcane crushed. It is a low-quality feed, mainly because of its high percentage of lignocellulose. When fed with energy and protein supplements, moderate levels of bagasse can promote satisfactory weight gains, but diets with more than 30% bagasse by weight tend to depress animal performance.

Cane tops are a medium-quality fodder when fresh and may be fed fresh or as silage during the off-milling season. Average production is estimated at 11.5 t/ha. More details on sugarcane by-products can be found in FAO (1988).

Citrus Pulp

Citrus pulp is the residue remaining after the extraction of juice. On average, citrus pulp represents 60% of the fresh weight of the fruit, and has a mean DM of 19.7% (Boucque and Fiems 1988). Pressing reduces the moisture to 65–75%. On a DM basis, it contains 12.5 MJ of ME and 6.7% CP (NRC 1989). Dried citrus pulp may successfully comprise a considerable part—up to 60%—of the concentrate mixture. In the form of silage, made in combination with other by-products with a high DM content, such as poultry litter, it can make a significant contribution to the nutrient requirements of growing ruminants (Hadjipanayiotou 1987, 1993).

Potato Processing Residue

Potato processing residue (PPR) represents a good source of carbohydrate for ruminants. It is available from processing plants as a slurry. Because of its high moisture content (88–92%), it is offered to farms close to the processing plants. It contains 14.9 MJ of ME in terms of DM, and 8.4% CP (NRC 1989).

Tomato Pulp

Tomato pulp, a mixture of peel (66%) and seed (33%), accounts for about 4.5% of the fresh weight. Despite its high nutritional value (8.9 MJ of ME/kg DM and

23.5% CP), dehydration of the by-product is difficult because of its high moisture content (approximately 86%). Additional information on other vegetable by-products and waste can be found in Boucque and Fiems (1988).

Grape Marc

Grape marc is a mixture of seed and pulp. After pressing, approximately 6 kg of grape marc, with about 50% DM, is obtained from 100 kg of grapes. Dried marc consists of 40% seed and 60% pulp. It is very palatable, and its intake should be limited. Dried grape marc has been used successfully in the diets of dairy cows, fattening calves, and lambs (Hadjipanayiotou 1987). Dehydration is uneconomic because of its relatively low nutritive value, with ME MJ 7.69/kg DM and 12.3% CP, which is only 20% digestible. Ensiling of grape marc, either alone or in combination with poultry litter in the proportion 3:2, gives good quality silage, which can be used to replace up to 25% of conventional feedstuffs in ruminant diets.

Almond Hulls

About 50% of the world production of almonds is concentrated in the countries of the Mediterranean basin. The hulls are a by-product of the almond crop and the ratio of hulls to nuts is estimated as 1.7:1 (Alibes et al. 1983). Boucque and Fiems (1988) give a value of zero for CP and 5.28 MJ of NE_i/kg DM of hulls.

Brewing By-products

Brewers' grain is the residue remaining after the liquor is removed from malted grain. It can be ensiled wet before being given to ruminants, but also may be used directly. Most moisture is on the surface of the grain, and 20% of the total weight may be lost as effluent during storage. Brewers' grain has a moderate energy content (10.4 MJ of ME/kg DM) but is rich in protein (25.4% CP, DM basis), which is of low rumen degradability. Good-quality blocks containing up to 65% fresh brewers' grain with urea, wheat bran, and dried poultry manure were successfully used to supplement ruminants on poor quality roughage. Fresh brewers yeast, which has 46.9% CP on a DM basis, can also be used in blocks.

Sugar Beet By-products

Sugar beet tops and crowns are an important source of feed in certain areas. The yield is approximately 30 t/ha of fresh material. Contamination with silica from soil can vary from 8 to 25% of DM. It is advisable to ensile sugar beet tops in alternate layers with dry by-products, such as straw, groundnut shells, and poultry litter, so that the liquid effluent is absorbed and fed.

About 5 kg DM of sugar beet pulp is obtained per 100 kg of sugar beets. The pulp may be used as produced in the factory, with a DM content of 10–12%, after pressing (20–25%), or dried (88–90% DM). In terms of dry matter, beet pulp has a nutritional value similar to barley grain, with 12.6 MJ of ME and 9.7% CP (NRC 1989). Good quality silage was made in Syria with fresh pulp and poultry litter or straw (Hadjipanayiotou et al. 1993b).

Molasses

Molasses contains 50–60% sugar, with some mineral elements, especially K and Ca. It can be mixed with urea in liquid licks, in mixtures of molasses, urea and vitamins to spray on poor-quality roughage, or formed into blocks. Some very promising results were obtained in Syria from feeding molasses/urea blocks to sheep grazing stubble or offered poor quality roughage (Hadjipanayiotou et al. 1993a).

Olive Cake

World olive production is confined almost entirely to the Mediterranean basin. Crude olive cake, a residue of kernels and pulp left after the oil has been extracted by pressure and centrifuging, is used to a limited extent in animal feeding. It has a low nutritive value, however, because of its high ether extract content (about 11.5%), and cannot be stored. The solvent extraction of oil from crude olive cake is essential to improve its storage quality. The solvent-extracted oil is also a valuable product. Removal of stones, using a screen, strong air draft, or a combination of the two, further improves the nutritional value.

Crude olive cake stored in heaps next to the processing plant deteriorates quickly. The voluntary intake of such cake decreases with storage. Ensiling such a product either alone or with screened poultry litter (Hadjipanayiotou 1994) gives a well-preserved palatable feedstuff. Consumption of such silage by mature sheep (66 kg BW), growing lambs (42 kg BW), and kids (35 kg BW) fed with conventional feedstuffs that met 70% of their daily energy requirements, was 1,270, 730, and 380 g silage DM/head/day, respectively. Performance was similar to that of the control groups fed concentrate and barley hay.

Waste Palm Dates

Waste palm dates are high in soluble carbohydrates (47%) and low in cell walls (NDF 25%) and CP (3.7%), and appear to be a satisfactory energy source. Rihani et al. (1984) used waste palm dates for up to 50% of the diet fed to growing lambs. Date pulp has also been used in the manufacture of urea blocks in Iraq (Mashreq Project Annual Report 1993/94).

Banana Plant Residue

In tropical and subtropical countries, banana and sugarcane are the two crops yielding the highest biomass per unit area. Banana plant waste is of considerable importance in feeding ruminants. The whole plant can be used as efficiently as the tops alone, if supplementary protein is provided to improve rumen function. The digestibility of banana leaves is lower than that of stems (65.2% versus 75.4%). The non-leafy portions of the banana plant (pseudostem, plantain sheath), constitute nearly 80% of the whole plant. The plantain sheath has only 5.2–8.9% DM, with 3.1–3.5% CP in terms of DM. Digestibility of the leaves and stems showed variations and was affected by the time of harvest, age of the plant, ratio of leaves to stems, and the proportion of other components in the rations. There are

no problems with the intake of leaves or pseudostems, fed alone or in mixtures with other forages.

Processing of High-moisture By-products

High moisture agro-industrial by-products (14–25% DM) such as citrus, sugarbeet, tomato pulp, etc., are often of high nutritional value. Dehydration of these by-products results in a product that is very easy to handle but increases cost. About 250–280 liters of fossil fuel and 200 kwh of electricity are required to produce one ton of dry material (88–89% DM). In some Mediterranean countries these by-products are given to animals fresh or after sun-drying. This limits the quantities that can be utilized. Feeding them fresh often results in high wastage. On the other hand, high-moisture by-products exposed to the sun for drying either ferment, go sour, or moldy quickly, lose considerable quantities of soluble nutrients in the effluent, and may become a breeding ground for flies. Transportation costs are high, and it is preferable to use these by-products close to the production site. The existence of animals in the area, and the development of simple, safe, effective, and low-cost methods for processing and feeding such by-products, are important to increasing their use.

Citrus pulp, grape marc, sugarbeet pulp, and tomato pulp have all been successfully ensiled with crop residues (chopped straw, groundnut shells, and partially dried grass or legumes) which have a low moisture content, or with screened poultry litter. Such silage can replace conventional feedstuffs, including concentrates. Some animal performance data are given by Hadjipanayiotou (1987, 1993) and Hadjipanayiotou et al. (1993b).

Animal Excreta

Animal excreta is a feed resource that is not presently used to its nutritional and economic potential. There is, however, abundant data both in (Hadjipanayiotou 1984; Hadjipanayiotou et al. 1993b; Kiflewahid 1983; Tagari, 1977; Muller 1980) and out of (Fontenot 1981) the region showing that animal excreta can be used as a partial replacement for conventional energy (barley, corn grain) and protein (soybean meal, cottonseed cake) feed resources. Smith and Wheeler (1979) suggest that animal excreta, including bedding and associated material, has a value 3–10 times greater as a component of animal feed than as a plant nutrient. The value of excreta was greater when used to replace a protein source rather than an energy source. The performance of different classes of ruminants fed on animal excreta products is reviewed by Smith and Wheeler (1979) and summarized in Table 3.

Table 3. Performance of animals fed diets containing animal excreta.

Class of animal	Excreta product	DM intake (kg/day)		Live weight gain or milk production (kg/day)		Feed conversion (kg feed/kg gain)	
		Control	Experimental	Control	Experimental	Control	Experimental
Cattle	PL	10.0	10.3 (24) [†]	0.99	0.94	10.4	11.4
Cattle	DPE	6.61	6.34 (15)	1.07	1.10	7.25	6.49
Cattle	CE	8.27	8.22 (12)	1.16	1.15	8.30	8.70
Sheep	DPE	1.07	1.04 (17)	0.189	0.171	7.06	6.59
Dairy cows	DPE	18.8	19.1 (12)	18.4	18.2		

PL = poultry litter; DPE = dehydrated poultry excreta; CE = cattle excreta.

[†] Percentage of excreta in the total DM

Source: Smith and Wheeler (1979).

Level of Inclusion

The level of inclusion of excreta in the finished diet depends on the quality of the excreta and the physiological state of the animals. Hadjipanayiotou (1984) included up to 30% dried poultry litter in concentrate mixtures for fattening lambs, kids, calves, and lactating ewes and goats. Table 5 shows the mean level of inclusion of animal excreta in diets of cattle and sheep tested in the United States (Smith and Wheeler, 1979). Additional information on inclusion rates is also given by Wilkinson (1988). In intensive systems, litter should not exceed 20% of the daily ration. In periods of low productivity (late lactation, dry period, early pregnancy), litter may comprise more than 35% of the diet. During late pregnancy and early lactation, only small quantities (about 5%) should be fed, whereas larger quantities (15–20%) can be fed immediately after weaning.

Safety considerations

An obstacle to feeding animal excreta to livestock is the presence of pathogenic organisms in the litter. It must be born in mind, however, that problems do not relate to waste alone; conventional feeds may also contain a large number of contaminants in the form of phytotoxins, pesticides, pathogens, and other xenobiotics. Fontenot (1981), Gilka (1985), Roothaert and Matthewman (1992), and Jakhmola et al. (1988) show that decontaminated, well-processed, and preserved animal excreta products incorporated in nutritionally balanced rations do not cause any ill effects in animals or in the humans consuming products from these animals.

Decontamination of animal excreta

It has been shown that animal wastes can be rendered free of pathogens by autoclaving, fumigation and dry heat either alone or in combination with paraformaldehyde treatment (Caswell et al. 1975). Other methods of processing, such as ensiling (Caswell et al. 1977) and deep stacking (Strickler 1977), have also been effective in eliminating pathogens. Arndt et al. (1979) discusses the selection of the processing procedure, taking into consideration the advantages and disadvantages in relation to the production system and local conditions. It is the author's belief, however, that ensiling is a safe, simple, and low-cost method that can be widely used by farmers in this region (Table 4).

Slaughter Offal

The production of abattoir by-products from different animal species as outlined by Politek and Bakker (1982) is given in Table 5. The nutritional value of these by-products is very high, and blood, meat, and bone meal are high-quality protein sources for both ruminant and non-ruminant animals.

Ensiling has received considerable attention in recent years as a means of preserving animal by-products, and has also been applied to the treatment of fish waste for use in animal feeds. Lactic acid fermentation is a cheaper and simpler alternative to drying for preserving slaughter offal. Ensiled slaughter offal has a high moisture content and, although drying costs are avoided, transportation costs

are high, and its use is restricted to areas close to the production site. Proper storage, preferably in airtight silos, is needed at the farm to ensure the stability of the product. The problem associated with the high moisture content of the slaughter offal silage can be overcome by incorporating a by-product of high DM content. El-Yassin et al. (1991) made good-quality silage (pH 4.56 and 2.4% lactic acid, in terms of DM) from a mixture containing 45% rumen contents, 15% whole blood, and 40% wheat straw.

Table 4. Estimated production (kg DM/day) of collectable animal excreta.

Cattle		Pigs		Poultry	
Dairy cows	Beef cows	Finishing	Sows	Caged layers	Broilers
4.5	3.5	0.06	0.1	0.026	0.02

After Politiek and Bakker (1982).

Table 5. Production (kg/head) of abattoir by-products by different animal species in Europe.

Animal	Blood meal	Meat and bone meal	Fat
Cattle	1.65	41.4	17.6
Sheep	0.26	5.82	0.6
Pigs	0.52	11.3	0.24
Poultry	0.0112	0.24	

After Politiek and Bakker (1982).

Pickling with acid is an alternative approach. Divikaran and Sawa (1986) produced a product with potential use as a source of protein in animal feeds by mixing fresh blood and ground offal with a mixture of concentrated sulfuric and phosphoric acids (1.5% each by weight, for a total acid concentration of 3% diluted with an equal weight of water before being added to the material) and leaving it at room temperature for 72 hours.

Milk Whey

Whey, a by-product of cheese processing plants (0.9 t/t of milk processed for cheese making), is a heavy pollutant because of its high organic matter content: the pollution load from a cheese factory processing 100,000 liters of milk per day is equivalent to that of a city of 60,000 inhabitants (Petillot 1976). Whey, however, is a useful source of nutrients. It is high in energy (13.2 MJ of ME/kg DM), but relatively low in nitrogen (14.2 kg CP/kg DM). Whey has a feeding value equal to about one-half that of skimmed milk or buttermilk, and 12 parts of whey may replace one part of complete feed (Enminger and Olentine 1979). Feeding liquid milk whey at the rate of 12.5 or 25 liters per cow and per heifer resulted in higher (27–35%) economic returns for the Cypriot dairy farmer (Economides and Antoniou 1990).

Economics

The energy and protein content, and the current price on an as-fed basis for barley grain and soybean meal were used as references for estimating the monetary value of selected by-products (Table 6). Values for energy and protein content were either taken from NRC (1989), and from studies in the region. The monetary value of at least some by-products is high enough to justify the additional costs of transportation, ensiling, labor, etc., associated with their use.

Table 6. Monetary value (CE/t as fed) of selected by-products and conventional feedstuffs.

	DM (%)	CP (% as fed)	ME (MJ as fed)	CE/t (as fed)
Soybean meal [†]	89	44.0	11.40	125
Barley grain [†]	88	10.50	11.40	56
Almond hulls [†]	90	2.42	8.21	29.74
Almond hulls + shell ^{††}	90	1.53	2.65	20.75
Citrus pulp [†]	21	1.53	5.84	11.14
Brewers grain [†]	21	5.33	2.18	17.55
Tomato pulp [†]	14	3.29	1.25	10.55
Beet pulp [†]	20	1.98	2.53	11.71
Beet's tops and crowns [†]	15	2.01	1.14	7.58
Poultry litter (PL) [‡]	75	18.8	6.53	58.41
Beet pulp + PL silage [§]	32	5.18	2.64	22.77
"	"	"	2.92	23.88
"	"	"	3.05	24.39
Olive cake (OC) silage ^{††}	50	3.15	2.23	13.21
OC silage ^{††}	"	"	4.15	19.00
OC+PL silage ^{††}	50	7.4	2.23	21.97
OC+PL silage ^{††}	"	7.4	4.15	27.75

¹ Cyprus pound (CE) = US\$ 2.25.

[†] Composition from NRC (1989).

^{††} Composition from unpublished Cypriot studies.

[§] Composition from Syrian studies, Hadjipanayiotou et al. (1993b).

^{††} Composition from Hadjipanayiotou (unpublished).

Recommendations

Animal waste represents a vast reservoir of cheap nutrients and, after being properly processed, should find wider application in ruminant diets.

Upgraded crop residues, via chemical treatment, ensiling, or supplementation can make a greater contribution towards meeting animal requirements and reducing imports of feedstuffs. Simple, low-cost, on-farm techniques should be preferred for processing crop residues, agro-industrial by-products, and animal wastes. The use of expensive machinery, however, may be justified in areas where by-products are available in large quantities and there are few animals.

By-products should be analyzed frequently, due to high variation between batches.

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Discussion

J. Gresham: Inclusion of new ideas from cattle industries provides helpful alternate, economical solutions. Can you use biomethanation to produce methane gas while stabilizing waste products?

M. Hadjipanayiotou: This has been done using cattle excreta (slurry) and/or excreta of cattle animals. The cost of production, however, has been high due to the lambing system prevailing in the region.

The Effect of Using Plastic or Mud Covers on Urea-treated Straw on Performance and Cost of Fattening of Awassi Lambs

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Abstract

Chopped barley straw with a crude protein content of 2.5% was treated, using a 4% solution of urea, and the pits covered with either plastic (P) or mud (M). *Ad libitum* diets based on treated straw from the P or M covering methods and supplemented with a ration of either a pelleted concentrate (C) or barley grain (B), were offered for 16 weeks to groups of nine Awassi lambs with an initial live weight of 23 kg. The treated straw contained 8.8% and 6.6% crude protein for plastic- and mud- covered materials, respectively. In spite of the lower protein content of the mud-covered material, there were only small differences in the intake and growth of lambs. There was little difference in the cost of the two methods of treating the straw, as the cost of plastic and of the extra labor for covering the pit with mud were very similar.

Introduction

Barley is an abundant feed of poor to moderate quality owing to its high cellulose content. This reduces barley's digestibility and value for ruminants. Treatment with ammonia or urea increases its protein content and makes it more digestible.

Since the use of plastic covers is a major part of the cost of straw treatment, using mud instead could reduce costs. An unreplicated feeding trial compared the feed consumption and growth rates of groups of Awassi lambs. The lambs were fed diets containing barley straw treated with urea in pits covered either with plastic or mud. The economic benefits of the two systems were compared.

Materials and Methods

Straw

Three tons of chopped barley straw were divided into two piles, which were treated with a solution containing 4% urea, placed in separate pits, and covered with either plastic or mud. After 45 days, the pits were opened for ventilation before the straw was fed to lambs.

Lambs

Immediately after weaning, 36 Awassi lambs were divided into four groups, with an average live weight per lamb of 23 kg.

Treatment

The animals on the four treatments were fed urea-treated straw *ad libitum*, from pits covered either with plastic or mud, together with a ration of either a pelleted concentrate formulated for dairy cows or whole barley grain. The trial lasted for 16 weeks, including a one week preliminary period.

Housing and Feeding

The four groups of lambs were housed in an open-sided barn in four pens, each of which had two feed troughs and a water trough. Treated straw was offered at a rate of 600 g/lamb/day. The concentrates or barley were fed at a rate of 2% of live weight, together with 0.2% of a mineral/vitamin mix. Water was available to the lambs at all times. Samples of the straw, concentrate, and barley were taken three times and chemically analyzed for dry matter, ash, fiber, and protein content. Feed refusals were collected and weighed each morning before fresh feed was offered.

Economic Analysis

The cost of feed, labor, materials, and other inputs was recorded.

Results and Discussion

Treatment with urea increased protein content from 2.5% to 8.8% for plastic, and 6.6% for mud (Table 1). The lower CP content of the straw in mud-covered pits was probably due to greater losses of ammonia through cracks in the mud.

Table 1. Analysis of feeds (%).

	Dry matter	Ash	Crude protein
Barley straw	86.8	8.7	2.51
Treated straw plastic covered	94.4	14.5	8.78
Treated straw mud covered	95.9	19.9	6.60
Concentrate	91.8	7.0	19.59
Barley grain	92.3	3.9	14.68

Intake of the concentrate or barley supplements was approximately 2% of mean live weight for lambs over the 105 day feeding period. Intake of treated straw (Table 2) was lower with the barley supplement than the concentrate supplement (174 vs 258 g DM/day), and slightly lower for material covered with mud than with plastic (200 vs 232 g DM/day). The difference in intake of crude protein was slightly greater.

Table 2. Mean daily intakes of supplement, straw and total, daily weight gain and feed conversion efficiency (kg live weight gain/kg total dry matter intake).

Treatment	Dry matter intake (g/head/day)				Weight gain (g/day)	Feed conversion (kg/kg)
	Supplement	Straw	Total	Total crude protein		
PC	675	259	934	155	107	0.115
PB	674	204	878	117	130	0.148
MC	669	257	926	149	114	0.123
MB	673	144	817	109	98	0.120

There was little difference in the mean live weight gains over the 105 day feeding period between the different methods, with means of 119 and 106 g/day for the plastic- and mud-covered materials, respectively.

Two lambs were selected at random for slaughter, and the carcasses were separated into fat tail, muscle and fat, termed meat, and bone. The mean values of the three fractions in kg and as percentage of the carcass weight (Table 3) showed no consistent pattern of response with treatment.

Table 3. Carcass composition.

Treatment	Carcass (kg)	Meat		Fat		Bone	
		kg	% [†]	kg	%	kg	%
PC	20.8	14.65	70.4	2.05	9.9	4.10	19.7
PB	19.05	12.20	64.0	3.15	16.5	3.70	19.4
MC	17.65	12.30	69.7	2.05	11.6	3.30	18.7
MB	17.95	12.55	69.9	2.00	11.1	3.40	18.9

[†] % of carcass weight

Table 4 presents estimates of the cost of treating straw and covering the pits by the two methods. There was little difference in the cost of the two methods, SYL 1.213/kg and SYL 1.195/kg for plastic- and mud-covered pits, respectively, as the cost of plastic was comparable to the cost of the 23 hours of extra labor required to cover the pit with mud. If, however, it is assumed that no hired labor was used and the labor costs are omitted from the calculations, the mud-covered pit was substantially cheaper, SYL 0.663/kg compared with SYL 0.975/kg for the plastic-covered pit.

This trial shows that although covering with mud results in a material with lower crude protein, there is little difference in the performance of lambs fed diets which consist mainly of concentrate or barley. Treated straw formed only 17–27% of the intake. In these circumstances, the method of covering urea-treated straw can be chosen according to the availability of plastic or hired labor.

Table 4. Costs in Syrian Pounds of treating 1500 kg of straw and covering with plastic or mud.

	Plastic	Mud
Digging pit by machine	500	500
Labor to apply urea solution (15 h)	315	315
Urea (60 kg at SYL 8.25/kg)	495	495
Labor to cover pit [†]	42	483
Plastic covering [‡]	467	.
Total	1,819	1,793
Cost per kg of treated straw	1.213	1.195

[†] 2 hours for plastic covering and 23 hours for mud.

[‡] 3 layers of 70 m².

SYL 49 = US\$ 1.

Using Urea Feed Blocks In Fattening Awassi Lambs

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Abstract

The potential of using urea feed blocks as a nitrogen supplement for fattening Awassi lambs was investigated in on-station and on-farm experiments. This was part of a program of adaptive research to demonstrate the possibility of improving the performance of fattening lambs fed whole barley grain, which is traditionally used by farmers in Iraq. Feed blocks were manufactured from urea and locally available agro-industrial by-products.

In an on-station experiment (Experiment 1), 24 Awassi lambs, aged 6 months (30 kg live weight) were divided into three groups and fed whole barley grain *ad libitum*, barley grain plus urea feed blocks, or a concentrate mixture.

Two on-farm experiments were conducted in the Mosul area of northwest Iraq using 80 (Experiment 2) and 90 (Experiment 3) Awassi lambs aged 6–7 months. The lambs in each experiment were divided into two groups and fed whole barley grain with or without feed blocks. Mean live weight gains (g/day) and feed conversion ratios (kg DM/kg live weight) were 174 and 6.54, 195 and 6.15, and 221 and 5.83, for groups 1, 2, and 3 respectively. These results show a similar trend to Experiment 1, which indicates that the urea feed blocks improved performance.

It was concluded that feed blocks can be used as a nitrogen supplement for fattening lambs on barley.

Introduction

Traditionally, barley is the most common feed for fattening sheep in Iraq. It is fed alone or combined with a small amount of roughage. This results in poor feed conversion (1 kg live weight for 8–10 kg barley grain), due largely to the deficiency of protein in the diet. Given Iraq's current situation, there is a serious deficiency of feed, because feed grains are now being used for human consumption, and there is a shortage of imported oil seed meal. Urea feed blocks have been used to improve sheep productivity when the main component of the diet is low-quality roughage (Pearce 1973; Sansoucy et al. 1988; Habib et al. 1991; Hendratio et al. 1991; Hadjipanayiotou et al. 1993).

This work investigated the possibility of using urea feed blocks as a nitrogen supplement in fattening lambs in intensive systems.

Materials and Methods

On-station Experiment (Experiment 1)

Twenty-four 6 month old Awassi lambs, with a mean live weight of 30 kg, were allocated (on the basis of live weight) to three groups of eight. The experimental diets were: whole barley grain alone (T_1), barley grain plus urea feed blocks (T_2), and concentrate mixture alone (T_3). The diets were offered *ad libitum*, together with 100 g/lamb/day of straw. Fresh water was always available. Feed intake was recorded daily, and lamb weight weekly. The experiment lasted for 63 days following a two week adaptation period.

On-farm Experiments (Experiments 2 and 3)

Two on-farm experiments were conducted in the Mosul area with 80 (Experiment 2) and 90 (Experiment 3) Awassi lambs, aged 6–7 months. At each location, the lambs were divided into two groups (on the basis of live weight) and fed either whole barley grain or barley grain plus urea feed blocks *ad libitum*. Feed intake was measured daily, and lamb weight was recorded at the beginning and end of each experiment.

The ingredients and chemical composition of the feed blocks and concentrate mixture used in these experiments are presented in Table 1. The feed blocks were manufactured at the feed block plant at the Fudhalia Research Station of the IPA Agriculture Research Center in Baghdad, which has a capacity of 5–6 tons per day.

Analysis of variance was applied to study the effect of diet on performance.

Table 1. Percentage of ingredients and chemical composition of the feed block and concentrate.

	Percent	Concentrate	Percent
Feed block			
Wheat bran	32	Barley grain	40
Rice bran	22	Wheat bran	52
Poultry litter	20	Groundnut meal	5
Urea	7	CaCO ₃	2
CaO	12	Salt	
CaSO ₄	2		
Salt	5		
Chemical analysis			
Dry matter	89.00		94.00
Crude protein	31.80		14.16
Ether extract	3.67		2.52
Crude fiber	4.46		6.58
Ash	30.2		5.57

Results and Discussion

No health problems or digestive disturbances were observed either on-farm or on-station when lambs were fed urea feed blocks. Lambs fed whole barley grain plus urea feed blocks readily accepted the latter, even when barley grain was offered *ad libitum* during the adaptation and experimental periods. The results of Experiment 1 are presented in Table 2. Mean daily feed block consumption was 74g/lamb. This is lower than that reported by Sansoucy et al. (1988), Habib et al. (1991), Hendratno et al., (1991), and Hadjipanayiotou et al. (1993), whose studies indicate that feed block consumption depends on the type of animal, the basal diet, and the hardness of the feed block. Hadjipanayiotou (1994) reports that the hardness of the feed block depends on the ingredients and the type of mixer used. Our experience with manufacturing feed blocks during the last three years has shown that it is also affected by the type of mold and press used.

Table 2. Performance of lambs in Experiment 1.

	Barley alone	Barley + feed block	Concentrate
Initial live weight (kg)	29.6	30.0	30.0
Final live weight (kg)	40.6 ^a	42.3 ^{ab}	44.6 ^b
Live weight gain (g/day/lamb)	174.0 ^a	195.0 ^{ab}	231.0 ^b
Intake, barley or concentrate (g/day/lamb)	1,139.0	1,127.0	1,347.0
Intake of feed block (g/day/lamb)	74.0		
Total feed intake (g/day/lamb)	1,139.0	1,201.0	1,347.0
Feed conversion ratio (kg DM/kg gain)	6.54	6.15	5.83

Means in the same row with different superscripts differ significantly ($P < 0.05$)

The mean live weight gain (g/day) and feed conversion ratios (kg DM feed/kg weight) were 174 and 6.54, 195 and 6.15, and 221 and 5.83, for groups T₁, T₂, and T₃, respectively. Lambs fed a concentrate mixture performed significantly better than those fed barley alone (Table 2). This was mainly due to higher (15%) feed intake, although feed conversion was also improved. Offering feed blocks with *ad libitum* barley grain resulted in a 12% increase in daily weight gain and an improvement in feed conversion, compared with barley alone. Pearce (1973) reports an increase in weight gain as a result of offering feed block.

The results of the on-farm experiments (Table 3) are similar to Experiment 1. Lambs offered feed blocks grew 13 and 9% faster in Experiments 2 and 3, respectively, than lambs fed the normal diet of barley alone. The intake of feed blocks in the on-farm experiment was larger than those observed in the on-station experiment. This might be because the lambs used in the latter experiment were taken from the breeding flock, which was fed a concentrate mixture supplemented with minerals. Sheep owners in northern Iraq, on the other hand, use whole barley grain without any mineral supplement and, therefore, the higher intake of feed blocks might result from an initial mineral deficiency in the lambs. Goodchild (1993) found that calcium supplementation resulted in a significant improvement in the performance of fattening lambs.

Table 3. Performance of lambs in the on-farm experiments.

	Experiment 2		Experiment 3	
	Barley alone	Barley + feed block	Barley alone	Barley + feed block
No. of lambs	37.0	39.0	45.0	45.0
No. of days	52.0	52.0	50.0	50.0
Initial live weight (kg)	29.0	28.7	29.3	29.1
Final live weight(kg)	37.9	39.1	38.3	39.1
Live weight gain (g/day/lamb)	170.0 ^a	199.0 ^b	179.0 ^c	199.0 ^d
Intake of barley (g/day/lamb)	1,170.0	1,240.0	1,090.0	1,170.0
Intake of feed block (g/day/lamb)		186.0		140.0
Feed conversion ratio (kg DM/kg gain)	6.9	6.1	6.1	5.9

Means in the same row with different superscripts differ significantly ($P < 0.05$).

Thus, using feed blocks made from urea and agro-industrial by-products as a nitrogen supplement for fattening 6–7 month old lambs fed barley grain will slightly increase growth rate.

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Discussion

M. Hadjipanayiotou: Urea block manufacturing and feeding has been tried in Jordan, Iraq, and Syria—three countries participating in the Mashreq Project. In Iraq this technology has been a success, in the other two countries it has not. Can you tell us why, in your opinion, this has happened?

A. Salman: In other countries, imported grain is given to farmers at subsidized prices, whereas the Iraqi government extended subsidies at the initial stages for the products of new technology that uses unconventional feed stuffs and animal wastes. Health aspects are raised as drawbacks, but we do provide quality control measures and guidelines at the initial stages.

The success of feed block technology in Iraq is mainly due to the work of the national team and to the shortage of feed grain due to the blockade.

S. Christiansen: ICARDA frequently talks about using NARS scientists to transfer successful technologies from one NARS to another. However, I can't think of many examples where this has actually occurred. Could you outline how the Iraqi team could transfer their experiences to an interested NARS?

A. Salman: The Iraqi team is ready to share its experience with other countries in the area.

A. Osman: How did you settle on the block size? Isn't it too large for handling? Also, you talked about pressing: wouldn't that make the blocks too hard for animals to eat?

A. Salman: There is no problem in the size of the feed block. It is around 4–6 kg per block. Hardness of feed blocks depends on ingredients and on the type of press used.

Rangeland and Marginal Land Improvement

Rehabilitation of Marginal Land Using Phosphate and Grazing Management

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Abstract

An experiment was initiated in 1984/85 at Tel Hadya in northwest Syria to test the hypothesis that the application of superphosphate to non-arable lands, also termed "marginal" because grazing is its only possible use, containing annual legumes will stimulate leguminous growth and reduce nitrogen deficiency, leading to increased herbage production. Phosphate fertilizer was applied at three levels: 0, 11, and 26 kg P/ha every year for seven years (1984–1990). The result has been improved legume and total herbage yield, and improved productivity of the sheep grazing the pasture. Annual applications of 11 and 26 kg P/ha raised the Olsen-P values in the soil from approximately 7 mg/kg to 20 to 40 mg/kg, respectively, by the end of the seventh season (July 1991). Since then, no more fertilizer has been applied, and the effects of residual phosphate on pasture and animals have been monitored and effects of residual phosphate recorded.

Introduction

Mediterranean pastures in West Asia and North Africa (WANA) can be classified into two categories according to climatic and edaphic factors: (i) *badia* or steppe pastures; and (ii) marginal land pastures. The first is characterized by flat lands with deep soils which can be cultivated for cereal crops (barley) but, because of erratic rainfall, only one crop can be harvested in ten years. The marginal lands are the non-arable lands within the cereal zone where edaphic rather than climatic factors are most important. They are controlled by individual or groups of villages and provide grazing primarily in the spring, although sheep continue to graze them throughout the summer. They constitute a considerable proportion of the total surface area of many countries in West Asia: in Syria and Lebanon, for example, 30–50%. Marginal lands are intensively grazed by sheep and goats, and normally suffer from severe overgrazing and soil erosion.

Despite all these difficulties, marginal lands are important for the people who live on them. For example, a study by Nordblom and Thomson (1987) shows that farmers with access to marginal land can own more sheep and have more profitable livestock enterprises than farmers without access. Marginal land pasture is heavily utilized in the spring, but because it is not productive in its present condition, livestock owners also need to use large quantities of supplementary feed, barley grain, cereal and legume straw, and crop by-products. Improving the productivity of marginal pasture is, therefore, expected to reduce the need for supplementation and to improve carrying capacity.

Soils

Pastures in West Asia are predominantly on calcareous soils. Calcium carbonate has a great influence on the chemistry of these soils, and deficiencies of major elements such as N and P are widespread (Velk et al. 1981; Cooper et al. 1987). Soils which contain less than 10 mg/kg P (NaHCO_3 extract) do not provide the 0.2 mg P in the soil solution necessary for maximum plant growth (Andrew 1962; Asher and Longerman 1967). A survey of the marginal lands in Syria indicated that 25–40% of the pastures have phosphorus levels of less than 10 mg/kg.

Vegetation

Plant cover on Mediterranean pastures consists of annual grasses and legumes, but perennial species can also be found in areas with high rainfall. The most common legumes on marginal land pastures are *Medic* and *Trifolium* species.

Mediterranean pastures are found in other parts of the world, such as North and South America and Australia, where productivity has been improved as a result of phosphate application and seeding with suitable medics and clover species.

In the present study, the effects of three rates of phosphate and two stocking rates were investigated in northern Syria, to test the hypothesis that the application of superphosphate to marginal land containing annual legumes stimulates legumes, eliminates nitrogen deficiency, and thus leads to increased production. It is expected that the effects will continue beyond the study. Significant effects of residual phosphate have been reported on succeeding crops in many countries of the Mediterranean basin (Kacar 1972; Orphanos 1988; Abdel Monem et al. 1990).

Materials and Methods

The experiment was conducted Tel Hadya (35° 55' N, 36° 55' E, altitude 362 m), the main research station ICARDA, 35 km south of Aleppo in northwest Syria. Tel Hadya has a mean annual rainfall of 342 mm (Dennett et al. 1983) and a growing period of 6.5 months. The climate is Mediterranean and rain falls from October to May.

The experiment was conducted on undisturbed native grassland. The predominantly annual vegetation included a few low shrubs, perennial grasses, and herbs. The soil is calcareous, with pH ranging between 7.8 and 8.4. Soil organic matter and available phosphorus averaged 3.5% and 5.8 mg/kg, respectively. The slope is moderate (3.7–7.2), 30–40% of the ground is covered with stones, and the soil depth varies from 1 to 50 cm. Triple superphosphate, supplying 0 (referred to as P_0), 11 (P_{11}) and 26 (P_{26}) kg/ha P was applied annually in September. Two stocking rates—low and high—were tested. The experimental design was a randomized complete block with three replications, and the total area was 85.5 ha.

Initially, five ewes aged 2–6 years grazed plots of 6.5 or 3.0 ha, representing low (0.8 sheep/ha per year) and high (1.7 sheep/ha per year) stocking rates, respectively, in each of the fertilized treatments. In the fifth season, two more ewes

(one 3 and one 4 years old) were added to each plot, raising the stocking rates to 1.1 and 2.3 sheep/ha per year, respectively. The ewes grazed the plots for the whole year, from early morning to sunset, and were sheltered at night. They were fed a supplement of barley grain during pregnancy, early lactation, and in July and August each year in preparation for mating. Barley and hay were also provided whenever the live weight of individual ewes fell below 43 kg. The lambs were weaned at eight weeks of age.

Results and Discussion

Available Phosphorus

Available phosphorus was less than 10 ppm at the beginning of the study in all treatments, and improved significantly as a result of phosphate application (Fig. 1). Surprisingly, there was no increase between 1986 and 1987, although there was a large increase in 1988. There was a gradual decline in phosphorus after 1990 following the cessation of annual fertilizer application. There was also a steady decline in available phosphorus in the control treatment until 1988. The level remained below 10 ppm throughout the period of the study.

Botanical Composition

In all years, the percentage of legumes in the pasture was higher after phosphate application. A similar effect was observed in the years following the end of phosphate application (Table 1). The differences were significant from 1992 to 1994, while in 1992 and 1993 legume percentage was higher under low stocking than under high stocking. The most frequent legumes were *Trifolium campestre*, *T. stellatum* and *T. tomentosum*.

Table 1. Effect of residual phosphate and stocking rate on annual legumes as a percentage of the whole above-ground biomass in April (1991–1995).

	Year			
	1992	1993	1994	1995
Phosphate[†] (kg P/ha)				
0	7.00	6.80	15.20	5.50
11	26.30	25.00	26.80	13.70
26	29.50	21.30	35.50	15.80
SEM	2.51	2.66	3.77	3.07
Stocking rate[‡]				
Low (1.1 sheep/ha per year)	24.20	27.60	23.00	12.60
High (2.3 sheep/ha per year)	17.70	7.90	28.70	10.80
SEM	2.05	2.14	3.08	2.50

[†] Last phosphate application was September 1990.

[‡] Means of the two stocking rates.

[§] Means of the three phosphate treatments.

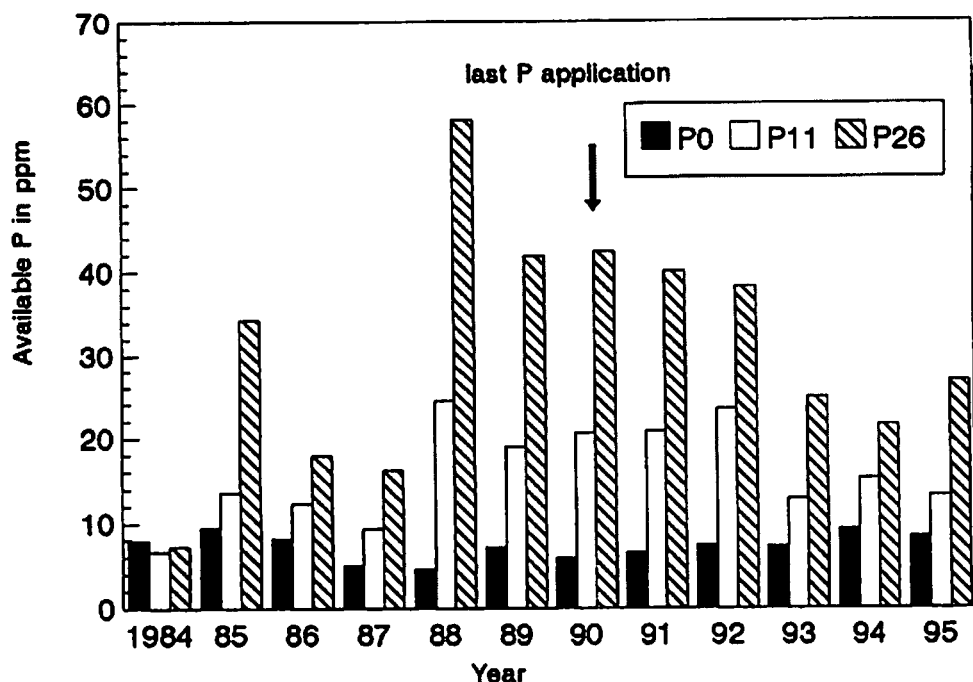


Figure 1. Available phosphorus in the soil (mg/kg) recorded in May every year between 1984 and 1995 at Tel Hadya for three levels of phosphate.

Herbage and Seed Yield

When fertilizer was applied annually, significant differences due to P application were recorded each year from 1985 to 1991 (Osman et al. 1991; Osman and Cocks 1993). The residual effect of the phosphate on herbage yield is shown for 1995 (Fig. 2), where the total herbage yield of legumes and all species show similar trends to previous seasons, with a high accumulation of biomass at both P_{11} and P_{26} , compared with the control, and significant differences for legumes in April ($P < 0.05$) and for all species ($P < 0.01$) from February to April (Fig. 2). The differences between P_{11} and P_{26} were not significant, and are known to be related to the amount of rainfall (see Osman et al. 1991).

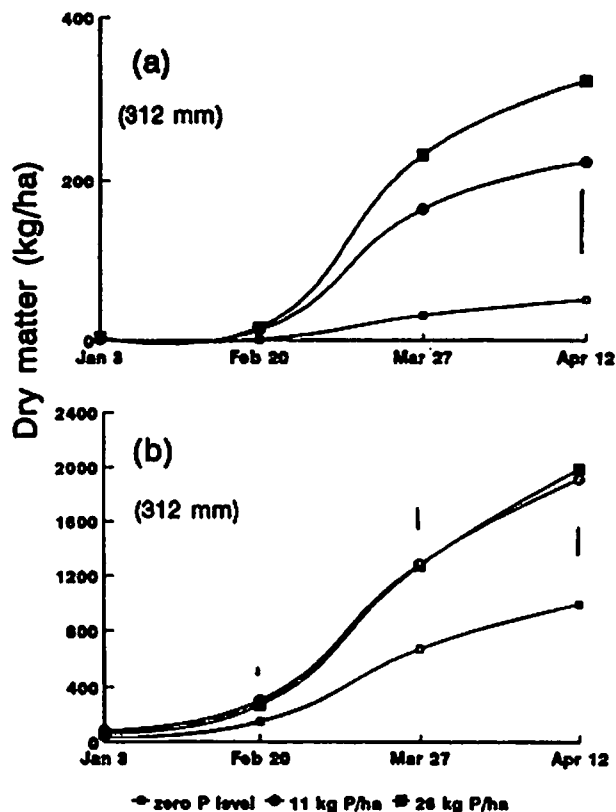


Figure 2. Cumulative legume (a) and total biomass (b) in kg/ha as affected by residual phosphate on marginal land at Tel Hadya in 1995. Vertical bars represent Ses (DF Error 10).

The number and mass of legume seeds were affected by residual phosphate in the four seasons (Table 2). Seed mass and seed number of legumes harvested in June at P_{11} and P_{26} were 8–10 times the amount at P_0 in 1992. Although such differences became smaller with time, in 1995 there were still twice the number of seeds and three times the seed mass compared with the control five years after the end of fertilizer application.

Milk Yield

The milk yield of the ewes at P_{11} and P_{26} was consistently higher than yield at P_0 from 1992 to 1994, with significant differences in 1992 and 1993 (Table 3). Total milk production (kg/ha) was always higher at the high stocking rate than the low. Milk production and savings associated with reducing supplementary feed are important when calculating the costs and benefits of applying phosphate. Osman et al. (1994) concludes that profits are substantial at high stocking rates, especially in years of below average rainfall.

Table 2. Effect of residual phosphate on the mass of legume seeds and number of seeds per m² in the top 1 cm of soil (g/m²), recorded in June (1992–1995).

Phosphate rate (kg P/ha)	Mass	Number
	1992	
0	0.8	1,060
11	8.0	8,657
26	6.7	8,553
SEM	1.08	1,178
	1993	
0	0.9	1,051
11	4.6	4,601
26	4.6	5,730
SEM	4.1	3,952
	1994	
0	1.1	1,437
11	4.3	5,281
26	5.6	7,073
SEM	0.63	895
	1995	
0	1.5	1,609
11	4.8	3,435
26	5.4	3,465
SEM	1.44	751

Each value for phosphate rate is an average of two stocking rates.

Table 3. Effect of residual phosphate on individual milk yield (kg per season) and total milk production (kg/ha) in 1992–1994.

Phosphate treatment	Stocking rate	1992	1993	1994
kg/ewe				
P ₀		41.5	53.3	55.3
P ₁₁		43.5	65.0	58.8
P ₂₆		52.6	74.3	60.6
SEM		2.94	3.54	3.84
kg/ha				
P ₀	Low	43.0	66.6	65.0
P ₀	High	99.6	104.6	117.6
P ₁₁	Low	45.6	110.3	68.0
P ₁₁	High	103.3	129.6	127.6
P ₂₆	Low	57.6	88.6	66.6
P ₂₆	High	121.0	155.3	138.0
SEM		8.04	16.23	9.41

Conclusion

The experiment shows that the degradation of communally owned land in West Asia can be reversed by the use of phosphate fertilizer, conservation, and the utilization of native legume populations (Osman et al. 1991). Phosphate application improves legume and total herbage yields (Osman et al. 1990; Osman et al. 1991; Osman and Cocks 1993) and improves productivity of sheep grazing the pasture (Bahhady et al. 1988, Osman et al. 1994). Annual applications of 11 and 26 kg/ha of P raised the Olsen-P values in the soil from approximately seven mg/kg to 20 and 40 mg/kg, respectively, by the end of the seventh season. The residual effect of the fertilizer continued to affect pasture and animal production for four years after the fertilizer application ceased.

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Discussion

A. Nefzaoui: Can you comment on the opportunity of applying P on steppe where rainfall is less than 200 mm? How do you explain the higher percentage of legumes with higher stocking rate as 1994 at Tel Hadya?

A. Osman: Under relatively lower rainfall (less than 250 mm) the two P levels show significantly different responses, while in years of higher rainfall the two P levels behaved quite similarly. These results suggest that P could benefit legumes in dryer areas, if the soil is deficient in phosphorus. Regarding the second question, the difference is not statistically significant. The general trend was toward higher legume percentage under low stocking rate.

B. Mawlawi: You have presented the use of phosphate and reseeding technique to improve the marginal land on the research station. What about the application of this technique on farmers' fields, and what about the economical feasibility of N?

A. Osman: Work is now being conducted under farmers' conditions in El Bab (four villages) and Lebanon (five villages), where the village communities are doing the work with support from scientists. Regarding economics, when we analyzed the first six years' results, we found that milk production and the savings associated with reduced supplementary feeding are important when calculating the cost benefit of applying phosphate. We found that the profit is substantial at high stocking rates, especially in years of below average rainfall.

M. Ababneh: How can adding phosphorus to marginal land reduce nitrogen deficiency? Can you elaborate on that point?

A. Osman: Phosphorus will enhance the legume component of the pasture, and legumes fix atmospheric nitrogen. So the whole assumption is based on adequate presence of legume plants.

H. Nabulsi: The work done on using phosphorus on marginal land needs to be complemented with shrub plantation on these lands. These shrubs have many uses in addition to providing feed. They can also help soil conservation.

A. Osman: Shrubs are most effective in areas with deep soil, usually in the foothills where there is also a better chance of moisture from water harvesting. This, plus P fertilization and seeding of marginal land, must be linked with pasture.

Effect of Phosphorus Fertilizer on Improving Vegetation Production and Legume Plants on Range

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Abstract

Rangelands in Jordan (areas receiving less than 200 mm average annual rainfall) are suffering from degradation of the natural vegetation cover and low productivity. Studies elsewhere have shown the possibility of increasing range production and enhancing legume plants through the application of phosphorus fertilizer to the rangelands, thus increasing livestock production.

This study was undertaken in Jordan as part of the Mashreq Project to investigate the effect of phosphorus fertilization on the productivity and legume plants of the rangelands between 1991 and 1994. Results indicate an increase in vegetation production and in the number of legume species and plants where phosphorus fertilizer was applied.

Introduction

Rangelands in Jordan are suffering from degradation and low productivity of the natural vegetation due to dry conditions and mismanagement. The latter includes overgrazing, cultivation, and uprooting of range plants. The botanical composition of the range is poor, with a very low proportion of legume species. Thus there is a need to improve range productivity and botanical composition under controlled range use.

Phosphorus is considered a major nutrient. It is essential in the energy transfer processes and is vital to plant growth. Phosphorus, when applied to deficient soil, enhances root growth, increases crop ability to extract moisture, hastens plant maturity, and is essential to seed formation. Phosphorus deficiency is accompanied by a marked reduction in plant growth (Samuel and Nelson 1975; Shepherd et al. 1987; Matar et al. 1992).

Several studies suggest the possibility of increasing range production and enhancing legume plants by application of phosphorus fertilizer, which improves the quality of the natural vegetation cover of the rangeland and results in increased livestock production.

Several studies, including Samuel and Nelson (1975), Shepherd et al. (1987), Matar et al. (1992), and NCARTT annual reports confirm the effect of phosphorus fertilizer on improving crops production and food and forage legumes. However, there is very limited information on the effect of phosphorus fertilizer on improving vegetation production and native legumes in the rangelands.

The Arab Center for the Studies of Arid Lands and Dry Areas (ACSAD) reported in 1982 that phosphorus fertilizer could be used on poor ranges. Broadcasting of the fertilizer on the soil surface is the cheapest and most common application method. Fertilizers generally increase the nutrients in plants (thereby increasing their feed value), increase palatability, and extend the growth period.

Osman et al. (1991) reports that annual applications of phosphorus reduce the deficiency in soil phosphorus and result in improved pasture production, even in dry years. Legume production increased 0.3–3 fold in comparison with the control treatment. After the fifth season legume seed mass increased three fold and the number of seeds six fold in the phosphorus treatment plots compared with the first season, while in the control plots there was little change.

Several researchers in WANA observed significant yield responses to phosphorus application in the dry and unproductive years and/or in shallow soils (Harmsen et al. 1983). At the wetter sites, there seemed to be little or no phosphorus response. This would imply that there is a considerable potential for increasing yield, even in low rainfall areas.

Objectives

The objectives were to study the effect of phosphorus fertilization on:

- Improvement of range vegetation production.
- Increases of legume species in the range.

Study Sites

This study was conducted at four range sites: Khanaseri Range Reserve, Eira Range Reserve, Khaldia Range Reserve Station, and Lajjoun Range Reserve during 1991/92–1994/95. These range reserves are located within the steppe rangelands and receive average rainfall of 150–200 mm per annum.

Materials and Methods

One hectare was selected at each site, divided into four plots, so that there were two replicates and two treatments in each replicate. Triple superphosphate (TSP 46% P_2O_5) fertilizer was used in 1991/92 and 1992/93, and di-ammonium phosphate (DAP 46% P_2O_5 , 16–18 N) in 1993/94 and 1994/95. Phosphorus fertilizer was broadcast on the treatment plot in each replicate at a rate of 10 kg/dunum (100 kg/ha). The other plot in each replicate (the control) was not fertilized. Triple superphosphate was not on the market in the last two seasons.

Before treatment in November of each season, a soil sample was taken from each of the four plots at each site. Each soil sample was composed of five sub-samples from each plot. Available phosphorus was measured for all samples.

A vegetation species list was prepared for each site.

Vegetation production was estimated in April 1995 using the weight estimate method described by Tadmor et al. (1975), where five transects (10 meters apart) were laid at each plot. Ten quadrates (50 × 50 cm each) were laid at each transect (a total of 50 quadrates at each plot, 200 quadrates at each site). Vegetation production was calculated by clipping and estimating in 10 quadrates, and estimating and correcting (through regression equation) in 40 quadrates at each plot.

Legume species in 10 quadrates (50 × 50 cm each) at each plot were identified for all sites. The number of legume species and number of plants in each species were counted.

Results and Discussion

The available phosphorus in the soil of the different sites before the application of phosphorus fertilizer (Table 1) was lowest at Khaldia and Lajjoun, followed by Eira and Khanaseri. Since Khaldia and Lajjoun were low in phosphorus, they were not opened for grazing and the experiment was implemented for one season only (1994/95) in these reserves.

Table 1. Available soil phosphorus in November before application of phosphorus at the experimental sites from 1991/92 to 1994/95.

Year	Phosphorus (ppm)			
	Khanaseri	Eira	Khaldia	Lajjoun
1991/1992	21.75	8.6		
1992/1993	16.2	14.25		
1993/1994	18.1	10.2		
1994/1995	12.35		7.4	6.35

The relatively high phosphorus at Eira and Khanaseri may be because reserves were opened for grazing, and the phosphorus content in the animal manure may have increased soil phosphorus. The experiment was repeated in these reserves on the same plots for more than one year, and this may also have caused accumulation of phosphorus. Because of the low rainfall in these reserves, it is possible that part of the phosphorus applied did not dissolve and was accumulated.

Based on studies in WANA and on previous research, it was concluded that a level of 10 ppm of soil phosphorus at sowing for winter cereals or legume crops should secure optimum phosphorus availability over the range of soils and climatic conditions of the region (Matar et al. 1992).

Triple superphosphate (TSP) was planned for use as the phosphorus fertilizer in this experiment. It was used in the 1991/92 and 1992/93 seasons, but was

replaced by di-ammonium phosphate (DAP) in 1993/94 and 1994/95 when it was not available in the market.

Vegetation lists for each of the four sites (Tables 2, 3, 4, and 5) show that the presence of legume species at each site.

Table 2. List of plant species at Khaldia study site (April 1995).

1. <i>Bromus tectorum</i>	8. <i>Hordeum spontaneum</i>
2. <i>Felago desertorum</i>	9. <i>Trifolium</i> spp.
3. <i>Salsola sandarica</i>	10. <i>Avena sterilis</i>
4. <i>Sisymbrium diandra</i>	11. <i>Astragalus</i> spp.
5. <i>Spergularia diandra</i>	12. <i>Poa sinaica</i>
6. <i>Koleria phlioides</i>	13. <i>Aegilops</i> spp.
7. <i>Hordeum murinum</i>	14. <i>Erodium</i> spp.

Table 3. List of plant species at Khanasari study site (April 1995).

1. <i>Stipa lagascae</i>	14. <i>Salsola vermiculata</i>
2. <i>Stipa capensis</i>	15. <i>Artimisia herba. alba</i>
3. <i>Koleria phlioides</i>	16. <i>Allium</i> spp.
4. <i>Hordeum murinum</i>	17. <i>Convolvulus</i> spp.
5. <i>Onobrychis caput. galli</i>	18. <i>Hershillia</i> spp.
6. <i>Poa sinaica</i>	19. <i>Haloxylon articulatum</i>
7. <i>Lagurus</i> spp.	20. <i>Trifolium</i> spp.
8. <i>Hippocrepis unisiliqua</i>	21. <i>Aegilops</i> spp.
9. <i>Carex divisa</i>	22. <i>Medicago</i> spp.
10. <i>Bromus tectorum</i>	23. <i>Anchusa strigosa</i>
11. <i>Astragalus spinosus</i>	24. <i>Centaurea damascena</i>
12. <i>Erodium</i> spp.	25. <i>Gypsophyle arabica</i>
13. <i>Noaea mucronata</i>	

Table 4. List of plant species at Lajjoun study site (April 1995).

1. <i>Poa sinaica</i>	14. <i>Plantago</i> spp.
2. <i>Stipa lagascae</i>	15. <i>Avena sterilis</i>
3. <i>Koleria phlioides</i>	16. <i>Hordeum murinum</i>
4. <i>Carex divisa</i>	17. <i>Hordeum spontaneum</i>
5. <i>Lagurus</i> spp.	18. <i>Anabasis articulata</i>
6. <i>Astragalus spinosus</i>	19. <i>Haloxylon articulatum</i>
7. <i>Bromus tectorum</i>	20. <i>Artemisia herba. alba</i>
8. <i>Avena sterilis</i>	21. <i>Aegilops</i> spp.
9. <i>Erodium</i> spp.	22. <i>Felago</i> spp.
10. <i>Felago</i> spp.	23. <i>Medigaco</i> spp.
11. <i>Iris sisyrinchium</i>	24. <i>Anabasis aphylla</i>
12. <i>Reboudia pinnate</i>	25. <i>Hypocrepis unisiliqua</i>
13. <i>Euphorbia</i> spp.	26. <i>Noeae mucronata</i>

Table 5. List of plant species at Eira study site (April 1995).

1. <i>Asphodelus aestivus</i>	13. <i>Anthymus syriaca</i>
2. <i>Iris sisyrinchium</i>	14. <i>Bromus tectorum</i>
3. <i>Stipa capensis</i>	15. <i>Ononis natrix</i>
4. <i>Helianthemum</i> spp.	16. <i>Hordeum murinum</i>
5. <i>Hershillia</i> spp.	17. <i>Sinapis arvensis</i>
6. <i>Centaurea calcitrapa</i>	18. <i>Ballota undulata</i>
7. <i>Urigena maritima</i>	19. <i>Paronychia argentea</i>
8. <i>Hordeum spontaneum</i>	20. <i>Gypsophila arabica</i>
9. <i>Hordeum bulbosum</i>	21. <i>Allium</i> spp.
10. <i>Poa sinaica</i>	22. <i>Erodium</i> spp.
11. <i>Carex divisa</i>	23. <i>Koleria phlioides</i>
12. <i>Avena sterilis</i>	24. <i>Onobrychis caput. galli</i>

Table 6. Average vegetation production (kg/du) of the different treatments at experimental sites (1991/92 to 1994/95).

Year	Treatment	Khanaseri	Eira	Khaldia	Lajoun
1991/1992	fertilized	grazed	55.5 A *		
	unfertilized	grazed	46.6 B		
1992/1993	fertilized	24.93 A	grazed		
	unfertilized	22.57 A	grazed		
1993/1994	fertilized	24.64 A	75.80 A		
	unfertilized	18.51 A	70.26 A		
1994/1995	fertilized	39.57 A	49.0 A	28.3 A	
	unfertilized	30.38 B	37.7 B	28.61 A	

* Significance is with site and year.

The average herbaceous vegetation production (kg/dunum) on dry matter basis was generally higher than the control in the plots treated with phosphorus fertilizer. Sometimes it was significantly higher, other times it was higher but not statistically significant (Table 6).

The positive effect of phosphorus in improving crop growth under low rainfall conditions can be explained as follows. With the improved stimulation of root growth by phosphorus fertilization, the effective availability of nutrients is increased due to the increase in accessible soil volume and concentration of soluble phosphorus in the thin moisture films around soil particles in contact with the root surfaces (Olsen et al. 1961). This explanation may apply to herbaceous range vegetation and explains the increased vegetation production in plots treated with phosphorus fertilizer. Similar results were mentioned by Osman et al. (1991).

The number of legume species increased in the plots treated with phosphorus fertilizer. The number of legume plants for each species in these plots increased compared with the control, indicating the positive effect of adding phosphorus fertilizer. The addition of phosphorus fertilizer to the treated plots may have enhanced the germination of legume seeds, increasing the number of legume species and the total number of legume plants in these treated plots.

Results of other work on the application of phosphorus fertilizer to food and forage legumes, and to natural pastures, revealed the positive effect of these applications. In West Asia and North Africa, economic responses to applied phosphorus have been observed (Matar et al. 1992). For many legumes and forage crops, the average response to phosphorus was much greater and more consistent in a dry year than in a wet one. Haddad (1986a, 1986b) obtained similar results on lentil and chickpea in Jordan. Osman et al. (1991) found that surface application of phosphorus on natural pastures in marginal grazing areas increases plant populations and yield of native legume species.

Conclusions and Recommendations

The results of this study show an increase in vegetation production and in the number of legume species and plants in the treatments where phosphorus fertilizer was applied.

This study should be repeated at Khaldia range research station (150 mm rainfall) and at another higher rainfall site to study the effect of phosphorus fertilizer on improving vegetation production and legumes on the range, and to study the cumulative effect of the phosphorus fertilizer.

Table 7. Number of legume species and plants (in 10 quadrats, 50 × 50 cm each) under different phosphorus treatments at three sites (1991/92, 1993/94 and 1994/95).

Year	Treat.	Khanaseri		Eira		Khaldia		Lajjoun	
		Sp. No.	Total	Sp. No.	Total	Sp. No.	Total	Sp. No.	Total
1991/92	Fert.	3	9	5	15				
	Unfert.	2	2	3	7				
1993/94	Fert.	4	14	4	12				
	Unfert.	1	1	4	7				
1994/95	Fert.	5	7			3	5	2	5
	Unfert.	2	2			1	1	2	2

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Discussion

B. Mawlawi: You have mentioned that the purpose of this new technique is to benefit from existing available pasture species and that you want to move to the 150 mm area. How can you be sure that this technique will be useful?

K. Tadros: Dr Osman undertook his experiments in the marginal (>200 mm) lands. I undertook it in the rangelands (<200 mm). I want to repeat this work at a range site (<200 mm) and on a marginal site (>200 mm) in Jordan to better understand the effect of phosphorus fertilizer and to better compare results.

G. Gintzburger: There are different type of phosphate fertilizer—single, triple super, and rock phosphate. Which one did you employ in your experiment, and why?

K. Tadros: I intended to use triple superphosphate, as it has only 46% P_2O_5 and because I am studying only the effect of phosphorus. So I used this fertilizer in the 1991/92 and 1992/93 seasons. In the last two seasons (1993/94 and 1994/95) triple superphosphate was not available on the market and I used DAP (diammonium phosphate 46% P_2O_5 and 16–18 N) instead.

A. Hadjichristodoulou: How do you explain the increase in the number of species in plots fertilized by phosphorus from the first year of its application?

K. Tadros: Actually the phosphorus was applied in 1990/91 season, but the results explained in the paper are from 1991/92 through 94/95. Secondly, maybe phosphorous encouraged germination of legume seeds.

A. Aw-Hassan: If the land is commonly owned, I wonder who is going to invest in phosphorous application?

K. Tadros: There are a number of governmental range resources, and there are cooperative range reserves that may apply this technique. The government either takes the responsibility for improving rangeland or leases this land. Private range users may through extension be convinced to apply any suitable techniques.

H. Nabulsi: Nobody is going to apply phosphorus on rangeland. What is the effect of this experiment?

K. Tadros: This experiment shows that there is a positive effect of applying phosphorus to the range. This study should be followed by economic analysis of the costs and benefits of such a techniques. Then it will be decided to follow or not and to extend these results to users or not.

M. Ben Younes: A number of the fodder shrubs presented on slides today are three or more years old. Shrub forage trees are interesting, but there is a particular case to be observed, especially during their first year of establishment, like watering, etc. I would like comments from some of the speakers regarding Jordan and Palestine.

K. Tadros: Seedlings are produced in nurseries and planted during December. If water is available it is recommended to water them once or twice in summer. Because of the unavailability of water and its high cost in Jordan, we don't water, but before planting we do some water harvesting preparation such as contour furrowing.

M. Al-Junidi: *Atreplic nummularia* is not only costly to regenerate, it is also not palatable.

K. Tadros: As a perennial, cost is distributed over many years if good management is applied. *Atriplex nummularia* has many benefits, such as high protein, and it yields good amounts of green or dry forage.

Utilization of Fourwing Saltbush for the Arid Rangelands of Highland Balochistan, Pakistan

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Abstract

Balochistan is the largest province in Pakistan, with considerable areas of degraded rangeland, often at altitudes above 1000 m, and a continental Mediterranean climate. Fourwing saltbush (*Atriplex canescens*) has shown considerable potential as a forage shrub to supplement the diet of the large population of small ruminants. Starting in 1985, the Arid Zone Research Institute (AZRI) in Quetta in central Balochistan started a comprehensive on-station and on-farm research program concerning the suitability of the shrub for Balochistan's harsh environment. Several trials studied the effect of different cultural practices on the growth and rainfall-use-efficiency of the shrub. Other trials investigated the nutritive value of the shrub fed alone or with supplements to penned and browsing sheep. The importance of conducting on-farm evaluation was emphasized, and much remains to be done in this respect. This paper presents the highlights of the research and concludes that the greatest challenge facing AZRI, the provincial departments, and development agencies remains the adoption of a forage reserve concept by farmers.

Introduction

The saltbushes (*Atriplex* spp.) are halophytes with considerable potential to provide forage and fuelwood in the arid and semi-arid regions of North Africa and West Asia (Le Houérou 1992, 1995). Fourwing saltbush (*A. canescens*) is a native species of the southwestern United States with a recognized potential for the semi-arid highlands of Balochistan. This potential was seen in the mid-1950s when it was first introduced in Balochistan (Shah Rahman, personal communication). The two subspecies being used, *A. canescens* subsp. *canescens* and *A. canescens* subsp. *linearis*, withstand the province's continental Mediterranean climate, which consists of cold winters when minimum temperatures can fall to -20° C at altitudes of 2,000–2,500 m, and dry summers when little or no rain falls between May and December. The average rainfall increases from about 230 mm in the center of the Balochistan to over 400 mm in the northeast.

This paper gives an overview of the main research activities and results from the research program on fourwing saltbush (FWSB) conducted by AZRI scientists from 1985 to 1995.

Suitability of Different Species of *Atriplex* in Balochistan

Screening of the different *Atriplex* species for adaptation to Balochistan's harsh climatic and edaphic conditions was limited to FWSB, since it has been found to be best suited to withstand the cold winters and long periods of moisture stress. However, *A. nummularia*, *A. halimus*, and *A. lentiformis* are grown in AZRI's nursery, although they all show varying degrees of susceptibility to cold. More attention should be given in the future to studying the extensive genetic variability within *A. canescens* in terms of leafiness and palatability, as well as ecotypes of other species that are adapted to the local environment.

Growth In Relation to Rainfall and Temperature

It is necessary to know the growth pattern of FWSB so that appropriate management practices can be recommended. Growth is dependent on the seasonal distribution of rainfall and the annual temperature cycle, as well as, *inter alia*, edaphic conditions and shrub density. Even though moisture is generally available, low winter temperatures limit growth during the rainy season in Quetta valley, the site of AZRI's main station. However, growth starts in March when mean temperatures exceed 10°C, and continues until late summer when moisture limits further growth (Fig. 1a). At Tomagh, the AZRI station near Sanjavi in Loralai Province (altitude 1,800 m), winter temperatures again limit growth, even though moisture is available. However, rain starts in March and can continue into autumn if the summer monsoon is plentiful, as in 1992 (Fig. 1b).

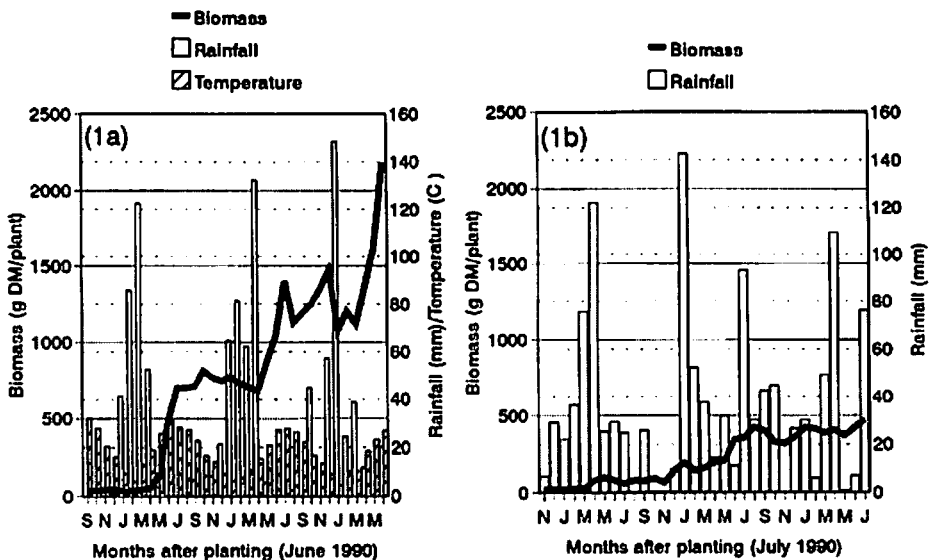


Figure 1. Effect of seasonal distribution of rainfall and temperature on the biomass production of FWSB at (1a) AZRI station near Quetta in central Balochistan and (1b) at Tomagh station in Loralai Province, northeast Balochistan (temperature at Tomagh not shown.)

Figure 1a indicates the substantially better growth at Quetta, which receives about 230 mm annual precipitation, than at Tomagh, where mean annual precipitation is about 250 mm. This difference is largely attributed to the deeper and more fertile soil at the AZRI station. At Tomagh the shrubs were growing on open degraded range with shallow stony soil resting on a calcareous crust that severely restricted root development. Moreover, the soil at Tomagh is so shallow that moisture storage capacity is poor, and growth can be reduced if there are extended periods without rain in spring and summer, as is often the case. Breaking the crust using a ripper resulted in enhanced growth (see below). Conditions on the research station are often better than on farms, and considerable caution is needed when extrapolating results from research stations to farm conditions.

Enhancing Growth Using Micro-catchment Water-harvesting, Manure, and Fertilizer

The late summer growth of FWSB is limited by moisture in central Balochistan and in the northeast in years when monsoon rains are poor. Micro-catchment water-harvesting (MCWH) was therefore considered to enhance growth. Further enhancement could be achieved by the application of manure or fertilizer, since even cultivated soils are generally deficient in nutrients. For example, the soil at a number of AZRI field sites close to Quetta contained 4.5–9.0 ppm Olsen P and 260–600 ppm Kjeldahl N per hectare (Rees et al. 1991). Trials were therefore conducted at AZRI's main station and at Tomagh during a three-year period to study the effect of MCWH and manure and fertilizer application on the growth of FWSB. Four different methods of MCWH were compared at Tomagh: saucer, V-catchment, furrow, and ripping. At Quetta only the first two methods were studied.

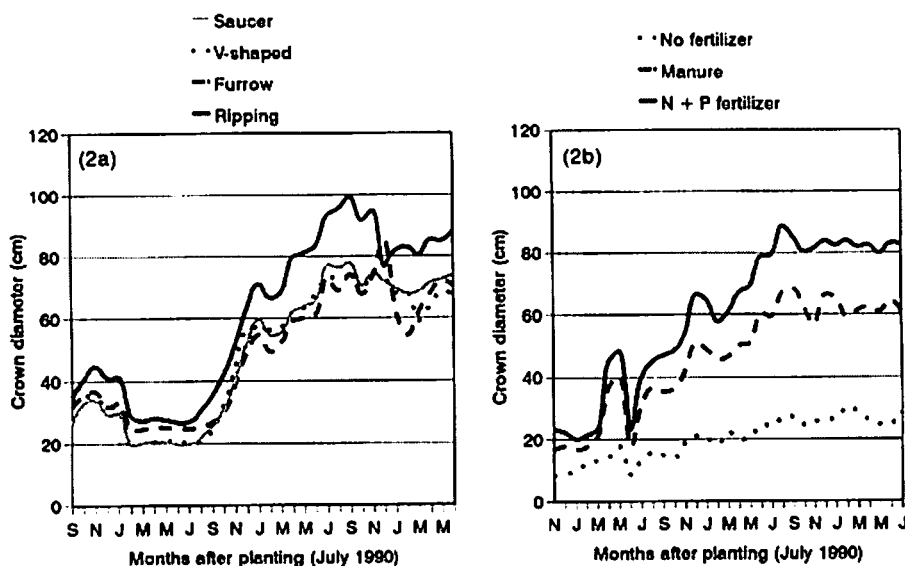


Figure 2. Effect of micro-catchment water-harvesting (2a) and manure and fertilizer application (2b) on growth of FWSB at Tomagh.

Similar ($P > 0.05$) growth of FWSB expressed as crown diameter was seen at Tomagh and Quetta for the different methods of MCWH. However, at Tomagh there were indications that growth was improved after ripping (Fig. 2a), which may have shattered the calcareous crust to some degree. Even if MCWH enhanced growth, the labor requirement to make micro-catchments such as 2 m diameter saucers is substantial, making this method too costly to be useful. Contour furrows and ripping seem a more feasible alternative, since tractors and bulldozers are available in most parts of Balochistan.

At Tomagh, where the soil is infertile and shallow, growth was improved ($P < 0.05$) by the application of N and P fertilizer and to a lesser extent by manure (Fig. 2b). But at Quetta, the response to additional nutrients was less evident due to better soil depth and fertility. It is uncertain whether farmers will apply fertilizer or even manure to forage shrubs when a more profitable option is to use it for fruit trees, which are an important source of revenue to farmers with access to water in Balochistan.

Predicting Aerial Biomass from Plant Height and Crown Diameter

Most studies on FWSB conducted at AZRI have used plant height and crown diameter as non-destructive indicators of growth (Aro et al. 1992). However, information on the yield of leaf and woody biomass is needed to assess the shrub's potential to provide grazing during periods of feed and fuelwood shortages in a province where few forest resources remain. A study was therefore conducted to use simple equations to predict aerial components of FWSB from plant height, crown diameter, and plant volume (Thomson et al. 1995).

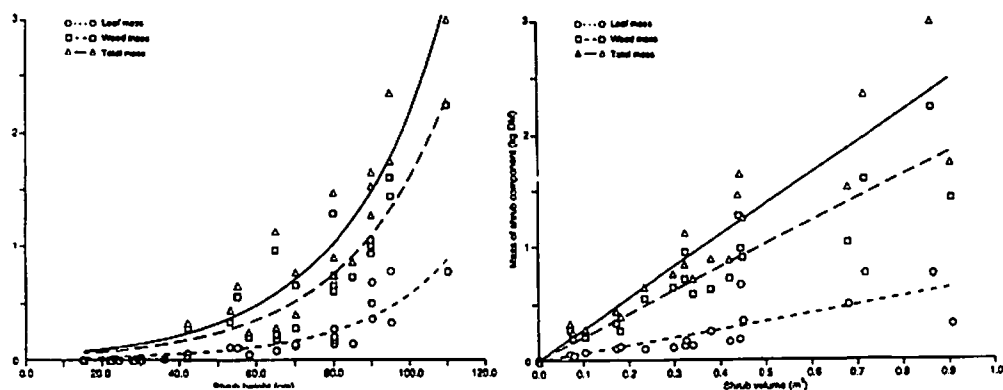


Figure 3. Relationships between plant height with total aerial biomass ($r^2=0.90$) and mass of leaf ($r^2=0.79$) and wood ($r^2=0.88$) (3a), and between plant volume with total aerial biomass ($r^2=0.90$) and mass of leaf ($r^2=0.72$) and ($r^2=0.90$) wood of fourwing saltbush (3b).

Mass of aerial components (Fig. 3a) was closely related to plant height using a simple exponential relationship, whereas mass of aerial components (Fig. 3b) was closely but linearly related to plant volume. It can be predicted from the results that a 1.0 m tall FWSB shrub—a height suitable for browsing by the local breeds of sheep—with a 0.60 m crown diameter, would provide about 0.25 kg DM as leaf and about 0.72 kg DM as wood. This amount of leaf offered each day, supplemented with wheat or barley straw or stubble, is sufficient to maintain the live weight of a sheep (Rasool et al. 1993). Thus, a reserve of 1 ha with 2,500 shrubs would maintain 28 sheep with browse for three months in late summer, autumn, or winter when range vegetation is extremely scarce in Balochistan.

Effect of Shrub Spacing

Moisture is the first factor limiting growth of FWSB in summer. Improved cultural practices are needed which maximize the use of this scarce resource. In addition to MCWH, efficiency of water-use can be improved by using closely spaced shrubs that ensure better ground cover and therefore lower evaporative moisture losses. A study was conducted at AZRI starting in February 1991 to quantify the growth of FWSB under rainfed conditions at three shrub spacings— 1×1 , 2×2 and 3×3 m, equal to 10,000, 2,500, and 1,111 shrubs per ha (Afzal, unpublished results).

Over the three years of the trial, the 1×1 m spaced shrubs produced 2,251 kg DM per hectare of total biomass annually, compared to 1,340 and 948 kg DM per ha, respectively, for the 2×2 and 3×3 m spacings (Fig. 4), with only a small reduction in the size of the shrubs. This was associated with an improvement in the rainfall-use-efficiency (RUE), from 2.7 kg DM/ha/mm in the 3×3 m spacing to 6.5 kg DM/ha/mm rainfall in the 1×1 m spacing. Wheat and barley crops grown under rainfed conditions in Balochistan had RUEs of about 9 and 11–14 kg DM/ha/mm, respectively (Rees et al. 1991). The smaller size of the closely spaced shrubs makes them more accessible for browsing. However, unless the seedlings are produced at virtually no cost by the farmers themselves, high shrub densities make planting costs far too high for farmers to contemplate establishing forage reserves.

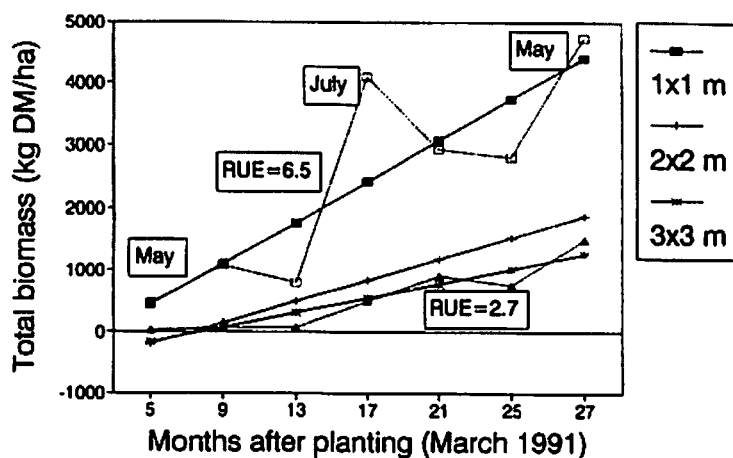


Figure 4. Relationship between shrub spacing and total biomass over three years at AZRI station in Quetta (mean annual rainfall 230 mm).

Intake and Digestibility of Leaves

Feeding small ruminants on saltbush alone is seldom recommended because of the poor energy value of the leaves and the associated moderate intake. Therefore, to obtain modest live-weight gain, supplementation is necessary, whether with barley (Hassan and Abdel-Aziz 1979), a diet containing adequate protein, or wheat straw (Atiq-ur-Rehman et al. 1990; Rasool et al. 1996; Ali et al., unpublished results). A series of trials was conducted at AZRI to assess the nutritional value of FWSB fed to sheep either alone or with supplements. For convenience, the trials used hand-harvested and sun-dried leaves, although the recommended practice is for animals to browse shrubs in combination with hand-fed supplements or stubble grazing.

The dry matter digestibility (DMD) of diets containing 700 g FWSB leaves alone or supplemented with 400 g barley grain or 400 g cottonseed cake was 69, 76, and 70 percentage units, respectively (Atiq-ur-Rehman, unpublished results). The diet of FWSB leaves alone contained an estimated 8.6 MJ metabolizable energy/kg DM, which is at the top of the range reported by Le Houérou (1995). In a second trial, leaves from FWSB and chopped wheat straw were offered to sheep in different ratios (Rasool et al. 1993; Rasool et al. 1996). There was evidence of an interaction between FWSB and wheat straw, seen from the non-linear change in the DMD of the total diet as the proportion of FWSB increased (Fig. 5). This result suggests that inclusion of FWSB up to 0.30 of the total diet, enhances straw intake. Linear regression analysis between the DMD and proportion of FWSB in the total diet gave a predicted DMD for the FWSB and straw of 41 and 56 percentage units, respectively (Rasool et al. 1993). This rather low DMD may be related to the feeding of leaves harvested in December. Low values have been reported in the literature for other saltbush species (König 1992). DMD of wheat straw bought on the local market and of unknown origin was very high and needs to be confirmed.

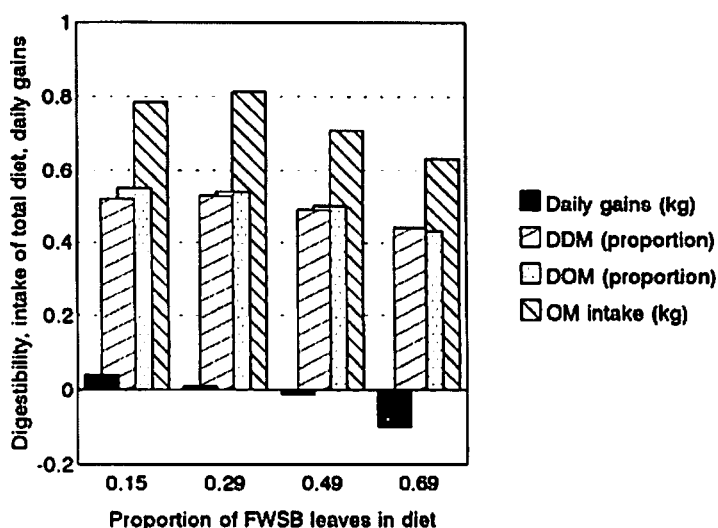


Figure 5. Changes in the organic matter intake (OM), proportion of digestible dry (DDM) and organic (DOM) matter, and daily gains of sheep offered diets containing FWSB leaves and chopped wheat straw.

Season of Harvest, Chemical Composition, and Feeding Value

It is still widely believed in Balochistan that FWSB is a solution to feed shortages in winter, when range plants are dormant. After its main period of vegetative growth from March to July (or later if monsoon rains occur), a period of leaf senescence begins in early winter following the completion of the reproductive phase in autumn. This indicates how delaying browsing until winter results in substantial leaf loss, if not reduced feeding value. This latter hypothesis was examined in two trials which investigated how the season of harvest might affect the feeding value of FWSB, and thereby provide a basis for making recommendations about the most appropriate browsing management of the shrub. It was also hoped that the results of the trial would help explain the low feeding value of FWSB leaves reported in the previous section. In the first trial determinations were made of the *in vitro* digestibility, protein content, and cell-wall composition of hand-harvested FWSB leaves collected between April 1993 and March 1994 (Mirza et al., unpublished results). A second trial used hand-harvested and sun-dried leaves collected from FWSB shrubs in June, August, October, and December, offered to sheep *ad libitum* with 200 g of chopped wheat straw (Ali et al., unpublished results).

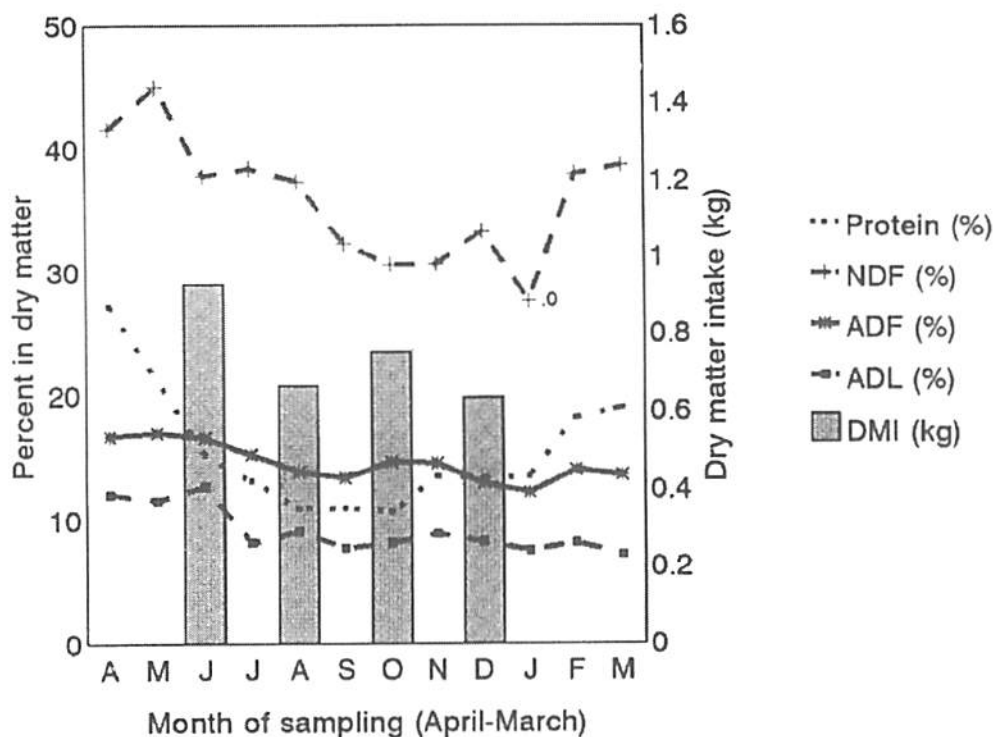


Figure 6. Seasonal changes in the chemical composition and dry matter intake of leaves harvested monthly from *Atriplex canescens* subsp. *canescens* at the AZRI station in Quetta.

The protein content of the FWSB leaves decreased from 25% in April to 10% in August before gradually increasing during the winter to about 20% (Fig. 6). The content of NDF peaked in May, decreased gradually during summer and autumn and recovered again during winter, whereas the content of ADF decreased gradually until September but then remained fairly stable. The content of ADL showed a parallel trend, representing two thirds of the ADF. This would depress the digestion, as well as intake, of the ADF (van Soest 1982).

Intake of leaves harvested in June was higher ($P < 0.05$) than intake of leaves harvested in the other similar months (Fig. 6). It is suggested that the presence of inflorescences and immature bracts may have depressed intake of leaves harvested in August, whereas the sheep were better able to avoid the mature bracts in the material harvested in October and therefore ingested more leaf. This preliminary trial indicates that the feeding value of leaves of FWSB decreases between June and December, as would be expected from the growth pattern of the shrub. However, with the exception of NDF it is difficult to relate this pattern of intake to chemical constituents. The trial needs to be repeated with particular attention given to the effect of the proportion of leaf, inflorescences, and bracts on intake. In a subsequent trial, using sheep weighing 35 kg, intake of mature bracts (fruiting bodies) of FWSB and chopped wheat straw was 335 and 477 g, 312 and 576 g, and 184 and 587 g DM, respectively (Mirza, unpublished results). The DM digestibilities of the total diets were 48, 46, and 47, respectively, and the daily live weight changes of the sheep were -19, 17, and -11 g, respectively. This trial showed that sheep could maintain live weight on 300 g DM of the highly fibrous bracts with 576 g wheat straw.

Performance of Sheep Browsing FWSB, With and Without Supplements

Browsing of shrubs in forage reserves is considered to be the appropriate way to use FWSB, although cut-and-carry may be used in cases where farmers wish to coppice large bushes for fuelwood and to encourage regrowth. Several studies were therefore conducted in which comparisons were made of the live weight gains of sheep browsing FWSB or range, alone or with different supplements.

In one study lasting 10 weeks, sheep on FWSB or range alone had lower gains than sheep grazing range and supplemented with lucerne hay or barley grain (Fig. 7) (Atiq-ur-Rehman et al. 1990). This benefit from supplementation was expected due to the poor condition of the rangeland in the area. However, one would still expect farmers to choose range, as it is a free feed resource, to maintain animals, or to supplement it if modest live weight gains are required or ewes are pregnant or lactating. In another trial lasting 15 weeks, daily intake of FWSB by 25 kg lambs was 466, 390, and 356 g DM and of chopped wheat straw 0, 176, and 371 g DM, and daily gains were 14, 18, and 22 g, respectively (Mirza, unpublished results). The stocking rate was 28.3 lambs per ha, similar to the value of 28 lambs per ha for the 12 weeks estimated above. In the first year of Afzal's study shrubs spaced at 1×1 , 2×2 , and 3×3 m were estimated to carry 37, 8.6, and 6.7 sheep per ha for 15 weeks. The high value of the 1×1 m spacing treatment was not sustained in the second year.

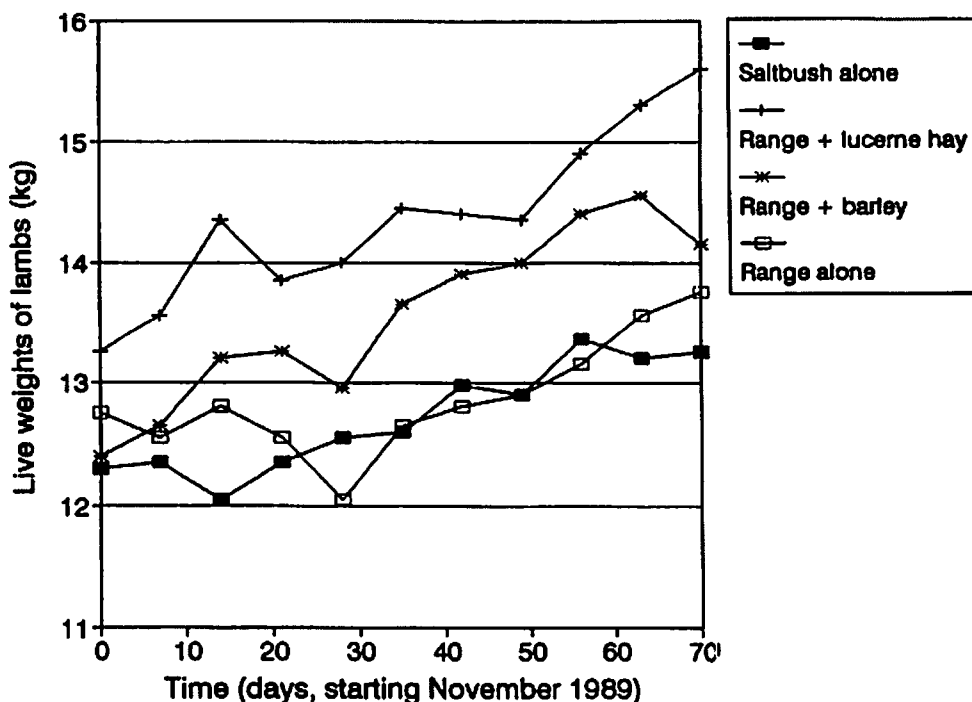


Figure 7. Live weight changes of lambs on FWSB browse or range grazing alone, or range grazing supplemented with barley grain or lucerne hay at Tomagh (Loralai Province).

The local criticism of FWSB—that it is unpalatable—was not supported by the evidence from penned and grazing trials conducted at AZRI, although browsing animals did take a few days to get accustomed to the shrub. Indeed, this partial unpalatability may be an advantage, since it protects the shrubs from excessive browsing which reduces persistency.

These results support those with penned sheep, i.e. that modest gains in live weight can be expected if supplements are offered with FWSB. Wheat straw would appear to be the most appropriate, particularly if the high feeding value observed in one trial can be confirmed. FWSB browse combined with wheat or barley stubble is another option that deserves investigation, particularly for any benefit this might have on fertility of ewes during the mating season.

Water Consumption by Sheep Offered Diets Containing FWSB

Ruminants ingesting halophytes, which include the *Atriplex* species, usually have a higher water intake to allow excretion of the increased load of sodium chloride (König 1992; Le Houérou 1995). Several of the trials conducted at AZRI included measurement of water intake. In one of them, sheep offered a diet containing FWSB had double the water consumption of sheep offered wheat straw and barley

grain (Atiq-ur-Rehman, unpublished results). In others, the effect of including FWSB was small (Rasool et al. 1996; Mirza, unpublished results). Indeed, differences in water intake were greater between than within trials, which were all conducted during summer. The lowest water intake reported by Rasool et al. (1996) may have been related to the reduced salt content in the FWSB leaves harvested in December after the start of the rainy season. Increased water intake of small ruminants could, however, be a constraint to the adoption of forage reserves in areas where water is insufficient for human needs, as in Balochistan.

On-farm Studies

This paper could have started with a discussion of the on-farm studies on FWSB, since getting an improved technology adopted by farmers is perhaps the most difficult task facing research and development agencies. The magnitude of these difficulties increases when the technology is alien to farmers, when the establishment costs are high, and when farmers would prefer to invest in a cash crop such as fruit trees. As all these difficulties face FWSB; getting it adopted by farmers will require considerable skill from extension services and local NGOs. Details of the efforts of these entities in Balochistan, and the cost of nursery production of FWSB seedlings, are reported elsewhere (Mirza 1995).

The on-farm testing of FWSB by AZRI expanded after 1990, although farmer participation in the establishment of the forage reserves and utilization by small ruminants has been limited. In this respect the numerous development projects in Balochistan have the appropriate skills, increasingly using participatory approaches. AZRI has established over 10 sites varying in area from 0.1 to 0.5 ha, and has demonstrated the technical feasibility of establishing shrub plantations. The shortest interval between planting and shrub utilization was nine months, at a site where shrubs were established next to contour furrows following good rains in April. However, this interval was generally 12–18 months, provided transplanting took place, as recommended, in mid-winter to exploit the winter rain.

In most plantations, shrubs were planted on gently sloping land, on the contour between the ridge and furrow made with a disk plow. Sites should have deep soil which allows sufficient moisture storage for the long dry summer season, and be free of native shrubs such as sagebrush (*Artemisia herba alba*), since FWSB is susceptible to competition from native shrubs. These site selection criteria indicate that the gently sloping valley bottoms of Balochistan are the most suitable areas for establishing FWSB reserves. There are *a priori* reasons for suggesting that intercropping FWSB with cereals has potential, and this aspect deserves special attention in the future by AZRI.

Conclusions

The introduction of the forage reserve concept in Balochistan will require considerable ingenuity on the part of the extension services and development agencies such as the Balochistan Rural Support Program. The cost of seedling production will have to be minimized by the establishment of village nurseries. Indeed, commercial production of seedlings is still several years off, since there is

little evidence that demand will appear in the foreseeable future. Direct seeding after mechanical dewinging (removal of bracts) to enhance germination will reduce costs. The cost of establishing a reserve also needs to be minimized, partly by preparing the land using tractor and plow, probably using 1 m inter-shrub spacing and 4 m between rows. Wheat or barley could be inter-cropped between the rows. Appropriate management of the shrubs is also needed to ensure the persistency of the stand for at least 10 years. These aspects certainly need further research, as does the potential of other cold-tolerant *Atriplex* species and ecotypes of *A. canescens*. However, the greatest challenge remains that of finding ways to achieve the adoption of the forage reserve concept by farmers. Without this, further detailed on-station research becomes a costly academic pursuit. AZRI intends to address this challenge in the future in collaboration with provincial departments and development agencies.

Acknowledgments

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Discussion

M. Al-Junidi: Please comment on the palatability of the subspecies mentioned in the lecture, and are these species naturally generating?

E. Thomson: Regarding palatability, low palatability was found, but this may not be a problem, as one is only using fourwing saltbush as part of the diet. Also, high palatability could result in excessive removal of leaves from shrubs, and lead to high shrub mortality. Although sheep did initially show reluctance to eat the shrub, after a few days their intake increased. To answer your second question, *A. canescens* shows little natural regeneration. This is a major weakness which makes it more difficult to introduce to farms.

E. Shehata: Did you consider the total vegetation grown on land when you measured the amount grown per unit of water at different intensity of salt bush plantation?

E. Thomson: There was little other vegetation growing on the plots. However, with wider spacing one could probably try to inter-crop with wheat or barley. This would increase the efficiency of rainfall use.

S. Rafique: What kind of studies do we need under the dry conditions of north Balochistan?

E. Thomson: In southern Balochistan (rainfall about 200 mm) productivity is low unless water harvesting is practiced. Reseeding the most degraded ranges with sagebrush seems the most appropriate approach, provided the state offers assistance and ways can be found to establish sagebrush. Sagebrush will provide a small part of the daily diet. It is a suitable supplement with wheat straw.

The Utilization of Fodder Shrubs (*Atriplex* spp., *Salsola vermiculata*) by Agro-pastoralists in the Northern Syrian Steppe

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Abstract

In 1983 Syria passed a law requiring all farmers holding cultivation licenses for land in the steppe to plant part of their land with fodder shrubs (*Atriplex* spp. and/or *Salsola vermiculata*). Farmers were provided with seedlings, and in some cases, irrigation. Today, most of these private plantations in northern Syria no longer exist. Thirty farmers who still had fodder shrub plantations in five provinces of northern Syria were interviewed about their management strategy and their opinion of the shrubs. Farmers have a low opinion of the benefits of fodder shrubs. They would prefer to cultivate barley, and tend to resent the obligation to maintain shrub plantations. Information on how best to manage the plantations is not available, and plantations are either overgrazed or not grazed at all. Trespassing is also a problem, related to local land tenure systems.

Introduction

It has been argued that fodder shrubs can provide many benefits to land users in semi-arid and arid areas. They can provide supplementary nutrition and green feed for animals when other feed sources are scarce, and in years of drought they can act as a feed reserve (Le Houerou 1989). Fodder shrubs may help stabilize the soil and reduce the effects of wind erosion (Everist 1986). They also provide shelter for livestock, and the woody parts of the bushes can be used as fuelwood. Shrubs can be established on rangeland and in areas unsuitable for agriculture, such as dunes, steep slopes, stony, shallow and/or saline soils, and land prone to flooding (Le Houerou 1989). While the productivity of rangelands has declined in Syria through the extension of cultivation and increasing stocking rates, it could, in part, be restored through artificial reseeding and transplanting with native and introduced *Chenopodiaceae* spp. shrubs, and, in particular, saltbushes (*Atriplex* spp.).

In 1972, the Syrian government started an experimental project in the 180–120 mm rainfall zone, to look at the growth and survival rates of shrubs such as *Atriplex* spp. and *Salsola vermiculata* (Sankary 1978a). At the same time, a number of pilot plantations were established on private land with the cooperation

of agro-pastoralists. In 1983 a law was passed restricting cultivation in the steppe to 45 ha per family, with the requirement that 30% of this land be planted with shrubs. To implement this law, the government provided seedlings to farmers with cultivation licenses, and in some cases followed up the planting of the seedlings, which was undertaken by the farmers, with one or two irrigations.

A study on the evaluation and management of marginal land on which shrubs had been transplanted was begun in 1989 by ICARDA's Pasture, Forage, and Livestock Program in collaboration with the Steppe Directorate and ACSAD (see Osman and Bahhady 1993). A collaborative study between ICARDA and the American University of Beirut (AUB) on the botanical composition of the diets of sheep grazing *Atriplex* spp. and *S. vermiculata* in the same project showed that during the dry season, in August, shrubs contributed about half the sheep diet (46%), composed of equal proportions of *Atriplex* spp. and *S. vermiculata* (Hamadeh and Osman 1993).

However, despite the apparent advantages of fodder shrubs, and both the requirement and support of the Syrian government to establish individual plantations, few still exist in northern Syria. Socioeconomic studies undertaken between 1991 and 1993 in northern Syria (Leybourne 1993; Wachholtz et al. 1993) indicate that shrubs contributed little to the diets of sheep flocks in areas where many plantations were established during the 1980s. Why have most plantations not survived? How do the land users in northern Syria view shrubs, and what management strategies do they use with plantations which still exist? It is important to understand the reasons for both success and failure in order to reduce degradation and improve the sustainability of rangeland systems in Syria, and in the Middle East in general. A study was undertaken in the summer and autumn of 1993 in northern Syria to determine the management strategies used by land users who still had fodder shrub plantations, and their attitudes towards fodder shrubs in general.

An attempt was also made to ascertain farmer reactions to a proposal to plant fodder shrubs in association with barley. Most agro-pastoralists based in the dry areas of northern Syria grow some barley each year, but repeated cultivation on the same land, with no fertilizer input, has resulted in reduced yields, an increasing incidence of "ground pearl" (*Porphyrophora tritici*) and greater wind erosion of soil disturbed by plowing. A potential solution to the problem of wind erosion is to plant windbreaks, but they would need to be productive in order to be acceptable to farmers. An experiment was begun by ICARDA in 1990 to look at the possibility of cultivating barley in between widely-spaced rows of shrub hedges (Jones 1992).

Materials and Methods

The study took place in the steppe (<200 mm annual rainfall) in the northern half of Syria, incorporating Aleppo, Hama, Raqqa, Deir Ezzor, and Hassakeh provinces, populated mostly by semi-nomadic agro-pastoralists. These people often have permanent houses near land they cultivate, but they may also migrate for part of the year to other areas, where grazing is available. In Deir Ezzor and Hassakeh provinces, there are also large areas of irrigated land in the steppe, and farmers there often keep only small numbers of sheep.

Thirty sedentary or semi-sedentary agro-pastoralists in northern Syria who had plantations of shrubs were interviewed in mid-1993. As only a small percentage of agro-pastoralists in the region who had attempted to establish fodder shrub plantations still had such plantations, farmers' names were obtained from the Steppe Directorate, earlier surveys by ICARDA, and from the agro-pastoralists themselves. All the plantations which still exist in Deir Ezzor and Hassakeh Provinces, according to information obtained from the directorates, were located. About 50% were in Aleppo and Raqqa provinces.

Each agro-pastoralist was formally interviewed through a questionnaire, followed by a visit to his plantation, where the type of shrubs, plantation, land and soil, and the presence of other types of vegetation and animals, particularly rodents, was recorded. For each plantation, the state of both the shrubs and the plantation was graded from zero (no shrubs remaining) to five; the length of time since the plantation had last been grazed was taken into consideration. The criteria used in determining the state of the shrubs were size, shape, woodiness, and herbage available, and, for the state of the plantation, the percentage of surviving shrubs and the types and coverage of vegetation between the rows of shrubs.

The questionnaire included details of cropping history, sheep diets, water use and source (quality and quantity), methods of establishment of shrubs, costs, and the opinion of each agro-pastoralist on the advantages and problems of the shrubs.

Results

The number of farmers interviewed in each province is shown in Table 1, as well as the estimated number of plantations that still exist and the approximate number of individuals who received seedlings from the steppe directorates.

Table 1. Breakdown of the number of private fodder shrub plantations in northern Syria.

Province	No. of plantations visited	Est. no. of plantations still existing	Est. no. of farmers who received seedlings from the government	Est. percent of plantations still existing
Aleppo	10	17	300	5.7
Hama	10	unknown	unknown	
Raqqa	5	9	.200	4.5
Deir Ezzor	3	3 [†]	.250	1.2
Hassakeh	2	2	600	0.3

Information obtained from the Steppe Directorates for each province.

[†] This does not include eight farmers with irrigated land who planted *Atriplex* spp. on salty land as a land reclamation exercise. These farmers did not receive shrubs from the government.

The average sheep flock size of farmers in this survey was 163 (SD 291) in August 1993. During the previous winter cropping season, November 1992 to June 1993, the farmers cultivated an average of 59 ha (SD 166) with barley, representing 57% of their total land areas (Table 2).

Table 2. Types of fodder shrubs found on surveyed plantations.

Latin name	English name	Arabic name	Origin	% distrib. in sampled plantations
<i>Atriplex canescens</i>	Fourwing saltbush	Qataf Amriki	USA	43
<i>Atriplex halimus</i>	Mediterranean saltbush	Qataf malhi	Middle East	37
<i>Atriplex nummularia</i>	Oldman saltbush	Qataf australy	Australia	6
<i>Atriplex polycarpa</i>	Desert Saltbush	Qataf californi	USA	3
<i>Salsola vermiculata</i>	Russian Thistle	Rowthah	Middle East	11

Only two farmers did not cultivate barley; they planted irrigated wheat and cotton. The farmers surveyed also had the use of, on average, 121 ha (SD 122) of rangeland for which they did not have cultivation licenses.

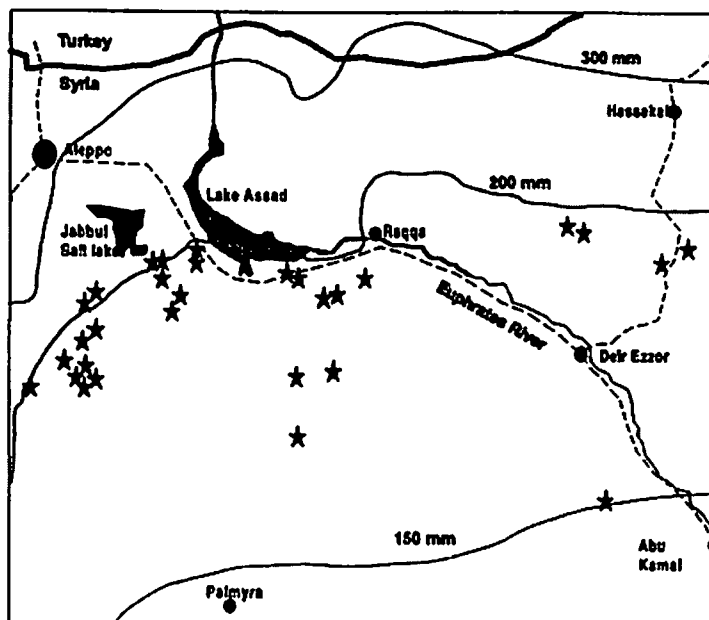
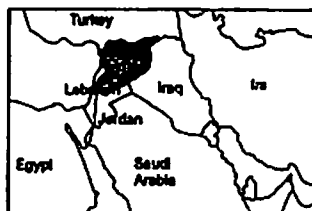


Fig. 1. A part of northern Syria, Showing sample sites of fodder shrub plantations and precipitation isohyets



Barley cultivation first began in some of the surveyed areas in 1915, but the majority began between 1953 and 1962, with the latest in 1971. About half of the farmers recorded a decrease in the amount of land cropped in 1992 compared to earlier years, because of a change in the law allowing cultivation on only 50% of land held under a license. The percentages of licensed land under shrubs, and size of shrub plantations for all farmers in the survey are shown in Figs. 2 and 3.

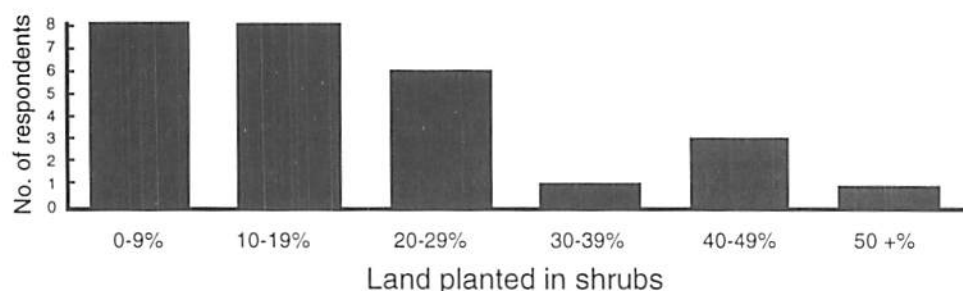


Figure 2. Frequency classes of respondents: percentage of licensed land planted in shrubs.

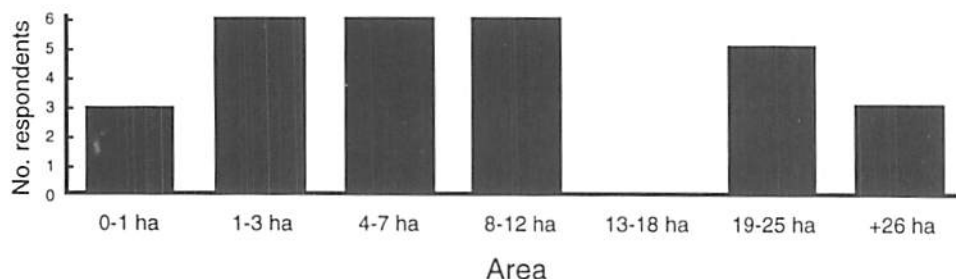


Figure 3. Frequency classes of respondents: size of shrub plantations.

The average area planted with shrubs by the farmers surveyed was 10.4 ha, with the smallest individual plantation 0.3 ha and the largest 30 ha. Some of the farmers interviewed in Hama Province shared plantations with others in their villages; the largest shared plantation was about 100 ha for 47 farmers. Individual plots were delimited with stones. Deir Ezzor and Hassakeh provinces had smaller areas of land and smaller fodder shrub plantations. This may be explained by the higher incidence of irrigated land in these two provinces, where all five farmers surveyed had land irrigated from private wells.

There were large differences in the years in which the plantations were established, but the mode year was 1983. Five farmers established their plantations prior to 1983, and the mean year was 1985. The optimum month for transplanting atriplex seedlings is January (Sankary and Goodin 1986), and all the farmers planted their seedlings within three months of the optimum planting period (the mode month was January, with 39% planting in that month). There was much variation in the number of times the shrubs were irrigated. The average number of irrigations was 2.6 (SD 2.9), with each plant receiving between 20 and

40 liters of water per irrigation. The average length of time from transplanting to when stock were allowed to graze the plantations was 2.7 (SD 0.76) years. Plantations in Deir Ezzor and Hassakeh Provinces received more irrigations, on average, than plantations in the other three provinces, and only two years elapsed before grazing was allowed, in all five samples. It is possible that the increased number of irrigations helped the shrubs to establish better so that they could be grazed earlier. Farmers were probably able to irrigate more frequently because they had their own wells, whereas farmers in the other three provinces had to truck water in.

Farmers usually chose their worst land—land which was salty, stony, sloping, or shallow-soiled—on which to plant the shrubs, leaving their better land for barley production.

The average condition of shrubs scored 2.5 and plantations 2.4. Plantation and shrub conditions were positively correlated ($r=0.96$). There was no consistent relationship between the state of the shrubs and/or plantations and the number of times the shrubs were irrigated ($r=0.42$), or the time of year when the plantations were established, or even the type of shrubs transplanted. *Atriplex canescens* was the most common shrub observed (43%).

Over 40% of the plantations had only one species of shrub present, with *A. halimus* in 50% of these single-species plantations, and 46% of the plantations consisted of two species. No plantation contained more than three different species.

Ephemeral Vegetation

One of the arguments for the establishment of shrub plantations is that regeneration of other types of vegetation will be made easier. Other types of ephemeral vegetation observed between the shrubs in the plantations varied, with 21 of the plantations (70%) having other types of vegetation present. Table 3 lists those present, and the number of plantations where they were found.

There was evidence of rodents (*Psammomys* spp.) in 33% of the plantations. The plantation most affected was one where the farmer had cultivated barley between the rows of shrubs during the 1991/92 season. The barley was not harvested, but grazed by sheep, a normal practice in perhaps a third of the years in this area.

Management

Seventy percent of respondents reported using the shrubs for one or more days at any time of the year. Thirty percent said their sheep did not graze their shrubs at all, in some cases because the shrubs were too poor. Thirty seven percent of respondents grazed the shrubs for an estimated average of 69 days between August and November. Nine respondents kept their flocks on the shrubs for at least 30 days (Fig. 4). In all cases, the farmers supplemented the sheep diet, either with hand-fed supplements or the grazing of barley stubble.

Table 3. Types of vegetation present in sampled fodder shrub plantations.

Species	No. plantations where plant observed	Palatability
<i>Peganun harmala</i> L.	15	Poisonous at the green stage, grazed at the dry stage when nothing else is available
<i>Noaea mucronata</i> Forsk.	13	low (grazed by camels)
<i>Torularia torulosa</i> Desf.	13	good
<i>Bromus tectorum</i> L.	8	good
<i>Heliotropium persicum</i> Lam.	8	low
<i>Hordeum glaucum</i> Stand	7	good before head formation
<i>Salsola inermis</i> Frosk.	5	medium (spring and summer grazing)
<i>Artemisia herba-alba</i> Asso	4	medium (autumn and winter grazing)
<i>Celisia lanceolata</i> Vent.	4	unpalatable
<i>Plantago</i> spp.	3	good
<i>Poa bulbosa</i> Koel.	3	good
<i>Artemisia scoparia</i> Waldstet Kit.	3	unpalatable
<i>Andrachne telephioides</i> spung.	3	poisonous
<i>Girgensohnia oppositifolia</i> (Pall.) fenzl	2	grazed at the dry stage
<i>Haloxylon articulatum</i> Cav.	2	good summer grazing shrub
<i>Helianthemum ledifolium</i> (L.) Mill.	2	medium
<i>Eryngium glomeratum</i> Lam.	2	unpalatable
<i>Anthemis deserti-syriaca</i> Eig.	2	good
<i>Malva aegyptiaca</i> L.	2	medium
<i>Astragalus cruciatus</i> Link.	2	good at the green stage
<i>Cousinia weshni</i> Post.	1	unpalatable
<i>Ononis</i> spp. Guss	1	low
<i>Brassica</i> spp. L.	1	low
<i>Prosopis stephaniana</i> willd.	1	unpalatable
<i>Onobrychis</i> spp.	1	grazed at the green stage
<i>Alhagi maurorum</i> Medik.	1	low
<i>Lopochloa phleoides</i> (vill)	1	good
<i>Choriospora syriaca</i> Boiss	1	unpalatable
<i>Achillea fragrantissima</i> DC	1	good at the dry stage (for camels)
<i>Arnebia decumbens</i> vent.	1	unpalatable

Source: ACSAD 1989; Deiri 1990; Mansour 1976; Quezel et Santa 1962; Post 1932; Sankary 1978b; Thalen 1979.

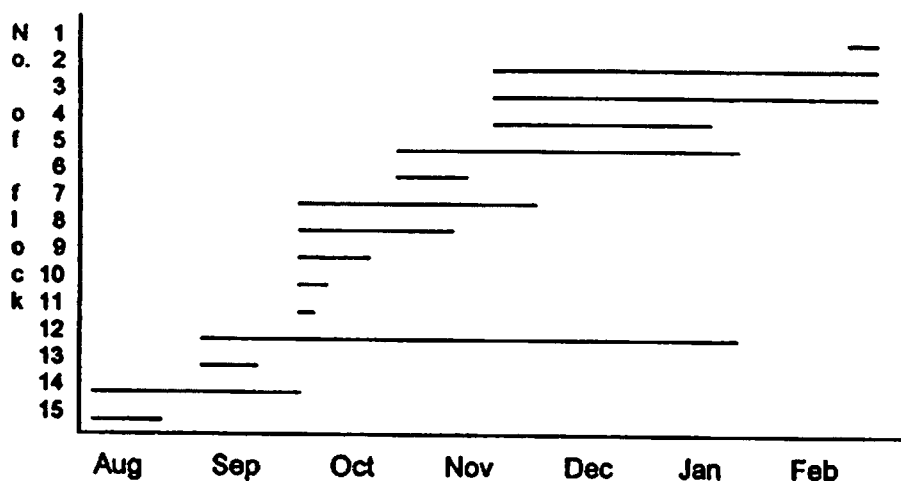


Figure 4. Estimated periods when sampled flocks graze shrub plantations.

There was no relationship between the amount of land planted to fodder shrubs and the number of sheep the farmers had. The number of sheep/ha averaged 44, with a minimum of one sheep/ha and a maximum of 333 ($n=26$). During the period when the plantations were grazed, the number of sheep/ha/year averaged 4.2 ($n=15$), with a minimum of 0.02 and a maximum of 33. By comparison, the highest stocking rate on fodder shrubs in Maragha was 1.3 sheep/ha/year.

The farmers estimated they used 144% of normal water requirements, 4.9–6.7 liters/sheep/day. Water sources usually were not salty. Even when slightly salty, they were still fit for human consumption. Only one in five farmers would grow the shrubs if not required by law to do so. Table 4 shows their opinions of shrubs.

Table 4. Farmers' opinions on fodder shrubs.

Response	Number responding [†]
Shrubs help natural vegetation regeneration	7
Shrubs are good	4
Source of salt for the sheep	3
Shrubs give sheep shelter	1
Shrubs are decorative	1
Shrubs help prevent wind erosion	1
Shrubs help establish land claims	1
They are of no benefit	11
They are bad for sheep	4
Taste bad	2
They give shelter to increased numbers of predators and rodents	2
Only for camels	2
Only good when nothing else is available	1

[†] Some farmers gave more than one answer.

When asked what the respondents' neighbors thought of fodder shrubs, the opinions appeared, for the most part, to be similar to those of the respondent. During some of the interviews, neighbors were present and voiced their opinions.

Discussion

Management of a fodder shrub plantation requires a high level of utilization by the animals, with the best grazing period in late summer and early autumn (Le Houerou 1992). The animals on these plantations either did not fully utilize the shrubs, or browsed only infrequently. Incomplete or infrequent browsing favors the development of branches and woody parts at the expense of foliage. This decreases the grazing value and, in two to three years, the shrubs may become totally unpalatable.

Hassan and El Masri (1987) suggest that pure *atriplex* plantations are less valuable to sheep than mixed plantations. It is, therefore, also important to consider mixed plantations, in particular mixing *Atriplex* species with *S. vermiculata* and/or other indigenous shrubs which are palatable to sheep. However, it must also be taken into consideration that *S. vermiculata* is more palatable to sheep than *Atriplex* spp.—the Bedouin call it the “queen of the rangeland” (Deiri 1990)—so particular care must be taken in plantation management not to allow the *S. vermiculata* to be so heavily grazed as to be destroyed.

As many of the plantations are so small—there were nine covering less than three ha—it is questionable whether the efforts expended to establish the plantations were worthwhile. Such small areas will have little effect on flock feeding patterns, and no major effects on the reversal of rangeland degradation.

Farmer Opinion

Problems in management practices may partly explain the farmers' preference for barley. Earlier surveys (Thomson et al. 1989; Leybourne 1993) have shown that the agro-pastoralists based in the Syrian steppe want to grow barley, because in a year with abundant and timely rainfall, they can make a large profit, while even in dry years they are able to benefit by grazing the land, either as standing barley or as stubble following harvest. Furthermore, Bedouin practice does not permit trespassing onto cultivated land, while rangeland is considered open access. Shrubs, according to the farmers, do not enjoy the same respect accorded to cultivated land. A total of 62% of respondents reported problems with trespassers onto their shrub plantations. In some cases, when families have migrated in late spring/early summer to higher rainfall areas, their plantations have been almost destroyed through being grazed by trespassing flocks in their absence.

Despite the 1983 law requiring farmers to establish shrubs on 30% of their licensed land, surveyed farmers averaged only 17.7%. It also appears that, while it was mandatory to plant shrubs, many farmers did not do so. One reason was because the local authorities experienced difficulties in providing all farmers with seedlings. Seedlings were distributed by the Syrian Steppe Directorate, which provided the farmers with whatever seedlings they had in stock at the time.

Despite the efforts by the Syrian government to help the farmers establish plantations, few still exist. In most cases the reason seems to be lack of interest or care. Many farmers made no effort to ensure the establishment of the plantations and, when they failed, returned to planting barley.

A considerable proportion of farmers have fairly negative attitudes about the possible benefits of the shrubs. Their main reasons for stating that fodder shrubs were of no benefit were based on the belief that they are unpalatable, and only valuable for their salt content. They claim that the sheep take a few bites from the shrubs to gain a supply of salt, then move on, and also that the sheep only graze plants growing between the rows of shrubs. Yet, in 44% of the sampled plantations, the shrubs had been well-, if not over-grazed. There are two points which must be made: (i) the sheep were not put onto the plantations when they are hungry, but only after they have either been hand fed concentrates, or after grazing cereal stubble, and (ii) the sheep were not given enough time to adjust to the change in the diet. Sarson (1970) found that ewes weighing 45 kg consumed 2 kg/day of *A. nummularia* or *A. halimus* after they had become accustomed to the diet over a period of at least one month, during which time the intake of *Atriplex* spp. increased, and the intake of straw and other concentrates decreased.

Intercropping fodder shrubs and barley does not appear, for the moment, to be acceptable to the farmers. Only 27% of respondents (n=26) thought it a good idea, but the objections were mostly due to their perception that one of the plants would reduce the growth and vigor of the other. The problem of protecting the shrubs from trespassers was also highlighted, but some farmers commented that barley cropping might help to protect the shrubs as other farmers would not allow their stock to graze another's barley land.

Conclusions

Private fodder shrub plantations have not been met with enthusiasm in northern Syria, and the majority of private plantations established during the 1980s no longer exist. Those that do are not being managed systematically, because shrubs are unpopular and correct management practices are unknown. The unpopularity of the shrubs is due to three principal factors.

1. There is a lack of knowledge on how best to exploit them, leading to inefficient management practices which tend to confirm the farmers' low opinion of the shrubs. The sheep graze the shrubs at the wrong time of year, or for periods that are too short; this does not give them time to adjust to the new diet, and the farmers conclude that the shrubs are unpalatable.
2. The shrubs are unpopular because they have taken over land which could have been planted to barley, the preferred crop. The farmers do not see any direct economic benefit emanating from the shrubs, as they clearly do with barley cultivation. Land/crop protection is also a problem, as barley is protected by social custom, while shrubs do not enjoy the same status, and trespassing is a major problem.
3. The farmers do not appear to like fodder shrubs because they have been imposed on them by the government. It was commented many times that fodder

shrubs were for the government, and not for private farmers. It might have been better to have proved the value of the shrubs to the farmers, through experimental plots, before private plantations were established.

Farmers who still maintain shrub plantations are exceptional in their circumstances. They are often resident year-round on their farms and some have easy access to water, if not a private well. Most agro-pastoralists in the area, however, migrate to the higher rainfall areas for part of the year and have no effective means of protecting a shrub plantation from trespassers.

The two most important issues to address if there is to be any improvement in the farmers' acceptance of fodder shrubs are, therefore, property rights and improved information on the benefits and use of the shrubs. Either the farmers need assurance that the blocks of land are theirs and are protected, or there must be some other form of control.

The problem of plantation management must also be considered. At present, little information is available on how to best to manage a plantation, and little or no information has been made available to the farmers. The problem is further exacerbated by current flock management practices. They will only utilize shrub plantations if they are the most economically viable option. Use of the plantations must fit into the current feeding cycle, or enhance it. As *Atriplex* spp. cannot be grazed as a sole feed source, additional sources must be available.

Acknowledgments

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Results of a Survey of Bedouin Groups with Contracts to Graze the Government Rangeland Plantation at Maragha, Aleppo Province, Syria

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Abstract

Ten Bedouin groups signed contracts for rights to graze the Maragha rangeland reserve in Aleppo province, managed by the Steppe and Range Directorate of the Syrian Ministry of Agriculture and Agrarian Reform for one month, in April 1995. This was the first legal use by private flock owners of government plantations of saltbush (*Atriplex* spp.) and *Salsola vermiculata* in the *badia* (steppe) in recent years, and is a significant development for rangeland management in Syria.

In this paper, the results of informal interviews with the ten contract holders, representing 72 Bedouin families, are presented. Summaries of their answers are given, regarding group identity and characteristics, opinions about this kind of grazing control, feeding calendars, grazing and movement, and the impact of grazing shrub plantation on water and feed use, milk yield, and flock management.

Introduction

The Maragha range reserve, 77 km southeast of Aleppo, was established by the Steppe and Range Directorate of the Syrian Ministry of Agriculture and Agrarian Reform (SMAAR) in 1985, on a site undulating between 300 and 400 m. Annual mean rainfall varies between 200 mm at Khanasser (30 km northwest of Maragha), and 160 mm at Wadi El Azib (35 km south of Maragha). The Maragha reserve is on gypsiferous terraces dissected by wadis draining towards a string of salty depressions or *sabkhah* (for example: Sabkhah Maragha and Sabkhah Jaboul).

The native vegetation (Deiri 1990) of low woody species such as *Salsola vermiculata*, *Haloxylon articulatum*, *Noaea mucronata*, *Artemisia herba-alba*, and *Teucrium polium* on the loamy soils of the calcareous terraces has been degraded to a mere 10% cover, interspersed with 10–20% cover of herbaceous species such as *Poa bulbosa*, *Carex stenophylla*, and *Peganum harmala*. The latter species is an indicator of extreme degradation of the range. Depressions and open plains in the area are cropped with rainfed barley, leaving the soil bare and subject to wind erosion.

In the Maragha area, shrubs and woody species (*Salsola spinosa* and *Artemisia herba-alba*) growing on gypsiferous soils have been uprooted for fuelwood. Large

areas are totally devoid of vegetative cover except for a few *Erodium glaucophyllum*. On the salty periphery of the *sabkhah*, a residual stand of native *Atriplex leucoclada* and *A. halimus*, with various *Salsola* and *Sueda* spp. can be found, along with occasional prostrate *Frankenia hirsuta*. These degraded stands yield no more than 200 kg DM/ha/year.

The heavily degraded status of the steppe prompted the Syrian authorities to initiate a range regeneration program based on the creation of chenopod fodder shrub reserves (Ziani 1970; Franclet and Le Houérou 1971; Elhamrouni and Sarson 1975; Sankari 1986; Le Houérou 1989) following the Australian rangeland experience (Graetz and Howes 1979).

Initially, flocks were excluded from grazing the 6,500 ha of heavily degraded rangeland in the Maragha reserve to allow the establishment of fodder shrub plantations in pure or mixed stands, after deep soil ripping and transplanting of seedlings produced at the nearby Adami Government Range Nursery (FAO 1970). *Salsola vermiculata*, *Atriplex halimus*, *A. leucoclada*, from Syria, *A. canescens* from North America, and *A. nummularia* from Australia—all capable of good growth on salty or gypsiferous soils in arid zones (Le Houérou 1992)—were planted at the Maragha station. After several years of protection and light grazing, the standing biomass reached an estimated 1–3 tons/ha, of which 20–40% may be available for grazing, with shrub density ranging from 300 to 1,000 shrubs/ha. The perimeter of the reserve is marked by a substantial trench to help prevent unauthorized grazing.

Until this year, the shrub plantations were used to produce seed. In two drought years (1989 and 1990), the Maragha reserve was opened to grazing by a government flock of 11,000 sheep from June to November, for 160 days in the first year and 100 days in the second (Osman and Shalla 1994).

In 1989, ICARDA and the SMAAR, in collaboration with ACSAD, established a grazing trial at Maragha to measure: (i) the effect of different year-round stocking rates on reseeded salty land and native rangeland areas; (ii) the productivity of reseeded rangelands; and (iii) the economic costs and returns of range improvement (Osman and Shalla 1994). Surveys of Bedouin flock owners (Thomson et al. 1989; Wachholtz et al. 1993; Leybourne 1993; Wachholtz 1995) show that, in rangelands surrounding Maragha, flocks graze for a few weeks of the spring season on herbaceous species (*Poa bulbosa* and *Carex stenophylla*), as most perennial shrubs have been uprooted from the area. Breeding flocks are taken away to higher rainfall and irrigated zones to graze crop residues in summer and autumn, and are almost entirely hand-fed through the winter. Today, virtually no large Bedouin flocks are kept in the Aleppo *badia* throughout the year. Since flocks are normally taken out of the *badia* in May, except where barley fields are being grazed, interviews for the present study had to be organized at short notice.

The grazing contracts for the Maragha reserve limited stocking rates to a maximum of three sheep per hectare for one month. Some allowances were made for poor range quality by charging for fewer hectares in the contract than were actually allocated. Charges were SL 125 (about USD 2.50) per hectare for the period and, in addition, each of the ten contract holders paid a refundable deposit of 20% of their fees to guarantee observance of rules. These included the requirement that,

within the reserve, there should be no tents, no uprooting of shrubs or annual plants, or any harvesting for firewood.

Method

We conducted an open discussion with household leaders grazing the Maragha reserve in April 1995. Questions asked concerned:

1. Group identity and characteristics.
2. Opinions about this kind of grazing control.
3. Calendars of feeding, grazing, and movement.
4. Impact of shrub plantation grazing.

Summaries of the responses are reported below.

Results and Discussion

Group Identity and Characteristics

The ten groups comprised 72 households, with a total of 16,100 sheep (averaging 224 sheep per household). However, because of the limit of three sheep per hectare, not all sheep were included in the Margha grazing contracts.

Several family links or ties were described within groups. Unrelated households were rare. Groups varied in permanence and cohesiveness; most separated at some times during the year.

When asked about their legal identity, eight groups gave their tribal affiliation, and two identified themselves as family members. Nine were of the Hadidin tribe, and one of the Haeb. There was no mixing of tribes within the groups.

Nine of the groups were identified in their contracts by the name of the individual household head, and one by its winter base.

Decisions regarding the movement of sheep were made individually by 58 of the households. Only 16 go to the same summer grazing areas in groups, while the remaining 56 graze individually. Six groups said that individual households were not free to move out of the grazing area, but the rest felt they were.

When asked whether problems existed in keeping flocks in their assigned grazing sectors at Maragha Station, answers were mixed. One group head complained that the neighboring group was letting their sheep graze his sector by night, but the rest said they faced no problems. One added that this was because the pasture was so poor there was no reason to make a fuss about it.

Seven groups felt that their group was a viable entity for handling future contracts.

Grazing Contract and Control

We asked whether there was any interest in longer contracts, of 5–15 years, or in limiting grazing to specific area, time of year, and number of sheep. Nine of the groups were interested, with certain reservations, and one said that, when the range was in good condition, there was no need for a reserve plantation such as at Maragha.

When asked about rules preventing them from grazing more sheep than allowed in their contracts, none were sure. One group, which had more sheep than permitted under the contract, kept some milking ewes outside the plantation, and another admitted to grazing the permitted number for two hours before taking them out and bringing in an equal number throughout the day, never exceeding the maximum number allowed inside at any moment.

The majority felt that this kind of grazing reserve was a success, although saltiness was a problem. Individual comments were:

- The sheep would not have been so seriously affected by the salty ground in winter or in March, since at that time they would be grazing the upper leaves of atriplex and green weeds. They would not pick up as much salt from the soil as they appear to do while grazing the dry plant material in April.
- Grazing should have been allowed one month earlier; the reserve provides little benefit for milk or lamb production in April/May.
- The best period for grazing atriplex is autumn, when the sap is not running, so there is less salt.
- The state should protect private atriplex fields.
- The reserve allows them to stay in the *badia* longer; it is a store of fodder and good against desertification.
- Such plantations are only good on non-salty land; the Maragha site is unusually salty.

It would have been useful to identify the diet of the flocks before they entered the Maragha reserve, to see whether they needed a period of adaptation to the new diet, which is high in minerals, especially in sodium chloride (Leigh 1974).

When asked the advantages and disadvantages of expanding these kinds of plantations, eight groups agreed that it was a good idea, but on certain conditions. One group said that it was impossible, with experience only of Maragha, to judge the general advantages of this kind of plantation.

Feeding, Grazing, and Movement Calendar

The interviews discussed the timing and relative proportions of hand-fed and grazed material in sheep diets over the course of the year ending in April 1995, when the shrub plantation at Maragha was grazed. Interviews on feeding and grazing calendars, and analysis, depended upon the Bedouins' ability to recall relevant facts, which they seemed able to do without confusion or hesitation.

The pattern of seasonal feeding and grazing is shown in Figure 1, with monthly averages from the ten interviews. The feed is divided into two classes: hand-fed (cereal straw, legume straw, and energy feeds), and grazed materials (cereal stubble, other crop residue, unharvested barley, rangeland, and shrub plantation). Hand-feeding dominated in winter and early spring. Rangeland grazing in March and April was supplemented with energy feeds, cereal straw, and legumes; unharvested barley was grazed. Cereal stubble grazing dominated May–August. Residues of irrigated crops, such as cotton and vegetables, were grazed in autumn.

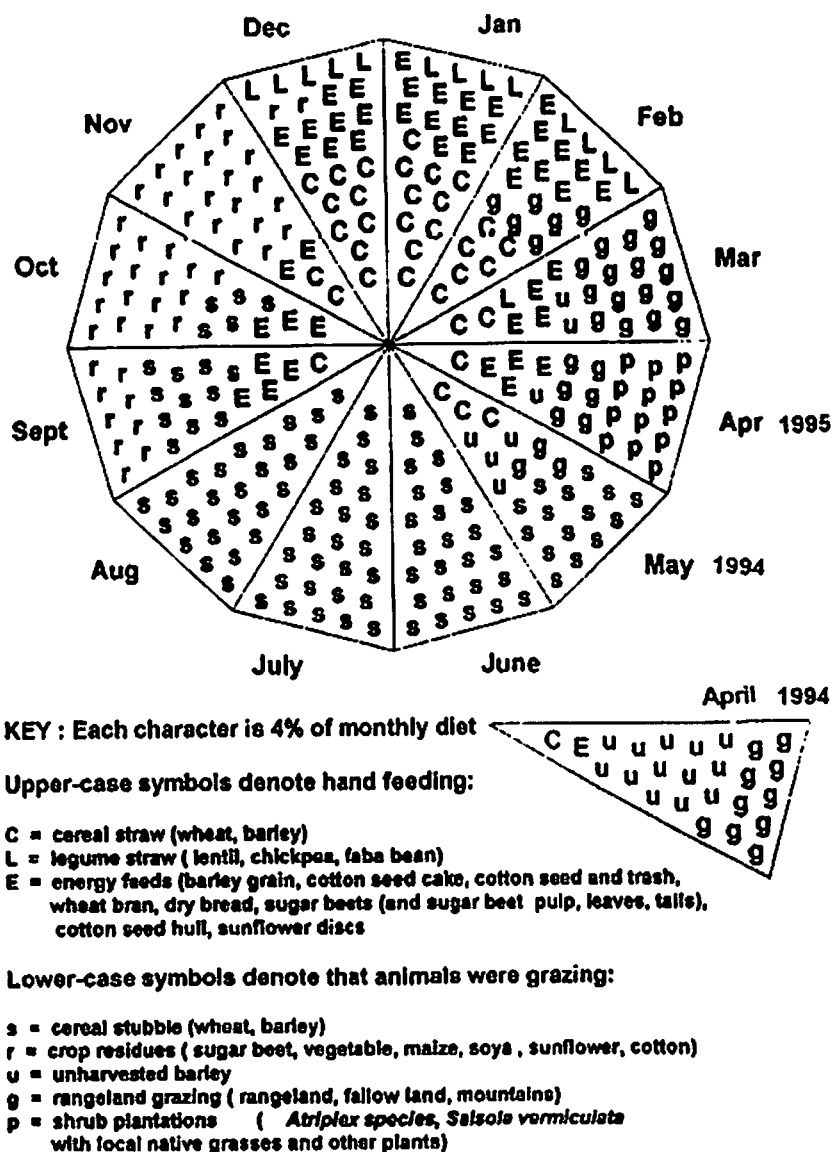


Figure 1. Small ruminant diets reported by ten Bedouin groups in Maragha, Syria (1994/95).

Cropping and livestock activities were carried out by most of the households. Sixty had non-irrigated barley cultivation in various places. The remaining twelve had no cropping.

All the groups had winter bases near Maragha. Twenty eight of the households claimed to have grazed their sheep on the site of the present Maragha reserve during the previous winter and spring, prior to the establishment of the reserve.

Benefits of Grazing the Shrub Plantation

When asked to compare the rental cost of one month's grazing at Maragha with alternative feed costs, there was some disagreement. Two of the groups claimed to be saving 15–50% of feed costs, but the rest said there was no benefit. Four groups said that they were losing money because the atriplex range was so poor. Casual observation confirmed differences in plant cover between the individual contract areas.

Water Consumption

We asked whether there were any changes in water consumption by flocks grazing in Maragha compared to normal consumption at this time of year. One reported that water transporting had increased by 200%, and the rest claimed increases between nil and 100%.

Consumption of water per sheep was calculated from the volume the Bedouin claimed to transport by tanker each day, and ranged from 4.5 to 22 l/head/day. This can be compared with 2–3 l/head/day in March, 9.1–9.9 in July, and 8–9 in September, measured in flocks grazing throughout the year in the ICARDA-SMAAR-ACSAD trial at Maragha Station. These results are consistent with those of Wilson (1978) for sheep grazing Australian rangelands.

Most groups were using fresh water from a variety of sources, up to 40 km away. More information is needed on water quality at Maragha.

Supplementary Feeding

The groups were asked whether there was any change in the consumption of supplementary feed by sheep grazing in Maragha. Seven said there was no change and two mentioned small savings.

Changes in Flock Management

When asked whether there were any changes from normal management at this time of year due to using the Maragha range, the majority reported no great change, while two complained about having to milk their ewes in Maragha and transport the milk to their camps outside.

Milk Production

Five groups reported decreases of 15–30% in milk production, and the rest said there were no changes. One group kept their milking ewes outside Maragha.

Possible Changes in the Contracts

When asked what practical changes they could suggest in the grazing contract, six groups said that they should be allowed to keep their tents on their grazing areas inside Maragha, rather than being forced to stay outside the perimeter, five or more km away. Others suggested allocating land according to the proximity of winter bases in the *badia*, a decrease in the fees, the provision of fresh water, and the changing of timing of the contracts.

Private Shrub Plantations

When asked under what conditions they would be interested in establishing their own saltbush plantations, the groups suggested that state protection for plantations was needed, along with state provision of seedlings, plowing and irrigation during establishment. There was some feeling that they should have documents to prevent the state from recovering the land after they had invested in it.

Fuelwood Supply

Women from most Bedouin households in the area spend considerable time and effort, in the winter and spring, uprooting and gathering native range shrubs for firewood (Pape 1994; Pape and Christiansen et al. 1995). When it was suggested that harvesting firewood could be combined with pruning the shrubs, three of the groups agreed that it was possible, but only with training and supervision. The majority felt either that it was impossible or that they did not need to gather firewood at the Maragha reserve.

Sheep Preferences for Rangeland Plants

The groups were asked whether they had any observations on which plant species were preferred by sheep. Their comments are summarized in Table 1.

When asked which was better, the atriplex shrubs or the plants growing between the shrub rows, the majority said their sheep preferred the other plants to the atriplex.

Table 1. Arabic and Latin names of plant species in the Maragha reserve, and their palatability according to Bedouins surveyed.

Reported Arabic name	Most probable Latin name	Choice of sheep
لثبا	<i>Poa</i> sp.	first
لربان	<i>Plantago</i> sp.	first
لثوية	<i>Bromus</i> sp.	middle
رجل الصلوان	<i>Lotus</i> sp.	middle
لأربان	<i>Anthemis</i> sp.	middle
لحصار	<i>Torularia</i> sp.	middle
لثوفان	<i>Avena</i> sp.	middle
لتميص	<i>Carex</i> sp.	middle
لبكري	<i>Ecodium</i> sp.	middle
الصر	<i>Noeae</i> sp.	middle
لظريح	<i>Artemisia</i> sp.	middle
لرغل	<i>Atriplex</i> sp.	last
المرار	<i>Centaurea</i> sp.	last

Conclusions

The experimental one month grazing contracts at Maragha in the spring of 1995 were successful and popular, judging from this small sample. Access to the reserve appears to be restricted to families who have ties with the Maragha site, which has been their traditional grazing area.

Though a number of problems were identified, most could be solved by altering the contracts. For example: earlier grazing access in spring to annual plants between the atriplex rows; the right to bring their tents into the plantation, to stop the movement of sheep; and advice on nutrition and management.

Contract holders at Maragha, and sites where salinity is not a problem, should be monitored. The information gained through this process will serve the participatory process of improving rangeland management.

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Technology Adoption and Impact

The Importance of the Development and Transfer of Technology

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Abstract

In arid and semi-arid areas agriculture is primarily based on rainfed farming and livestock production. Farmers face continuously scarce and highly erratic rainfall that induces high fluctuations in crop and livestock production. Average yields obtained by farmers are low compared to yields achieved in research stations or by the most skilled farmers. This situation indicates the importance of agricultural research to improve farmer productivity and wealth. To do so, an integrated approach to technology transfer was developed and applied at the Aridoculture Centre through the Dryland Applied Research Project and the IFAD/ICARDA/AFESD Project. This approach integrates researchers, farmers, and extension workers. This study highlights the need for an integrated approach to the development, evaluation, and adoption of new technology in Morocco.

Introduction

In the developing countries of West Asia and North Africa (WANA), agriculture is still the main source of income, employment, and food for a large section of the population. These countries are, however, net importers of cereals, food legumes, animal feed, and meat, and deficits are expected to be higher in the year 2000 (Oram 1988). The challenge for the region is to increase food production. Sources of increase have been projected by FAO (1987) as 7% from expanding arable land, 21% from more intensive cropping, and 72% by increasing productivity. Increases from the latter two sources need to be sustained at over 5% a year, a level virtually unmatched in modern agricultural history (Van Schoonhoven 1991).

In arid and semi-arid areas, agriculture is predominantly based on rainfed farming and livestock production. Rainfall is erratic and scarce, and fluctuations in crop and livestock production are large. Average yields obtained by farmers are low compared to yields achieved at research stations or by the most skilled farmers.

Agricultural research and transfer of technology play an important role in increasing food production in WANA. This paper highlights the need for an integrated approach to the development, evaluation, and adoption of technology in West Asia and North Africa.

Environmental Constraints

Precipitation is low and irregular, with a high risk of drought. Erosion and the encroachment of desert aggravate the situation.

Socioeconomic Constraints

Population growth and changes in nomadic or semi-nomadic systems have resulted in greater pressure on marginal land reserved for grazing. Cereal monoculture is increasing, with reductions in the area of fallow, cultivation of marginal lands, and overgrazing of natural pastures and steppes. Land tenure and the size of holdings limit the adoption of technology. The lack of adequate infrastructure limits the availability of seed, fertilizer, and pesticide. There are no stores for excess production from good years.

Technical Constraints

Farming systems in WANA are characterized as dual agriculture: modern and traditional. Traditional farming remains an underdeveloped, hazardous venture, and cropping is opportunistic. Avoidance of crop failure is often more important than maximizing yield. Farmers in drier areas minimize the risk by growing barley. Marginal land and, in drought years, mature and immature crops are grazed.

The countries of the region have in general done much to improve their agriculture through the introduction of improved crop varieties, mechanization, commercial fertilizers, and herbicides, especially on land with favorable rainfall and irrigation. However, new technology has sometimes had negative consequences.

The Need for Technology Transfer Is Greater

Development of new technology cannot be efficient unless adopted by farmers over large areas. Technology transfer plays a crucial role in attaining the goal of increased agricultural and farm income.

Decision makers are increasingly realizing that greater emphasis should be given to technology transfer, with less emphasis on technology development (Merril-Sands 1991). Farmers have not adopted many improved technologies developed by research institutions. Technology transfer cannot be separated, however, from technology development and on-station research, and an integrated approach is necessary.

An Integrated Approach to the Development and Transfer of Technology

The traditional approach to the transfer of technology has been unsuccessful for a number of reasons. On the research side: projects are developed without any initial diagnosis of the problem or setting of priorities; projects are mainly discipline or commodity oriented; innovations are copied from developed

countries, including machinery, fertilizers, and new crops; the technology is more appropriate to large farmers and more favorable environments; researches have no contact with farmers; and research institutions are understaffed and under-budgeted.

On the extension side: extension agents are not trained in the new technologies; information is prepared at the national level, whereas agricultural problems are local and specific; extension agencies are oriented to products, selling seed, fertilizer, pesticide, and equipment; extension agencies are understaffed and underbudgeted; extension agents are often passive; information material (bulletins, pamphlets, books, etc.) are not disseminated at the local level; and farmers are not involved and experts decide what is good for them.

A new approach is needed where farmers play an active role and where research and the transfer of technology are client-oriented, in order to accelerate the development, evaluation, delivery, and adaptation of new technologies, and to optimize the use of limited financial, human, and physical resources.

This new approach is called Farming Systems Research and Extension (FSRE) and involves the rapid diagnosis of farm problems by multidisciplinary teams, to provide the basis for on-farm research, supported by socioeconomic research on-farm and in the farm community, together with laboratory and on-station research and the simultaneous dissemination and diffusion of results. Merrill-Sands (1991) summarizes the advantages of the FSRE approach as:

- Integrating links with farmers.
- Ensuring the social scientist's input.
- Developing effective links with extension (technology transfer).
- Institutionalizing the approach with research and extension service.

Implementation of Technology Transfer in the Arid and Semi-arid Regions of Morocco

The DAAR Project

The Morocco Dryland Applied Agricultural Research Project (DAAR), initiated in 1979 as a joint effort involving INRA, Morocco, and MIAC (USA), implemented a new contract in 1988 to increase food production to meet the needs of Morocco's rapidly growing population, to improve the income of farmers with small and medium sized land holdings, and to establish a sustainable applied research capacity appropriate to dryland farming systems in southern Morocco, with a rainfall of 250–450 mm

The project undertakes on-station and on-farm research trials, researcher-managed and farmer-managed on-farm trials, demonstration trials, and socioeconomic and agro-ecological studies.

The IFAD/ICARDA Regional Research and Technology Transfer Project.

This project was initiated in 1990 by IFAD and ICARDA and aims to increase barley, food legume and livestock production in North Africa by:

- Developing practical, profitable, and ecologically sound recommendations for improving the production of barley, lentil, and chickpea crops and associated pasture, forage, and livestock, in project areas in Algeria, Morocco, Tunisia, and Libya.
- Strengthening the national research programs in these countries.
- Providing the means for evaluating the effectiveness of the project.

In Morocco this project undertakes back-up research, on-station trials, and researcher managed and farmer managed on-farm trials.

The Moroccan Aridoculture Center

The Aridoculture Center in Morocco has been developed to address the needs of farmers in the semi-arid regions. Research project activities are developed using Project Management Systems based on national and regional agricultural objectives through sub-programs of one or several disciplines, which are involved in technology transfer. The Aridoculture Center has recently begun to address research problems from a systems perspective, using holistic Programming by Objective. The introduction in 1992 of the log-frame approach to project development provides an opportunity for a smooth transition to a systems strategy.

Fundamental Relationship and Implementation Concepts

Relationships between researchers, extensionists, policy makers, and farmers provide the basis for the introduction of a technology transfer program (Fig. 1). Assessing successes and setbacks encountered during conceptualization and implementation of a program results in a clearer understanding of why, when, and how it should proceed. The cooperation between the Mid-American International Agricultural Consortium (MIAC), the Institut National de la Recherche Agronomique (INRA), and the International Fund for Agricultural Development (IFAD) to provide administrative support and technical assistance, is a model for future efficient technology transfer in Morocco.

Technology transfer is conceived and implemented on the basis of interactions among research, extension, farmers, and policy makers. The first interaction results from a liaison and demonstration function which is extension managed and overseen by INRA's Services de Recherche et Développement. The second interaction, linking research and extension, is undertaken by INRA—through an On-farm Technology Evaluation team, which is also part of the Service de Recherche et Développement, and is farmer-managed—and IFAD. A third activity, On-farm Diagnostic Trials, provides a limited opportunity for INRA researchers for

trials on farms with the limited participation of farmers and extension. These three activities are discussed within the context of a broader Research Systems Approach (Fig. 2) being adopted by the Aridoculture Center.

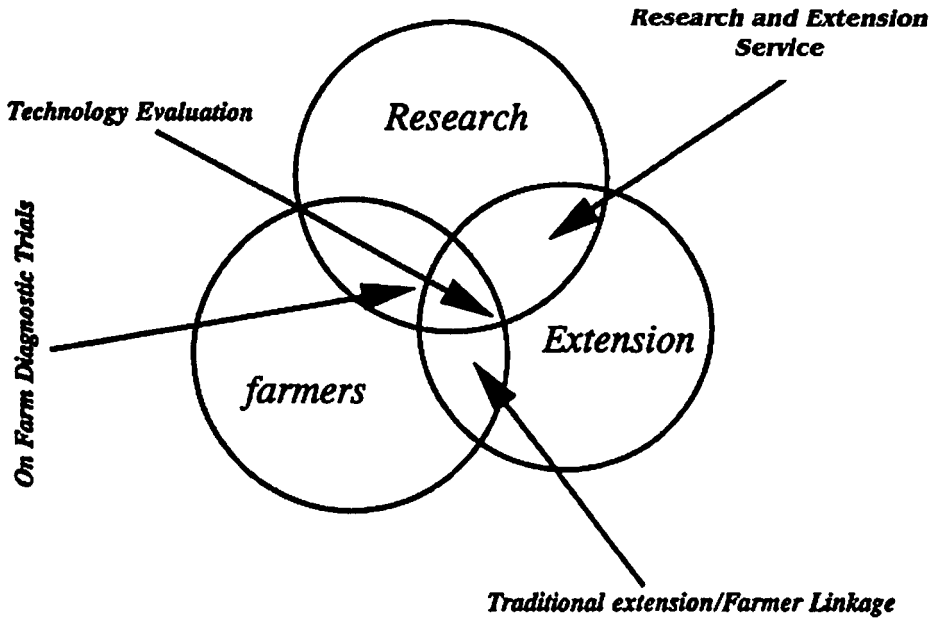


Figure 1. Technology transfer diagram.

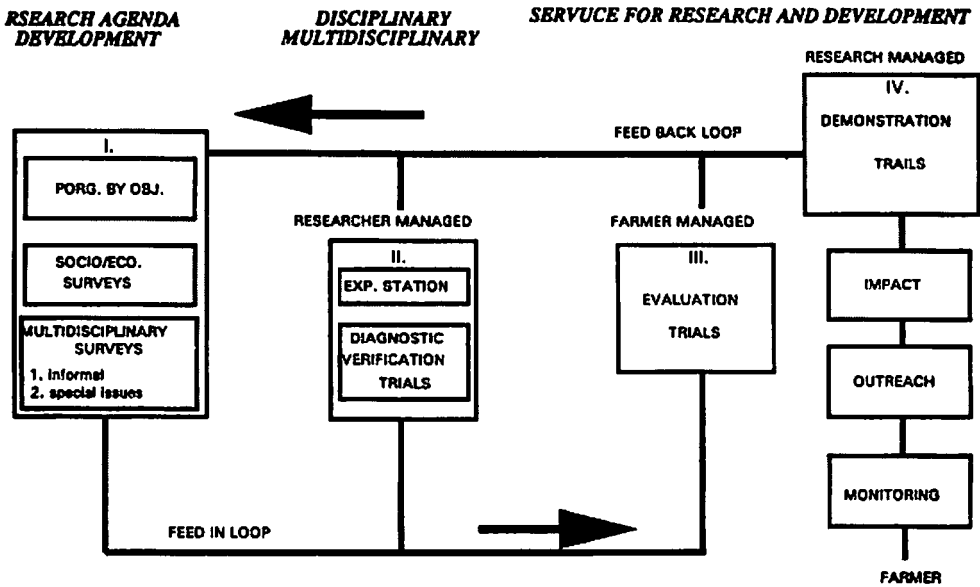


Figure 2. Moroccan technology development and transfer process.

Policy Making, Research, Extension, and Farmers

INRA recognized the need for a mechanism to transmit and disseminate information to farmers. The Aridoculture Centre, therefore, decided to incorporate the goals of the extension service into those of research, and to involve farmers through the *Chambre d'Agriculture*. This linkage failed to generate broad-based feedback from farmers because of the limited scope of the farmers' organization and the unrepresentative nature of those participating. The research did not incorporate regional differences and farmers' demands.

Systems Approach and Research Process

A primary measure of the potential impact of a systems approach on agricultural development is the extent of its integration into the research system. The three components of FSRE—household consumption, marketing and crop–livestock production—are so closely interrelated that consideration of any one without consideration of the other two may result in the design and implementation of inappropriate research activities.

The major impact of Programming by Objectives has been a redefinition of research activities in three main production systems—wheat, barley, and rangeland—and three areas for systems analysis—socioeconomic, agro-climatological, and specialized research.

A systems perspective provides opportunities to focus research priorities and for the evolution of collaborative research projects for larger development problems, but it does not effectively link consumption and marketing. The Rural Sociology and Economics Sub-Program at the Aridoculture Centre is addressing this issue.

The Aridoculture Centre production system strategies are related to:

- The rainfall gradient inland and from north to south.
- Soil types, the depth and quality of which decrease from the Atlantic coastline to the interior.
- Activities of agricultural researchers to improve efficiency in each system.

The objectives are:

- Increased crop and livestock production and reduced variability.
- Maintenance or improvement of sustainable natural resources.
- Development of sustainable farming systems capable of generating increased incomes.

The SRD is mandated to transfer information on technology developed at the Center to agencies which can utilize it to increase productivity in the agricultural sector, and to disseminate information through demonstration trials. Together with the On-farm Technology Evaluation Program, it undertakes on-farm trials to evaluate promising technologies under farm conditions.

Technology Transfer Transitional Stages

Technology transfer activities undertaken during the course of the DAAR project have included the distribution, from 1985 to 1989, of improved varieties to farmers in the Chaouia and Abda region of Morocco using transect and cluster sampling. Researcher-managed diagnostic on-farm trials had an indirect technology transfer objective. Economic, sociological, and agricultural baseline data were collected.

In 1990, the first training program using the Farming Systems Approach to research and extension was introduced and placed under the Service for Research and Development in 1991.

The Research Systems Approach was introduced during the 1991/92 season. Formal surveys and training in the conduct of on-farm trials and program evaluation involving MIACTA and extension agencies started in 1992 and 1994, respectively.

The IFAD Project laid out a framework, starting with information development, followed by researcher-managed on-station and on-farm trials and farmer-managed evaluation trials.

IFAD/ICARDA Project

This project began in 1989 with surveys involving INRA, ENA-Meknes, and the Direction Provinciale de l' Agriculture and Centre de Travaux. On-station and on-farm trials on dual purpose barley/peas and triticale/peas packages were carried out from 1989 until 1993.

Since 1992, the results have been evaluated by the IFAD project, which has supported studies of adoption constraints, training of extension workers, and analysis of project impact.

Technology Development and Transfer Process (TDT)

Figure 2 presents the technology transfer and development process in the Aridoculture Centre and INRA in Morocco.

Research Systems Approach

Training in sondeos, research project management, communications, management of on-farm trials, and the use of socioeconomic baseline information was introduced from 1991 to 1993.

Several research and administrative challenges remain, including:

- Expansion of the research process component through research proposal development and successful competition.

- Increased efficiency of research agenda development through the articulation of farmers' and extension workers' perspectives.
- The development and utilization of monitoring and impact assessment.
- The incorporation of socioeconomic data into all aspects of the research systems approach.

Research Agenda Development

Advances have been made in research development at the CRRA at Settat. These advances will be incorporated into the IFAD Project. Research development capability has been augmented by:

- The development of the technology transfer component at Ouled Said CT and the completion of the training center at Jemaa Shaim.
- The introduction of the log frame approach to support research project management, monitoring, and evaluation.
- Improved information on rural sociology and economics, through seminars, published reports, and interaction between researchers.
- The completion of the Rapid Rural Reconnaissance survey in Ouled Said, identifying constraints on production system which can be addressed by researchers and used in support of INRA and IFAD Project.
- The recognition by rural sociology and economics staff of the need for efficient and effective assessment of the impact of technology.

Training in Morocco on the design and implementation of on-farm trials has provided opportunities for the incorporation of the views of farmers and extension staff on constraints to be included in their research and development. Research development is supported by Programming by Objectives, surveys, and project management training.

Survey Activities

The program of trials has been supported by Background Information Surveys (BIS), Zoning Surveys (ZS), Sondeos, and Special Issue Surveys (SIS).

Background Information Surveys

These surveys are undertaken by SRD personnel with a working knowledge of an area where a sondeo will ultimately be undertaken, and are essentially surveys of existing literature. While the usefulness of this procedure cannot be understated, much of the information collected is from outdated sources and should therefore be combined with formal survey results.

Zoning Surveys

These are intended to improve access to and understanding of an area and its people.

Sondeos

These informal surveys, which may be general or targeted, are intended to identify constraints on agriculture and to build teams.

Special Issues Surveys

Special Issue Surveys (SIS) may be necessary to identify coefficients for use in the economic analysis of agronomic trials, and may include surveys of costs and prices, labor requirements, demographic information, and marketing. Specific examples include studies of farm machinery (1988), seed sales (1990), and drought (1992, 1993). In addition, special issue surveys may be undertaken during periods of structural change or when complex issues are being addressed at the farmer level.

Formal Surveys

Formal Surveys (FS) to identify production, consumption and marketing constraints may be undertaken simultaneously with agronomic trials.

The above surveys lead to a more comprehensive ability to prioritize research.

Prioritization of Research and Research Agenda Development

Effective research requires appropriate prioritization, which is dependent upon information from policy makers, researchers, secondary sources, and farmers.

Research Process

Research represents the bulk of CRRA activities at Settat and in the IFAD project, and includes the development and testing of technologies.

On-farm Trials

On-farm trials are undertaken by researchers to diagnose biological and technical constraints which differ with location.

Farmer-managed On-farm Trials

In 1988, researchers at the Center initiated farmer-managed on-farm trials (FMT), which provide a mechanism for the collection of economic and sociological data in

addition to biological data. These were extended in 1991 to include extension services from Settat's and Safi's Direction Provinciale de l'Agriculture.

Monitoring and Impact Assessment

The capacity to measure the impact of technology is directly related to the Aridoculture Center's ability to transfer technology appropriate to the farmers needs. This process has been slowed by the lack of baseline information on the project area. This problem is now being rectified by the Service de Recherche et Developpment.

Conclusion

The DAAR and IFAD projects both have the basic components for the transfer of appropriate technology. The outstanding challenge is to develop methods for helping farmers to understand and use the technology being developed by research organizations in Morocco.

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The Transfer of Feed Block Technology to Manufacturers and Sheep Owners

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Abstract

This study aimed to develop a technology transfer model for the IPA Agricultural Research Center in Iraq, based on Mashreq Project methodology. The model is presented by using the example of the transfer of feed block technology in the Mashreq Project in northern Iraq from 1992 to 1995.

Methodology consists of the following stages:

- Research, development, and improvement of feed blocks, using various ingredients.
- Testing the research findings at research and production stations.
- Verification in commercial flocks under the direction of the research team.
- Production of the feed blocks on a larger scale.
- Demonstration of the new technology in commercial flocks under the supervision of an agricultural extension team.
- Expansion of production through contracting with private firms and agricultural companies.
- Large scale adoption and dissemination of the new technology through provision of inputs and technical support.

The coordination between IPA and the Ministry of Agriculture to expand feed block production by private firms, and its use by sheep owners throughout the country, is discussed.

Introduction

The IPA Research Center, in cooperation with the Mashreq/Maghreb Project, has successfully implemented a project to produce and disseminate a new technology among sheep owners in Iraq.

The deterioration in sheep productivity has accelerated in recent years because of feed shortages due to competition for land from food crops, and the closing,

because of the economic blockade, of factories which produce feed concentrates from imported materials.

Agricultural by-products such as straw, wheat, and rice bran are low in protein. To utilize these by-products efficiently, they must be supplemented with barley or oil seeds. The IPA Research Center undertook a project to develop a suitable technology to overcome the problem.

Multinutrient feed blocks, using local agro-industrial by-products, were introduced in the Mashreq Project area of Northern Iraq in 1993 as a supplementary diet for sheep grazing stubble or low quality pasture. A long-term project to establish plants to produce feed blocks to feed two million sheep has been recently initiated. The Iraqi National Team has adopted a step-wise methodology for development and dissemination.

Materials and Discussion

The methodology adopted by the IPA links research with both extension and farmer activities. Following is a representation of the ten stages which comprise the feed block project (Fig. 1).

Initial Experimentation

Experimentation with feed blocks began in November 1992 at an experimental unit in Fudhalia experimental station. The unit consisted of a mixer, hand pressing machine, and block cases, all locally made. Several methods, including mixing, packing, and pressing, were tested using locally available by-products, which included wheat bran, rice bran, corn cobs, beet pulp, tomato pulp, corn gluten, bagasse, and whey, before an acceptable feed block was produced. Urea was added as a nitrogen source and calcium sulfate was added as a source of sulfur. Different combinations of ingredients were tried, with 4–8% of urea.

Field Trials and Adaptation at Research Stations

Analysis of the feed blocks showed that they contain adequate crude protein and major minerals, especially calcium, phosphorus, sodium, and magnesium, as well as some trace elements. Trials at experimental stations to evaluate responses to the feed blocks showed significantly higher growth rates in animals given feed blocks (Table 1).

Table 1. Growth rate of sheep offered feed blocks.

Experimental Station	Age	Mean growth rate (%)	Increase (g/day/animal)
Fudhalia	1.5 years	100 g	50 g
Fudhalia	3–5 years	50 g	72 g
Radhwaniya	6 months	195 g	12 g

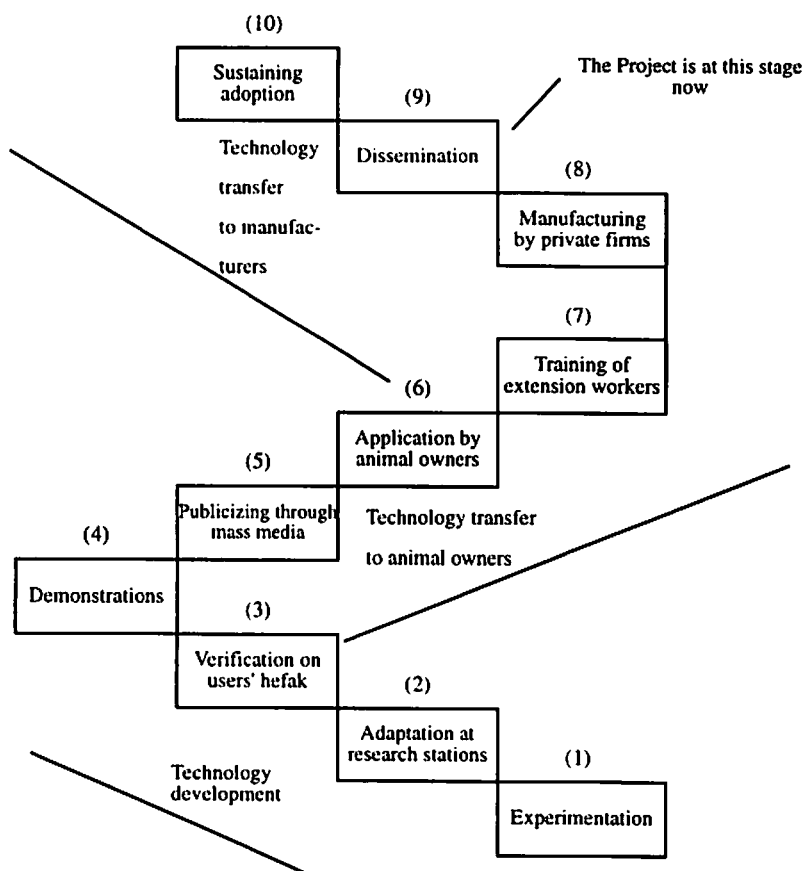


Figure 1. Mechanism of the development and dissemination of feed block technology.

Verification In Commercial Flocks

Trials were then made in flocks of cooperating sheep owners in the Mosul area, with the objective of verifying the results obtained at the experimental stations and assessing the degree of acceptance by sheep owners. The results are summarized in Table 2. The feedback from sheep owners was quite positive and encouraging.

Table 2. On-farm trials of feed blocks.

Village	Age	Mean growth	Increase % [†]
Abu Saif	3-5 years	117 g	56
Al Masayed	3-5 years	115 g	100
Al Erbeed	3-5 years	75 g	47
Al Sihajee	6 mo.	204 g	20

[†] Percentage gain over unsupplemented animals.

Demonstrations

Demonstrations were then conducted at various locations to show the importance of feed blocks and their economic advantage in overcoming the nitrogen shortage, especially when grazing in dry seasons. Feed blocks were distributed to sheep owners, and their use was followed up by the National Team.

The results convinced the sheep owners of the value of blocks as a supplement. Continuous involvement of the researchers and extension workers in the demonstrations provided valuable feedback. By the end of 1993, 42 sheep owners were regular users of feed blocks.

Publicizing Through Mass Media

Shortly before commencing the fourth phase, and throughout the following phases, a series of programs was presented on the main television channel of Baghdad TV to inform flock owners of the new technology, and to prepare the ground for further expansion. Extension leaflets were prepared and distributed to interested sheep owners. The new technology was one of the main features at the Agricultural Fair in Baghdad in 1993 and in 1994.

Application by Animal Owners

The limited number of participants in the feed block program was gradually expanded to include the most active cooperating sheep owners—24 in the Mosul area and 10 in the Salaheddeen area. They were considered the spearhead of the application phase, and each was given 100 blocks. The quick success made it impossible to meet the increasing demand from this group as well as the demand from other sheep owners. Because of this, the daily capacity of the Fudhalia experimental station pilot plant increased to 1.5 tons and later to 2.5 tons. In July 1994 an additional production line was established to increase the daily capacity to 4 tons.

The application phase also featured visits of sheep owners to the Fudhalia plant, where they viewed the production process and were given answers to their inquiries. The feed blocks were also distributed to some of the cattle stations in the country.

Training of Extension Workers

The training program may be said to have begun in the earlier stages, as field workers were actively involved in all of the phases of experimentation and verification. The program was then geared to training extension workers in the Ministry of Agriculture, since IPA had no extension workers in most of the remaining provinces. Two training courses were held in 1993, and two in 1994. The stage was set in late 1994 to establish a link with the Ministry of Agriculture to gain their active involvement in disseminating the new technology.

Technology Transfer to Private Firms

The IPA plant's production capacity was insufficient to meet the growing demand for feed blocks, and so new steps were taken to transfer the technology of manufacturing feed blocks to private firms. One of the cooperating sheep owners in the Mosul area had the finances to start a factory in early 1994, using locally available by-products such as beet pulp. Initial capacity was 2.5 tons per day, later increased to 4 tons. The National Team supervised the quality of the feed blocks, their distribution, and the pricing of inputs and output.

A campaign to enlist the involvement of other private firms was started in provinces with large numbers of animals and substantial amounts of by-products.

During 1994, 1,043 tons of feed blocks were produced by the IPA and the private firm in Mosul, and distributed to 483 sheep owners. By mid-1995, four other private plants were in production and six more were about to start production. In the first half of 1995, 3,152 tons were produced, and 1356 sheep owners in most of the provinces were using them. A workshop to discuss technology transfer to private firms was held in Mosul in June 1995.

Dissemination

The stage was set for wide-scale dissemination of feed block manufacturing and use with the establishment of a coordinated program with the Ministry of Agriculture in early 1995.

The three-year project has as its first phase goal the establishment of 18 feed block plants in different provinces of Iraq, with a total capacity of 54,000 tons annually, sufficient for two million sheep. Supervision of the plants, quality control of the product, and the pricing policy for inputs and output will be exercised by IPA in coordination with the Ministry of Agriculture. During this period, IPA will train extension workers in the various provinces to assist sheep owners in using feed blocks.

Sustaining Adoption

Sustaining adoption is perhaps the most neglected phase of technology transfer in most countries. The linkage that should exist between the resource agency and the users is not simply a two-person interaction. It should go beyond the point of improving individual problem-solving towards the creation of a stable and long-lasting network of social influence. The National Team at IPA is working on this strategy.

Impact and Success Factors

Four basic factors emerge in the success story of feed block adoption in Iraq. These are technical suitability, economic benefits, step-wise methodology, and synergy. Each one of these factors will be briefly discussed below.

Technical suitability

The new technology of feed block manufacture clearly meets Schumacher's four basic requirements (1973) for successful adoption by private firms:

1. Workplaces should be created in the areas where people are living.
2. Workplaces should not require an unattainable level of capital costs and imported inputs.
3. Production methods employed should be relatively simple, minimizing the demand for high skills in both the production process and in matters of organization.
4. Production should be mainly from local materials and mainly for local use.

Economic benefit

Results of on-farm trials show that the use of supplementation with feed blocks can increase the efficiency of sheep production in Iraq in a number of ways (Mohammed et al. 1995):

- By reducing the use of barley and concentrates by 50% for much of the year and by 100% during stubble grazing.
- By optimizing the use of agro-industrial by-products.
- By conserving the nutritional value of by-products with high moisture content, such as date pulp, beet pulp, and tomato pulp.
- By using and improving the nutritional value of non-conventional by-products such as reeds, corn cobs, and poultry waste.

The use of feed blocks with stubble grazing led to a higher rate of weight gain, resulting in additional net return of 90 Iraqi dinars (ID) per ewe at 1993 prices. The rate of return of feed blocks is ID3, whereas that of other supplements, such as cotton seed meal, does not exceed ID2.

The use of feed blocks with barley grain increases the economic efficiency of sheep. As a result of the increase in body weight gain and reduction in feed costs, an additional profit of ID67/head was obtained, at 1993 prices.

Step-wise methodology

It has been observed that the failure of innovation may often be attributed to an inadequate consideration of various problems of phasing and timing.

Although it may often be tempting to skip certain phases of technology transfer in order to accomplish the change as rapidly as possible, this may result in difficulties. Change can be accomplished without the active collaboration of farmers, but the process is immensely easier if farmers have gone through the phase of motivation-to-change.

Each of the phases of adoption should correspond to the appropriate phases of research-extension activity, as depicted in Figure 2. Researchers and extension workers should understand what stage potential adopters have reached, so they can plan to be with them, not ahead or behind. They must know when to switch from one mode of communication to another.

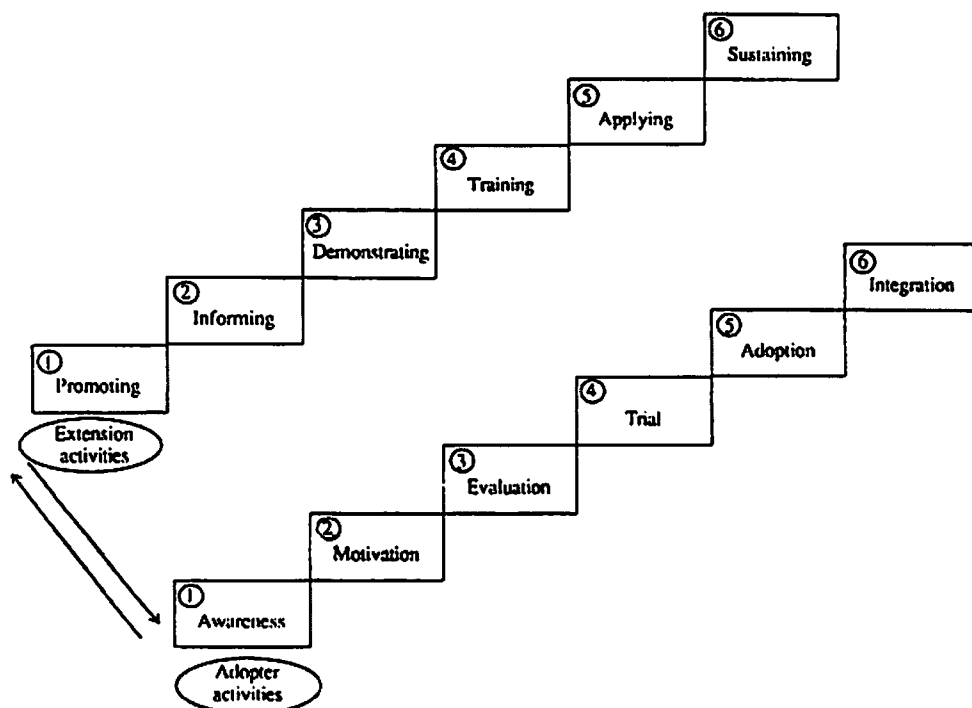


Figure 2. Coordinating phases of extension and adopter activities in the adoption process.

The first three phases of technology development, as depicted in Figure 1, slowed down the entire transfer process. This effect, however, was positive, as it clearly demonstrated that the success of later phases depended, to a great extent, upon experimentation and verification at the farm level by interested sheep owners.

Synergy

The term synergic is defined as “exerting force together or in combination, or upon the same point” (English and English 1958). For our purposes, the “same point” is the adoption of an innovation. This means that several inputs of knowledge working together over time produce the behavior which is identified as “adoption.” But synergy goes beyond simple repetition, and suggests that various messages relating to the same piece of information must be generated, and that these messages must be directed at the potential user through a number of different channels and in different formats, all coordinated to the one goal: the adoption of the innovation (Havelock et al. 1971). IPA brought together a variety of messages and focused them—in combination, in sequence, and with repetition—upon the

potential user. This required leadership to pull together and structure diverse resources, and develop and execute strategies for their effective dissemination and utilization on a continuing basis.

Conclusion

With the increased demand for feed blocks and the wide adoption by sheep owners of the technology, new opportunities and challenges arise. These are:

1. Increasing the proportion of non-conventional by-products in feed block manufacturing is needed to substitute to a large extent for wheat and rice bran. Recent research results show the possibility of developing new formulas with 35% reed or poultry waste. This would reduce the percentages of both wheat and rice bran to no more than 20%.
2. The development of an efficient and effective system of quality control to standardize the blocks is essential. Although currently the project team is maintaining a program for field inspection and quality control, as the number of plants increases and spreads nationwide, additional well-trained extension workers will be needed.
3. Feed block production decreases significantly during winter, because there are fewer sunny days to dry the product. As drying is a major constraint for the current technology, several attempts have been made to solve this problem, so far without success.

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Adoption of Barley Production Technologies In Iraq: A Farm Level Analysis

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Abstract

The main components of the adoption of new barley production technology were analyzed using the results of interviews with 250 farmers in rainfed areas. Farmers were classified into: participants in demonstrations (58), neighbors and/or participants in field days (95), and non-participants (97). An improved cultivar and/or fertilizers were adopted by 52.4% of the farmers. All those who participated in the project demonstrations adopted both, whereas 37% of neighbors and non-participant farmers adopted only fertilizers.

Both probit and logit models were used to estimate the relationship between adoption rate and degree of adoption. Intensity of adoption was analyzed using a multiple linear regression model. Results show that farm size and profitability are the most significant factors affecting the three indicators of adoption. The predicted probabilities of adoption at the mean values of explanatory variables are 0.252 and 0.533 for probit and logit models, respectively.

Introduction

Rainfed farming is a major source of wheat and barley production in Iraq. Nearly 85% of wheat and 48% of barley were produced under rainfed conditions in the last four decades (Annual Statistical Abstract). However, wheat and barley yields are very low, ranging between 400 and 800 kg/ha during the period 1967–1991. These low yields contribute directly to food and feed deficits, although there is capacity for higher domestic agricultural production through greater efficiency. Productivity (output per unit of all inputs) measures the efficiency with which resources are converted to commodities and services (Lu et al. 1979). Increased agricultural productivity enables a farmer to produce more with the same amount of resources.

Although many factors contribute to growth in agricultural productivity, technology is the most important force in the long run (Griffith et al. 1995). To a large extent, the rate of adoption of a new technology is subject to its profitability, the degree of risk and uncertainty associated with it, capital requirements, agricultural policies, and the socioeconomic characteristics of farmers.

Research generally suggests that individual characteristics influence observed adoption decisions (Deuson and Day 1990; Jarvis 1981; Kebede et al. 1990;

Sarap and Vashist 1994). It also suggests that the use of information on the relationship between these characteristics and observed behavior can enhance policies for adoption. The Mashreq Project, sponsored by UNDP and AFESD, was implemented in Iraq, Jordan, and Syria to transfer improved agricultural technology, such as a new barley cultivar (Rihane 3) and fertilizers, to farmers in low rainfall areas (200–350 mm). Most adoption studies in the Mashreq countries (e.g. Tutwiler 1994; Mamdouh et al., unpublished) have focused on the factors which influence the adoption of new technology introduced by the Mashreq Project. The question of adoption or non-adoption is important at the initial stage, but the more relevant issue at this stage of the Project is the intensity of adoption. The main objectives of this study are to:

- Identify and analyze socioeconomic characteristics which influence adoption. The acceptance of technology, adoption rate, performance, and constraints on adoption will be identified.
- Analyze the degree of adoption, measured by the proportion of land under the new barley cultivars.
- Analyze the intensity of adoption.

These three components will be analyzed using cross-sectional data from farmers in rainfed areas. The results will provide useful information for technology transfer. An understanding of how individual characteristics tend to influence adoption decisions can improve the effectiveness of technology in enhancing growth in productivity.

Materials and Methods

The study is based on data collected in 1994/95 through a questionnaire from 250 farmers. They were classified into three groups: participants in demonstrations (58), neighbors and/or participants in field days (95), and non-participants (97). The farmers were selected by random sampling regardless of adoption of the new technology.

The improved cultivar and/or fertilizer were adopted by 52.4% of all the farmers. All those who participated in project demonstrations adopted both (Table 1), whereas 37% of neighbors and non-participant farmers adopted only fertilizer.

Table 1. Percentage of adopters according to type of participation.

Type of participation	Total no. of farmers in group	Adopter farmers in the group (%)	Number
Participants in demo	58	100	58
Neighbors or FD	95	39	37
Non-participants	97	37	36
Total	250	52.4	131

Demo = demonstration.

FD = field days.

Table 2 shows the type of technology adopted, according to farmer participation. Most of those who adopted fertilizer and all those who adopted the improved cultivar had participated in field demonstrations.

Table 2. Type of technology adopted according to farmer participation.

Type of participation	Fertilizer		Improved cultivar	
	Percentage	Number	Percentage	Number
Total farmers	50.0	125	22.8	57
Farmers in demo	43.2	54	100	57
Neighbors or FD	28.8	36		
Non-participants	28.0	35		

Demo=demonstration.

FD=field days.

Fertilizer application was adopted by 50% of all farmers and the improved variety was adopted by 22.8%. Fertilizer was used for one year only by 50% of the farmers, but 42% continued to apply it on a regular basis (Table 3).

Table 3. Adoption of fertilizer application according to type of participation (percentage of farmers).

Type of participation	Used fertilizer once		Continued to use fertilizer	
	Percentage	Number	Percentage	Number
Total farmers	50.0	125	2	105
Farmers in demo	43.2	54	5.8	48
Neighbors or FD	28.8	36	27.6	29
Non-participants	28.0	35	26.6	28

Demo=demonstration.

FD=field days.

Non-availability and high price of fertilizer were the main constraints on the adoption of fertilizer for 56% and 38% of farmers, respectively (Table 4).

Table 4. Main constraints affecting the adoption of fertilizers.

Constraints	Farmers	
	Percentage	Number
Unavailability	56.2	136
High price	38.4	93
Poor quality	4.2	10
Lack of experience	1.2	3

Therefore, given the high degree of complementarity between components of the new technology, the availability of publicly supplied fertilizers and seed encourages a maximum rate of adoption (Wiss 1972). Specifications of the model are presented below.

A univariate binary model defined as:

$$P(Y_i=1) = F(X_i\beta) , i = 1, 2, \dots, n$$

where Y_i is a sequence of dependent binary random variables taking the values of 1 or 0; X_i is a K-vector of known constants; β is a K-vector of unknown parameters; and F is a certain known function.

The functional forms of F most frequently used in applications are as follows (Amemiya 1981).

Linear probability model:

$$F(x) = x$$

Probit model:

$$F(X) = \Phi(X) = \int_{-\infty}^x \frac{1}{\sigma\sqrt{2\pi}} \exp\left[-\frac{t^2}{2\sigma^2}\right] dt$$

Logit model:

$$F(X) = \Omega(X) = \frac{e^X}{1 + e^X}$$

The linear probability model has a defect, in that F of this model is not a proper distribution function as it is not constrained to lie between 0 and 1. However, the probit model, like many other models using the normal distribution, may be justified by appealing to a central limit theorem. A major justification for the logit model is that the logistic distribution function is similar to a normal distribution function but has a much simpler form. With regard to probit and logit models, Amemiya (1981) concludes that: "Because of the close similarity of the two distributions, it is difficult to distinguish between them statistically unless one has an extremely large number of observations." The choice between them is largely one of convenience and program availability (Perry 1986).

Both probit and logit models have been used in applied research on technology adoption. The logit model, however, is more common (Kebede et al. 1990; Bagi 1983; Jarvis 1981; Sarap and Vashist 1994). For this study both probit and logit models were used to assess the first two objectives, adoption rate and degree of adoption, where the probability of adoption depends on the characteristics of the farmers. If the coefficient of a particular variable is positive, it means that higher values of that variable result in a higher probability of adoption, while a lower value implies a lower probability of adoption (Sarap and Vashist 1994).

The third objective of the study, intensity of adoption, was analyzed using a multiple linear regression model. For the three models (probit, logit, and multiple linear regression), the explanatory variables are farm size, weather risk, farming

enterprise, and profitability. Farm size was expected to have a positive relationship with the adoption of improved cultivars and fertilizers (Kebede et al., 1990; Sarap and Vashist 1994; Bagi 1983).

The attitude of farmers to risk is an important factor in adoption. It is generally understood that farmers averse to risk are reluctant to invest in innovations of which they have little first-hand experience (Deuson and Day 1990). Weather variability was taken as a major risk in rainfed farming. A dummy variable was chosen to quantify weather risk, and given a value, based on farmers' responses, of 1 for good or moderate, and 0 for low rainfall seasons. The effect of this variable on adoption, degree of adoption, and intensity of adoption is expected to be positive.

Farming enterprise is another factor that may affect adoption and can be positive or negative, depending on its relative contribution to farm income. In this sample, 28% of the participating farmers had only crops, and the remaining 72% had crops and livestock. This implies that mixed farming enterprises are a major determinant of farm income, and may have a negative effect on the adoption of new technology. A dummy variable was chosen to represent the farming enterprise, taking a value of 1 for crop farms and 0 for mixed farms.

Profitability is the most important determinant of the rate of adoption and diffusion. Griliches (1967) indicates that hybrid maize diffuses more rapidly in areas where it is more profitable. Jarvis (1981) found that both the rate and extent of diffusion were positively related to changes in the profitability of the technology. The farmers' initial perceptions of its usefulness were taken as a measure of profitability, represented by a dummy variable, taking a value of 1 if the farmer was satisfied and 0 if not.

Empirical Results

The probability of adoption of technology (PAdopt) was specified as a function of farm size, weather risk, farming enterprise, and profitability. For the technology adoption model, farmers were categorized as adoptors (Padopt=1) or non-adoptors (Padopt=0). Assuming a normally distributed error term, the maximum likelihood estimation procedure was used to estimate the probit and logit models, using a TSP program. The estimated coefficients were consistent, efficient, and asymptotically normal estimators (Amemiya 1981).

These estimates are presented in Table 5. Both models provided similar estimates with respect to the statistical significance and the direction of effect of the independent variables on the probability of adoption. However, the coefficients of the logit model were twice those of the probit model. Both farm size and profitability were found to be significant in determining the probability of adoption. This is similar to the results of Kebed et al. (1990), Jarvis (1981) and Sarap and Vashist (1994), and implies that the likelihood of adoption of the Rihane barley cultivar and of fertilizer use is significantly influenced by farm size and profitability.

Table 5. Maximum likelihood estimates of probit and logit models for technology adoption.

Independent variables	Probit model	Logit model
Intercept	-1.34** (-3.39) [†]	-2.34 (-3.18)
Farm size	0.0002* (2.22)	0.0004* (2.33)
Weather risk	0.518 (1.38)	0.99 (1.43)
Farming enterprise	-0.197 (-0.807)	-0.379 (-0.847)
Profitability	2.588** (10.51)	4.54** (9.13)

* = $P > 0.05$

** = $P > 0.01$

[†] = t value

The estimated coefficients of weather risk and farming enterprise dummy variables had the expected signs, but were not statistically significant. The weather risk coefficient supports the risk-averse behavior of farmers. The more averse to risk a farmer is, the less willing is he to use new technology in a low rainfall season.

Degree of Adoption

The degree of adoption, measured by the percentage of area planted with the Rihane cultivar, was also hypothesized as a function of farm size, weather risk, farming enterprise, and profitability. The parameter estimates of the probit and logit models are presented in Table 6.

Table 6 Maximum likelihood estimates of probit and logit models for degree of adoption.

Independent variables	Probit model	Logit model
Intercept	-3.26 (-1.13) [†]	-5.86 (-1.44)
Farm size	-0.002** (-14.38)	-0.004** (-2.73)
Weather risk	1.97 (0.68)	3.17 (0.775)
Farming enterprise	-1.47** (-4.16)	-3.11** (-4.04)
Profitability	1.73** (5.05)	3.94** (3.71)

** = $P > 0.01$

[†] = t value

These parameters are consistent with expectations, as farm size, farming enterprise, and profitability were statistically significant ($P > 0.01$). Profitability

had a positive effect on the degree of adoption. This variable had the greatest significant effect on the degree of adoption of the Rihane cultivar. Farm size has a negative impact on the degree of adoption. Sarap and Vashist (1994) also showed that the degree of adoption of new varieties tends to decline with farm size. Survey data in this study showed that the average area sown to the Rihane cultivar was 38.6 ha per farm, whereas that for the local cultivar was 58.55 ha. The negative effect of farm size on the degree of adoption was due to the limited scope for expanding the area of the Rihane cultivar compared to the local variety. The main reason for this limitation is the scarcity of Rihane seed. Diversification is a probable explanation for the negative relationship between farm size and degree of adoption as farmers adopted risk-averse behavior. Farmers tend to use more than one cultivar to hedge against uncertain weather and to allocate more of the area to the local variety with which they have first-hand experience. Therefore, the degree of adoption of a new variety tends to decrease as farm size increases.

The degree of adoption estimates provide similar evidence to adoption rate in that the estimated parameters of the logit model are double those of the probit model. This implies that the predicted probabilities of adoption and degree of adoption are sensitive to model specification.

Intensity of Adoption

To analyze the intensification of modern inputs, a multiple linear regression model was estimated by the ordinary least squares procedure. The estimated coefficients are shown in Table 7. These estimates have the expected signs. Both farm size and profitability enhance the intensive use of modern inputs. The estimated coefficients of these two variables are positive and statistically significant.

Table 7. Ordinary least squares estimates for the intensity of adoption model.

Independent variables	Estimated coefficients
Intercept	2.638 (0.557) [†]
Farm Size	0.001* (1.73)
Weather Risk	3.09 (0.675)
Farming Enterprise	0.205 (0.066)
Profitability	52.63** (18.03)
R ²	0.58
F-(4,245)	86.25**
D-W stat.	0.94

* P > 0.05

** P > 0.01

[†] t value

The variables explain 58% of the variation in the intensity of adoption. The overall regression equation is significant at the 1% level of significance according to the F test, suggesting that the model is reliable.

Since heteroscedasticity is a potential problem in cross-section studies, a Park test was used to detect this problem (Gujarati 1978). For the purpose of this test, farm size was considered a potential cause of heteroscedasticity.

The estimated regression equation is:

$$\text{Log } e_i^2 = 4.469 + 0.066 \text{ Farm size}$$

$$t = 9.22 ** 0.742$$

The presence of heteroscedasticity could not be verified because the estimated coefficient for slope was not statistically significant. This result was supported by graphical analysis relating farm size to the squared residuals, which showed no systematic pattern in the error distribution with farm size.

Conclusions

This study analyzed the influence of farm size, weather risk, farming enterprise, and profitability on the adoption of barley production technology in Iraq. Both probit and logit models were used to quantify the effects of these factors on adoption rate and degree of adoption. The intensity of adoption was analyzed using a multiple linear regression model.

Results show that farm size and profitability are the most significant factors affecting the three indicators of adoption. Estimates of the degree of adoption provide similar evidence to that of adoption rate in that the estimated parameters of the logit model are almost double those of the probit model. This has important implications for the associated probabilities of adoption. The predicted probabilities of adoption at the mean values of the variables were 0.252 and 0.533 for probit and logit models, respectively. The model used in adoption studies should, therefore, be carefully selected.

Although this study is limited to an analysis of adoption at the farm level, it should be emphasized that future studies need to have a wider scope. The widespread adoption of a technology, leading to sustainable increases in barley production, will have sector-wide effects. Therefore, assessing the potential economic impacts of adoption requires the use of a model which considers both farm and market components.

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Discussion

J. Gresham: Does the profitability component include direct costs to farmers, such as time and money invested in processing and implementation?

K. Shideed: The profitability variable in the studies is a proxy variable in the form of a qualitative (dummy) variable reflecting the satisfaction of farmers with the performance of the technology. It does not measure actual profits achieved at the farm level. Therefore, direct cost components are not incorporated explicitly into the model.

E. Qararah: You stated that farm size is negatively correlated with adoption. In Jordan data shows the opposite. What recommendation do you have for introducing new technology for small farmers?

K. Shideed: Farm size positively affects the adoption rate, whereas its effect was negative on the degree of adoption. Each farm size has its designated technology, but the intensity of adoption and adoption rate increases as the farm size increases.

R. Tutwiler: What was the actual adoption rate among the farmers exposed to the technology?

K. Shideed: The adoption rate was 52.4% for at least one of the introduced technologies, improved cultivars and fertilizers.

E. Al-Karablieh: The logit and probit models should give the same results. We cannot control the weather, so it is not important to put weather in the explanatory variables.

K. Shideed: The estimated coefficients of probit and logit models have important implications on the predicted probabilities of adoption, as was indicated, especially since the interest is not in the estimated coefficients as such but in their implications and use.

The model relates the observed adoption behavior to the specified socioeconomic factors. The weather variable reflects the risk associated with production under rainfed conditions.

Adoption of Improved Barley Production Technologies In Syria: Impact of the Mashreq Project, 1989–1994

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Introduction

The Mashreq Project in Syria was a cooperative effort between the Directorate of Agricultural Scientific Research (DASR) of the Ministry of Agriculture and Agrarian Reform, and the International Center for Agricultural Research in the Dry Areas (ICARDA). The Project's objective was to transfer improved production technologies developed by the national agricultural research program to farmers and sheep owners in the 200–350 mm average annual rainfall zones. This paper reviews the progress made in transferring barley production technologies, based upon the results of a survey conducted with 138 farmers following the 1994 harvest. The sample was stratified according to degree of participation in the project and included farmers hosting demonstrations during the project period, their neighbors, participants in field days who were exposed to the new technologies, and farmers who did not participate in any Mashreq Project activities.

The results show that the project successfully met its objective. The use of improved technologies greatly increased among participating farmers, and the rate of increased adoption was much greater among participating farmers than among non-participants. Although most farmers expressed a willingness to adopt new barley technologies, their actual adoption of individual components of the full package varied. Some components were easier to adopt than others, and the survey identified the constraints to increased adoption rates.

The impact of the project was greatest in terms of increased use of improved cultivars and lowered seed rates. The impact on adoption of the other two components of the full package—chemical fertilizers and seed drill use—was less, for two reasons: (i) use of fertilizer and seed drills was widespread before the project began; and (ii) increased adoption rates of these two components are primarily constrained by cost considerations. Lack of availability and risk aversion were also cited as constraints to increased fertilizer use by farmers in the driest areas.

Factors constraining increased use of improved cultivars include lack of farmer knowledge about them, availability, and preferences regarding grain color. The cost of using a new cultivars is not a major issue. Most farmers have little

experience with the recommended lower seed rates. But those who experimented with a lower rate tended to adopt its use. Reduced rates were encouraged by the immediate economic benefit of saved seed.

The Technology Package and Demonstration Program

The Syrian Government has committed considerable resources to increasing barley productivity. National yield levels have averaged well below 1 ton per ha for the past 30 years, and there is some evidence of a downward trend as the cultivated area has expanded into more marginal environments, and the traditional practice of annual fallowing has been increasingly replaced by continuous barley cultivation. With the support of international and regional institutions such as ICARDA and the Arab Centre for Studies of Arid Zones and Drylands (ACSAD), promising barley varieties combining relatively high and stable yield potential under stress conditions have been selected and released. Associated agronomic practices, such as proper tillage, sowing method and date, seed rate, and other techniques, have been developed and tested, and recommendations have been formulated for different agro-ecological zones.

Although progress has been made in developing appropriate technologies for barley in dry areas receiving less than 350 mm annual rainfall, the mechanisms for transferring the technology to farmers were either inadequate or nonexistent. With support from the United Nations Development Programme (UNDP) and the Arab Fund for Economic and Social Development (AFESD), the Mashreq Project initiated an extensive program of technology transfer through direct farmer participation in 1989. Local extension services played a vital role in contacting farmers, conducting demonstrations and field days, and especially in monitoring the results of the activities at the farm level. Extension constituted an indispensable link between researchers developing and adapting new technologies and the farmers who are the intended beneficiaries.

The Mashreq Project focused its efforts in Agricultural Stability Zones 2 and 3, which together constitute the major barley production areas. Zone 2 is defined by an annual rainfall of 250–350 mm, with no less than 250 mm falling during two thirds of the years. Assuming a minimum requirement of 250 mm, two barley harvests are possible every three years. Zone 3 has annual average rainfall greater than 250 mm, with no less than 250 mm falling during half the years. Thus, a barley harvest can be expected in half the years. Because of the greater frequency of low rainfall years, barley production in Zone 3 is more risky than in Zone 2. Many farmers, in fact, do not expect their crop to reach full maturity. Rather, the intention is to provide green grazing for sheep in the spring. If rains are good, then there is the welcome benefit of a grain harvest, but annual grain harvests are not necessary for farmers to continue planting barley.

In recognition of environmental differences and constraints, Mashreq Project scientists matched individual components in the improved production package to areas most appropriate for their demonstration. The extension services contacted farmers in the target areas, explained the technologies and the demonstration procedures, and allowed farmers to decide whether or not to participate.

Demonstration participants were self-selected, based on their interest in the new technologies.

The full package consisted of the following components: improved cultivar developed for the target environment, chemical fertilizer applied according to recommended rates, seeding with a mechanical drill, and seeding using the recommended amount of seed per hectare. In addition to varieties already released, improved cultivars offered included promising lines selected by researchers but not yet released by the national program. Four types of demonstrations were designed using different combinations of components of the full packages. The first demonstration type used a full package of released variety, fertilizer, seed rate, and seed drill. The second demonstration used promising lines, fertilizer, seed rate, and seed drill. The third demonstration followed farmer practice in general, but used the recommended seed rate and a seed drill. The fourth demonstration followed farmer practice in all respects except the application of fertilizer at the recommended rate. All demonstrations were farmer managed, with the farmer cultivating, sowing, and harvesting using inputs provided by the project. Extension agents provided advice on crop management when requested.

The 210 demonstrations, conducted from 1989 to 1994, were distributed across two zones within four provinces, roughly divided between Zone 2 and Zone 3. The full package demonstrations using released varieties were all in Zone 2, but the package demonstrations using promising lines were more equally distributed between zones. About two thirds of the seed rate plus seed drill demonstrations were in Zone 2, and about three quarters of the fertilizer demonstrations were in Zone 3. There were good technical reasons for these differences. The released varieties had been developed for the more favorable conditions in Zone 2, but the newer promising lines were selected for the drier zone. Zone 2 farmers tend to use excessive seed rates more often than farmers in Zone 3, and in Zone 3 fertilizer is used less often than in Zone 2.

Table 1. Distribution of survey sample.

Participation Category	Location		
	Zone 2	Zone 3	Total
Demonstration farmers	38	32	70
Field day attendees	22	17	39
Non-participants	21	8	29
Total farmers	81	57	138

On hundred and thirty eight barley producers were surveyed after the 1994 harvest. The sample was designed to differentiate farmers according to their degree of participation in the project. Seventy farmers who had hosted demonstrations in one or more years were included, accounting for 56% of all demonstrations implemented by the project. Twenty seven of the 70 demonstration farmers had hosted more than one type of demonstration in one or more years. Although they had not hosted demonstrations, 39 farmers in the sample had attended one or more field days or had visited the demonstrations privately. Most of these farmers were close neighbors of demonstration farmers and had followed the performance of the technology during the season. The third group of 29 farmers was randomly selected, and had not participated in either the

demonstrations or field days and had, in fact, no direct knowledge of the project before being contacted by the survey. This group was intended to serve as a control group in determining the impact of the technology transfer program.

Impact of the Project

The starting point for assessing the Mashreq Project's impact in transferring barley technology to farmers is the farmers' practices prior to participation in the Project. These are presented in Table 2 by participation category. As the table shows, many farmers were using individual components of the improved package prior to their involvement in the Project. In particular, fertilizer was widespread and there was considerable use of seed drills. An average of 20% of the farmers practiced the recommended seed rate, although this was more a result of their own experience than because they followed the recommendations of extension agents. Only one farmer out of the 138 interviewed was using an improved cultivar before 1989. The incidence of farmers using no components of the improved package prior to the Project was substantially higher among those who became demonstration farmers than among the non-participants, with field day attendees in the middle.

Table 2. Barley technology use prior to Mashreq Project (percentage of use within farmer category).

Participation category	No use of any package components	Improved cultivar	Fertilizer	Recommended seed rate	Seed drill
Demonstration (n=66) [†]	24	0	41	19	30
Field days (n=38) [‡]	18	3	54	23	36
Non-participants (n=29)	11	0	59	24	41
Total sample (n=133)	22	1	49	21	34

[†] Excludes four farmers who abandoned barley cultivation before the 1994 season.

[‡] Excludes one farmer who abandoned barley cultivation before the 1994 season.

Table 3 summarizes technology use after five years of the project. The numbers should be compared with those in Table 2. The farmer perspective on adoption is expressed in two ways. The majority of farmers expressed an interest and willingness to adopt new technology of which they had at least some knowledge, if not direct experience through use or observation. Willingness was higher among participating farmers than among non-participants, although interest was still high in the latter category. The second measure of their attitude was the actual change in technology use. Here the difference among categories was quite large. Although willingness to adopt, *per se*, cannot be directly attributed to the project, actual adoption behavior is transparently linked in farmers' responses to questions about their reasons for adoption. Overwhelmingly, participating farmers cited the information and experience gained through the project as the fundamental factor in deciding to adopt new technology.

Table 3. Impact of Mashreq Project on surveyed farmers.

Participation category	Percent willing to adopt one or more new components	Percent adopting one or more new components	Percentage of farmers using technology at end of Project (1994)			
			Cultivar	Fertilizer	Seed rate	Seed drill
Demonstrations (n=66) [†]	89	67	30	59	53	49
Field days (n=38) [‡]	77	39	18	63	51	38
Non-participants (n=29)	52	3	3	52	24	41
Total sample (n=133)	77	45	20	58	46	44

[†] Excludes four farmers who abandoned barley cultivation before the 1994 season.

[‡] Excludes one farmer who abandoned barley cultivation before the 1994 season.

It is clear that participation in the project, either by demonstration farmers or field day attendees, resulted in both a greater willingness to adopt new technology and higher actual adoption rates. Perhaps the most dramatic is the difference in actual adoption of new technology during the five years. Between 1989 and 1994, 61% of demonstration farmers had adopted at least one component of the improved package. The corresponding figure for field day attendees was 46%. In contrast, non-participants experienced virtually no change in their technology use. Fully one third of demonstration farmers adopted improved cultivars, and the increase in fertilizer use was almost as great. Interestingly, the highest rate of increase for any one component was the reduction in seed rate among demonstration farmers. Some 34% reduced their previously high seed rates to conform more closely with the recommended rate.

Although a large number of farmers used some form of improved technology prior to the project, most used only one component out of the four in the recommended package. Among the entire sample, the rate of use of single components was: fertilizer (25%), recommended seed rate (17%), and seed drill (10%). For use of two components in combination, the distribution was: fertilizer plus seed drill (22%), fertilizer plus seed rate (1.5%), and seed rate plus seed drill (1.5%). One farmer combined improved cultivar plus fertilizer plus recommended seed rate. Farmers who subsequently participated in the project used recommended technologies at a lower rate than non-participants in 1989.

Table 4 indicates the change in component adoption between the start of the project and 1994. Not only did use of recommended technologies increase considerably, but use of multiple components in combination also increased, from 24% of participants in the first year of demonstrations to 59% in 1994. The most common single components in 1994 were fertilizer (15%) and recommended seed rate (14%). This was the same as in 1989. In terms of two component combinations, the most common were fertilizer plus seed drill (11%) and fertilizer plus seed rate (7%). As predicted by these numbers, fertilizer continued to be the

dominant partner in three component combinations, appearing in all but two of the 32 farmers using more than two of the package components. Fertilizer is followed by seed rate, seed drill, and cultivar in order of frequency. If the pattern of step-wise component adoption is a guide, the most readily adopted technology is fertilizer, and the most difficult is improved cultivar. However, it should be stressed that the base line for the two components is very different. Farmers are much more familiar with fertilizer. It is widely available, and has a long history of use. Improved cultivars are a very recent introduction. Farmers have little knowledge of their performance and availability, and seeds are not easy to obtain.

Table 4. Single and multiple component adoption (percentage of farmers within categories).

Number of components adopted	1988/89			1993/94		
	Non-participants	Field days	Demo farmers	Non-participants	Field days	Demo farmers
No components	11	18	24	14	3	7
1 component	55	45	56	52	39	27
2 components	31	34	20	27	37	26
3 components	3	3	0	7	18	34
Full package	0	0	0	0	3	6
Total	100	100	100	100	100	100

Degree of participation in the project had a clear effect on subsequent adoption of recommended technologies. To better appreciate this factor, demonstration farmers were subdivided into those hosting multiple demonstrations and those hosting only a single demonstration in a single year. The results of this distinction are presented in Table 5.

Table 5. Technology adoption by degree of participation (Percentage of farmers within categories).

Degree of participation	Adopting one new component	Adopting two or more new components	Total adopting
Multiple demonstrations	23	50	73
Single demonstration	38	27	65
Field day attendees	18	21	39
Non-participants	3	0	3
Total sample	23	23	46

The important difference between hosts of multiple and single demonstrations was one of multi-component adoption. Multiple demonstration farmers were almost twice as likely as their single demonstration colleagues to adopt more than one component of the package. There was a marked difference between participation categories in terms of combinations adopted. Whereas field day attendees and single demonstration farmers tended to use fertilizer in combination with either seed drill or reduced seed rate, multiple demonstration farmers more frequently added improved cultivar. The adoption of a cultivar by this group is all the more noticeable when it is recalled that a fair proportion of farmers were already using fertilizer, recommended seed rate, or both before the project began.

Constraints to Increased Adoption Rates

The major technological innovation introduced by the Mashreq Project was improved barley cultivars. Few farmers knew they even existed before the project began. Of 51 farmers hosting demonstrations that included improved cultivars, 21 (41%) adopted them after the demonstration year. Twenty two rejected the improved cultivars included in their trials, but the remaining eight farmers expressed a preference for the improved cultivars, although for various reasons they have yet to adopt them. The principal reason given for adopting an improved cultivar was yield advantage over the local landrace, including higher straw yield in years when there was no appreciable grain yield. Paradoxically, about half the rejecters gave the same reason for rejection: that the local landrace out-yielded the improved cultivars.

The project has made a significant contribution to the dissemination of improved cultivars. However, the contribution has been mainly providing farmers with an opportunity to experiment and test the cultivars in their own fields. Most farmers who did not host cultivar demonstrations reserved their judgment and neither adopted the cultivars nor rejected them. Among project participants who only saw improved cultivars in demonstration fields, about 17% either adopted or expressed a willingness to adopt. Only two farmers rejected them outright. The role played by the Mashreq Project is indicated by what happened among non-participants. None of those in Zone 3 had heard about improved barley cultivars in 1994. In Zone 2, 73% of the non-participants had not heard about improved barley cultivars, and among the remainder, one had adopted and five expressed an interest in adopting. Although the Mashreq Project has been instrumental in introducing information about improved cultivars, the information does not appear to have spread outside project participants.

The pattern of adoption and rejection of improved cultivars indicates a number of factors of potential importance to future technology transfer. First, the ratio of adoption to rejection is about the same in the two agricultural stability zones, although there is slightly more interest in adopting new cultivars in Zone 2 than in Zone 3. The figures also show that there are differences among governorates. Improved cultivars are most readily accepted in the southern governorate of Deraa, where there was universal acceptance, and 5 out of 6 demonstration farmers surveyed adopted an improved cultivar. By contrast, in the northeastern governorate of Hasaka no farmer adopted any new cultivars. In the central governorate of Hama farmers showed a clear preference for white-seeded cultivars, whereas in the northern governorate of Raqqa farmers preferred black seeds.

The pattern of cultivar adoption reveals an interesting phenomenon. One third of adopters grew more than one improved cultivar, often as a mixture in the same field. This was most common in Zone 2 with white-seeded varieties. In Zone 3, mixture was rare, but this could be a reflection of the narrow range of types offered in the demonstration. For example, in Zone 3 in Hama Governorate, only one white-seeded type was demonstrated. Although it had modest adoption success, the larger number of black-seeded types offered in this area were rejected. One explanation for growing mixtures is the nature of the farmers' seed sources. Most farmers rely on the previous year's harvest for the next year's seed. Certified seed from government sources is considered expensive, and the improved varieties are

not always available. Local landraces often contain considerable heterogeneity, so striving to maintain uniformity is not particularly important to farmers. If a farmer hosted a trial with several cultivars of the same color and they were adopted, then it is likely that they would be kept together as a mixture for the next year's planting. It should be noted that there were no cases of mixing cultivars with different seed color.

All the Mashreq Project demonstrations included fertilizer application. A little less than a quarter were single component comparisons of recommended fertilizer application with farmer practice. The increased rate of adoption of fertilizer was much the same in all demonstrations, whether single component or multiple component. None of the non-participant farmers adopted fertilizer during the project. However, this group already had a high fertilizer adoption rate. Participation in the project, either as a demonstration host or as a field day attendee had a positive effect on fertilizer adoption among both groups. Interestingly, 7 of the 37 demonstration farmers rejected fertilizer, but none of the field day attendees rejected did. About half of them adopted fertilizer. The two reasons expressed for not adopting by those who nevertheless expressed a willingness to adopt were that fertilizer was not available in their area (usually Zone 3) or that it was available but too expensive. The principal reason given for rejecting fertilizer use was, as expected, that the risk of receiving insufficient rainfall outweighs the possible benefits of fertilizer use should there be sufficient rainfall.

Fertilizer use is widespread, but it is usually applied in doses below recommended levels. Participation in the Mashreq Project appears to have encouraged more appropriate rates, but the survey also indicates that the rainfall zone has a greater influence. Generally speaking, farmers in Zone 2 apply fertilizer in doses much closer to the recommended rates than their colleagues in Zone 3. The demonstration program consciously targeted its single component fertilizer demonstrations to Zone 3. Ironically, success in getting farmers to adjust their rates more in line with the recommendation was greater in Zone 2 than in Zone 3.

A recommended seed rate of 100 kg/ha, regardless of zone, was included in all demonstrations, either as an explicit comparison with the farmer's rate or as an implicit comparison with local usage in demonstrations where a uniform recommendation was applied to all plots. The project's effectiveness in getting farmers to lower seed rate is evident. None of the non-participants lowered their seed rates. In contrast, about 28% of the project participants lowered their rates. All of the farmers hosting explicit seed rate demonstrations lowered their rates, making these the most effective trials in the entire program.

There is little statistical relationship between use of a seed drill and use of the recommended seed rate. The survey results tend to disprove the prior assumptions that seed drill users will use lower and more uniform rates, and that a farmer needs to adopt a seed drill before being willing to adopt a lower seed rate (for the technical reason of having a uniform sowing depth before accepting a lower seed rate). Only three farmers said they needed a seed drill in order to benefit from a lower rate. Although a higher percentage of farmers in Zone 2 lowered their seed rates than participants in Zone 3, the Zone 3 farmers tended to lower their seed rates more dramatically than did Zone 2 farmers.

The principal reason farmers gave for lowering seed rates was economic. A lower rate had no negative impact on yield and it saved them seed costs. The principal reasons for not lowering seed rates were environmental. Farmers said their experience had proved to them that a high rate gives the best results given their rainfall and/or soil conditions. The source of seed seems to have little bearing on whether or not a lower seed rate is accepted. The vast majority of farmers use seed from their previous harvest. All of the farmers adopting the recommended rate used this source. For the 15 farmers purchasing certified (landrace) seed through the agricultural credit bank, eleven continued to use a high rate, two were previously using the recommended rate, and two reduced their rates slightly. Farmers adopting improved cultivars did not lower their seed rate because of the cultivar, although adopting a new cultivar was combined with a lowered rate in seven out of the 27 cases of new cultivar adoption.

Conclusions and Recommendations for Future Transfer Activities

The Mashreq Project achieved its objective of transferring recommended barley production practices to farmers in the drier rainfall zones. This was accomplished even though two of the technologies, improved cultivars and reduced seed rate, were not well known among farmers or had negative connotations. Demonstrations, combined with field days, were an effective mechanism of technology transfer. However, the survey results show that a number of adjustments in the program could improve its effectiveness and efficiency. These adjustments are outlined in the following recommendations.

Recommendation 1: Demonstration Program

The demonstration program has proven very effective in encouraging the adoption of new technologies. Farmers hosting demonstrations are much more likely to adopt than farmers without demonstrations, although farmers attending field days associated with demonstrations also have a high rate of acceptance of the improved technologies. The demonstrations should be continued, with greater emphasis placed on field days to reach a larger number of farmers.

Recommendation 2: Improved Cultivar Demonstrations

Demonstrations focusing on improved cultivars have been instrumental in transferring this technology to farmers. There is a surprisingly high degree of interest in the new cultivars and very good adoption rates when seed of the cultivars is made available. However, some modifications in the strategy should be made. First, it would be wise to use black-seeded cultivars in Zone 2 demonstrations in the Raqqa and Hasaka governorates. Second, white-seeded cultivars should be used in both zones in the Hama governorate. Third, fertilizer application and seed rates at recommended levels should be included in the cultivar demonstrations in Zone 2, although these factors seem less efficacious in Zone 3. Additional efforts need to be made to hold field days highlighting improved cultivars, and measures should be taken to increase the availability of

seed for released varieties. Priority should be given to disseminating information about improved cultivars, since their existence is largely unknown outside project participants.

Recommendation 3: Seed Rate Demonstrations

This set of demonstrations had the highest positive response from farmers. Although initially skeptical, a majority of farmers accepted the results, and a large number reduced their rates. These demonstrations should continue to be a priority—and possibly be expanded—if seed rate reduction continues to be an issue. However, extension agents and researchers organizing the demonstrations should pay close attention to the soil conditions of the demonstration fields. Farmers tend to apply higher rates on more fertile soils within the same rainfall zones.

Recommendation 4: “Fertilizer Only” Demonstrations

Survey results indicate that “fertilizer only” demonstrations are ineffective in encouraging farmers to adopt fertilizer or to apply fertilizers at recommended rates. None of the fertilizer demonstrations covered in the survey achieved their purpose, since none of their host farmers adopted fertilizer. There is already a high degree of fertilizer adoption among all farmer groups. While fertilizer is useful when combined with cultivar or seed rate demonstrations, it would appear that demonstrations with fertilizer only are not worth the resources invested. By and large, farmers will adopt fertilizer without the aid of a demonstration or field day specifically designed to show its effectiveness. The factors constraining increased fertilizer use are either economic or perceptual and beyond the scope of the demonstration program to address. Fertilizer application should, of course, be continued within the context of demonstrations of other component technologies.

Recommendation 5: Single vs Multiple Demonstrations

Farmers who hosted more than one demonstration either in the same year or in different years adopted package components more often than farmers hosting only one demonstration. However, it is worth considering the cost involved in concentrating efforts on individual farmers rather than communities of farmers. The effects of single demonstrations spread among a wider groups of farmers need to be compared with the effectiveness of multiple demonstrations with a smaller number of farmers. Cultivar and seed rate demonstrations would probably have a more significant impact if they included a larger number of farmer hosts.

Adoption of Improved Barley Production Technologies In Jordan: Impact of the Mashreq Project, 1989-94

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Introduction

The Mashreq Project in Jordan was a cooperative effort between the National Center for Agricultural Research and Technology Transfer (NCARTT) and ICARDA. Supported financially by the United Nations Development Programme (UNDP) and the Arab Fund for Economic and Social Development (AFESD), the project's activities began in 1989 and continued through 1994. Its objective was to transfer improved production technologies developed by the Jordanian national program to farmers and sheep owners in the 200-350 mm average annual rainfall zones. This paper examines the progress made by the project in transferring improved barley production technologies, based upon the results of a survey conducted among 285 barley producers following the 1994 harvest. The sample was stratified according to degree of participation in the project, i.e.: farmers who hosted demonstrations of improved technologies in their fields, participants in field days associated with the demonstrations, and farmers who did not participate in any project activity.

Farmers in all categories adopted one or more of the individual components of the improved production package to a considerable extent during the project period. However, the adoption rates were considerably higher among project participants than among farmers who did not participate, demonstrating considerable success in achieving the project's objective. Project impact was greatest in the use of chemical fertilizers and seed-drill machinery. Adoption rates among project participants were twice the rate among non-participants. Regarding the use of the recommended seed rate and early planting, the adoption rate among participants was about 50 percent greater than among non-participants. More modest—although still substantial—gains were made for the use of improved cultivars. Even greater wins were made in transferring multiple component use. At the end of the project, the use of the full package of improved technologies was two and a half times greater among participants than among non-participants.

The survey revealed uneven adoption rates among Jordanian barley producers. There was a considerable difference in technology use according to location, intended utilization of production, and source of household income. These patterns indicate continuing constraints to the adoption of improved technologies

among certain groups of farmers and suggest strategies for improving the effectiveness and efficiency of future technology transfer efforts.

Technology Package and Demonstration Program

In the early 1990s, barley surpassed wheat as the most widely grown crop in Jordan. The decline in wheat and the rise in barley area is largely a response to the greatly increased size of the national flock of sheep and goats. Barley grain and straw are the principal feed for small ruminants. Nevertheless, despite the considerable increases in the barley area, production has been unable to keep pace with demand, and Jordan has had to resort to a large and costly barley import program.

There are two reasons for the feed gap. First, the growth in small ruminant numbers has been much greater than the increase in barley area. Second, barley yield per hectare has not improved. It has remained below the level of one metric ton per hectare, and there is evidence of a declining trend in yield as the proportion of barley grown in lower rainfall areas is increasing. There is also a large annual variation of yield and production levels directly related to yearly differences in rainfall.

In response to this situation, Jordanian researchers have devoted considerable effort to developing an improved barley production technology package suitable to the drier areas. The package promises to increase yield and stability performance under low and uncertain rainfall conditions. The package recommended by researchers consists of a combination of improved inputs and agronomic practices. In terms of inputs, the most important are recently released improved varieties with higher genetic potential than the commonly used local landraces and chemical fertilizers containing nitrogen and phosphate.

Agronomic practices recommended in combination with these inputs are: early sowing before the onset of the winter rainy season; a seeding rate of 80–100 kg per ha; and planting with a mechanical seed drill that places seed at a uniform depth and alignment within the field. It should be noted that the prevailing, traditional practice among farmers is to use landrace cultivars and no fertilizer, plant with a seed rate substantially lower than that recommended for the broadcasting method, and often to plant after the early rains have fallen. Late sowing is often cited as a risk avoidance practice to insure sufficient soil moisture for plant germination, but research indicates that it may result in reduced total moisture availability during the season.

The technology transfer strategy followed by the Mashreq Project was direct farmer participation through an extensive program of on-farm technology demonstrations. Local extension services played a vital role in contacting farmers, explaining the benefits of the improved technologies, recruiting farmers to host the demonstrations, working with them to implement the demonstrations, and conducting field days at the demonstration sites during the growing season for farmers living in the surrounding communities. The farmers who hosted the demonstrations were self-selected. The project provided them with the needed inputs, but the farmers themselves managed the demonstrations and performed all the production operations.

Mashreq Project researchers and extensionists developed the demonstration program to target different agro-ecologies and socioeconomic environments with different technology components and combinations of components. In higher rainfall areas at 300–350 mm, for example, demonstrations consisted of a full package of five components: improved cultivar, fertilizer application, recommended seed rate, use of seed drill, and early sowing. In low rainfall sites, two-component (variety and fertilizer) or single-component (variety or fertilizer) demonstrations predominated. In Showbak governorate in the south of Jordan, farmers have little access to machinery, and mountainous topography constrains its use, so there were no full package demonstrations planned for that area.

Many of the full package demonstrations included an important management innovation. Particularly in the higher rainfall areas, holding fragmentation, in which farms are typically divided into numerous small scattered plots, is seen as an impediment to the efficient and economic use of improved practices, especially mechanization. As an experiment to address the fragmentation problem, consolidated full package demonstrations were organized for groups of farmers with adjacent plots who agreed to host a demonstration and manage their fields collectively, and to see if consolidated management applying recommended technologies would result in production improvement.

At the end of the 1994 season, NCARTT and ICARDA researchers surveyed farmers who had participated in the demonstrations and field days to assess the impact of the project on their production practices. Included in the survey sample were randomly selected barley producers in the project area who had not participated in project activities. This last category served as a control group to estimate technology adoption trends without the Mashreq Project.

Table 1. Survey sample distribution (number of farmers).

Farmer category	Location				Total farmers
	Ramtha	Madaba	Kerak	Showbak	
Full package–individual	15	9	11		35
Full package–consolidated	11	6	8		25
Variety and fertilizer	9	13	20	24	66
Variety only	3	1	1		5
Fertilizer only	9	3	7	9	28
Field days	16	21	24	10	71
Non-participants	21	10	20	4	55
Total	84	63	91	47	285

As indicated in Table 1, the sample was distributed across four major barley production areas. Ramtha governorate in the north is an area where farmer dependence on on-farm income tends to be greater than in the country as a whole, as does farm size. Many farms display a high degree of on-farm crop–livestock integration, with farmers relying on their own barley production to feed their fairly large sheep flocks. There is a marked trend in Ramtha towards replacing the prevailing barley–fallow rotation with continuous barley cultivation. Madaba in north central Jordan has a smaller average farm size than Ramtha, and there is

proportionately less fallow land. Located near the greater Amman metropolitan area, 78% of the Madaba farmers surveyed report that less than half their household income is derived from on-farm sources, but farmers in Madaba have greater access to purchased inputs than do their colleagues in other locations. Kerak, in south-central Jordan, has many characteristics similar to Madaba, although the average farm size is considerably larger. Off-farm income is an extremely important factor, and barley production is market oriented. Annual fallowing is practiced by 75% of Kerak farmers interviewed, indicating little movement towards increased cropping intensities. Showbak is rather different from the other locations. The area is relatively isolated from Jordan's major urban centers, and the topography is more mountainous and broken. Average farm size is considerably smaller than the other locations. Perhaps most striking is the orientation of Showbak farmers towards producing barley for on-farm consumption rather than sale.

Impact of the Project

A majority of farmers in all surveyed categories used at least one component of the recommended package prior to the start of the Mashreq Project in 1989. As Table 2 shows, however, the 60% of farmers using at least one component of the recommended package were mostly either using the recommended seed rate or early planting or both. There was comparatively little use of improved cultivars, fertilizer, or seed drills. Particular seed rates and planting dates are management decisions that do not require external inputs, and the widespread use of the recommended rates and dates prior to the project is essentially the farmers' own adaptation to their circumstances.

Table 2. Barley technology use prior to the Mashreq Project (percentage of farmers in category).

Farmer category	No use of any package components	Improved cultivar	Fertilizer	Seed drill	Recommended seed rate	Early planting
Demonstrations (n=159)	43	6	6	4	26	39
Field days (n=71)	32	1	3	3	35	47
Non-participants (n=55)	40	2	4	2	31	55
Total (n=285)	40	4	5	4	30	44

Table 3 shows how production practices and technology use changed among all farmer categories during the project. The effect of participation on individual component use is obvious. Although non-participants had substantial rates of adoption for each component, participants had much higher rates of adoption. The differences are particularly marked for input (as opposed to management) components, and especially for fertilizer and seed drill use.

Table 3. Impact of Mashreq Project on technology adoption (percentage of farmers in category).

Farmer category	Farmers using technology at the end of Project (1994)				
	Cultivar	Fertilizer	Seed drill	Seed rate	Early planting
Demonstrations (n=159)	57	57	37	74	94
Field days (n=71)	52	49	38	80	90
Non-participants (n=55)	42	33	18	64	89
Total (n=285)	53	51	33	74	93

Analysis of individual component adoption tells only part of the story. The full package was assembled by researchers in large part because of the benefits derived from using components in combination. The interaction effects between, for example, improved cultivars and fertilizer application, are greater than the effects of using them separately. If the package performed in the farmers' fields to the level at which it was designed to perform, then it could be expected that multiple component adoption among farmers exposed to the package would be greater than among farmers exposed to only a single component. Moreover, it should be expected that multiple component adoption by participating farmers would be greater than among non-participants. The validity of these assumptions is substantiated by the results presented in Table 4.

Farmers hosting full package demonstrations had the highest rates of adoption during the project, and this, combined with recommended components in use prior to the project, resulted in this group having the highest percentage of complete package use at the end of the project. It should be noted that there was no great difference in adoption between hosts of full package individual demonstrations and hosts of full package demonstrations on consolidated plots. This is a most encouraging result in terms of overcoming land fragmentation through collective management.

Table 4. Adoption and type of participation (percentage of farmers in categories).

Farmer Category	Percentage adopting during Project				Percentage using full package	
	No new Adoption	1-2 Components	3-4 Components	Full Package	1989	1994
Full package	18	32	33	17	2	33
2 components	29	31	23	23	0	27
1 components	31	30	21	18	0	18
Field day	30	24	26	20	0	28
Non-participant	49	16	22	13	0	13
Total sample	30	27	25	18	0	25

An unanticipated result of the technology transfer activities was the high rate of multiple component adoption among field day attendees. This indicates a willingness among these farmers to accept new technologies as packages, rather

than a preference to accept only one component at a time. The indication is that the full package demonstration was particularly effective in showing the benefits of the interaction effects among components. In this regard, the field days associated with full package demonstrations appear to have been more effective in achieving farmer adoption than the more costly single component demonstrations. Nevertheless, single component demonstrations still achieved higher rates of adoption among their hosts than otherwise would have been the case, judging from the lower rates of adoption among non-participants.

Improving Impact

By 1994, all the farmers covered by the survey, regardless of their participation in the project, were using at least one component of the recommended package. However, a large majority (83%) of those using only one component were following early planting. For those using two components, 67% were using early planting and the recommended seed rate. In part, the widespread use of early planting and the recommended seed rate cannot be attributed to the Mashreq Project. For a number of years media campaigns and extension programs have informed farmers of the benefits of these two components. The real impact of the project is in the increased use of fertilizer, improved cultivars, and seed drills in combination with each other or with early planting and the appropriate seed rate.

An interesting finding of the survey, which may be considered in the design of future technology transfer efforts, is the link between improved cultivar and fertilizer adoption. During the project, 125 surveyed farmers adopted improved cultivars and 129 adopted chemical fertilizers. However, in 91 cases the two components were adopted together. Only 34 farmers were using improved cultivars without fertilizer, and 38 were using fertilizer without an improved cultivar. What is perhaps surprising is that the association between improved cultivar and fertilizer use was made by full package demonstration hosts and field day attendees almost as often as among hosts of the cultivar plus fertilizer, two component demonstrations. Of the 66 farmers who hosted cultivar plus fertilizer demonstrations, 25 (38 percent) adopted both components, whereas 34 percent of the rest of the project participants (demonstration hosts and field day attendees) also adopted improved cultivars and fertilizer together.

Although the project has had considerable impact, there is scope for improvement in future technology transfer efforts. This can be achieved in three ways: (i) increasing the effectiveness and efficiency of the demonstration and field day program; (ii) addressing farmer-identified constraints to technology adoption; and (iii) better targeting of technology transfer.

The adoption response by participants in the Mashreq Project indicates that the most effective and efficient demonstrations are those using the full package. Dual- and single-component demonstrations were much less effective in achieving either single- or multiple-component adoption by host farmers and their neighbors. Moreover, the full package demonstrations provide a better vehicle for field days to disseminate information about the new technologies and, especially, the benefits of using several components in combination. The multiplier effect of the full package demonstrations through field days should not be underestimated.

Farmers' answers to questions concerning the constraints to increasing adoption of the production package and its components reveal two important factors favoring the almost complete adoption of recommended seed rates and early planting dates, but discouraging greater use of external inputs and seed drills. Remembering that use of a seed drill was the least adopted component, 75% of the surveyed farmers said that the appropriate machinery was not available in their area, either for purchase or for custom hiring. For all purchased inputs, including improved seed, fertilizer, and machinery, 82 percent said that the high costs of one or more of these inputs discouraged their use. This factor was most often cited in reference to fertilizer, where the risk of not receiving sufficient rainfall seemed to outweigh the possible benefits of fertilizer use by many farmers.

It is difficult to see how technology transfer efforts, as undertaken by the project, can overcome these availability and price constraints. However, researchers could re-examine the economic returns to fertilizer under different rainfall conditions with a view to modifying the existing recommendations and providing farmers with more options for using fertilizer than the present blanket recommendations.

As if to underscore the point about risks associated with variable rainfall, 14 percent said they felt the package was not appropriate for low rainfall areas, and that they preferred the known performance of the local landrace over the improved cultivar. These responses suggest that researchers should consider developing enhanced germplasm more narrowly targeted to low rainfall conditions. In a similar vein, 8% of the interviewed farmers expressed a concern that the improved varieties in the demonstrations were less palatable to sheep than the local landrace.

Finally, 12 percent of the farmers said they remained unconvinced about the performance of the package relative to their experience using traditional practices, both in terms of yield and economic return. This last constraint could, with some confidence, be overcome by continuing the demonstration program. Among the 159 farmers who hosted demonstrations, 79% reported that the improved technologies performed better than their local practice, 17% reported no difference between the two, and only 4% said that the local practice had better performance than the demonstrated technologies in their fields.

The project has not been equally successful in transferring technologies in all locations or among all farmers. It should be noted that there is no great difference in adoption rates when producers are distinguished on the basis of either farm size or relative dependence on on-farm income. The two most significant contrasting factors revealed by the survey are location and utilization of production. Kerak had the highest rate of adoption, followed in descending order by Madaba, Ramtha, and Showbak. The difference in all locations between commercial barley producers and those who use their barley as feed is quite remarkable, especially with regard to the adoption of external inputs. Commercial producers are much more likely, on average, to invest in improved varieties, fertilizers, and the use of seed drills than are those who use their production on-farm to feed their sheep and goats. Both groups are more or less equally following the recommended seed rate and early planting. The actual rates of adoption by location and by utilization are presented in Tables 5 and 6.

Table 5. Technology use and barley utilization: Madaba and Kerak, 1994 (percentage of farmers).

Technologyuse	Madaba			Kerak			Total Jordan sample average		
	Sell	Feed	Av.	Sell	Feed	Av.	Sell	Feed	Av.
	n=27	n=36	n=63	n=72	n=19	n=91	n=167	n=118	n=285
1 component	11	19	16	10	37	16	13	31	20 [†]
2 components	18	31	25	4	11	5	14	32	21 [‡]
3 components	15	19	17	8	26	12	17	21	19 [§]
4 components	30	14	21	14	0	11	20	6	14
Full package	26	17	21	64	26	56	36	10	26
Total percentage	100	100	100	100	100	100	100	100	100

Table 6. Technology use and barley utilization: Ramtha and Showbak, 1994 (percentage of farmers).

Technologyuse	Ramtha			Showbak			Total Sample		
	Sell	Feed	Ave.	Sell	Feed	Ave.	Sell	Feed	Ave.
	n=27	n=27	n=84	n=11	n=36	n=47	n=167	n=118	n=285
1 component	16	26	19	27	42	38	13	31	20 [†]
2 components	19	41	26	37	39	38	14	32	21 [‡]
3 components	26	22	25	27	19	22	17	21	19 [§]
4 components	25	7	19	9	0	2	20	6	14
Full package	14	4	11	0	0	0	36	10	26
Total percentage	100	100	100	100	100	100	100	100	100

Notes for Tables 5 and 6

[†] Early planting accounts for 83 percent of single component use.

[‡] Early planting plus recommended seed rate accounts for 67 percent of two component use.

[§] Early planting and recommended seed rate pair combined with one other component account for 81 percent of three component use.

Based upon the results across locations and between commercial and non-commercial barley producers, future technology transfer efforts should focus on non-commercial producers with medium to large flocks in Showbak, Ramtha, and, to a lesser extent, Madaba. Adoption of the complete package is well established among commercial producers in Kerak, although efforts should continue to transfer the package to non-commercial producers through field days.

Conclusion

The Mashreq Project succeeded in transferring new barley production technologies to Jordanian farmers. There was particular success in having farmers adopt multiple components of a full production package. Achievements were greatest among commercial barley producers and farmers in Kerak Governorate.

Increased adoption rates would be encouraged by continuing the demonstration program in farmers' fields and associated field days. Results from 1989-94 indicate that the full package demonstrations are the most effective and efficient means of increasing the adoption rate. Single component demonstrations are the least effective.

Impact of Technology Transfer on Cereal Production in Tunisia

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Abstract

Technology transfer involves a great deal more than simply the production of new technology or technological packages. New technology should contribute to the increase of sustainable food production in such a way that both the nutritional level and the general economic well-being of low-income farmers are improved. Concerns for efficiency, equity, and the environment are explicit. Another important aspect is research on resource management aimed at attaining balanced production systems with moderately high productivity.

In Tunisia, the implementation of new technology has resulted in significant production increases. Varietal improvement has contributed significantly to this increase in production. Many new wheat varieties have been grown in Tunisia over the last 25 years. Twelve bread wheat varieties have been commercially grown for different periods. Some lasted for two crop seasons (Tobari) and others are still being cultivated (Ariana, Dougga). The same applies for durum wheat. Nine varieties were commercially grown all over the country; Badri lasted two crop seasons, and INRAT 69 is still in cultivation. Barley varietal development has not been well supported in Tunisia. Cultivars Feiz, Tej, and Roho, all released in 1982, were grown for only a short time period, and since 1986 have been replaced by Rihane. With the new wheat varieties there has been a steady increase in yield per hectare. The current average yield for wheat is greater than 1,500 kg/ha, compared with approximately 500 kg/ha during the 1960s.

The improved varieties often lose their yield potential advantage if appropriate management techniques are not used. The combination of improved crop management and better adapted varieties has produced an increase in production levels, particularly in the semi-arid region (SAR). A net increase in durum wheat yield was observed in association with nitrogen and weed control applications.

Important technological developments that contribute to increased crop production include fertilizers, weed control, high-yielding varieties, and improved cultural practices. In addition, the availability of research funds and the training of scientists both play a major role.

Introduction

Technology transfer involves a great deal more than the production of new technology or technological packages. It is essential to have clear objectives: first,

what kind of changes should we strive to achieve using our skills at developing agricultural technology, and second, on whom should we focus our efforts? Often farmers' decisions to reject or adopt a technology are not anticipated in the development and transfer of technology, and often a newly developed technology is not used by farmers in the way scientists expected it to be used. It is important therefore, that farmers' opinions and reactions be assessed in every technology transfer program.

General Approach to Technology Transfer

Ideally, farmers should routinely participate in evaluating the portfolio of technologies developed at experimental stations. Systematic feedback on farmer performance should become a normal component of the data available to scientists in formulating recommendations. A farming production system approach would insure that farmers have significant input into research planning, and that improvements in agricultural systems are relevant to a farmer's circumstances and environment. Hence, it is important in the technology transfer process to involve the individual farmer in decisions which directly affect his livelihood. The involvement of farmers in research, the need to undertake base-line studies of physical, climatic, biological resource, and socioeconomic conditions are essential elements for success.

Increasing agriculture productivity by raising crop yield is the best way to increase food production. But improving productivity has a direct impact on the natural environment, because changes in crop, soil, and water management are needed to achieve increases. New and improved varieties responsive to improved management and the use of manufactured inputs are also needed. The new technology should increase sustainable food production in such a way that the nutritional level and the general economic well-being of low-income farmers are improved. Concerns for efficiency, equity, and the environment are explicit. Another important aspect is research on resource management aimed at attaining balanced production systems at moderately high levels of productivity.

In developing countries, new technologies should take into account the crop and animal production systems used by small-resource farmers, for whom the risks involved in making monetary investments for fertilizers and pesticides are high. These farmers need varieties that are not only stable under traditional management systems but also responsive to whatever improved management they can afford. Subsistence farmers often cannot afford to maintain conservation programs which in some instances have deprived them of the use of portions of their lands. Only when low-income farmers have increased their income will there be any hope of restoring soil and sustaining erosion control.

Status of Technology Transfer and Cereal Production In Tunisia

In North Africa, the largest cereal production area is located in the semi-arid region. In Tunisia it represents 71% of the country's total cereal production area. In the SAR, the area placed under cereal production varies considerably from year to year, and yield is relatively low. Hence the genetic potential of the newly developed varieties cannot be realized due to the lack of good management practices. To reach a production level that responds to national needs, cereal yield has to be increased by at least two fold, since most farmers are not prepared to risk investment in costly inputs. The national and international breeding programs have developed varieties that perform well under optimal growing conditions, particularly in the northern areas, where improved soil and crop management techniques and better adapted varieties have provided an increase in production (Hepworth et al. 1975).

Table 1 shows the evolution of cereal production in Tunisia over the past 30 years. A significant increase in production has been achieved. At this rate national production could reach 23 MQ by the year 2005. Varietal improvement has contributed significantly to this production increase. There has been a steady increase in crop yield (Table 2). The current average yield for wheat is greater than 15 Q/ha, compared to about 5 qx/ha during the 1960s. Over the past quarter of a century several varieties have been commercially grown in Tunisia (Figs. 1, 2, and 3). The duration of their exploitation varied. Some varieties lasted for no more than five years (Tobari BW and Amal DW), while others are still in cultivation.

Table 1. Growth of cereal production (1966–2005).

Period	Production (Mqx)	Growth (%)		
1966–1975	7.7			
1976–1985	11.3	47		
1986–1995	16.5	108	41	
1996–2005	23.0	198	103	43

Table 2. Growth of average cereal yield in Tunisia (1961–1995).

Period	Yield (kg/ha)			
	Durum wheat	Bread wheat	Barley	Average
1961–1965	406	595	281	382
1966–1970	427	470	293	395
1971–1975	709	800	639	704
1976–1980	423	1051	455	599
1981–1985	1020	1560	680	920
1986–1990	940	1260	620	880
1991–1995	1240	1440	900	1140

Direction Générale de la Production Agricole, Ministry of Agriculture.

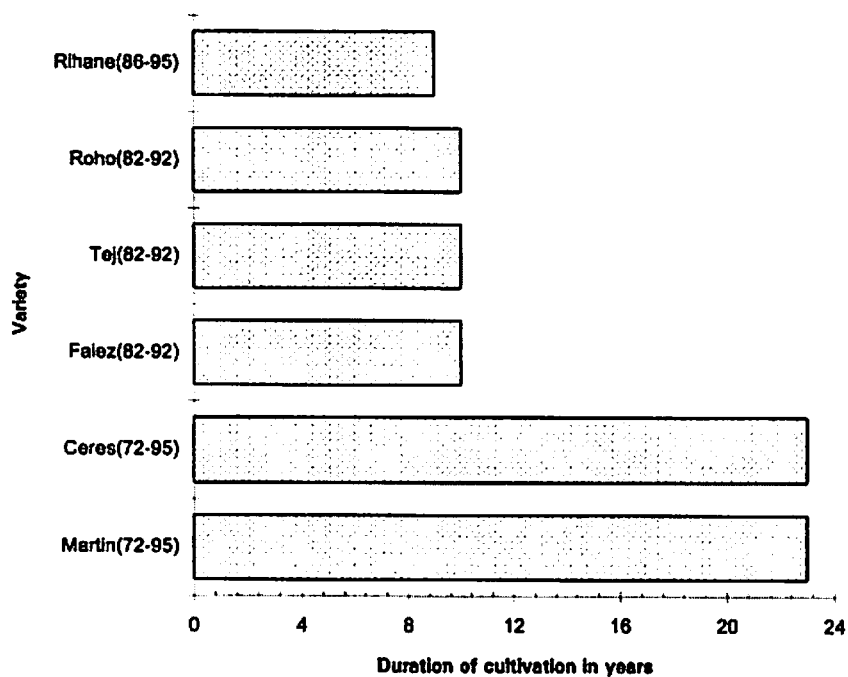


Figure 1. Barley varieties cultivated in Tunisia since 1972.

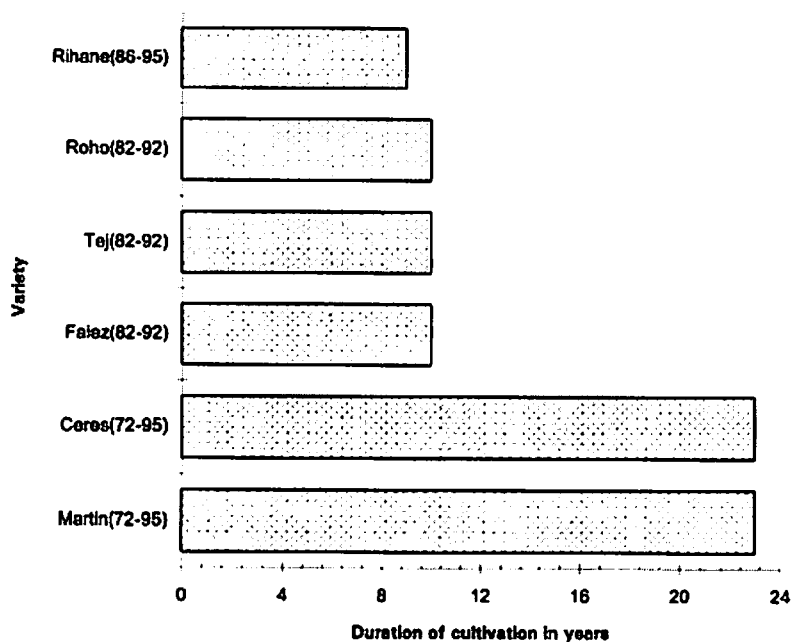


Figure 2. Bread wheat varieties cultivated in Tunisia since 1972.

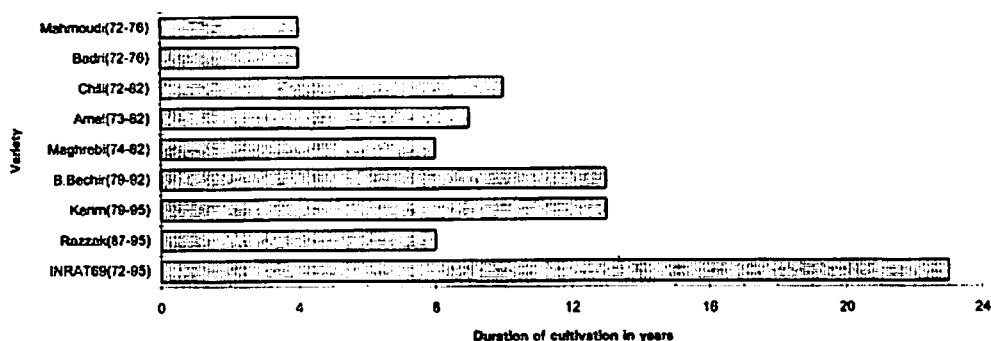


Figure 3. Durum wheat varieties cultivated in Tunisia since 1972.

Varietal Adaptation

In the low rainfall zones of the SAR, the newly developed cultivars only slightly out-yield local cultivars when poor management practices are used. Yield of barley, bread, and durum wheat varieties has been tested on farmers' fields under optimal management practices and different climatic conditions.

Figure 4 shows the relative yield of barley, bread, and durum wheat varieties tested during a favorable crop season (1992/93) in farmers' fields in a major cereal zone of the SAR. Average grain yield for durum wheat varied from 1,300 kg/ha to 2,300 kg/ha, compared to bread wheat yield which varied from 2,050 kg/ha to 2,400 kg/ha, and barley yield which varied from 2,650 kg/ha to 3,400 kg/ha. Standard cultivars showed only limited yield potential under optimal management.

Average grain yield varied from 109 kg/ha to 630 kg/ha, from 200 kg/ha to 470 kg/ha, and from 210 kg/ha to 520 kg/ha for durum wheat, bread wheat, and barley, respectively (Fig. 4). During this period most crops remained unharvested, and were grazed as an economic alternative.

Table 3 shows the relative performance of cultivated barley and wheat varieties during the last four years in different cereal growing areas. High yields were observed during the favorable growing seasons (1991/92 and 1992/93), and relatively high fluctuations in yield were registered for all varieties. During the dry seasons (1993/94 and 1994/95), barley varieties had yielded better than bread wheat. Durum wheat varieties also outperformed bread wheat.

In Tunisia, varietal development has had a significant impact on total cereal production. An important yield gain has been realized during the last 30 years (Table 2). Several varieties have been developed (Figs. 5 and 6) and exploited by farmers in the different cereal producing areas. This was particularly true in northern parts of the country.

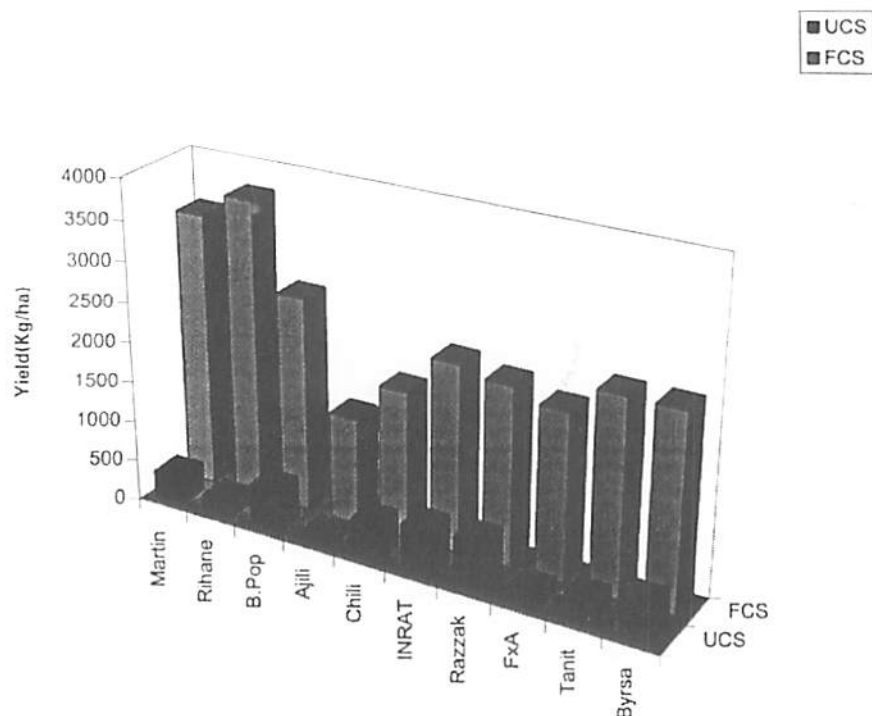


Figure 4. Grain yield of barley, durum, and bread wheat varieties during favorable crop season (FCS) and unfavorable crop season (UCS) at Sers.

Table 3. Average grain yield (kg/ha) of barley, durum wheat, and bread wheat varieties in the semi-arid region (1991-95).

Variety	Sers				Tejr	Zaaf	BRb	BMc	Krib	Sil
	91/92	92/93	93/94	94/95	92/93	92/93	94/95	94/95	94/95	94/95
Barley										
Martin	3,520	3,400		350	1,930	2,250	850	1090	2,010	2,420
Rihane	4,830	3,700	1,230	210	2,130	3,180	490	1430	2,000	1,830
Popln	4,810	2,650	1,250	520	2,000	2,440	790	1270	670	2,290
Durum wheat										
Ajili		1,300	380	109	930	680	36	410	430	1,600
Chili		1,800	720	460	1,600	1,125	183	620	390	1,530
INRAT	4,070	2,300	570		2,060	1,500	300		600	
Karim		2,100	470		2,400	1,370	770			760
Razzak	3,520	2,200		630	2,530	1,500	1,400	780	320	1,130
Bread wheat										
FxA	2,960	2,050	1,100	200	1,600	1,300	270	720	910	300
Tanit		2,400	1,180	300	1,930	1,500	310	840	620	870
Byrsa		2,400	1,950	470		1,180	470	740	700	1,480

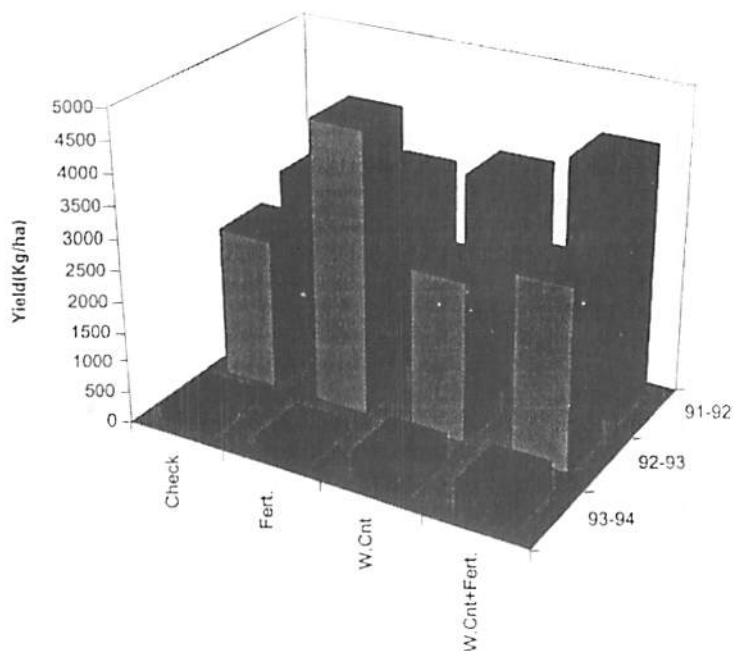


Figure 5. Average yield of durum wheat in response to fertilizer and weed control applications during three seasons at Sers.

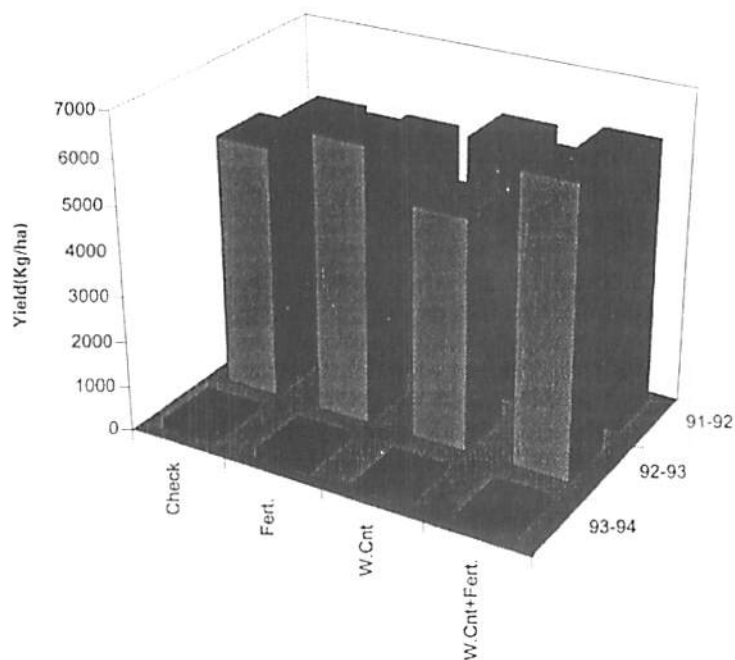


Figure 6. Average yield of Barley in response to fertilizer and weed control applications during three seasons at Sers.

Cultural Practices

To reach a production level that responds to national needs, cereal production has to exceed 23 million quintals by the year 2005 (Table 1). This is a two fold increase. National as well as international programs have developed varieties (Figs. 1, 2, 3) that perform well under optimal conditions, particularly in northern parts of the country. In the SAR, high yielding varieties only slightly out-yield local cultivars under poor management practices. If appropriate management techniques are not implemented, the improved varieties cannot contribute to increased production. In most cases the advantage of increased yield potential is lost. Despite the use of improved varieties, the average farmer's yield in the SAR is still very low.

The combination of improved crop management techniques and better adapted varieties has produced an increase in production (Hepworth et al. 1975). Incorporation of appropriate management techniques tested at the farm level has produced significant increases in production at various sites in the SAR. On-farm trials were conducted at several climatic zones and dealt with tillage and seeding methods, fertilizers, and weed control applications. Results of these experiments were significant and were reported at the ICARDA Regional Coordination Meeting. (Research Highlights and Work Plans: 1991/92, 1992/93, and 1993/94).

Tillage Systems

In the SAR, fallow-crop rotations constitute the major cropping system for cereal production. The practice is still controversial, mostly among professionals, because of the inefficiency in soil water storage and the wind and water erosion problems associated with fallow. The fallow system in the SAR continues to be used despite its critics. Recent innovation in stubble mulch tillage has alleviated some of the erosion problems and increased moisture storage. In Tunisia, this system could not be well implemented due to grazing management and the use of straw for feed. Stubble mulch is replaced by reduced tillage during the fallow year. This tillage system allows the grazing of the straw in the summer, and the weeds in the spring of the fallow year. Results from on-farm trial experiments show no significant difference in the yield of durum wheat under reduced and conventional tillage systems. The purposes of tillage for seedbed preparation, weed control, enhancement of infiltration, and erosion control have been reviewed by many (Van Doren 1967; Cooper 1971; Baver et al. 1972; Russel 1973; Phillips and Young 1973). The advocated reduced tillage requires herbicides for weed control during the crop season. In the reduced tillage system the number of plowings is reduced to a minimum. Sweep cultivators are used for late spring plowing following "weed grazing," or can be delayed until fall. One or two passes with tandem or offset disks prior to planting is recommended. Conventional tillage involves a deep plowing in the fall of the fallow year followed by disking in early winter if time and weather permit. A second deep plowing in the spring is followed by disking in the summer and prior to planting.

Weed Control and Fertilizer Application

Timely weed control, even with poor management, results in large yield increases (Hapworth et al. 1975). Chemical weed control results in an increase in yield for both barley and durum wheat. As weeds tend to be prolific and persistent, specific as well as polyvalent herbicides add strength and flexibility to a farmer's weed control program. An effective dryland weed control system includes the coordinated and integrated use of cultural practices as well as herbicides.

The cereal-producing regions of Tunisia, particularly the SAR, have suffered varying degrees of soil erosion over the centuries. This is due in large part to the erosive nature of the environment, but it is further aggravated by soil and crop management practices that promote soil loss. The recommended use of fertilizers could alleviate this problem and is the most economical way of increasing crop production. The use of nitrogen fertilizer more than doubled yield at some on-farm experimental trials, particularly for durum wheat, and, to a lesser extent, barley.

Weed control and fertilizer application are the determinant factors for the improvement of crop production. If fertilizers are introduced as an improved practice and weeds are left uncontrolled, the weeds may respond more to the increased fertility level than the crop, and may in some cases reduce yield, as shown in Figures 5 and 6 for Sers, where the yield of the check plots was higher than that associated with fertilizer application. The appropriate association of weed control and fertilizer use gave by far the best results compared to each component and to the check.

A striking example of improving production at the farm level is shown by the use of combined chemical fertilizers and weed control (Figs. 5 and 6). A net increase in durum wheat yield was observed in association with nitrogen and weed control applications. With barley, the use of nitrogen fertilizer and chemical weed control did not significantly affect yield, particularly during the dry crop seasons.

Conclusion

The predominant model for the generation and transfer of agricultural technology is generally based on systems for breeding. Appropriate methodologies and practices for the development, testing, and promotion of new technologies based on improved varieties in cereal crops have been established through the national breeding programs and supported by international agricultural research centers (IARCs).

Through the cooperative research programs sponsored by IFAD/AFSED and IARCs, on-farm research has been promoted as a way to develop appropriate technology and adapt it to the specific conditions of target farmers. As new technologies become available, whatever finds its way into the everyday practices of the farmers and villagers is often modified or adapted to local conditions and preferences. Modifications and adaptations are necessary, but the foundation of development should be indigenous. In certain areas, informal field visits are supplemented with regular events such as field days, which are used as a mechanism for transferring technology to a large target group of farmers. In some cases new technology has spread spontaneously among resourceful farmers (Ewell 1990).

The important technological developments that contribute to increased crop production include the use of fertilizers, weed control, high yielding varieties, and improved cultural practices. The availability of research funds and the training of scientists play a major role.

International assistance has played an important role in upgrading the level of research within developing countries, mainly through the training of scientists. Many qualified researchers are now located in several countries in WANA, and are involved in developing appropriate research methodologies and cultural practices for specific local conditions, and hence are contributing to increased crop production. Regional research activities are being developed and adapted.

Improved and new technologies are expected to lead to increased food production, increased income, and the improved well-being of farmers. The benefits, however, will depend mainly on the speed of transfer and on the manner in which the technology is actually transferred. Nonetheless, in developing countries, care should be taken to avoid excessive specialization and to increase efforts that optimize the talents and skills of individuals and their organizations. Special attention should be given to the efficient use of scarce resources in traditional farming systems, particularly in semi-arid regions.

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Constraints on the Adoption of New Barley Varieties In Khouribga Province, Morocco

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Abstract

Barley is a major crop in Morocco's Khouribga Province. Studies on the province's cropping systems indicate a limited adoption of new barley varieties. The objectives of this study were to: (i) determine the extent of adoption of new barley varieties in the province; (ii) identify the major constraints to the adoption of such varieties; and (iii) to assess farmers' opinions regarding new barley varieties. The study sample consisted of 88 farmers. The results show that the level of adoption of new barley varieties in the province is quantitatively and qualitatively higher than had been indicated in previous studies. Seventy-six percent of surveyed farmers cultivated new varieties, with 36% of their total barley area was sown to such varieties. High grain yield, early maturity, resistance to lodging, and high-quality grain for human consumption were the most appreciated characteristics of new barley varieties. Farmers felt the disadvantages of new barley varieties included their low straw yield, poor grain quality for animal feeding, and unsuitability for green grazing compared to local varieties. The major constraints identified by farmers were local unavailability of seed and the high price of certified seed.

Introduction

Barley is a major crop in Khouribga Province. The average barley area is estimated at 90,000 ha annually, which represents 45% of the cereal area and about 60% of the province's cereal production (MAMVA 1994). The average barley yield of 1.2 t/ha is higher than that of bread wheat (1.0 t/ha) and durum wheat (0.8 t/ha). However, barley yield is still low given the potential of the area and the productivity potential of the new barley varieties produced by the Institut National de la Recherche Agronomique (INRA).

Since 1973, 14 new barley varieties have been developed (Amri 1992). The majority of these varieties are characterized by higher productivity and wider adaptation than old barley varieties. On-farm verification trials in different environments have shown that new barley varieties are more productive than the old ones (El Baghati et al. 1990; Al Hailouch 1991; Amri 1992). The possibilities of expanding the land area to barley cultivation are limited. Consequently, the adoption of new barley varieties is the most sustainable and most rational way to increase barley production. However, available information indicates that the adoption of new barley varieties is limited compared to that of bread and durum

wheat. This assessment of adoption is based on annual sales of certified seed by the Société Nationale de Commercialization des Semences (SONACOS), the parastatal agency responsible for coordinating, organizing, and controlling certified seed production, distribution and marketing.

The average amount of certified barley seed purchased from SONACOS, in Khouribga Province, during the last 10 years, was 20 tons, compared to 7 tons of bread wheat and 350 tons of durum wheat (MAMVA 1994). The study by Bouhima (1991) in the three *centres de travaux* (CTs) of the province (Boujaâd, Oued Zem, and Khouribga), found that certified seed was used in 28, 14, and 0% of the cases for bread wheat, durum wheat, and barley, respectively. Studies of the cropping systems in the region also found that the number of users of certified wheat seed was increasing, while that of certified barley seed users was stagnant (El Baghati et al. 1990; Benaouda et al. 1993). National statistics showed that the limited use of certified barley seed was not unique to Khouribga Province. The national use of certified barley seed was very low (0.7%), compared with 1% in Khouribga Province (El Baghati et al. 1990). El Khyari (1992) found that the national rate of certified barley seed use was less than 2%.

The figures presented above require some comment. First, there are insufficient statistics on the sale of certified barley seed to assess the extent of adoption of new barley varieties by farmers, as SONACOS is not the only source. Farmers also acquire barley seed from local markets, other farmers, or from their own production. Second, these indications on adoption do not provide an explanation for the reasons behind the limited use of certified barley seed or the major constraints which limit wider adoption of new barley varieties. To fill this gap, a study was conducted in 1992/93 by INRA, the Ministry of Agriculture's Direction de la Production Végétale (DPV), and ICARDA. The objectives of the study were to determine the level of adoption of new varieties by farmers; identify the major agronomic, socioeconomic, and institutional constraints to the adoption of new barley varieties; and propose recommendations which could alleviate these constraints (Saade 1994).

In 1993/94, Khouribga Province was chosen as a focal point of intervention in the IFAD/AFESD/MAGHREB Technology Transfer Project. This province includes the three CTs: Boujaâd, Oued Zem, and Khouribga. Khouribga was included in the 1992/93 study (Saade 1994), while the other two were studied in 1993/94.

Methodology

Survey Area

The survey area covered the three CTs in Khouribga Province, which is located in a semi-arid zone, characterized by cereal production combined with livestock production. The major cereals are barley, durum wheat, and bread wheat. Barley, the most important cereal in the province, is grown on about 35% of the total arable land in each of the three CTs. The second most important crop is bread wheat in Oued Zem and Khouribga, and durum wheat in Boujaâd. Sheep production is important in all three CTs, with a total of 517,506 sheep, followed by goats in Boujaâd and cattle in Oued Zem and Khouribga.

The majority of farmers (78%) in the three CTs operate farms that are less than 10 ha. The average farm size is smaller in Boujaâd (5.8 ha) than in Oued Zem (10.2 ha) and Khouribga (10.1 ha), with less major farm equipment such as tractors, combine harvesters, and planting drills.

Sample Characteristics

The sample for the study consisted of 88 farmers selected from two categories of farmers. The first category included 40 farmers who had tested new barley varieties in on-farm trials conducted in the region, designated trial farmers. The second included 48 farmers chosen randomly from the farm population at large, designated non-trial farmers. The farmers were interviewed, using a structured questionnaire, by the agents from their respective CTs. Table 1 summarizes the study by farm size, farmer category, and CT.

Table 1. The study sample by farm size and farmer category in the three CTs.

Farm Size (ha)	Boujaâd		Oued Zem		Khouribga		Total
	NT	T	NT	T	NT	T	
1-9.9	4	1	3	2	5	0	15
10-29.9	5	4	5	7	4	6	31
≥ 30	7	8	9	8	6	4	42
Total	16	13	17	17	15	10	88

NT = non-trial farmers; T = trial farmers.

Table 2. Mean characteristics of the sample in the three CTs.

Characteristic	Boujaâd		Oued Zem		Khouribga	
	NT	T	NT	T	NT	T
	(n=16)	(n=13)	(n=17)	(n=17)	(n=15)	(n=10)
Average age of farmers	55	60	52	53	54	61
Average family size	12	10	13	13	13	13
Average number of male adults	4	3	4	4	3	4
Average number of female adults	4	3	4	3	4	4
Average number of children	4	4	5	6	6	5
Average arable land	36	46	39	48	43	31
Average number of dairy cows	2	3	4	3	3	2
Average number of cattle	5	4	5	6	7	3
Average number of sheep	117	104	59	81	103	40
Average number of draft animals	55	23	11	21	4	
% of farmers having off-farm work	3	3	3	3	2	2
Source of income (in %)	50	45	47	69	47	40
Farming	71	71	88	85	84	83
Other activities	29	29	12	15	16	17

NT = non-trial farmers; T = trial farmers.

Table 2 details the general characteristics of surveyed farmers. The average age was 56 years. Farmers in Oued Zem were slightly younger than those in Boujaâd

and Khouribga. Farmers in all three CTs had large families, with an average size of 12 persons. The family structure was similar in the two categories and the three CTs, dominated by adults of both sexes. The average farm size was 40 hectares. The mean number of animals per farm was 40 sheep, 8 cattle, 19 goats, and 3 draft animals. Fifty percent of the farmers were engaged in off-farm work which contributed about 20% to farmer income.

Results

Table 3 summarizes the distribution of barley varieties grown by survey farmers in the three CTs. New varieties were grown on 36% of the 1,078 hectares sown with barley during the survey years (1992/93 for Khouribga and 1993/94 for Oued Zem and Boujaâd). A similar proportion of the area was allocated to new barley varieties in the two categories of farmers in all three CTs. The proportions allocated to the different new varieties varied. Arig 8 and Rihane, both six-rowed varieties, were the dominant varieties in Boujaâd, ACSAD varieties (two- and six-rowed) in Oued Zem, and ACSAD 60 (two-rowed variety) and Arig 8 in Khouribga.

Table 3. Percentage of barley areas by variety and farmer category in the three CTs.

Variety	Boujaâd		Oued Zem		Khouribga	
	NT	T	NT	T	NT	T
	(n=16)	(n=13)	(n=17)	(n=17)	(n=15)	(n=10)
Rihane	15.7	11.0	5.0	2.0		
Arig 8	12.8	28.5			8.4	7.8
ACSAD 60					21.9	17.4
ACSAD [†]			11.0	26.0		
Two-rowed barley	5.1			1.0		
Rouiza	3.1	0.5	9.1	2.0		
Serbissa [‡]			9.1	1.5		
Other [§]			2.4		3.3	11.3
Total new varieties	36.7	40.0	36.6	32.5	33.6	36.5
Local varieties	63.3	60.0	63.4	67.5	66.4	63.5
Percent of farmers growing new varieties	56.2	75.0	70.6	76.5	100.0	80.0

NT = non-trial farmers. T = trial farmers.

[†] As used by farmers, it indicates all ACSAD varieties.

[‡] Serbissa is presumed to correspond to Brasserie du Maroc.

[§] Other includes ACSAD 68, ACSAD 176, Tamellalt, Tiddas, and Azilal.

Another measure of adoption of new barley varieties was the percentage of farmers growing these varieties. New barley varieties were grown by 77% of trial farmers in the three Cts. Among non-trial farmers adoption varied between 56% in Boujaâd and 100% in Khouribga. Small farmers with less than 10 ha of land allocated an average of 55% of their barley area to new varieties, while medium-sized farmers (10–29 ha) allocated only 32%. For large farmers, new varieties accounted for 38% of the barley area (Table 4).

Table 4. Percentage of land allocated to new barley varieties by farm size and farmer category in the three CTs.

Farm size (ha)	Boujaâd		Oued Zem		Khouribga		Average
	NT	T	NT	T	NT	T	
1-9.9	16.7	100.0	00.0	100.0	60.0		55.3
10-29.9	50.0	21.0	13.8	18.2	63.6	25.6	32.0
≥30	36.0	42.0	43.3	35.9	27.9	42.8	38.0

NT = non-trial farmers; T = trial farmers.

With the exception of trial farmers in Oued Zem and Khouribga (who planted their own seed), 65% of the surveyed farmers purchased barley seed (Table 5). More than 40% of the farmers purchased certified seed.

Table 5. Percentage of farmers by major source of barley seed in the three CTs.

Source of seed	Boujaâd		Oued Zem		Khouribga	
	NT	T	NT	T	NT	T
	(n = 14)	(n = 12)	(n = 13)	(n = 11)	(n = 15)	(n = 10)
Own farm	7	8	23	64	40	70
SONACOS/CT	43	75	46	18	47	20
Farmers	21		31	18	13	
Souk	29	17				10
Total	100	100	100	100	100	100

NT = non-trial farmers; T = trial farmers.

The new barley varieties included both two and six-rowed varieties. The farmers were asked about their advantages and disadvantages. The majority identified high grain yield as the main advantage of the two-rowed varieties, and low straw yield, followed by neck-breakage, as the major disadvantages. The most important characteristics that these farmers wanted in new barley varieties were high grain and straw yields, followed by high quality grain for human consumption.

In summary, rates of adoption for new barley varieties were higher in Khouribga Province than expected. The results show great similarities between the trial and non-trial farmers across the three CTs in this province.

Production Constraints

The majority of farmers reported purchasing their barley seed annually, or every two to three years. The most important constraints faced by farmers were, however, related to seed procurement. Lack of seed was often stated by farmers as a handicap to adopting new barley varieties. Two thirds of the farmers said that the desired varieties were not available locally (Table 6). Over 40% of the study farmers found that the price of seed, especially certified seed, was high. Farmers also reported having difficulties acquiring seed because of the distance to places where seed was sold, lack of availability, and high price.

Table 6. Major constraints faced by farmers (percentage of respondents) in the three CTs.

Major constraint	Boujaâd		Oued Zem		Khouribga	
	NT (n=16)	T (n=12)	NT (n=16)	T (n=17)	NT (n=15)	T (n=10)
Desired varieties unavailable	40.0	58.3	85.7	86.7	86.7	40.0
Desired varieties expensive	6.3	18.2	64.3	64.3	60.0	40.0
Difficulties in seed procurement	13.3	16.6	60.0	37.5	53.3	30.0

NT = non-trial farmers; T = trial farmers.

Difficulties in the procurement of seed demonstrate the kind of input constraints that are not under the farmers' control. Farmers said new barley varieties have more requirements than local varieties, with purchased inputs increasing quantitatively and qualitatively. To many farmers, the use of new barley varieties calls for other changes in their cultural practices. These modifications vary from a change in planting date to an increased use of seed, fertilizer, and herbicides. The majority of farmers in both Oued Zem and Khouribga reported making important changes in their cultural practices for new barley varieties, including changing their crop rotation, planting on higher quality soil, and increasing the seed rate (Table 7).

Table 7. Percentage of farmers reporting changes in their cultural practices with the introduction of new barley varieties.

Modification of cultural practice	Boujaâd		Oued Zem		Khouribga	
	NT (n=10)	T (n=12)	NT (n=11)	T (n=17)	NT (n=15)	T (n=10)
Use of more fertile land			36.4	29.4	80.0	50.0
Use of better rotation		9.1	40.0	43.7	80.0	60.0
Change in planting date			18.2	28.6	33.3	40.0
Increased seeding rate	20.0	9.1	45.4	50.0	28.6	12.5
Increased use of fertilizer	20.0	33.3	33.3	35.3	20.0	
Increased use of herbicides		9.1	50.0		71.4	25.0
Give up green grazing			9.1	28.6	21.4	12.5
Mechanical harvest method			10.0	12.5	57.1	25.0
Earlier harvest date			45.4	33.3	64.3	25.0

NT = non-trial farmers; T = trial farmers.

Utilization Constraints

Barley production differs from other cereal crops in its multiple uses. Barley, grain, and straw are primarily destined for on-farm use, either through immediate consumption after harvest or after storage. Sales of straw, and, to a lesser extent grain, can occasionally be important. The use of barley products for animal feeding is typical of mixed farming systems, where cereals are interdependently combined with livestock, such as in Khouribga Province. Farmers fed an important proportion

of their grain production to their own livestock (Table 8). Grain sales averaged 15% and varied between nil for trial farmers in Khouribga and 34% for non-trial farmers in Oued Zem. About 17% of production was stored by farmers for later use. Given the importance of barley as feed, it was not surprising that surveyed farmers were concerned with grain quality for animal feeding. The majority of survey farmers believed that local varieties had better grain for animal consumption. Farmer comparisons revealed a positive assessment of the new varieties. The most positive characteristics were high grain quality for human consumption, early maturity, and resistance to lodging. Weakest characteristics were inability to regenerate after grazing and low quality of the grain for animal feeding.

Table 8. End uses of barley grain and straw by farmer category in the three CTs (percentage of total barley production).

End use	Boujaâd		Oued Zem		Khouribga	
	NT (n=16)	T (n=13)	NT (n=17)	T (n=17)	NT (n=15)	T (n=10)
Grain						
Animal consumption	46	55	31	26	54	66
Human consumption	6	5	5	5	12	8
Seed	9	9	11	18	18	17
Storage	27	21	19	21	8	9
Sales	12	10	34	30	8	0
Total	100	100	100	100	100	100
Straw						
Animal feeding	37	61	80	57	100	100
Storage	53	28	5	31		
Sales	10	11	15	12		
Total	100	100	100	100	100	100

NT = non-trial farmers; T = trial farmers .

Discussion

The results of the study show that the major reason behind the limited adoption of new barley varieties is closely linked to seed availability at the right place and the right time, seed price, and the kind of varieties provided to farmers. In fact, the amount of certified seed sold nationally each year represents a small proportion of total barley seed needs. Certified seed distributed by SONACOS continues to include old barley varieties such as Rabat 071 and Merzaga 077, both first registered in 1956. On-farm testing of these varieties in comparison with varieties registered in 1976 has shown that the old varieties are the least productive in several environments (Amri 1992). Currently, the production and distribution of certified seed is limited to Arig 8 and Brasserie du Maroc, registered in 1973, and ACSAD 60, registered in 1984. Amri (1992) reports, however, that the registration of Tamellalt in 1984 was justified by its yield increases of 62% and 14% over Rabat 071 and Arig 8, respectively. During the last 10 years, the amount of certified seed of Tamellalt produced and sold by SONACOS was insignificant. In addition, none of the new varieties registered since 1988 have been produced by

SONACOS, although on-farm verification trials of these varieties consistently confirms their high productivity (Amri 1992). During 1987/88 and 1992/93, sales of certified seed were limited to ACSAD 60 in Boujaad and Oued Zem. In 1993/94, Rihane was the only variety distributed nationwide. Thus, unavailability of seed is the major constraint to the adoption of new varieties.

There is a preconception regarding the adoption of new barley varieties that farmers are resistant to growing two-rowed varieties. Agro-concept (1990) found that none of the farmers used certified barley seed in the Abda and Chaouia regions. Two-rowed varieties were rejected by all farmers because of the impression of lower productivity. Amri (1992) also noted that many farmers resisted two-rowed varieties. The results of the present study show high acceptance of two-rowed varieties. The new barley varieties currently grown include more of the two-rowed than the six-rowed barley types, especially in Oued Zem and Khouribga. ACSAD 60, a two-rowed variety, was actually the most adopted, the most widely known, and the most appreciated for human consumption. A further factor is the large importation of barley during drought years, which has essentially been of the two-rowed barley type commonly known as *rouiza*.

Farmers are more than willing to adopt new barley varieties. But as shown in the study, lack of availability of seed at reasonable prices is a major constraint to a wider use of new varieties. The practice of purchasing and renewing cereal seed is increasing among farmers because of the lack of seed from their own production, and also because of a determination to experiment with new varieties. It is true that farmers do not purchase certified barley seed annually, but it is also true that, given the areas grown to barley, the multiple uses made of the production, and the critical mass of farmers growing barley nationwide, barley is and will remain an important crop in Morocco (Nassif 1992). Consequently, there is a need for certified seed to sow more than two million hectares at a rate of least 100 kg/ha.

Unfortunately, the current system of seed production and marketing is not able to satisfy these needs. SONACOS, which has a monopoly over the distribution of certified seed, must respond to farmers' needs, preferences, and the current and future uses of barley. Rigorous study of farmer demands in relation to production costs, climatic variability, and cereal market fluctuations is necessary. Without an understanding of the national demand for barley seed, it is difficult to make rational decisions with respect to the varieties and quantities of seed to produce and market nationally. SONACOS could stimulate demand for certified barley seed by educating farmers on the advantages of new varieties. Selection of high-yielding varieties is necessary, but it is not enough to improve production in Morocco if it is not accompanied by adequate production, distribution, and marketing of seed.

Conclusions and Recommendations

The adoption of new barley varieties by farmers in Khouribga Province was higher than expected. The major constraints were lack of seed at the right time and place, and the high price of certified seed. The main disadvantages of new barley varieties were low straw yield, lack of capacity to regenerate after green grazing, and the low quality of the grain for animal feeding. The new varieties were

appreciated for high grain yield and high quality grain for human consumption. Several recommendations are made, as detailed below.

From a Research Perspective

- Include quality factors in relation to different uses of barley in the research program.
- Reinforce the research effort on drought resistant varieties.

From a Development Perspective

- Increase seed production of new varieties, especially those registered since 1988.
- Diversify the range of varieties made available to farmers.
- Review the current system of seed distribution and marketing.
- Conduct studies on the needs of farmers.
- Take into account the adoption zones in seed production and distribution.
- Provide farmers with information to optimize their choice of varieties.

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Discussion

K. Shideed: Ex-ante monitoring of farmers is required before the official release of new varieties. The monitoring of farmers must be consistent with the specified objectives of breeding program. Given the tendency to use barley for human consumption, this may not encourage breeding activities to improve straw quality since increasing grain yield will continue to be the first priority for most of national programs.

M. Ababneh: You mentioned that new barley varieties give low straw yield. What is the harvest index for that and why?

F. Nassif: I don't know the harvest index for different barley varieties. However a simple visual appreciation clearly shows that local barley varieties are taller than new varieties. In addition, farmers do not base their evaluation of a particular variety on its harvest index but on the quantity of straw collected from the field.

A. Adary: Do the governmental authorities influence the pulling of old varieties from farmers and the enhancement of new varieties?.

F. Nassif: Unfortunately, the government, through it is seed production agencies, continues to produce old varieties.

E. Shehata: If farmers say that the price of new varieties is high, they should be asked whether they recognize if the price difference is compatible or not.

F. Nassif: Farmers recognize the price gap between certified seed and common seed, and perceive it as a constraint and an extra burden on their low resources.

S. Al-Chaabi: Imagine yourself a farmer; the question is, why do you refuse to use new varieties or other new technology if you know the benefit you will reap by applying the new technology?

F. Nassif: If I were a farmer and I knew that a given technology was good for me and would benefit me, I would be stupid not to use it. Our farmers are not stupid and do not refuse good technologies that have benefits. Studies have shown that farmers are not resistant to technological change. Nor are they irrational in terms of using what is best and beneficial to them

Technological Change Bias of Barley Production Technology In Jordan

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Abstract

The bias of technological change is caused by different rates of change in the marginal productivity of factor inputs. The technological bias measures which factors of production produce relatively more through technological change. Cross-sectional data were used to investigate the nature of barley production technology in Jordan. Data collected in Jordan for the 1989/1990 season, from a random sample of 311 barley farmers in the rainfed areas, were used to examine the sources and directions of technological change biases. A primal measure of technological change bias was estimated using a translog production function with constant returns to scale specifications.

Results show that new varieties are land-saving and fertilizer-using. New varieties and early planting seem to be capital-neutral, whereas machinery is land-saving and capital-using. The application of herbicides, as expected, is capital-saving. Machinery is family- and hired labor-neutral. In general, the new technology is fertilizer-using, land-saving, and family labor-saving.

Introduction

There are five factors of importance in determining the distribution of economic gain from technological change in agriculture. These are: (i) the nature of the change (factor-using or factor-saving); (ii) the structure of the agricultural sector, particularly the land tenure system; (iii) the structure of the market for inputs (fertilizers, labor, etc.) and credit; (iv) the market for the product; and (v) agricultural policy (Andersen and Hazell 1985). The effects of new techniques are highly disputed in the literature. Some authors state that agricultural employment increases because larger areas are cultivated or cultivation is more intensive (Bayri and Furtan 1989). Others conclude that the overall employment effect is increased, because a decrease in the agricultural sector is compensated by an increase in activity related to agriculture (Aresvik 1976). A third group of authors admits an overall decrease in employment opportunities, but disregards this as a short-term disadvantage (Lanzendörfer 1985). A fourth group concludes that there is a reduction in employment together with a severe degradation of the lowest classes' situation without any improvement in sight (Rassam 1984). The fifth group emphasizes that technology leads to a rescheduling of labor input and farm

activities (Tully 1990). Many studies indicate the importance of access to capital for technology adoption (Qasem 1986c), and others (e.g., Jansen et al. 1990) indicate that the lack of institutional credit is an important determinant of variation in adoption rates.

New agricultural technologies are introduced in packages that include new varieties, fertilizers, and cultivation methods. While these components may complement each other, some of them can be adopted independently, and farmers may adopt parts of, or the entire package.

The Problem

There is great potential for increasing barley production in rainfed areas through the use of better technology. However, both the adoption rate of technology and productivity growth rate are low in these areas. Low productivity is the result of many factors¹, including use of land unsuitable for cultivation and irregular rainfall, which induces farmers to minimize their risks by limiting inputs to seed and plowing. The importance of the need to adapt technology to suit local conditions must be stressed.

Increasing productivity does not necessarily imply a general increase in the wealth of all farmers. In particular, the extent to which poor farmers are suffering from the introduction of labor-saving technologies is not addressed. In Jordan, landless laborers are becoming more available, leading to a change in farm patterns, e.g. the cultivated area of cereals is declining because the peak shortage of labor increases the cost of harvesting. On the other hand, new technology, which decreases labor requirements, might remove one of the most important sources of income for rural people, particularly unskilled laborers and women. Therefore the impact of new technology on employment should be examined to help policy makers balance positive and negative impact. New techniques being developed in Jordan include changes in the time and method of seedbed preparation and planting, new types of machinery, improved techniques for weed control, fertilization, pest control, alternative crops and rotations, and new crop-livestock interactions. All these can be assumed to alter the labor-capital input ratio, sometimes requiring more, sometimes less, and sometimes rescheduling activity.

Objectives

The influence of other economic and socioeconomic factors on agricultural production should be taken into consideration when seeking effective means of exploiting natural resources. Technological change bias in agriculture has important effects on, and is affected by other changes in the economy as well. Changes in relative factor prices have been said to be the prime sources of technological change bias. Labor-saving technological change, for example, enables

¹ The factors can be classified into five categories: environmental, institutional, farming system, economical, and technological factors. These factors have been discussed by authors like Haddad. (1988); Taimeh (1991); Sunnaa et al. (1985); Duwayri (1991) p.44; Qasem and Mitchell (1986).

more farm laborers to migrate to the non-farm sector. A land-using bias, on the other hand, may stimulate efficiency differentiation among farm groups and lead to a rise in farm land price, while a machinery-using bias accelerates the rate of investment in agricultural machinery. All these affect income distribution, as well as economic growth. The specific objective of this study is to examine the sources and directions of technological change biases of new techniques in barley production in Jordan's rainfed farming areas.

Methodology

Changes in production can be realized in various ways at the farm level: through improved methods of utilizing resources so that a higher output rate per unit of input is obtained, often referred to as disembodied technological change; through a change in input quality, such as a new variety, referred to as embodied technological change²; and through the introduction of new processes and new inputs, such as fertilizer application. If disembodied technological change occurs in an existing production process, it can be modeled in terms of a shift in the production surface.

Kislev and Peterson (1981) classify technological change as external and internal. Innovations in the manufacturing sector—machines, fertilizers, etc.—could be described as external technological change, and those in the agricultural sector, resulting from research and experiments, as internal technological change.

Several methods for measuring technical change biases have been used³. Clark and Youngblood (1992) point out that the ideal way to estimate technical change biases is to obtain a direct and accurate measure of technical change. In the absence of such a measure, technical change is a conceptually omitted variable in empirical applications (Antle 1984).

The difficulty with Hicks' definition of bias is that it requires pair-wise comparisons of marginal products of all factors. Therefore, it is not clear whether technological change is using or saving each input. To overcome this difficulty, Binswanger (1974) developed a modified version of Hick's definition of bias for each factor.

Let the production function take the form $y=f(x,t)$, where f is a function of x , $x=f(x_1, \dots, x_n, t)$, where t denotes an index of technological change. As noted by Binswanger (1974), the bias of technical change will be evident from changes in factor shares if, and only if, the factor price ratio remains constant. The attraction of the factor-shares definition is that it generalizes many easy-to-handle factors of production. A single measure of bias for each factor (Berndt and Wood 1975; Antle and Capalbo 1988) is given by:

² "Embodiment" means that the new inputs are more efficient than the old inputs because of the new technology. See also Antle and Capalbo (1988) p. 34.

³ For an in-depth discussion of different methods of measuring a technical bias refer to Antle (1984); Clark and Youngblood (1992); Binswanger (1974); Antle and Capalbo (1988); and Capalbo and Denny (1986).

$$B_i(x,t) = \frac{\partial S_i}{\partial t} \cdot \frac{1}{S_i} \quad \left| \begin{array}{l} > \\ = 0 \\ < \end{array} \right.$$

where S_i stands for the i^{th} factor share and $\partial S_i / \partial t$ refers to the share change keeping the factor combination constant. The overall bias $B_i(x,t)$ can be interpreted as the change in the i^{th} factor share which would occur if factor prices changed so that the firm's original cost minimizing input x remained on the expansion path. Technological change is defined as i^{th} saving, neutral or using as $B_i(x,t) < 0$, $B_i(x,t) = 0$ or $B_i(x,t) > 0$. This version has the advantage that it makes a single measure of bias for each factor (see also Mitchell 1990; Antle and Capalbo 1988). This measure was proposed for use with a homothetic cost function. However, if the technology is non-homothetic, optimal factor proportions, and thus factor shares, will depend on the output level, and a change in scale of production will induce a change in the optimal factor proportions, because it represents a renumbering of the isoquant map. Consequently, in a non-neutral technological change, the bias measure $B_i(x,t)$ represents two distinct effects: a scale effect, due to the movement along the expansion path, and the bias effect, due to the shift in the expansion path. If the technology is homothetic, the scale effect is zero (Antle and Capalbo 1988). Therefore, under cost minimization behavior for homogeneous functions, the primal measure of technological bias will be equal to the dual measure.

Hence, neoclassical production theory is the basic tool for analysis of bias, where biases of technological change can be conveniently defined in terms of certain characteristics of a production function. In view of the simplicity, and the desirable set of neoclassical properties of the translog function, which facilitate the measurement and interpretation of technological change, this function is considered suitable for characterizing technological bias in barley production. The technologies have been introduced as a mechanical-biological-chemical-agronomic package of techniques, combining factor biases of their components.

The Model

Let $Y=f(x,t)$, where f is a function of x , $x=f(x_1, \dots, x_n)$, $t=g(t_1, \dots, t_r)$ and where Y is output measured in weight of barley, x is a vector of input variables, land in cropped area (B), capital as a current goods, including machinery in term of service flow (K), family labor (L) and hired labor (H) in adult man-hours directly used for barley production, and quantity of fertilizers applied in kg. (F). Also, t is interpreted as an a binary index of the technological package for new seed varieties (V), herbicides (C), drill machinery (D) and planting date of barley (A). An external technological change mostly leads to a shift in the production function, whereas an internal technological change could have occurred due to learning by doing or the introduction of new varieties or new production practices. This reflects a quality change in inputs, which could be represented by a movement along an isoquant or the production function. If the technological components are not strongly separable form inputs, then a nonhomothetic production function with non-neutral technological change can be written as:

$$\ln Y = \alpha_0 + \sum_{i=1}^n \alpha_i \ln x_i + \frac{1}{2} \sum_{i=1}^n \sum_{j=1}^n \omega_{ij} \ln x_i \cdot \ln x_j \\ + \sum_{m=1}^f \beta_m T_m + \sum_{i=1}^n \sum_{m=1}^f \rho_{im} \ln x_i T_m$$

where the Greek letters are parameters to be estimated. If the production function is homothetic, then the technological change bias for each piece of the technological package can be easily captured. The interesting characteristic of homothetic production functions is that the marginal rate of technical substitution (*MRTS*) remains constant as all inputs are increased proportionately. When the marginal rate of technical substitution is constant, as in homothetic functions, any change in the value of output will effect the optimum input levels proportionately as long as input prices remain unchanged. Perhaps the production function is nonhomothetic in inputs, therefore homotheticity restrictions are obtained by assuming the production function is homogeneous. Therefore, if the production function is characterized by constant returns to scale (CRTS) in inputs, then the following restrictions on parameters are imposed on the translog production specification:

$$\varepsilon_i = \alpha_i + \sum_{j=1}^n \omega_{ij} \ln x_j + \rho_{im} T_m$$

The necessary conditions for producer equilibrium are given by the equalities between the factor share and the output elasticity share. For producer equilibrium under constant returns to scale, the partial output elasticity and the factor shares are identical for all inputs and equal unity. Given this identity and the equalities between the factor shares S_i and the partial output elasticity, the logarithmic derivatives can be identified as the condition that marginal products are positive. Therefore, the partial output elasticity for factor x_i given as:

$$\varepsilon_i = \alpha_i + \sum_{j=1}^n \omega_{ij} \ln x_j + \rho_{im} T_m$$

whereas, the elasticity of scale is defined as:

$$\varepsilon = \sum_{i=1}^n \alpha_i + \sum_{i=1}^n \sum_{j=1}^n \omega_{ij} \ln x_j + \sum_{i=1}^n \rho_{im} T_m$$

Homogeneity in inputs is a sufficient condition for homotheticity in the translog specification (Antle 1984). The degree of homogeneity is given by $\sum_i \varepsilon_i$ and if the production function is linear homogeneous in inputs then $\sum_i \varepsilon_i = 1$. This is similar to the result obtained from the Cobb-Douglas (C-D) function with constant returns

to scale specification. However, in the case of C-D the individual production elasticities are constant. For the CRTS translog model, the individual production elasticities change as input levels change, but their sum remains constant (Boisvert 1982). Using the elasticity share which is defined as a normalized factor share:

$$\frac{\varepsilon_i}{\sum_{i=1}^n \varepsilon_i}$$

The technological change bias of technology m either towards or against input x_i can be written as:

$$B_{im}(x, t) = \frac{\partial \ln \left(\frac{\varepsilon_i}{\sum_{i=1}^n \varepsilon_i} \right)}{\partial T_m}$$

One can drive the technological bias towards input from the partial output elasticity such that:

$$B_{im}(x, t) = \frac{\partial \ln \varepsilon_i}{\partial T_m} - \frac{\partial \ln \varepsilon}{\partial T_m}$$

By taking the logarithmic derivative with respect to T , we obtain

$$\frac{\partial \ln \varepsilon_i}{\partial T_m} = \frac{\rho_{im}}{\varepsilon_i}$$

$$\frac{\partial \ln \varepsilon}{\partial T_m} = \frac{\sum_{i=1}^n \rho_{im}}{\varepsilon}$$

by substitution, thus the factor bias can be evaluated in terms of output elasticity such as

$$B_{im}(x,t) = \frac{\rho_{im}}{\varepsilon_i} - \frac{\sum_{i=1}^n \rho_{im}}{\varepsilon}$$

Therefore, in the case of a non-homothetic production structure, the bias measure $B_{im}(x,t)$ represents two distinct effects, a scale effect bias which is represented by the second term, due to the movement along the expansion path, and the technological change bias, due to the shift in the expansion path⁴. Both Berndt and Khaled (1979) and Lopez (1980) have shown the difficulty in accurately distinguishing non-neutral technological change in a non-homothetic production structure. Hence, if the production function is homothetic, the scale bias is neutral due to the imposed restriction of homotheticity as $\sum \rho_{im} = 0$. Where ε equal one and ε_i is also positive in a linear homogeneous specifications. Therefore, only under the assumption of linear homogeneous technology, the technological change biases can be obtained by using the following formula:

$$B_{im}(x,t) = \frac{\partial \varepsilon_i}{\partial T_m} = \rho_{im}$$

Note that $B_{im}(x,t)$ is equivalent to the Binswanger measure of technological change bias, because $\varepsilon_i / \varepsilon = S_i$ in producer equilibrium behavior. The overall bias measure $B_{im}(x,t)$ is useful, because it tells us that if the elasticity of the factor share (and therefore the marginal product) of factor i is increasing relative to all others, then $B_{im}(x,t) > 0$ and technology is a factor i -using overall. If technological change is neutral then all $B_{im}(x,t) = 0$. Therefore, $B_{im}(x,t) = 0$ is a necessary condition for Hicks neutrality and can be used to formulate a statistical test for neutrality. Thus if technological change is biased, at least one B_i must be positive and one must be negative. If $B_{im}(x,t) = 0$ for all i , the hypothesis of Hicks-neutral technical change cannot be rejected. Otherwise, technical change is biased. Note a factor's declining share does not necessarily indicate declining productivity of that factor.

Therefore, the bias of technological change is determined by the sign of ρ_{im} . If ρ_{im} (and hence $B_{im}(x,t)$) < 0 , the technology is saving with respect to the i th input. If ρ_{im} (and hence $B_{im}(x,t)$) is not significantly different from zero, the technology is neutral. The technology is factor using if ρ_{im} (and hence $B_{im}(x,t)$) > 0 . This is identical to Binswanger's approach. Therefore, if the production function is homothetic, then $\delta \varepsilon_i / \delta t$ will be a sufficient measure of the direction of the technical change bias towards factor inputs (compare Debertin et al. 1990; Berndt and Wood 1984, 1982; Stevenson 1980). The interpretation of the bias coefficient ρ_{im} requires some care. Firstly, ρ_{im} is constant, and thus does not vary in response

⁴ Antle and Capalbo (1988, p. 40) show the two distinct effects in the bias measure B_i for a nonhomothetic cost function.

to a relative input change as a result of an input price change. Secondly, the bias parameter represents a relative rather than an absolute effect of technological change on the demand for production factors (see also Berndt and Wood 1984).

Source of Data and Estimating Procedure

Cross-sectional data were used to investigate the nature of barley production in Jordan. The study analyzed data collected for 1989/1990, from a random sample of 311 barley farmers in the rainfed areas. A linear homogeneous production function was estimated directly, without using side conditions. A five-input production function with a technological package represented by four components was used. The regression equation was linear in parameters. Therefore, a generalized nonlinear least squares⁵ procedure was used, where iterated by the Gauss-Newton technique.

In estimating a production function, one is faced with the problem of a simultaneous bias, which provides that inputs are determined by the level of output. However, it can be safely argued that the inputs are pre-determined in terms of anticipated output, and the x_i are not functionally related with the disturbance term u . In addition, technological change dummies are expected to absorb the possible functional relationship between factor inputs and the disturbance term. Even if there is the additional problem of heteroscedasticity, these problems may be neglected (see also Lee 1983). In this case farmers are not likely to be using similar production technology. However, the technological change index captures the technology differences which are included in the model specifications. It is a form of partitioning the sample into different subsets (for more detail see Griffiths et al. 1993). Therefore, the heteroscedasticity part will be absorbed in the disturbance term, and since both output and input were transformed into a logarithmic scale (Maddala 1992), the disturbance term u is assumed to follow the conventional assumption.

The translog function is potentially subject to the serious multicollinearity problem. Such multicollinearity is defined as the general problem which arises when some or all of the explanatory variables in a relation are highly correlated with each other. Then it becomes difficult to disentangle the separate influences of each independent variable and obtain a reasonably precise estimate of their relative effects. We would expect large farms to employ more capital, more labor, and more other services, and small farms to use less labor, less fertilizer, and fewer other services. Klein (1962) suggested that multicollinearity is not necessarily a problem in cross-section studies unless it is high in relation to the overall degree of multiple correlation among all variables simultaneously.

The use of a broad cross-sectional database allows the translog function to be estimated directly. A major disadvantage of estimating the translog function directly, as in this study, is that a large database is needed to reduce possible

⁵ For more details about nonlinear least squares techniques see Hall et al. (1991); Griffiths et al. (1993) and their references.

problems of multicollinearity. However, this problem can be overcome by estimating the production function indirectly. This alternative for estimating the parameters of the translog function is, unfortunately, not possible in our case, whereas there is information available about the prices of inputs.

Discussion

The coefficients of the translog production function are displayed in Table 1. The parameters themselves do not have a direct economic interpretation. The absolute values of the coefficients have little intuitive meaning except the coefficients which represent the input interactions with the technological index.

A supplementary test is employed to appraise whether the monotonicity and convexity requirements are satisfied for the estimated parameters. Firstly, we check the first logarithmic derivative to see if the fitted output elasticities, or to be precise, the factor shares are positive. All the fitted output elasticities are positive for all observations. We can conclude that our estimated translog function satisfies the conditions of monotonicity. A production function is strictly quasi-concave if the bordered Hessian matrix is negative definite. Strict quasi-concavity is a sufficient condition for the production function to have convex isoquants. The conditions for strictly convex isoquants are satisfied when the bordered Hessian matrix is negative definite. The determinants of the matrices along the leading principle diagonal are calculated as described by Berndt (1972). The determinants of the matrices along the principle diagonal alternate in sign. It can be concluded that the estimated translog function satisfies the requirements for strict convexity of the isoquants.

The bias of technological change is caused by differential rates of change in the marginal productivity of factor inputs. The importance of measuring the technological bias stems from the fact that it measures which factor of production produces relatively more through technological change. The measure of technological change bias $B_{lm}(x,t)$ as defined by earlier measures the proportionate rate of change of factor share. As stated earlier, the coefficient (ρ_{lm}) provides only one single measure of bias for each factor with respect to each technology. To determine the direction of the technological change biases, the (ρ_{lm}) coefficient should be significantly different from zero.

Results on the nature of technological bias for all adopted technologies are shown in Table 1. The new barley varieties are land-saving, family labor-saving, and fertilizer-using. The yield response to fertilizer was increased with the new varieties, whereas fertilizer is a complement to other inputs such as new seed variety and labor, since weeding requirements typically increase significantly when fertilizer is used. The application of a large amount of fertilizer to new varieties of barley without a simultaneous change in weed control practices may increase the probability of low yield, since weed growth is encouraged by high fertilizer levels. New varieties have a relatively small effect on hired labor and management requirements, and are expected to be slightly capital-using and moderately yield-increasing when used alone. The use of fertilizer is associated with change in the method of production and is mainly a substitute for land, rather than other inputs such as labor or capital.

Table 1. Regression results.

Variable	Parameter	Estimate	t-statist	Variable	Parameter	Estimate	t-statist
	α_0	-2.4340	(-9.4834)	A	β_A	0.0789	(0.4867)
<i>ln B</i>	α_B	0.6285	r	D	β_D	-0.1035	(-0.3748)
<i>ln K</i>	α_K	0.3453	(2.1569)	H	β_H	0.3468	(1.5215)
<i>ln L</i>	α_L	-0.0093	(-1.1367)	<i>ln B V</i>	ρ_{BV}	-0.0010	r
<i>ln H</i>	α_H	0.0663	(1.8244)	<i>ln B A</i>	ρ_{BA}	-0.0805	(-1.0782)
<i>ln F</i>	α_F	-0.0308	(-0.7861)	<i>ln B D</i>	ρ_{BD}	-0.2060	(-1.4328)
<i>ln B ln B</i>	ω_{BB}	0.0594	r	<i>ln B C</i>	ρ_{BC}	0.1882	(0.9166)
<i>ln K ln K</i>	ω_{KK}	-0.0019	(-0.0386)	<i>ln K V</i>	ρ_{KV}	0.0395	(0.6058)
<i>ln L ln L</i>	ω_{LL}	-0.0040	(-0.2839)	<i>ln K A</i>	ρ_{KA}	0.0569	(0.7930)
<i>ln H ln H</i>	ω_{HH}	-0.0423	(-2.6224)	<i>ln K D</i>	ρ_{KD}	0.1532	(1.1761)
<i>ln F ln F</i>	ω_{FF}	-0.0062	(-0.4687)	<i>ln K C</i>	ρ_{KC}	-0.2021	(-1.9862)
<i>ln B ln K</i>	ω_{BK}	-0.0444	(-1.7571)	<i>ln L V</i>	ρ_{LV}	-0.0221	(-1.9992)
<i>ln B ln L</i>	ω_{BL}	0.0226	(0.7707)	<i>ln L A</i>	ρ_{LA}	-0.0107	(-0.5213)
<i>ln B ln H</i>	ω_{BH}	0.0432	(1.2408)	<i>ln L D</i>	ρ_{LD}	-0.0327	(-1.7625)
<i>ln B ln F</i>	ω_{BF}	-0.0100	(-0.8522)	<i>ln L C</i>	ρ_{LC}	-0.0409	(-1.1478)
<i>ln K ln L</i>	ω_{KL}	-0.0042	(-0.1520)	<i>ln H V</i>	ρ_{HV}	-0.0102	(-0.3941)
<i>ln K ln H</i>	ω_{KH}	-0.0104	(-0.3127)	<i>ln H A</i>	ρ_{HA}	0.0476	(0.1893)
<i>ln K ln F</i>	ω_{KF}	0.0133	(1.4776)	<i>ln H D</i>	ρ_{HD}	-0.0004	(-0.0069)
<i>ln L ln H</i>	ω_{LH}	-0.0142	(-0.9902)	<i>ln H C</i>	ρ_{HC}	0.0161	(0.3645)
<i>ln L ln F</i>	ω_{LF}	-0.0010	(-0.3603)	<i>ln F V</i>	ρ_{FV}	0.0732	(1.0434)
<i>ln H ln F</i>	ω_{HF}	0.0003	(0.0844)	<i>ln F A</i>	ρ_{FA}	0.0147	(2.3351)
				<i>ln F D</i>	ρ_{FD}	0.0194	(2.0927)
				<i>ln F C</i>	ρ_{FC}	-0.0016	(-0.2371)
V	β_V	-0.0547	(-0.3430)				

Adjusted $R^2 = 0.953$; standard error of estimate = 0.232; residual sum square = 29.50; log of likelihood = 44.7; number of var. = 44; number of sign. vari. = 19; r = evaluated as residual.

Early planting is land-saving and fertilizer-using and family and hired labor-neutral. It is also capital-neutral, where (ρ_{KA}) is not significantly different from zero.

Seed drills are capital-using, fertilizer-using, land-saving, and family-labor-saving. As expected, they are hired-labor-neutral, since most users of machinery hire contractors, whereas manual broadcasting is performed by the family. Seed drills raise the productivity of labor, mainly by making it possible for a given area of land to be worked by a smaller amount of labor or by reducing labor costs and becoming more capital-intensive, changing the allocation of resources. Less labor, more capital, with more staff management required. This does not generally lead to an increase in yield per unit of land, unless it is accompanied by other biological, chemical, or agronomic technologies.

The application of herbicides was expected to be capital-using, but it is capital- and family-labor-saving, where the farmers use either their family members for manual hand weeding or hired labor to apply herbicides.

The results are consistent with others from West Asia and North Africa in relation to new cereal production techniques. For example, Ruttan (1977) points out that yield increasing technologies are considered to be land-saving and labor-using. New varieties were expected to increase labor demand through a greater need for fertilizers, irrigation, weed control, and harvesting. Bayri and Furtan (1989) found that wheat technology in Turkey was fertilizer-using and labor-saving. However, they show that the demand for labor increased without changing the real wage rate because the supply of labor in rural areas is ample. The study by Sidhu and Byerlee (1991) on the introduction of new inputs in Indian villages between 1972 and 1987 suggests that technological change is consolidated through further intensification in the use of land-saving inputs, especially fertilizers and herbicides. The use of labor-saving techniques has diffused even more rapidly since the introduction of new varieties. The study found that there were no major changes in input prices, but that there had been a consistent decline in the price of barley received by producers. Bisaliah (1975) studied the technological change bias of cereal production technology in the Punjab district of India. He found that new varieties were land-saving, labor-saving, and capital and fertilizer-using.

In general, the package introduced into the Jordanian barley system is fertilizer-using, capital-using, land-saving, and family labor-saving. Table 2 shows the bias of technological change for each specific technology. For example, new varieties are fertilizer-using, family labor-saving, land-saving, and hired labor-neutral. Herbicides, however, have a neutral effect on land, hired labor and fertilizer.

Table 2. Bias of technological components toward/against factor inputs.

Technologies	Land (B)	Capital (K)	F-labor (L)	H-labor (H)	Fertilizer (F)
Seed Varieties (V)	<i>saving[†]</i>	<i>neutral</i>	<i>saving</i>	<i>neutral</i>	<i>using</i>
Early Planting (A)	<i>saving</i>	<i>neutral</i>	<i>neutral</i>	<i>neutral</i>	<i>using</i>
Drill Machine (D)	<i>saving</i>	<i>using</i>	<i>saving</i>	<i>neutral</i>	<i>using</i>
Herbicide (C)	<i>neutral</i>	<i>saving</i>	<i>saving</i>	<i>neutral</i>	<i>neutral</i>

[†] Calculated as a residual

Source: Regression equation.

However, a distinction should be made between biological and mechanical technology. While biological and chemical technologies, such as improved seed varieties and fertilizer, are divisible and can be applied to all farm sizes, mechanical technology is indivisible and conditioned by farm size. Since new technology increases output, it also increases the derived demand for primary inputs, including land. As the supply of land is inelastic, the results should be a relatively increase in the shadow price of land.

Conclusions

New barley varieties are land-saving and fertilizer-using. New varieties, early planting and machinery seem to be capital-neutral. However, the application of herbicides is, as expected, capital-using. The machinery is capital- and hired labor-neutral and family labor-saving. Generally, it can be said that barley production

technology is fertilizer-using, capital- and hired labor-neutral, land- and family labor-saving.

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Sequential Adoption of Divisible Technologies in Barley Production in Jordan

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Abstract

New agricultural technology is usually promoted as a mechanical-biological-chemical-agronomic package. Nevertheless, many farmers adopt only parts rather than the entire package. Data collected from a sample of 311 barley farmers in rainfed areas were used to investigate the effects of sequential adoption of new technologies on output, and a linear homogeneity model was used to characterize rainfed barley production technology in Jordan. Use of seed drills without adopting other components increased output by 5.7%. The adoption of new varieties increased output by 3.2%. Adopting new varieties and machinery increased output by 7.9%. The entire package increased total output by 24.2, 31, and 74% in Zones 1, 2, and 3, respectively.

Introduction

An important way of increasing agricultural productivity and farmer income is the adoption of new technology. New technology is usually introduced as a mechanical-biological-chemical-agronomic package, of which farmers might choose a part rather than the whole. Ryan and Subrahmanyam (1975) and Szmedra et al. (1990) postulate that adopting parts of the package might be looked upon by farmers as less risky in terms of what the farmer could lose in the event of crop failure. In other words, although expected profits may be maximized by adopting the entire package, the expected utility may be maximized by adopting one or more components. Indeed, most adoption studies have considered the adoption of a single component in isolation and have ignored the process of adopting the set of components. Empirical evidence (see Feder et al. 1984) suggests that farmers often adopt pieces of the package in a "step-wise" fashion. Farmers are uncertain about the returns associated with adopting a new technological package, and the uncertainty may not be resolved by adopting the whole package. Economists have argued that sequential adoption may reflect a rational choice by farmers, but the reasons for that choice are not clearly understood. Byerlee and Polanco (1986) state that "because of capital scarcity and risk considerations, farmers are rarely in a position to adopt complete packages." Farmers who operate for more than one operation period decide, in each period, whether to adopt a new variety, fertilizers, or both. The adoption process involves six consequential decisions.

First, the farmer decides whether or not to adopt a technological package, or one or more components of that package. Second, the farmer decides the type of component(s) (i.e., in the case of fertilizer technology, whether manure, nitrogenous, phosphorous, NPK, or mixed should be chosen, and which trade mark). Third, the farmer decides how much to adopt (in the above case, the area to be fertilized). Fourth, the farmer decides on the intensity of usage (i.e., the amount of fertilizer to apply). Fifth, the farmer decides the application method (i.e., broadcasting, spraying, or seed drill). Finally, the farmer evaluates the new technology in terms of its incremental benefit and decides whether or not to continue using it. However, the decision process is simplified here, because there are different, additional decisions such as the date on which the decision should be carried out, and the possibility of interaction with inputs and any other technological components. Therefore, it can be hypothesized, as in Welch (1978), that farmers know that what they have learned today will be useful in the future, and they may therefore deliberately experiment with inputs, knowing that by not optimizing in the short run they will discover more about the probability distribution of output to help achieve optimal behavior in the future. Leathers and Smale (1991) suggest a simple economic explanation of the adoption behavior: "a farmer will choose the most profitable technology and will continue to use that technology as long as relative prices remain unchanged."

This suggests that farmers under the same conditions will choose identical technological combinations. As economic conditions change, farmers will, sometimes switch from components to the whole package and, in other cases, from the whole package to components. Szmedra et al. (1990) suggests that providing new technological information to producers should involve presentation of a complete technological package as well as appropriate modifications, or partial packages.

The Problem

As more technological components become available in the recommended package, the decisions faced by farmers increase. One would expect that each farmer would adopt a set of components different from the others. The sequential adoption might be a rational choice for farmers who have not been fully informed, therefore this might not need to be viewed as evidence of institutional shortcomings or farmer irrationality¹. The adoption pattern may vary among and within agro-ecological zones, and among farmers facing similar market and institutional constraints.

Given Jordan's limited agricultural resources, raising productivity is one of the most important ways to increase production. Average productivity in the rainfed areas is low compared to what could be attained by applying new technology. This would be determined either by agricultural research in Jordan or by adopting proven technology from comparable agro-ecological environments.

¹ A more recent article from Smale, Just, and Leather provides four explanations for partial adoption of new technology: input fixity, portfolio selection (rationing), safety-first behavior (risk and uncertainty), and farmer experimentation and learning. For more detail see Smale et al. (1994).

New technology increases factor productivity and changes the income shares among factors or revenue shares among outputs. Policy makers want to know how policies and technology will affect different segments of the economy and how farms of different size and type in different geographical regions will be affected. The challenge for agricultural economists is to provide policy makers with relevant information on the impact of different technological options and to help them understand the trade-offs that will occur. Also, they can play a significant role in the drafting of policy to encourage the development of new technology.

The Objective of this Study

The objective of this study was to examine the effects of divisible technologies on barley production in Jordan's rainfed farming areas by quantifying the difference in output of new and traditional technology, and between farms adopting the whole package and farms adopting one or more component of the package. Furthermore, to analyze the income distribution among inputs, the contribution of each input to growth of output is determined by estimating the partial output elasticities with respect to production factors.

Methodology

The neoclassical definition of production technology is based on a production function which may be determined in a mathematical form. More specifically, the single-output production function $f(x)$, where x is an input vector, is defined as a positive, continuous, twice-differentiable function with certain monotonicity and concavity properties (Chambers 1988). Production functions incorporate several technical characteristics, including: efficiency of production, technical change, biases of technical change, elasticity of substitution, distributive share, economies of scale, and homotheticity specification. These are generally expressed in terms of the production function's first and second derivatives. The total change in output can be broken down into three forces: a change in input use, economies of scale, and technological change. The influence of those forces on the output change can be empirically quantified.

For empirical research, it is desirable to impose as few restrictions on a functional form as possible to keep the function empirically tractable. In view of the properties of the translog function, which facilitates the measurement and interpretation of technological change, this function is considered suitable for the purposes of this study. The translog models will be developed to quantify the effects of the introduction of new technology to barley production in Jordan, where new technology has been introduced as a mechanical-biological-chemical-agronomic package of techniques.

The Model

To estimate the effect of adopting either a piece of the package or the whole package, a mathematical model should allow the choice of either one or more components or the whole package. Let $Y=F(X,T)$, where Y is output and F is a function of X , where $X=f(x_1, \dots, x_n)$, $T=g(T_1, \dots, T_l)$ where X is a vector of

variables, land in cropped area (B), capital as a current good (K), family labor (L), hired labor (H) in adult man-hours used for barley production, seed in kg (S) and fertilizer in kg (F). The T is interpreted as an index of the technological package for new seed varieties (V), herbicides (C), drill machinery (D) and planting date of barley (A), which are represented as binary variables for adoption or non-adoption. The individual component effect is expected to vary with the level of other technology used. An interaction effect will exist and technological components could either substitute or complement each other². Therefore, we must incorporate the interaction effect into the model and estimate it. A nonhomothetic translog production function with non-neutral technological change can be written as Model I³.

$$\ln Y = a_x + \sum_{i=1}^n a_i \ln x_i + \frac{1}{2} \sum_{i=1}^n \sum_{j=1}^n w_{ij} \ln x_i \cdot \ln x_j + \sum_{m=1}^f \beta_m T_m$$

$$+ \sum_{i=1}^n \sum_{m=1}^f \rho_{im} \ln x_i \cdot T_m + \frac{1}{2} \sum_{m=1}^f \sum_{k=1}^f \psi_{mk} T_m T_k + \sum_{s=1}^r \delta_s d_s$$

where the Greek letters are parameters to be estimated and δ_s denotes the coefficient of the s -th dummy variable designed to capture the effect of regional and soil structure on the farm. The d_s s are the regional dummies that take a value of one for the observations in the region under consideration and zero for the observation of other regions. The translog function is strictly quasi-concave if and only if the bordered Hessian matrix F is negative definite⁴.

There are many advantages to working with non-homothetic functions. One can derive sufficient conditions under which the translog function is homothetic and homogeneous. A testing of different functional hypotheses is done by the introduction of a restriction for the functional parameters. Model I assumes an

² Szmedra et al. (1990) investigated the technological package complements and substitutes by developing a dynamic theoretical model.

³ Since technological components are to be treated as binary variables, the term T_m^2 does not appear in any equations. As a consequence, the $1/2$ set forth is not permitted to enter in estimations. For more details about measuring the interaction effects in the dummy variables see Johnston (1991) p. 231-234.

⁴ F is negative definite if the successive principle minors alternate in sign. Defining the $k+1$ principle minor by F_k , F is negative definite if $F_1 < 0$, $F_2 > 0$, $F_3 < 0$, ..., $(-1)^n F_n > 0$.

unrestricted nonhomothetic specification. Model I-a has a homothetic as well as a homogeneous specification. Model I-b has a linear homogeneous specification. The linear homogeneity with Hick's neutral technological change is presented in Model I-c, and a Cobb-Douglas function with a technological change specification is presented in Model I-d. Therefore, a non-homothetic translog production function will be employed, the homothetic and homogeneous specification will be tested rather than set *a priori*. The translog is attractive because it has a minimum number of parameters needed to represent economic behavior without imposing arbitrary restrictions on it⁵.

Homotheticity (Model I-a)

Every homogeneous production function is homothetic, but the homothetic family contains non-homogeneous functions as well. Homogeneity in Model I was imposed by setting the following restrictions⁶:

$$\sum_{j=1}^n \omega_{ij} = 0 \quad \forall i ; \quad \sum_{m=1}^f \rho_{im} = 0 \quad \forall i ;$$

If these restrictions are satisfied, then the translog is homothetic and homogeneous in inputs. A maximum likelihood ratio test will be employed to test the significance of deviation from the unrestricted model.

Linear Homogenous (Model I-b)

If the production function is linear homogeneous in inputs, then the sum of partial output elasticity is equal to one. This is similar to the result obtained from the Cobb-Douglas function (C-D), with constant returns to scale specification (CRTS). However, if the production function is characterized by constant returns to scale in inputs, then the following restrictions on parameters are imposed on the translog specification:

$$\sum_{i=1}^n \alpha_i = 1 ; \quad \sum_{j=1}^n \omega_{ij} = 0 \quad \forall i ; \quad \sum_{m=1}^f \rho_{im} = 0 \quad \forall i .$$

Linear Homogenous with Hick's Neutral Technological Change (Model I-c)

The technological change is Hicks-neutral if the marginal rate of substitution between each pair of inputs is independent of the technological change. If production possibilities are characterized by both CRTS and Hick's neutral technological change (HNTC), then it implies that for Model I the following additional restrictions should be placed on the translog parameters:

$$\sum_{i=1}^n \alpha_i = 1 ; \quad \sum_{m=1}^f \beta_m = 1 ; \quad \sum_{j=1}^n \omega_{ij} = 0 \quad \forall i ; \quad \rho_{im} = 0 \quad \forall i .$$

⁵ See : Antle and Capalbo (1988).

⁶ See Antle and Capalbo (1988), Chambers (1988), and Corbo and Meller (1979).

Cobb-Douglas Function (Model I-d)

The C-D function provides a simple computational indication of the production relationships whose parameters are easily interpreted. Its chief drawback is that the elasticities of substitution among all inputs have to equal one. The translog function is rendered to the C-D specification if the following restrictions hold:

$$\omega_{ij} = 0 \quad \forall i, j \quad ; \quad \rho_{im} = 0 \quad \forall i, m.$$

The Partial Elasticity of Output

The partial elasticity of output with respect to input x_i can be computed by taking the logarithmic marginal product of the input. The factor share of input is equal to the partial elasticity share, under conditions of profit maximization in competitive product and factor markets. The partial output elasticity can be computed from the following formula:

$$\varepsilon_i = \alpha_i + \sum_{j=1}^n \omega_{ij} \ln x_j + \sum_{m=1}^f \rho_{im} T_m$$

Economists are often interested in the rate at which output changes when all factors are changed by the same proportion. This output response is generally referred to as the economies of scale, embodied in the production function. For a homogeneous production function, returns to scale may be less than, equal to, or greater than unity, but for a linear homogeneous function the returns to scale are invariant with respect to the initial input levels and are equal to the sum of the partial production elasticities.

Technological Change

Technological change is usually interpreted as an upward shift of a given production function. It is also defined as an inward movement of the production-isoquant frontier in input space. Since the pioneering studies by Solow (1957), Schultz (1958), and Griliches (1964), a large body of literature has been published focusing on the measurements and explanations of technological change and agricultural productivity. For the above model the total effect of a technological change can be computed as the sum of the individual effects of each technological component on output. The individual effect of technology m on output can be obtained from the following expressions:

$$\tau_{mk} = \beta_m + \sum_{i=1}^n \rho_{im} \ln x_i + \sum_{k=1}^f \psi_{mk} T_{kp}$$

This expression measures the percentage change in output due to neutral and non-

neutral technological change and allows the effect of individual components of the package to be isolated.

Source of Data and Estimation Procedure

Cross-sectional data were used to investigate the structure of barley technology in Jordan, in three different farming systems. This study analyzed data collected in 1989/90 from a random sample of 311 barley farmers in rainfed areas.

Rainfall is the limiting factor in barley production. The rainfed areas were therefore divided into three major rainfall zones on the basis of average annual rainfall. Zone 1 receives 200–300 mm of rainfall annually, Zone 2 receives 300–400 mm, and Zone 3 receives 400–500 mm. The translog functions are estimated directly, i.e., without using side conditions. There are few empirical attempts that have estimated a translog function directly⁷. A six-input production function with a technological package represented by four components, is used. The model consists of four additional sub-models as a restricted form of the model. These regression equations are all linear in parameter. The generalized nonlinear least squares procedure is used⁸.

Discussion of the Results

The coefficients of the translog production function and its variants are displayed in Table 1.

The parameters themselves do not have a direct economic interpretation. It is apparent that the restricted parameter estimates do not differ greatly from the unrestricted estimates. The absolute values of the coefficients have little intuitive meaning, with the exception of the coefficients, which represent the input interactions with the technological index and dummy variables for rainfall zones. Due to limited space, only the significant t-statistics are classified into three levels of significance and displayed in Table 1. An indication of the effectiveness of fit of the estimated models is provided with *adjusted R*²s as displaced in Table 2. The *adjusted R*² is 0.979 for the unrestricted Model and has the same value for Model I-a and Model I-b. This indicates a fairly good fit, where 97% of variations in the dependent variable are explained by the included independent variables in the equation.

Model I has non-homothetic and non-neutral technological change specifications. The test of linear restrictions was done by a likelihood ratio test as shown in Table 2. The restriction of homotheticity and homogeneity (Model I-a), and of linear homogeneity (Model I-b) cannot be rejected as shown in the Table 2. Hick's neutral technological change (Model I-c) and Cobb-Douglas specification (Model I-d) cannot

⁷ Corbo and Meller (1979), Lee (1983), Gyimah-Brempong et al. (1987), and Mirotschie and Taylor (1993) use OLS techniques to estimate the translog production function directly.

⁸ For more details about nonlinear least squares techniques see Hall et al. (1991), Griffiths et al. (1993), and their references.

be accepted to characterize the production. Because there is no statistical difference between the unrestricted model and the linear homogeneous (Model I-b), the most restricted and acceptable variants were the constant returns to scales specification. Therefore, Model I-b is superior to Models I and I-a in representing barley production technology. Moreover, the inference ability of Model I-b is approximately the same. Therefore the latter will be used to characterize rainfed barley production technology in Jordan.

A further test on Model I-b is employed to appraise whether the monotonicity and convexity requirements are satisfied for the estimated parameters. Firstly, we check the first logarithmic derivative to see if the fitted output elasticities are positive. The mean values of fitted output elasticities are displayed in Table 3. All the fitted output elasticities are positive for all observations. We can conclude that our estimated translog function satisfies the conditions of monotonicity.

Mathematical model:

$$\begin{aligned} \ln Y = & \alpha_0 + \sum_{i=1}^n \alpha_i \ln x_i + \frac{1}{2} \sum_{i=1}^n \sum_{j=1}^n \omega_{ij} \ln x_i \cdot \ln x_j \\ & + \sum_{m=1}^f \beta_m T_m + \sum_{i=1}^n \sum_{m=1}^f \rho_{im} \ln x_i T_m \\ & + \frac{1}{2} \sum_{m=1}^f \sum_{k=1}^f \psi_{mk} T_m T_k + \sum_{s=1}^r \delta_s d_s \end{aligned}$$

Restriction : Symmetry

Model I : Unrestricted

Model I-a : Homogeneous

Model I-b : Linear Homogeneous

Model I-c : Linear Homogeneous with Hicks' Neutral Technological Change

Model I-d : Cobb-Douglas.

Table 1. Regression results.

Variable	Param.	Model I	Model I-a	Model I-b	Model I-c	Model I-d
	α_0	-2.9363 a	-2.9999 a	-2.7970 a	-2.6030 a	-2.4366 a
ln B	α_B	1.1659 a	1.0720 a	1.1227 r	1.2750 r	0.8666 a
ln K	α_K	0.2139 c	0.2346 c	0.1843 c	0.1134	0.0103
ln L	α_L	-0.0629	-0.0600	-0.0973 c	-0.1373 a	-0.0005
ln H	α_H	-0.0916 c	-0.0876 c	-0.1179 b	-0.1656 a	0.0001
ln S	α_S	-0.1241	-0.0584	-0.0876	-0.0925	0.0577 a
ln F	α_F	-0.0046	-0.0061	-0.0042	0.0069	0.0068 a
ln B ln B	ω_{BB}	0.1904 c	0.1361 r	0.1295 r	0.2087 r	
ln K ln K	ω_{KK}	-0.0440	-0.0547	-0.0587	-0.0971 c	
ln L ln L	ω_{LL}	0.0096	0.0093	0.0112 c	0.0052	
ln H ln H	ω_{HH}	-0.0084	-0.0089	-0.0076	-0.0115	
ln S ln S	ω_{SS}	-0.0201	-0.0489	-0.0512	-0.0873 c	
ln F ln F	ω_{FF}	0.0005	0.0000	0.0008	0.0005	
ln B ln K	ω_{BK}	-0.0676	-0.0511	-0.0457	-0.0619	
ln B ln L	ω_{BL}	-0.0138	-0.0121	-0.0251	-0.0367 c	
ln B ln H	ω_{BH}	-0.0480 c	-0.0461 c	-0.0564 b	-0.0702 b	
ln B ln S	ω_{BS}	-0.0876	-0.0526	-0.0532	-0.0849 c	
ln B ln F	ω_{BF}	0.0014	0.0008	-0.0008	0.0049	
ln K ln L	ω_{KL}	-0.0115	-0.0115	-0.0039	0.0182	
ln K ln H	ω_{KH}	-0.0193	-0.0198	-0.0148	0.0046	
ln K ln S	ω_{KS}	0.0745	0.0704	0.0738	0.1132 b	
ln K ln F	ω_{KF}	0.0093 c	0.0091 c	0.0093 c	0.0056	
ln L ln H	ω_{LH}	0.0110	0.0107	0.0117 c	0.0062	
ln L ln S	ω_{LS}	0.0189	0.0171	0.0231 c	0.0224 c	
ln L ln F	ω_{LF}	-0.0022	-0.0025 c	-0.0029 c	-0.0024 c	
ln H ln S	ω_{HS}	0.0644 a	0.0627 a	0.0685 a	0.0715 a	
ln H ln F	ω_{HF}	-0.0032 c	-0.0035 c	-0.0039 c	-0.0036 c	
ln S ln F	ω_{SF}	-0.0058	-0.0048	-0.0038	-0.0054	
V	β_V	0.2971 b	0.2840 b	0.2862 b	0.0109	0.0147
A	β_A	0.2733 b	0.2828 b	0.3186 b	0.0658 a	0.0752 a
D	β_D	0.3010	0.2227	0.2725	-0.0052	-0.0027
C	β_C	0.3031 c	0.3184 c	0.2604 c	0.0931 a	0.0873 b

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Variable	Param.	Model I	Model I-a	Model I-b	Model I-c	Model I-d
V A	Ψ_{AV}	0.0362	0.0340	0.0302	0.0292	0.0116
V D	Ψ_{VD}	0.1423 c	0.1308 c	0.1365 c	0.0155	0.0197
V C	Ψ_{VC}	-0.0077	-0.0049	-0.0038	0.0479	0.0428
A D	Ψ_{AD}	0.0163	0.0093	0.0009	0.0278	0.0081
A C	Ψ_{AC}	-0.1833 a	-0.1933 a	-0.1884 a	-0.1260 a	-0.1081 b
D C	Ψ_{DC}	0.0276	0.0121	0.0150	0.0049	0.0026
InB V	ρ_{BV}	0.0892 c	0.0862 r	0.0872 r		
InB A	ρ_{BA}	-0.1135 c	-0.1214 c	-0.1336 b		
InB D	ρ_{BD}	0.0646	0.0421	0.0580		
InB C	ρ_{BC}	-0.1294 c	-0.1459 c	-0.1245 c		
InK V	ρ_{KV}	0.0393	0.0416	0.0423		
InK A	ρ_{KA}	0.0591 c	0.0555 c	0.0488		
InK D	ρ_{KD}	-0.0386	-0.0234	-0.0377		
InK C	ρ_{KC}	-0.1557 b	-0.1593 b	-0.1405 b		
InL V	ρ_{LV}	-0.0001	-0.0005	0.0003		
InL A	ρ_{LA}	-0.0199 c	-0.0192 c	-0.0180 c		
InL D	ρ_{LD}	-0.0468 c	-0.0540 b	-0.0531 c		
InL C	ρ_{LC}	0.0055	0.0093	0.0085		
InH V	ρ_{HV}	0.0032	0.0028	0.0033		
InH A	ρ_{HA}	-0.0240 c	-0.0238 c	-0.0225 c		
InH D	ρ_{HD}	0.0195	0.0316	0.0283		
InH C	ρ_{HC}	-0.0134	-0.0119	-0.0078		
InS V	ρ_{SV}	-0.1401 a	-0.1378 a	-0.1394 a		
InS A	ρ_{SA}	0.1419 a	0.1453 a	0.1535 a		
InS D	ρ_{SD}	-0.1093	-0.1033	-0.1073		
InS C	ρ_{SC}	0.0423	0.0303	0.0335		
InF V	ρ_{FV}	0.0124 b	0.0121 b	0.0127 a		
InF A	ρ_{FA}	0.0076 c	0.0079 c	0.0091 c		
InF D	ρ_{FD}	0.0165 b	0.0162 b	0.0161 b		
InF C	ρ_{FC}	0.0007	0.0001	0.0005		
Z2	δ_{Z2}	0.3126 a	0.3131 a	0.3120 a	0.2987 a	0.2890 a
Z3	δ_{Z3}	0.7471 a	0.7492 a	0.7465 a	0.7318 a	0.7189 a
D1	δ_{D1}	-0.0198 c	-0.0201 c	-0.0197	-0.0235 c	-0.0306 b

(a) significant at $|t| > 2.57$; (b) significant at $|t| > 1.96$; (c) significant at $|t| > 1.28$; (d) evaluated as a residual.

Table 2. Goodness of fit of the estimated models.

Model Specifications	Model I	Model I-a	Model I-b	Model I-c	Model I-d
Adjusted R ²	0.975	0.975	0.975	0.974	0.972
Percent of sign. variables	0.46	0.45	0.48	0.46	0.50
No. of Restrictions		2	3	4	2
Log of Likelihood value	213.0	212.7	212.1	196.8	181.5
-2 (L _R -L _U)		0.6	1.8	32.4	63.0

The production function is strictly quasi-concave if the bordered Hessian matrix F is negative definite. Strict quasi-concavity is a sufficient condition for the production function to have convex isoquants. The conditions for strictly convex isoquants are satisfied when the bordered Hessian matrix is negative definite. The determinants of the matrices along the leading principle diagonal are calculated as described by Burgess (1974)⁹. The determinants of the matrices along the principle diagonal alternate in sign. It can be concluded that the estimated translog function satisfies the requirements for strict convexity of the isoquants.

Table 3. Partial output elasticity and returns to scale

	Model I	Model I-a	Model I-b	Model I-c	Model I-d
Model specifications					
ϵ_B	0.8268 (0.111)	0.8270 (0.107)	0.8221 (0.109)	0.9051 (0.079)	0.8666 [0.031]
ϵ_K	0.0722 (0.057)	0.0711 (0.056)	0.0615 (0.050)	0.0186 (0.065)	0.0102 [0.022]
ϵ_L	0.0170 (0.014)	0.0172 (0.014)	0.0184 (0.015)	0.0054 (0.018)	-0.0004 [0.007]
ϵ_H	0.0262 (0.020)	0.0263 (0.020)	0.0267 (0.020)	-0.0008 (0.031)	0.0001 [0.008]
ϵ_S	0.0700 (0.050)	0.0606 (0.049)	0.0589 (0.049)	0.0486 (0.089)	0.0577 [0.025]
ϵ_F	0.0154 (0.007)	0.0173 (0.007)	0.0136 (0.008)	0.0155 (0.004)	0.0067 [0.002]
Scale elasticity	1.0277 (0.167)	1.019 (0.047)	1.0012 (0.043)	0.9924 (0.034)	0.9409 [0.095]
Effects of technological components					
τ_V	0.0322 (0.078)	0.0315 (0.075)	0.0324 (0.078)	0.0268 (0.023)	0.0249 (0.017)
τ_A	0.0558 (0.071)	0.0544 (0.074)	0.0548 (0.075)	0.0609 (0.039)	0.0657 (0.034)
τ_D	0.0588 (0.111)	0.0613 (0.105)	0.0570 (0.108)	0.0087 (0.014)	0.0064 (0.009)
τ_C	0.1011 (0.097)	0.1003 (0.101)	0.0980 (0.096)	0.0710 (0.063)	0.0688 (0.054)
Entire Package	0.2478 (0.160)	0.2475 (0.161)	0.2422 (0.163)	0.1674 (0.058)	0.1657 (0.056)

Standard deviations and standard error of estimate are in round parentheses and square parentheses, respectively.

To investigate the question of whether the parameters of the production function governed by new technology are different from the parameters generated by old production practices, a test was done to show whether the structural change was caused by a shift in the intercept, a shift in slope parameters, or both. Thus, the additional parameters representing these shifts were tested. The null hypothesis,

⁹ For proof see Boisvert (1982) p. 7.

is: $\beta_m = 0$, and $\psi_{mk} = 0 \forall m, k$, for the shift in intercept, where the null hypothesis for slope shift is: $\rho_{im} = 0 \forall i, m$. The results of parameter estimates shown in Table 1 indicate that the coefficients which represent the shift in intercept are significant. For the slope shift, out of 24 coefficients (ρ_{im}) there are 11 statistically significant coefficients. Therefore, we reject the null hypothesis that the parameters of production function governed by old technology are the same as those governed by new technology.

The positive value of the new seed varieties, early planting, and chemical coefficients supports the hypothesis that there are neutral shifts in the production function. For example, the coefficient (β_v) on the intercept is positive and statistically significant, meaning there is a neutral upward shift in the production function brought on by adopting new seed varieties. Coefficients of the new seed varieties associated with input seed and fertilizer (ρ_{sv} and ρ_{fv}) are statistically significant, suggesting a non-neutral difference between the old and new varieties. Furthermore, a parameter representing the interaction between new varieties and machinery is positive (ψ_{vd}), indicating that planting the new varieties with machinery is more effective than new varieties and machinery individually. The positive sign implies an upward parallel shift in the production function if these two components are adopted simultaneously.

Results indicate that herbicide application has a structural break, causing a non-neutral shift by decreasing the output elasticity of land, capital, and family labor. The parameters of early planting associated with the input variables, land, family labor, hired labor, seed, and fertilizers, are statistically significant, suggesting a non-neutral technological difference between the two practices. The results indicate that early planting causes a non-neutral shift by decreasing the output elasticity of land, family labor, and hired labor, and increasing the output elasticity of seed and fertilizer.

The parameters of drill machinery with family labor and fertilizer (ρ_{ld} and ρ_{fd}) are statistically significant, suggesting a non-neutral difference between the farms adopting machinery and farms performing the seeding operation by broadcasting. Machinery increases the production elasticity of fertilizer and decreases the production elasticity of family labor.

The individual effects of technological components for Model I and its variants are displayed in Table 3. New varieties increased the total output of barley by 3.2%. Early planting increased total barley production by 5.5%. This can be explained by the fact that *afeer*¹⁰ farmers are in general not as risk-averse as *saky* farmers. They start sowing regardless of the rainfall, and the benefits from soil moisture are higher for seed planted early than for seed planted late. With late planting, farmers need to cultivate the soil again to cover the seed, and a significant reduction of soil moisture occurs. On the other hand, using drills for planting increases barley production by 5.7% because of the uniform density of plant per unit area. Broadcasting seed by hand is usually done by a skilled laborer to get

¹⁰ Arabic term meaning early planting regardless of the first rainfall; on the other hand, *saky* means waiting for the first rainfall to get rid of weeds and to be sure there is enough moisture in the soil. However, with *saky* the chance is more than 80% that the agricultural season will not be a dry one.

acceptable plant density in the field. Herbicide application increased output by 9.8%. As shown in Table 3, the effect of technological components on output remains approximately the same under the assumption of non-neutral technological change specifications.

The technological package is designed to exploit interaction among components, e.g., yield increases from the adoption of a new variety may be further improved by using appropriate levels of plant density, which can be achieved by using a seed drill. Nevertheless, many farmers adopt parts of the package in a sequential fashion rather than the whole package. The effects of adopting 1, 2, and 3 components, and the entire package are shown in Table 4. This shows the negative synergy effect of technological components. As expected, the individual effect of components varies with the use of other items. This emphasizes the existence of both positive and negative interactions between package components and technological components which can substitute or complement each other. As an illustration, let us consider the two components adopted in rainfall Zone 1, new varieties and machinery. The adoption of machinery without adoption of other items of the package increased output by 5.9% compared with traditional technology, whereas the adoption of new varieties alone increased output by 4.1%. Adopting new varieties with machinery will increase the output by only 7.9% instead of 10%, the sum effect of the two components. If the farmer decides to adopt additional components such as early planting, output increases by 14.7% instead of 16.9%. If the farmer decides to adopt herbicides instead of hand weeding, an increase in total output of 24.2% can be expected instead of 26%. The difference between the realized increase and the theoretical increase is due to the negative interactions between the technological components.

Where many farmers adopt parts rather than the entire package, in a sequential fashion, results in Table 4 indicate that output did not rise as the number of components utilized by farmers increased. The application of the entire package did not yield the expected increase in barley production. The effect of the components varied with agro-climatical zone. Barley production increased by 31% and 74% for farms located in Zones 2 and 3, respectively, compared to Zone 1. As expected, the individual effect of components varied with the adoption of other components.

The theory of functional income distribution categorizes factor inputs according to their share of total income. This division is oriented from the marginal productivity approach, where each factor is rewarded according to its marginal product. Therefore, discussion based on the acceptance of the marginal productivity theory is a guide to income distribution. Farmers own or control various quantities of primary factors, which are mainly land, labor, and capital. These factors allocate income and determine the distribution of individual income. As noted earlier, output elasticity is identical to factor share in a linear homogeneous function. The results of output elasticities shown in Table 3 indicate that output elasticities for each factor of production are positive. These estimates seem to be reasonable in the sense that output elasticity for each input has the postulated sign and low standard error. The output elasticity of land is greater than output elasticities of other factors. This result is consistent with results in less developed countries. Kawagoe and Hayami (1985) point out that the factor share is higher for land and lower for new inputs such as fertilizer and machinery.

Table 4. Percentage increase in barley production as a result of sequential adoption of technological package.

Adoption Level	Technology	Zone I	Zone II	Zone III
No component	Traditional	0.0	31.2	74.7
One component	V	4.1	35.3	78.8
	A	6.9	38.1	81.6
	D	5.9	37.1	80.6
	C	9.1	40.3	83.8
Two components	V, A	10.3	41.5	85.0
	V, D	7.9	39.1	82.6
	V, C	16.8	48.0	91.5
	A, D	8.1	39.3	82.8
	A, C	14.3	45.5	89.0
	D, C	16.9	48.1	91.6
Three components	V, A, D	14.7	45.9	89.4
	V, A, C	16.5	47.7	91.2
	V, D, C	22.4	53.6	97.1
	A, D, C	15.8	47.0	90.5
Entire package	V, A, D, C	24.2	55.4	98.9

V = new varieties; A = early planting; D = drill machine; C = chemical herbicides.

The results in Table 3 indicate the rising relative importance of fertilizer, seed, and other capital services in increasing output under new practices compared to traditional production practices, whereas family and hired labor seem to have lost their relative importance under the new practice. Purchased inputs, fertilizer, new varieties, and other capital services, are more important in generating output, and have a major implication in promoting growth.

Labor elasticities are very low compared to other elasticities. The results are not surprising, because farmers utilize family labor very intensively. In addition to this, the interviewed farmers might have overestimated their own and their family labor inputs. These results are consistent with the conclusions of Kawagoe and Hayami (1985), showing that labor elasticity is very low in developing countries. A less effective use of family labor in large as opposed to small farms is reasonable. On the other hand, the partial output elasticity of hired labor shows a steady increase from small farms to large. One reason for this could be the effective use of hired labor in large as opposed to small farms. As indicated by Snober and Arabiat (1984), farmers cannot depend on family members to perform necessary agricultural operations, because family members have been increasingly looking for jobs outside the agricultural sector. Moreover, a diminished dependence on family members has created labor shortages in the peak season and higher costs for hired labor. Therefore, the introduction of new technology has solved the problem of labor shortage. Socioeconomic changes in the agricultural sector show that farmers, particularly full-time farmers, accept the new technology as a substitute for farm labor. Fertilizers represent one of the important factors in barley production. Their importance is dependent not only on the amount used but also on the amount and distribution of rainfall, soil fertility, and the dominant crop rotation.

Conclusions

The recent agricultural transformation in Jordan's rainfed areas, which is the result of the spread of new cereal production technologies, has generated new hope for agricultural development. The estimated scale elasticity is approximately equal to one for all non-neutral technological change translog specifications. Generally, this indicates that the resources used for cereal production by an average farmer are fully utilized. The output elasticity of land is greater than output elasticities of other factors, e.g., the production elasticity of land is 0.82, indicating that land is scarce and is a limiting factor for increasing output.

The results show that the adoption of new varieties, machinery, the practice of early planting, and herbicide application, lead to a non-neutral shift in the barley production function which is equivalent to 3.2, 5.7, 5.4, and 9.8%, respectively, as an increase in total output. New varieties were found to be worse than old varieties when using high levels of fertilizer. This result indicates that the technological package accounts for 24.2% of the total change between farms employing traditional technologies and farms employing new technologies. This result also indicates that as output does not rise with an increase in the number of components utilized, the application of the entire package does not yield the expected increase. As expected, therefore, the most efficient solution for Jordan seems to be an increase in the adoption rate of new technologies. However, as total arable land is likely to decline in the future, an increase in labor will have only limited effects on total production and on increasing the adoption rate of new technologies, especially chemical and biological technology, which have the greatest potential for increasing production.

There are important implications from this study for the optimal policy to increase barley production. This is illustrated by increasing input subsidies. An increase in the output price will obviously benefit all producers, but farmers who own large tracts will benefit more than those with small farms. Therefore, the cost of the policy will be high. On the contrary, a subsidy for new inputs will benefit only those farmers who use a new technique. Hence, the cost of input subsidies is not high, and is limited to the recommended technological package. In other words, the policy may be designed to reward only those who respond to the government's signal to use new technologies.

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Discussion

N. Chaherli: On what grounds was the CRS specification chosen? The input level used is based on a particular price environment. How can you check your results on other price vectors?

E. Al-Karableih: Four models were tested—homothetic, linear homogeneous hicks, neutral, and Cobb-Douglas. The linear homogeneous was the best (CRS). If we had data on prices, we would have estimated cost functions and not production functions. More literature is available on cost functions.

The Impact of Government Subsidy Policy on Barley Production In Jordan: the Policy Analysis Approach

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Abstract

The main objective of this study was to measure the impact of government subsidy policies on the production of dryland barley in Jordan. The cost of production and of the total subsidy for locally produced and imported barley was estimated from primary and secondary data. Primary data were collected in interviews with 120 farmers. The policy analysis matrix (PAM), which depends on enterprise budgets, was used to estimate economic protection.

The subsidy for imported barley was estimated to be JD 0.90/t in 1993. For locally produced barley the subsidy was JD 40/t. However, the estimated value of the subsidy for barley producers was JD 17.6/t.

Because the domestic resource coefficient was less than one, the results of the study indicate that Jordan has a comparative advantage in producing dryland traditional barley and barley using new technology. A protection of 14 and 20% exists for traditional barley and for barley using new technology, respectively. The results indicate that the government provides a subsidy for DAP. This subsidy amounts to JD 0.458/t and JD 0.846/t for traditional barley and for barley using new technology, respectively. A subsidy on domestic resources was indicated, amounting to JD 0.917/t and JD0.897/t for traditional barley and for barley using new technology, respectively. Price policy had no effect on the use of manual labor, land rent, seed, and machinery operations.

Introduction

Barley is considered a strategic agricultural crops in Jordan due to its importance as livestock feed. The total consumption of barley in 1993 was 583,400 tons. Local barley production was 44,300 tons, about 8.2% of total consumption.

Despite its relative importance, the production and areas of barley have fluctuated. These fluctuations in production and planted areas are attributable to various factors, the most important of which is rainfall.

The average area of barley for 1980–1993 was 12,100 dunums, or 2.6% of the area. This was due, in part, to barley subsidies, which led to an expansion of the area planted to barley at the expense of rangeland.

Annual average production of barley for the period was 34,700 tons, with an annual increase of 2,500 tons.

The average barley yield was 76 kg/dunum for 1980–1993. Average yield increased by 4.1 kg/dunum or 5.7%. The average value of imported barley for the period 1980–1986 was JD 3.1 million. This value increased to JD 17.1 million for the period 1987–1993. Self-sufficiency in barley was only 40.7% for the period 1980–1994.

The main problems of dryland barley production in Jordan are variations in production, area planted, and yield.

Barley is a strategic crop with an important role in livestock diets. In the period 1988–1993, mean annual production of barley was 48,000 tons. Annual consumption was 314,000 tons, with the government importing 266,000 tons. The total annual subsidies for imported and locally produced barley were about JD 3.3 million and JD 653,000, respectively. Despite government subsidies for barley producers, local production of barley is variable, with very low yields and limited areas planted.

Objectives

The main objective of this study was to examine the impact of government policy on dryland barley production in Jordan. The specific objectives were:

- Preparation of enterprise budgets for barley (estimating return and cost using market and world prices).
- Estimation of the cost of subsidies on locally produced and imported barley.
- Computing various measures of economic protection.

Methodology

Primary and secondary data were used. Primary data were collected in interviews with 120 farmers in the various barley production areas in Jordan using a structured questionnaire. The sample size was calculated using the following formula:

$$n = \frac{P(1-p)(Z^2)}{e^2}$$

where n =sample size; p =sample proportion that will occur; $1-p$ =sample proportion that will not occur; Z =standardized value with 92% confidence interval; and e =error term of 8%.

A descriptive economic analysis was used together with measures of economic protection and policy analysis matrix. Based on the policy analysis matrix (Monke 1989) in Table 1, the measures of economic protection were defined, computed, and used in the analysis.

Table 1. Policy analysis matrix.

	Revenues	Costs		Profits
		Tradable inputs	Domestic factors	
Private prices	A	B	C	D
Social prices	E	F	G	H
Policy effects	I	J	K	L

A = total revenues in private prices (market prevailing prices, sometimes called financial prices). B = costs of tradable inputs (e.g. fertilizers, seeds, etc.) in private prices; C = costs of domestic factors (e.g. labor, capital, etc.) in private prices; D = private profit; E = total revenues in social prices (prices which are adjusted to government interventions); F = costs of tradable inputs (e.g. fertilizers, seeds, etc.) in social prices.

Private profits (D) $D = A - B - C$; Social profits (H) $H = E - F - G$; Output transfers (I) $I = A - E$; Input transfers (J) $J = B - F$; Factor transfers (K) $K = C - G$; transfers (L) $L = D - H$

Source: Monke, E.A. and Scott R. Pearson. 1989. Policy Analysis Matrix for Agricultural Development, Cornell University Press, Ithaca and London,.

Measures of Economic Analysis

1. Private Cost Ratio (PCR) = $C/(A-B)$

2. Domestic Resource Cost Ratio (DRC) = $G/(E-F)$

3. Nominal Protection Coefficient (NPC):

a. for tradable outputs (NPCo) = A/E

b. for tradable inputs (NPCi) = B/F

4. The Effective Protection Coefficient (EPC) = $(A-B)/(E-F)$

5. Profitability Coefficient (PC) = $(A-B-C)/(E-F-G) = D/H$

6. Subsidy Ratio to Producers (SRP) = $L/E = (D-H)/E$

7. Nominal Protection Rate (NPR):

$$\text{NPR} = \frac{(\text{Commodity farm gate price} - \text{commodity border price})}{\text{Border price of commodity}} * 100$$

Review of Literature

El-Habbab and Jabarin (1991a) studied the impact of government price policy on the production of wheat in the rainfed areas of Jordan using a policy analysis matrix and various measures of economic protection and comparative advantage. The results indicate that the nominal protection coefficient (NPCo) of wheat using traditional and modern methods was 1.01, indicating that the price received by farmers was 1% higher than world prices. The nominal protection coefficient for inputs (NPCi) for production inputs for both production techniques was 1.06, indicating an increase in the cost paid by farmers as fees of 6%.

The effective protection coefficient (EPC) was equal to 1, indicating that the final result of the price policy was almost 0. The study also indicated that there is a comparative advantage to producing wheat.

The study by Salem (1994) on the impact of government policy on dryland wheat production in the Republic of Yemen showed that the subsidy policy was biased towards consumers rather than producers. Overvaluation of the exchange rate was an implicit tax on the farmer, and the consumer benefited more from the wheat subsidy. The total cost of the subsidy in 1993 was estimated at YR 8.1 billion for imported wheat, while the total cost of the subsidy for production inputs was YR 477 million, or about 6% of the subsidy on imported wheat. The study showed the comparative advantage for Yemen of producing dryland wheat. A comparison of the cost of imported wheat with local dryland wheat shows that the benefit from local production was YR 5.94/kg using the exchange rate in the parallel market, and a loss of YR 1.92/kg using the official exchange rate.

Using various measures of economic protection, it was found that there is some protection for the output using the official exchange rate, but none using the exchange rate in the parallel market. The study indicated that the subsidy for tradable inputs and domestic factors for dryland wheat was YR 3098/t, or about 4.7% of the subsidy cost of imported wheat in 1992. There was a tax of YR 416/t on machinery, which did not encourage the introduction of agricultural machinery because of its high price and the very high prices of spare parts.

Analysis and Results

Two types of enterprise budgets for barley were used in the analysis: private budgets, using prevailing market prices, and social budgets, using the social prices of inputs and outputs.

The policy analysis matrix was used to measure the impact of government policy on the profitability of agricultural systems and resource use efficiency, which is measured by social efficiency. Inefficiency, however, is measured by private profitability. As long as market prices diverge from social prices, inefficiency exists as a result of the particular agricultural policies adopted.

Several measures of economic protection were used to judge the impact of agricultural price policy on production, cost of agricultural inputs, cost of domestic resources, and net returns to farmers, in addition to the subsidy given to consumers. The value of the government subsidy of imported barley amounted to JD 3.3 million annually.

The value of subsidies for imported and locally produced barley for the period 1985-1993 is shown in Tables 2 and 3. In 1993 the subsidies for imported barley, locally produced barley and for barley producers were estimated to be JD0.9, 40 and JD17.6, respectively.

The analysis was based on the enterprise budget for dryland barley on the basis of one dunum and one ton and on PAM (Table 4) to compute the measures of economic protection and comparative advantage.

Table 2. Barley imported 1980–1993 and the cost of the barley subsidy.

Year	Imported quantities (1000 t)	Cost (JD/t)	Selling price (JD/t)	Value of (JD) subsidy
1985	32.6	39.8	45	(-169.5)
1986	106.6	31.8	45	(-1407.1)
1987	113.9	31.7	45	(-1514.9)
1988	113	56.5	45	1299.5
1989	232.8	77.8	60	4143.8
1990	202.2	84.4	60	4928.8
1991	242.2	83.8	60	5764.4
1992	289.4	75.3	65	2980.8
1993	486.7	65.9	65	438

Source: Ministry of Supply (1993), Department of Statistics (1993).

Table 3. Purchase prices of local barley and the cost of the barley subsidy (1980–1993).

Year	Purchased quantities (1000 t)	Purchase price (JD/t)	Selling price (JD/t)	Cost of subsidy (1000 JD)
1985	2.9	74	45	84.1
1986	2.9	74	45	69.6
1987	12.8	74	45	350.9
1988	26.8	74	45	777.2
1989	0.5	82	60	11
1990	6.2	100	60	248
1991	9.1	105	60	409.5
1992	53.2	105	65	2128
1993	8.6	105	65	344

Source: Ministry of Supply (1993).

Traditional Barley

Table 4a shows the results of the measures of economic protection for dryland barley. Using a private cost ratio (PCR) of 63%, the results indicated that the costs or the money invested were less than the achieved added value. However, the domestic resource coefficient (DRC) was 0.80, indicating that the economy provides hard currency for local production in addition to efficiency and international competitiveness. This ratio also measures the comparative advantage in producing crops, and indicates that Jordan has a comparative advantage in producing traditional barley.

Table 4. The policy analysis matrix for dryland barley in Jordan (1995).

a. Traditional barley.

Item	Return		Cost (JD/t)	Profit (JD/t)
	Tradable input (JD/t)	Domestic resource (JD/t)		
Private prices	126.82	32.91	59.44	34.47
Social prices	110.83	33.37	60.36	17.11
Policy impact	15.99	(0.46)*	-0.92	17.36

b. Barley production using new technology.

Item	Return		Cost (JD/t)	Profit (JD/t)
	Tradable input (JD/t)	Domestic resource (JD/t)		
Private prices	142.84	54.12	54.73	31.31
Social prices	121.85	54.57	58.33	8.96
Policy impact	20.99	(0.45)*	-0.9	22.35

Figures in parenthesis are negative values.

The nominal protection coefficient for tradable outputs was 1.14, indicating that current agricultural policy allows the domestic price to be 14% greater than the international price. This indicates protection of traditional barley. The effect of divergence is entirely the result of distorting policy, not market failure. The nominal protection coefficient for tradable inputs of 0.99 indicates that the costs of these inputs are close to world prices and that there is only a very slight decrease in the costs paid by the producer as a result of the government subsidy. The effective protection coefficient of 1.21 indicates a positive effect of government subsidy to farmers. The profitability coefficient of 2 indicates that barley production using traditional methods is profitable and competitive.

The subsidy ratio to producers (SRP) indicates that distorting policies have increased the gross returns of the system by 15.7%. The nominal protection rate (NPR) showed that there was a protection of 19.3% on traditional barley. As far as tradable inputs are concerned, the difference between local prices and world prices is the result of distorting policies. The government provides a subsidy on DAP. This subsidy amounts to JD 0.458/t, 18.6% of the export parity price, 1.37% of economic price.

Local prices did not diverge from world prices for labor, land rent, seed, and machinery operations, indicating no effect of the price policy.

The government provides subsidies on domestic resources, amounting to JD 0.917/t, 1.45% of the economic price of domestic resources owing to the effect of price policy on capital costs only.

Barley Technology

The private cost ratio of 0.65 (Table 4b) indicates that the value added was higher than the investment cost. The domestic resource coefficient of 0.90 indicates a comparative advantage in producing barley using new technology, which translates into more efficient use of domestic resources.

The nominal protection coefficient for tradable outputs was 1.2, suggesting that protection for barley production using new technology occurs and that agricultural policy allows the local price to be 20% higher than the international price. The nominal protection coefficient for tradable inputs of 0.99 indicates that the effect of government policy on the cost of these inputs is almost zero.

The effective protection coefficient of 1.32 indicates the positive effect of government subsidy to farmers. The subsidy ratio to producers indicates that distorting policies have increased the gross returns of the system by 18.3%. The nominal protection rate of 25% indicates that there was a protection of 25% on barley using new technology.

Table 5. Economic protection coefficients and the comparative advantage coefficient for dryland barley in Jordan, 1995.

	Coefficient	
	Traditional	With new technology
Private cost ration (PCR)	0.633	0.647
Domestic resource cost (DRC)	0.779	0.867
Nominal protection coefficient (NPC)		
a. for tradable outputs (NPCo)	1.144	1.172
b. for tradable inputs (NPCi)	0.986	0.992
Effective protection coefficient (EPC)	1.212	1.319
Profitability coefficient (PC)	2.015	3.492
Subsidy ratio to producer (SRP)	15.671	18.333
Nominal protection rate (NPR)	19.277	25

The government levies taxes on urea and herbicides: JD 0.153/t, and JD 248/t for barley grown with new technology. The government also subsidizes DAP with JD 0.846/t. There was no divergence of local prices from world prices for labor, land rent, seed, and machinery, indicating no effect of the price policy. The government provides a subsidy on domestic resources of JD 0.897/t, 1.54% of the economic price of domestic resources because of the effect of price policy on capital costs only.

Conclusions

- Domestic resources are efficiently allocated in barley production. Consequently there is a comparative advantage in producing dryland barley either traditionally or using new technology.
- There is a protection of 14% and 20% for barley produced traditionally and using new technology, respectively.

- There was a decline of less than 1% in the costs paid by farmers as a result of the subsidy policy.
- Profitability and competitiveness were higher without the agricultural policy for barley grown both traditionally and with new technology.
- The subsidy ratio to producers indicates that there is a subsidy of 15.5% and 18.7% for barley grown traditionally and with new technology, respectively.
- The effective protection coefficient indicates a positive effect of the government subsidy to farmers.
- The government subsidy on DAP is JD 0.458/t and JD 0.846/t for barley grown traditionally and with new technology, respectively.
- The government provides a subsidy on domestic resources of JD 0.917/t and JD 0.897/t for barley grown traditionally and with new technology, respectively.
- There is no effect of price policy on labor, rent, seed, or machinery.

Recommendations

- Dryland barley should be grown in its production areas because it is economically feasible, and Jordan has a comparative advantage in producing it by both traditional and new methods.
- Efforts should be made to increase the productivity of barley because it has not yet reached its horizontal and vertical potential.
- In this respect, the emphasis should be placed on applied research on dryland barley.
- The government subsidy should be gradually eliminated, because the government cannot afford it.
- Private and cooperative sectors coupled with a reduction of government intervention, especially in the supply of inputs, should be encouraged.

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Discussion

S. Christiansen: I thought you were comparing barley subsidization versus barley production without government support for both traditional and improved barley production technology. You conclude that both traditional and improved barley production technology would be subsidized. What am I missing here?

A. Jabbarin: Both production systems are currently subsidized. The subsidy is in the form of price output. Domestic prices of barley produced under both systems are the same. The comparison was between the market price and the international price. We did not compare barley subsidization versus barley production with and without government support.

B. Al-Rawi: What are the implications of cereal prices when or if Jordan or Syria or Iraq join the General Agreement on Trade and Tariffs? What will happen to our cereal commodities if the Western nations raise the price of machinery, equipment, herbicides, or insecticides?

A. Jabbarin: If we consider freeing regional trade, an increase in world cereal prices would encourage more bilateral trade. As far as I know Syria has a comparative advantage in producing barley, and so Syria can efficiently produce and export barley to neighboring countries. The prices of chemicals are not expected to rise because it is not subsidized in producing countries.

M. Tahir: While calculating subsidies, did you consider and add the transportation and handling costs of buying barley from abroad? Furthermore, the net profit from traditional and new technology is more or less the same in your study. Was there an increase in total production with new technology? This is the most important aspect and needs to be reflected in your studies, because the farmer may not get greater benefit but the country will benefit with increased production.

A. Jabbarin: Social prices of tradable inputs and outputs were adjusted for all distortions. Regarding your second question, yes, there was an increase in improved barley production.

A. Khniefs: What about the impact of PAM on livestock production.

A. Jabbarin: It is important to consider livestock in the PAM analysis. Livestock enterprise are complicated and need special care when conducting PAM, but I think that it can be done.

Daily and Seasonal Labor Allocation In Bedouin Farming Systems of Northern Syria

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Abstract

Differences in labor constraints, financial incentives, and income control may lead to different evaluations of innovations and technologies by women and men, influencing interest and adoption. This study identifies the roles of male and female family members in labor processes at the family, household, and farm levels. The identification of gender roles in small ruminant production and management in three defined Bedouin farming systems can help extension and research institutions to address the appropriate household members involved in decision making and carrying out activities, and to make them more sensitive to gender in their work.

The three systems differed in flock size, cultivated area, off-farm income, and the extent to which they were sedentary. The off-farm activities of male family members and their temporary absence from the farm increase the workload and responsibilities of female family members. In all three systems, women are responsible for milking and milk processing, and for feeding the flock. This should be considered by research and extension personnel when introducing new methods to improve flock management.

Introduction

Problem Statement

Fifty-five percent of Syria receives less than 200 mm annual rainfall. This area is the base for the two thirds of Syria's 14 million sheep (FAO 1990). The quality of the natural range vegetation has declined in the past decades. Among the factors contributing to this is the increased level of mechanization, which allows the cultivation of barley in the rangeland and improved mobility. With tractors and trucks, flocks can be transported easily and moved to remote areas of the range that still provide grazing. The total number of sheep has also increased, leading to overgrazing. The absence of effective control of grazing or barley cultivation in the rangelands and the increased demand for firewood has led to the destruction of the vegetation cover and degradation and soil erosion.

In 1991 research was initiated to analyze Bedouin farming systems in the marginal zones (ICARDA/Hohenheim 1989). During the first round of interviews the important contribution of women and children to the farm and household system became obvious (Wachholtz 1995).

Experience in other developing countries shows that, because of labor constraints, financial incentives and income control, women and men have different perceptions of problems. If research and extension services are sensitive to the existence of gender-specific responsibilities in farm households, they can more effectively target their activities (Berger 1984; Ellis 1988; Evans 1988; Loudon 1986). Because of long-held traditions, it is important to obtain information not only from the male head of household, but also from female family members, to obtain a more complete picture of the farm and household (Feldstein and Poats 1993; Tully 1990).

Data Collection and Study Area

A study area was selected starting about 40 km southeast of Aleppo and extending a further 100 km into the rangelands. Precipitation in this area varies from 275 mm in the northeast to 100 mm in the southwest (Wachholtz et al. 1993). Households were a random sub-sample of a larger survey of Bedouin farming systems by Wachholtz (1993 1995). The data were collected using a standardized questionnaire, with the assistance of a female Syrian translator, in single interviews with female heads of households.

Characteristics of Farming Systems

The 74 sampled households were divided into three farming systems according to differences in resources and lifestyles (Table 1).

Table 1. Mean characteristics (SD) of the three farming systems.

	Sedentary system	Semi-sedentary system	Migratory system
Cultivable land (ha)	27.3 (25.5)	116 (112.9)	no land
Mean flock size	59.5 (96.8)	188.9 (202.1)	160.4 (138.8)
Off-farm income [†] (as % of total income)	65.4	1.5	8.7
Migration			
Days/year	138	157	180
Percentage of families	71	90	100

[†] Source: Wachholtz 1995.

Sedentary mixed farming system (n=34) with small flocks, little cultivable land and high dependence on off-farm income.

Semi-sedentary Bedouin system (n=20) with large flocks, a large area of cultivable land and very little off-farm income.

Migratory Bedouin system (n=20) with no cultivation of crops, no houses, living in tents all year, large flocks and little off-farm income.

Labor Division In the Yearly Cycle

Information is needed on labor allocation to main activities in the daily and yearly cycle to assess the implications of changes in the farming systems on time constraints, incentives, and income control among household members.

Yearly Cycle of Activity In the Three Farming Systems

Table 2 shows the yearly calendars of the three farming systems for the main activities carried out by males and females in each age group, as reported by at least two thirds of the households in 1991/92.

Seventy one percent of the sampled families in the sedentary system and 90% in the semi-sedentary system move with their flocks. Among the 29% of families in the sedentary system that stay in their villages, 80% had small flocks of less than 20 sheep and found sufficient feed in the area of the village. In the semi-sedentary system, the 10% of families that did not migrate hired shepherds to take their flocks on migration.

In the sedentary system, most off-farm activities—harvesting cotton, maize, vegetables, and olives—were carried out in June, July, and October. Families in the semi-sedentary system moved mainly in the rangeland and spent less time in high rainfall areas, which limited the opportunities for off-farm income.

By the end of October, families in the sedentary and semi-sedentary systems return to their villages to sow barley and wheat. Supplementary feeding of the flocks starts in late October because the range vegetation does not produce enough feed. Since the families in the migratory system have no cropping, the grazing period is extended a month in the cropping areas. In the sedentary and semi-sedentary systems, shepherding and grazing only happen during the migratory period, unlike the migratory system, where the sheep graze year round. From December to March, Bedouins use the term “taking the sheep out for a walk,” because exercise is considered a healthy for the animals. Shepherding generally is the work of boys.

Sheep manure is collected by females in the feeding areas for fuel or, in the sedentary system, sold as fertilizer for irrigated areas.

Milking starts in February and lasts until the end of July in the sedentary and the semi-sedentary systems. In the migratory system, milking begins one month later, as lambs are allowed to take more of the milk. Milking and milk processing are done by women and girls. In the sedentary system, 55% of cereals are hand-harvested by the women and girls, and the threshing is done by the whole household. Women and girls collect straw from the combine-harvested areas for later use as fodder. In the semi-sedentary system most of the cereal is combine-harvested. Straw is not collected, but rather grazed on the spot. After harvest, the families of the sedentary and the semi-sedentary systems start moving again with their flocks.

Table 2. Labor allocation among tasks by gender, age, and month as reported by women of three Bedouin farming systems in northwest Syria (Oct. 1991–Sept. 1992).

Activity	Permanent system	Transitional system	Pastoral system
	ONDJFMAMJJAS	ONDJFMAMJJAS	ONDJFMAMJJAS
Moving time	HH HHHHH	HH HHHH	HHH HHHHH
Off-farm work	HH HHHH .		
Sheep production			
Hand feeding	. FFFFFFF	FFFFFFFFF	FFFFFFFFF
Manure collection	. FFFFF	. FFFFF	. FF
Shepherding	b b b b b b b	b b b b b b b b	b b b b b b b b b b b
Lambing	. HHHH	. HHHHH	. . HHHHH
Milking	 FFFFFFF . .	 FFFFFFF . .	 FFFFF . .
Shearing	 M M	 M M	 M M
Cereal production			
Sowing	. m m	. m m	
Harvest (machine)	 m m	 m m	
Harvest (hand)	 F F		
Threshing	 H H		
Straw collection	 F F		
Household			
Cooking	FFFFFFFFFFFFFFF	FFFFFFFFFFFFFFF	FFFFFFFFFFFFFFF
Bread baking		FFFFFFFFFFFFFFF	FFFFFFFFFFFFFFF
Cleaning	FFFFFFFFFFFFFFF	FFFFFFFFFFFFFFF	FFFFFFFFFFFFFFF
Child care	FFFFFFFFFFFFFFF	FFFFFFFFFFFFFFF	FFFFFFFFFFFFFFF
Firewood collection		FFFF	FFFFFFFFFF
House/tent repair	 W W	 W W	. W W

H = all males and females in a household; M = males (men below age 50 and boys above age 13); F = females (women below age 50 and girls above age 7); m = men only (below age 50); w = women only (below age 50); b = boys only (above age 13)

Source: Adapted from Pape (1994).

Household activities, such as cooking, cleaning and child care, are time-consuming daily tasks, done without the benefit of electricity or modern conveniences. In the sedentary system during the migration period in the higher rainfall areas, dry cotton stalks are collected by women and girls for use as fuel in winter. In the semi-sedentary system women and girls uproot and collect shrubs in the rangeland for fuel from December until the end of February. In the migratory system shrub collection continues until June because, unlike the houses of the sedentary and semi-sedentary households, tents cannot be heated with diesel stoves in winter, so that the amount of shrubs needed for fuel is higher. In contrast to the sedentary system, where bread is bought in the market by most of the families, bread is baked daily by the women in the other two systems.

Off-farm Activities

In the sedentary system, 85% of families have additional income from off-farm activities. On average, 2.2 (standard deviation: 2) persons per household worked off-farm during the agricultural year of 1991/92. The duration of off-farm jobs ranges from two weeks to all year round. The period spent in off-farm work is longer for men than for other family members, with means of 27, 19, 13, and 12 weeks, for men, boys, women, and girls, respectively. Men and boys receive a higher income per hour than women or girls. Thus, the contribution of men and boys to the family cash income is more important than that of women and girls.

Seasonal Labor Constraints

May and June are labor-intensive months for farmers in the sedentary and semi-sedentary systems, because the barley and wheat harvest overlap with the main milking season. In addition, in the sedentary system, some members of most families are involved in off-farm activity in June. Labor requirements are also high, especially in the semi-sedentary and migratory systems, in March, April, and May, as the flocks are hand fed and milked, and milk is processed. All these periods are more demanding for women and girls than for men and boys.

Influence of Age and Gender on the Division of Labor

Women over 50 years old are not usually involved in feeding, milking, and milk processing if there are younger women in the household. Older women are mainly responsible for minding the small children while the younger women and girls do both farm work and housework. Until the age of seven, girls do little work, but between the ages of 7 and 13 they help in the household, and over 13 they help the women with the farm work as well. Boys start working later than girls when, at about 13, they begin to take responsibility for herding sheep.

Traditional Labor Division

The division of labor among family members does not depend on seasonal labor constraints or shortages, but is more influenced by traditional gender roles, according to which men carry out all mechanized activities on the farm and women

do the physical, labor-intensive work on the farm and in the household. Even though women and girls are fully occupied during the handfeeding and milking seasons with these tasks and household work, they rarely have support from any of the men and boys.

The influence of tradition can also be seen in the exclusion of women from the public market, where men are responsible for buying all household items and for marketing farm products (UNIFEM/UNDP 1992; UNU/WIDER 1990), and the restriction of women in traditional, rural societies to the compound and the extended family. In this study, women report that they went to the market about once a year, only to buy clothes and cloth.

A study by UNESCO (1985) on women in agriculture in other countries of the Middle East describes a similar situation. Boys start work much later than girls because girls are needed in the household at an early age. *Pastoral Women and Change in the Middle East* (UNIFEM/UNDP 1992) emphasizes the general lack of recognition of the contribution of women in agriculture in the region and, in particular, the underestimation of the role of young girls under 15 in on-farm and off-farm activities.

Gender Division of Labor

Because handfeeding, milking, and migratory periods are labor-intensive, they were selected to study the division of labor and the allocation of time.

Handfeeding period

The majority of women and girls in all three farming systems report handfeeding as their main activity in this period. In addition, women and girls carry out all household activities. Men and boys also report handfeeding as their main activity on 10% of the farms (Fig. 1a). The majority of men (60–90%) are not involved in agricultural activities during this period and have a lot of leisure time. They spend their time socializing and organizing food, water, and fodder supplies for both the flock and family. The main activity of boys during this period is shepherding.

During the handfeeding period of 5–7 months, women and girls spend 1–8 hours per day carrying out this activity (Table 3). Feeding times are longer in the semi-sedentary and migratory systems because the flocks are larger. Feeding times are influenced by the number of people helping with the feeding, the amount of grazing, feeding management, and the amount and mixture of feeds. The frequency of handfeeding per day was higher in systems with smaller flocks, although the total time spent on this activity was shorter than in the larger flocks.

Table 3. Labor requirements for feeding period in the three farming systems (means standard deviation).

Feeding season	Sedentary	Semi-sedentary	Migratory
Length of feeding season (months)	4.6 (SD=1.8)	5.8 (SD=2)	7.1 (SD=2.3)
Feeding time (minutes/day)	1		
Mean	24 (SD=58)	165 (SD=60)	252 (SD=100)
Median	100	150	240
Range	60-240	120-300	120-360
Feeding frequency per day	3.7 (SD=1.2)	3.5 (SD=0.7)	2.4 (SD=0.6)

Milking period

Women in all three systems are responsible for milking and milk processing and in more than 70% of households, girls help the women with these activities (Fig. 1b). In the semi-sedentary and migratory systems with larger flocks, men and boys also help with milking the sheep by dividing the flock into groups of about 20 sheep for the women to milk. The majority of men are not involved in any particular activity in this period, except in provisioning the flock and household, and marketing products. In about 10% of households in the sedentary and semi-sedentary systems, men are mainly occupied with the cereal harvest and off-farm activities during this period. In 20, 35, and 10% of households in the three farming systems, respectively, the main responsibility of boys is shepherding, but in about 50% of all households, boys have no responsibilities during this period.

The length of the milking season varies from 3 to 4 months. The time needed for milking and milk processing per day is not highly correlated with the number of ewes milked ($r=0.39$). The median of the total milking and milk processing time is three hours in the sedentary system and four hours in the semi-sedentary and migratory systems (Table 4).

Table 4. Labor requirements for milking and milk processing in the three farming systems (means standard deviation).

	Sedentary	Semi-sedentary	Migratory
Milking period (months)	3.5 (SD=1.1)	3.7 (SD=0.8)	3.8 (SD=1)
Total time (minutes/day)			
Mean	206 (SD=60)	270 (SD=90)	250 (SD=78)
Median	180	240	240
Range	120-360	120-420	120-420
Milking frequency per day	2	2	2

The relation between milking and processing time and flock size is influenced by the amount of milk sold unprocessed, the number of women in the household, and yield. In all households, the ewes are milked twice a day. Milking takes about one third of the total time. After milking, the milk is boiled and processed into yogurt, cheese, and ghee.

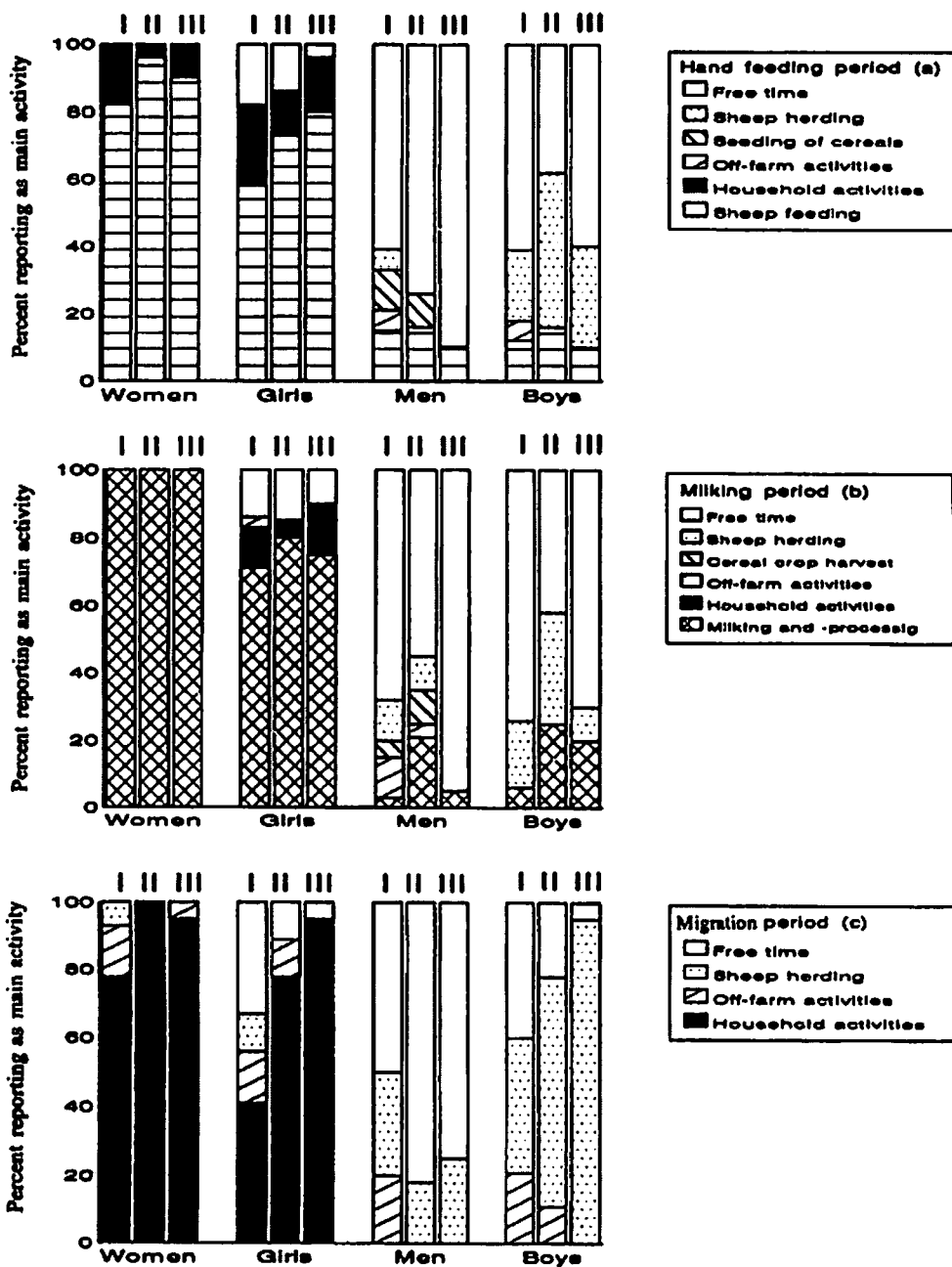


Figure 1. Division of activities between household members in the sedentary (I), semi-sedentary (II), and migratory farming systems (III). Source: PAPE (1994).

Migration period

The most important activity during this period is herding the sheep, which is mainly the responsibility of boys. In 20–30% of households, however, this is done by the men (Fig. 1c). A shepherd is hired for this period in 12% of the sedentary system households and in 30% of those of the semi-sedentary system. In a few households in the sedentary system where male members work off-farm during this period, women or girls are responsible for herding.

Labor Constraints from the Women's Perspective

According to the women, the only technical innovation which has helped to ease their burden is the tractor. Most families own, or have access to, a tractor, which is used mainly for transportation. With the help of a man and a tractor, shrubs **uprooted and collected** by the women and girls are transported and do not have to be carried home on women's backs or on a donkey. The tractor is also used to carry water to the household so women no longer have to walk long distances to fetch it. There were few household appliances in the sample households; only three households owned washing machines and stoves.

About half of the women thought their workloads were the same or higher today than 20 years ago, because of increases in flock size or in area of cultivation.

Farm Level Decision Making

Supplementary feeding

Analysis of the division of labor shows that in 90% of household women, with help from girls, mix the fodder and fed the sheep. There is, however, a difference between carrying out, and having the responsibility for, an activity. In 30–40% of households, women carry out these activities, but they are under the direction of men (Table 5). In the remainder, however, women have the entire responsibility for feeding. The off-farm activities of men and their absence from the household influence the degree of responsibility and decision making of women. This increases the need for women to have access to information on the management of feeding.

Table 5 Household member deciding the amount and composition of supplementary feed.

	Sedentary	Semi-sedentary	Migratory
Women	59%	60%	50%
Women if men work off-farm	18%	5%	5%
Men or oldest son	20%	30%	40%
Shepherd	3%	5%	5%

Milk processing and marketing

The main products processed from milk were yogurt, cheese and ghee (clarified butter). The main marketed livestock product, except for lambs, in all three farming systems was cheese. The sale of milk and milk products was organized by men, who contacted a cheese dealer in the city and transported the cheese and other products there every two or three days during the milking season. In the migratory system, some farmers sold their milk to mobile cheese makers who set up near the Bedouin camps. More than 50% of the women said they would prefer to sell the milk unprocessed and only 19% and 30%, respectively, believed that it was more profitable to sell milk products (Table 6).

Table 6. Women's opinion on milk versus milk-product sale in sampled households of the study region.

Women's answers	Sedentary	Semi-sedentary	Migratory
Would rather sell milk unprocessed	59%	71%	50%
Selling milk products is more profitable than selling milk.		19%	30%
Do not sell anything because amounts are too small.	15%		
They sell milk only.	26%	10%	20%

Future Development of Farming Systems and Implications for the Role of Women

Small flock size and area of cultivation in the sedentary system lead to the involvement of many family members in off-farm employment and to a higher degree of sedentarization, which likewise increases women's workload and responsibilities. It also gives women the opportunity to go to the market and thereby control some of the household expenditures. In all three systems, it is mainly women who are responsible for mixing feed and feeding sheep. Their expertise should be considered in efforts by research and extension personnel to improve the feeding management of flocks. The milk marketing system could be improved to ease the workload of women during the milking season. Cooperatives could be used to organize farmers interested in marketing milk instead of milk products.

The interview technique used in this study (interviewing the women apart from the men) was very successful in obtaining information and opinions from the women without men interfering. This is an important precondition for creating an open and trusting atmosphere and for obtaining better information.

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Discussion

A. Yahyaoui: This study is interesting and will help target the technology development implementation. Family income should be calculated based on whether the Bedouin own a flock or not. Education of children should also be considered.

A. Pape: Flock sharing is no longer practiced by many Bedouins. Rather, the flocks are owned by the Bedouins themselves because of the availability of sufficient capital. Only two families, in the transitional system, are practicing flock

sharing today. Two decades ago, more than two thirds of flocks were not owned by the Bedouins themselves.

A. Nefzaoui: You show us in a very clear way that most of the work is done by women and boys. What do you suggest to alleviate this situations?

A. Pape: In two-way communication between farmers and researchers and extension workers, women's knowledge and experience have to be considered and can be helpful. They spend most of the time in close contact with sheep and are likely to know a lot about diseases, nutrition, and fodder mixing.

A. Khniefs: I am very happy when you speak about the Bedouin system. What is the recommendation to improve or develop the situation in the future?

A. Pape: Infrastructure (health services, water supply, and electricity) should be improved. Regarding agricultural production, there should be improved feeding management; those in a position to do so should encourage the sale of milk as fresh milk/yogurt instead of as cheese and *semneh* (ghee). That would ease the women's labor burden. Cash availability is mentioned as a major constraint: short-term, low-interest rate loans should be made available in a non-bureaucratic manner.

A. Shihadeh: What about schools for the Bedouin?

A. Pape: We have heard about the existence of moving schools for moving Bedouins. From the 146 families we interviewed in the Aleppo and Hama steppe, very few families had experience with schools. In the majority of villages there was a school building, but recruitment of teachers was a major problem, although university graduates are required to work in villages for some time before they can get a job in a town or city. Generally, boys had much higher literacy rates than girls in all three systems.

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The Importance of Forage Legumes in Rotations

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Abstract

Multiple-location, on-farm trials were conducted over three seasons (1989–1992) to introduce forage legumes in crop rotation with barley, to integrate crop and livestock, to replace fallow, to increase barley productivity, and to provide green feed to sheep in dry areas.

Barley yield in rotation with forage legumes was 19–28% greater than barley/barley or barley/fallow. This means that forage legumes are an economic alternative to fallow, providing green and high quality feed to improve livestock production.

This system provides high-quality green forage for grazing or hay to meet livestock requirements throughout the winter. It also increases grain cereal yields as a result of increased soil fertility. This system represents a socioeconomic improvement for farmers.

Pathological and Entomological Problems in Barley in Syria

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Abstract

Field surveys (1989/90–1994/95) on pathological and entomological infections on barley in the Hasakeh, Raqqa, Hamah, and Daraa regions of Syria were examined. The following conclusions were reached.

There are variances in distribution of barley diseases and insects from area to area, and powdery mildew is common to all. Susceptibility of barley varieties to rhynchosporium scald and helminthosporium leaf blotch in the same area varies.

Ground pearls are the most harmful barley pest, followed by thrips in Raqqa and Hasakeh. As a result of barley monoculture, ground pearls, rhynchosporium scald, powdery mildew, and brown leaf blotch infections are on the increase. Infection ratios and severity decrease after fallow.

Rhynchosporium scald and ascochyta blight are reduced by sufficient fertilizer application (2–3 times). The effect on powdery mildew was found to be contradictory.

The Phenomenon of Empty Barley Spikes In Some Areas of Syria

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Abstract

The phenomenon of empty barley spikes was observed in 1988 in Syria in the environs of Jerablus, Al-Bab, and Manbaj on the local barley cultivar, Arabi Aswad. The symptoms in the field start at seedling stage as yellow rows. These rows are located on the straw left by combine harvesters during the previous year's harvest. The yellow rows turn black at maturity. The spike subsequently becomes fragile and empty.

A nematode of *Anguina* subsp. causes the infection of the barley grain. Nematodes also affect the leaf and stem of the plant. The source of infection is the infected barley grain and plant debris.

Improved and Promising Barley Cultivars and their Role In Yield Increases of Rainfed Agriculture In Syria

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Abstract

The Syrian National Program has used several breeding methods to improve the barley crop. These methods include plant introduction, hybridization, mutation, and local landraces.

As a result of the continuous breeding efforts it has been possible to release and identify several cultivars and lines with potential in low rainfall areas.

Cultivars for moderate rainfall (250–350 mm) areas:

- Furat 1: Six-rowed, released in 1987, outyielded the local variety by 9%.
- Furat 2: Two-rowed, released in 1987, outyielded the local variety by 11%.
- Improved Arabi Abiad: released 1992, outyielded the local variety by 19%. It also outyielded Furat 1 by 11% and Furat 2 by 12%.
- Furat 4128, a promising six-rowed line, is suitable for the Raqqa area. It outyielded the local variety by 28%. Lubnan, a two-rowed line suitable for the Hasakeh area, outyielded the local by 15%.

Cultivars for low rainfall (around 250 mm) areas:

- Furat A 4807, a promising mutant two-rowed line, outyielded the local variety by 31%.
- Furat 4484, a six-rowed line, outyielded the local variety by 11% in the Hasakeh area.
- Promising lines 5330 and SLB-0-2-47, both two-rowed lines, are suitable for the Hasakeh and Aleppo areas.

The Effect of By-product Feed Blocks on the Weight of Awassi Sheep Grazing Stubble

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Abstract

By-product feed blocks consist of a mixture of agricultural by-products with some additives, and may be comprised of the following: poultry litter, sugar beet pulp, olive cake, bran, molasses, urea, salt, vitamins and minerals, and others substances. Feed blocks were found to be a useful nutritional supplement during stubble grazing.

An experiment was conducted on sheep flocks in southern Syria to evaluate feed blocks as a supplemental feed on sheep grazing cereal stubble. Sixty-four head were provided with the feed blocks, with 71 head serving as a control. The study lasted for 30 days. Daily weight gain in the treatment group was 87 g/head/day compared to 31 g/head/day for the control. The daily consumption of the feed block was 60 g/head.

**جدول يبين بعض خلطات المكعبات العلفية
(القيم مأخوذة على أساس النسبة المئوية)**

Matter Block ⇒ ↓ number	10	9	8	7	6	5	4	3	2	1	المادة رقم ↓ الخلطة
Urea	10	10	10	8	10	10	10	10	10	10	يوريا
Salt/Minerals	10	5	9	10	9	9	10	10	10	10	ملح طعام
Minerals & Vitamins			1		1	1					معادن وفيتامينات
Cement	15	10		15	8	5	7	15	20	5	إسمنت
Gypsum				-			7			10	جبصين
Poultry Litter	10		26	20	22	20					فرشة فروج
Poultry Manure											زرق بياض مجفف
Wheat Bran	55	25	25	25	21	24	31	30	60	65	نخالة قمح
Dried Olive Cake				22	20	20	35	35			عرجون زيتون
Molasses		50	20	-							مولاس
CaO			8	-	8	10					أكسيد الكالسيوم
CaOH				-							ماءات الكالسيوم
Na ₂ SO ₄			1	-	1	1					كبريتات الصوديوم
Water (L/10 kg mixt)	4	1	4	4		3	4	4.7	4	4	ماء لتر/10 كغ خلطة
Hardness	G	G		G			G	G	S	M	القساوة
Compactness	G	M		G			G	G	N	M	الانضغاط
Chemical composition (% D.M. Basis) التركيب الكيميائي (% من المادة الجافة)											
Crude Protein	37.5	31.6		23.9		30	32	38.1	39.1		بروتين خام
Ash.	30.3	26.6		19		29.5	28	33.6	29.4		رماد خام
Ca	6.9	4.6		5.4		6.5	4.9	5.2	5		كالسيوم
P	0.6	0.3		1.5		0.4	0.4	0.5	0.4		فوسفور

M:Medium - S : soft - G : good - N: Null - M/G : between medium and good - N/A : not available.

جدول يبين بعض خلطات المكعبات العلفية
(القيم مأخوذة على أساس النسبة المئوية)

Matter Block ⇒ ↓ number	20	19	18	17	16	15	14	13	12	11	المادة رقم ↓ الخلطة
Urea	8	10	10	10	10	10	10	10	8	10	يوريا
Salt/Minerals	10	5	10	10	9	6	10	9	5	10	ملح طعام
Minerals & Vitamins				1	1			1			معادن وفيتامينات
Cement	15	10	8	7			15				إسمنت
Gypsum			7	7						20	جبصين
Poultry Litter	40	25					40				فرشة فروج
Poultry Manure			20	23	27	37		35	31		زرق بياض مجفف
Wheat Bran	20		25	22	26	35	25	34	30	60	نخالة قمح
Dried Olive Cake											كسبة زيتون
Molasses	7	50	20	20	20	23		5	20		مولاس
CaO								6			أكسيد الكالسيوم
CaOH						7			6		ماءات الكالسيوم
Na ₂ SO ₄				1	1						كبريتات الصوديوم
Water (L/100 kg mixt)	2.5	1	2	1.5	1.5	3.7	4	4	2	4	ماء لتر/100 كغ خلطة
Hardness	M/G	-	G	G	G	S	G	G		S	القساوة
Compactness	N	-	G	G	G	M	M	M		N	الإنضغاط
Chemical composition (% D.M. Basis) (التركيب الكيميائي (% من المادة الجافة))											
Crude Protein	34.5	N/A	32.2				42.6				بروتين خام
Ash.	37.3		26				34.7				رماد خام
Ca	8.9		4.7				7.8				كالسيوم
P	0.8		0.5				0.3				فوسفور

M:Medium - S : soft - G : good - N: null - M/G : between medium and good - N/A : not available.

أية مواد مكلفة أو بحاجة إلى نقل من مسافات بعيدة حتى تكون العملية اقتصادية أكثر .
• إن سهولة تصنيع المكعبات العلفية وإمكانية نقلها إلى أي مكان، ومن قبل كل مربّي الثروة الحيوانية أكبر الأثر في سهولة نشر هذه التقنية، وتعريف المربين بها وبفوائدها وانعكاس ذلك على قطعانهم بشكل عام، والتوفير الجيد في تكلفة العلائق.

المراجع:

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- 4- تقرير حول إدخال زرق الدواجن المجفف في علائق المجترات، م. اللبان لؤي (1991).
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- إن الخلطة 10 التي استُخدمت فيها نخالة القمح بنسبة 23% مع فرشة الفروج بنسبة 10% أعطت مكعبات ذات قساوة وانضغاط جيدين، حيث كانت نسبة البروتين فيها 37.5% والرماد 30.3%.
- إن الخلطة رقم 18 التي استخدم فيها زرق الطيور المجفف بنسبة 20% و 20% مولاس أعطت مكعبات ذات قساوة وانضغاط جيدين، وقد وصلت نسبة البروتين الخام فيها إلى 32.5% والرماد إلى 26%.
- إن استخدام المولاس بنسب مرتفعة تزيد عن 40% قد أعطى مكعبات هشة وغير مناسبة، (الخلطة 19).

تأثير استخدام المكعبات على الأبقار الشامية الجافة:

- إن التأثير الذي يحدثه استخدام المكعبات في تغذية الأبقار مشابه من حيث النتيجة لتأثير استخدامه على الأغنام. ويمكن توضيح ذلك من نتائج التجربة التالية:
- تم تغذية الأبقار الشامية الجافة غير المنتجة بمكعبات اليوريا العلفية، بالإضافة إلى العلف المالى، حيث قُسمت الأبقار إلى مجموعتين قُدمت لها الأعلاف التالية:
- المجموعة الأولى قُدم لها التبن بالإضافة إلى قشرة القطن (علف مالى فقط).
- المجموعة الثانية قُدم لها التبن وقشرة القطن بالإضافة إلى مكعبات اليوريا وذلك حسب الجدول التالي:

المؤشر	مع مكعبات اليوريا	بدون مكعبات اليوريا
العلف المستهلك		
تبن شعير عادي	4.240	3.690
قشرة قطن	2.000	2.000
مكعبات اليوريا غ/يوم	0.950	-
التبن المستهلك لكل ١ كغ وزن حي	0.850	0.820
تغيرات الوزن اليومية غ/يوم	265+	265-

الخلاصة:

- يُنصح باستخدام مكعبات اليوريا العلفية عند تغذية الحيوانات الجافة (غير المنتجة) سواء تلك التي ترعى على مخلفات الحصاد أم على مخلفات المزرعة-والتي تكون عادة فقيرة في قيمتها الغذائية-أو التي يُقدم لها العلف في الحظائر. ويعتبر ذلك حلاً عملياً لتجاوز فترة محدّدة بدون فقد بالأوزان بالنسبة للحيوانات أو بأقلّ فقد ممكن. وهذا يساعد الحيوانات على تجاوز هذه الفترات الحرجة، حيث لا تتوفر الأعلاف، وخاصة المراعي، بشكل كافٍ، وبالتالي يساعدها على دخول الموسم الإنتاجي اللاحق وهي بحالة صحية جيدة. ولا يمكن استخدام المكعبات العلفية لحيوانات التسمين لأن هذه الحيوانات تخضع بالأساس لتغذية بالأعلاف المركزة.
- إن تكوين خلطة المكعب العلفي تخضع للمواد المتوفرة لدى المربي، ويجب عدم استخدام

المناقشة:

من الجدول رقم (٥) نجد بأنه، وحسب (MAFF 1975 page 55)، والواردة في دراسة للدكتور (ملتبادس حاجي بنيوتو 1991-دمشق)، يمكن تفسير النتائج على الشكل التالي: إذا كانت الطاقة اللازمة لزيادة وزنيتها قدرها 50 غ هي 3 ميكا جول. وإذا كان فرق الزيادة الوزنية لمجموعة التجربة التي تناولت المكعبات عن مجموعة الشاهد التي لم تتناول المكعبات هو 56 غ/يوم؛ (87-31=56) غ/يوم، فإن 56 غ/يوم تحتاج إلى 3.36 ميكا جول، وهي موجودة في 290 غ شعير، وذلك لأن كل 1 كغ من الشعير يحتوي على 11.59 ميكا جول من الطاقة؛ (290 $\times$ 3.36 = 974.4) $\approx$ 11.59. وبما أن سعر 1 كغ من الشعير حسب السعر الرسمي حالياً هو 7 ليرة سورية، فإن سعر

$$\frac{700 \times 290}{1000} \approx 203 \text{ قرش سوري}$$

وبما أن 60 غ من مكعبات اليوريا هي التي حققت هذه الزيادة، فإنها تساوي نظرياً لهذه القيمة، أي 203 قرش سوري، وبالتالي فإن كل 1 كغ من المكعب يساوي قرشاً سورياً $\frac{203000}{60} \approx 3383$ ، وبالتالي:

فإن كل 1 كغ من مكعبات اليوريا يعادل في قيمته التغذوية $\frac{3383}{7} = 4.8$ كغ شعير تقريباً.

ويمكن أن تصل تكاليف تصنيع الكغ الواحد من المكعبات بين 4-7 ليرات سورية تبعاً للمواد المصنّع منها وأجور اليد العاملة المستخدمة في ذلك. هذا ويمكن ملاحظة النقاط التالية من خلال استعراض جداول خلطات تصنيع مكعبات اليوريا العلفية واستخدامها في التغذية الواردة في نهاية هذه الدراسة:

- لم يلاحظ أن استخدام الإسمنت أو أحد مركباته كمادة رابطة ومصدر للمعادن المختلفة قد أعطى أية آثار جانبية للحيوانات بالحدود التي استخدمت فيها، أي بنسبة 1-3% من كامل العليقة، (على أساس المادة الجافة).
- إن زيادة نسبة اليوريا في المكعب عن النسبة التي استخدمت فيها وهي 10% قد تؤدي إلى خفض الاستهلاك من المادة الجافة للأعلاف الأخرى، وقد تؤدي إلى تسمم الحيوان، وعند ذلك يمكن إعطاء 2-4 ليتر من محلول حمض الخل، لذلك لا ينصح بزيادة النسبة عن 10% من اليوريا عند تصنيع المكعب.
- لقد أظهر التحليل الكيميائي للمكعبات العلفية احتواء المكعبات على نسبة مرتفعة من البروتين الخام وصلت في بعضها إلى 42% من المادة الجافة (الخلطة 14).
- لوحظ ارتفاع نسبة الرماد في المكعبات التي احتوت على نسبة مرتفعة من فرشة الفروج (الخلطة 20) وأقل نسبة في الخلطة 7.
- كما لوحظ أيضاً أنه كلما زادت نسبة نخالة القمح في تصنيع المكعب كلما انخفضت قساوة وانضغاط المكعب (خلطة 1)، وقد كانت نسبة البروتين فيها 39.1%.

كما سُجِّلَت النتائج التالية لأغنام عواس موجودة ضمن الحظائر عند تغذيتها بالتبن العادي والمعامل باليوريا وقليل من العلف المركز والمكعبات:

الجدول (3):

المؤشر	تبن عادي	تبن معامل باليوريا	تبن عادي + مكعبات
عدد الحيوانات	16	16	16
الوزن الأولي	39.75	39.75	39.81
الوزن النهائي	42.44	43.44	43.63
الزيادة الوزنية (غ/يوم)	47	65	67
العلف المقدم (غ/يوم)			
علف مركز حلوب	250	250	250
تبن	741	792	727
مكعبات اليوريا	-	-	122

وفي تجربة أخرى حول تقديم المكعبات للأغنام العواس التي ترعى على مخلفات الحصاد في مدينة السلمية فقد تمّ تسجيل النتائج التالية:

الجدول (4):

المؤشر	مجموعة التجربة	مجموعة الشاهد
عدد الحيوانات	83	86
عدد أيام التجربة	60	60
الخسارة الوزنية (غ/يوم)	6	56
المستهلك من الأعلاف (غ/يوم)		—
مكعبات اليوريا	47	

وفي تجربة مماثلة في السويداء حول تغذية الأغنام العواس التي ترعى على مخلفات الحصاد فقط، تمّ تقديم مكعبات اليوريا للأغنام ضمن مجموعتين:

الجدول (5):

المؤشر	مجموعة التجربة (مكعبات)	مجموعة الشاهد (بدون مكعبات)
عدد الحيوانات	64	71
عدد أيام التجربة	60	60
الوزن الإبتدائي	44.68	42.76
الوزن النهائي	49.87	44.60
الزيادة الوزنية (غ/يوم)	87	31
العلف المستهلك (غ/رأس/يوم)		
مكعبات اليوريا	60	-

- يجب تجفيفها في الظل لضمان عدم تشققها.
- يجب تقديمها بشكل كامل للحيوانات وعدم تكسيرها أو طحنها.
- يجب عدم تقديمها لحيوانات جائعة.
- يجب توفير المياه الكافية للشرب عند تقديمها.

نتائج استخدام مكعبات اليوريا العلفية في تغذية الحيوان
في تجربة على استخدام المكعبات في تغذية ثنايا الأغنام العواس في حماة تم استخدام ثلاث علائق مختلفة هي :

- القش العادي
 - القش المعامل باليوريا
 - القش العادي + مكعبات اليوريا العلفية
- وقد سُجِّلَت النتائج التالية:

الجدول (1):

المؤشر	قش عادي	قش معامل باليوريا	قش عادي + مكعبات
عدد الحيوانات	35	35	35
الوزن الابتدائي	40.1	40.1	40.7
الوزن النهائي	34.9	35.7	37.5
الخسارة الوزنية (غ/يوم)	88	73	53
النسبة المئوية للانخفاض الوزني	12.97%	10.97%	7.86%
	100%	83%	60%
العلف المستهلك (غ/يوم)	744	744	770
القش	-	-	90
مكعبات اليوريا	-	-	-

وفي تجربة مماثلة على استخدام مكعبات اليوريا العلفية في تغذية الأغنام البالغة عند أحد المربين في القامشلي، محافظة الحسكة، فقد تم تسجيل القراءات التالية:

الجدول (2):

المؤشر	مجموعة التجربة	مجموعة الشاهد
متوسط الوزن في بداية التجربة	49.1	48.9
متوسط الوزن في نهاية التجربة	51.78	49.3
مدة التجربة (يوم)	60	60
الزيادة الوزنية (كغ)	2.680	0.440
استهلاك الأعلاف للرأس الواحد (غ/يوم)	8.3	660
مكعبات يوريا	660	660
شعير	كمية مفتوحة	كمية مفتوحة
تبين عدس	كمية مفتوحة	كمية مفتوحة

كما أن معامل هضم المادة العضوية بالزرق يصل إلى 69.4% و70% للطاقة، ومعامل هضم البروتين الخام إلى 84.3%، وذلك حسب (Muller 1982). وهذا البروتين يتألف من قسمين:

• بروتين حقيقي True Protein وهو المشتق من الأحماض الأمينية، ويشكل حوالي 55-60% من كامل البروتين في الزرق.

• القسم الثاني هو الجزء الأزوتي غير البروتيني (NPN) (Nitrogen non Protein) مثل البيورينات (Purines) أو حمض البول (Uric Acid) والألنتوين (Allantoin)، وهذه الأجزاء تستخدم من قبل بكتيريا الكرش لتصنيع البروتين.

وبالنسبة إلى وجود اليوريا في العليقة بهذا المعدل فليس له أية أضرار ملموسة إذا لم يتناول الحيوان المكعبات بكميات كبيرة.

٢- إن وجود الملح وأوكسيد الكالسيوم والجبصين والإسمنت والأملاح المعدنية يغني المكعب بالأملاح اللازمة للحيوان بالإضافة إلى إعطائه المتانة والترابط اللازمين لسهولة النقل والتداول والتقديم للحيوانات.

يضاف ملح الطعام إلى خلطة المكعبات بنسبة 5-10% وأوكسيد الكالسيوم بنسبة 7-15% والجبصين 5-10% والإسمنت 5-15%.

3- إن إضافة خلطة الفيتامينات والمعادن إلى المكعب أثناء التصنيع تزود الحيوانات بما تحتاجه من الفيتامينات الضرورية لنموها والقيام بالوظائف الفيزيولوجية المختلفة في أجسامها، وهي تضاف إلى المكعبات بنسبة 1%.

4- إن وجود تغل الشوندر-والمولاس في المكعبات يزود الحيوانات بالطاقة السهلة اللازمة لهضم الأعلاف الأخرى، كما أنه ينشط عمل البكتيريا في كرش المجترات ويساعد على زيادة عددها وبالتالي يسرع من عملها. وعند موتها يستفيد الحيوان من مكونات أجسامها البروتينية.

٥- إن لإمكانية إضافة بعض المواد والأدوية البيطرية للمكعبات أهمية خاصة في معالجة وتحصين القطعان الكبيرة من الأغنام، مما يسهل ويقلل تكاليف الرعاية البيطرية، ويساعد في مكافحة الطفيليات التي تصيبها.

كميات استهلاك بعض أنواع الحيوانات من مكعبات اليوريا العلفية:

- أبقار (شامية) جافة 180 غ/كغ وزن حي
(محطة بحوث دير الحجر لأبقار الشامية قرب دمشق)
- ماعز (شامي) جافة 121 غ/كغ وزن حي
(محطة بحوث قرحتا للماعز الشامي قرب دمشق)
- أبقار (جرسي) (الهند) 150-185 غ/كغ وزن حي
- الجاموس (الهند) (1.4) كغ/يوم

بعض النصائح الواجب اتباعها عند تصنيع وتقديم مكعبات اليوريا العلفية:

- يجب إذابة كافة المواد بشكل جيد أثناء تحضير المكعب.
- يجب كبس المكعبات جيداً عند تشكيلها في قالب.

• تستهلك ببطء وبكميات محدودة، مما يساعد المجترات على هضم أعلافها الخشنة بصورة أفضل، عن طريق خلق بيئة مثالية لنمو وتكاثر البكتيريا في الكرش، بمساعدة الموارد التغذوية المتوفرة في المكعبات من يوريا وزرق دواجن وفيتامينات وغيرها، وبالتالي رفع معامل هضم المادة الجافة للأعلاف الفقيرة وزيادة المأكول منها.

4- دورها في التغذية وتحسين هضم الأعلاف الأخرى: من المعروف بأن الثروة الحيوانية في القطر وخاصة (الغنمية) منها تنتشر بشكل كبير في البادية السورية، وهي تتوجه لرعي بقايا المحاصيل الزراعية في مناطق الزراعات البعلية والمروية، وذلك بعد الإنتهاء من الرعي في البادية.

في بداية موسم الرعي على المخلفات تلتقط الأغنام المتساقط من السنابل والأوراق الجافة والقش الطري. وبعد فترة من الرعي تنتهي هذه البقايا، ويتبقى القش الخشن الجاف، عندها تبدأ مرحلة الاستفادة من مكعبات اليوريا العلفية.

في المرحلة الأولى من دخول الأغنام إلى المرعى، تحافظ الأغنام على أوزانها أو حتى قد تزيد من أوزانها، وتغطي في هذه المرحلة احتياجاتها الحافظة والإنتاجية، عن طريق الرعي فقط. ولكن وبعد انتهاء هذه البقايا تبدأ أوزانها بالتدهور، نتيجة لعدم كفاية المواد المغذية في القش المتبقي في المرعى، وهذا التراجع اليومي بالأوزان يؤدي إلى دخول الحيوانات موسم التلقيح في نهاية هذه المرحلة، وهي في حالة ضعيفة، مما يؤثر بالنهاية سلباً على نسبة التلقيح والإخصاب ونسبة التوائم في الموسم اللاحق، وعلى نسبة الولادات الحية وإلى ضعف أوزان المواليد الناتجة.

لذلك ولهذه الأسباب مجتمعة، فإن تقديم المكعبات في بداية دخول الحيوانات إلى المرعى، وخلال موسم الرعي على المخلفات، يؤدي إلى تحقيق أكبر الأثر في المحافظة على صحة وأوزان الحيوانات وإعطاء إنتاجية أعلى في الموسم اللاحق.

وتتجلى فوائد استخدام المكعبات في التغذية من خلال التأثيرات التالية:

1- إن وجود اليوريا-وزرق الدواجن المجفف-والنخالة يعطي المكعبات قيمة آزوتية عالية (بروتين خام)، حيث تدخل اليوريا (46% آزوت) في تركيب مكعبات اليوريا العلفية بنسبة تتراوح بين 8 و10% ، كما يدخل زرق وفرشة الدواجن بنسبة تتراوح بين 20 و50%، وتدخل النخالة بنسبة 20 و65%، وهي جميعاً مصادر بروتينية كما هو معروف.

ويوضح الجدول التالي التركيب الكيميائي لزرق الدواجن (%).

المادة	D.M.	C.P.	C.F.	Ca	P	ASH	TDN
زرق فروج (•)	87	33	11	2.6	1.9	12	60
زرق بياض (•)	75	25	17	5	2.1	26	40
زرق بياض من المؤسسة العامة للدواجن (••)	92.1	19.9	18.5	11.4	2.69	17	46

(•) Muller 1982

(••) تحليل المخبر المركزي للأعلاف.

الطرق والمواد المستخدمة

الأهمية التغذوية للمكعبات العلفية:

1- تعريف مكعبات اليوريا العلفية: هي عبارة عن خلطات من بعض المخلفات الزراعية، وبعض مخلفات التصنيع الزراعي الغذائية، مع بعض المواد المضافة، تصنع وفق نسب مختلفة، وتستخدم في تغذية المجترات كمتِمَمات علفية عند الرعي والتغذية على أعلاف فقيرة بالمواد الغذائية (مثل الأتبان، القش، مخلفات الحصاد، أحطاب القطن..).

2- تركيبها: تُصنع المكعبات من مجموعة كبيرة من المخلفات منها:

- زرق الطيور المجفف
- فرشة الفروج
- نقل الشوندر السكري
- عرجون الزيتون
- نخالة القمح
- المولاس
- بالإضافة إلى
- ملح الطعام
- اليوريا
- خلطة المعادن والفيتامينات
- أوكسيد الكالسيوم
- الجبصين
- الإسمنت
- كبريتات الصوديوم
- كما قد تستعمل مواد أخرى، بالإضافة إلى الماء.

3- مميزاتا: تتميز المكعبات بأنها:

- سهلة التحضير: حيث يمكن تحضيرها على مستوى المزارع الصغيرة ذات الإمكانيات المحدودة، مثلما يمكن تحضيرها في المزارع الكبيرة حيث تتوفر مستلزمات التصنيع الآلي وبكميات كبيرة.
- سهلة النقل والتخزين: إن عملية النقل والتخزين للمكعبات العلفية لا تتطلب شروطاً خاصة، فقط يجب أن تجفف في مكان ظليل بعيداً عن أشعة الشمس المباشرة لمنع تشققها، ومن ثم تُخزَّن في مستودعات بعيداً عن الرطوبة، كما أنها لا تحتاج إلى حيز تخزيني كبير.
- تعتبر حاملاً للمصدر الأزوتي غير البروتيني (NPN)، القابل للتحويل من قبل بكتريا الكرش في المجترات إلى بروتين حقيقي حيث تستفيد منه الحيوانات فيما بعد، كما أنه مصدر للكثير من العناصر المعدنية والفيتامينات، ويمكن إضافة بعض الأدوية البيطرية إليها كما أنها مصدر سهل للطاقة بسبب وجود المولاس في تركيبها.

للرأس الواحد قدرها 31 g/h/d ، ولم يتجاوز المأكول من المكعبات الـ 60 g/h/d لمجموعة التجربة.

وفي تجربة أخرى على الأبقار الشامية الجافة (غير المنتجة للحليب وغير حامل) أعطت التغذية على المكعبات العلفية نتائج مشابهة، فقد زاد الوزن لدى المجموعة التي قُدِّم لها المكعب بمقدار 265 g/h/d، بينما تراجع الوزن بنفس المقدار تقريباً للمجموعة الثانية التي لم يُقدِّم لها المكعب. وقد قُدِّم للمجموعتين تبن الشعير وقشرة القطن فقط، وقد بلغ الإستهلاك من التبن 0.85 kg/100 kg L.WT.، و 2 kg/h/d من قشرة القطن للرأس الواحد في كلا المجموعتين، وبلغ استهلاك المكعب 0.950 kg/h/d لمجموعة التجربة.

مقدمة:

يعتبر تصنيع مكعبات اليوريا العلفية، وإدخالها في خطط التغذية للحيوانات المجترة، في المزرعة أو في الحقول، من الحلول العملية لتحقيق أكبر فائدة لهذه الحيوانات، وذلك عند تغذيتها على الأعلاف الفقيرة أو الخشنة، ومخلفات المحاصيل المختلفة، خلال الفترات الأكثر حرجاً لتوفر الأعلاف.

كما أن تقديم هذه المكعبات يحقق فوائد اقتصادية عن طريق توفير في تكلفة العليقة، وذلك حين تغذية الحيوانات الجافة (غير المنتجة)، والتي لا تتغذى غالباً سوى على أعلاف فقيرة بالأساس.

إن فترات التغذية على هذه الأعلاف الفقيرة بقيمتها الغذائية قد تطول أو تقصر وذلك حسب المنطقة، كما أنها تعتمد أساساً على الإمكانيات المادية لمربي الحيوان، حيث يكفي مربي الثروة الحيوانية في أغلب الحالات بتقديم الأتبان مع بعض الشعير، وخاصة عندما تكون الحيوانات في نهاية موسمها الإنتاجي.

من جهة أخرى فقد أظهر المسح الميداني لكميات المخلفات الممكن الاستفادة منها في التغذية الحيوانية، بأنها كميات كبيرة وتتوفر على فترات مختلفة على مدار العام. هذه المخلفات تستغل بصورة غير مناسبة وغير مفيدة بالشكل الأمثل للحيوانات. فقد تحرق كميات القش المتبقية في الأراضي الزراعية بعد الرعي أو حتى يمكن أن تحرق بدون رعي. كما أن بعض هذه المخلفات يُنتج بكميات كبيرة ولفترة محدودة من السنة، مثل تفل الشوندر، حيث يلجأ المربون إلى تجفيفها مع ما يرافق ذلك من فقد للسوائل بما تحتويه من أملاح معدنية ومواد تغذوية أخرى، أو قد تتعفن بعض أجزائها عند التجفيف نتيجة لسماكة طبقة التجفيف، مما يؤدي إلى الإضرار بالحيوانات التي تتغذى على هذه الأعلاف لاحقاً.

لذلك ولمجموعة هذه الأسباب فقد تمت تجربة عدد من طرق تحسين الاستفادة من هذه المخلفات في قسم بحوث الإنتاج الحيواني والمحطات التابعة له، ولدى عدد من مربي الثروة الحيوانية في سورية، حيث تمت تجربة تصنيع مكعبات اليوريا العلفية؛ هذه التقنية أثبتت فائدتها، ليس فقط لحسن استغلال هذه المخلفات على الوجه الأمثل فحسب، ولكن لتحسين أداء بقية المخلفات الفقيرة عند التغذية عليها، وزيادة معدل الاستفادة منها أيضاً.

أهمية المكعبات العلفية في تغذية الأغنام التي ترعى على بقايا المحاصيل

م. جميل أمين

الملخص

يُعتبر تصنيع المكعبات العلفية وإدخالها في خطط التغذية للحيوانات المجترة، في المزرعة أو في الحقول، من الحلول العملية والواقعية لتحقيق أكبر فائدة لهذه الحيوانات، وذلك عند تغذيتها على:

• الأعلاف الفقيرة أو الخشنة.

• مخلفات المحاصيل المختلفة.

• أو عند التغذية في الفترات التي تقل فيها الأعلاف الخضراء والمركزة.

إن لتقديم المكعبات في هذه الفترة من السنة فوائد كبيرة في المحافظة على وزن الحيوانات وتهيتها للدخول في الموسم التناسلي بصحة جيدة، وهو يحقق نسبة إخصاب عالية. كذلك فإن تقديم هذه المكعبات يحقق فوائد اقتصادية عن طريق توفير في تكلفة العليقة، وذلك حين تغذية الحيوانات الجافة (غير المنتجة)، حيث تدعو الحاجة إلى التوفير في العلف المركز المقدم مع المحافظة على صحة الحيوانات في نفس الوقت. لذلك فإن استخدام المكعبات العلفية هو الحل الأمثل للاستفادة من الأعلاف الفقيرة والتوفير في تكلفة العلف المركز.

والمكعبات العلفية: هي عبارة عن خلطات من بعض المخلفات الزراعية، وبعض المواد المضافة، تصنع وفق نسب مختلفة، وتستخدم في تغذية المجترات كمتماطات علفية عند الرعي أو التغذية على الأعلاف الفقيرة (مثل الأتبان، مخلفات الحصاد، أحطاب القطن..). وتصنع المكعبات من مواد مثل: زرق الطيور المجفف، تفل الشوندر، عرجون الزيتون، نخالة القمح، المولاس، بالإضافة إلى ملح الطعام، اليوريا، خلطة المعادن والفيتامينات، أو أكسيد الكالسيوم، الجبصين، الإسمنت، كبريتات الصوديوم، وغيرها، بالإضافة إلى الماء.

وتتميز المكعبات بكونها: سهلة التحضير والتخزين والنقل، ومصدر للطاقة والبروتين والمعادن والفيتامين وبعض الأدوية البيطرية. وهي تساعد في تحسين رفع معامل هضم الأعلاف الأخرى.

وقد تمت تجربة المكعبات العلفية في محطات قسم بحوث الإنتاج الحيواني ولدى العديد من المربين، ولقد كان لها آثاراً إيجابية. ففي السويداء ولدى أحد المربين، تمت تجربتها على مجموعتين من الأغنام التي ترعى على مخلفات الحصاد فقط وبدون أية أعلاف أخرى وقد أعطت النتائج التالية خلال فترة التجربة والتي استمرت ستون يوماً:

حققت أغنام التجربة (التي قُدِّمت لها المكعبات) زيادة وزنية يومية للرأس الواحد قدرها 87 g/h/d. وحققت الثانية مجموعة الشاهد (التي لم يُقدِّم لها المكعب) زيادة وزنية

تم إدخال الأصناف المذكورة في المشروع المشرقي للشعير والأعلاف والأغنام
لموسم 96/1995 لاختبار أدائها تحت ظروف المزارعين (Farmer- managed).

المراجع:

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نبيل الخالدي، معهد البحوث الدولي للسياسة الغذائية - واشنطن D.C ، تموز 1992.

3-2 المنطقة الشرقية (محافظة الرقة):

جدول (7): الغلة الحبية (كغ/هـ) لأصناف الشعير المبشرة في محافظة الرقة في الحقول الاختبارية بمنطقة الاستقرار الثالثة للمواسم 93/1992 ولغاية 95/1994، (عدد المواقع 8).

الصنف/الموسم	92/91	%	93/92	%	94/93	%	95/94	%	المتوسط العام	%
عربي أسود (شاهد)	595		865		683		1104		772	
عربي أبيض	336		617		447		787		512	
فرات 4807			515	40-	568	17-	1037	6-		
فرات 4484	591	1-	736	15-	471	31-	1055	4-	695	11-
CV%									13	
LSD.5%									98	

ونستنتج من الجدول (7) مايلي:

- 1- لم يتفوق أي صنف على الصنف المحلي عربي أسود (شاهد) في جميع مواسم الاختبار.
 - 2- كان أداء الصنف عربي أسود أفضل من الصنف عربي أبيض في جميع مواسم الاختبار وبالمتوسط العام.
 - ومن الجداول (4-5-6-7) نستنتج مايلي:
 - 1- كان أداء الصنف فرات 4807 جيداً جداً في المنطقة الغربية وبمعنوية إحصائية عالية في درعا وحماة، وجيداً في محافظة حلب ومقبولا في محافظة الحسكة. لكنه تخلف بشكل واضح في محافظة الرقة.
 - 2- كان أداء الصنف فرات 4484 مقبولا في درعا وحماة وضعيفاً نسبياً في حلب. إلا أنه تفوق بشكل واضح وبمعنوية إحصائية عالية في محافظة الحسكة وتأخر في محافظة الرقة.
 - 3- تميز الصنف المحلي عربي أسود في مناطق انتشاره بوضوح على الصنف عربي أبيض في كل من محافظات (حلب-الرقة-الحسكة). إلا أن أدائه كان أقل كفاءة من الصنف عربي أبيض في كل من درعا وحماة حيث الصنف العربي الأبيض هو صنف المنطقة.
- وعليه ومما تقدم يمكن أن نوجه:

أ- في منطقة الاستقرار الثانية:

- 1- إمكانية اعتماد الصنف فرات 3717 في المنطقة الغربية.
- 2- إمكانية اعتماد الصنف فرات 3717 في المنطقة الشرقية (محافظة الحسكة).
- 3- يوجد تفاوت بأداء مميز للصنف فرات 4128 في المنطقة الشرقية (محافظة الرقة).

ب في منطقة الاستقرار الثالثة:

- 1- إمكانية اعتماد الصنف فرات 4807 في المنطقة الغربية.
- 2- إمكانية اعتماد الصنف فرات 4484 في المنطقة الشرقية (محافظة الحسكة).
- 3- زيادة الجهود التربوية لتحسين الشعير في المنطقة الشرقية (محافظة الرقة).

نستنتج من الجدول (5) مايلي:

1- تفوق الصنف فرات 4807 بالغلة الحبية على الشاهد عربي أسود في 3/3 مواسم بنسب قدرها 15%، 44% على التوالي وفي 4/3 مواقع، وتفوق بالمتوسط العام بنسبة 9% بدون فروق إحصائية.

2- تفوق الصنف فرات 4484 على الشاهد بـ 3/2 مواسم، وبنسب قدرها 5% و 24% وتختلف في موسم واحد بـ 24%، وكان أقل غلة بالمتوسط العام وبنسبة 11%.

3- كان أداء الصنف المحلي عربي أسود (صنف المنطقة) أفضل من الصنف عربي أبيض في 2/2 مواسم وبالمتوسط العام، وكان تفوقه أيضاً في جميع المواقع.

3-2- المنطقة الشرقية (محافظة الحسكة):

جدول (6): الغلة الحبية (كغ/هـ) لأصناف الشعير المبشرة والشاهد في شرقي سورية (محافظة الحسكة) في الحقول الاختبارية بمنطقة الاستقرار الثالثة للمواسم 93/1992 ولغاية 95/1994 (عدد المواقع 14).

الصنف/الموسم	92/91	%	93/92	%	94/93	%	95/94	%	المتوسط العام	%
عربي أسود (شاهد)	1564		1408		1283		1935		1529	
فرات 4484	1624	4	1713	22	1364	6	2517	30	1849**	21
فرات 4807			1570	12	1277	0	2206	14	1673	9
عربي أبيض	1169		1382		1210		2074		1432	
CV%									16	
LSD.5%									186	
LSD.1%									252	

ونستنتج من الجدول (6) مايلي:

1- تفوق الصنف فرات 4484 بالغلة الحبية على الشاهد عربي أسود في جميع سنوات الاختبار بنسب قدرها 4%، 22%، 6% و 30% على التوالي، وكان التفوق في 14/10 موقعاً. وبالمتوسط العام تفوق الصنف 4484 على الشاهد بدلالة إحصائية على مستوى 1% (مواسم 92-95).

2- تفوقت غلة الصنف فرات 4807 بالغلة الحبية على الشاهد عربي أسود في 3/2 مواسم وبنسب قدرها 12% و 14%، وكانت غلته في الموسم الثالث قريبة من غلة الشاهد، وبالمتوسط العام كانت غلته أعلى من غلة الصنف الشاهد بـ 9%.

3- كانت غلة الصنف عربي أسود (شاهد) أعلى من غلة الصنف عربي أبيض في 4/3 مواسم وكذلك بالمتوسط العام.

٢- منطقة الاستقرار الثالثة:

1-2- المنطقة الغربية: تميز الصنفان التاليان:

– فرات 4807 A – فرات 4484

جدول (4): الغلة الحبية كغ/هـ لأصناف الشعير المبشرة والشاهد في وسط وجنوبي سورية (درعا وحماة) في الحقول الاختبارية بمنطقة الاستقرار الثالثة للمواسم 93/1992 ولغاية 95/1994. (عدد المواقع 6).

الصنف/الموسم	93/92	%	94/93	%	95/94	%	المتوسط العام	%
عربي أسود	3428		593		1681		1900	
عربي أبيض (شاهد)	3656		469		1749		1958	
فرات 4484	3797	4	773	30	1959	12	2176	11
فرات 4807	4461	24	928	50	2231	34	2540**	30
CV%							10	
LSD.1%							369	

ومن الجدول (4) نلاحظ مايلي:

1- تفوق الصنف فرات 4807 بشكل مميز على الصنف المحلي عربي أبيض في 3/3 مواسم وفي جميع المواقع المدروسة وينسب قدرها 24%، 50% و34% على التوالي، وبالمتوسط العام بنسبة 30% وبدلالة إحصائية على مستوى 1%.

2- تفوق الصنف فرات 4484 على الصنف عربي أبيض، في المواسم الثلاثة بنسب قدرها 4%، 30% و12% على التوالي وفي 6/5 مواقع، وتفق بالمتوسط العام بنسبة 11% وبدون دلالة إحصائية.

3- كان أداء الصنف المحلي عربي أبيض (الشاهد) أفضل من الصنف عربي أسود في 3/2 سنوات وفي 6/4 مواقع.

جدول (5): الغلة الحبية كغ/هـ لأصناف الشعير المبشرة والشاهد في شمالي سورية (محافظة حلب) في الحقول الاختبارية بمنطقة الاستقرار الثالثة (عدد المواقع 4).

الصنف/الموسم	93/92	%	94/93	%	95/94	%	المتوسط العام	%
عربي أسود (شاهد)	1293		1250		758		1184	
عربي أبيض	916		1007		688		881	
فرات 4484	982	24-	1308	5	938	24	1052	11-
فرات 4807	1305	1	1439	15	1094	44	1298	9
CV%							12	
LSD.5%							214	

نلاحظ من الجدول أنه:

1- لم يكن هنالك استقرار بتفوق غلة الصنف المبشّر فرات 3717 على الشاهد المحلي عربي أسود، حيث تفوق في 4/2 مواسم وفي 7/5 مواقع وإن كان متوسط غلته أعلى بـ 22% من غلة الشاهد ويدون فروق معنوية.

2- هنالك بعض المؤشرات الإيجابية للصنف فرات 4128 حيث تفوق في 2/2 موسم.

3-1- المنطقة الشرقية (محافظة الحسكة):

جدول (3): الغلة الحبية كغ/هـ لأصناف الشعير المبشّر في شرقي سورية (محافظة الحسكة) في الحقول الاختبارية بمنطقة الاستقرار الثالثة للمواسم 92/1991 ولغاية 95/1994. (عدد المواقع 10)

الصنف / المرسم	92/91	%	93/92	%	94/93	%	95/94	%	المتوسط العام	%
عربي أسود (شاهد)	2689		1805		1595		1906		2017	
عربي أبيض	2028		1480		1408		1568		1632	
فرات 1	2295		1903		1614		2151		1959	
فرات 2	2007		1972		1614		2052		1883	
فرات 3717	2537	6-	2288	27	1705	7	2469	30	2206*	9
فرات 4128			2093	16	1570	2-				
CV%									11	
LSD-5%									184	

يبين الجدول (3) مايلي:

1- تفوقت الغلة الحبية للصنف فرات 3717 على الصنف المحلي عربي أسود في 4/3 مواسم بنسب قدرها 27%، 7% و 30% على التوالي، حيث تخلّفت في موسم 92/1991 وبالمتوسط العام تفوقت غلته على الصنف عربي أسود بدلالة إحصائية على مستوى 5% وبنسبة 9%.

2- تفوق الصنف فرات 4128 على الصنف عربي أسود بموسم واحد من موسمين.

ومن الجداول (3-2-1) نلاحظ مايلي:

1- كان تفوق الصنف فرات 3717 واضحاً وبدلالة إحصائية (بالمتوسط العام)، وقد تفوق في أغلب مواقع اختباريه في شمالي ووسط وجنوبي سورية، بينما لم يكن أدائه كافياً للحكم في الرقة. أما في الحسكة فقد كان أدائه متوسطاً.

2- كان أداء الصنف فرات 4128 جيداً في محافظة الرقة ولم يكن كذلك في محافظة الحسكة.

3- على مستوى الأصناف المحلية (عربي أبيض وعربي أسود) نجد بأن أداءهما كان متقارباً في الشمال والوسط والجنوب، أما في الحسكة والرقة فنجد أن أداء الصنف عربي أسود هو المميز.

جدول (1): الغلة الحبية كغ/هـ لأصناف الشعير المبشرة والمحسنة والمحلية في (شمال- وسط- وجنوب سورية) في الحقول الاختبارية بمنطقة الاستقرار الثانية لموسم 92/1991 ولغاية 95/1994. (عدد المواقع 25 موقعاً).

الصفة/الموسم	92/91	%	93/92	%	94/93	%	95/94	%	المتوسط العام	%
عربي أبيض (شاهد محلي)	3250		3041		2767		2565		2939	
فرات 1 (شاهد محسن)	3680	13	3660	20	3477	26	2974	16	3465	18
فرات 2 (شاهد محسن)	3676	13	3661	20	3435	24	3213	25	3513	20
عربي أبيض محسن	4158	28	-	-	3355	21	3054	19	-	-
شاهد محسن	4040	24	3949	30	4191	51	3709	45	3969	35
فرات 3717	3508		3332		2717		2267		3009	
عربي أسود									12	
CV%									223	
LSD.5%									295	
LSD.1%										

من الجدول (1) نلاحظ:

تفوق الصنف المبشر فرات 3717 بالغلة الحبية على الصنف المحلي عربي أبيض في مواسم الاختبار الأربعة، بنسب قدرها 24%، 30%، 51% و 45% على التوالي وفي 25/24 موقعا. كما تفوق على الشواهد المحسنة جميعاً عدا موسم 92/1991 حيث تفوق عليه فقط الصنف المحسن عربي أبيض محسن بنسبة قدرها 3%. وبالمتوسط العام تفوق على جميع الأصناف المحسنة والمحلية بدلالة إحصائية على مستوى 1%.

1-2- المنطقة الشرقية (محافظة الرقة):

ليس من السهل التوصل إلى أصناف تتلائم بشكل فعال مع الظروف البيئية الصعبة لمحافظة الرقة، ولكن يوجد بعض المؤشرات على تحسن نواتج العمل التريوي لهذه المنطقة.

جدول (2): الغلة الحبية كغ/هـ لأصناف الشعير المبشرة في المنطقة الشرقية (الرقة) في الحقول الاختبارية بمنطقة الاستقرار الثانية للموسم 92/1991 وحتى 95/1994. (عدد المواقع 7).

الصفة/الموسم	92/91	%	93/92	%	94/93	%	95/94	%	المتوسط العام	%
عربي أسود (شاهد محلي)	1629		1561		750		1446		1432	
عربي أبيض	1048		1271		536		1464		1157	
فرات 1	1416		2296		440		1451		1509	
فرات 2	1076		2108		583		1513		1425	
فرات 3717	1486	9-	1469	58	671	10-	1828	26	1748	22
فرات 4128			2068	32	1036	38				
CV%									21	
LSD.5%									430	

المواد وطريقة العمل :

المصدر الوراثي: أصناف متفوقة تم اختبارها في محطات البحوث لعدة سنوات ضمن تجارب (yield trial). مدة الاختبار 3-4 سنوات في تجارب (on -farm yield trial) في منطقتي الاستقرار الثانية والثالثة.

عدد المواد الوراثية: مختلف من موسم لآخر.

التصميم R.C.B: 3 مكررات لمنطقة الاستقرار الثانية و 4 مكررات للتالثة، مساحة الصنف الواحد ضمن المكرر 32م²

عدد المواقع: 1-4 حسب أهمية المحافظة.

معدل البذار: 100 كغ/هـ

التسميد:

منطقة الاستقرار الثانية: 40 وحدة P₂O₅ للهكتار، 40 وحدة أزوت نقي للهكتار على دفعتين متساويتين.

منطقة الاستقرار الثالثة: 35 وحدة P₂O₅ هـ، 30 وحدة أزوت نقي /هـ على دفعتين متساويتين.

تاريخ الزراعة: تشرين الثاني.

عملية الزراعة والحصاد: آلية.

النتائج والمناقشة:

1- منطقة الاستقرار الثانية:

تم تحسين غلة الشعير في شمالي ووسط وجنوبي سورية من خلال الأصناف المعتمدة (فرات 1 - فرات 2 - عربي أبيض ومحسن)، إلا أن المنطقة الشرقية مازال معتمدة على الصنف المحلي عربي أسود، ولا تزال الجهود تبذل لتحسين غلة تلك المنطقة (الحسكة والرقعة).

1-1 المنطقة الغربية: (شمال ووسط وجنوب)

رغم أن غلة الشعير في المنطقة الغربية قد تم تحسينها، إلا أن البحوث مازالت جارية لزيادة قدرته الإنتاجية عن طريق استنباط أصناف جديدة أفضل من تلك المتاحة.

رفع غلة الشعير من خلال شبكة من الأصناف المبشرة في المناطق المطرية السورية

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مقدمة :

تتزايد الحاجة في سورية إلى الشعير (باستخداماته المختلفة) مع التنامي المضطرد للثروة الحيوانية. فعلى سبيل المثال تضاعف عدد الأغنام أكثر من مرة بعد عام 1975 ليصل إلى 5 مليون رأس بنهاية 1980 بعد أن كان 1,5 مليون رأس، وهذا الرقم أخذ بالزيادة ليصل إلى 10 مليون رأس والذي يعادل 60% من مجموع الثروة الحيوانية في القطر. ولتأمين الكم المطلوب من الشعير فقد تمّ التوسّع بمساحات الشعير لتصل إلى 2,2 مليون هكتار في عام 1994، حيث يبلغ متوسط ما يُزرع في القطر 1,7 مليون هكتار (1979-1990) بمتوسط إنتاج قدره 1,5 مليون طن سنوياً. ويمكن للتحسين الوراثي أن يساهم بشكلٍ أو بآخر بزيادة غلة الشعير وبالتالي زيادة الإنتاج العام.

تتميّز مناطق زراعة الشعير في سورية بالتباينات البيئية الواضحة، مما يجعل من الصعوبة بمكان البحث عن صنف ما يلائم جميع الأراضي تحت معدل مطري محدّد. من خلال اختبار العديد من المواد الوراثية للشعير في الحقول الاختبارية (Researcher-managed) عبر سنوات لوحظ أن الوصول إلى تركيب وراثي يخدم زيادة غلة جميع مزارعي الشعير في منطقة الاستقرار الثانية (250-350 ملم سنوي)، على سبيل المثال، ليس سهلاً إذا اعتمد على المتوسط العام لأداء الصنف أو الأصناف المبشرة، لأن النتيجة سوف تخدم شريحة من المزارعين دون آخرين، وأن الأمر ينطبق أيضاً على منطقة الاستقرار الثالثة (250 ملم سنوي). لذا اعتمد على طريقة تحليلية بسيطة لمناطق زراعة الشعير حسب المحافظات السورية لمنطقتي الاستقرار المطرية الثانية والثالثة، وذلك باعتبار محافظة الحسكة (الشمالية الشرقية) بيئة، ومحافظة الرقة بيئة أخرى، ومنطقة الغرب (الشمال والوسط والجنوب) بيئة ثالثة، حيث تتميّز محافظة الحسكة بارتفاع مستوى الكلس في تربتها، ويزداد المستوى في محافظة الرقة، وكلا المحافظتين تتميّزان بانخفاض مستوى الرطوبة الجوية النسبية مع نشاط نسبي بموجات اللفحة الحرارية المبكرة في المراحل المتقدمة من نمو المحصول مقارنة مع المنطقة الغربية.

الهدف: رفع غلة الشعير في سورية عن طريق تحديد أصناف جديدة جيّدة تكون كفاءتها أكثر وضوحاً في منطقة (محافظة) ما من أخرى.

رفع غلة الشعير من خلال شبكة من الأصناف المبشرة في المناطق المطرية السورية

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الملخص:

تتميز مناطق زراعة الشعير المطرية في سورية بالتباينات البيئية الواضحة، حيث وُجد أنه من أجل رفع غلة هذا المحصول وبكفاءة أكبر يمكن اعتماد طريقة التربية الموجهة لتلك البيئات، وتخصيص أصناف محددة تخدم المنطقة أو المناطق المستهدفة. ومن خلال البحوث التي أجريت على تحسين الشعير في المناطق قليلة - إلى - متوسطة الأمطار (250-350 ملم سنوياً) تمّ التوصل إلى أصناف تلائم المناطق المطرية التالية:

1- منطقة الاستقرار الثانية (250-350 ملم):

- 1-1- صنف الشعير المبشر فرات 3717، زادت غلته على غلة الشاهد المحلي الصنف عربي أبيض بنسبة قدرها 35% في المنطقة الغربية (الشمال-الوسط-والجنوب) وبمعنوية إحصائية على مستوى 1%، كما زادت غلته على غلة الشاهد المحلي عربي أسود بنسبة 9% في المنطقة الشرقية (محافظة الحسكة) وبمعنوية على مستوى 5%.
- 1-2- صنف الشعير المبشر فرات 4128 جيد الأداء في محافظة الرقة لكنه يحتاج لمزيد من الاختبار.

2- منطقة الاستقرار الثالثة (250 ملم):

- 2-1- صنف الشعير المبشر فرات 4807: زادت غلته على غلة الشاهد عربي أبيض بنسبة قدرها 30% وبمعنوية إحصائية على مستوى 1% في غربي سورية (محافظة درعا وحماة)، وزادت أيضاً على غلة الشاهد عربي أسود بنسبة قدرها 9% في محافظة حلب.
- 2-2- صنف الشعير المبشر فرات 4484: زادت غلته على غلة الشاهد عربي أسود بنسبة قدرها 21% وبمعنوية إحصائية على مستوى 1% في المنطقة الشرقية (محافظة الحسكة).
يمكن أن يتم اعتماد الأصناف المذكورة لتساهم في زيادة غلة الشعير في سورية.

- بالعدّ المخبري لهذه النيماتودا وُجِدَ أن عدد النيماتودا في الحبة الواحدة يتراوح ما بين 3200 و3800 وحدة.

- هذه النيماتودا متخصصة بالشعير ولا تصيب القمح.

- تختلف شدة الإصابة تبعاً لكمية مادة العدوى وملاءمة الظروف الجوية.

- هناك علاقة ما بين الإصابة بالنيماتودا وحساسية النبات لمرض التبّع الشبكي حيث يصبح النبات المصاب أكثر حساسية لهذا المرض.

- هناك اختلاف في حساسية الأصناف المختلفة من الشعير للإصابة بالنيماتودا.

- العوامل المساعدة على انتشار الإصابة:

١- تداول البذار الموبوء لدى المزارعين بدون غريلة أو تعقيم.

٢- عدم التخلص من بقايا المحصول السابق (شعير).

٣- عدم تطبيق الدورة الزراعية.

جدول (1): نسب الإصابة بمرض التبقع الشبكي في مرحلة الاشتهاء.

الصفة	شعير عربي أسود	شعير عربي أبيض	فراة 2
إنتاج المزارع			
نسبة الإصابة بالتبقع الشبكي	5/4	2/2	3/2

سلم القراءات : الرقم الأول : يمثل ارتفاع الإصابة على النبات.

الرقم الثاني : يمثل شدة الإصابة على الورقة.

تم استخدام مقياس 1-9 حيث الرقم 1 يعني أن النبات مقاوم، و الرقم 9 يعني أن النبات شديد الحساسية.

جدول (2): نسب الإصابة بمرض التبقع الشبكي والسفحة الحقلية في مرحلة الاستطالة وبداية ظهور السنابل.

الصفة	شعير أسود	شعير أسود محسن	شعير أبيض	فراة 2
إنتاج المزارع				
نسبة الإصابة بالتبقع الشبكي	7/6	4/5	2/3	4/3
نسبة الإصابة بالسفحة الحقلية	3/2	2/2	1/2	4/3

المقياس : نفس السلم السابق.

جدول (3): نسبة الإصابة بالسنابل الفارغة على 100 نبات.

الصفة	شعير أسود	شعير أسود محسن	شعير أبيض	فراة (2)
إنتاج المزارع				
نسبة الإصابة	5%	3%	0,5%	2%

النتائج والمناقشة

- تم التأكد من أن المسبب لظاهرة السنابل الفارغة هي نيماتودا (ديدان ثعبانية) تصيب

الحبوب من جنس Sub Anguina sp.

- هذه النيماتودا تتجمع داخل الحبة فتصبح الحبة خفيفة خالية من الجنين متطاولة وتغزل أيضاً من الساق النهائية.

- لوحظ انتشار مرض التبّع الشبكي الذي يسببه فطر *Perynophora teres* وبنسبة 5/4 على الشعير عربي أسود من إنتاج المزارع، بينما كانت الإصابة على الخطوط 1/1 (الجدول 1)
- فُحصت جذور النباتات مخبرياً وكانت سليمة من ناحية الممرضات الأخرى.

مرحلة الاستطالة (أذار)

- لوحظ وجود إصابة لمرض السفحة الحقلية المتسبب عن فطر *Rhynchosporium secalis* على الصنف فرات 2 بنسبة 4/3 (الجدول 2).
- لوحظ اختفاء ظاهرة الاصفرار على النباتات والتي ظهرت على شكل شرائط سابقاً نتيجة ارتفاع الحرارة وانخفاض الرطوبة والظروف الجفافية التي سادت اعتباراً من الأسبوع الثاني من شهر آذار.

مرحلة الإسيال (نيسان)

- تطوّرت الإصابة بمرض التبّع الشبكي ووصلت إلى نسبة 7/6 على الصنف عربي أسود من إنتاج المزارع.
- ظهرت أول علامات السنابل الفارغة وكانت الحبوب ضامرة في بعض السنبيلات.
- لم تكن هناك فوارق بالإصابة بالأمراض الفطرية (تبّع شبكي) بين القسم المعامل بالمبيدات الفطرية والقسم غير المعامل وكذلك على ظهور السنابل الفارغة.

مرحلة النضج العجيني

- لدى الفحص المجهرى للحبوب الضامرة من السنابل الفارغة تبين وجود نيماتودا حدّدت على أنها نيماتودا الحبوب من جنس *Sub Anguina sp.* وكانت النباتات المصابة بهذه النيماتودا أشدّ إصابةً بالتبّع الشبكي.

مرحلة النضج التام

- تم أخذ 100 نبات بشكل عشوائي من كل صنف وتقدير نسبة الإصابة بالسنابل الفارغة (جدول 3).
- لدى مراقبة حقول موبوءة بظاهرة السنابل الفارغة على الشعير في الموسم السابق تمت زراعتها في الموسم الحالي بمحصول قمح قاسي صنف شام 3 وقمح طري صنف مكسيياك تبين عدم وجود أية إصابة بهذه النيماتودا.

دراسة ظاهرة السنابل الفارغة على الشعير في بعض مناطق سورية

م . عبد الرزاق الدقسي

مقدمة :

لوحظ وجود ظاهرة السنابل الفارغة على الشعير في حقول متفرقة في منطقة جرابلس بمحافظة حلب شمالي سورية بدءاً من عام 1988 على أصناف الشعير عربي أسود ثم انتشرت هذه الظاهرة حتى عمت مناطق جرابلس - منبج - الباب وهي مناطق استقرار ثانية وثالثة ولا تتبع نظام الدورة الزراعية حيث يتم زراعة الشعير بعد الشعير بشكل متوالي. وتتمثل الظاهرة في أن النبات يقوم بتشكيل سنابل فارغة من الحبوب وهي ذات لون غامق مسود، وتكون الحبوب ضامرة وضعيفة وتكون النباتات المصابة عادة أطول من مثيلاتها السليمة وذات سوق رفيعة. ينتج عن هذه الظاهرة خسارة في الإنتاج قد تصل حسب الموسم وشدة الإصابة إلى 40% ويكون الوزن النوعي للبذور منخفض حيث يكون وزن كيس الشعير المحصود من حقل مصاب بحدود 80-85 كغ. هدف البحث : دراسة هذه الظاهرة وتحديد المسبب المرضي وسلوكه وتحديد العوامل المساعدة على انتشاره وكيفية انتقاله والتوصل إلى طريقة فعالة في السيطرة عليه.

الطرق والمواد :

- تمت زراعة ثلاثة أصناف من الشعير المعتمد فرات 2، عربي أبيض محسن، وعربي أسود، بالإضافة إلى الصنف عربي أسود من إنتاج المزارع كشاهد في قرية كاوكلي وفي حقل مصاب بهذه الظاهرة مساحته 4 هكتارات.
- تم تقسيم القطع المزروعة إلى قسمين: قسم عومل بالمبيدات الفطرية بايلتون (بيسون)، رشّة أولى في منتصف شباط ورشّة ثانية بمبيد كريندازيم في الأسبوع الثاني من آذار، والقسم الآخر بدون معاملة.
- تمت إضافة الأسمدة التالية قبل الزراعة : سوبر فوسفات 46% بمعدل 80 كغ/هكتار. نترات أمونيوم 33% بمعدل 80 كغ/هكتار
- تمت الزراعة الآلية للبذار بتاريخ ١٣/١١/١٩٩٤

الملاحظات المسجلة :

مرحلة الإشتاء (كانون الثاني وشباط)

- لوحظ وجود خطوط صفراء اللون شاحبة وخطوط مجاورة خضراء يانعة في جميع المعاملات والأصناف. هذه الفروق كانت على أشدها في الصنف عربي أسود من إنتاج المزارع. وقد لوحظ أن هذه الخطوط الصفراء هي نفسها خط رمي التبن من الحصاد من حصاد الموسم السابق.

مما تقدّم يُلاحظ أن لآليء الأرض تُعتبر الآفة الأكثر خطورة، فهي بمثابة عامل محدّد لزراعة الشعير خاصة في المناطق الشمالية الشرقية من سورية. يليها من حيث الأهمية حشرات المنّ والتربس وبنفس السوية.

من الناحية المرضية يُعتبر البياض الدقيقي المرض الأكثر انتشاراً في حقول الشعير وخاصة في مناطق شرق حماة حيث ينتشر المرض وبانياً في بعض السنين التي يكون ربيعها رطباً. يليه من حيث الأهمية سفحة الرينكوسبوريوم وأمراض التبقة الهلمنزوسبوروي.

ملخص

نتيجة المسح الحقلّي للإصابات المرضية والحشرية على محصول الشعير في محافظات الحسكة والرقّة وحماة ودرعا خلال المواسم 90/1989 - 95/1994 توصلنا إلى النتائج التالية:

* التوزع المتباين للأمراض والحشرات في مناطق زراعة الشعير في محافظات الحسكة والرقّة وحماة، بينما ينتشر البياض الدقيقي في معظم المناطق بغضّ النظر عن حساسية الصنف المزروع.

* تباين حساسية أصناف الشعير تجاه الأمراض كالرينكوسبوريوم والهلمنزوسبوريوم في المنطقة الواحدة.

* يُعتبر البق الدقيقي من أكثر الحشرات ضرراً بمحصول الشعير في محافظات الرقّة والحسكة، ويليه من حيث الأهمية التربس.

* أدّت زراعة الشعير عامّاً بعد آخر إلى زيادة نسبة إصابته بالبِق الدقيقي وسفحة الرينكوسبوريوم والبياض الدقيقي والتبقة البني، في حين خفّض التبوير نسب الإصابات وشدّتها.

* إن إضافة الأسمدة كحزمة متوازنة على دفعتين أو ثلاث قد خفّض من إصابة نباتات الشعير بالأمراض كسفحة الرينكوسبوريوم والأسكوكيتا، بينما كانت النتائج متضاربة تجاه مرض البياض الدقيقي في الأرض المسمّدة وغير المسمّدة.

جدول (5): تأثير الدورات الزراعية على إصابة الشعير عربي أسود بالأمراض في ظروف العدوى الطبيعية (%). كطار ** - الرقة : 91/1990.

شعير/شعير	شعير/بيقية	شعير/جلبان	شعير/كرسنة	شعير/بور
سفة الرينكوسبوريوم	100	80	73	68
البياض الدقيقي	30	18	8	9
				7

نتائج متضاربة سُجِّلَت من خلال تطبيق الدورة الزراعية عام 1995 تجاه مرض البياض الدقيقي. فبينما كانت النتائج إيجابية في منطقة عين عيسى - بيليو تان بمحافظة الرقة باستعمال صنف الشعير عربي أسود، حيث انخفضت الإصابة من 65% عند زراعة الشعير بعد الشعير حتى 15% عند زراعة الشعير بعد البور، لم يلاحظ تأثير واضح للدورة الزراعية على الإصابة بالمرض في منطقة المالبية - الحسكة حيث بلغت الإصابة 83% (شعير/شعير) وبشدة 3-4 درجات في حين كانت في معاملة شعير/بور 80% وبكثافة 4 درجات.

وقد سُجِّلَت نتائج مماثلة في منطقة شولة بمحافظة الحسكة عام 1995 حول عدم فعالية الدورة الزراعية تجاه إصابات سفة الرينكوسبوريوم التي بلغت 75% وبشدة 4 درجات في الدورة شعير بعد شعير، في حين وصلت إلى 78% وبشدة 4 درجات في دورة الشعير بعد البور.

تُعتبر الدورة الزراعية والفلاحة المتكررة الحل المثالي والوحيد المتاح حالياً لمكافحة لآليء الأرض، حيث بلغت الإصابة 95% وبكثافة 3-6 حوريات/نبات في الأرض المزروعة شعير بعد شعير من صنف عربي أسود بمنطقة عين عيسى (بيليو تان) في محافظة الرقة، بينما انخفضت الإصابة إلى 8% وبكثافة 1-3 حوريات/نبات في الأرض المزروعة بالشعير بعد فترة تبوير (الجدول 6).

جدول (6): تقويم فعالية الدورات الزراعية تجاه إصابة نباتات الشعير /عربي أسود/ بلآليء الأرض (%، 1995

المنطقة	شعير/شعير	شعير/فلاحة بور	بور/بور
عين عيسى/بيليو تان ***- الرقة	95 (6-3/نبات)	8 (3-1/نبات)	0 (0)
المالبية ***- الحسكة	85 (7-3/نبات)	0 (0)	0 (0)
شولة ***- الحسكة	87 (8-4/نبات)	0,4 (3-1/نبات)	0 (0)

وقد تمّ التوصل إلى نتائج مماثلة فيما يتعلق بأفة لآليء الأرض باللجوء إلى الدورة الزراعية في منطقتي المالبية والشولة في محافظة الحسكة حيث بلغت الإصابات 85-87% في دورة الشعير بعد شعير، بينما انعدمت الإصابة تقريباً عند زراعة الشعير عربي أسود بعد التبوير والفلاحة الدورية.

جدول (3): تأثير التسميد على إصابة أصناف الشعير (%) بسفحة الرينكوسبوريوم، الرقة 91/1990.

أرض غير مسمدة				أرض مسمدة			
				اللويبة **			
ريحان 3	فرات 654	فرات 1	عربي أسود	ريحان 3	فرات 654	فرات 1	عربي أسود
0,0	5,0	0,5	0,5	0,0	3,0	0,0	0,0
				قطار **			
0,0	6,0	8,0	80,0	0,0	2,5	8,0	81,0

وفي موقع آخر أدى استخدام السماد ومبيد الأعشاب في معاملة واحدة أو كل على حدة إلى انخفاض مستوى الإصابات بسفحة الرينكوسبوريوم على صنف الشعير فرات 1 ولفحة الأسكوكيتا على أصناف الشعير فرات 1، فرات 654 وريحان 3 مقارنة بمعاملات الشاهد (الجدول 4).

جدول (4): تأثير التسميد وإضافة مبيد الأعشاب على إصابة أصناف الشعير بسفحة الرينكوسبوريوم ولفحة الأسكوكيتا ضمن ظروف العدوى الطبيعية - أم جهة/استقرار ثمانية/الحسكة 91/1990:

س = سماد؛ م = مبيد أعشاب؛ ش = شاهد (%)											
فرات 1				فرات 654				ريحان 3			
ش	س	م	س+م	ش	س	م	س+م	ش	س	م	س+م
6	2,5	0	0	-	-	-	-	-	-	-	-
3,5	0	0	0	3	1	0,5	0	2	0,5	0,5	0,5

أدت زراعة الشعير من صنف عربي أسود للعام التالي على التوالي إلى زيادة الإصابة بسفحة الرينكوسبوريوم البياض الدقيقي مقارنة بنباتات الشعير التي تلت البقوليات أو البور (الجدول 5).

أدى استخدام الأسمدة الأزوتية والفوسفاتية في موقع سيد علي بمحافظة الحسكة عام 1991 وبمعدل 25 كغ يوريا + 75 كغ نترات الأمونيوم + 100 كغ سوبر فوسفات / للهكتار إلى انخفاض إصابة نباتات الشعير بلفحة الأسكوكيثا مقارنة بالنباتات المزروعة في الأرض غير المسمدة (الجدول 1).

جدول (1): تأثير التسميد على إصابة أصناف الشعير بلفحة الأسكوكيثا (%) في ظروف العدوى الطبيعية سيد علي** - محافظة الحسكة 91/1990..

أرض غير مسمدة		أرض مسمدة	
عربي أسود	فرات 1	عربي أسود	فرات 1
45,0	47,0	22,5	28,5

بينما كانت النتائج متضاربة بشأن مدى استجابة صنف الشعير عربي أسود تجاه مرض البياض الدقيقي في الأرض المسمدة وغير المسمدة (الجدول 2).

جدول (2): إصابة أصناف الشعير بالبياض الدقيقي في الأرض المسمدة وغير المسمدة (%) ضمن ظروف العدوى الطبيعية 91/1990.

محافظة حماة فريتان**							
أرض غير مسمدة				أرض مسمدة			
عربي أسود	تدمر	W12291	عربي أسود	عربي أسود	تدمر	W12291	عربي أسود
70	100	0,0	100	100	100	0,0	70
محافظة الرقة - اللويبة**							
عربي أسود	فرات 1	فرات 654	ريحان 3	عربي أسود	فرات 1	فرات 654	ريحان 3
100	4	3	0,0	55	6,5	5,5	0,0

من جهة أخرى لم يؤثر تسميد التربة في حساسية أصناف الشعير تجاه سفحة الرينكوسبوريوم باستثناء الصنف فرات 654 الذي ازدادت شدة إصابته في الأرض غير المسمدة (الجدول 3).

تُعتبر لآليء الأرض Ground Pearls (*Porphyrophora spp*) الآفة الحشرية الأكثر انتشاراً وخطورة على محصول الشعير في سورية وخاصة في منطقة الاستقرار الثالثة وأحياناً الرابعة في محافظات الرقة والحسكة، حيث تراوحت الإصابات ما بين 3 و63% على أصناف الشعير عربي أسود وW12291 وتدمر في مناطق تل خضر وأم حجيرة في محافظة الحسكة، وإلى ما يزيد عن 45% في منطقة الكنطري بمحافظة الرقة عام 1990. هذا وقد بلغت الإصابات أوجها 95% في منطقة شارة بمحافظة الحسكة /1994/ وحوالي 35% في منطقة الحمر أما في محافظة الرقة فقد تشابهت إصابات البق الدقيقي مع مثيلاتها في الحسكة حيث بلغت 66% في منطقة بيليوتان و45% في منطقة كطار.

وفي عام 1995 تراوحت إصابات لآليء الأرض على الشعير عربي أسود وتدمر ما بين 7 و93% في مواقع سيده وتل أبيض وبيليوتان في محافظة الرقة وبكثافة 1-5 حوريات/نبات، في حين تراوحت الإصابات في مناطق الشويلة وسميتك في محافظة الحسكة ما بين 0 و37% وبكثافة 1 و7 حوريات/نبات.

هذا ويُعتبر انتشار آفة لآليء الأرض إلى مناطق جديدة لم يُعهد تواجدها فيها من قبل، كمحافظة أم العمد بمحافظة حماة، من الأمور الخطرة والتي ينبغي أن تتخذ في سبيل القضاء عليها مختلف الإجراءات الزراعية وبالسريعة الممكنة للحيلولة دون انتشار الحشرة إلى مناطق جديدة، علماً بأنه لم يُسجل خلال سنوات الدراسة وجود حشرات لآليء الأرض في محافظة درعا.

تحتل حشرات التريس Thrips المرتبة الثانية من حيث سعة الانتشار والضرر الذي تحدثه. وقد تراوحت نسب الإصابة على سنابل الشعير من الأصناف تدمر، عربي أسود وW12291 ما بين 30 و38% في منطقة بيرصران /استقرار ثالثة/ بمحافظة الرقة عام 1990 وبكثافة 11 حورية/سنبلة. أما في منطقتي السعن الجنوبي والسعن القبلي في محافظة حماة عام 1991 فقد رُصد انتشار واسع لحشرات التريس على أصناف الشعير عربي أسود، فرات 1، فرات 654 وريحان 3 وتراوحت الإصابات ما بين 35-90% وبكثافة 5-9 حوريات/سنبلة، وفي منطقة محجة بدرعا (1995) فقد أصاب التريس 65% من سنابل الشعير من صنف أكساد 1028 وبكثافة 10 حوريات/سنبلة.

بلغت إصابات المنّ Aphid على أصناف الشعير عربي أسود، ريحان 3، فرات 1 وفرات 654 المزروعة أشدها في مناطق سيد علي وتل باكو بمحافظة الحسكة عام 1990، حيث تراوحت ما بين 6 و51%، بينما كانت ضعيفة إلى متوسطة في محافظة الرقة. هذا وقد سُجل انتشار محدود جداً لحشرات المنّ (1,5%) عام 1991 على أصناف الشعير فرات 1 بمنطقة السعن الجنوبي بحماة، وعلى الأصناف عربي أسود وفرات 1 وريحان 3 (0,5%) في مناطق مختلفة من محافظة الرقة. كما سُجلت نفس نسبة الانتشار (0,5%) في منطقة أم حجيرة بمحافظة الحسكة. أما في عام 1994 فقد لوحظ انتشار واسع لحشرات المنّ على نباتات الشعير من مختلف الأصناف في محافظة الحسكة، حيث تراوحت الإصابات ما بين 19 و70% في موقع الحمر، بينما كانت إصابات المنّ متوسطة إلى ضعيفة في محافظة الرقة ومعدومة تقريباً في محافظتي حماة ودرعا. هذا ولم يُسجل نشاط ملاموس لحشرات المنّ في مواقع التجارب لعام 1995.

العمد في محافظة حماة عام 1994. كذلك رُصد التبّع الشبكي Net blotch الناتج عن تطفّل الفطر *H.teres* على صنف الشعير عربي أبيض وعربي أبيض محسّن (92%) في منطقة معرّس بحماة- وعلى الصنف عربي أبيض محسّن (70) في منطقة محجة بدرعا عام 1995.

تنتشر لفحة الأسكوكيّا *Ascochyta blight* (*A.graminicola*) على نباتات الشعير في مناطق محدودة في القطر العربي السوري حيث تراوحت نسب الإصابة في محافظة الرقة عام 1990 ما بين 0 و21% على أصناف الشعير عربي أسود، W12291، تدمر، ریحان 3، وفرات 1، وبلغت الإصابة حدّها الأعظمي (35-39%) على صنف الشعير عربي أسود وفرات 1 في منطقة سيد علي بمحافظة الحسكة.

وعلى الرغم من محدودية انتشار المرض فقد رُصد ثانيةً عام 1991 على صنف ریحان 3 (0,5%) في موقع الجرن الأسود بمحافظة الرقة وبدرجة أشدّ (6-55%) على الأصناف عربي أسود، فرات 1، فرات 654 وریحان 3 في موقع سيد علي بمحافظة الحسكة. هذا ولم يُسجّل المرض على الشعير في الأعوام اللاحقة من عمل الدراسة كما لم يُعثر له على أثر في محافظتي حماة ودرعا.

وفيما يتعلّق بالتبّع السبّتوري *Septoria leaf spot* فقد رُصد المرض على صنف الشعير فرات 654 وریحان 3 بنسبة لم تتجاوز 1% في محافظة الرقة عام 1990. ولم تتجاوز نسبة المرض 3% على الأصناف W12291، تدمر، ریحان 3، وفرات 1 في مناطق سيد علي، تل أخضر وأم حجية بمحافظة الحسكة. هذا ولم يُسجّل حدوث المرض في الأعوام اللاحقة للدراسة.

تمّ تسجيل مرض صدأ الورقة *(P. hordei) leaf rust* على نباتات الشعير في موقع السعن القبلي والسعن الجنوبي بمحافظة حماة على الأصناف ریحان 3، فرات 654، فرات 1 وعربي أسود، حيث تراوحت الإصابات ما بين 3 و100% (1991). هذا وقد سُجّل حدوث المرض أيضاً في منطقتي أم العمد وبرّي شرقي عام 1994 على صنف الشعير عربي أبيض (5MR)، وفي منطقتي معرّس (50MR) على الصنف فرات 2 وقنص (2-7MR) على الأصناف أكساد 1028 وأكساد 410 وعربي أبيض وفرات 1 وفرات 2 في محافظة حماة عام 1995.

يحتلّ مرض التفحم المغطى والسائب Loose and covered smuts المركز الأخير من حيث الانتشار على نباتات الشعير في سورية، حيث لم تتجاوز نسبها 0,001% في معظم حقول محافظات الرقة والحسكة وحماة، باستثناء بعض المواقع ككطار (الرقة) حيث بلغت الإصابة أوجها (7%) على صنف الشعير عربي أسود، وتراوحت ما بين 0 و70% على نفس الصنف في مواقع تل خضر وأم حجية في محافظة الحسكة عام 1990، بينما بلغت الإصابة 0,5% على الصنف تدمر في منطقة تل التوت شرق محافظة حماة عام 1991.

هذا وقد سُجّل وجود التبّع الألتيرناري *Alternaria spot* والعفن الزيتوني *Olive mould* في بعض المواقع على الأوراق الجافة من الطوابق السفلى لنباتات الشعير من مختلف الأصناف وذلك بعد سقوط الأمطار /0-9% في محافظتي الرقة والحسكة عام 1990، في حين لم تُلحظ الإصابات البكتيرية والفيروسية على نباتات الشعير خلال مراحل الدراسة بشكل ملموس.

أوجها (100%) وبشدة 5-6 درجات على أصناف الشعير عربي أسود وتدمر خلال موسم 91/1990 وعلى الصنف عربي أسود للموسم 94/1993 ، وعلى الأصناف عربي أسود وأكساد 410 للموسم 95/1994 . في حين تدرجت الإصابات ما بين 0 و90% في مختلف المواقع ولمختلف الأصناف. وتعتبر سفحة الرينكوسبوريوم *Rhynchosporium (R.secalis)* من الأمراض الواسعة الانتشار على محصول الشعير في مختلف المحافظات التي أجريت فيها الدراسة، وخاصة في المناطق الشمالية الشرقية من القطر حيث بلغت نسبة انتشار المرض 100% على الصنف W12291 في منطقة بيليو تان، الرقة، 1994، وحوالي 84% على صنف فرات 654 في منطقة حشيشة، الرقة، 1990 ، وما بين 60 و87% في منطقة سيميتك، الحسكة، 1994 و1995، وما بين 76 و94% في منطقة أم حبيرة، الحسكة، 1990، وبشدة 4 درجات في حدّها الأعظمي.

أما في محافظة حماة فلم تلاحظ إصابات ملموسة بسفحة الرينكوسبوريوم خلال المواسم 90/1989، 91/1990، 93/1992، وتراوحت ما بين 45 و87% في منطقة قنص عام 1995. تختلف حساسية أصناف الشعير تجاه سفحة الرينكوسبوريوم، فبينما كانت الإصابات شديدة على الصنف W12291 (94%) ، انعدمت الإصابة على الصنف ريجان 3 خلال الموسم 90/1989، وقد تمّ التوصل إلى نتائج مماثلة في السنوات اللاحقة فيما يتعلق بنفس المرض.

يصيب التبقع الهلمنزوسبوري *Brown leaf blotch (H.sativum)* أصناف الشعير المزروعة في القطر بدرجات متفاوتة، وهو يحتل المرتبة الثالثة من حيث الانتشار وشدة الإصابة. فقد تراوحت نسب انتشار المرض ما بين 0 و40% في محافظة الرقة لعام 1990 على مختلف الأصناف المزروعة (تدمر، عربي أسود، فرات 1، فرات 654، ريجان و W12291) ، وبلغ انتشاره 30-90% على صنف الشعير تدمر في منطقتي بيليو تان واللويبة في عام 1994، في حين كان تواجد المرض ضعيفاً جداً في مواسم 91/1990 و95/1994.

من جانب آخر تراوحت نسب إصابة نباتات الشعير في منطقتي صفيا وسيد علي في محافظة الحسكة لعام 1991م 5-12% على الأصناف عربي أسود وفرات 1 ، ثم ارتفعت نسبة الإصابة وشدتها عام 1994 فتراوحت ما بين 5 و75% على الأصناف تدمر، زنبقة وعربي أسود. وفي عام 1995 بلغت نسب الإصابة أوجها (35-80%) وبشدة 2-6 درجات.

وبينما كانت الإصابة بالتبقع البني الهلمنزوسبوري معدومة في حقول الشعير بمحافظة حماة عام 1991، انتشر المرض في المحافظة عام 1994 وبلغت نسبته 85% على الصنف عربي أبيض (معرشور) وبشدة 3 درجات، ووصلت الإصابة إلى 93% على الصنف أكساد 1028 في منطقة قنص عام 1995 وبشدة 4 درجات.

ومن بيانات الإصابة بالتبقع الهلمنزوسبوري للمواسم الخمسة الماضية تبين أنه لا توجد اختلافات في حساسية أصناف الشعير المزروعة تجاه المرض، حيث تعتمد شدة الإصابة وانتشارها على حمولة البذار من مادة اللقاح وعلى وجود تعضيات الفطر الممرض في البقايا النباتية للموسم السابق. إذ تبين أن الصنف غير المصاب في منطقة ما أكساد 1028 درعا) يُصاب بشدة في منطقة أخرى (قنص بمحافظة حماة: 92% -1995).

فيما يتعلق بأمراض التبقع الهلمنزوسبوري الأخرى فقد سجّل تخطّط الشعير *Barley stripe* الناتج من تطفل الفطر *H.gramineum* على صنف الشعير عربي أبيض في منطقة أم

إن زراعة مساحات واسعة بالشعير وتكرار الزراعة عاماً بعد آخر، ومع استخدام البذار غير المغريل الحاوي على الشوائب، أدى إلى انتشار الأعشاب الضارة التي تنافس نباتات الشعير في غذائها وتحد بالتالي من إنتاجية هذه النباتات في وحدة المساحة، حيث يُقدّر فقد الغلة السنوي نتيجة لتطفل الأعشاب الضارة ما بين 6,8-15,7% وعموماً يبلغ متوسط الفقد في الغلة على المستوى العالمي والناتج عن تطفل الحشرات والأمراض والأعشاب الضارة على المحاصيل الزراعية بمختلف أنواعها حوالي 25-43,3%.

مما تقدّم يتضح الدور الهام الذي يمكن أن تؤديه عمليات الوقاية من الأمراض والحشرات ومكافحة الأعشاب الضارة في الحد من الخسائر وفي رفع مستوى الإنتاج والإنتاجية في وحدة المساحة.

إن الهدف الرئيسي من مسح الإصابات المرضية والحشرية على محصول الشعير في سورية هو الوقوف على المعوقات التي تحول دون زراعة الشعير في بعض المناطق وتخفيض الإنتاج والإنتاجية، ومن ثم ترتيبها حسب أهميتها ومدى انتشارها بغية إيجاد الحلول العملية لها.

مواد وطرق العمل:

تمّ الكشف على نباتات الشعير في تجارب مشروع المشرق في حقول المزارعين الموزعة في مناطق الاستقرار الثانية والثالثة في محافظات الحسكة والرقّة وحماة ودرعا خلال المواسم 90/1989، 91/1990، 93/1992، 94/1993، 95/1994، حيث تمّ تحديد الإصابات بالفحص الحقلّي - العيني والمخبري وقدرت نسب الإصابة بالأمراض والحشرات وشدها ضمن ظروف العدوى الطبيعية ووفقاً للمقاييس المعتمدة دولياً على أصناف الشعير: عربي أسود، عربي أبيض، عربي أبيض محسن، تدمر، فرات 1، فرات 2، فرات 645، ربحان 3، زنبقة، أكساد 410، أكساد 1028.

كذلك دُوّنت نسب الإصابة وشدها في بعض تجارب مشروع المشرق لدراسة تأثير الدورات الزراعية والتسميد على الإصابات المرضية والحشرية. أُخذت القراءات لمرة واحدة خلال موسم النمو ابتداءً من نهاية شهر آذار وحتى بداية شهر أيار وبواقع عشر مكررات لكل قراءة وبمعدل عشرون نباتاً في كل مكرر.

النتائج والمناقشة :

تتوزع الإصابات المرضية والحشرية على نباتات الشعير بشكل متباين في محافظات القطر حيث تختلف شدها من موسم لآخر على نفس الصنف وفي الموقع نفسه، وفقاً لحساسية الأصناف المزروعة وكثافة مادة اللقاح وفوعة المسبب الممرض والظروف البيئية السائدة في المنطقة.

يعتبر البياض الدقيقي (Powdery mildew (*E. graminis* f.sp. *hordei*) المرض الأكثر انتشاراً على أصناف الشعير في مختلف محافظات القطر (حماة، الحسكة، الرقة ودرعا)، وخاصة في مناطق الاستقرار الثانية والثالثة شرق محافظة حماة حيث بلغت الإصابات

المشاكل المرضية والحشرية على محصول الشعير في سورية

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مقدمة

يعتبر الشعير أحد المحاصيل الزراعية الاستراتيجية في القطر العربي السوري حيث يحتل مساحة تقارب 2,196,000 هكتاراً وهذا يعادل حوالي 40,5% من مجمل المساحات الكلية المزروعة فعلاً في سورية لعام 1993، وهو يشغل 51,4% من مجمل المساحات المزروعة بعلاً بالمحاصيل الشتوية.

هذا ونتيجة للتوسع المخطط في زراعة المحاصيل الزراعية الاستراتيجية فقد ازدادت المساحات المزروعة بالشعير من 1,032,565 هكتار عام 1978 إلى 1,569,866 هكتار عام 1987، وإلى حوالي 2,196,000 هكتار عام 1993 م وبلغ إجمالي إنتاج القطر من الشعير 728,695 طن عام 1978 ووصل إلى 756,300 طن عام 1987 وحوالي 1,553,000 طن عام 1993، بإنتاجية تراوحت ما بين 706 و716 كغ/هـ.

ونظراً لأهمية محصول الشعير كمكون أساسي في علائق الحيوانات، ولكونه مادة أولية تدخل في العديد من الصناعات الغذائية فقد أصبح الاهتمام بالإنتاج كماً ونوعاً أمر يشغل المخططين والباحثين. وفي هذا المجال تعتبر وقاية نباتات الشعير من الإصابات المرضية والحشرية إجراء على غاية من الأهمية للتقليل ما أمكن من الفقد النسبي في الإنتاج والذي يصل في بعض مناطق القطر إلى حد أعظمي /أكثر من 50%/.

وعلى المستوى العالمي تسبب أنواع الصدأ فقداً سنوياً في محصول الشعير يقارب 10%، ويصل الفقد إلى 40% في حالة التفحم السائب، بينما يتراوح الفقد الناتج عن البياض الدقيقي ما بين 15 و20%، وقد يرتفع في بعض الأحيان ليصل إلى 40%، وبالنسبة لمرض السبثوريا والتبقع المخطط فقد يحدث فقداً في الإنتاج يصل إلى 20%، وفي حالة الأسكوكيثا إلى 20-30% والتبقع البني إلى 30-40% وإلى حوالي 3,5-15% بالنسبة لأعفان الجذور. وتختلف عموماً شدة الإصابة المرضية من مكان لآخر ومن موسم لموسم وذلك تبعاً لحساسية الصنف المزروع ونوعية المسبب الممرض وكثافة مادة اللقاح والظروف البيئية المحيطة.

من ناحية أخرى تسبب الحشرات الضارة فقداً كبيراً في إنتاج الشعير وتسيء إلى نوعية المنتج، وقد يستمر ضرر بعضها لما بعد الحصاد. وعموماً يعتبر البق الدقيقي /آلئ الأرض / عاملاً محدداً في زراعة الشعير في بعض المناطق السورية. وحسب المراجع العلمية يبلغ الفقد السنوي الناتج عن تطفل حشرات التريبس على محاصيل الحبوب 5-24% وذلك اعتماداً على كثافة الحوريات في السنابل.

تل حديا. إن المشكلة تكمن في إدارة الرعي والحاجة إلى آليات الحش وكبس البالات ويمكن القول أن مرعى من البقوليات العلفية يمكن أن يقدم العلف اللازم لـ 20/ نعجة / هكتار تنتج حوالي 1500 كغ حليب/هكتار. وهكذا فإن نظام الانتفاع بالأرض يؤدي إلى زيادة خصوبة التربة وبالتالي زيادة مردود محصول الشعير.

الاستنتاج :

يمكن توفير تقنية مناسبة لتحسين واستقرار معظم الأنظمة المزرعية البعلية والفوائد الاقتصادية واضحة، كما يمكن زيادة العائد من محصول الحبوب والمواشي على السواء. والتحدّي الذي يواجه الزراعيين هو تطوير هذه التقنيات إلى تطبيق حقلّي وإقناع المزارعين وواضعي السياسات الزراعية بفائدتها.

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3. الرعي :

في كل دورة كانت تتم عمليات رعي البقوليات العلفية وتتراوح ما بين 25 و70 يوم حسب عدد الأغنام الذي يتراوح ما بين 70 و100 رأس من الخراف أو النعاج. وقد لاحظ مربو الأغنام أهمية البقوليات العلفية للرعي، والتي حققت لهم الاستقرار وعدم التنقل إلى مناطق بعيدة للبحث عن أعلاف إضافية. كما لوحظ إقبال الأغنام بدرجة كبيرة على رعي محصول البيقية العلفية وحسن استساغتها لهذا المحصول وقلة استساغتها للمحصول الكرسة الذي كان إقبال الأغنام عليه ضعيفاً، حيث بقيت نسبة بدون رعي - وكانت الاستساغة 95% لمحصول البيقية العلفية و80% للجلبانة و55% للكرسة. وقد أكد معظم المزارعين أن البيقية العلفية جيدة للرعي كمحصول علفي. فقد ظهرت زيادة وزنية على الخراف وبمعدل 6-7 كغ/الرأس الواحد. وأعطت النعاج التي ترعى البيقية كميات كبيرة من الحليب. وتولدت الرغبة لدى المزارعين بزراعتها من أجل تقديم أعلاف إضافية لأغنامهم، خاصة وأنهم لمسوا أن للمحصول أثر إيجابي في تحسين خصوبة التربة وبالتالي في تحسين إنتاج الشعير في المواسم التالية. كما تولدت لديهم القناعة الكافية بأن إدخال البقوليات سيؤثر إيجاباً في الحد من انتشار الأمراض والآفات وخاصة حشرة بق الحبوب الدقيقي.

جدول 3: عدد الأغنام وعدد أيام الرعي والزيادة الوزنية غ/راس/يوم حسب المواسم.

الموسم	عدد الأغنام	عدد أيام الرعي	الزيادة الوزنية
1991/1990	50	30	158
1992/1991	25	70	170
1993/1992	70	25	125
1994/1993	100	50	170
1995/1994	100	50	168

المناقشة :

إن نظام الإنتفاع بالأرض وتحقيق قدر من الربح في القطاع الزراعي بشقيه النباتي والحيواني يحتم تغيير النظام الزراعي المتبع والتخلص من البور عن طريق إدخال البقوليات العلفية التي تلعب دوراً مهماً في الزراعة البعلية للمحافظة على خصوبة التربة وتوفير الأعلاف وتحقيق إنتاج مقبول.

وإن الزراعة المطرية لا تقتصر على توفر المياه فحسب، بل لابد من توفر تقنيات أخرى مثل الأسمدة. وقد يؤدي إدخال المحاصيل البقولية وتربية المواشي مع زراعة الحبوب إلى خلق نظام اقتصادي زراعي ثابت ومنتج.

تؤدي زراعة البيقية مكان البور وإضافة الأسمدة الفوسفاتية إلى زيادة كفاءة الزراعة من خلال زيادة عدد الأغنام. ثم إن إنتاج الحبوب من الشعير لم يتناقص نتيجة استبدال البور بالبيقية، وهذه النتائج تم تأكيدها بتجارب أخرى في مناطق أكثر جفافاً في

المادة الخضراء إذ تزداد بازدياد الهطول المطري وتوزيعه أثناء موسم النمو ودوره إيجابي في زيادة الغلة.

إن إدخال البقوليات العلفية في الدورة الزراعية يحقق إنتاجية مقبولة من المادة الخضراء والجافة التي تفيد في تغذية المواشي وتأمين المراعي الخضراء خلال فصل الشتاء حيث تندر الأعلاف في المراعي الطبيعية وحيث ينشط موسم الولادات وإنتاج الحليب.

جدول 1: متوسط إنتاج البقوليات العلفية خلال مواسم 1990-1992 من المادة الخضراء والجافة. (الإنتاج طن/هـ)

المحصول / الموسم		1991/1990		1992/1991		متوسط الثلاث سنوات	
المادة		خضراء	جافة	خضراء	جافة	خضراء	جافة
بيقية	19,8	4,3	13	4,5	16,4	4,4	
جلبان	15,7	3,2	10,2	2,9	12,9	3,05	
كرسنة	16,9	3,8	11,5	3,25	14,2	3,25	

2. إنتاج الشعير :

تختلف الغلة باختلاف الدورة الزراعية وتتراوح من 1615 كغ/هـ في دورة شعير/شعير و17.7 كغ/هـ بعد بور إلى 1879 كغ/هـ بعد بقوليات علفية. وهكذا يظهر بأن غلة الشعير تزداد بعد البقوليات العلفية وتتناقص بعد بور وبعد شعير باستمرار. وهذا يفسر دور البقوليات العلفية في تأمين عناصر غذائية تغني التربة ويستفيد منها محصول الشعير التالي. كما أن إنتاج الشعير بعد بقوليات علفية يتفوق بمقدار 16% مقارنة بإنتاج الشعير بعد شعير وبمقدار 5% بعد بور، وإن الفروق في إنتاج الشعير بعد بقوليات علفية هي فروق غير معنوية.

جدول (2): إنتاج الشعير من الحب حسب الدورة الزراعية للمواسم 1990-1993. (الإنتاج كغ/هـ).

الدورة / الموسم	1991/1990	1992/1991	1993/1992	متوسط 3 سنوات	الرقم القياسي
شعير/بقوليات	1210	2617	1811	1879	116 105
شعير/بور	1262	2088	1770	17.7	1.6 100
شعير/شعير	1238	2200	14.7	1615	100 -

صُمِّمَتْ كل مشاهدة لتحتوي ست دورات ثنائية بمكررين وبمساحة /24 دونم/ لكل موقع. (دورة شعير/شعير - شعير/بيقية - شعير/جلبان - شعير/كرسنة - شعير/بور رعي - شعير/بور نظيف). واستخدمت البذارة الآلية للزراعة وبمعدل 100 كغ/هـ للشعير والبقوليات العلفية وأضيفت الأسمدة الآزوتية والفوسفورية التالية للشعير : 100 كغ/هـ سوبر فوسفات، 46٪ تضاف 46٪ منها عند الزراعة. 50 كغ/هـ سمار يوريا، يُضاف 46٪ منها كدفعة أولى عند الزراعة. 75 كغ/هـ سمار ونترات الأمونيوم، يُضاف 33٪ منها كدفعة ثانية عند الإشطاء. بينما أضيفت الكميات التالية للبقوليات العلفية : 30 كغ/هـ نترات الأمونيوم، 33٪ منها يُضاف عند الزراعة. 90 كغ/هـ سوبر فوسفات، 46٪ منها يُضاف عند الزراعة. تمَّتْ للمكافحة حسب الحاجة بمبيد رايكو بور كومبي وبمعدل 675 مل/دونم لحقول الشعير. كما تمَّ رعي البقوليات العلفية بعدد محدود من الأغنام ولفترة محدودة، وتمَّ حصاد الشعير عند النضج التام. كما نفَّذت مشاهدات البيقية العلفية للرعي المباشر في دورة شعير/بيقية علفية خلال المواسم /1992-1995/ في المواقع التالية :

حماة - مواقع : طيبة الإمام، موسم 1993/1992

أم العمد - معردس - طيبة الإمام، موسم 1994/1993

أم العمد - معردس - معر شحور - كوكب - الجاجية، موسم 1995/1994

الرقعة - مواقع : حمام التركمان، موسم 1993/1992

كطار، موسم 1994/1993

كطار - سكرية - المالحه - جاموس - بنر محيسن - لوبيدة، موسم 1995/1994

الحسكة - مواقع : صوفيا، موسم 1993/1992

تل براك، موسم 1991/1990

تل براك - أم جهفة - سيمتك - موسم، 1994/1993

تل براك - سيمتك - سيجوا - الشيخ أمين، موسم 1995/1994

وقد بلغت مساحة كل موقع 5/ دونم واستُخدم مع بذار 120 كغ/هـ لصنف البيقية العلفية للرعي. وفي بداية الإزهار تم تقدير المادة الخضراء والجافة. وتمَّ رعي الحقول من قبل المربين وبمعدل أربع ساعات يومياً بجولة 30/ رأس/هـ.

النتائج :

1. إنتاج المادة الخضراء :

تراوح إنتاج المادة الخضراء للبقوليات من 9/12 طن/هـ إلى 4/16 طن/هـ والمادة الجافة من 25/3 طن/هـ إلى 4/4 طن/هـ وتلعب الظروف المناخية دوراً مهماً في إنتاج

أهمية البقوليات العلفية في الدورة الزراعية

م. ياسين سويدان، م. فايز عنبر، م. عبد اللطيف الشامي، م. محمد ويسو محمد

مقدمة :

منذ بداية السبعينات بدأ يظهر بوضوح النقص الكبير في إنتاج اللحوم الحمراء مقارنة بالكمية المستهلكة. ولربما يعود السبب الرئيسي في هذا النقص في الإنتاج إلى قلة إنتاج الأعلاف، والتي تشكل العامل الرئيسي الفاعل في تقدم تربية المجترات. ومن أهم طرق معالجة نقص الأعلاف اللازمة لتغذية المواشي هي القيام بزراعة البقوليات العلفية ضمن دورة زراعية في المناطق البعلية ذات الأمطار الجيدة أو الأراضي المتروكة بوراً، مما يؤدي إلى زيادة في إنتاج الأعلاف اللازمة لتغذية المواشي، بالإضافة إلى تحسين خواص التربة وتقليل ضغط الرعي على المراعي الطبيعية للحد من تدهورها. لازالت الجهود المبذولة لتطوير النظم الزراعية بإدخال البقوليات العلفية محدودة رغم أهميتها البالغة. ولم يحظى هذا الموضوع بالقدر اللازم من الاهتمام ليصبح النظام الزراعي (بقول/حبوب) بدلاً من (بور/حبوب).

الهدف من البحث :

يهدف البحث إلى زيادة إنتاجية المزارعين الذين يطبقون نظام التكامل بين زراعة المحاصيل وتربية الأغنام، وإلى استقرار الغلة وزيادة إنتاج الأعلاف وإدخال البقوليات العلفية في مناطق إنتاج الحبوب. كما يهدف إلى إيجاد نظام زراعي متكامل بين الإنتاجين النباتي والحيواني والقضاء على البور وتحسين خواص التربة وزيادة إنتاج الشعير في المناطق الجافة وتأمين الأعلاف الخضراء أثناء ندرتها خلال فصل الشتاء حيث موسم الولادات وإنتاج الحليب.

مواد وطرق البحث :

أجريت المشاهدات في حقول المزارعين خلال السنوات 1989-1995/ حول إدخال البقوليات العلفية للرعي في دورة شعير/بيقية علفية في مناطق الاستقرار الثانية في محافظات حماة والرقعة والحسكة لإيجاد نظام زراعي متكامل والقضاء على البور وزيادة إنتاج العلف ومحصول الشعير. وخلال المواسم 1989-1992/ نفذت مشاهدات الدورات الزراعية في المواقع التالية :

محافظة حماة - موقع الكبارية خلال مواسم 1989-1992/.

محافظة الرقة - موقع قطار خلال مواسم 1989-1992/.

محافظة الحسكة - موقع سيد علي خلال مواسم 1989-1992/.

أهمية البقوليات العلفية في الدورة الزراعية

م. ياسين سويدان، م. فايز عنبر، م. عبد اللطيف الشامي، م. محمد ويسو محمد

أجريت خلال السنوات 1989-1992 مشاهدات في حقول المزارعين بهدف إدخال البقوليات العلفية في دورة زراعية مع الشعير لإيجاد نظام زراعي إنتاجي متكامل للإنتاج النباتي والحيواني للقضاء على البور وزيادة إنتاج الشعير وتأمين الأعلاف الخضراء للأغنام أثناء ندرتها في المناطق الجافة.

أشارت النتائج إلى تفوق إنتاج الشعير في تناوب مع البقوليات العلفية وبحدود 19-28% زيادة عن إنتاج الشعير بعد شعير أو بعد بور، مما يجعل منها بديلاً اقتصادياً مهماً عن التبوير ضمن توفير أعلاف خضراء لتنمية الثروة الحيوانية: 13 طن مادة خضراء و4,5 طن مادة جافة من البقية العلفية و10 طن مادة خضراء و2,9 طن مادة جافة من الجلبان و11 طن مادة خضراء و3,25 طن مادة جافة من الكرسة.

وهكذا فإن هذا النظام يضمن توفير كميات كافية من الأعلاف الخضراء لرعي الأغنام أو تحفظ كدريس لمواجهة متطلبات الثروة الحيوانية خلال فصل الشتاء، بالإضافة إلى تحقيق زيادة أكيدة في إنتاج الحبوب المزروعة في أعقاب تلك البقوليات وذلك بسبب الأثر الخصوبي الذي تتركه الأعلاف الخضراء.

كما يمثل هذا النظام تطوراً اقتصادياً واجتماعياً يتيح للمزارع استغلال الأرض سنوياً بدلاً من استغلالها كل سنتين.

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- 7 - المشاكل المرضية والحشرية على محصول الشعير في سورية.
(د. صلاح الشعبي)
- 16 - دراسة ظاهرة السنابل الفارغة على الشعير في بعض مناطق سورية.
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- 20 - رفع غلة الشعير من خلال شبكة من الأصناف المبشرة
في المناطق المطرية السورية.
(م. بهاء الدين جمال، م. محي الدين جية)
- 29 - أهمية المكعبات العلفية في تغذية الأغنام التي ترعى على بقايا المحاصيل.
(م. جميل أمين)
- البحوث المقدمة باللغة الانكليزية.

تحسين نظم تكامل الإنتاج النباتي والحيواني في غربي آسيا وشمال إفريقيا

6-8 تشرين الثاني/نوفمبر 1995

عمان، الأردن



المركز الدولي للبحوث الزراعية في المناطق الجافة
(إيكاردا)

