

PASTURE, FORAGE AND LIVESTOCK PROGRAM

Annual Report for 1992



Established in 1977, the International Center for Agricultural Research in the Dry Areas (ICARDA) is governed by an independent Board of Trustees. Based at Aleppo, Syria, it is one of 18 centers supported by the Consultative Group on International Agricultural Research (CGIAR), which is an international group of representatives of donor agencies, eminent agricultural scientists, and institutional administrators from developed and developing countries who guide and support its work.

The CGIAR seeks to enhance and sustain food production and, at the same time, improve socioeconomic conditions of people, through strengthening national research systems in developing countries.

ICARDA focuses its research efforts on areas with a dry summer and where precipitation in winter ranges from 200 to 600 mm. The Center has a world responsibility for the improvement of barley, lentil, and faba bean, and a regional responsibility—in West Asia and North Africa—for the improvement of wheat, chickpea, and pasture and forage crops and the associated farming systems.

Much of ICARDA's research is carried out on a 948-hectare farm at its headquarters at Tel Hadya, about 35 km southwest of Aleppo. ICARDA also manages other sites where it tests material under a variety of agroecological conditions in Syria and Lebanon. However, the full scope of ICARDA's activities can be appreciated only when account is taken of the cooperative research carried out with many countries in West Asia and North Africa.

The results of research are transferred through ICARDA's cooperation with national and regional research institutions, with universities and ministries of agriculture, and through the technical assistance and training that the Center provides. A range of training programs are offered extending from residential courses for groups to advanced research opportunities for individuals. These efforts are supported by seminars, publications, and by specialized information services.

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**International Center for Agricultural Research in the Dry Areas
P.O. Box 5466, Aleppo, Syria**

This report was written and compiled by program scientists and represents a working document of ICARDA. Its primary objective is to communicate the season's research results quickly to fellow scientists, particularly those within West Asia and North Africa, with whom ICARDA has close collaboration. Due to the tight production deadlines, editing of the report was kept to a minimum.

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Introduction

This year has been a busy and unsettled year with the preparation of the final draft of the 1994-1998 Medium Term Plan, and the arrival of a new program leader at the end of August 1992.

The Pasture, Forage and Livestock Program (PFLP) is committed to increasing the productivity and efficiency of small ruminant production in rainfed farming systems, through low input and low cost techniques and management.

It is organized into projects for the improvement of:

- small ruminant systems and their management
- sown pastures and forage production
- native pastures and rangelands

supported by cross-disciplinary activities on:

- agroenvironmental land resources and conservation
- microbiology and Nitrogen fixation
- socioeconomics
- and training

The 1992 annual report is in six sections, following this structure

Section 1, on small ruminant systems and flock management, gives basic information on feed and livestock trends in WANA as well as farmer-pastoralist perceptions of annual feeding and grazing patterns.

Contributions on small ruminant nutrition describe methods of predicting voluntary intake of cereal straw, an important component of sheep diets in most of the region. These methods will help the selection of varieties producing crop residues of high feeding value. Anti-nutritional factors have been assessed in forage legumes such as Vicia and Lathyrus. Finally, the forage value of fodder shrubs such as Atriplex and Salsola spp. is being examined, because of their potential in rangelands systems from Morocco to Balochistan.

Studies related to flock management are being expanded. The first results are reported from a series of experiments to define more precisely the effects of body condition, or fatness, and level of nutrition at mating on fertility and prolificacy of Awassi ewes. The performance of different strains of the Awassi breed is also being evaluated.

Epidemiological surveys of flocks in Syria have highlighted viral, lungworm and blood parasite infections, whose control may also improve the output of small ruminant production.

Section 2, on sown pastures and forage production, discusses the development of simple, sustainable cereal-legume rotation systems for the semi-arid environments of WANA. Continuous cereal cropping is the trend in the region, as shown in the Hassakeh Province survey. The importance of stimulating the exploitation of forage and pasture legumes is more and more acute, with feed shortages and declining cereal grain yields.

The seeds of Pasture legumes, such as medics, are expensive and not readily available in the region, therefore pasture persistence is essential. Persistence, assessed by changes in the seed bank of annual pasture legumes, is being carefully monitored in a barley/medic rotation at Breda, a site with 280mm annual rainfall. Understanding how each medic species maintains a seedbank in the soil is of paramount importance in understanding what constitutes an appropriate medic ideotype for low rainfall cropped and/or grazed environments.

The L13 long term wheat-medic rotation trial at Tel Hadya (350 mm rainfall/year) showed that cereal yields were lower after medic pasture than after bare fallow. In this trial, wheat will eventually be replaced by barley, because the barley grain yield is not depressed after medic compared with fallow and the output of the system is improved.

Research activities on nitrogen fixation were maintained during Dr Materon's sabbatical and have regained vigour since his return, with the emergence of new ideas. Section 3 deals with the

expansion of research on marginal land (unploughable land in cropping areas) to rangelands.

The work on the residual effect of phosphate application on marginal land is continuing, with the monitoring of the changes in vegetation on the unploughable land at Tel Hadya Station, Syria, under various stocking rates. The effect of these treatments on the rhizobial population of native Trifolium spp. of the plots was also assessed.

Fodder shrub plantations have been encouraged by many governments and international development agencies as a potential feed reserve in arid environments. The establishment and management of these plantations is not easy. Studies of the plantation of fodder shrubs (Atriplex spp.) on rangelands of Syria and Balochistan (AZRI-MART) and their utilisation by sheep are now expanding and yielding encouraging results. Socioeconomic studies are needed to assess the feasibility of transfer to sheep owners. Preliminary understanding of the feeding patterns of bedouin flocks in the NW Syrian steppe may help in determining the potential role of these plantations on rangelands.

Finally, the evaluation of land resources and rangeland began in the Jebel Abdel-Aziz, NE Syria, to support the crop-livestock integration in the neighbouring plain in Hassakeh province.

In Section 4, the first economic analysis of medic pastures in WANA is presented. The replacement of bare fallow by annual pasture legumes, such as medics, has long been advocated to improve the output of the cereal-livestock systems in the mediterranean region. In spite of their demonstrated merit in South and Western Australia, pasture legumes in rotation with cereals have had little success in west Asia and north Africa. This report indicates the possible reasons for the poor adoption of this system, based on results from the L13 rotation-grazing experiment carried out at Tel Hadya, complemented by on-farm and market survey data, and integrated in a whole farm model.

This model is also of importance for PFLP outreach activities (Section 5) in north Africa, where we have developed a project for improved integration of sheep-cereal-pasture in rainfed farming systems. This project has now been launched in Algeria with the Institut Technique des Grandes Cultures (ITGC), with whom large scale rotation and grazing trials have been established in El Khroub, near Constantine, in NE Algeria. The Inoculation Network (INONET) also has experiments with annual medics at this site.

Technology transfer, extension and training are slow processes (Section 6), especially when dealing with pasture production and utilisation. Seed production has long been identified as a constraint in the WANA region on pasture and forage development. A pod sweeper, thresher and seed scarifier were constructed and tested under practical conditions. These machines have now been sent to several national agricultural organizations for testing by extension workers and farmers.

In 1992, PFLP training involved some 60 participants on the main projects in livestock, sown pastures, rangelands, survey techniques, economics and computer data handling. Two post-doctoral fellows completed their studies as well as one PhD and two M.Sc.s.

Acknowledgements

I should like to thank the PFLP scientists and students who contributed to this annual report, as well as the technical staff for their unfailing support under difficult conditions. Special mention is due to Dr Luis Materon, who coordinated the collation and editing of this annual report. He worked in close cooperation with Ms Sonia Noaman, who prepared the manuscript, and Mrs Jan Treacher, who edited the English.

I also express my deep appreciation to the Japanese International Cooperation Agency for their support on animal health activities, and to the Tropical Agricultural Research Center on land

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Finally, thanks to all the other ICARDA programs, Units and regional coordinators for their active collaboration on various projects. - G. Gintzburger

Section I Small ruminant systems and management

1.1 Feeds and livestock trends, diet calendars

1.1.1 Rapid characterization of feeding and grazing calendars: techniques for single-visit interviews, summary and graphic presentation

Introduction

The need for information on the feeding and grazing calendars of ruminant livestock is greatest prior to the formulation of long running experiments on ways to improve animal nutrition in a given district. Such information is also needed to describe farming systems where livestock have important roles in resource use and income generation. Here we elaborate methods for a single-interview survey of farmers on livestock diets; we explain how the results can be summarized in tabular form and we describe a graphics technique for presenting the diet calendar in analog form.

An argument for multiple visits over several seasons is that the farmer's ability to recall dates, facts and numbers is quite poor. This is true, perhaps, for one-off events, such as the purchase or sale of a ewe, or for points of minor importance to the farmer, such as the purchase of foodstuffs for the family. For routine and important seasonal activities, such as feeding and grazing, we argue that it is possible to obtain accurate and detailed information in single-visit interviews.

The question of livestock diets will arise in the context of a specific district or farming area and in studies of national supply and demand for feed. Examples of national aggregate livestock and feed balances across the WANA region are given elsewhere in this volume by Nordblom and Shomo (1993). In countries where ecosystems and farming systems are diverse, national aggregate data will be of little value in understanding the use of feed and grazing resources

in a particular district. Where several species of ruminant livestock, such as sheep, goats, cattle, buffalo, equines and camels, depend in part on the same dietary resources, even district-level inventories of the various feeds will not alone distinguish species-specific diets. Where diets of some species are defined, however, the feed and grazing resources remaining for the others may be inferred using the district-level inventories.

Here we limit the discussion to methods for ascertaining the diet calendar of a single ruminant species. Though our methods apply as well to other species, we refer to sheep, and specifically to flocks of breeding ewes kept for milk and lamb production, to simplify our illustrations.

Single vs. multiple-interview surveys

The single-interview method may be contrasted, in terms of cost and completion time, with methods using multiple visits. Examples of the latter are given by Thomson et al (1989) and Jaubert and Oglah (1985) who report on separate three-year monitoring surveys. The sheep diet results of those surveys were similar to those from a single-interview survey in the same districts by Wachholtz et al (1993).

The single-interview survey of livestock diets can be rapid and still record farmers' information from recall, season by season, for the past year or for a "typical" year. Examples of single-interview survey results on sheep diets are given by Nygaard et al (1982), who covered 14 directors and 79 members of sheep and range cooperatives across seven provinces in Syria. Hand-fed feeds are covered in detail in the surveys of Nygaard et al (1982), Jaubert and Oglah (1985) and Thomson et al (1989), as these items are handled, purchased and sold by farmers and subject to direct measurement.

Although the proportions of diets grazed were not quantified in any of these three studies, the grazing sources in each case were named in rough terms.

Rapid surveys of crop livestock interactions at 33 sites in sub-Saharan countries by McIntire *et al* (1992) elicited grazing calendars from farmers. These indicated proportional quantities of three rough aggregations of grazing and feed sources (pasture, crop residue and browse) for cattle at several points in the annual cycle of rainy and dry seasons; no details of the survey methods were given.

Sampling methods

An informal survey of the study area and a thorough review of available literature and secondary data (maps, official statistics, etc.) are necessary to provide the initial basis for defining a sampling plan. Farming households may be chosen for interview in a two-stage sampling process. In the first stage, sub-sampling areas can be chosen at random or purposively, based on prior information about concentrations of livestock, etc. and visited. With the help of village heads in each sub-area, names of heads of households can be listed, a random sample of these drawn and willingness to participate confirmed. The sampling process requires informal discussions, which should be used to inform local authorities and heads of families about the aims and needs of the survey, and to gain their support.

Sample size will depend upon several points: diversity or homogeneity among sheep management systems in the study area, the need for accuracy of description within groups of systems and, most importantly, the time and resources allocated for the data collection phase of the study. These should be balanced against the time and costs of increments in sample size, and against the time

and costs which must be budgeted for analysis, interpretation and reporting of the results.

Interview methods

After pretesting the questionnaire with households outside the sample, a single round of formal interviews can be conducted. Questions for defining detailed sheep feeding and grazing calendars will probably form part of a larger questionnaire designed to collect other information. Here we focus on the diet calendar questions, adapted from those used in an earlier single-visit survey in Idleb Province, Syria (Nordblom, 1987).

The feed calendar questionnaire comprises a single sheet of paper with a column for each of the 12 months. A side column lists two main categories of feeds, hand-fed and grazed. In each category, names of feeds and grazing sources, known from the informal survey and pre-testing phases, are listed along with several blank spaces for "other" sources.

The first step, after describing the overall purpose of the questions, is to ask the sample farmer which feeds and grazing sources were consumed by his flock through a given one year period, on a month-by-month basis. This is an iterative procedure of putting check-marks in the cells of the table according to the farmer's responses, reviewing these with him, adding unlisted feeds where mentioned and making necessary corrections.

The second step is to ask the farmer to provide estimates in rough percentage terms of how the checked feeds in the table are comprised in each monthly diet. We have observed that farmers in Syria have no trouble with the concept of percentages and can be helpful in adjusting their original estimates, balancing them to give their best estimates for each period of the year, and checking that these add to 100 for each month.

In some months, several grazing sources are used and some hand-feeding takes place. Because it is impossible for them to know with certainty the proportions of hand-feeding and grazing in a monthly diet, except where these are at zero or 100 percent levels, farmers are asked to give their best estimates. This they have done with some confidence.

The feed table is reviewed once more with the farmer, allowing adjustments to the estimates, to complete the diet calendar questions. Information on quantities of hand-fed materials and areas of crops and stubbles grazed can also be elicited during the first stage of the interview. Earlier surveys, by Thomson *et al* (1989) and Jaubert and Oglah (1985), focused on quantities of hand fed materials, but did not pursue in detail the use of grazing resources, even though the latter were the main dietary source for 8 or 9 months of the year.

The total time required for questions on sheep diet calendars is from 20 to 30 minutes. In two recent surveys, of 128 sheep-owning households in the steppe and marginal dry farming areas of NW Syria, and of 214 farming households in the agricultural zones of NE Syria, the diet calendar questions were included in longer questionnaires (see Wachholtz *et al*, 1993, and Nordblom *et al*, 1993, this volume). These covered questions on feed sources, prices and quantities, transport costs, grazing areas, grazing rights, etc., as well as questions on cultivation practices, costs and returns.

Data summary methods

Where pre-testing and pre-coding have missed some feed or grazing sources in developing the questionnaire, new coding will be necessary. It will be desirable to combine feed titles that refer to the same or very similar materials, such as lentil straw and lentil tibun, while maintaining the identities of distinct feed or grazing

sources.

Clustering of sample farmers according to similarities in diet calendars is useful in identifying different types of livestock management in a study area. Separation of clusters may be according to differences in access to various feed resources, in farm size, flock size, etc. The discussion which follows refers only to the final summary of the average diet calendar for a given cluster of farmers.

Given a cluster of, for example, 10 farmers, there will be 10 pages of raw diet calendar data. A data file will be established for each month's diet across the 10 flocks. The **January** file will have 10 columns, each totalling to 100 percent and containing the January data for a different flock, and as many rows as there are reported feed or grazing sources. The average of the 10 values in each feed row is the average percentage contribution to the diets of the 10 flocks by that feed in January. Standard deviations for each feed may be computed at the same time.

New files are created and analyzed for each of the other months. The 12 monthly average columns may then be transferred to a single page, the diet calendar for the cluster of flocks. It is most convenient to round off percentage values: fractions greater than, or equal to, 0.5 are rounded up to the nearest whole percent, values less than 0.5 are shown as traces (+), and cases where no one reported use of a feed in a given month are shown as a point (.). For convenience, the diet calendar may be condensed by grouping categories of feeds under single headings. Cereal straw, for example, could include barley straw and wheat straw. For other purposes, it will be useful to report the results in detail.

Where several feeds appear in only trace amounts, or at low percentage levels, for only a few months of the year, these may be listed in the text to reduce the number of rows in the calendar

table. Examples of diet calendar tables from the earlier mentioned 1992 Aleppo and Hassakeh surveys are presented elsewhere in this volume by Wachholtz et al (1993) and Nordblom et al (1993).

A method for graphic display of diet calendars

Detailed tables are most valuable for archival documentation to allow different levels of aggregation for different uses. For visual impact and easy comprehension, however, a graphic display of the diet calendar is needed. Here we develop a graphic technique which allows the reader to take in the entire calendar year in a glance and yet easily distinguish monthly diets at the resolution of one percent.

Time is shown, clockwise, as a sequence of months equally spaced around a circle. Each month is assigned a 30° ($= 360^\circ/12$) slice of this pie chart. We define X and Y cartesian coordinates for each of 100 characters within each monthly slice, according to a precise geometric pattern.

The pattern is established as a compact arrangement of 100 circles within a 30° angle (Figure 1.1). Given a radius of 1, the coordinates of the center-point of the first circle (labeled 0) can be determined by trigonometry as follows:

Let C be the center of the chart of the annual diet calendar, and the origin of our X,Y coordinate system.

Let a be the X-coordinate of center point 0, and 1 the Y coordinate. Since the angle subtended by the X axis and the line from C to centerpoint 0 is 15° , we have: $a = 1 / \tan 15^\circ \approx 3.732$. The x-coordinates of the centerpoints of the circles touching the x axis are shown in Figure 1.1 as a, a+2, a+4, a+6, and so on.

The x-coordinates of the second row of circle centerpoints are shown in Figure 1.1 as a+3, a+5, a+7, a+9, and so on.

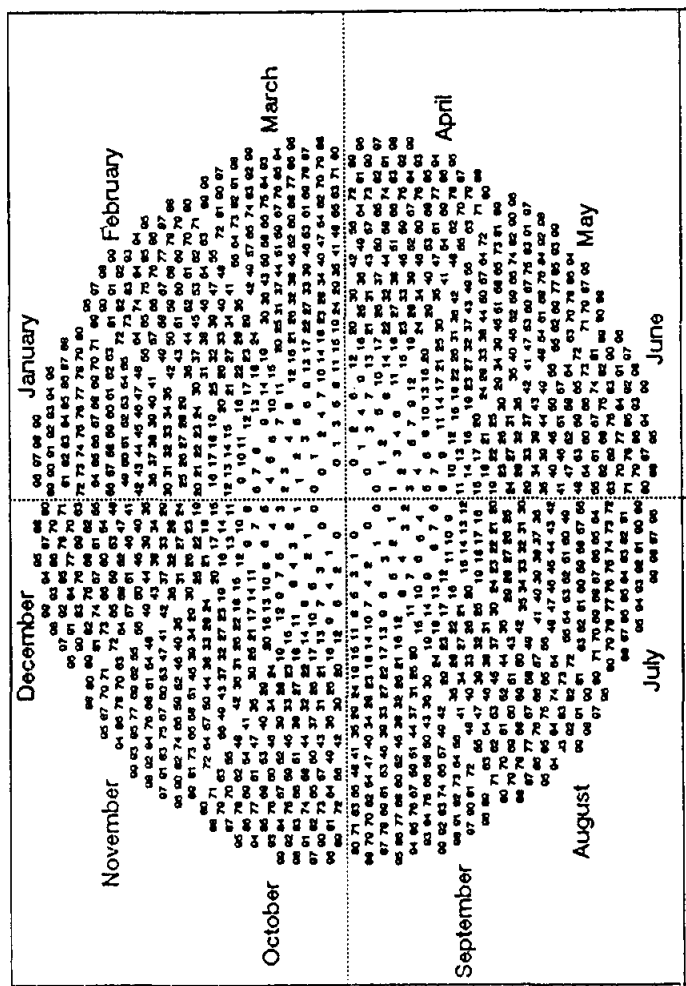


Figure 1.2. Feed symbol addresses for a diet calendar

The second line of centerpoints lies above that for the first row of circles by the length of the line **b** which bisects the equilateral triangle defined by centerpoints 1, 2 and 3 in Figure 1.1. From Figure 1.1, we calculate: $b = 1 / \tan 30^\circ \approx 1.732$. We have already defined the Y-coordinates of the first row of circle centerpoints as 1. Now it is clear that we can define the Y-coordinates of the second row of centerpoints as $1+b$, that of the third as $1+2b$, the fourth as $1+3b$, and so on.

We have labeled the circle centerpoints in a regular pattern of unique addresses as shown in Figure 1.1. These are expressed in a data file as follows:

Centerpoint Address	Coordinates	
	X	Y
0	3.732	1
1	5.732	1
2	6.732	2.732
3	7.732	1
4	8.732	2.732
5	9.732	1
6	9.732	4.464
7	10.732	2.732
8	11.732	1

and so on.

The month of March in Figure 1.2 continues the pattern of addresses, from 0 to 99, for a total of 100. The coordinates for addresses in February (Figure 1.2) are the same as those for March, but with rotation of the axes by 30° . This is done by transforming the cartesian coordinates of the March addresses to polar coordinates, adding 30° to each address angle, then transforming back to cartesian coordinates. Address coordinates for January were defined by a further 30° rotation, and so on through the other months, to complete the calendar graph.

To create a diet calendar graph, we define a symbol for each feed and specify the positions for these in the graph, according to

the address plan in Figure 1.2. Where a particular feed accounts for, say, 15 percent of the livestock diet in a given month, the symbol for that feed will be assigned to 15 of the graph addresses for that month. Examples of the use of our graphic technique for display of diet calendars are given elsewhere in this volume by Wachholtz *et al* (1993) and Nordblom *et al* (1993).

For convenience in data entry and plotting, one of the authors (Goodchild) has created a Quatro-Pro spreadsheet template. In the template file, months of the year, centerpoint addresses and X,Y coordinates are ready for use. The user needs only specify which symbols he/she wishes to be plotted at each address. The template occupies some 135 kb of disk memory and is available from the authors on request. - T.L. Nordblom, A.V. Goodchild and R. Wachholtz

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1.1.2 Feed and livestock trends in the WANA region

Introduction

A summary of livestock and feed trends in the west Asia/north Africa (WANA) region over the past twenty years is presented here in terms of livestock numbers, domestic feed production and diet compositions, using national data for fifteen selected countries. This addresses a gap in understanding the place and role of the various livestock and feed classes, and the growing importance of concentrate feeds in particular. Using population projections to the years 2000 and 2025, and assumed expansions in production of crop residues, we project strong declines in the per capita numbers of livestock units supported by domestic sources of feedstuffs and grazing.

Implications for ICARDA's research planning are explored, and a proposal is outlined to develop desegregated data bases, in partnership with NARS, in the planning stages of collaborative research projects.

Trends in livestock and poultry in WANA

National aggregate estimates on livestock numbers published by FAO (1991a) provide us with a starting point for a study of trends in 15 WANA countries (Afghanistan, Algeria, Egypt, Ethiopia, Iran, Iraq, Jordan, Libya, Morocco, Pakistan, Saudi Arabia, Sudan, Syria, Tunisia and Turkey). We chose to summarize the FAO livestock population data in four main classes:

1. **small ruminants** (sheep and goats),
2. **bovines** (cattle, buffalo),
3. **camels and equines** (horses, mules, donkeys), and
4. **poultry** (chickens and turkeys).

Year to year changes in national livestock numbers reflect fluctuations in weather, feed supplies and prices. Therefore, we calculated five-year averages in each of these four livestock classes for the periods 1967-71 and 1987-91 to show trends over a twenty-year span in Figure 1.3. Trend lines connecting the two five-year periods are plotted with livestock numbers in log scales. The diversity and trends in livestock populations among the countries are illustrated.

The explosive growth in poultry production is the most prominent feature of Figure 1.3. Nowhere was this growth greater than in Libya and Saudi Arabia.

The economic forces behind the expansion of poultry production are the same as those which should fuel an expansion in feedlot production: growing demand for livestock products, full use of existing crop residue and natural grazing resources, and the relative efficiencies of concentrate feeding.

There is no consistent trend among the 15 countries in changes in ruminant livestock numbers over the past 20 years. Pakistan, Ethiopia and Sudan are among the states with the largest ruminant populations in the WANA region and have reported steady or increased numbers in all classes (see Figure 1.3). Tunisia has shown similar trends, though it is among the states with lowest ruminant populations.

Turkey and Morocco have reported reduced populations of ruminants in all classes over the past 20 years.

Afghanistan and Iraq have reported strong reductions in small ruminant populations, likewise with Afghanistan's bovine population, while Iraq's was reduced slightly. Both countries reported nearly constant numbers of camels and equines.

AF = Afghanistan, AL = Algeria, EG = Egypt,
 ET = Ethiopia, IN = Iran, IQ = Iraq, J = Jordan,
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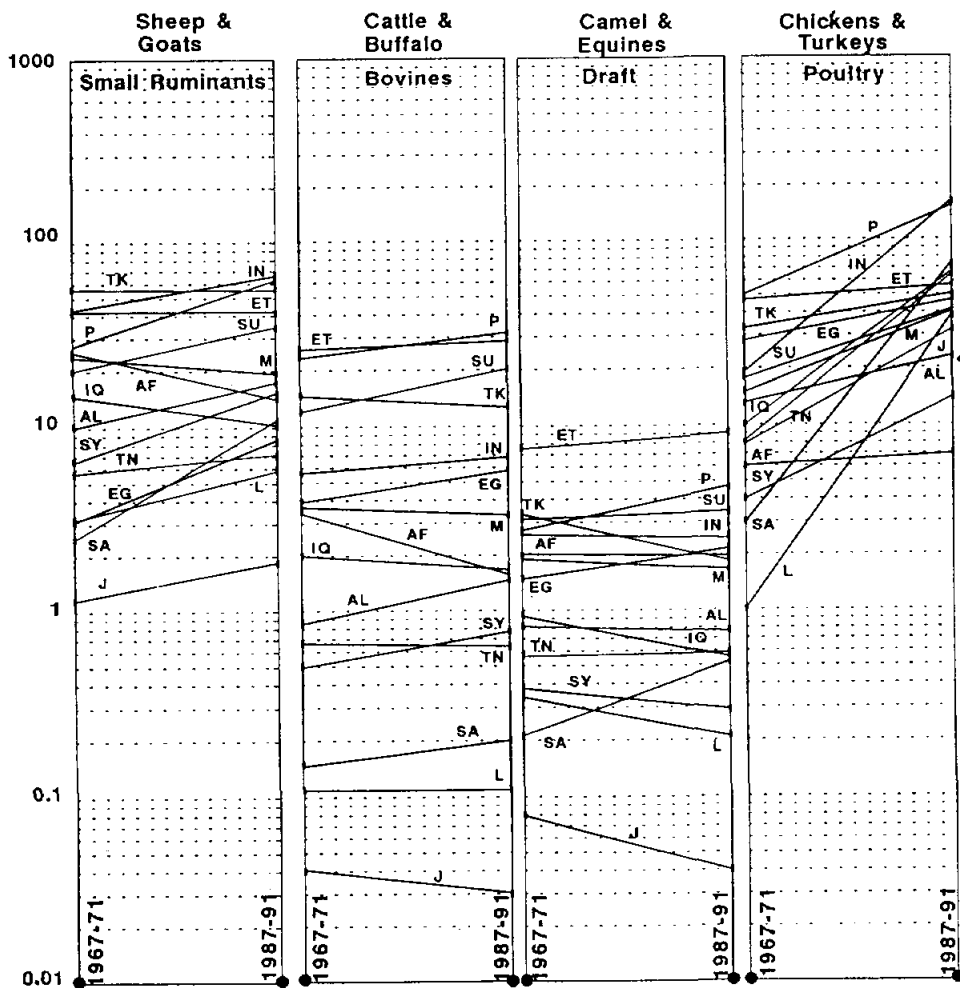


Figure 1.3. Livestock numbers in WANA countries by classes, 5-year averages, 1967-71 and 1987-91 (in million head)

Jordan and Libya reported strong increases in small ruminant populations, accompanied by little change in bovines and reductions in camel and equine populations.

Syria and Algeria have reported strong increases in small ruminant and bovine populations and decreases in camels and equines.

In 1987-91, Iran had the largest population of small ruminants among WANA countries, having surpassed Turkey and Ethiopia over the previous two decades. Increases reported in Iran's bovine numbers came with a small decline in the camel and equine class. The remaining states, Egypt and Saudi Arabia, reported increases in populations of all ruminant classes. These states met great increases in demand for livestock products, pushed by different forces, population and income growth, with large increases in imports of feed grains financed by very different means, foreign aid and oil wealth.

These trends in livestock populations are presented later, in terms of aggregate livestock units in conjunction with aggregate feed availabilities. It is useful first to discuss the major trends in feedstuff and pasture use in desegregated terms.

Trends in feed use in WANA

Feeds in the WANA region present a challenge to anyone wishing to describe them briefly. Crop residues of all sorts are used, as well as grazing of native pastures and forest areas. Feed grains and other concentrates are also widely used. In general, livestock populations in WANA are closely matched to local amounts of free or very cheap feed which has little or no other use. This point is made clearer in the subsequent section on "mega-trends". We first examine the feed story, class by class.

Crop residues (straws, stalks, leaves, roots and wastes) are not generally reported in the statistical series of any country in the

region, nor in FAO statistics, even though these materials are often the major feed resources supporting ruminant livestock. Quantitative estimates for these can be derived, with more or less confidence, by taking the reported statistics for the relevant crops harvested and multiplying by a factor specific to each.

Under the heading of crop residues and forage crops we include estimates for the following: wheat and barley straws and stubbles, rice straws, maize stalks and leaves, sorghum and millet stalks and leaves, sugar cane and beet crop residues (including bagasse and pulp), lentil and faba bean straws, cotton leaves, vetch, berseem (Trifolium alexandrinum) in Egypt and Pakistan, and teff (Eragrostis tef) straw in Ethiopia. Details on the above estimates run to several pages of tables and are given in Nordblom, Shomo and Rodriguez (1993). Using the same reporting years as for livestock numbers, the five-year averages for aggregate estimates of these feeds are plotted in Figure 1.4.

The 20 year trend lines for most countries show an increase in crop residues and forage crops, reflecting general increases in crop production across the region. Notable exceptions are provided by Afghanistan and Jordan, with decreases in this feed category; Iraq and Algeria held nearly constant over the 20 years (Figure 1.4).

Native pasture (rangeland) and forest grazing areas are the most important feed sources for a number of countries in the region. Data sources for areas were the FAO Production Yearbooks of 1972, 1987 and 1991b. Quantities of grazing offtakes from these lands are, however, not reported in any regular statistical series. We have estimated grazing offtake by multiplying the reported native pasture and forest areas by country-specific kg-per-hectare assumptions.

For 10 countries, our assumptions were based on ACSAD/AOAD (1985) values: Algeria, 300; Egypt, 90; Jordan, 79; Libya, 100; Iraq, 110; Morocco, 500; Saudi Arabia, 20; Sudan, 500; Syria, 200;

and Tunisia, 600 kg/ha. For Pakistan, we have taken Noor's (1987) estimate of native pasture offtake, 660 kg/ha. For the remaining countries (Afghanistan, Ethiopia, Iran and Turkey) we have assumed pasture offtake is 500 kg/ha.

Where the bases of statistical reporting remain unchanged, one would expect to see pasture and forest areas change little over time. This is the case for most countries in Figure 1.4. Afghanistan, however, reported a major decrease in pasture areas and a slight decrease in forest, and Turkey showed a slight increase in forest areas too small to offset the decrease in pasture area. Morocco, Iran, Saudi Arabia and Syria gave indications of increases in pasture and/or forest areas.

These inconsistencies may contribute errors of greater or lesser significance to our aggregate feed estimates, depending on the relative importance of this feed category, country by country.

Feed grains and other concentrates, including barley grain, maize grain, cottonseed (whole, meal and cake), both domestic and imported, comprise the smallest feed category for most countries in WANA. Exceptions are provided by Saudi Arabia, Jordan and Libya (Figure 1.4), where spectacular increases in feed imports have been reported over the past 20 years.

There is little doubt that much of the increase in this feed category has been absorbed by various feeding businesses, poultry, dairy and meat production. We recognize that quantities have also gone to "mobile" small ruminant dairy and fattening operations in a number of countries in which transhumant and sedentary flocks of small ruminants are hand fed, see Nabulsi *et al* (1992) for examples in Jordan, and Wachholtz *et al* (1993) for examples in Syria. Sources of feed grain and concentrate data included FAO (1991a) and ERS (1991), the latter being particularly useful in defining feed imports.

AF = Afghanistan, AL = Algeria, EG = Egypt,
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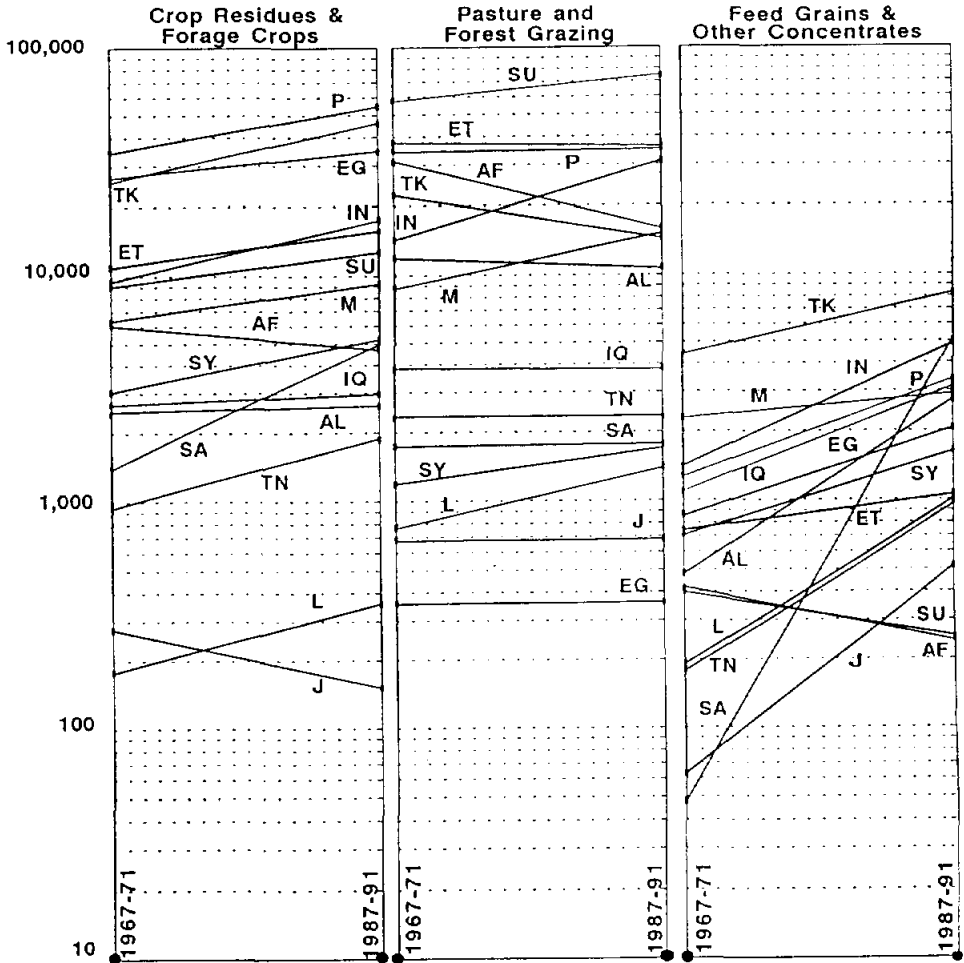


Figure 1.4. Trends in quantities of three major feed classes in WANA, 1967-71 and 1987-91, (dry matter, metric tons x 1000, log scale).

Mega-Trends in Feed and Ruminant Livestock: The Big Picture

The overall trends and balances of feed and ruminant livestock can be shown by subtracting the calculated quantities of feed grains and concentrates for poultry for each country and plotting the remainder, added to the other feed categories (crop residues and forage crops, and pasture and forest grazing), against an aggregate sum of ruminant Livestock Units.

The latter are derived by taking the numbers of each kind of ruminant times a factor for conversion to a standard Livestock Unit (LU), in this case, a 500 kg bovine at maintenance. We follow Kosilla (1988) in conversion factors: sheep, 0.09; goats, 0.08; cattle, 0.7; buffalo, 1.0; camels, 1.1; horses and mules, 0.8; donkeys, 0.6. The resulting aggregate Livestock Units are plotted against total feed for ruminants (in Figure 1.5) as 20 year trend arrows, with tails at the 1967-71 levels and heads at the 1987-91 levels.

Our "mega-trend" chart (Figure 1.5) summarizes a large amount of data in a simple form, illustrating a fairly close match between aggregate Livestock Units and total feed availabilities across small and large populations of livestock in the WANA region. Such a close match should not surprise us. Demand for livestock products by the burgeoning human populations of the region suggests that very little "cheap feed," in the form of crop residues or native grazing, will go unused. On the other hand, livestock numbers could not be sustained for long beyond the annual carrying capacity of available feed resources.

Indeed, in Figure 1.5, the envelope of annual dry matter consumption covering the range of 1.5 to 3.0 percent of liveweight per day, for our 500 kg Livestock Unit, includes all but three of the 15 countries in the 1987-91 period.

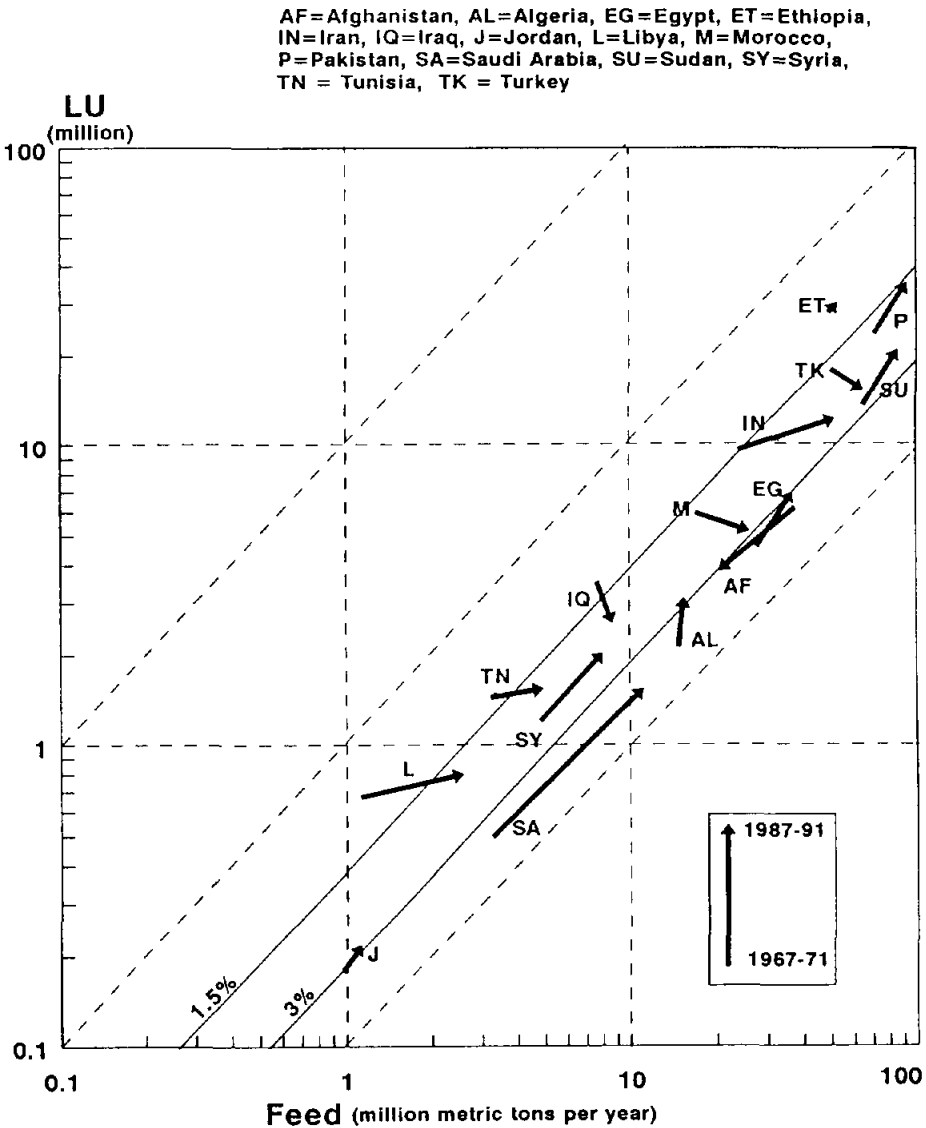


Figure 1.5. Ruminant livestock and feed in selected countries of WANA, 1967-71 and 1987-91 (log-log scale).

Ruminant populations in Pakistan and, particularly, Ethiopia appear outside this envelope on the "hungry side", while those in Saudi Arabia appear outside on the "well-fed" side. Remarkably, those of most of the remaining 12 countries appear not only within the envelope, but with their 20 year trend arrows converging from all directions toward its center (Figure 1.5).

Any significant departure from the envelope on the "hungry side," such as in the cases of Ethiopia and Pakistan, may indicate that we have neglected to include some major feed sources, underestimated the contributions of some, or over-estimated animal liveweights. In the case of Pakistan, for example, we have not included the contribution of elephant grass because we could find no data on this source. In the case of Ethiopia, we have probably overstated the weight of cattle in our Livestock Unit calculations. This points to the need to enlist local experts, familiar with livestock and feeds in their own countries, in order to arrive at a complete picture.

Shifting Compositions of Ruminant Diets in WANA

Our mega-trends chart (Figure 1.5) shows that Turkey and Sudan have very similar, large total feed resources and numbers of ruminant Livestock Units. Likewise, Afghanistan, Egypt and Morocco appear in a tight cluster. Finally, large and equally balanced increases in ruminant Livestock Units and in total feed use appear to have been made in Saudi Arabia over the past twenty years and small ones have been made in Jordan. We can now show how very different the countries within these clusters are, and in which ways the compositions of ruminant diets have shifted during the apparently balanced expansions in Jordan and Saudi Arabia.

Having removed poultry and poultry's share of feed grains and concentrates from the national feed availabilities, which include

imports, we can express the gross compositions of the remaining ruminant diets in percentage terms. The three categories, (1) crop residues and forage crops, (2) natural pasture and forest grazing, and (3) feed grains and other concentrates, nominally add up to 100% of ruminant feed use for any country at a given time. Thus, we are able to plot 20 year trend lines for each of the countries in a three-dimensional composition chart (Figure 1.6) which works on the same principle as a soil chart showing the fractions of sand, silt and clay.

Contrasts in the feed resource endowments of Turkey and Sudan are readily apparent in Figure 1.6. Sudan's ruminant population, by our reckoning, subsists on a diet comprised mostly of pasture and forest grazing (86%), and partly of crop residues (13%), with very little feed grain or other concentrates (1%). In sharp contrast, ruminant diets in Turkey have shifted out of pasture and forest grazing into crop residues and forage crops, with a modest increase in grains and concentrate feeds (Figure 1.6).

Even greater contrasts are shown between Afghanistan, Egypt and Morocco. Each occupies a different sector of Figure 1.6. Ruminants in Afghanistan appear to have diets more closely related to those in Sudan, comprised mainly of natural grazing resources. Ruminants in Morocco appear to take about half their feed from natural grazing, over 30% from crop residues and forage crops and, over 10% from grains and concentrates. Egypt differs in the extreme, with very little natural grazing, over 70% from crop residues and forage crops, and over 20% from grains and concentrates. Thus, similar numbers of ruminant Livestock Units are kept under very different feed conditions (Figure 1.6). This reflects differences in natural resource endowments, and how these are managed in the three countries.

AF = Afghanistan, AL = Algeria, EG = Egypt,
 ET=Ethiopia, IN=Iran, IQ=Iraq,
 L=Libya, M=Morocco, P=Pakistan,
 SA=Saudi Arabia, SU=Sudan, SY=Syria,
 TN = Tunisia, TK = Turkey

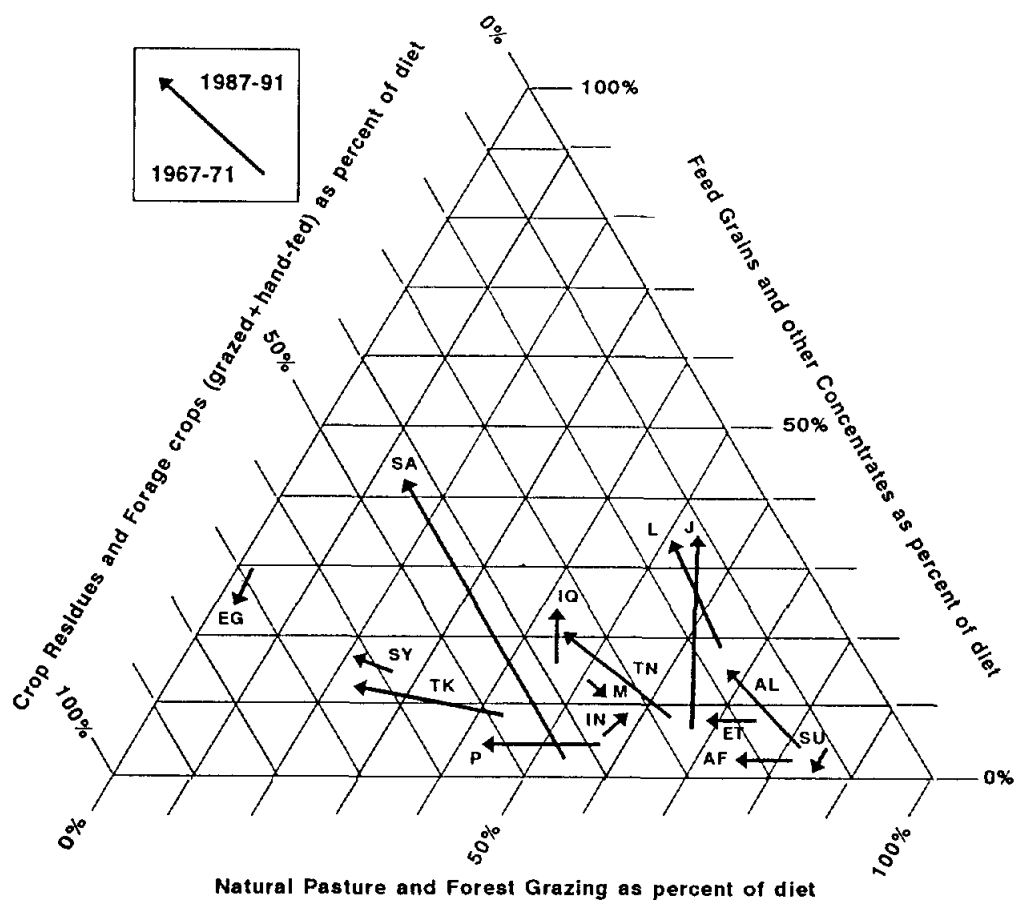


Figure 1.6. Diet compositions of ruminant animals, by feed category: 20-year trends (1967-71 to 1987-91) for selected countries of the West Asia-North Africa Region.

Comparisons between Saudi Arabia and Jordan, in terms of shifts in ruminant diet compositions in the past 20 years, are useful. Saudi Arabia exhibited the greatest proportional expansions of feed and livestock among the WANA countries. It also has made the most remarkable shift in diet compositions, with grains and other concentrates increasing from near zero to over 40%, with an equivalent reduction in the role of natural grazing, and with the contributions of crop residues and forage crops holding steady at over 40%. In Jordan, grains and other concentrate feeds increased to over a third of the ruminant diet, with both other feed/grazing categories losing shares.

In recent years, ruminant diet compositions in Libya have shifted to levels very similar to those in Jordan, with about a third coming from feed grains and other concentrates (Figure 1.6). Four other countries, Algeria, Tunisia, Turkey and Syria have exhibited ruminant diet shifts towards greater proportions of grains and concentrates and crop residues, at the expense of natural grazing, Iran and Iraq have made shifts towards grains and concentrates while reducing shares held by crop residues and forage crops (Figure 1.6). Pakistan, Ethiopia and Afghanistan appear to have shifted to somewhat greater dependencies upon crop residues and forage crops at the expense of natural grazing. Ruminants in these countries and those in Iran, receive the lowest levels of feed grains and other concentrates in their diets; only Sudan uses less. Only Morocco and Iran, among the 15 WANA countries, have increased the share of ruminant diets supported by natural grazing over the past 20 years, but by less than 4%.

There is in WANA, generally, little room for a sustainable increase in production by cultivating larger areas of arable land. Increases in yield and increased cropping intensity are the only avenues still open (Alexandratos, 1988). Pushed by growing economic

demand for livestock products, rising ruminant populations are using most of the natural grazing resources and crop residues in the WANA region. Enhancement and sustained productivity of these most important feed resources, through efficient use and management, have, from ICARDA's early days, been major goals of the Pasture, Forage and Livestock Program.

The general trend toward greater use of feed grains and concentrates can confidently be expected to continue through the foreseeable future. Much of this will be substitution of these feeds to supplement diets based primarily on limited quantities of crop residues and natural grazing. Rising amounts, however, will inevitably be used in expanded feeding operations for dairy, meat and poultry production in most countries. Some reasons for this are set out in the following section.

Livestock units per capita supportable by domestic feed production

Domestic feed production in most WANA countries is likely to expand with advances and developments in crop and sown pasture production. Quantities of both domestic crop residues and feed grains will increase, as will better management of crop rotations with the inclusion of forage crops. For purposes of illustration, we assume that domestic feed production from crop lands will reach 125% of current levels by the year 2025 in all WANA countries. We also assume the path of this increase is linear, so that a proportional increase can be assumed for the year 2000. We further assume that offtake from grazing of native pastures and forests will continue at current levels, though there are indications of decline in these resources because of widespread overgrazing and other unsustainable practices.

Large increases in human populations are predicted throughout the WANA region over the coming decades. We take the World Bank (1991) estimates and projections for national populations in the years 1989, 2000 and 2025. With these, and the domestic feed supplies projected for the same years, assuming continued current levels of efficiency, we derive estimates of per capita Livestock Units (IU) supportable in the future without imports (Figure 1.7), assuming that one IU is the equivalent of a 500 kg bovine at maintenance (Kosilla, 1988). Afghanistan is missing from this chart because population projections were not available.

The large projected growths in human populations will cause a dramatic decrease in the number of domestically supported IU's per capita, even though we assume the absolute quantity of domestic feeds from crop lands will increase by 25% by the year 2025. Human populations are growing much faster. This is a useful way to illustrate some of the practical implications of population growth in the future of this region. For the poorer states, it will mean lower quality diets, in the sense of animal protein, for the majority. For the middle income and rich states, it will mean increasing dependence upon feed grain and/or livestock product imports to fill the demand gap to a lesser or greater degree. With rising incomes will come rising demands for livestock products, spurring domestic production, but also increasing the gap to be filled by imports.

What is remarkable in our per capita IU chart (Figure 1.7) is the general similarity across countries. Most countries show per capita numbers of domestically supported Livestock Units in the range of 0.1 and 0.2 in 1989, considerably below levels that western Europeans or North Americans enjoy. For example, per capita meat consumption in Egypt and Turkey was less than 20 kg in 1990, but over 90 kg in France, Australia, Hungary and the USA, among others

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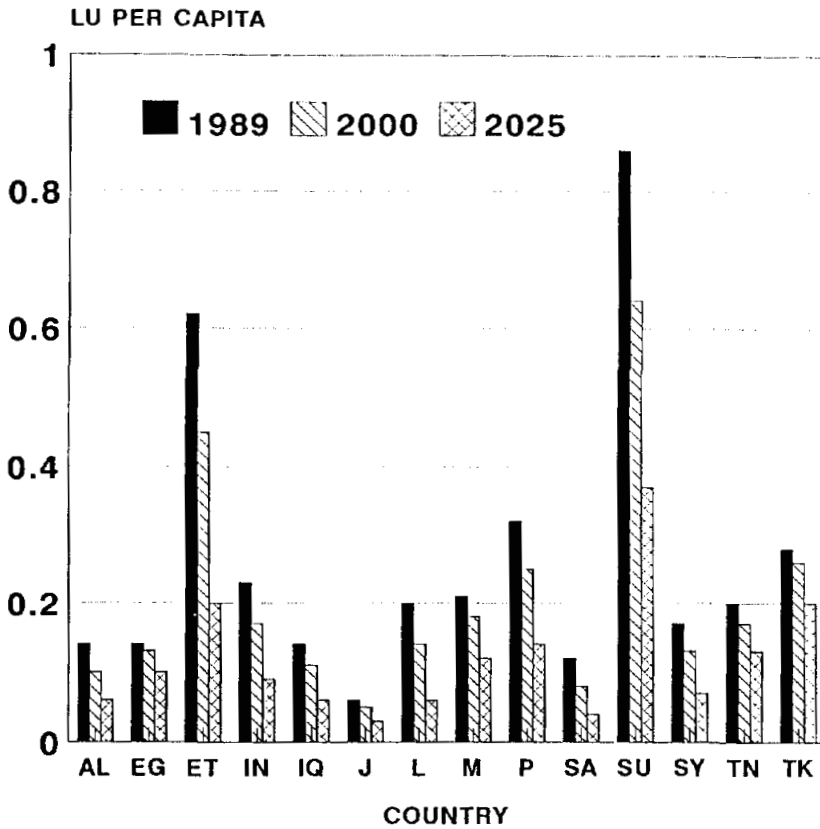


Figure 1.7. Livestock units per capita supported by domestic feed production in selected WANA countries for the years 1989, 2000 and 2025.

(Durning and Brough, 1991). The high per capita LU's in Ethiopia and Sudan point out a need for caution in interpretation of this chart. These are cattle countries, but their cattle live under harsh conditions and may have considerably lower productivity than suggested by their numbers.

Based on domestic feed production or on purchasing power, the excesses and health hazards of over-consumption of livestock products in the developed countries seem almost totally out of reach of the majority in most WANA countries. But the environmental degradations of overgrazing, deforestation and soil loss, that come with mismanaged livestock, are already evident in most of these countries. The health and environmental problems associated with high consumption of livestock products have been well documented by Barkin et al (1990), Durning and Brough (1991) and Rifkin (1992), among others, who point out the damage being caused also to developing countries in the course of meeting demands for livestock exports. Most WANA countries, however, are net importers of livestock products and/or feeds.

Future increases in concentrate feeding of livestock and poultry

Concentrate feeding, whether of poultry for egg or broiler production, of dairy animals, or feedlotting of cattle, sheep or swine, is practised around the world only when, and if, it pays farmers in the short run to do so. Rates of production are controlled by diet quality (digestibility of feed energy, and balance of other nutrients with energy), among other management factors. Young, growing animals have high potential efficiency of feed conversion to muscle growth, but are very sensitive to diet quality, including protein and mineral content. Dairy animals with high genetic capacity for milk production are similarly sensitive (Anthony Goodchild, personal communication, 1993). Low quality diets

mean slow production and poor efficiency of feed use as larger proportions of feed go for body maintenance rather than growth.

In many countries there is a stratification of ruminant livestock production, with breeding/dairy stock making good use of pastures and crop residues throughout the rural districts. The young stock, mainly males, but including females not recruited to the breeding herd/flock, are destined for the slaughter market. The most profitable means farmers find for handling these animals will vary from country to country, and district to district, depending on relative price ratios among all factors of production and outputs. Where meat prices are high, relative to feed grains and other concentrates from any source, there exist irresistible incentives to feed these materials for fast and efficient weight gains (Brokken et al, 1980).

This feeding need not take place in confinement, per se; the point is to offer a diet of higher energy digestibility and quantity than is required for maintenance. It may be done in the form of hand-feeding concentrates to growing animals on rangeland, in cases where it is practical to keep other animals away from the feed intended for the growing animals. Confinement feeding is a way of increasing labor efficiency, reducing energy waste in trekking, and increasing security from predators.

Sources of feed grains and concentrates include domestic production and imports. According to Sarma (1986): "Promoting cultivation of feed grains, especially coarse grains, can be justified from an equity standpoint because coarse grains are usually grown on poorer lands by poor farmers." Khaldi (1984) showed that shifts toward coarse grain production, with better technology, would partly reduce WANA's deficits of 5.6 million tons of meat, 25 million tons of milk and 0.5 million tons of eggs, projected for the year 2000. Where countries are fully integrated into the world

market, they will produce the things for which they have comparative advantages and import those which can be purchased more cheaply outside. This logic holds in most places, but needs the qualification that it may not extend to subsistence cropping areas, and certainly not to areas of human starvation, except where reliable coarse grain crops are also used directly in human diets.

Domestic feed sources can be supplemented with imports. Transport costs will generally limit such imports to concentrate feeds of one kind of another, typically feed grains with good value for weight. Of course, something more than "need" is required to bring about imports: effective demand, or ability to pay. This can be modified by direct food aid, which overlaps with "dumping" of underpriced grains by developed countries on the markets of less developed countries. These latter sources of feed grain are unreliable, but can be used profitably in the short run.

The most reliable, and expensive, option is for countries with feed deficits to buy cheap feed grains on the world market. A few WANA countries have this as an easy option because of their oil wealth, others because of growing industrial production and exports.

Where we see prospects of human starvation in a few countries, for whatever reason, there is little sense in discussing how to fill gaps in feeding grain to livestock. Crop residues and grazing resources in these areas and elsewhere, however, are likely to remain vitally important because, through ruminant livestock, these materials yield high quality products for human use.

The characteristic of concentrate feeding in general, and feedlotting of cattle and sheep in particular, which many people find most objectionable, is the waste of grains which could be consumed directly by humans. Put another way, it is the waste of resources used in feed production which could instead be directed to

growing food for humans (Barkin et al., 1990, Durning and Brough, 1991, and Rifkin, 1992). These are added justifications for finding the most efficient feeding systems for local livestock and feeds.

But whose job is this? We argue that this is chiefly the business of the people most interested in it, the farmers and merchants who are investing their own capital in feedlotting, and the NARS looking after the interests of their countries' agriculture and consumers. The same arguments apply to research on poultry production. Though egg and broiler production in WANA is likely to continue expanding rapidly, ICARDA's involvement in this area of agri-business would be very difficult to justify.

Indications for ICARDA's research programs

As mentioned earlier, farmers' decisions to feed grain to animals (including poultry) for slaughter or higher output are based upon calculations of profits in the short run. As grain and livestock prices change from year to year, the feedlotting and broiler businesses will expand or contract, though we expect general expansion over the next three decades. But this business is likely to take place largely "off the land," outside the dryland farming districts which are ICARDA's central focus.

Apart from the all-important price considerations, several management factors are likely to have an effect on the profitability of feedlotting: diet quality, efficiency or waste in diet delivery, and health factors. We consider that much research has already been done on sheep fattening in other countries and that it is easy enough for NARS in WANA to pick this up where it adds to the already considerable indigenous knowledge. We also think most NARS of WANA have the ability to conduct most of the locally needed research on fattening, and that a great deal of private experimentation is done by farmers who see the opportunity to make a profit. Results of

private experimentation, however, often take on the status of trade secrets and may not be disseminated very quickly among farmers.

ICARDA lacks detailed information on feedlotting practices outside Syria (Nygaard et al 1982) and Jordan (Nabulsi et al 1992), and lacks statistics showing desegregated feed use in the various countries. Such statistics are generally neither collected nor published by the states of the WANA region. ICARDA should instigate (with NARS) rapid surveys of livestock management, feed and grazing resources, feeding practices and farm economics, in advance of committing itself to long running field trials to improve these things in any particular district. The feed and livestock data summarized here, and given in detail by Nordblom et al (1993), are inadequate for specific field trial planning owing to their nature as national aggregates derived by rather tenuous assumptions on conversion factors, etc.. These data should be desegregated, corrected, completed and updated, in partnership with NARS, for districts in countries where collaborative projects are envisaged.

We would not agree that ICARDA itself should engage in comparative feedlot fattening research, on the age of lambs and ration ingredients, including concentrates, hay, by-products and grazing, as allowed by Nabulsi et al (1992). We believe that research on confinement feeding is simple and inexpensive, if the end product is marketed, and ideal for small research units or university MSc projects. Advice by ICARDA to NARS on the design of such trials could be offered upon demand.

Only where issues in feedlotting efficiency are identified which are beyond the capacity of individual NARS to tackle, and which hold the promise of reducing feed wastage substantially, should ICARDA become involved. Such issues have not been identified to date. In the mean time, ICARDA should continue its focus on dryland livestock and farming systems, dealing mainly with sustainable and more

productive management of crops, pastures and flocks. - T.L. Nordblom and F.I.H. Shomo

Acknowledgements

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1.2 Small ruminant nutrition

1.2.1 Methodology

1.2.1.1 Laboratory methods for predicting the voluntary intake of barley straw

Cereal straw is an important feed for ruminants for a major part of the year in the WANA region. Plant breeders, therefore, need to take greater account of cereal straw quality. At ICARDA, plant breeders and ruminant nutritionists are testing a wide range of chemical, biological and physical techniques against the results of animal trials in order to develop methods for estimating the genetic component of straw quality. The aim should be to develop indicators which predict straw quality with sufficient accuracy, can be measured on relatively large numbers of genotypes, and are not negatively correlated with desirable morphological or phenological traits (Ceccarelli 1991). The tests must use small samples of straw, predict quality in future years and preferably be inexpensive in time and use of facilities.

Tests are being screened that can predict from single samples the long-term mean ranking of varieties for voluntary intake. The long-term mean intake of nine varieties of barley straw has been estimated from more than 100 lots of straw harvested in seven years (see Section 1.1). The straws include enhanced six-row, enhanced two-row, and landrace varieties.

For a set of 35 samples harvested between 1985 and 1989, the suitability of a number of tests to predict long-term mean intake was investigated. Of these tests, the best statistical predictions ($P < 0.01$) were from Near Infrared Reflectance Spectroscopy (see Section 1.2 for details), gas production in vitro (see below), digestibility in vitro ($r = 0.58$ in 34 samples) and acid detergent fibre ($r = -0.48$ in 35 samples). Acid detergent lignin ($r = -0.47$,

n = 33) and total gas production ($r = 0.50$, $n = 23$) were also significant ($P < 0.05$). In contrast, straw intake in any particular trial ($r = 0.29$, $n = 35$), neutral detergent fibre ($r = -0.25$, $n = 35$), crude protein ($r = 0.25$, $n = 35$), and energy to grind the sample ($r = -0.10$, $n = 25$) were not suitable ($P > 0.1$) methods for predicting long-term mean intake.

Gas production in vitro

The voluntary intake of a large range of low-quality byproducts is well correlated with parameters describing the rate of gas production from samples incubated in diluted rumen fluid (Blümmel 1993). He used the Hohenheim Feeding-value Test (HFT, Menke *et al.* 1979). Included in this set were the parameters of HFT gas production of 23 of the 35 ICARDA barley straw samples mentioned above. The C (rate) parameter of HFT gas production had the best correlation with actual DM intake ($r = 0.88$). The parameters were also well correlated with long term mean DM intake, in particular A ($r = -0.82$, $P < 0.001$). The correlation with B was $r = 0.66$ and with C, $r = 0.61$ (both $P < 0.01$). Values of the three parameters for the 1988 straw samples are shown in Table 1.1, in which A again showed strong negative correlations.

Paired-preference test

Farmers in the WANA region value those varieties of straw that sheep prefer to eat. One of the main reasons why Beecher variety of barley was not adopted by farmers was the tendency of sheep to reject its straw. "Preference" for a straw variety may be measured as the relative quantity that a sheep will eat when presented with more than one variety simultaneously, under defined conditions. For eight varieties of barley harvested in 1988, preference was calculated from the quantities eaten when two varieties of coarsely-milled

Table 1.1. Chemical analyses and other tests on straw harvested in 1988, and correlations with actual dry matter intake (DMI) or long-term mean ranking for DM intake (DMImean).

Code:	BE	EA	CS	ER	AR	RI	AN	AS	AB	r	DMI	r	DMImean
DMI ^a , g/kg/d	8.97	9.00	10.69	12.33	12.26	9.53	11.83	12.59	13.42	1.000	0.758	*	
DMI(mean), g/kg/d	13.0	14.2	14.7	14.9	15.0	15.4	889	905	906	16.3	0.758*		1.000
OM, g/kg DM	924	914	908	906	911	914	889	905	906	-0.620	-0.768	*	
NDF, g/kg DM	808	772	760	764	747	765	723	751	778	-0.468	-0.668	*	
ADF, g/kg DM	501	490	460	467	441	481	436	465	455	-0.771*	-0.703	*	
ADL, g/kg DM	-	89	74	67	79	82	73	76	66	-0.818*	-0.528		
N, g/kg DM	2.3	2.3	2.7	2.4	3.6	2.2	3.3	2.6	2.9	0.600	0.423		
ivDOMD, g/kg	344	378	410	399	464	431	436	423	465	0.731*	0.817	**	
ivDOMD, g/kg	320	336	372	369	417	392	376	375	426	0.731*	0.733		
DMI x ivDOMD	3.09	3.40	4.38	4.92	5.69	4.11	5.16	5.33	6.24	0.961***	0.821	**	
HFT-A, ml gas	-1.13	0.25	-0.57	-1.74	-2.46	-0.69	-1.15	-2.73	-4.41	-0.905	***	-0.709*	
HFT-B, ml gas	41.0	41.5	45.0	49.0	51.6	48.5	45.7	47.1	56.2	0.794*	0.674*		
HFT-C x 100	3.33	3.60	3.60	3.47	4.40	3.38	3.98	3.77	4.13	0.685*	0.532		
Rumen NH ₃ N	15.3	18.4	13.9	1.2	7.4	11.8	3.3	4.8	9.1	-0.516	-0.739	*	
N:ivDOMD ratio	7.26	7.19	6.85	5.61	6.50	8.78	6.81	6.93	8.63	0.293	0.085		

^a DMI = dry matter intake (units g/kg body weight/day); DMI(mean) = long-term mean ranking for DMI; OM, NDF, ADF, ADL and N = organic matter, neutral detergent fibre, acid detergent fibre, acid detergent lignin and nitrogen analyzed chemically; ivDOMD and ivDOMD = *in vitro* digestible DM and OM in the DM of the sample; HFT-A, HFT-B and HFT-C = parameters of gas production in the Hohenheim Feeding-value Test; Rumen NH₃N = rumen ammonia N, mg/litre, measured 24 hours after feeding.

straw were placed in identical containers in front of the sheep. There were 28 possible pairs of varieties of straw; each pair was tested on three different days, using a different group of sheep each time. In detail, sheep that had been eating barley straw ad libitum for a month were given no food from 18:00 hours and used for tests from 08:00 hours the following day. Each test consisted of presenting a sheep with 20 g of two different varieties of chopped barley straw in identical 4-litre buckets. At the end of five minutes, the quantity of straw refused was recorded. After 20 minutes, sheep were used for further tests.

In about 75% of these tests, each sheep ate a total of 10 to 25 grams. If a sheep had eaten more or less than this, the two straw varieties were re-tested with another sheep. To perform 28 successful tests with 7 sheep, some sheep were used for 6 tests, with the result that the whole procedure took 2.5 hours. The results were analyzed using SPSS ANOVA (analysis of variance), in which each test was considered as a separate block, and are reported in the column labelled preference in Table 1.2.

The correlation coefficient (r) between preference and voluntary DM intake was +0.94, i.e. $R^2 = 0.88$ ($P < 0.001$). Significant correlations between preference and laboratory analyses were -0.92 with ADF ($P < 0.01$), 0.78 with crude protein ($P < 0.05$) and 0.74 with in vitro DOMD ($P < 0.05$). The multiple correlation R^2 between preference and both protein and voluntary intake was 0.95 ($P < 0.001$).

These coefficients are based on five or six degrees of freedom, and so their actual values are not precisely estimated. They suggest that sheep have the ability to detect food of good nutritional value, using one or more of the senses of sight, smell, taste and touch.

Table 1.2. Ability of paired preference or grinding energy (various times) to predict voluntary intake.

Variety of barley straw	Code	Voluntary DMI, g/kg/d	Pref- erence (g/5 min)	Grinding energy, Watt-hr/20g ^a			
				29 s	58 s	115 s	HH [#]
Antares	(AN)	11.83	10.7ab	1.11	1.56	2.00	1.12
Arabi abiad	(AB)	13.42	10.8ab	1.29	1.80	2.37	1.22
Arabi aswad	(AS)	12.59	11.2ab	1.31	1.72	2.14	0.99
Arar	(AR)	12.26	13.0a	1.05	1.47	1.92	0.88
Badia	(BA)	9.00	1.8cd	0.89	1.24	1.58	0.99
Beecher	(BE)	8.97	-0.2d	1.36	1.86	2.27	1.20
C63	(CS)	10.69	-	1.19	1.68	2.19	1.15
ER/Apam	(ER)	12.33	9.1b	1.01	1.36	1.67	1.24
Rihane (S)	(RI)	9.53	2.8c	1.28	1.70	2.15	1.25
SE of means		-	0.99	0.088	0.109	12.6	n.d.
Correlations:							
with DM intake	(1)	0.940***		0.053	0.065	0.150	-.109
with mean ranking		0.758*	0.749*	0.127	0.107	0.209	-.038
with preference		0.940***	(1)	-.096	-.071	0.039	-.354

^a Multiply by 1.8 to obtain Joules per gram.

[#] done by M. Blümmel.

Sheep consumed one of nine varieties of barley straw harvested in 1988, before the paired-preference trials.

When results were analyzed separately, according to the variety of straw fed to sheep prior to the trials, recent nutritional experience did not appear to affect the preference of sheep for varieties.

Long-term mean voluntary intake was predicted by preference ($r=0.75^*$) equally as well as it was predicted by voluntary intake ($r=0.76^*$). This suggests that preference tests, here requiring no more than 0.5 kg of each variety for a total of three replicates, are as useful as voluntary intake trials requiring 100 kg or more of each variety.

Grinding energy. It may be expected that straws which require the most energy to chew will be eaten in the smallest quantities, and will probably also require the most energy to grind. In rice and, to some extent, wheat straws, the voluntary intake of straw varies inversely with the electrical energy needed to grind a sample of given size.

We have measured the electrical energy required by a Wiley mill to grind 20 grams of straw through a 1-mm screen (Table 1.2). Tests were stopped after two minutes, whether or not grinding was completed, to minimize the effects of baseline drift. Further data, from measurements by M. Blümmel, is included in the same table. In the set of nine straws harvested in 1988, grinding energy (whether done at ICARDA or Hohenheim) did not show any significant correlation with DMI, with long-term mean DMI or with preference ($P>0.1$). The correlation coefficients were so small that some were negative and some were positive.

Other analyses were made on the straws harvested in 1988 and are shown in Table 1.1.

Preliminary conclusions. It seems that some methods, in particular Near Infrared Reflectance Spectroscopy, gas production or digestibility when samples are incubated with rumen fluid, and acid detergent fibre, have potential in estimating the genetic merit of barley straw varieties for voluntary intake across a wide range of growing conditions. Work in 1993 will concentrate on refining calibrations and applying them to large numbers of samples, and on ensuring that calibrations are effective when straw quality is most important, i.e. in wet years.

A mathematical technique used for distinguishing between the long-term mean nutritional value of varieties is being developed, with the objective of eliminating the effects of interactions

between genotype and season or location. - A. Goodchild and I. Said

References

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Said.

1.2.1.2 Using near infra red spectroscopy to predict the voluntary intake and composition of barley straw

ICARDA is testing near infrared reflectance spectrometry (NIRS) as a method of predicting the voluntary intake by sheep of samples of barley straw produced by cereal breeders. At the same time, ICARDA is using NIRS to predict the chemical composition and in vitro digestibility of the straws. NIRS offers the possibility of rapid non-destructive screening of thousands of samples, each of which can weigh less than 10 grams. If successful in predicting voluntary intake, NIRS would minimize the number of varieties of which straw needs to be fed to animals, usually in quantities totalling more than 100 kg. Since barley straw yields rarely exceed 100 times the quantity of seed sown, NIRS could be used two or three generations earlier than animal trials.

NIRS works by scanning a beam of infrared radiation across the surface of the sample and measuring the energy that is reflected at a large number of wavelengths. The NIRS 5000 apparatus installed at ICARDA is manufactured by NIR systems, U.S.A. and uses near infrared of wavelengths between 1100 and 2500 nanometres (0.0011 and 0.0025 millimetres). Sample sizes are in the order of five grams. It is linked to an IBM PS/2 microcomputer which processes data by means of NSAS software, developed by Perstorp Analytical Chemistry Group, 12101 Tech Road, Silver Spring, MD 20904. This software transforms NIRS spectral data into more meaningful forms, develops calibrations

on sets of samples with known characteristics (typically using 3 or 4 wavelengths), and predicts the characteristics of samples of which only the NIRS spectra are known. The software can also fine tune a calibration, using new samples with measured characteristics.

For the purposes of this section, we define the mean ranking of barley straw intake as the long-term mean intake of dry matter, measured in over 100 trials and averaged by the least-squares procedure. If the exceptional results for landraces in dry years are ignored, NIRS (Table 1.3) predicted ranking rather better than did animal intake trials (Table 1.4). This may have reflected the lower errors of measurement with NIRS than with animal trials.

In the drought years 1989 and 1990, sheep consumed less of the landraces Arabi abiad and Arabi aswad than of varieties having lower mean rankings (Table 1.4). These lower intakes were also predicted by NIRS (Table 1.3). The landraces were better adapted to drought conditions than the other varieties. As a result, drought did less damage to grain filling in landraces, and nutrients likely to promote voluntary intake were less abundant in their straw.

In addition to voluntary DM intake, we have calibrated NIRS on the DOMD, ADF, N and ADL of 35 samples of straw. The wavelengths of near infrared and their coefficients are shown in Table 1.3

All calibrations, except that for ADF, used the second derivative (the slope of the slope) of the graph of reflectance against wavelength. When transformed in this manner, peaks in the original spectrum became troughs, giving rise to negative coefficients, and vice-versa. The calibration for ADF alone used the first derivative (slope).

The same calibrations have been used to calculate DMI, DOMD, ADL and nitrogen in 786 samples of barley straw from a breeding methodology trial (courtesy of Dr J. Hamblin, Cereal Program). The statistics of the results are summarized in Table 1.4.

Table 1.3. Wavelengths and coefficients used for the near infrared calibrations for barley straw quality (set of 35 varieties)

Wavelength (nm)	Measurement predicted				
	DMI, g/kg body wt (3) ^a	DOMD g/kg (3)	ADF g/kg (4)	Nitrogen g/kg (4)	ADLignin g/kg (3)
Constant	44.0	72.5	46.5	0.29	9.3
1240	.	.	.	.	+1891
1300	.	.	-6811	.	.
1500	.	.	.	+73	.
1540	.	-6978	.	.	.
1680	.	.	.	.	-894
2000	.	.	-529	.	.
2100	.	-4468	.	.	.
2140	.	.	-1449	.	.
2160	.	.	.	-287	.
2180	-5658	>9999	.	-543	.
2200	.	.	.	+502	.
2240	-905	.	.	.	.
2360	.	.	+4773	.	.
2380	+2140	.	.	.	-1583

^a Number of wavelengths is shown in parentheses.

Correlation coefficients (r) between the estimates of DMI, DOMD, ADF, ADL and N were rarely higher than 0.71, indicating that NIRS was distinguishing different entities in the samples.

Straws of 100 of these 786 genotypes giving extreme NIRS values will be analyzed in the Forage Laboratory to allow fine-tuning of the NIRS calibrations. It is planned to multiply some of these extreme samples to obtain sufficient straw for use in voluntary intake trials, again to improve the accuracy of the NIRS calibration.

Table 1.4. Results of near infra red spectroscopy of 786 breeder's samples of barley straw.

	DMI g/kg BW	DOMD g/kg	ADF g/kg	ADL g/kg	Nitrogen g/kg
Samples	786	786	786	786	786
Lowest	10.2	286	419	17.6	-2.47
Highest	29.6	547	536	107.6	13.15
Mean	21.93	432.1	471.8	51.0	7.75
SD	2.14	35.1	20.4	10.3	1.323
<u>Correlation coefficients between NIRS estimates:</u>					
with DMI	1.000	0.660	-.590	-.823	0.708
with DOMD	0.660	1.000	-.277	-.544	0.329
with ADF	-.590	-.277	1.000	0.505	-.455
with ADL	-.823	-.544	0.505	1.000	-.726
with nitrogen	0.708	0.329	-.455	-.726	1.000

In conclusion, near infrared spectroscopy appears to be a rapid, precise method for screening barley straw for five characteristics important in nutritional quality. In 1993 the calibrations will be refined, using as many of the available samples as possible, and the method will be presented as a technical package to the barley breeders. If the ability of NIRS to predict the DOMD, ADF, ADL and N of the hundred samples taken has a correlation R^2 of at least 0.80, we shall be satisfied that breeders have an efficient method of screening barley straw for quality. - F. Jabi El-Haramein, A. Goodchild

1.2.2 Feed quality, nutrient factors, nutritional deficiencies and intake

1.2.2.1 Nutritive value of barley stubble

A programme of research to quantify the intake of nutrients by sheep grazing stubble alone, and when supplemented with concentrated feeds, began in 1991, as part of the work for a PhD thesis at the University of Reading, England. The background to this area of research was discussed in the PFLP Annual Report 1990/1991, pp 149-153 and 158-162. The second experiment of the series was carried out from June to September 1992, using a 2 x 3 factorial design to examine the removal of different stubble fractions from areas of stubble grazed at stocking rates (SR) of 20 and 40 ewes/ha for 3 successive periods of 28 days, when the ewes were fed ¹200 g of cotton seed cake, which supplied 1.68 MJ of metabolizable energy (ME) and 73 g of crude protein (cp), or ²200 g of barley daily, which supplied 2.36 MJ of ME and 22 g of cp, or ³were given no supplement.

There were 8 ewes, aged 17 months, on each treatment. They grazed each day, from 06.45 h until 12.00 h, and were then moved for one hour to a paddock on the field for watering and rest, after which they were returned to graze until 18.00 h. On their return from grazing, minerals and vitamins were fed to all ewes and those on supplements were fed individually, while yoked. At the start of the second period, rams were put with the ewes at night and the pattern of mating was recorded.

The experiment was carried out on a field of barley, cv Arabi Abiad, harvested at a height of 10 cm, using a combine harvester with a straw collector which deposited the straw at 40 - 50 m intervals. This straw was baled and removed from the field and the areas on which it had been deposited were not used for the experiment. The stubble was sampled to ground level prior to grazing and on days 2, 4, 6, 8, 13, 18, 23, and 28, using a 2m² quadrat (4.25

x 0.47 m).

Before grazing started, there was a mean of 1135 kg DM/ha on the stubble. The quantities removed by the unsupplemented sheep were similar to those, at the same stocking rates, in the previous year's experiment, with 645 and 345 kg DM/ha remaining on day 18, and 485 and 55 kg DM/ha on day 28, at stocking rates of 20 and 40 ewes/ha respectively.

The effects of stocking rate and, particularly, supplementation on the patterns and rates of removal of the different stubble fractions were complex and are still being analyzed. In the first days of grazing, the removal was lower in ewes supplemented with barley.

Linear regression equations were fitted to the estimates of total stubble dry matter (kg/ha) at each quadrat sampling time for each treatment and replicate. All equations had R^2 values above 0.95 and there were no significant differences between intercepts. Analysis of variance on the slopes of the regressions (b), which estimate the mean rates of removal of dry matter, showed that significantly greater removal occurred at the higher stocking rate ($P < 0.001$) and with supplementation ($P < 0.001$). Mean daily removals of stubble were 1.33, 1.28 and 1.20 kg/ewe for ewes supplemented with cotton seed cake, with barley and for unsupplemented ewes, respectively, at 20 ewes/ha, and 1.01, 0.92 and 0.882 kg/ewe for the same treatments at 40 ewes/ha.

Intakes of metabolizable energy (ME) and crude protein (CP) were calculated from analyses of the in vitro digestibility (ME assumed to be 0.15 DOMD%) and crude protein contents of the head, leaf and stem, and the differences in weights of these stubble fractions between the quadrat cuts. Preliminary calculations indicate that, between days 1 and 6, the intake of ME from stubble was higher in ewes supplemented with cotton seed cake (19.5 and 14.6 MJ/day at 20

and 40 ewes/ha) and lower in those supplemented with barley (14.5 and 11.6 MJ/day), than in non-supplemented ewes (16.6 and 14.0 MJ/day). During the remainder of the period, the differences were small, but slightly higher with the barley supplement.

The weight changes of the ewes were affected by both stocking rate and supplementation. The effects of stocking rates were similar to the previous experiment, with maintenance of liveweight over 96 days of grazing at 20 sheep/ha without supplementary feeding and a loss of 5 kg at 40 sheep/ha. The mean liveweight changes were 10, 5, and -3 kg for ewes supplemented with cotton seed cake, barley and for unsupplemented ewes, respectively.

In spite of the small number of animals on the experiment, analysis of the number of days from the introduction of rams at the beginning of the second period of grazing to the ewes becoming pregnant indicated significant effects of both stocking rate ($P < 0.001$) and supplementation ($P < 0.01$). The mean numbers of days were 30.1 and 42.2, 40.5 and 28.8, and 36.0 and 66.4 at SRs of 20 and 40 ewes/ha, for ewes supplemented with cotton seed cake, barley and for unsupplemented ewes, respectively.

This experiment demonstrated that offering small amounts of supplements to young ewes grazing stubble increased both intakes of stubble and liveweight gains. Intakes of stubble and the performance of the sheep on the unsupplemented treatments were similar to those at the same stocking rates in the first experiment of the series. -
S. Rihawi, T. Treacher, A. Termanini, A. Goodchild and E. Owen
(Reading University, England)

1.2.2.2 Intake and digestibility of barley straw varieties

The intake of up to nine varieties of barley straw has been measured over a number of years at ICARDA, as it is considered to be one of the major determinants of barley straw quality (Goodchild et al.

1992). Results from barley straws harvested in 1982 onwards have been published by Capper et al. (1986), Capper et al. (1989), Herbert, the late F. and Thomson, E.F. (1992a, 1992b) and in the PFLP annual report for 1987. Unpublished results of A.A. Malek (1991) have also been included in the present analysis.

Voluntary intake (reported here) was measured together with laboratory analyses (see 1.2.1.1), with the objective of finding quick and simple predictors of intake for use by the cereal breeders. Data were collected in several years to quantify year x genotype interactions in voluntary intake and to identify predictors of voluntary intake that are stable from year to year. In addition, information is being collected on the effects of environmental factors on the nutritive values of barley straw varieties.

Barley straws harvested in 1988, 1989 and 1990, seasons with high, low and medium spring rainfall respectively, were evaluated in 1992. Before feeding, they were passed through a hammer-mill with a 20-mm screen, to produce milled straw, which is termed tibn in Arabic.

The nine varieties of straw harvested in 1988 (Trial 1) were evaluated, using Awassi yearling ewes weighing 45 kg. They were fed Arabi abiad tibn ad libitum for 10 days (allowing subsequent intakes to be corrected by covariance), followed by one of the straws ad libitum for an 11-day adaptation period and a 10-day collection period. Twenty-four hours after the last meal was offered, rumen fluid was collected for subsequent analysis of ammonia.

Next, seven varieties of barley straw harvested in 1989 were fed ad libitum for 13 days (Trial 2). Because intake became stable on or before day 7, the mean intake on days 9 through 13 is reported here. Simultaneously, two varieties of straw harvested in 1988 were fed, to check the repeatability of intake measurements. Finally, in Trial 3, six straw varieties harvested in 1990 were fed.

In all trials, sheep were fed tibn once a day. The quantity of tibn offered was generally 1.2 times greater than the mean intake on the previous three days. When sheep, however, were adapting to higher-quality diets, they were offered an additional 100 or 200 g/day. All sheep were given a mineral mixture comprising dicalcium phosphate (12 g/day), sodium chloride (6 g/day) and a trace element/vitamin concentrate (2 g/day).

Trial 1: straw harvested in 1988.

Table 1.5 shows the composition of straw actually consumed by sheep after allowing for the analysis of refusals. The quality of the straw was extremely poor: in no variety did the crude protein content exceed 24 g/kg DM. The ADF content generally exceeded 500 g/kg, and was 620 g/kg in the case of Beecher.

Table 1.5 Composition of the diet of Awassi sheep fed barley straw harvested in 1988 (g/kg DM).

Variety of barley	Code	Organic matter	Crude protein	Acid detergent fibre	Neutral detergent fibre
Antares	AN	914	13.2	553	847
Arabi abiad	AB	902	17.2	519	850
Arabi aswad	AS	914	17.6	515	906
Arar	AR	918	23.3	498	829
Badia	BA	913	16.4	562	892
Beecher	BE	936	13.9	620	883
C-63	CS	928	8.3	516	855
ER/apam	ER	908	17.2	517	852
Rihane 'S'	RI	915	14.0	509	848

The dry matter intakes of the local landraces Arabi abiad and Arabi aswad were significantly higher than the intakes of Beecher, Badia and Rihane 'S' ($P < 0.01$) but there were no significant differences between them and ER/Apam, C-63, Arar and Antares (Table 1.6)

Table 1.6. Voluntary intake and digestibility of nutrients by Awassi sheep of barley straw harvested in 1988.

Code	Body mass kg	DM intake g/day	DOM ^a in DM g/kg	NDF digest. g/kg	OM intake g/kg BW	DOM intake g/kg BW	CP:ME ratio g/MJ [#]
AN	46.6	521bc	422abc	505b	10.2bcd	4.97bc	2.08e
AB	44.7	626a	391bc	478b	12.6a	6.13a	2.94b
AS	45.6	605ab	439ab	560a	12.1ab	5.80ab	2.69cd
AR	45.8	583ab	433abc	520ab	11.8ab	5.55ab	3.59a
BA	44.4	428d	380c	499b	8.8d	3.65d	2.88bc
BE	43.3	395d	456a	564a	8.6d	4.16cd	2.04e
CS	45.7	532bc	471a	560a	10.8abc	5.47ab	1.18f
ER	45.4	588ab	438ab	530ab	11.8ab	5.67ab	2.62d
RI	45.1	450cd	417abc	500b	9.1cd	4.15cd	2.25e
SE of mean		30.0	18.3	18.3	0.624	0.294	0.073
Significance		***	**	*	***	***	***
LSD		89.9	54.9	54.9	1.871	0.881	0.219

^a DOM = digestible organic matter.

* P<0.05; ** P<0.01; *** P<0.001.

[#] Crude protein : metabolizable energy ratio, assuming that 1 kg DOM contains 15 MJ metabolizable energy.

Where straw intake was lower than expected for a given variety, it could be accounted for partly by the protein: ME ratio being lower than normal. If not enough protein is available to microbes in the rumen, they will be unable to multiply and secrete enzymes sufficiently to digest fibre at the optimum rate. We would recommend that farmers feeding animals at around maintenance levels of production provide a supplementary source of protein or non-protein nitrogen for rumen microbes, so that the CP: ME ratio exceeds 5 g CP/MJ of ME. (See 1.2.2.5). Higher levels of production would require higher protein: energy ratios.

Rumen ammonia. The rumen ammonia concentration 24 hours after feeding straw harvested in 1988 was not correlated with the nitrogen content of the straw ($r=-.01$), but was negatively correlated

($P < 0.05$) with the following quality indicators: long term mean DMI, $r = -0.74$, in vitro DM digestibility, $r = -0.68$, in vitro digestible OM in DM, $r = -0.72$, parameter B of gas production, $r = -0.75$. This shows that ration digestibility positively affects the uptake of ammonia by rumen microbes and/or prevents their lysis in the hours before the subsequent meal, and that it can therefore affect the quantity of microbial protein available to the animal.

The maintenance requirement of metabolizable energy for a 45 kg sheep kept indoors is about 5.4 MJ/day (MAFF, DAFS and DANI 1984). That would be provided by 8.0 g digestible OM per kg body mass. The intakes of the nine varieties of straw harvested in 1988 failed to cover this requirement; Arabi aswad, ER/Apam, Arar and Arabi abiad covered between 69 and 76% of maintenance requirement, while Badia, Beecher and Rihane 'S' covered only 46-52% of it.

Intakes of barley straw harvested in the drier years 1989 and 1990.

Intakes of straw harvested in both 1989 and 1990 were at least double the intakes of the same varieties harvested in 1988 (Table 1.7). The straws were softer to the touch and contained less fibre and more protein. The yield of straw was much reduced in these years, and, because voluntary intakes were high, there was not sufficient straw to allow us to perform in vivo digestibility.

Poorly-developed grains were seen amongst the straw. The intake of varieties harvested in 1989 ranked in an unusual way, with the generally highly-preferred Arabi aswad and the closely related Tadmor both having the lowest intakes. On examination, milled straw of these two varieties contained less grain and thicker stems, showing that they maintained their ability to mature in a season in which it was difficult to harvest grain from the other varieties. As a result, their voluntary intakes were increased less by the drought conditions than were intakes of the less-adapted varieties.

The in vitro DOMD (digestible organic matter in DM) was between 0.59 and 0.65 in the straw harvested in 1989, a drought year. If one assumes that digestible OM intakes were the product of DM intake and in vitro DOMD, it varied between 13.2 g/kg body mass for Arabi aswad and 19.5 g/kg for Antares. This would provide between 150 and 240% of the energy requirement for maintenance. The lower nutritive value of the straws of the landraces in such years would be more than compensated for by the higher yields of grain they produced. If grain is imported in years of insufficiency, as occurs in many of the barley-growing countries of the WANA region, farmers so lack a source of roughage that the price of straw can approach or exceed the price of grain. In such circumstances farmers might prefer to have a straw of high, rather than low, fibre content, and therefore prefer the landraces.

Table 1.7. Dry matter intakes of barley varieties harvested in 1989 and 1990, with 1988 results for comparison (g/kg body weight/day).

Rainfall / Variety	Code	1989	1990	1988	1988 ^a
Annual rain (Sep-Aug)		234	233	504	504
Spring rain (Feb-Apr)		24	73	219	219
Antares	(AN)	30.1	23.1	10.2	11.4
Arabi abiad	(AB)	.	20.6	12.6	.
Arabi aswad	(AS)	22.5	16.9	12.1	.
Arar	(AR)	.	18.8	11.8	.
Badia	(BA)	.	17.9	8.8	.
Beecher	(BE)	27.3	.	8.6	.
C63	(CS)	30.5	.	10.8	.
ER/Apam	(ER)	29.6	.	11.8	.
Rihane 'S'	(RI)	28.9	.	9.1	7.8
Tadmor	(TA)	26.9	18.9	.	.
SE of means	-	1.27	1.26	0.68	1.27

^a the intake of these two varieties was measured again, simultaneously with the 1989 samples.

The voluntary intake of varieties of barley straw measured at ICARDA since 1982

The intakes of straw as g OM intake per kg metabolic body size in 22 experiments performed since 1982 are given in Tables 1.8 and 1.9. A typical metabolic body size was $20 \text{ kg}^{0.75}$, so that an intake of 30 g OM/kg $^{0.75}$ was equivalent to 600 g OM/day, which is about 640 g DM/day, or 11.8 g DM/kg body weight. The harvest years 1982, 1983, 1986 and 1988 are considered to be wet, with over 100 mm rain falling in the spring months of February through April. The years 1984, 1985 and 1989 are considered to be poor, with less than 100 mm rain in the same three months. It can be seen, from Table 1.7, that differences between varieties are more consistent in wet years, in which the production of both grain and straw is high, but of relatively poor quality. Supplementation in dry years does not greatly affect the ranking of varieties, but in wet years it generates information of relevance to farmers, by distinguishing straws with inherently low intakes from those in which protein deficiencies need to be corrected.

To be economically relevant, any test for straw quality must reflect the needs of the farmer. We believe that the voluntary intake of straw in mixed diets is the largest factor in the economic value of straw (Goodchild *et al* 1992). Since breeders need to extrapolate quality measurements from one year to the future, the results of tests must rank varieties of straw in as similar manner as possible each year. In other words, the test results must be stable. The **general mean straw intake**, calculated in Table 1.9, estimates the long-term mean ranking of the nine varieties. We are screening tests that can predict the general mean straw intake well (Sections 1.2.1.1. and 1.2.1.2). - A. Goodchild and A. Termanini

Table 1.8. Voluntary organic matter intakes, g/kg^{0.75}, of nine barley straw varieties between 1982 and 1989 without supplementation, listed by type of year. Means are least-squared means (SPSS).

Year	Spring rain, mm	Organic matter intake, g per kg metabolic body size								Source	
		BE	BA	AR	CS	ER	RI	AN	AS		AB
1988	219	19.5	.	.	15.9	25.6	.	.	.	29.6	1
1988	219	24.7	.	.	19.9	24.8	.	.	.	29.8	2
1988	219	21.2	21.4	29.3	25.6	29.4	22.7	28.4	30.1	31.9	3
1983	178	25.8	.	.	.	32.9	.	.	.	34.4	4
1983	178	22.2	.	.	.	27.0	.	.	.	34.7	5
1982	126	25.6	.	.	.	.	.	.	.	40.5	7
1982	126	38.9	.	.	.	.	.	.	.	43.3	8
1986	124	32.0	.	.	33.0	36.6	.	.	.	39.4	6
mean of wet years		24.7	22.7	30.6	24.4	30.0	24.9	28.7	31.3	34.0	
1985	95	36.3	34.9	40.5	41.1	33.2	41.6	48.3	41.9	37.8	10
1984	82	35.6	39.2	31.0	45.9	34.9	36.6	40.8	.	47.5	9
1990	72	.	44.8	47.0	.	.	.	57.8	42.2	51.5	12
1989	24	66.5	.	.	75.6	67.8	.	.	.	66.2	11
1989	24	70.9	.	.	80.1	75.9	74.2	77.8	68.0*	.	12
mean of poor years ^a		48.4	49.1	47.8	56.7	49.0	51.3	56.1	49.5	52.8	
mean of all years		35.1	35.4	37.2	39.5	38.6	37.8	42.2	38.3	43.0	

* Of Tadmor, a closely related variety. The low intake was probably a result of good adaptation with relatively high grain yield. ^a excluding 1990 (least-squares mean not yet calculated).

Sources: 1, 2) A.A. Malek experiments 3 and 4 (unpublished); 3) Present annual report; 4, 5) Capper *et al.* 1986 (combine harvested and hand harvested); 6) Dry ewes, PFLP annual report for 1987, pp. 95-101; 7, 8) Capper *et al.* 1986 (experiments 1 and 2); 9) Capper *et al.* 1989; 10) Herbert and Thomson (1992b); 11) A.A. Malek expt 3 (unpublished); 12) Present annual report.

Table 1.9. Voluntary organic matter intakes, g/kg^{0.75}, of nine barley straw varieties between 1982 and 1989 with supplement, listed by type of year. Means are least-squared means (SPSS).

Year	Spring rain,mm	Supplement		Organic matter intake, g per kg metabolic body size								Source	
		type	g/day	BE	BA	AR	CS	ER	RI	AN	AS		AB
1988	219	Soya bean	54	23.6	.	.	34.4	38.2	.	.	.	41.8	13
1986	124	Mixture*	853	33.5	.	.	32.6	39.9	.	.	.	40.4	14
1986	124	Mixture*	330	38.8	.	.	35.2	44.6	.	.	.	46.1	15
1986	124	Mixture*	643	34.2	.	.	38.5	37.3	.	.	.	45.2	16
1986	124	Mixture*	883	31.0	.	.	28.4	33.2	.	.	.	36.8	17
mean of wet years				32.2	.	.	33.8	38.6	.	.	.	42.1	
1985	95	Soya bean	200	39.0	48.3	48.2	48.6	46.5	50.7	49.0	51.0	47.0	20
1984	82	Barley	170	37.4	40.6	.	51.8	41.7	.	.	.	.	18
1984	82	Cottonseed	130	43.5	54.4	.	55.7	55.6	.	.	.	.	19
mean of poor years				39.6	47.4	49.1	51.6	47.5	51.6	49.9	51.9	47.9	
mean of all years				35.8	41.5	43.8	41.3	42.8	46.3	44.6	46.4	46.2	
mean (including unsupplemented)				35.4	38.4	40.5	40.4	40.7	42.1	43.4	42.4	44.6	
Stem and leaf, respectively:													
1986	316	soya bean	100	19.7	.	.	21.3	19.0	.	.	.	21.3	21
1986	316	soya bean	200	62.1	.	.	58.1	58.8	.	.	.	52.7	22

Sources: 13) A.A. Malek expt 4 (unpublished); 14) Ewes in early lactation, PFIP annual report for 1987, pp. 95-101; 15-17) The same ewes, low, medium or high supplementation, PFIP annual report for 1987, pp. 95-101; 18, 19) Capper et al. 1989 (barley and cottonseed cake); 20) Herbert and Thomson (1992b); 21, 22) Herbert and Thomson (1992a)

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1.2.2.3 Effects of time of feeding supplement relative to time of feeding straw: voluntary intake and digestibility

In West Asia, supplements of concentrates are fed over a large part of the year in which the bulk of the diet is obtained from grazing natural pastures or stubble or from hand-fed straw. Farmers generally offer supplements, when feeding small quantities, in the evening, when the flocks return from grazing, as they believe that this prevents the reduction of intake from grazing during the day and helps to keep the animals warm at night. Although the composition of supplements, particularly their protein/energy ratio, can affect the rate of digestion of fibrous forage components of the diet, no work has been done to establish whether the time of feeding of supplements relative to the time of offering low quality, fibrous feeds affects their intake. This has important practical implications for systems in West Asia, where flockowners can choose between feeding in the morning before grazing, when the flock returns for watering at mid-day, or in the evening.

Two experiments were carried out to establish whether the time of feeding different supplements affected the voluntary intake of straw, when it was offered for 8 h daily. In the first experiment, the supplements provided the same amount of nitrogen, and in the second, the same amount of digestible organic matter.

Methods. In the first experiment, supplements of 240 g/day of barley or 80 g/d cotton seed cake were fed 3.5 h before, at the same time as, and 3.5 h after milled straw was offered ad libitum for 8 h from 10.30 h each day. In the second experiment, supplements of 230 g/day of cotton seed cake, 165 g/day of barley, and the same quantity of barley with 17 g/day urea were fed 4 h before, at the same time as, and 4 h after milled straw was offered for 8 h from 10.50 h each day. In addition, in each experiment a control group

was offered straw alone. Both experiments were carried out on Awassi ewe lambs fed ad libitum in digestibility crates. After an initial 11 day adaptation period, the intake and composition of feed and output of faeces were measured for 10 days. In experiment 1, there were four sheep per treatment (mean weight 41 kg) and in experiment 2, three sheep per treatment (mean weight 38 kg).

Table 1.10. Dry matter intake (g/d) of straw when supplements were fed before, at the same time as, or after straw was offered.

	Time of feeding supplement			SE
	before	same	after	of Mean
<u>Experiment 1:</u>				
None	410			
Barley, 240 g		575	595	525
Cottonseed cake, 80 g		595	635	550
				35
<u>Experiment 2:</u>				
None	490			
Barley, 165 g		625	580	605
Barley 165, urea 17 g		625	600	650
Cottonseed cake, 230 g		635	750	680
				38

All the supplements significantly ($P < 0.001$) increased the intake of straw, but the effect of time of feeding supplements was not significant. In both experiments, however, supplementing with cotton seed cake, but not barley, at the same time as the straw was fed, increased intake to a slightly greater extent than feeding the supplement earlier or later. Supplementing with barley and urea did not increase the intake above that of diets supplemented with barley alone, suggesting that, for sheep of 1.5 years, the diet of barley and straw already contained sufficient rumen-degradable protein. - S. Rihawi, A. Termanini, T. Treacher, A. Goodchild and E. Owen (Reading University, England)

1.2.2.4 The effects of urea treatment, urea supplementation and coarse milling on the nutrient intake of sheep fed barley straw

Farmers in the Middle East have traditionally chopped cereal straw during threshing. This chopped straw is called tibn in Arabic. Feeding straw in the form of tibn reduces feed selection and waste. Recently, farmers have developed hammer mills with large screens to make a similar product from combine-harvested straw. Treatment of straw with urea or ammonia to improve digestibility and nitrogen content has been widely recommended. Supplementing with a smaller quantity of urea, or with forage crops which may themselves have been fertilized with urea may also be used to improve the nitrogen content of diets (Greenhalgh 1984).

Coarse milling allows particles to flow more rapidly from the rumen, reducing rumen fermentation and increasing the quantity of nutrients digested in the small intestine. Part of the fibre that escapes from the rumen is fermented in the large intestine. Because digestion of microbial protein formed in the large intestine is much less complete than of that formed in the rumen, coarse milling is likely to increase the animal's protein requirements.

A 3 x 2 factorial experiment compared methods of using urea (treatment, T, vs. supplementation, S, vs. none, C) on long, L, and on milled, M, barley straw. There were 4 replicates, using 24 mature castrated Awassi males initially weighing between 43 and 54 kg. One unsupplemented sheep became sick and was removed.

Batches of the long and the milled straw were treated by adding 0.4 l of a solution containing 100 g urea/l to each kg of straw (M. Hadjipanayiotou, personal communication). The batches were placed in large, black, heavy-gauge polythene bags. After three months (January to March), the bags were opened and the straw laid out in the shade to lose gaseous ammonia and moisture. Treated and untreated straw contained 84 g and 30 g crude protein/kg DM

respectively; the untreated straw was supplemented with 16 g urea/kg air-dry matter to give a calculated crude protein that was equivalent to that of the treated straw. Milling produced a coarsely ground straw, 40% of which passed through a 1.0 mm screen.

Straw was offered at 1.2 times the mean intake in the previous 3 days. The urea supplement, if fed, was sprayed on to the straw as a 500 g/l solution. All sheep were fed 20 g/day of a mixed mineral supplement. During the first 10 days (covariance period), the voluntary intake by all 24 sheep of a single batch of barley straw was recorded. The experimental diets were then offered ad libitum for an 11 day adaptation period. Intakes and faeces outputs were recorded in the following 10 days. Samples of rumen fluid for analysis for ammonia concentration were taken by stomach tube at 4, 8 and 24 hours after feeding on the last day of the experiment.

In a separate experiment, the pattern of DM degradability of four samples of straw, TL, TM, CL and CM, was measured in sacco using 4 rumen-cannulated Awassi wethers fed barley straw supplemented with urea at the same rate as group S. Bags were removed at 4, 8, 16, 24, 48, 72 and 96 hours.

The diet actually consumed by the sheep is indicated in Table 1.10. The crude protein (nitrogen x 6.25) contents of the S and T treatments were not significantly different, and were 54 g/kg DM higher than in the unsupplemented group. Urea treatment tended to reduce the neutral detergent fibre (NDF) and acid detergent fibre (ADF) contents of long straw.

Table 1.10. Composition of the diets consumed (g/kg DM).

Treatment	Organic matter	Crude protein	NDF	ADF
Urea treated straw				
Long	902	85	596	345
Milled	934	79	796	492
Urea supplemented straw				
Long	772	86	693	399
Milled	855	82	788	431
Unsupplemented straw				
Long	765	31	696	395
Milled	892	27	805	449

Coarse milling of straw reduced spillage to practically nil. Because selection was eliminated by milling, the CP concentration was lower and fibre fractions were higher (Table 1.10). The difference in OM content between the diets of sheep fed long straw and milled straw was the result of the high level of soil contamination of the long straw.

Milling had little effect on intake or digestion when adjustment was made for the lower ash content of the milled straw (Table 1.11). The quantity of faecal nitrogen produced per kg OM intake was not affected, suggesting that coarse milling does not result in increased microbial activity in the large intestine.

Voluntary DM intake was increased from 717 to 1026 g/day by the urea supplement, but was no greater (1030 g/day) with urea treatment (SE of C, S or T means 54). The respective organic matter intakes were 607, 854 and 951 g/day (SE 49). A lack of response of intake to urea treatment has also been shown in sheep by Greenhalgh (1984). Rumen ammonia levels were very low with unsupplemented straw and probably adequate with supplementation or treatment (Table 1.11). OM digestibility was increased from 479 to 525 g/kg by supplementation

and was increased further to 589 g/kg by urea treatment (SE 11.7) and resulting in sheep fed treated straw having the highest digestible OM intakes. Similar responses to ammonia treatment have been reported by, for example, Kernan, Crowle, Spurr and Coxworth (1979) and Silva, Greenhalgh and Ørskov (1989). Live weight gains ranked similarly to DOM intakes, but the differences were not significant. Urea treatment increased the in sacco disappearance of straw DM by 28-42 mg/g at all stages of incubation and increased its potential extent of fermentation (a+b) in the rumen (Table 1.12). The relative rate of fermentation (c) was not increased, in contrast with the results of Tuah, Lufadeju, Ørskov and Blackett (1986).

Table 1.11. Daily intake and digestibility of nutrients, rumen ammonia concentration, and dietary N:DOM ratio.

	DM intake (g)	OMD (g/kg)	DOM intake (g)	4h NH ₃ , (mg N/l)	24h NH ₃ , (mg N/l)	Faecal N (g/kg OMI)	N:DOM ratio (g/kg)
Urea treated straw							
Long	1102	586	587	207	87	6.5	25.6
Milled	957	592	533	147	83	6.6	22.6
Urea supplemented straw							
Long	972	517	396	140	43	6.4	34.7
Milled	1081	533	503	119	60	6.2	28.7
Unsupplemented straw							
Long	721	480	273	26	8	6.4	13.5
Milled	713	478	307	12	6	6.2	10.1
SE mean	76	16.6	49	32.1	12.8	0.30	0.86
Significance ^a	**	***	***	***	***	ns	***

^a Significance of differences between the means for treated, supplemented and unsupplemented straw. Length of chop not significant in any case.

Table 1.12. The in sacco DM disappearance (DML) of straw.

	DM disappearance, mg/g					Rate h ⁻¹ c ^a
	8 h	24 h	48 h	96 h	a ^a	a+b ^a
Urea treated straw						
Long	210	510	600	667	102	690
Milled	270	511	629	690	135	726
Urea supplemented straw						
Long	208	483	596	638	101	673
Milled	175	476	576	631	99	670
SE mean	15.6	16.8	20.3	10.0	7.0	12.2
(S vs. T)	**	ns	ns	***	*	*

^a Coefficients of the equation $DML = a + b \cdot e^{-c \cdot t}$

In this experiment, treatment of straw with urea increased the intake of digestible organic matter from 290 g/day to 560 g/day (+93%). Supplementation with urea, which required only 40% of the quantity of urea needed to treat straw (16 v 40 g/kg straw), increased DOM intake to 448 g/day (+54%). It is likely that a similar response could have been obtained using less than half this amount of urea supplementation.

As urea is a scarce resource in many developing countries and the crude protein content of straws is generally a greater constraint on intake than the digestibility of its OM, it might be better to supplement a larger number of sheep with urea or urea-fertilized forage than to feed a smaller number of sheep on urea-treated straw. - A. Termanini, A. Goodchild, T. Treacher, S. Rihawi and E. Owen (University of Reading, England)

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1.2.2.5 Value of Atriplex halimus and Salsola vermiculata foliage as supplements for barley straw

There is an ecological need to introduce shrubs into the barley/livestock zone, because they capture wind-blown soil, can help prevent water erosion, are tolerant of drought and are efficient users of water (McKell 1975). Well-established shrubs are also a source of fuel wood. These are all long-term benefits, likely to be of interest only to farmers with secure land tenure. In many countries of the WANA region farmers and pastoralists do not have assured land tenure, or are forced to make decisions on a short-term basis. To encourage the adoption of shrubs, an alternative approach would be to find short-term economic justification for them. For example, the shrubs may make a useful contribution to ruminant feeding.

High concentrations of sodium (32-82 g/kg dry matter, Wilson 1966), potassium (13-41), calcium (13-21) and magnesium in Atriplex spp. are said to contribute to the efficiency of water use and drought tolerance in halophytes. They are accompanied by about 5% oxalate, which protects cell contents against these cations by functioning as a chelating agent. It is, however, a compound that is potentially toxic to some rumen microorganisms, and in certain circumstances it can reduce blood calcium and form stones in the urinary tract.

We have commenced research to determine how the intake of barley straw, and the digestibility of the nutrients it contains, responds to supplementation with two levels of each of three halophytes: two ecotypes of Atriplex halimus and one of Salsola vermiculata. Since the sheep were fed in individual metabolism crates, the results will be of most direct relevance to a cut and carry system, but they would also indicate the effect of supplementation of sheep grazing stubbles with halophytes.

Four castrated male Awassi sheep were allocated to each treatment by a randomized block design. All sheep were fed coarsely milled barley straw (tibn) at the rate of 1.2 times the previous day's intake. Treatments were: 1) Basal diet (barley tibn with mineral mixture, 20 g/day); 2) and 3) Basal diet + Salsola vermiculata, low and medium levels; 4) and 5) Basal diet + Atriplex halimus ecotype 1, low and medium levels; 6) and 7) Basal diet + Atriplex halimus ecotype 2, low and medium levels. The low level was calculated to supply 200 g dry matter/day, and the medium level 400 g/day. In addition to the measurements usually made in an intake and digestibility trial, water consumption was recorded.

Table 1.13. The dry matter composition of the halophytes used in the experiment, g/kg DM.

Trt Nos.	Supplement matter fibre	Organic detergent fibre	Acid detergent	Neutral protein	Crude
2, 3	<u>S. vermiculata</u>	815	250	433	140
4, 5	<u>A. halimus</u> ecotype	1823	309	476	140
6, 7	<u>A. halimus</u> ecotype	2866	383	559	121
SE of means		7.5	5.4	8.8	5.9

The barley straw in the basal diet was of the Arabi abiad variety harvested in 1992 and contained 33 g crude protein/kg DM.

The composition of the three halophyte varieties is shown in Table 1.13. Their ash content (1000 minus organic matter) was in the range 130-190 g/kg DM. Sheep refused little of the halophyte offered them (Table 1.14). The intake of straw was increased significantly at the higher level of all varieties of halophyte offered, with the lower level giving an increase that was proportional to the halophyte intake.

Table 1.14. The effect of halophyte supplements on the intake of milled barley straw by sheep.

Trt No.	Supplement	DM intake, g/day		
		supplement	straw	total
1	None	0	705	705
3	<u>S. vermiculata</u>	207	751	958
2	<u>S. vermiculata</u>	389	860	1249
5	<u>A. halimus</u> 1	209	783	992
4	<u>A. halimus</u> 1	351	869	1220
7	<u>A. halimus</u> 2	218	882	1099
6	<u>A. halimus</u> 2	409	923	1333
SE of means		9.3	37.8	41.5

Table 1.15. The effect of halophyte supplements on dietary protein content, digestible DM intake, and the digestibility of barley straw by sheep.

Trt No.	Supplement	Crude protein g/kg DM	Digestible DM intake		DM digestibility	
			g/day	g/g	ration	halophyte g/g
1	None	33.0	321	0.450	-	-
3	<u>S. vermiculata</u>		56.2	480	0.499	0.67
2	<u>S. vermiculata</u>		66.4	655	0.524	0.68
5	<u>A. halimus</u> 1	55.6	512	0.512		0.74
4	<u>A. halimus</u> 1	63.9	652	0.531		0.73
7	<u>A. halimus</u> 2	50.4	563	0.513		0.74
6	<u>A. halimus</u> 2	60.0	736	0.544		0.76
SE of means		c.5.9	31.3	0.0174		c.0.1

There was a non-significant tendency for *A. halimus* ecotype 2 to increase DM intake more than the other varieties. Halophytes, on the average, increased the digestibility of dietary DM (Table 1.15). The calculated DM digestibility of salsola was 0.67, that of both ecotypes of *A. halimus* was 0.74. Because of the high content of soluble ash, digestible organic matter in DM would have been lower, and in any case the standard error of the estimate approached 0.1.

The three types of halophyte fed seemed to be suitable supplements for barley straw. For each kg of halophyte dry matter fed, the voluntary barley straw intake increased by between 340 and 630 g DM. The mechanism by which this occurred may have been the ability of halophytes to correct a protein deficiency; the crude protein (CP) contents of the respective halophytes were 140, 140 and 121, in comparison with the barley straw which contained 33 g CP/kg DM. The diets, therefore, contained on average 33, 54 and 63 g CP/kg DM at the halophyte supplementation levels of nil, low and high (Table 1.15). If digestible DM contained 0.9 OM, an assumption that may prove different after faeces are analyzed, the ratio between CP and ME (=15 MJ/kg digestible OM) averaged 5.4, 7.9 and 9.0 g/MJ. Recent findings at ICARDA suggest that in Awassi sheep consuming approximately their maintenance requirements, 5 g CP/MJ of straw is sufficient to provide degradable protein for rumen function. The intake response to higher protein levels suggests that a component in the halophyte, possibly protein not degraded in the rumen, has an important effect on intake.

In future work, given adequate resources, we intend to estimate differences in the palatability and voluntary intake of halophyte plants, to measure dietary preferences and effects on the performance of sheep grazing stubble when halophytes grow as rows in barley fields, to check whether the large urine volume in sheep eating halophytes is a drain on energy or protein metabolism, to

determine how the rumen adapts to oxalates and to define the other consequences to the animal of minerals and oxalates. - A. El Awad, A. Goodchild and A. Osman

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1.2.2.6 Nutritive value of fourwing saltbush (Atriplex canescens) in Balochistan, Pakistan

The potential of saltbush is being studied for two uses: (1) as a supplement to grazing on rangelands which are generally heavily degraded, owing to over population of small ruminants and removal of the shrubs for fuelwood, and (2) as a supplement to other feeds such as wheat straw. A study was, therefore, conducted at AZRI to investigate the value of saltbush as a supplement to a basic diet of wheat straw purchased from the local market. Effects of feeding saltbush on levels of sodium, calcium, phosphorus and potassium in the blood were studied (to be reported later) and daily water intake was recorded.

The feeding trial had three phases. In the preliminary phase (six days) sheep were offered ad-libitum chopped wheat straw and 200 g daily of cottonseed cake (CSC), containing about 20 percent crude protein in the dry matter (DM). During the main experimental phase (28 days), four groups, each containing four mature Harnai male castrates, were offered ad-libitum wheat straw in addition to one of four levels of dried saltbush leaves

harvested in November and December 1991. The four levels were 150, 300, 450 and 600 g of leaves (air dry matter). Faeces were collected during the last seven days of the experimental phase. Feed, refusal and faecal samples were dried and ashed according to standard procedures and intakes of dry (DMI) and organic matter (OMI), and digestibility of the dry (DMD) and organic matter (OMD), and DOMD, were calculated. (DOMD is the amount of organic matter digested per 100 g dry matter ingested).

The final phase of the experiment lasted 13 days. Sheep were again offered ad-libitum wheat straw and 200 g CSC. Faeces from one sheep in each group were collected, so that the digestibility of the wheat straw/CSC diet could be calculated.

There was a tendency for the digestibilities of the dry (DMD) and organic matter (OMD) to remain the same at the low and medium levels of feeding saltbush leaves and then to decrease at the higher levels. The treatment differences, however, were only significant in the case of the OMD (Table 1.16).

Table 1.16. Digestibility of dry and organic matter, DOMD, daily intakes of dry and organic matter, and daily gains of sheep offered diets containing four different levels of fourwing saltbush leaves and wheat straw in the winter.

	Quantity of air-dry saltbush				Sign.
	150	300	450	SD ¹ 600	
Number of observations (n)	4	3 ²	4	3 ²	
Actual saltbush in DM ³	0.15	0.29	0.49	0.69	
Digestibilities (%)					
- dry matter	52.4	53.3	48.9	44.4	4.41 ns
- organic matter	54.7	54.3	50.1	43.3	4.68*
- DOMD	48.2	47.0	42.2	35.7	3.90**
Total intakes (g/day)					
- dry matter	892	939	836	765	61.2*
- organic matter	785	814	707	631	54.3 **
- digestible organic matter	430	442	354	273	
Daily gains (g)	41	10	-14	-100	39.8*

¹Residual standard deviation. For each treatment, divide SD by the square root of number of observations to calculate standard errors of the mean.

²One sheep in each of these treatments refused large amounts of saltbush leaves and for this reason the data were not included in the analysis.

³Actual proportion of saltbush leaves in the dietary dry matter.

There were statistically significant differences between the treatments in terms of dry (DMI) and organic matter (OMI) intake (Section III Table 3.12). Definite trends were apparent. The total intakes at the low and medium levels of inclusion of saltbush leaves were similar, but decreased as the proportion of saltbush leaves in the total diet increased.

Linear regression analysis was conducted between DMD, OMD, DMI or OMI, and the proportion of saltbush leaves in the total diet (S) (Section III Table 3.13). This made it possible to estimate the digestibilities and intakes for diets containing wheat straw only and saltbush leaves only. The extrapolated DMD and OMD of the wheat straw were high, and conversely, the extrapolated DMD and OMD of the saltbush leaves low. The digestibility of straw from the local landrace of wheat has not yet been determined at AZRI and there is no information about the origin of the straw. The in vivo DMD of straw in the current experiment appeared to exceed 50 percent. Three varieties of wheat straw harvested at ICARDA headquarters in 1986, a year with average rainfall, had a mean DMD of 43% (PFLP 1987). The DMD and OMD values of the wheat straw used in this experiment are therefore relatively high. Similarly, the DMD and OMD values of the saltbush leaves are surprisingly low. The decreasing DMD values and digestible OM intakes of the total diets as the proportion of saltbush leaves increased is reflected in the decreasing liveweight gains of the sheep (Table 1.19). The sheep would have been in liveweight balance at a saltbush proportion in the total diet of 0.38.

Table 1.19. Constants of linear regression between the dry matter (DMD) or organic matter (OMD) digestibility of the total diet, or daily total intakes of dry matter (DMI) and organic (OMI) matter, and the proportion (S) of saltbush leaves.

Y	a ¹	(SE)	b	(SE)	R ²	P	RSD	a+b ²
DMD	55.6	(2.55)	-14.4	(5.73)	0.34	0.0274	4.37	41.2
OMD	58.5	(2.77)	-19.3	(6.21)	0.45	0.0091	4.74	39.2
DMI	977.7	(32.69)	-299.9	(73.38)	0.58	0.0015	56.0	677.8
OMI	869.9	(27.31)	-338.8	(61.29)	0.72	0.0001	46.8	531.1

¹These values indicate the estimated values for diets containing no saltbush leaves.

²Extrapolation for S=1 (i.e. when diet contains 100 percent saltbush leaves).

It was only possible to prevent sheep from refusing a large proportion of the highest level of saltbush leaves by limiting the amount of wheat straw on offer. This finding is in marked contrast to an earlier experiment in which sheep consumed, without difficulty, 700 g daily (air-dry basis) of saltbush leaves, even when offered 400 g daily of barley grain or cottonseed cake as well (Atiq-ur-Rehman *et al.*, unpublished data). A likely explanation for these contrasting results is that, in the present study, the leaves were harvested late in the season, when their digestibility was low, whereas in the study of Atiq they were harvested in June. Elsewhere in this Annual Report, supplements of *Atriplex halimus* and *Salsola vermiculata* harvested at Maragha, Syria in early August are shown to increase the intake of barley straw.

Further studies are needed before it can be stated that saltbush harvested at the beginning of winter has a feeding value below the maintenance requirement of local sheep. It appears, however, that sheep browsing on saltbush at that time would also need to be fed wheat straw of similar digestibility to that fed here, if the range grazing available were poor, as is usually the case. - Principal Investigators: E. Rasool (AZRI), S. Rafique (AZRI) and E. Thomson (ICARDA, Quetta)

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1.2.2.7 Nutritional and anti-nutritional characteristics of selected Vicia spp. genotypes¹

Introduction

The principal agricultural activity in the dry areas of West Asia and North Africa (WANA) is small ruminant (sheep and goat) production, with rangeland grazing providing most of the animal feed (Cocks *et al* 1986). When livestock feed prices are high, feed legumes such Vicia species, which may be fed to small ruminants in the form of straw and grains, are increasingly attractive to farmers in WANA (Abd El Moneim *et al* 1988). In view of ICARDA's overall objective of developing sustainable farming systems in the dry areas, there is a clear need for feed legume crops. One of the most attractive legume species for grain and straw production is Narbon vetch, Vicia narbonensis. It is a good source of protein, with seeds containing up to 28% protein and yielding about 364 kg ha⁻¹ protein whilst the straw contains about 9% protein (Abd El Moneim, 1992). The International Center for Agricultural Research in the Dry Areas (ICARDA) currently maintains breeding lines of Vicia species which include V. narbonensis L, V. sativa L, V. ervilia and V. palestina R. In this study, we present compositional data on selected lines of these species with respect to their crude protein (CP), trypsin inhibitor activity (TIA), catechin equivalents (CE) and protein precipitable tannin (PPT) content. These parameters are of interest, because both trypsin inhibitors and tannins are implicated in poor protein digestibility (Liener, 1969; 1988), while the latter have been generally associated with poor digestibility and palatability (Menhansho *et al* 1987; Hagerman *et al* 1992). It is hoped that the provision of this information, along with those on *in vitro* characteristics, will arouse greater interest in the exploitation of their potential in human and/or animal feeding.

¹A collaborative project with Legume Program (ICARDA)

Experimental methods and materials

The Vicia genotypes evaluated were obtained from the genetic breeding program at ICARDA, Tel Haydia, Syria (36° 40 'N, 37° 20 ' E; 390m elevation). The current breeding procedure uses germplasm evaluation and seed multiplication in nursery rows and evaluates selected genotypes in microplots and promising genotypes in advanced yield trials. The samples analysed were mature grains, comprising 91 lines of V. narbonensis (Narbon vetch), 23 of V. sativa (common vetch), 16 of V. ervilia (bitter vetch) and 16 of V. palaestina. About 50 g each of the dried seeds were ground, using a UD cyclone sample mill (UD Corporation, Fort Collins Co, USA) fitted with 1mm mesh sieve before use.

The dry matter (DM), crude protein (CP) and ash were determined as described by MAAF, UK (1981) while neutral detergent fibre (NDF) and acid detergent fibre (ADF) were determined, using the method of Goering and van Soest (1970). Some random selections were also evaluated for in vitro organic matter digestibility (IOMD) and dry matter digestibility (IDMD) using the technique of Tilley and Terry (1963). The weight of 100 seeds were estimated, using a mechanical seed counter (Numigral, Seed counter, Franken BV) before weighing.

All samples for tannin determination were milled just before analysis to prevent the oxidation of phenolic compounds. 200 mg of the defatted (ethyl ether) flour was extracted with 60% methanol and the PPT content determined, using standard bovine serum albumin (Sigma Chemical Co, MO; Lot 41H0520) as outlined by Hagerman and Butler (1978). Catechin equivalent, which detects simple flavonoids as well as condensed tannins, or the so-called polyphenols, with molecular weight ≥ 5000 , was determined by the vanillin-HCl method of Burns (1971) as modified by Price and Butler (1977) and, Price et al (1978). Commercial catechin($\pm$) (Sigma, Co.; Lot C-0774) was used as reference standard. The TIA content of the grains was evaluated in terms of the extent to

which an extract of the defatted flour inhibits the action of bovine trypsin (EC 3.4.21.1) on the substrate: benzoyl-DL-arginine-p-nitroanilide hydrochloride (BAPNA.HCl; Sigma Co, Lot 110H0329) as modified by Smith et al (1980).

Results

The weight of 100 seeds, CP and the levels of the various anti-nutrients are summarized in Table 1.20. Seed weight was considerably larger in V. narbonensis, representing about four times the weight of the other species. Crude protein content ranged from $264.38 \pm 6.34 \text{ g kg}^{-1} \text{ DM}$ in V. ervilia to $341.87 \pm 8.55 \text{ g kg}^{-1} \text{ DM}$ in V. palaestina, with all species showing little intraspecific variabilities.

Protein precipitable tannin was mainly restricted to V. narbonensis while none was detected in any of the lines of both V. sativa and V. ervilia. Catechin, a monomeric unit of many condensed tannins, was no more than $8.27 \text{ g kg}^{-1} \text{ DM}$ in any of the species and, seven of the 91 lines of V. narbonensis had no detectable CE levels. There was considerable intraspecific variability in CE as indicated by the high coefficients of variation (CV), which ranged from 17.48% in V. palaestina to 68.99% in V. sativa. In comparison with most conventional legumes, TIA in all the species were generally low, with values ranging from $0.36 \text{ g kg}^{-1} \text{ DM}$ in selection IFLVP 2524 to $5.00 \text{ g kg}^{-1} \text{ DM}$ IFLVS 2560. Values for TIA in V. palaestina were particularly low ($0.51 \pm 0.13 \text{ g kg}^{-1} \text{ DM}$); and a CV of 25.86% suggests that selection for lower inhibitor levels is possible.

The OM and ash content of all the lines were similar, but the ADF and NDF values (Table 1.21) of V. narbonensis were significantly ($P < 0.05$) higher than those of the other species. Mean IVDMD and IVOMD of the species also differed significantly ($P < 0.05$). Higher IVDMD (90.95%) and IVOMD (88.30%) of V. ervilia paralleled the relatively lower ADF and NDF values.

Seed weight was significantly ($P < 0.05$) correlated with CE in

both V. sativa and V. palaestina (Table 1.22) while CP was weakly correlated ($r = -0.48$) with TIA among the V. sativa genotypes. There was no significant relationship between seed weight and TIA in any of the species investigated. The poor correlations between seed size, CP and the various anti-nutrients suggest that a selection programme based on these criteria in these species may be difficult. With regard to tannins, a selection programme based on matching seed and flower colours in these breeding lines is envisaged, since seed and flower colours are known to be strongly correlated with tannin levels (Cabrera and Martins, 1986; Garrido et al 1988).

Conclusion

It is evident that the protein content and in vitro characteristics of these species of Vicia compare quite favourably with those of the more conventional and higher-priced grain legumes. Additionally, their content of anti-proteinases, typified by TI and tannins, appears to be much lower than found in the more conventional legumes. Clearly, much more information is needed on their content of other anti-physiologic agents including β -cyanoalanine, and on simple treatments to ensure their safe use as dietary components for monogastrics and ruminants under feed-lot. The need for more evaluatory tests on Vicia has become compelling in the wake of reported cases of purposeful adulteration with Vicia, of some of the more conventional and higher-priced grain legumes. - **V.A. Aletor, A.V. Goodchild and A. Abdul Moneim (LP)**

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Table 1.23. Seed weight, dry matter, crude protein, protein precipitable tannin, vanillin-HCl catechin equivalent and trypsin inhibitor activity of the seeds of *Vicia* spp.

Attributes	Species			
	<i>V. narbonensis</i>	<i>V. sativa</i>	<i>V. ervilia</i>	<i>V. palaestina</i>
Number of lines	91	23	16	16
100-seed mass (g)	16.0±2.66	4.6±1.21	4.6±0.35	3.8±0.28
Crude protein (g/kg DM)	290±14.4	317±18.7	264±6.4	342±8.6
PPT (g/kg DM)	4.42±0.17	not det	not det	4.37±0.04
CE (g/kg DM)	1.98±0.71	2.83±1.95	2.01±0.59	3.15±0.55
TIA (g/kg DM)	3.43±0.55	4.29±0.50	3.46±0.36	0.51±0.13

Values are means ± standard deviation for the number of lines indicated. not det = none detected.

Table 1.24. Chemical and *in vitro* characteristics of a random subsample of the seeds of *Vicia* spp.

Analysis (g/kg DM)	Species			
	<i>V.narbonensis</i>	<i>V.sativa</i>	<i>V.ervilia</i>	<i>V.pal.</i>
Ash	36.7±2.72	34.4±3.25	31.6±1.20	34.7±1.72
ADF	134±12.2a	84±11.4b	57±2.2c	92±5.8b
NDF	221±25.4a	144±8.5b	139±16.2b	150±27.5b
IVDMD	882±4.8b	854±17.8b	910±6.7a	820±6.6c
IVOMD	847±4.2b	825±22.9bc	883±7.3a	792±10.4c

Means with dissimilar letters in the same horizontal rows differ significantly ($P < 0.05$).

Table 1.25. Correlation coefficients (r) between 100-seed mass, crude protein and anti-nutritional constituents.

	n	PPT	CE	TIA
<u>V.narbonensis</u>				
100-seed mass, r	91	-0.45	-0.12	-0.02
Significance		*	ns	ns
Crude protein, r	91	-0.21	0.01	0.17
Significance		*	ns	ns
<u>V. sativa</u>				
100-seed mass, r	23	-	-0.65	-0.31
Significance		-	***	ns
Crude protein, r	23	-	-0.04	-0.48
Significance		-	ns	*
<u>V. ervilia</u>				
100-seed mass, r	16	-	-0.41	-0.34
Significance		-	ns	ns
Crude protein, r	16	-	0.32	-0.05
Significance		-	ns	ns
<u>V. palaestina</u>				
100-seed mass, r	16	-0.2	0.55	-0.27
Significance		ns	*	ns
Crude protein, r	16	-0.16	0.65	-0.28
Significance		ns	*	ns

n, no. of observations.

ns, P>0.0

5; *, P<0.05; **, P<0.01; ***, P<0.001.

1.2.2.8 Evaluation of seeds of selected lines of three Lathyrus species for BOAA, protein precipitable tannins, catechin equivalents, trypsin inhibitor activity and certain in vitro characteristics²

Introduction

In the WANA region, Lathyrus species could be important grain legumes for animals and humans. The major factor limiting utilization is the potent low molecular weight neurotoxin β -N-oxalylamino-L-alanine (BOAA). This non-protein amino acid is implicated in the neurodegenerative condition in humans called lathyrism (Qureshi *et al.* 1977; Nunn *et al.* 1987). The major sign of lathyrism is an irreversible spastic paralysis of the legs and death is possible (Bell and Nunn, 1985). Lathyrus, however, is a common food for labourers in India and Bangladesh (Bharati and Neupane, 1989), and is used to adulterate chickpea and mung bean. Lathyrus is also a crop that is easy to cultivate, is tolerant of drought and low soil fertility has good resistance to pests and diseases and gives reasonably good yields.

Most studies on the quality of Lathyrus varieties have centred on their BOAA content, but plant breeders need to know how the content of this compound is correlated with other undesirable and desirable characteristics. In addition to BOAA content, this study reports on, two measures of tannin (protein precipitable tannin (PPT) and catechin equivalent (CE)), trypsin inhibitor activity (TIA) and 100-seed mass. Some samples were also analysed for crude protein and in vitro digestibility. The material analysed was 68 improved lines of Lathyrus species in the germplasm collection at the International Center for Agricultural Research in the Dry Areas, Aleppo, Syria (ICARDA).

²A collaborative project with Legume Program

suggests the feasibility of genetic detoxification. - **V. Aletor, A. Abdul Moneim (LP) and A. Goodchild**

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Table 1.26. Seed weight, drymatter, crude protein and anti-nutritional characteristics of the seeds of *Lathyrus* spp.

Attributes	Species		
	<i>L. sativus</i>	<i>L. cicera</i>	<i>L. ochrus</i>
Number of lines	36	16	16
100-seed mass (g)	9.6 ± 4.12	6.9 ± 0.86	11.2 ± 1.40
Crude protein (g/kg DM)	312 ± 17.7	295 ± 18.7	302 ± 11.4
PPT (g/kg DM)	4.54 ± 0.31	4.32 ± 0.03	4.43 ± 0.34
CE (g/kg DM)	2.39 ± 0.66	3.99 ± 0.93	20.63 ± 4.27
TIA (g/kg DM)	16.67 ± 2.11	8.74 ± 1.24	14.42 ± 1.58
BOAA (g/kg DM)	4.90 ± 0.69	1.26 ± 0.18	5.63 ± 0.45

Values are means ± standard deviation for the number of lines indicated.

Table 1.27. Chemical and *in vitro* characteristics of a random subsample of the seeds of *Lathyrus* spp.

Analysis (g/kg DM)	Species		
	<i>L. sativus</i> (8 lines)	<i>L. cicera</i> (4 lines)	<i>L. ochrus</i> (4 lines)
Ash	35.3 ± 2.50	34.7 ± 0.75	37.0 ± 0.87
ADF	82 ± 11.4a	96 ± 5.4b	115 ± 17.2a
NDF	141 ± 9.5	161 ± 20.8	169 ± 31.9
IVDMD	929 ± 26a	886 ± 8.8b	908 ± 5.9a
IVOMD	902 ± 24a	855 ± 8.5c	877 ± 7.9b

Means with dissimilar letters in the same horizontal rows differ significantly ($P < 0.05$).

Experiment

The legume seeds analysed were advanced lines or their crossings, comprising: Lathyrus sativus (common chickling or grass pea, 36 lines, Lathyrus cicera (dwarf chickling 16 lines) and Lathyrus ochrus (ochrus chickling, 16 lines).

The BOAA concentration in the seeds was determined spectrophotometrically, using the o-phthaldehyde fluorescent dye method (Rao, 1978) as modified by Briggs *et al* (1983). The PPT content of defatted chickling flour was determined, using bovine serum albumin, Hagerman and Butler (1978) fraction V (Sigma; Lot 41H0520). The vanillin-HCl test, which detects simple flavonoids as well as condensed tannins as catechin equivalents, was measured by the procedure of Burns (1971) as modified by Price and Butler (1977) and Price *et al* (1978). The major modification of the Burns method was the correction for the background absorbance of the samples obtained at 500 nm by subtracting the blanks prepared without vanillin. The TIA was measured in terms of the extent to which an extract of defatted flour inhibits the action of bovine trypsin (EC 3.4.21.4) on the substrate benzoyl-DL-arginine-p-nitroanilide hydrochloride (BAPNA.HCl), (Smith *et al* 1980). All samples were analysed for dry matter (DM), crude protein (CP) and ash (MAFF, 1981).

Eight randomly chosen lines from L. sativus and four lines each from L. cicera and L. ochrus were, in addition, analysed for neutral detergent fibre (NDF) and acid detergent fibre (ADF) (Goering and van Soest, 1970). In vitro organic matter digestibility (IVOMD) and dry matter digestibility (IVDMD) were measured, using the method of Tilley and Terry (1963).

Results

The species with the lowest and highest CP were L. cicera ($295 \pm 18.7 \text{ g kg}^{-1} \text{ DM}$) and L. sativus ($312 \pm 17.7 \text{ g kg}^{-1} \text{ DM}$) respectively (Table 1.26). BOAA concentration was least in L. cicera ($1.26 \pm 0.18 \text{ g kg}^{-1} \text{ DM}$) and highest in L. ochrus ($5.63 \pm 0.45 \text{ g kg}^{-1} \text{ DM}$).

There were higher intraspecies variations in BOAA levels among L. sativus and L. cicera than in L. ochrus genotypes. On the average, BOAA levels in L. ochrus and L. sativus were about four to five times higher than those in L. cicera. The PPT level in L. sativus ($4.54 \pm 0.31 \text{ g kg}^{-1} \text{ DM}$) was similar to that in the other species, but there were some lines in all the species without detectable PPT. Catechin equivalent was no more than $6.10 \text{ g kg}^{-1} \text{ DM}$ in all the lines analysed, except for L. ochrus, in which CE ranged from 14.07 g kg^{-1} in IFFLO 104 to $28.50 \text{ g kg}^{-1} \text{ DM}$ in IFLLO 545, with a mean of $20.63 \pm 4.27 \text{ g kg}^{-1} \text{ DM}$. There were high variabilities between and within species in CE values as shown by the high coefficients of variation (CV). Pooled mean TIA in all the L. sativus lines ($16.67 \pm 2.11 \text{ g kg}^{-1} \text{ DM}$) was similar to that in L. ochrus and about twice the level in L. cicera. The coefficients of intraspecie variability ranged from 10.93% in L. ochrus to 17.13% in L. sativus.

The ash, organic matter (OM) and NDF content (Table 1.27) of the lines did not differ significantly. The ADF, IVDMD and IVOMD (Table 1.27), however, differed significantly ($P < 0.05$) between the species. The IVDMD and IVOMD of L. cicera ($88.55 \pm 0.80\%$ and $85.53 \pm 0.85\%$, respectively) were significantly lower ($P < 0.05$) than in the other species. Seed weight correlated significantly ($P < 0.05$) with CE and TIA in both L. sativus and L. ochrus (Table 1.28), while CP correlated significantly ($P < 0.01$) with TIA in both L. sativus and L. cicera, with respective r values of 0.70 and -0.75. These observations suggest that selections based on seed weight and crude protein will not exclude lines having low levels of anti-nutrients.

The study clearly indicates the high potential of Lathyrus grain in the provision of high levels of digestible organic matter and crude protein for both man and animals. The principal problem is the presence of various toxic or potentially toxic factors which could greatly undermine this potential. The wide range in concentrations, however, in some of the anti-nutrients

Table 1.28. Correlation coefficients (r) between weight of seeds, crude protein and anti-nutritional constituents.

	n	PPT	CE	TIA	BOAA
<u>L. sativus</u>					
Wt. of 100 seeds					
r	36	-0.41	-0.50	-0.58	-0.26
Significance		ns	*	*	ns
Crude protein					
r	36	0.60	0.17	0.70	0.45
Significance		*	ns	**	ns
<u>L. cicera</u>					
Wt. of 100 seeds					
r	16	0.60	-0.52	0.48	0.01
Significance		ns	*	ns	ns
Crude protein					
r	16	-0.15	0.17	-0.75	0.23
Significance		ns	ns	***	ns
<u>L. ochrus</u>					
Wt. of 100 seeds					
r	16	-0.41	-0.52	0.54	0.49
Significance		ns	*	*	*
Crude protein					
r	16	-0.35	-0.74	-0.11	0.79
Significance		ns	***	ns	***

n, no. of observations.

ns, $P > 0.05$; *, $P < 0.05$; **, $P < 0.01$; ***, $P < 0.001$.

1.3 Flock Management

1.3.1 Effects of body condition and level of nutrition at mating on the reproductive performance of Awassi ewes

Part of the PFLP programme on small ruminants is devoted to defining responses of Awassi ewes to changes at critical stages of the productive cycle. In 1991, work was started to examine the effects of nutrition, before and at mating, on reproductive performance.

Body weight or body fatness, which is generally termed body condition, affects the lambing percentage (number of lambs born or reared per 100 ewes put to the ram) in many breeds. Differences in lambing percentage result mainly from the effect of body condition on the number of ova shed. There may also be some effect on embryo survival in the days immediately after mating. The level of nutrition immediately before mating can also affect ovulation rate, but this response to short-term nutrient intake only occurs within a specific range of body condition. Above and below this range, which varies with breed, there is no additional effect of current level of nutrient intake on ovulation rate and the actual body condition is the most important factor determining lambing percentage (Gunn, 1983).

A few studies indicate that the reproductive performance of Awassi ewes is affected by body weight at mating. Kassem *et al.* (1989) found that, in different years, lambs born per ewe mated increased by 0.007 to 0.013 ± 0.0029 for each kg increase in weight in May, 6 to 8 weeks before mating. The percentage of fertile ewes was not, however, affected by weight in May. This contrasts with the results of Thomson and Bahhady (1988), which showed that the percentage of ewes lambing, in relation to ewes put to the ram, increased rapidly with weight up to 43 kg, and reached 100% at weights above 51 kg. Neither of these studies was specifically designed to investigate the effects of weight or body condition or level of nutrition before mating on the reproductive performance of Awassi ewes.

In 1991/1992, an experiment was carried out to assess the separate effects of body condition at mating, and level of feeding before mating, on the fertility and prolificacy of Awassi ewes. A 3 x 2 factorial design was used, with three levels of nutrition in the four weeks before mating and 2 levels of body condition at mating. The levels of nutrition prior to mating were designated as body condition changes over four weeks: the loss of 0.5 of a condition score, as defined by Russel et al (1969), maintenance of condition, or a gain of 0.5 of a condition score, designated L, M and H, respectively. The body conditions at mating were designated as 3.0 and 1.5, designated H and L, respectively. This design necessitated having ewes with initial body scores, 4 weeks before mating, of 3.5, 3.0, 2.5, 2.0, 1.5 and 1.0 for treatments IH, MH, HH, LL, ML and HL, respectively.

On 14 June 1991, the preliminary feeding period began. 192 ewes were blocked for body condition within age groups and allocated to the six treatment groups. Body condition ranged from 3.0 to 1.0, with a mean of 1.9 ± 0.04 and a mean weight of 45.9 ± 0.47 kg. Each treatment contained 32 ewes, comprising 15 ewes aged 2.5 years, 3 each of 3.5, 4.5 and 5.5 years and 4 each of 6.5 and 7.5 years. The changes in body condition needed to achieve the initial body condition scores for each ewe's designated treatment were calculated and the ewes were regrouped into five groups and fed to achieve body condition score changes of $>+1.25$ (P1), $<+1.0$ (P2), 0 (P3), <-1.0 (P4) and >-1.25 (P5) in eight weeks. Groups P1 and P2 grazed a standing barley crop for 6 and 3 h/day and received 200 g/head/day of cotton seed cake. Group P3 was fed a ration of barley and cotton seed cake calculated to provide maintenance less 1 MJ, which they were assumed to obtain from grazing dry native pasture for 11 h/day. Groups P4 and P5 grazed bare native pasture for 11 h/day and received 300 and 200 g/day of barley straw, respectively. The ewes were body scored each week and, when they reached their designated initial condition, they were transferred to group P3.

Later, groups P1 and P2 were amalgamated and the feeding increased. Similarly, P4 and P5 were amalgamated and the feeding reduced.

On 6 August, although the majority of ewes had not reached their designated initial condition, the experiment was started, with the ewes remaining in their allocated treatment groups. Treatments LH and IL were fed 0.25 of maintenance, MH and ML maintenance and HH and HL 1.75 of maintenance, using diets of barley straw and a concentrate mixture of 85% barley and 15% cotton seed cake. On 20 August, Cronogest sponges were inserted into the ewes to synchronise oestrous after sponge removal on 3 September. Ten rams with harnesses and marking crayons were put with each group of ewes for the first and third cycles following sponge removal and mating dates were recorded. After sponge withdrawal, all ewes were fed at maintenance. After mating, all ewes were managed in a single group through pregnancy. At lambing, the number of lambs and their dates of birth were recorded.

This was the first time that the body scoring system as described by Russel et al (1969) had been used in ICARDA. In the preliminary period, when the attempt was made to establish the initial body condition scores required for the design, it soon became clear that the changes could not be achieved in the periods of time allowed. Although the designated initial scores had not been achieved, it was decided that the treatment groups should be maintained and widely differing feeding levels be imposed to obtain information for future use on their effects on change in body condition. Table 1.29 shows the body conditions achieved at each stage.

Table 1.29. Mean liveweights and body condition scores 4 weeks before mating and at mating and number of lambs born per ewe mated at the first oestrous after sponge withdrawal.

Treatment	4 weeks before mating		Mating		Change in score	Mean lambs/ewe
	Weight	Score	Weight	Score		
LH	55.7	2.3(3.5)*	47.9	1.9(3.0)*	-0.4	0.69
MH	55.8	2.3(3.0)	52.2	2.1(3.0)	-0.2	0.75
MH	53.8	2.1(2.5)	53.8	2.2(3.0)	+0.1	0.75
LL	51.1	1.9(2.0)	42.0	1.7(1.5)	-0.3	0.50
ML	49.6	1.7(1.5)	46.3	1.8(1.5)	+0.1	0.78
HL	44.8	1.5(1.0)	46.8	1.9(1.5)	+0.4	0.91
SE of mean	0.50	0.03	0.51	0.02	0.02	0.038

* designated score for the treatment.

Initial analyses of the results showed that body condition at mating, with treatment means ranging from 2.2 to 1.6, instead of 3.0 to 1.5, as stipulated in the design, had no effect on the lambing performance (Table 1.29). The effects of change in body condition over the 4 weeks before mating, although never significant at the conventionally accepted levels of probability, always had considerably higher probability levels than those for the effect of actual body condition. Chi-square analysis was made, using SAS, on the results relating to the first cycle of oestrous, with the data grouped according to the change in body condition that actually occurred in the ewes during the four weeks before the first mating, irrespective of their actual body score. The ewes were put in five groups; gains of >0.5 and 0.5 to 0.25 of a score, maintaining body condition, and losing 0.5 to 0.25 and 0.5. Table 1.30 shows that a considerably greater proportion of ewes in the groups losing body condition did not become pregnant at the first oestrous and that, of the small proportion of ewes producing two lambs, 75% were in the groups gaining condition.

The Mantel-Haensel Chi-square test was significant at a probability of 0.003.

Table 1.30. Number and proportion of ewes producing 0, 1 or 2 lambs after mating at the first oestrous cycle following sponge withdrawal for ewes making different body condition changes in the 4 weeks prior to lambing and mean number of lambs per ewe.

Change in score	Number of ewes producing			Mean lambs/ewe
	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
	11(0.20)	42(0.78)	1(0.02)	0.81
+0.5 to +0.25	9(0.25)	23(0.64)	4(0.11)	0.86
> +0.5	3(0.15)	15(0.75)	2(0.10)	0.95

* Proportion

Extending the Chi-square analysis to include the data for the third oestrous cycle complicated the pattern of the results, probably because all ewes were fed at maintenance from the time of sponge removal, resulting in ewes previously at 0.25 and 1.75 of maintenance being at a considerably higher and lower level, respectively, for 32 to 35 days before the third oestrous. The changes in feeding level may not have been fully reflected in changes in body condition in this length of time.

These results must obviously be interpreted with great caution, because of the difficulties in making the changes in body condition and the failure to achieve the designated body condition levels in a large proportion of the ewes. There is an indication that severe underfeeding during the month before mating in ewes with body conditions in the range 1.6 to 2.2 may decrease the proportion of ewes becoming pregnant. The low level of feeding imposed in this experiment, 0.25 of a maintenance level, can occur in the latter stages of grazing an area of

stubble, the normal feed for flocks in west Asia in the mating period, if the ewes are forced to consume almost all the stubble residue. The information gained in this experiment on the rates of change in body condition on different feeding regimes will enable future experiments to be carried out with greater precision. The relationship between body condition and the levels of the different fat depots in Awassi ewes will also be investigated. - **S. Filo, T. Treacher, A. Goodchild and F. Yassin (University of Aleppo)**

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1.3.2 A comparison of the performance of Turkish and Syrian strains of Awassi ewes, at two level of nutrition

The Awassi is the dominant breed of sheep in the Near East. It is the only breed in Jordan, Lebanon and Syria, countries with a total sheep population of 16.9 million (FAO, 1991). In Iraq, about 50% of the 7.8 million sheep are Awassis. There are also approximately 1 million Awassi sheep in Turkey, where they are the main breed along the southern Turkish border with Syria. Turkish Awassi ewes have been selected for milk yield for many years at the Ceylanpinar State Farm. Selection has been

intensified recently by the establishment of two nucleus flocks with approximately 50 ewes, with exceptionally high milk production, obtained by screening ewes in commercial flocks in five provinces and on Ceylanpinar Farm itself.

In March 1991, ICARDA purchased 40 ewes, aged 2 years, and 2 rams from the Ceylanpinar flock. In 1992 these ewes and 40 ewes selected at random from the 2 year old ewes in the flock at ICARDA's Tel Hadya station at Aleppo, in northern Syria, were compared using two levels of nutrition in lactation.

The ewes in the ICARDA flock are typical of well managed flocks in northern Syria. The flock was started in 1979 with ewes purchased from the Wadi el Azeb Sheep and Range Centre, which had obtained ewes from bedouin flocks in the north - western part of the Syria steppe. No ewes have been introduced into ICARDA's flock since 1985, although a small number of rams are purchased occasionally from El Krain Station, Selamieh.

Design

The ewes of the Turkish (T) and Syrian (S) strains were blocked for weight after lambing and allocated at random to high (H) and low (L) nutritional treatments, which were defined as the metabolizable energy requirements for ewes producing 2 and 1 kg of milk per day. These levels were chosen on the basis of the expected peak yields of the two strains. The peak milk yield in 1988 and 1989 of a representative group of ewes from the strain at Ceylanpinar State Farm was 2.0 kg/day (Gursoy, personal communication). The peak yield of the better ewes in the ICARDA flock is approximately 1 kg/day. At the end of week 14 of lactation, the levels of feeding were reduced.

Management

The ewes were synchronized for oestrous, using Cronogest sponges, and mated to rams of the same strain. The mean mating date was 9 September 1991. The ewes were managed as one group in pregnancy.

Initially, they grazed stubble with supplementation to maintain their weights. From six weeks before lambing, they were fed individually according to ARC (1980) requirements, with feeds adjusted for their initial weights. Daily feed for a 50 kg ewe was cereal straw 700 g fresh wt, cotton seed cake (csc), 120 g and barley grain, which was increased from 405 g at six weeks before lambing, to 595 g in the week before lambing. After lambing, the four treatment groups were managed separately. Individual feeding levels were adjusted on the basis of weight on the day after lambing. From lambing until 10 May, daily feed allowances for 50-59 kg ewes were vetch hay 510 g fresh weight, csc 150 g and barley grain 1470 g at level H and cereal straw 770 g, csc 150 g, and barley 770 g at level L. Each day, the ewes were grazed on very poor pasture from 9.00 to 17.00 hr, but it was considered that grazing made no significant contribution to feed intake. Intakes were reduced by approximately 25% on 10 May and then, more drastically, on 7 July, to assist the ewes to dry off.

After lambing, the management of lambs and of milking was typical of flocks specializing in milk production in Syria. The lambs remained with the ewes continuously for four weeks. This was followed by two weeks of partial sucking, in which the lambs were removed at 20.00 hr and offered concentrates in separate pens. The ewes were hand milked at 08.00 hr and the lambs were then returned to spend the day with their mothers.

Individual milk yields were recorded weekly, starting in week 5. In weeks 5 & 6, there was only one milking each day, but subsequently, morning and evening yields were recorded each Thursday.

Results

Results were analysed from 18, 14, 15 and 17 ewes on treatments SH, SL, TH and TL respectively.

Lamb growth

There were five pairs of twins from the Turkish and only one from the Syrian ewes, which resulted in the significant differences in birth weights between strains (Table 1.31). The ewes only suckled one lamb. Although the Turkish lambs had slightly higher growth rates in the period of full suckling (weeks 1 to 4), the differences were not significant. When the period of partial suckling, in weeks 5 & 6 of lactation, was included, growth rates were very similar, but showed a significant effect ($P>0.05$) of feeding level of the ewe. The growth of lambs from weaning at 6 weeks until 14 weeks was not affected by treatment. The overall growth from birth to 14 weeks was higher ($P>0.05$) in Turkish lambs but the weight at 14 weeks, although higher in Turkish lambs, was not significantly greater than in Syrian lambs.

Table 1.31. Lamb weights and daily gains.

	Syrian		Turkish		Significance	
	H	L	H	L	Strain	Level
Birth wt.	4.71	4.75	4.52	4.21	*	ns
Daily gain						
1-4 wks	280	280	320	285	ns	ns
1-6 wks	280	265	310	270	ns	*
7-14 wks	250	255	270	280	ns	ns
1-14 wks	260	260	285	275	*	ns
Wt at 14 wks	29.9	29.9	31.8	30.3	ns	ns

Feed intakes of ewes

There were few refusals of feed after the second week of lactation. Mean intakes of metabolizable energy (MJ/day) from lambing until week 14, when feeding level was changed, and from 15 to 21 weeks, were SH 21.2 and 17.0, SL 14.5 and 11.0, TH 21.3 and 17.3 and TL 14.7 and 11.2 respectively.

Weight changes of ewes

After lambing, the Turkish ewes were 4 kg heavier than the Syrian

ewes. At no stage did strain have a significant effect on weight change. Before the lambs were weaned, at six weeks after lambing, ewes on the low level of feeding lost significantly more weight than those on the high level. There were no significant differences between treatments in the gains made in weeks 7 to 14. When feed intake was reduced at the end of week 14, weight declined again and the losses were significantly greater at the lower level of feeding.

Table 1.32. Liveweight and weight changes of Ewes

	Syrian		Turkish		Significance	
	H	L	H	L	Strain	Level of nutrition
Weight after lambing	49	49	53	53	***	ns
Change (g/day)						
1-6 wks	-0	-105	-30	-115	ns	***
7-14 wks	200	170	185	155	ns	ns
15-21 wks	-15	-90	-5	-105	ns	***

Milk Yields

Milk yields were not estimated in the full suckling period. During the period of partial suckling, in weeks 5 and 6, milk production at the morning milking was significantly lower at the lower level of feeding (Table 1.33). Between weeks 7 and 14 the Turkish ewes produced 25% more milk than the Syrian. The 16% difference in yield between feeding levels was close to significance ($P>0.06$). In weeks 15 to 21, when energy intake was reduced by 20% at level H and 24% at level L, the difference between the strains declined to 14% and was not significant. Over the whole period, from 7 to 21 weeks, the Turkish strain produced 22% more milk ($P>0.01$) and there was a significant effect of feeding level ($P>0.05$).

Table 1.33. Mean milk yields (g/day)

Weeks	Syrian		Turkish		Significance	
	H	L	H	L	Strain	Level of nutrition
5 & 6	580	445	660	420	ns	***
7-14	1045	935	1370	1140	**	ns
15-21	515	400	615	460	ns	**
7-21	800	685	1015	825	**	*

There were large variations in milk yield between ewes in each treatment. The coefficient of variation for milk yield was higher in the Syrian ewes than in the Turkish (40% v 23%), indicating that the variability in yield between individuals was considerably higher in unselected Syrian ewes. - **T. Treacher, F. Bahhady, A. Goodchild, H. Heritani, and A. Termanini**

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1.3.3 Responses of fattening lambs to calcium and trace element supplements

Diets for fattening sheep in Syria and Jordan have been reported to contain less than 20 % roughage, and are not supplemented with minerals other than salt or, occasionally, commercial vitamin-mineral additives. In cooperative feedlots, the ratio between concentrate consumption and body weight gain was worse than eight to one (Nygaard, Martin and Bahhady 1982). Calcium deficiency is likely to be a problem, because roughages are the main vegetable source of calcium for ruminants and calcium requirements are large when animals are making rapid skeletal growth.

We designed a fattening trial to test the effect on food

intake and body weight gain, and aspects of carcass and bone composition, of adding supplements of ground limestone and/or trace minerals to a low-roughage diet containing sodium chloride. The objective was to provide guidelines for fattening operations using simple rations.

In most of the Middle East, the meat of uncastrated Awassi ram lambs is prized. Lambs of this description, aged about 4 months and weighing 24 kg, were divided into 5 groups of 6 according to body weight, housed in individual cages, and fed a high-concentrate ration. The concentrate portion consisted of 0.800 barley, 0.197 semi-decorticated cottonseed cake and 0.003 feeding-grade salt, which was supplemented in the same container with 0, 0.27 or 0.81 g ground limestone/kg body weight (treatments Ca0, Ca1, Ca2). Two other groups of sheep were also fed 0.27 or 0.81 g ground limestone/kg body weight and supplemented with a trace element-vitamin premix at the recommended rate (treatments Ca1T, Ca2T). Barley tibn of average quality (c. 30 g crude protein/kg) was fed in a separate container. All sheep were provided with unrestricted de-ionized drinking water, intended to resemble river water in mineral content. All lambs were injected with vitamins A, D₃ and E once every four weeks, to mask the effect of the corresponding vitamins in the trace element-vitamin premix fed to treatments Ca1T and Ca2T.

In a four week period before the experiment began, lambs were fed a restricted level of concentrate (30 g DM/kg body weight) and unrestricted coarsely-ground barley straw (tibn). In the next three periods, each of four weeks, concentrate was fed at the rate of 1.2 x their daily concentrate intake in the previous week, and 200 g/day of tibn was offered.

After twelve weeks of experimental feeding, two sheep from each treatment were weighed and immediately slaughtered. As indicators of body composition, their skin-with-wool, carcasses, tail fat, head, stomach contents, liver and thoracic contents were weighed. Fore and hind cannon bones (i.e. metacarpus and

metatarsus) were also taken for measurement and analysis. All the remaining sheep were removed from the experiment.

Data were subjected to an analysis of variance to estimate the significance of the effects of treatment. If the variance ratio (F) was significant, differences between treatments were evaluated by Student's "t" test.

Results

Concentrate intake (air-dry) averaged 33.7 g/kg body weight in all treatments except Ca0. This implies that limestone provided 9.1 g/kg of diet in treatments Ca1 or Ca1T and 27.3 g/kg diet in Ca2 or Ca2T -- equivalent to 3.6 or 10.8 g calcium per kg diet.

The total body weight gain was nearly twice as great when sheep were supplemented with a high level of calcium (treatments Ca2 and Ca2T) as when they were not supplemented (treatment Ca0). The weight gain of sheep fed the high level of calcium (Ca2, Ca2T) was significantly higher than those fed the low level of calcium when no trace element supplements were fed (Ca1). The effect of calcium on body weight gain did not appear until after period 1. Efficiency of feed conversion, however, which ranked similarly overall to body weight gain, was affected by calcium level from the beginning of period 1 (Table 1.37). Concentrate intakes were not depressed by lack of calcium until periods 2 and 3 (Table 1.35).

Straw intake was significantly increased in the diet not supplemented with calcium (Ca0) in periods 1 and 2, suggesting that sheep tried to compensate for the lack of calcium by increasing their intake of straw (Table 1.36).

Table 1.34. Body weight, of lambs at when they were introduced into pens and body weight change (kg) in the 4 weeks before the trial, in three 4-week periods, and in the last 12 weeks.

Treatment (number of sheep)	Body wt. 92-05-28	Gain before trial	Gain Period 1	Gain Period 2	Gain Period 3	Gain Periods 1 - 3
Ca0 (5)	25.26	7.12	7.28	1.78a	3.42a	12.48a
Ca1 (6)	23.68	6.78	8.82	5.13b	4.12ab	18.07b
Ca1T (5)	22.56	8.12	8.86	5.70b	6.86bc	21.42bc
Ca2 (5)	23.14	6.66	9.46	7.32bc	6.10ac	22.88c
Ca2T (6)	23.52	6.75	8.45	8.30c	6.60c	23.35c
SE of mean	0.919	0.529	0.577	0.887	0.899	1.367
Variance ratio (F) at 4, 22 d.f.	1.20	1.30	1.96	7.97***	2.98*	10.86***

* $P < 0.05$ *** $P < 0.001$

Table 1.35. Concentrate intake per sheep (kg) in three 4-week periods, and 12-week total intake.

Treatment	Intake, Period 1	Intake, Period 2	Intake, Period 3	Intake, Periods 1 to 3
Ca0	37.6	26.3a	28.8a	92.7a
Ca1	38.7	36.0b	35.5b	110.1ab
Ca1T	39.4	36.7ab	41.1b	117.2b
Ca2	36.7	41.6b	39.3b	117.6b
Ca2T	35.7	41.7b	42.5b	119.9b
SE of mean	1.47	2.50	2.18	5.11
F(4,22 df)	1.03	6.29**	6.40**	4.73**

* $P < 0.05$ ** $P < 0.01$

Table 1.36. Straw intake per sheep (kg) in three 4-week periods, and 12-week total intake.

Treatment	Intake, Period 1	Intake, Period 2	Intake, Period 3	Intake, Periods 1 to 3
Ca0	2.39	4.44c	3.99b	10.80c
Ca1	2.25	3.16b	2.96a	8.38ab
Ca1T	2.62	3.26b	2.78a	8.66ab
Ca2	2.87	3.19ab	2.86a	8.92b
Ca2T	2.43	2.54a	2.46a	7.43a
SE of mean	0.202	0.228	0.191	0.428
F(4,22 df)	1.39	9.18***	9.12***	8.39***

*** P<0.001

Table 1.37. Food conversion ratios (kg concentrate per kg gain) in three 4-week periods, over all periods, and final body weight.

Treatment	FCR, Period 1	FCR, Period 2	FCR, Period 3	FCR, Periods 1 to 3	Body wt. at end of Period 3
Ca0	5.23b	10.34	11.09	7.52b	44.9b
Ca1	4.45ab	8.45	17.05	6.42ab	48.5ab
Ca1T	4.48a	6.77	6.70	5.60a	52.1a
Ca2	3.89a	6.03	7.40	5.15a	52.7a
Ca2T	4.41ab	5.12	6.68	5.16a	53.6a
SE of mean	0.271	4.278	4.342	0.457	1.82
F(4,22 df)	3.10*	0.23	1.05	4.85**	3.96*

* P<0.05

** P<0.01

Table 1.38. Mean values of carcass and bone characteristics, and values and significance of the variance ratio (F) due to treatment in the analysis of variance (with 4, 7 d.f.), after adjusting for live weight at end of experiment by covariance.

Measurement	mean	Variance ratios due to treatment, F (4, 7 df)	
		actual	as ratio to EBW
Live weight before slaughter, kg	48.55	29.70***	0.13
Skin weight (with fleece), kg	5.48	0.91	0.50
Stomach contents, kg	4.14	0.39	0.13
Stomachs (empty), kg	1.21	0.96	0.12
Heart and lungs, kg	0.92	6.42*	2.50
Liver, kg	0.79	13.99**	4.35*
Tail fat, kg	3.83	4.07#	1.59
Head, kg	2.90	1.17	1.71
Carcass, kg	22.1	2.36	0.26
Empty body weight (EBW), kg	44.41	41.59***	
Fore cannon dimensions:			
weight, g	43.7	0.78	
DM, g/kg	706	2.22	
ash, g/kg DM	490	5.33*	
specific gravity, g/g	1.337	8.39**	
cortex thickness, mm	2.54	4.69*	
Hind cannon dimensions:			
weight, g	43.0	4.14*	
DM, g/kg	678	1.74	
ash, g/kg DM	521	2.43	
specific gravity, g/g	1.335	3.89#	
cortex thickness, mm	2.71	2.32	
# P<0.1 * P<0.05 ** P<0.01 *** P<0.001			

Table 1.39. Effects of treatment on selected measurements, after correcting for differences in live weight at the end of the experiment by covariance.

Treat- ment	Heart+ lungs, kg	Liver, kg	Tail fat, kg	Fore cannon			Hind cannon mass, g
				ash, g/kg	s.g. g/g	cortex, mm	
Ca0	0.92	0.65	3.68	471	1.32	2.45	40.8
Ca1	0.91	0.85	3.15	506	1.39	2.86	43.9
Ca1T	0.88	0.87	3.58	495	1.30	2.33	43.1
Ca2	0.84	0.87	4.52	502	1.37	2.62	40.4
Ca2T	1.06	0.92	4.45	501	1.36	2.58	50.0

In slaughtered sheep, live weight and empty body weight varied with treatment. Treatment significantly ($P < 0.05$) affected the weights of heart-and-lung and liver (Tables 1.38, 1.39). As ratios to empty body weight, only liver was significantly affected by treatment, being reduced where no supplement was fed. In hind cannons, weight was exceptionally high in treatment Ca2T, and in fore cannons, ash content was low in treatment Ca0. Specific gravity and thickness were lowest in treatment Ca1T, as well as in treatment Ca0.

Supplementation with calcium improved body weight gain more than it increased concentrate intake, so that the quantity (in kg) of concentrate needed per kg body weight gain (FCR) fell from 7.5 (Ca0) to 5.2 kg (Ca2 and Ca2T). Nygaard *et al.* (1982) reported FCR to be 8.4 or 9.1, according to season, for sheep starting at 30 or 39 kg and finishing at 45 or 56 kg body weight. Lambs began the present experiment at the weight of 31 kg and finished at 54 kg in the high-calcium treatments. When lambs started at 40 kg body weight, as at the beginning of Period 2, the high-calcium treatments Ca2 and Ca2T reduced the FCR from 10.6 (Ca0) to about 5.8. Calcium deficiency was, therefore, a possible reason for the poor efficiencies of feed conversion reported by Nygaard *et al.* (1982), in addition to the feed wastage that they observed.

Tap water in Aleppo, which is a source of water for many commercial fattening operations, is drawn from the River Euphrates. In 1987, it was analyzed to contain 33 mg/litre of calcium (A. Mattar, personal communication). The water used at Tel Hadya, which is drawn from deep wells, contained 60 or 68 mg/litre. Since the sheep in the current experiment consumed no more than four litres of water daily, intake of calcium from water was unlikely to exceed 0.3 g/day, or equivalent to less than 0.8 g limestone/day. In the present experiment, the sheep showed responses when they were supplemented with at least 10 g limestone/day, a quantity rarely obtainable in water.

It may be concluded that a source of calcium equivalent to at least 9 g limestone per kg concentrate is necessary in fattening diets supporting moderate weight gains. Sheep not receiving any calcium supplement grew more slowly, developed an increased appetite for straw and showed a reduction in the ash content, specific gravity and cortical thickness of cannon bones. - A. Goodchild, O. Ankuz (Steppe Directorate, Syria), M. Khalily (Swedish University of Agricultural Sciences, Uppsala), F. Bahhady and A. Termanini

Reference

- Nygaard, D.; Martin, A.; Bahhady, F. 1982. Range and sheep cooperatives and fattening cooperatives in Syria: supplementary feed purchases and credit requirements. Project Report No. 4. ICARDA, Aleppo.

1.4 Animal Health Studies

Epidemiological survey of viral diseases, lungworm and blood parasite infections in sheep flocks in Syria

Respiratory disorders are common in small ruminants and cause considerable losses, through both morbidity and mortality. The acute respiratory disease complex of sheep is dominated by pneumonic pasteurellosis superimposed on viral infections. Although Thomson and Orita (1988) had shown that heavy infestations of lungworms occur in Syrian sheep, there had been no studies of the interaction between virus and lungworm infection and it was decided, therefore, to survey the epidemiology of respiratory viruses and the synergy between lung viruses and lungworms. At the same time, samples were collected to assess the incidence of haemoprotozoal parasites.

A representative number of 73 flocks from Syria's 13 provinces, based on the size of their sheep populations, was sampled between November 1991 and February 1992. In each flock, 20 sheep were selected for sampling in proportion to the number of ewes, rams and yearlings in the flock. Lambs were not sampled, because of the difficulty of interpreting the results, owing to the presence of antibodies obtained from their mothers. Faeces, blood serum and blood smear samples were collected from 1473 individual sheep.

Faeces were processed fresh to detect the presence of Dictyocaulus filaria and protostrongylids. Each genus of lungworm was counted after the larvae had been extracted from the faeces by a modified Baermann technique, incubating 3g of faeces for 16h at room temperature.

Serum samples were stored at -20°C, until examination for antibodies against Border disease and Maedi visna. Samples were retained for examination at a later date for respiratory syncytial virus (RSV), parainfluenza virus type 3 (PI3), respiratory enteric orphan virus (REO) and adenovirus. Samples were tested for antibodies against Border Disease by indirect immuno-fluorescence (Wellems and Leunen, 1973) and for Maedi visna by an agar gel immuno-diffusion test, using kits obtained from the Central

Veterinary Laboratory, Weybridge, England.

Blood serum samples were tested for toxoplasmosis, using the Latex agglutination test (Eiken Co., Japan) and assuming that a reaction of $\geq 1:64$ was positive. Samples were retained for immunological tests for babesiosis and theileriosis at a later date. Blood smears were examined for the presence of Theileria species and Anaplasma ovis.

Table 1.40. Percentage of sheep infected with lungworms

Province	No Samples	D. filaria	Protostrongylids			
			Muel*	Cyst	Prot	Neos
Aleppo	281	54	20	37	2	9
Idlib	87	54	66	75	13	32
Hama	160	39	49	51	8	22
Homs	281	49	26	71	16	24
Lattakia	41	17	63	49	0	85
Raqqa	140	26	4	20	0	0
Dair Ezzor	120	38	1	2	0	0
Hassakeh	220	48	10	18	0	0
Damascus	61	23	61	66	21	2
Dar'a	40	38	30	80	8	8
Suweida	20	100	65	100	85	0
Qunaytra	20	75	0	0	0	0

* Muel = Muellerius spp. (M.capillaris)

Cyst = Cystocaulus spp. (C.ocreatus)

Prot = Protostrongylus spp.

Neos = Neostongylus spp. (N.linearis)

The results for the coastal provinces of Lattakia and Tartous, (presented together as Lattakia in the tables), and the southern provinces of Damascus, Dar'a, Suweida and Qunaytra, must be treated with great caution, because of the small number of flocks (1-3) sampled in each province. Table 1.40 shows that lungworm infections are widely distributed in Syria, confirming the results obtained by Thomson and Orita (1988), in a limited area of northern Syria.

The serological tests showed a high overall level of infection with Border disease (Table 1.41), with a very high prevalence in Aleppo and Idlib provinces. The incidence is higher than in other countries, where large numbers of sheep have been screened for this disease, but clinical symptoms have rarely been reported in Syria. The results may indicate, therefore, a high level of subclinical infection. The mean percentage of positive tests for Maedi visna was only 6%, although there were considerable differences between provinces in the percentage of serological tests that were positive. Generally, the percentages were higher in the provinces in northern Syria, with no seropositive samples from sheep in the provinces of Damascus, Suweida and Qunaytra in southern Syria, and only 1% in Hassakeh in the east.

Table 1.41. Percentage of sheep with positive tests for Border disease and Maedi visna.

Province	n	Border disease	Maedi visna
Aleppo	282	70	8
Idlib	86	94	6
Hama	161	23	8
Homs	283	46	8
Lattakia	41	51	12
Ragga	140	18	4
Dair Ezzor	122	48	6
Hassakeh	220	50	1
Damascus	52	0	0
Dar'a	40	12	10
Suweida	20	0	0
Qunaytra	20	0	0

The number of blood serum samples examined for *Toxoplasma* antibodies was less than for viral infections, because, after tests for viruses had been completed, samples were too small for further testing. Table 1.42 shows *Toxoplasma* antibodies were present in samples collected in all provinces of Syria. Although in some

provinces the incidence was very low, the results indicate that problems in humans from this important zoonosis can be expected throughout Syria.

Table 1.42. Percentage of sheep infected with toxoplasma, Theileria spp. and Anaplasma ovis

Province	No. of samples	Toxoplasma	No. of samples	<u>Anaplasma ovis</u>	<u>Theileria</u> spp.
Aleppo	206	18	202	84	88
Idleb	79	14	40	98	100
Hama	113	19	60	90	85
Homs	243	20	19	68	84
Lattakia	41	49	44	59	48
Raqqa	65	8	-	-	-
Dair Ezzor	56	7	120	90	91
Hassakeh	153	21	60	87	88
Damascus	30	3	40	78	95
Dar'a	38	47	40	50	70
Suweida	20	10	23	96	100
Qunaytra	10	30	20	100	90

Table 1.42 shows that the incidence of the haemoprotozoa Theileria spp and Anaplasma ovis was high, 86% and 83%, respectively, in a sample of 668 blood smears. These parasites were found in all parts of Syria. More samples will be collected in 1993/4 to assess the incidence of haemoprotozoal infections, using immunological tests. - M. Giangaspero (FAO), H. Nishikawa (JICA), F. Bahhady and D. Tabaa (Ba'ath University, Hama)

References

- Thomson, E. F. and Orita, G., 1988. Seasonal prevalence of protos trongylids and Dictyocaulus species of lungworms in Awassi sheep in north-west Syria. Tropical Animal Health and Production, 20:187-189.
- Wellemans, G. and Leunen, J., 1973. La rhinotracheite infectieuse des bovins (IBR) et sa serologie. Ann. Med. Vet. 117:507-511.

Section II Improvement of Sown Pasture and Forage Production

2.1 Wheat and barley grain yields after medic and other common crop rotations in northwest Syria

In 1986, an experiment was initiated to study the performance of annual Medicago spp. in rotation with wheat. The objective was to compare biological yields and economic benefits from several two-phase, wheat-based rotations. Several common crops (lentil, vetch and watermelon) and fallow were included in rotations for comparison with a pasture legume system (medic) using stocking rate treatments of 4, 7 or 10 ewes/ha. Methods used to conduct the trial and related research are presented in PFLP's Annual Reports for 1987 (pp. 43-62), 1988 (pp. 74-88), 1989 (pp. 74-80) and 1990/1991 (pp. 67-117).

Materials and Methods

In the long-term trial, a randomized complete block design was used: three replicates of 'Cham-2' bread wheat rotated with vetch, lentil and fallow. Both phases of each treatment were present in each year. The entire experimental area received 60 kg/ha of P_2O_5 at the start of the experiment. Wheat, lentil (ILL 4401, Syrian Local Small) and vetch (Vicia sativa) were planted with a seed drill at 120, 80, and 100 kg/ha, respectively. Wheat is usually fertilized in both autumn and spring, but in dry years there is no spring application; rates, therefore, vary between 45 and 90 N kg/ha.

Broadleaf weeds in wheat plots are controlled with Brominal Plus herbicide (Bromoxynil+MCPA) at 2 L active ingredient (AI)/400 L H_2O /ha. Fusilade 25 EC-W (Fluazifop-Butyl) is sprayed at 2 L AI/400 L H_2O /ha on vetch and lentil plots to control cereal volunteers. Fallow plots are cultivated whenever necessary to destroy weeds, the objective being to conserve water.

In 1991-1992, a split-split plot experiment was introduced into the cereal phase of the rotation trial to compare three seedling rates of wheat and barley (80, 120 and 160 kg/ha), using either 0 or 60 kg/ha of nitrogen, split into two applications of 30 kg N/ha applied at planting and in spring. We define 0 N as the "N-" condition and 60 kg/ha as the "N+" condition. Five land use treatments, i.e., rotations, were "main" plots, statistically speaking, representing three cereal/legume systems, lentil, vetch and medics, and two cereal/fallow systems, fallow and watermelon. Watermelon was not sown in 1990-1991 because of dry weather and it was evaluated, therefore, as a fallow. Cereals on the three medic plots in each replication were grown on land previously grazed with three stocking rates of Awassi sheep. Subplots were distinguished by the presence or absence of nitrogen and the second division of the sub plots within each fertilizer level were three seeding rates of 'Cham-2' wheat or 'Harmal' barley.

Cereal grain and straw yields were estimated from ripened plants cut to ground level. The fields were then combine harvested. Vetch and lentil were sampled at full maturity to estimate seed and straw yields and then hand-harvested.

Statistical analysis

Separation of error variability from variability attributed to treatment factors was done using analysis of variance. A number of comparisons were of interest: crop rotations with wheat represented two different methods of utilization -- one fallow system composed of fallow (F) and watermelon (W) and the other a legume system composed of lentil (L), vetch (V) and medics (M). Thus, variation from land use systems (6 df) was partitioned into fallow vs. legume systems (F vs. LVM -- 1 df) fallow vs. watermelon (F vs. W -- 1 df) variation among legume systems (L vs. V vs. M -- 2 df) and variation

among stocking rates in medic (2 df). The 5 df from cereal x seeding rate combinations were partitioned into barley vs. wheat (1 df) seed rates of barley (2 df) and seed rates of wheat (2 df). Since seeding rates were quantitative factors they were disaggregated to study linear (1 df) or quadratic (1 df) relationships between cereal straw and grain yield with seeding rate. Data were analyzed with GENSTAT. The analysis of variance (Table 2.1) presents only the effects that were significant for grain or straw, grouping all other terms into a 'Remaining Effects' term.

Locality and Climate

ICARDA's headquarters at Tel Hadya are located 30 km southwest of Aleppo, Syria, in Agricultural Stability Zone 2, a primary wheat-growing region of Syria. The site has heavy calcareous Luvisol soils (Terra Rossa) with montmorillonitic clays as main clay minerals. The soil is poor in organic matter (1.0%), slightly basic (pH=8.0) and low in phosphorus, averaging 5 mg/kg available P at soil depths of 0-20 cm.

The climate is mediterranean with average annual precipitation of 330 mm. The 1991-1992 season could be considered normal for total precipitation (349 mm); the year was, however, abnormally cool in winter and early spring. Thus, low rainfall in March and April was counterbalanced by lower than normal rates of evapo-transpiration and crop development, leading to average crop yields.

Results and Discussion

Rotations were subdivided in the analysis into those containing legumes (medic, vetch, lentil) or those remaining, namely watermelon and fallow treatments. Since, in 1990-1991, watermelon was not planted, wheat harvested after watermelon in 1992 may be considered similar to wheat after fallow, as a treatment.

Significant statistical differences ($P < 0.05$) existed between 1) grain and straw yields in a comparison of wheat vs. barley, 2) between fallow vs. legume rotation systems and 3) between vetch, lentil and medic within the legume system (Table 2.1). When N was applied, not all rotations increased grain and straw yields to the same degree (Tables 2.1 and 2.2). Indeed, for grain, response to N in rotations was very different for wheat compared to barley.

When N was applied, the highest grain and straw yields were harvested from wheat or barley following fallow systems. When N was not applied, the situation was different: barley grown in rotation with medic out-yielded barley in the fallow rotation by a third of a ton each for grain and straw.

Within the barley/legume rotations, the cereal/medic rotation gave 1.47 and 0.98 t/ha more barley grain and 1.19 or 1.58 t/ha more barley straw than that measured in lentil and vetch rotations, respectively. With wheat/legume rotations, the yield advantage of wheat grown after medic compared to lentil and vetch was not as large as that shown for barley: 0.15-0.03 t/ha grain; 0.70-0.86 t/ha straw.

In 1991-1992, for wheat and barley and for both levels of N, the cereal/medic rotation system produced equal or greater cereal grain and straw yields compared to lentil or vetch rotations (Table 2.2). These results are the reverse of the tendencies shown in the first six years of the trial, when average wheat grain yields were greatest (about 2.1 t/ha) after watermelon or fallow, about 0.5 t/ha lower after lentil or vetch, and a further 0.2 t/ha less after medic (Nordblom *et al.* 1992).

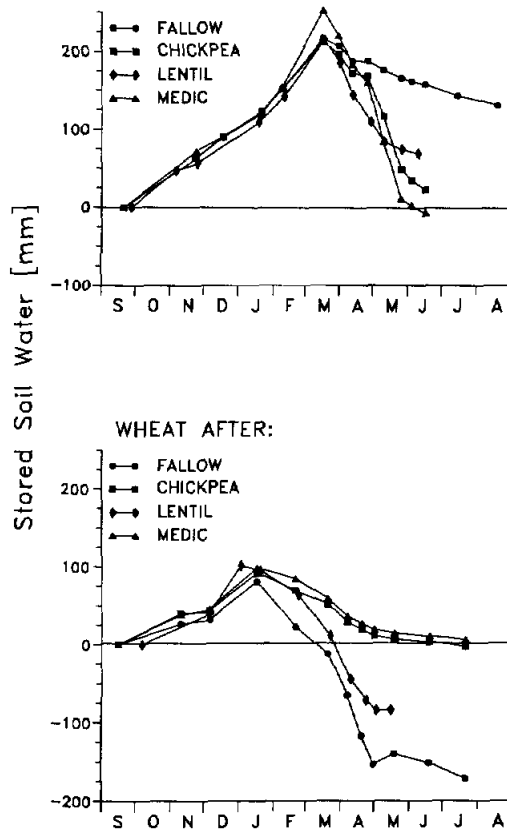


Figure 2.1. Stored soil water, defined as the change from the first values in the season. Negative values represent plant extractable water stored at that time. Data for legumes and fallow are from 1887-1988 (470 mm) and 1988-1989 for the following wheat (238 mm).

When fertilized with N, total (straw plus grain) yields were 0.28–1.68 t/ha higher for barley than wheat across all rotations. Barley/medic gave the largest percentage increase (18.4%) in total dry matter yield, when comparing wheat and barley crops under the same rotation and level of N (Table 2.2). The wheat following medic might not express its full yield, owing to greater water use during the pasture phase (Figure 2.1), leaving the soil too dry for the subsequent wheat crop to mature without suffering from moisture stress. It would appear, however, that there was adequate moisture for grain filling and ripening of barley under the weather conditions of 1991–92.

When N was not applied, wheat gave greater total yields than barley in all rotations except for cereal/medic. In the barley/medic treatment, total unfertilized barley yields were equal to, or better than, results obtained from fallow and watermelon rotations (7.45 vs. 6.78 or 7.39 t/ha for medic, fallow and watermelon rotations, respectively). Total yields of barley/medic rotations were 3.05 or 2.17 t/ha greater than barley/lentil and barley/vetch rotations (Table 2.2). This is an important result for legume systems in which N_2 fixation is supposed to reduce N fertilizer costs on subsequent cereals. It is possible that higher levels of total soil N and organic matter in medic plots permitted more vigorous growth of barley; it is however, difficult to explain why the same phenomenon did not occur for cereal grown in the vetch rotation, which was also known to have accreted higher levels of total soil N (White 1992). Little is known about the quantity, time and duration of availability for the labile N mineralizing from the total N in these rotations.

Fertilizer N application improved the yield of cereal grain and straw in all cases, but, in every case, fertilizer use was more efficient for barley than for wheat. N application across all

rotation treatments increased grain yields for barley by 0.58-2.32 t/ha, while for wheat the increase was lower, from 0.16-0.88 t/ha (Table 2.2).

Improvement in yield due to N fertilization was usually better for fallow compared to legume rotation systems rotated with wheat, while grain and straw yield of barley grown after lentil responded better to N than the other legume rotations (Table 2.2).

Improvement in cereal yield due to N fertilization was usually better for fallow systems compared to legume rotation systems. Within legume rotations, N gave the best boost to barley grain and straw grown after lentil (Table 2.2), suggesting that lentil rotations provide less biologically fixed nitrogen from the legume phase than do medic or vetch (White 1992).

It is possible to explain variability in cereal response to fertilizer and rotation system by understanding the response to the three seeding rates used in the experiment. For example, an N x Fallow System x Barley Seed Rate (quadratic) interaction was detected in the analysis of variance (Tables 2.1 and 2.3), suggesting that 120 kg/ha seeding rates for barley are optimum for grain and straw production in fallow systems. On the other hand, in legume rotations, barley seed rates did not influence final grain yield. Recommending a lower seed rate can save money for the farmer. It also implies that cereal breeding should not be carried out in isolation from the rotation in which the cereal will eventually be used.

For wheat straw production, the rotation system and N both affected ultimate yield; there was, however, no interaction with seeding rate. Yield increased linearly with seeding rate. For higher straw production, seed rates above 160 kg/ha might be considered.

Conclusions

The results of this single year of experimentation point to the likelihood that medic pastures dry down the soil to a degree that makes wheat compare less favorably than barley as a crop rotated with medic in NW Syria. Indeed, water relations data from another long-term rotation trial next to the trial under discussion confirm the degree to which medic depletes water in the soil profile (Figure 2.1).

The site of the experiment is in a district that typically produces both wheat and barley, but greater price subsidies on wheat in Syria make it the crop of choice from an economic point of view. Nevertheless, results presented here suggest that barley might be better matched as a companion with medic in a pasture/cereal rotation because of the shorter maturation period of barley and, hence, lower demand for water compared to wheat. Our results comparing the two cereals showed greater fertilizer and water use efficiency of barley. Barley will be further investigated to see whether the trends presented in this paper will be repeated.

In the economic analysis of the rotations, using six years of wheat data, Nordblom et al. (1992) reported that an increase of wheat grain yields of about 0.6 to 1.0 t/ha would make the medic rotation competitive with wheat/lentil on farms of 16 to 32 ha in size. This magnitude of increase in wheat yield in our rotations is unlikely with wheat but may be possible with barley.

One objective in the coming year will be to undertake an analysis comparing the economics of using barley instead of wheat in this rotation experiment, using sensitivity analyses to define the place of medic in NW Syria. - N. Nersoyan, M. Singh, T. Nordblom, F. Bahhady, H. Harris and S. Christiansen

References

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- White, P.F. 1992. Nitrogen balances in integrated crop/livestock systems. ICARDA/PFLP Annual Report for 1990/91. ICARDA, P.O. Box 5466, Aleppo, Syria. pp. 97-108.

Table 2.1. Probability values corresponding to significant ($P < .05$) effects on grain and straw yields of wheat and barley and mean squares (MS) of residuals in the split-split-plot design. Nonsignificance (ns) was reported when $P > 0.05$.

Source	df	Grain	Straw
Rep	2	-	-
Rotation (ROT): Fallow (FAL) and/or Legume (LEG) Systems			
ROT System	1	<0.001	<0.001
LEG System	2	<0.001	<0.001
Remaining Effects	3	ns	ns
Residual MS	12	4.376×10^5	1.419×10^6
Nitrogen (N) x ROT			
N	1	<0.001	<0.001
N x ROT System	1	<0.001	<0.001
N x LEG System	2	<0.013	<0.007
Remaining Effects	3	ns	ns
Residual MS	14	2.335×10^5	2.356×10^5
N x ROT x Cereal (CER): Wheat (WHT) and/or Barley (BAR)			
N x ROT System x CER	1	<0.001	ns
N x LEG System x CER	2	0.036	ns
N x FAL System x BAR			
SR Quadratic	1	0.022	ns
Wheat (WHT) and/or Barley (BAR)	1	<0.001	<0.001
Seeding Rate (SR)			
WHT SR Linear	1	ns	0.001
BAR SR Linear	1	ns	0.004
N x CER	1	<0.001	0.006
N x WHT SR Linear	1	ns	0.022
ROT System x CER	1	0.050	0.001
LEG System x CER	2	<0.001	0.031
ROT System x BAR			
SR Quadratic	1	0.002	0.001
FAL System x WHT			
SR Quadratic	1	ns	0.045
Remaining Effects	56	ns	ns
Residual MS	140	1.18×10^5	1.772×10^5

Table 2.3. Effect of seeding rate on cereal grain and straw yields when grown after various land use systems including fallow (F), lentil (L), vetch (V), watermelon (W), medics (M) and two fertility levels of N: 0 (N-) and 60 kg/ha (N+), applied as splits in autumn and spring.

Barley seed rate (kg/ha)	Grain				Straw					
	Fallow system		Legume system		Fallow system	Legume system		Mean		
	N-	N+	Mean	N-		N+	Mean			
80	3.59	5.67	4.63	3.37	4.22	3.79	4.03	4.42	3.53	3.79
120	3.82	6.14	4.98	3.31	4.20	3.75	4.10	5.08	3.51	3.96
160	3.60	5.72	4.66	3.57	4.32	3.95	4.15	4.80	3.76	4.06

Wheat seed rate (kg/ha)	Land Use				Straw			
	Fallow system		Legume system		Fallow system	Legume system		Mean
	N-	N+	Mean	N-		N+	Mean	
80	5.76		4.26		4.14	5.24	4.69	
120	5.95		4.42		4.16	5.55	4.86	
160	6.41		4.81		4.50	6.03	5.27	

S.E._m for comparing:

	Grain		Straw	
	F	L	F	F
N and seed rate at same rotation system and same or different seed rates	±0.15	±0.10		
Seed rate at same N and rotation	±0.14	±0.09		
Any other pair of combination of N, seed rate and rotation	±0.16	±0.10		
Seed rate at same rotation system	±0.10	±0.06		
Any other of pair of combinations between seed rate and rotation	±0.12	±0.08		
Any pair of combination of seed rate and N	±0.09	-		
Seed rate	±0.05	-		

2.2 Seed bank development of medic pastures grown in rotation with barley at a 280 mm average rainfall site

Abstract

Changes in seed bank size and botanical composition of a mixture of seven species of medic (*Medicago*) grown in rotation with barley were monitored during 1987-88 to 1991-92 at Breda, Syria (414, 195, 184, 244 and 263 mm precipitation, respectively, all but the first below the average). Both phases of the rotations were present each year. Medics sown in 1987-88 maintained seed banks ranging from 65 to 794 kg/ha of seed throughout the experiment. Medics sown in 1988-89 produced only 25 kg/ha seed, which necessitated reestablishment in 1990-91, when a seed crop of 100 kg/ha of seed was produced. A medic/medic/barley rotation was then introduced to see if the seed bank could be built up more quickly. Seed bank yields remained about the same in 1991-92 after receiving 263 mm of rainfall on plots with medic for a second consecutive year. In the successfully established medic: 1) *M. rigidula* was best adapted, 2) *M. polymorpha* persisted in the seed bank because of its big initial contribution, 3) *M. polymorpha* consisted of several accessions and cultivars whose success was mainly due to the Australian cv 'Circle Valley', 4) *M. rotata* and *M. noeana* consistently represented 5 to 10% of seed present and 5) *M. aculeata*, *M. scutellata* cv 'Snail' and *M. truncatula* cv 'Jemalong' failed to sustain seed banks.

Introduction

Most data on the adaptation of a ley farming system for Syria have been based on work in the wheat growing zones, receiving 300 to 350 mm rainfall. Native species of *M. rigidula*, *M. rotata* and *M. noeana* were selected in this zone to combine frost tolerance and adaptation to pasture/cereal rotations (Abd El-Moneim and Cocks 1986; Cocks and

Ehrman 1987). It is also recognized, however, that an equally important objective is to select legumes for drier zones, typified by continuous barley, and where principles similar to those in wetter zones apply for selection of medics within rotations (Cocks 1988).

Breda, with 280 mm annual rainfall, therefore, served to test whether medics could contribute to sustainable rotation systems in drier areas. It also provided an opportunity to include, in a mixture, the successful medic ecotypes from previous experimentation at the main ICARDA station at Tel Hadya (345 mm annual rainfall).

The chance that medics might not produce seed in a given year, owing to drought, is high. If a medic/barley rotation could not sustain a seed-bank at Breda, it was hypothesized that a medic/medic/barley rotation would be a more secure alternative. Since density is directly related to pasture dry matter production (Abd El Moneim and Cocks 1986), bigger seed banks should improve grazing potential of pastures, especially as the seeds are also a good source of nutrition.

This paper reports on how we hope to identify adapted medics, capable of maintaining adequate seed banks when grown in rotation with barley. The objective was to test whether medics could establish seed banks that would result in medic-dominant, spontaneously regenerating pastures in dry areas, in either a medic/barley or a medic/medic/barley rotation.

Methods

The experiment was conducted at Breda (35° 56'N, 37° 10'E, altitude 300 m), 50 km southeast of Aleppo, in north Syria. It has a typical mediterranean climate, the rain falling between November and May (280 mm/year).

A pasture/barley treatment with a 2-phased entry was compared

with continuous barley, barley/fallow and barley/chickling (Lathyrus sativus). In 1990-91 and 1991-92, a medic/medic/barley rotation was introduced into the experiment by splitting the medic/barley rotation in two. Pasture size was 1.0 ha and there were three replicates in a randomized complete block design. Superphosphate (40 kg/ha P_2O_5) was applied to the medic plots at the beginning of the experiment.

Mixtures of equal proportions (by weight) of seven species, including several ecotypes within M. rigidula and M. polymorpha (Table 2.4), were sown at a rate of 30 kg/ha on 21 Nov 1987 (first year of establishment) and 10 Nov 1988 (first establishment in the second phase). This later phase had to be repeatedly resown because of dry conditions. The appropriate Rhizobium for each accession was used to inoculate seed. In the year following medic, the land was cultivated to a depth of 10 cm and sown to barley. The barley stubbles were grazed and then pastures were allowed to regenerate.

After medic seed was set in establishment years, pastures were grazed by sheep between June and October. For regenerating pastures, grazing occurred in winter, spring and summer and was terminated when either the setting of seed or maintenance of a 200 kg/ha seed bank were jeopardized.

The above- and below-ground seed bank data represent the mean of 100 soil cores per pasture, each of 10 cm diameter, to a depth of 10 cm in both the barley and pasture phases. In June 1992, the number was doubled to 200 cores per pasture. Medic pods were separated from other residues and soil, and then classified to species and accession based on pod characteristics (Lesins and Lesins 1979). The pods were threshed by rubbing between corrugated rubber matting and the seed was cleaned and weighed. Data were interpreted using analysis of variance procedures and means separation by LSD ($P < 0.05$).

Results and discussion

Medic established well in 1987-88 because of the 415 mm of rainfall. The 195 and 184 mm in the following two years were well below average (280 mm), and very little medic seed was produced in either the first establishment year for the second phase (1988-89), or in the regeneration year for the first phase (1989-90). In fact, the summer seed bank sampling of 1990 was canceled, because of the absence of medic pods (Table 2.5).

The 244 mm rainfall in 1990-91 was 40 mm below average, but was very well distributed; 102 kg/ha of seed, therefore, were measured in June 1991 for medic that was re-established for a second time (ME2, 6/91 in Table 2.5). M. rigidula, M. polymorpha and M. rotata contributed one-half, one-third and one tenth, respectively, of the seed, regardless of phase.

Medic sown in 1987-88 yielded 672 kg/ha of seed, which was lowered, because of grazing, to 439 kg/ha by the end of the summer (Table 2.5). The main difference between phases was one of seed bank size. M. rotata and M. noeana were not failures, but they did not contribute more than 10% of the seed to the seed bank at any time. Apparently, the late maturation of M. noeana imparts a disadvantage to its persistence in a dry zone. M. aculeata, Jemalong and Snail medic all failed to sustain seed banks.

A medic/medic/barley rotation was initiated in the well established plots in 1990-91 and an additional 610 kg/ha of seed was produced on the plots that grew medic for the second year in a row (2M2B, 6/91 in Table 2.5). Seed pods were grazed throughout the summer, leaving a total seed bank of 656 kg/ha in Oct 1991 (Table 2.5).

M. rigidula and M. polymorpha represented a mix of accessions within each species (Table 2.4). M. rigidula entries, listed in Table 2.4, produced similar proportions of the total seed formed.

M. polymorpha, the Australian cv Circle Valley produced copious quantities of seed during the medic establishment year of 1987-88: it contributed about half the seed set from all species of medic (by weight) in the summer of 1988 and was by far the most successful M. polymorpha entry. Circle Valley maintained its performance relative to the other M. polymorpha entries throughout the experiment, and in June 1992 it still had a seed bank of 58 kg/ha from a total seed bank of all species of 205 kg/ha (MB, 6/92 in Table 2.5). Although Circle Valley is susceptible to frost (Cocks 1988), it is clearly also capable of copious seed production. Since the pods of Circle Valley are spineless and relatively small, it is more difficult to deplete the seed stock by grazing.

The results show that medics survive some very dry years and are able to persist for several seasons without major new inputs of seeds, provided there is an initial year when the seed bank can get established. Management should concentrate on maximizing seed production when conditions permit. Practically speaking, little can be done to build up seed banks in dry years because there is a low biological capacity for seed production and farmers need the pasture for grazing. It is interesting, however, that, although the seed bank set in 1987-88 was depleted to one third of the original level by two successive dry years, full recovery in June 1991 was possible in a less than average rainfall year (2M2B, 6/91 and 10/91, Table 2.5).

The experiment was located 35 km from ICARDA headquarters and medic plots were grazed over short but frequent periods, using large flocks of sheep owned by farmers. This management is the rule rather than the exception in west Asia and north Africa. It will be difficult for medics to set seed and persist unless farmers can be taught the proper grazing techniques to preserve the medic. They must also be convinced that above-ground pods serve a valuable

purpose as an emergency feed and that below-ground pods are a necessity for regeneration of pastures and improvement of soil fertility.

This experiment will be continued until 1994-95 in order to directly compare seed banks of the medic/medic/barley and medic/barley rotations, when the plots come in to synchrony in the same phase under the same weather conditions. - **S. Christiansen and P. Cocks**

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Table 2.4. The species sown, their accession (Acc) and selection (Sel) numbers at ICARDA and their site of collection.

<u>Medicago</u> species & authority	ICARDA Germplasm Identification	Collection Site
<u>M. rigidula</u> (L.) All.	Acc 811 Sel 716	Jisr Al Shagour, Syria
<u>M. rigidula</u> (L.) All.	Acc 835 Sel 1295	Kasab, Syria
<u>M. rigidula</u> (L.) All.	Acc 2116 Sel 1865	Hankendi, Turkey
<u>M. rigidula</u> (L.) All.	Acc 2713 Sel 1919	Terbol, Lebanon
<u>M. rigidula</u> (L.) All.	Acc 2066 Sel 1900	Kahranan Marash, Turkey
<u>M. polymorpha</u> L.	Acc 1172 Sel 1036	Ben Cherga, Tunisia
<u>M. polymorpha</u> L.	Circle Valley	Coolgardie, Australia
<u>M. polymorpha</u> L. Tah	Tah	Idleb, Syria
<u>M. aculeata</u> Willd. ^a	Acc 1480	Tel Amara, Lebanon
<u>M. rotata</u> Boiss.	Acc 2600 Sel 2123	Azaz, Syria
<u>M. truncatula</u> Gaertn.	Jemalong	Forbes, Australia
<u>M. noeana</u> Boiss.	SA 15485	near Khorramabad, Iran
<u>M. scutellata</u> (L.) Miller	Snail	Noarlunga, Australia

^a Synonym M. doliata Carm. (Lesins and Lesins 1979).

Table 2.5. Total seed (kg/ha) above and below the soil surface for seven *Medicago* species. Codes: ME1=1st attempt at medic establishment; ME2=2nd attempt at medic establishment; ME3=3rd attempt at medic establishment; BME=barley after ME (1, 2 or 3); MB=medic after barley in a 2-phase rotation; BMB=barley after medic in a 2-phase rotation; 2MBB=1st medic in a medic/medic/barley rotation; 2MBB=2nd medic in a medic/medic/barley rotation, and B2MB=barley after two years of medic. Repeat samplings on the same treatment in the same year have solid underlines, sampling before and after setting of new medic seed.

		Sampling date and treatment									
Sown 1988-89; resown 1990-91 & 1992-93		6/89	2/90	2/91	6/91	2/92	2/92	6/92	2/93	2/93	6/93 ²
		ME1B	BME1	ME2	ME2	BME2	2MB2	2MB2	B2M	ME3	ME3
<i>M. rigidula</i>		19 ^a	16 ^a	7 ^a	54 ^a	17 ^a	17 ^a	53 ^a	12 ^a	10 ^a	
<i>M. polymorpha</i>		<1 ^b	<1 ^b	<1 ^b	31 ^b	6 ^b	5 ^b	21 ^b	2 ^b	2 ^b	
<i>M. rotata</i>		1 ^b	1 ^b	<1 ^b	10 ^b	1 ^c	2 ^b	6 ^b	1 ^b	<1 ^b	
<i>M. noeana</i>		3 ^b	2 ^b	1 ^b	3 ^c	2 ^c	1 ^b	2 ^b	<1 ^b	<1 ^b	
<i>M. aculeata</i>		<1 ^b	<1 ^b	<1 ^b	1 ^c	2 ^c	0 ^c	<1 ^b	<1 ^b	<1 ^b	
<i>M. truncatula</i>		<1 ^b	<1 ^b	<1 ^b	2 ^c	<1 ^c	<1 ^c	1 ^b	<1 ^b	<1 ^c	
<i>M. scutellata</i>		0 ^b	0 ^b	0 ^c	1 ^c	0 ^c	<1 ^c	<1 ^b	<1 ^b	0 ^c	
Total		25	21	9	102	28	27	84	17	13	-
±S.E.		6	5	1	41	4	6	42	5	<1	
Sown: 1987-88		2/90	2/91	6/91	2/92	2/92	6/92	2/93	2/93	6/93	
		2MB1	2MB2	2MB2	B2M	MB	MB	B2M	2MB1	2MB1	
<i>M. rigidula</i>		105 ^a	73 ^a	469 ^a	134 ^a	37 ^a	100 ^a	38 ^a	82 ^a		
<i>M. polymorpha</i>		135 ^a	80 ^a	216 ^b	105 ^b	35 ^a	64 ^{ab}	19 ^{ab}	39 ^f		
<i>M. rotata</i>		26 ^b	13 ^b	33 ^b	14 ^b	6 ^b	27 ^{bc}	4 ^b	7 ^b		
<i>M. noeana</i>		12 ^b	10 ^b	50 ^b	23 ^b	3 ^b	5 ^c	1 ^b	13 ^b		
<i>M. aculeata</i>		7 ^b	2 ^b	8 ^b	1 ^b	2 ^b	3 ^c	<1 ^b	<1 ^b		
<i>M. truncatula</i>		8 ^b	5 ^b	15 ^b	5 ^b	4 ^b	5 ^c	1 ^b	4 ^b		
<i>M. scutellata</i>		6 ^b	1 ^b	3 ^b	<1 ^b	<1 ^b	<1 ^c	1 ^b	<1 ^b		
Total		299	184	794	283	87	205	65	146	-	
± S.E.		48	36	197	35	20	64	19	28		

¹ Means within a column with the same letter in the upper or lower halves of the table are not different using Fisher's Protected LSD ($P < 0.05$). ² Next scheduled sampling date.

2.3 Seed bank development and hardseededness of amphicarpic legumes and annual medics

Abstract

Amphicarpic legumes produce both above- and below-ground seed and the underground seed helps to avoid the negative consequences of overgrazing. They are also well adapted to low rainfall areas. We compared hard seed breakdown of above- and below-ground seeds in four accessions of Vicia sativa subsp. amphicarpa and one accession of Lathyrus ciliolatus to the seed yield and hardseededness of Medicago rigidula and M. noeana. The seeds were originally sown in Nov 1990. No defoliation treatments were applied, so that above- and below-ground seed yields and plant biomass could be compared when the plants reached maturity in spring. M. rigidula had more than double the forage dry matter compared to the amphicarpic legumes. M. noeana matures late, so it did not attain optimum yields in this relatively dry year (292 mm rainfall). In the year of establishment, M. rigidula and M. noeana produced 412 and 110 kg/ha seed yield, while V. sativa subsp. amphicarpa and L. ciliolatus produced 1174 and 736 kg/ha, of which >95% was below ground. In wetter seasons, more seed is produced above-ground. Hardseed breakdown was monitored on 1 July, 1 Aug, 1 Sep and every 2-weeks thereafter, until the end of Feb 1992. Seeds of all species were >90% hard when newly set seed was tested for germination in summer 1991. Laboratory tests of seeds taken from the field at each sampling time showed that >95% of the underground seed of the amphicarpic legumes had softened by Feb 1992. By contrast, only about 5% and 40% of the above-ground seeds of V. sativa subsp. amphicarpa and L. ciliolatus, respectively, had softened by Feb 1992. Interestingly, after seedlings stopped emerging there were still considerable amounts of seed in the soil (348-483 kg for V. sativa subsp. amphicarpa accessions), suggesting a form of dormancy

season had below average precipitation (292 mm) and *M. noeana* flowers later than *M. rigidula*, which may have affected its ability to mature fully and to set seed.

Below-ground seed production of vetches was greater than that of lathyrus, but there were no differences among the vetch accessions (Tables 2.6, 2.7). Total seed production was highest for vetch accessions among all those tested, owing to the large contribution from underground seeds. The amphicarpic legumes do not produce much above-ground seed, therefore multiplication of desirable accessions will be difficult, because of the need to excavate the seed. Medics do not need to devote energy to underground seed production and as a result they tend to produce more above-ground herbage mass.

Above-ground hard seed breakdown: Above-ground seeds of all accessions initially possessed high levels of hardseededness. The seed gradually softened until the start of autumn rains. Thereafter, the seeds that were taken from the field had higher hardseed percentages, because most of the permeable seeds had germinated. GENSTAT's quadratic/quadratic function gave the most suitable fit:

$y = A + (B+Ct)/(1+Dt+Et^2)$ where constants A, B, C, D, and E are unknown parameters, are estimated from the hardseed breakdown data from all species and t is time measured every two weeks. The following accumulated analysis of variance indicates that species differ in each of the parameters.

yields were measured at the beginning of each month, until May 1992.

The data for above- and below-ground hardseed breakdown, accumulated seedling germinations and biomass accumulation in 1992, were all time-series data and were described with mathematical functions. One-time responses, such as seed and straw yields, were subjected to analysis of variance (ANOVA) to separate experimental error variances from the variability due to accessions, cultivation and their interactions. An examination of residual plots indicated the need for log transformations of the data, so the probability values in Table 2.6 are from transformed data, while the figures in Table 2.7 are untransformed.

Responses that were measured repeatedly over time were tested with analysis of variance procedures. We partitioned 'time x accession' and 'time x accessions x cultivation' interactions into orthogonal polynomial contrasts and they were tested with appropriate error terms. Significant interactions indicated the need for some non-linear functions. The FITCURVE command in GENSTAT provides options for 10 standard non-linear curves. From these, we found the 'quadratic/quadratic' and the 'logistic' functions most descriptive of hardseed breakdown in above- and below-ground seed, respectively. The 'linear' relationship best modelled accumulated seedling germination and the 'exponential' function best described dry matter production.

Results and discussion

Establishment year: Initial cultivation did not affect seed or straw yields of the legumes studied (Table 2.6). The amphicarpic legumes were no different from each other in their ability to produce above-ground seed, but, as a group, the amphicarpic legumes produced less above-ground seed and straw than did medics. M. rigidula produced more seed and straw than M. noeana. The 1990-1991

other than hardseededness. Medics remained more than 90% hardseeded. Dry matter accumulation was again monitored in the spring of 1992 (349 mm rainfall): M. rigidula yielded significantly more above-ground herbage than amphicarpic legumes. The amphicarpic legumes can be highly recommended for use on uncultivated, marginal land or they can be rotated with barley when adequate legume seed banks have been developed.

Introduction

Vicia sativa subsp. amphicarpa (Dorth.) Aschers. & Graebn., as its name suggests, produces seeds above and below the soil surface. Unlike subterranean clover (Trifolium subterraneum L.), which buries its seeds after flowering, V. sativa subsp. amphicarpa also flowers beneath the surface of the soil. It is a common weed in marginal lands, which implies that it is tolerant of grazing and hence a potentially useful pasture plant for improving marginal lands. It is also tolerant of disturbance (Ehrman and Maxted 1990), which makes it a candidate as a self-regenerating pasture legume in a rotation with cereals. Another amphicarpic legume, native to the Mediterranean basin, Lathyrus ciliolatus Guss., (known synonymously as L. saxatillis (Vent.) Vis.) is also included in this experiment.

If the species are to be used in a cereal pasture rotation system, they will need sufficient hardseededness or dormancy to form a long-lasting seed bank. Their ability to bury seeds will affect this requirement, because hardseededness of buried seeds is usually much greater than of seeds lying on the soil surface (Taylor 1984; Taylor and Ewing 1988).

The objective of the experiment was to compare hardseed breakdown for above- and below-ground seeds of V. sativa subsp. amphicarpa and L. ciliolatus with that of two annual medics: Medicago rigidula All. (L.) and M. noeana Bois. A secondary

objective was to quantify the effect of cultivation with a duck's foot cultivator versus no cultivation, on subsequent dry matter production of pasture legumes.

Materials and Methods

The following species were examined in this experiment: M. rigidula ICARDA Acc 2713 Sel 1919, from Terbol, Lebanon; M. noeana, SA 15485, from near Khorramabad, Iran; L. ciliolatus ICARDA Acc 835 Sel 589 from Barchine, Sweida Province, Syria; and four selections of V. sativa subsp. amphicarpa: Acc 2614 Sel 2569 and Acc 2660 Sel 2562 from the Central Anatolian Plateau of Turkey; Acc 2647 Sel 2570 and Acc 2650 Sel 2571 from Bardoneh, Idlib Province, Syria.

The experimental design was a split-plot in randomized complete blocks with four replicates. The main plots were cultivation treatments, using either a ducksfoot cultivator and disc harrowing or no cultivation. The amphicarpic legumes and medics were drilled into 8 x 3 m sub-plots with a Oyord seeder at 60 kg ha⁻¹ and 30 kg ha⁻¹, respectively, in Nov 1990. Seed and straw yields were measured in May 1991. Seed yield of amphicarpic legumes was determined by separating seed from soil cores taken to a depth of 10 cm. Hardseededness was determined by placing 50 to 100 seeds on moist paper in Petri dishes. After 15 days at 25°C the percentage germination, not just imbibition was determined. These measurements were made on seed samples taken from plots on 1 Jul, 1 Aug, 1 Sept and at intervals of 2 weeks thereafter, until Feb 1992.

In the autumn of 1991, half the plots were again cultivated as mentioned above, to incorporate the above-ground seeds and to disturb the soil. Thereafter, germination of seedlings was monitored in fixed quadrats on a weekly basis after the onset of rains. At each counting time, seedlings were removed and an accumulated number for germinated seedlings was noted. Beginning on 1 Jan 1992, herbage

Table 2.6. Variability in vetch, lathyrus and medic accessions for above- (ASYLD) and below-ground seed yield (BSYLD), total seed yield (TSYLD), seed number and straw in terms of probability of significance ($P=0.05$) for management and germplasm effects in May 1991 and Feb 1992. All variables were log transformed. Values in bold print are residual mean square values, not probabilities.

SOURCE	df	5/91		2/92	
		ASYLD	BSYLD	TSYLD	Straw
REPLICATIONS	3	-	-	-	-
MANAGEMENT					
Cultivation	1	0.964	0.224	0.132	0.626
Residual Mean Square	3	0.025	0.130	0.024	0.392
ACCESSIONS					
Genus (Amphicarpic vs <u>Medicago</u>)	1	<0.001	-	<0.001	<0.001
Amphicarpic (<u>Vicia</u> vs <u>Lathyrus</u>)	1	0.718	<0.001	<0.001	0.091
Vetches (within <u>Vicia</u>)	3	0.004	0.225	0.208	0.001
Medics (within <u>Medicago</u>)	1	0.001	-	<0.001	0.030
MANAGEMENT*ACCESSIONS					
Cultivation*Genus	1	0.478	-	0.073	<0.001
Cultivation*Amphicarpic	1	0.681	0.193	0.224	0.704
Cultivation*Vetches	3	0.198	0.420	0.425	0.144
Cultivation*Medics	1	0.754	-	0.617	0.295
Residual Mean Square	36	0.202	-	0.079	0.079
Residual Mean Square	24	-	0.076	-	-

Table 2.7. Mean seed yield, seed number and straw yields of vetch, lathyrus and medic species: above-ground seed yield (ASYLD) below-ground seed yield (BSYLD), total seed yield (TSYLD) in May 1991 and Feb 1992.

<u>Vicia sativa subsp.</u> <u>amphicarpa</u>	5/91				--2/92--	
	ASYLD	BSYLD	TSYLD	Straw	TSYLD	
			kg/ha			
Acc 2614 Sel 2569	40	1308	1348	324	428	
Acc 2647 Sel 2570	28	983	1011	205	483	
Acc 2650 Sel 2571	48	1208	1255	231	448	
Acc 2660 Sel 2562	23	1059	1082	178	348	
Mean	35	1139	1174	234	427	
<u>Lathyrus ciliolatus</u>						
Acc 835 Sel 589	36	700	735	230	90	
<u>Medicago</u>						
<u>rigidula</u> Acc 2713 Sel 1919	412	0	412	795	230	
<u>noeana</u> SA 15485	110	0	110	623	43	
Mean	261	0	261	709	136	

Table 2.8. Accumulated ANOVA for above-ground hardseed breakdown

SOURCE	df	Mean Square	R ² % ^a
Time	4	220	25.1
Accessions	6	159	54.6
Time*Accessions	12	31	62.0
Separate Non-linear parameters	12	42	81.1
Residual Mean Square	44	7	

^a Percentage variance accounted for by the current source and accumulated over preceding entries.

The curves describing hardseed breakdown in the above-ground seed of the tested accessions are given in the Figure 2.2.

Below-ground hard seed breakdown: Hardseededness in below-ground seed stayed relatively stable until November, when a rapid decrease took place in the course of the next two months. GENSTAT's logistic curve provided the best fit to model the breakdown of hardseededness across time:

$y = A + C / (1 + e^{-B(t-M)})$ where A, B, C, and M are unknown parameters to be estimated from data and t is time in periods of two weeks. These were estimated and compared for the amphicarpic species.

Table 2.9. Accumulated ANOVA for below-ground hardseed breakdown

SOURCE	df	Mean Square	R ² % ^a
Time	3	35215	95.7
Accessions	4	491	97.4
Time*Accessions	4	27	97.3
Separate Non-linear parameters	8	197	98.9
Residual Mean Square	40	21	

^a Percentage variance accounted for by the current source and accumulated over preceding entries.

The breakdown of hardseededness in the below-ground seed is shown in the graph in Figure 2.3.

Germination in the field -- accumulated seedling counts: A straight line described the response of seedling counts accumulated from the onset of rainfall in Autumn 1991 to Feb 1992:

$y=A + Bt$ where A is the intercept, B is the slope and t represents time measured in weekly intervals.

Table 2.10. Accumulated ANOVA for accumulated seedling germination

SOURCE	df	Mean Square $\times 10^4$	R ² % ^a
Time	2	20.67	2.0
Accessions	6	106.4	97.4
Time*Accessions	6	2.10	99.3
Residual Mean Square	77	0.0502	

^a Percentage variance accounted for by the current source and accumulated over preceding entries.

The pattern of accumulated seedling germination is given in Figure 2.4.

Dry matter yield accumulation in 1992: Dry matter accumulation of the accessions tested could also be described exponentially: $y=A + B(3.173)^t$ where A is the intercept, B is the slope and t represents time in months.

Table 2.11. Accumulated ANOVA for dry matter accumulation

SOURCE ^a	df	Mean Square $\times 10^4$	R ² % ^b
Time	2	1568	57.1
Accessions	6	215.7	79.0
Time*Accessions	6	114.4	96.7
Separate Non-linear parameters	6	4.27	95.8
Residual Mean Square	7	8.15	

^a Each source adjusted for the preceding entry.

^b Percentage variance accounted for by the current source and accumulated over preceding entries.

Patterns for dry matter accumulation are shown in Figure 2.5

Conclusions

Amphicarpic vetches and lathyrus were less productive than medics, in terms of forage dry matter, in this experiment conducted at Tel Hadya. They produced a large quantity of seed below-ground, but very little of it remained hardseeded, according to laboratory tests, by mid-winter after the seed was first produced. The above-ground seed is harder, but has far lower levels of impermeability than found in medics. Interestingly, by 26 Feb 1992, after all seedlings had been plucked from within a fixed quadrat, we excavated a soil core from within the quadrat and found many ungerminated seeds of amphicarpic legumes (Table 2.7).

The three genera differed in the number of residual seeds ($P < 0.001$) present in the soil and the two medics differed from each other ($P < 0.001$). The four accessions of *V. sativa* subsp. *amphicarpa*, however, were similar in the number of residual seeds recovered. The seeds of vetch and lathyrus, harvested on 26 Feb, were mostly underground seeds, as could be ascertained from seed size. By this time all seed was considered soft, according to our laboratory germination tests (Table 2.7). Nevertheless, the presence of residual, ungerminated under-ground seed in the soil, after plucking all seedlings from fixed quadrats (Table 2.7), suggests that, in addition to hardseededness, there might be another mechanism operating in these amphicarpic legumes. Cocks (1989, p. 141) found that *M. rotata* needs a sufficiently long period of exposure to moisture before germination occurs. Although we do not have actual soil water measurements, a total of 301 mm of precipitation had been received by the end of Feb 1992 and the long-term average value for accumulated rainfall by the end of February is 241 mm. Therefore, we can assume that soil conditions were moist enough for germination to occur. Although temperatures might have inhibited germination (3–5°C minimum; 6–10°C maximum at –5 cm maximum in the last week of Feb

1992), no further germination occurred, even in March and April. It appears that more work will be needed to understand the mechanisms for persistence for seeds of amphicarpic legumes.

The amphicarpic legumes studied in this experiment produced more seed below the ground, less seed above the ground and less biomass than did medics. Observations from wetter years show that amphicarpic legumes produce a greater proportion of seeds above-ground. Hopefully, this trait could be exploited to facilitate seed multiplication. Concerning dry matter production, breeding efforts, crossing *V. sativa* x *V. sativa* subsp. *amphicarpa*, will attempt to direct some of the plant energy into above-ground herbage production at the expense of some under-ground seed production.

What sort of farming system will be best for amphicarpic legumes? The amphicarpic legumes can be highly recommended for use on uncultivated, marginal land, or they can be rotated with barley when adequate legume seed banks have been developed.

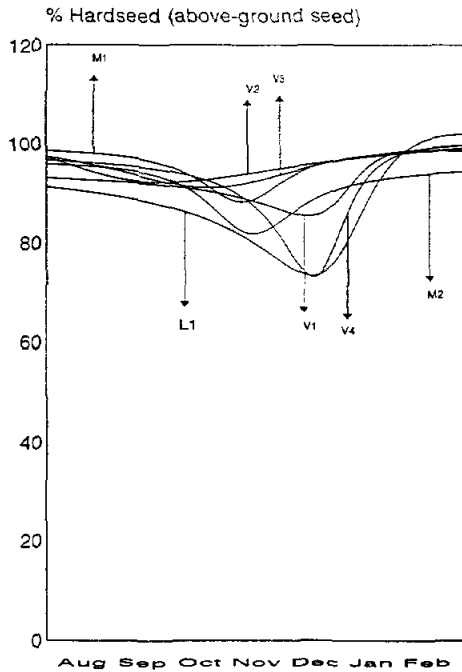
The current trial established the pattern of hardseed breakdown for the amphicarpic legumes; now that two crops have set seed, continued determination of hardseededness will not be able to separate differences in hardseededness between the seed from the first and second years. The trial was discontinued to enable us to harvest the underground seed, to be used to start a grazing experiment. - S. Christiansen, A. Abd El-Moneim, P.S. Cocks and M. Singh

Acknowledgements

The authors wish to thank Marwan Jabboulieh and Amin Katib for their diligent contribution to this project.

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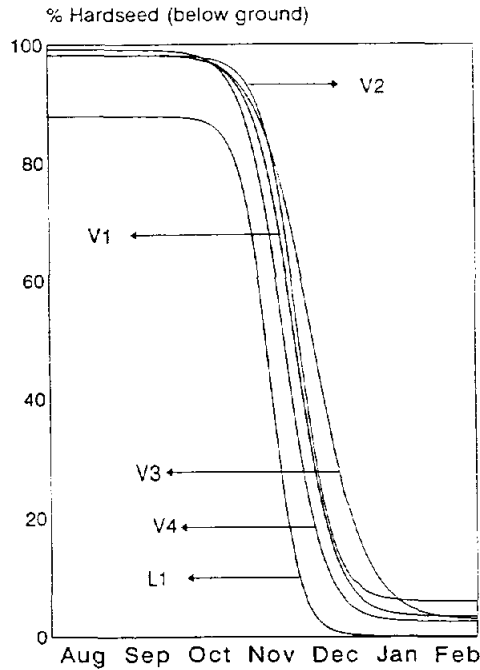
Coefficients of fitted curves for each accession using the formula:
 $y = A + (B+Ct)/(1+Dt+Et^2)$

Accession	Key	A	B	C	D	E
<u>Vicia sativa</u>						
subsp. <u>amphicarpa</u>						
Acc 2614 Sel 2569	V1	95.2	-2.20	0.485	-0.469	0.057
Acc 2647 Sel 2570	V2	104.3	-6.99	-3.080	-0.259	0.156
Acc 2650 Sel 2571	V3	101.4	-4.02	0.112	-0.543	0.117
Acc 2660 Sel 2562	V4	98.8	-2.11	0.404	-0.504	0.065
<u>Lathyrus ciliolatus</u>						
Acc 835 Sel 589	L1	96.7	-5.47	1.109	-0.456	0.055
<u>Medicago rigidula</u>						
Acc 2713 Sel 1919	M1	99.3	-0.79	0.001	-0.677	0.123
<u>Medicago noeana</u>						
SA 15485	M2	96.0	-0.20	-0.297	-0.659	0.117

R² for all accessions
 (d.f.=44)

81.1

Figure 2.2. Dynamics of hardseeded breakdown for above-ground seed of four accessions of Vicia sativa subsp. amphicarpa, one accession of Lathyrus ciliolatus and two medic species, Medicago rigidula and M. noeana.



Coefficients of fitted curves for each accession using the formula:

$$y = A + C / (1 + e^{-B(t-M)})$$

Accession

Vicia sativa

Key

subsp. amphicarpa

Acc 2614 Sel 2569

V1

3.55

94.65

-3.77

3.40

Acc 2647 Sel 2570

V2

6.09

92.09

-4.31

3.44

Acc 2650 Sel 2571

V3

2.98

96.30

-2.80

3.64

Acc 2660 Sel 2562

V4

2.67

96.49

-3.88

3.25

Lathyrus ciliolatus

Acc 835 Sel 589

L1

-0.19

87.72

-5.22

3.06

R²% (Accessions differentiated)

98.9

d.f. = 40

For all amphicarpic spp.

3.81

92.63

-3.74

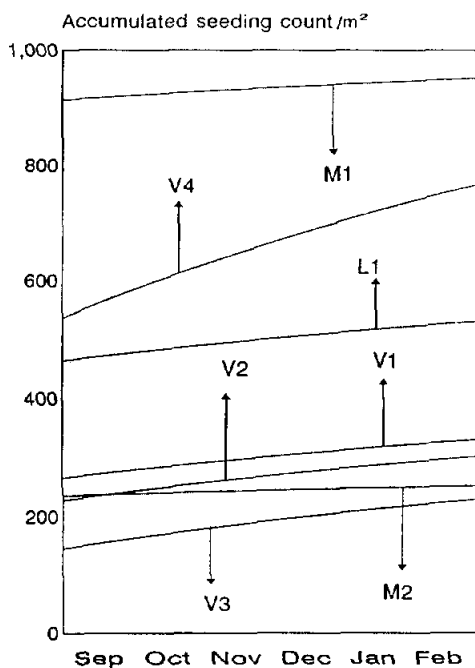
3.34

R²% (Accessions undifferentiated)

95.7

d.f. = 56

Figure 2.3. Dynamics of hardseeded breakdown for below-ground seed of four accessions of Vicia sativa subsp. amphicarpa and one accession of Lathyrus ciliolatus.



Coefficients of fitted curves for each accession using the formula:

$$y = A + Bt$$

Accession

Vicia sativa

subsp. amphicarpa

	Key	A	B
Acc 2614 Sel 2569	V1	288.1	8.95
Acc 2647 Sel 2570	V2	253.6	10.26
Acc 2650 Sel 2571	V3	172.8	11.76
Acc 2660 Sel 2562	V4	613.5	31.60

Lathyrus ciliolatus

Acc 835 Sel 589	L1	485.9	8.99
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Medicago rigidula

Acc 2713 Sel 1919	M1	925.9	5.40
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Medicago noeana

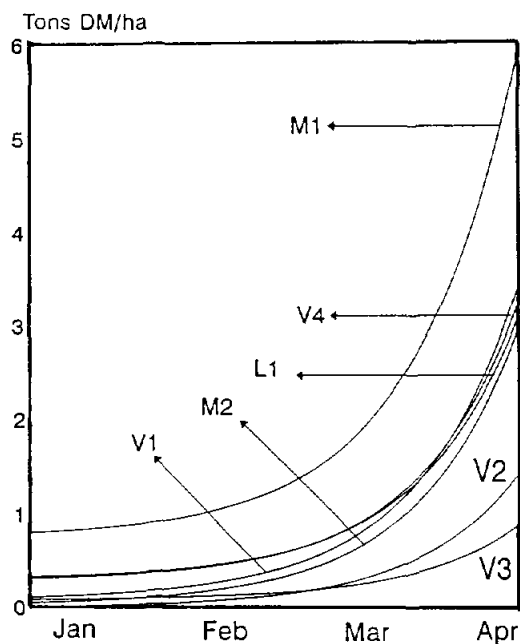
SA 15485	M2	243.1	2.08
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R²% for model with all accessions

99.3

d.f. = 77

Figure 2.4. Dynamics of accumulated seedling germination for four accessions of Vicia sativa subsp. amphicarpa, one accession of Lathyrus ciliolatus and two medic species, Medicago rigidula and M. noeana.



Coefficients of fitted curves for each accession using the formula:

$$y = A + B(3.173)^t$$

Accession

Vicia sativa

subsp. amphicarpa

	Key	A	B
Acc 2614 Sel 2569	V1	84.9	32.8
Acc 2647 Sel 2570	V2	-2.9	14.1
Acc 2650 Sel 2571	V3	83.8	7.9
Acc 2660 Sel 2562	V4	289.2	28.8

Lathyrus ciliolatus

Acc 835 Sel 589	L1	310.8	27.2
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Medicago rigidula

Acc 2713 Sel 1919	M1	760.9	50.9
-------------------	----	-------	------

Medicago noeana

SA 15485	M2	28.1	28.8
----------	----	------	------

R²% for model with all accessions
d.f. = 13

96.7

Figure 2.5. Dynamics of accumulated dry matter in spring 1992 for four accessions of Vicia sativa subsp. amphicarpa, one accession of Lathyrus ciliolatus and two medic species, Medicago rigidula and M. noeana.

2.4 Nitrogen nutrition and the nodulation of medics

Nitrogen is one important factor of the soil environment which greatly affects the development of the Rhizobium-plant symbiosis. The symbiosis is generally inhibited by nitrogen, but nodulation may also be promoted under some conditions. Extensive research on the subject has shown that effects can vary with the host species and rhizobial strain. It is important to understand the effects of combined nitrogen on the symbiosis between any newly selected medic and Rhizobium, because concentrations of mineral nitrogen in the soil are often high just after the germinating rains, when nodules are forming on plants.

This initial investigation describes the effect of combined nitrogen on the nodulation of a range of medics of interest to the Program. A number of strains of Rhizobium, also isolated from the region, were used for inoculation. The aim was to determine which medic species, regarded as potentially suitable for pastures in the area, were most sensitive to mineral nitrogen in terms of nodule formation and plant response.

Six rates of nitrate (0, 1, 3, 6, 12, 18 Mm NO_3) were applied to five species of annual Medicago (M. rigidula 716, M. rotata 2123, M. noeana 2351, M. polymorpha ecotype Tah and M. truncatula cv Jemalong), in combination with four strains of Rhizobium meliloti (ICARDA M15, ICARDA M28, ICARDA M176 and ICARDA M201). Plants were grown in modified Gibson tubes, where the agar in Gibson's procedure was replaced by vermiculite wetted by the N-free nutrient solution. The rooting medium filled the entire tubes and their tops were covered with pieces of aluminium foil. Seeds were pregerminated, transferred to the tubes and inoculated, using 2 ml of broth culture. Uninoculated controls, with and without mineral nitrogen, were also included.

Significant differences on shoot dry weights were detected for strain and mineral nitrogen application at harvests taken 30 and 38 days after planting (Figure 2.6). Strain ICARDA M201 was responsible for high nitrogen fixation rates in *M. noeana* and *M. truncatula*, regardless of nitrate concentration. Nitrogen fixation rates were significantly increased when *M. truncatula* and *M. rigidula* were supplied with 6, 12 and 18 Mm of NO_3^- and enhanced by the highly effective strain M201. There was no clear effect of nitrate on nodulation of *M. rotata* within and between treatments.

The interacting effect of mineral nitrogen on nodulated plants depends largely on the type of strain and medic species. For instance, when strain ICARDA M201 nodulated *M. rigidula* the response of the plant was stronger in the presence of 1, 3 and 6 Mm of nitrate in the rooting solution. A similar response was observed in *M. truncatula* when nodulated by all the tested strains and, to a lesser extent, in *M. polymorpha*. It was also observed that the addition of 1 mM of nitrate into the mineral solution stimulated the formation of nodules in all species of medics tested. Strain ICARDA M176 consistently produced ineffective nodulation in all species of medics. In particular, roots of *M. rotata* contained an average of 30 ineffective nodules, whereas approximately 15 effective nodules were present in *M. rigidula* (Figure 2.7). In fact, abundant nodulation is one of the characteristics of a medic plant nodulated by ineffective bacteria. Nodulation by effective rhizobia produces fewer nodules than in those medic plants nodulated by ineffective rhizobia. It was observed that strain ICARDA M201 was effective in all medic species except *M. rotata*, indicating specificity between the plant and the rhizobial strain.

Results obtained from this experiment indicate that the response of nodulation to nitrogen of medics, indigenous to the region, depends on the particular combination of host species and their

rhizobial partner. Furthermore, very different conclusions about the effectiveness of a particular strain of Rhizobium will be reached if assessment is based only on nodule number and appearance at different nitrate levels. For example, the number of nodules formed on M. rotata by ICARDA M201 in the presence of nitrate was almost twice that formed by the plant in the absence of nitrate; thus, it would be possible to reach very different conclusions about their nitrogen fixing properties. Nodulation in M. rotata was ineffective, with abundant parasitic nodules in the root. For this reason, assessment on nodules is not accurate. Shoot dry weight gives a better indication of plant response, when compared with appropriate uninoculated controls, with and without mineral nitrogen. Although some valid inferences can be made from the results of this experiment, caution must nevertheless be exercised in interpreting the data.

Some technical problems were detected in this experiment: 1) the low number of replications, due to the three harvests throughout the growing season, 2) the presence of cross contaminants in some treatments, 3) the rooting solution seemed not to favor the growth of the plants, as shown by the reduced vigor of the nodulated plants, 4) nitrogen analysis on the shoot tissue was not done, because of the small size of the dry samples, and 5) a plant growth curve for nitrogen concentration in the solution, based on shoot dry weight, was not possible, using the range of nitrate concentrations. The experiment will be repeated under more nutritionally and microbiologically controlled conditions. - L. Materon and M. Zaklouta

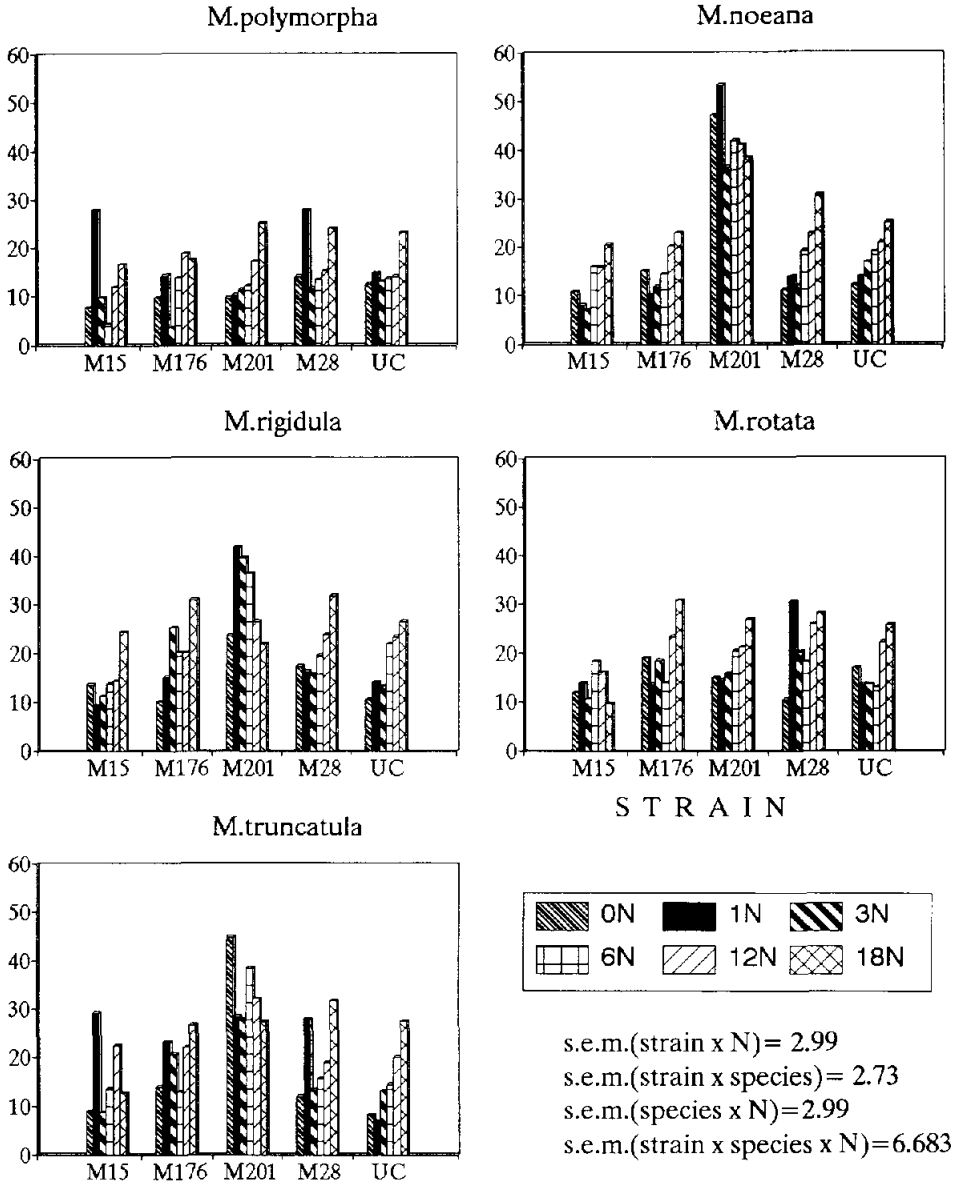


Figure 2.6. The effect of nitrate application on the dry weight of shoots of four species of annual Medicago inoculated with four strains of Rhizobium meliloti.

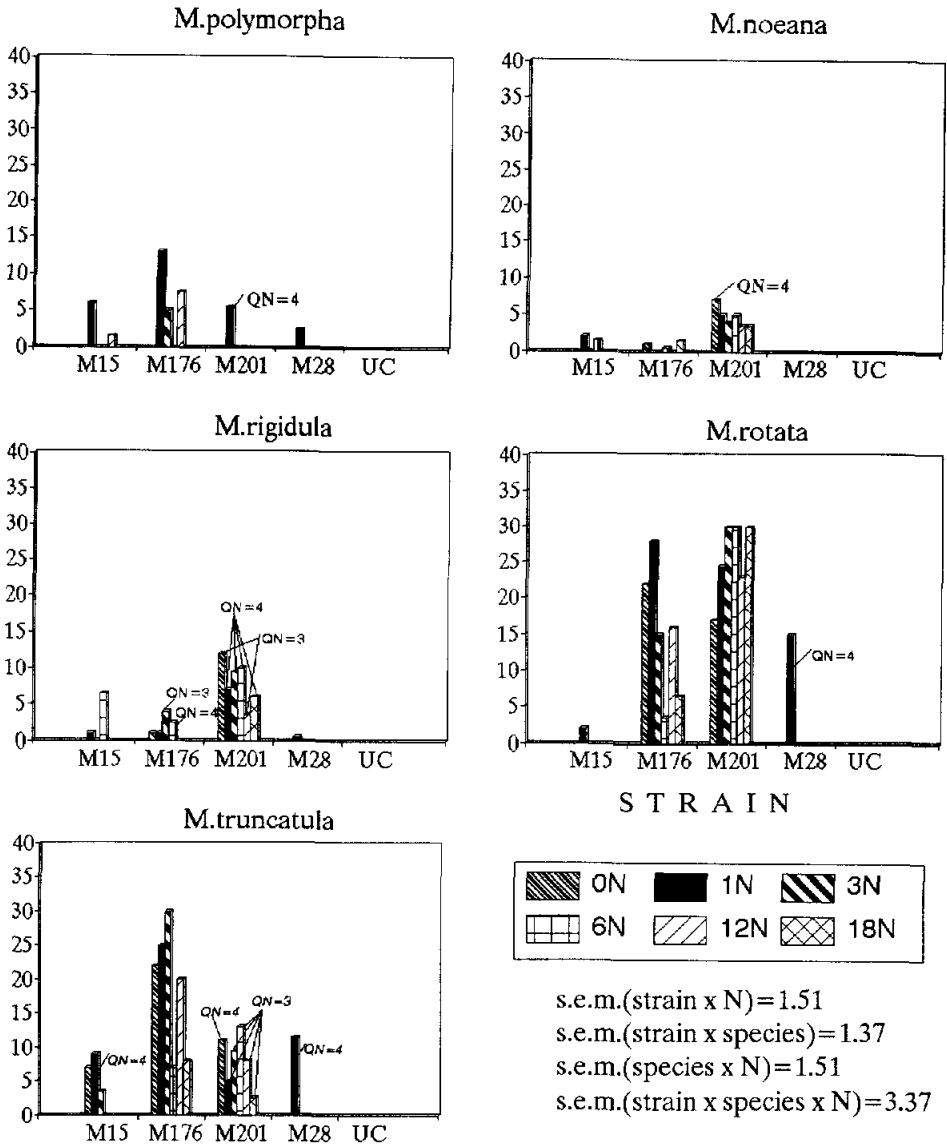


Figure 2.7. The effect of nitrate application on the number of nodules of four species of annual *Medicago* inoculated with four strains of *Rhizobium meliloti*.

2.5 Effect of phosphorus on growth and nodulation of medics

Establishing self-regenerating cereal-fallow rotations has been one important way of increasing the feed available to animals in the region. Introduction of the technology, however, has required extensive selection of both medic species and Rhizobium strains adapted to the various environments. Much of the selection has been conducted at relatively high P levels, although most of the soils of the region are deficient in P and, in the main livestock zones, little P is applied to the soil.

Phosphorus is an important factor in the soil environment, which will affect the development of the N₂-fixing symbiosis. Phosphorus is specifically involved in nodule initiation, growth and other plant metabolic functions, so that the efficiency with which medics take up phosphate may influence the effectiveness of the symbiosis.

It is well known that legumes differ markedly in their ability to take up and utilize P. The medics selected from west Asia and north Africa also appear to differ in their response to P. Furthermore, it has been shown that strains of Rhizobium vary in their tolerance to low P levels. It is to be expected that different Medicago-rhizobium combinations may vary in their ability to nodulate and fix nitrogen in soils low in P levels.

Plastic-house and field experiments were designed to determine which of the medic species regarded as potentially suitable for pastures in west Asian and north African regions are sensitive to levels of soil phosphorus, in terms of nodulation and nitrogen fixation. The experiments are described as follows:

Plastic-house experiment. A pot experiment was conducted at Tel Hadya to determine the influence of P on medics grown under controlled conditions, using the same soil as the corresponding

field trial at Tel Hadya. The effect of five rates of phosphorus (0, 12, 24, 36 and 48 kg P/ha, applied as KH_2PO_4) on the growth and nodulation of four species of medics (Medicago rigidula sel. 716, M. rotata sel. 2123, M. truncatula cv Jemalong and M. polymorpha sel Tah), inoculated with two strains of Rhizobium meliloti (strains ICARDA M3 and ICARDA M53), was determined. Strains of rhizobia were isolated in northern Syria and were first tested for symbiotic expression. The above amounts of P, expressed as mg P per pot, corresponded to 0, 6.15, 12.3, 18.45 and 24.6 respectively.

The experiment had a split-split plot arrangement layout, in which strains were the main plots, species the subplots and P levels the sub-sub plots. There were three replicates for each treatment. Plastic pots were filled with 2.4 kg of soil (pH = 8.36; P-Olsen = 11.5 ppm; NH_4 = 1.56 ppm; NO_3 = 7.84 ppm; mineral N = 9.4 ppm). Phosphorus was applied in solution to the surface of the soil in the appropriate pot and allowed to dry. Pots were then watered to 90% of field capacity and left to equilibrate for one week. Pots were maintained near 90% of field capacity for the duration of the experiment. Uninoculated controls, with and without mineral nitrogen, were included. Nitrogen controls were treated with 15.38 and 46.14 mg N/pot (applied as KNO_3), corresponding to the levels of 30 and 90 kg N/ha.

Seeds were scarified and germinated before sowing by placing them in aerated deionized water. Six seeds per pot were sown, approximately 1 cm deep, and inoculated with the corresponding strain of Rhizobium by applying 5 ml of the inoculum (approximately 10^7 cells per ml) to the root crown of 7-day old seedlings. After two weeks of planting, seedlings were thinned out to three per pot.

Measurement of plant vigor was made throughout the period of the experiment. Plants were harvested eight weeks after sowing. Soil was washed from the roots and nodulation was assessed, using the

following rating scale: 1 = no nodules, 2 = small white nodules, 3 = small pink, 4 = large pink nodules. Nodules were then separated from the roots, counted and stored in vials containing a desiccant for subsequent identification of the rhizobial strain occupying the nodule and determination of the dry weights. The procedure of Materon and Danso (1990) was used to identify the strains, using yeast mannitol agar plates supplemented with 100 μ l of the antibiotic streptomycin per ml of agar medium. The dry weight of shoots and roots was recorded, after drying in a forced draught oven for 48 hours at 72°C.

M. polymorpha and M. truncatula were responsive to inoculation with the two strains of Rhizobium. Both species produced shoots ranging between 220 and 350 mg of dry weight. In contrast, plants of M. rigidula and M. rotata were statistically superior ($P < 0.05$) and produced shoots ranging between 450 and 600 mg of dry weight (Figure 2.8). The levels of P did not affect the growth of the plants at a significant level of 5%. It was found, however, that the concentration of P in the tissues of the shoots of M. polymorpha increased from 0.25% to levels higher than 0.38% (Figure 2.9) and, at the higher P levels, mineral nitrogen in the uninoculated controls correlated with higher P contents in the shoot tissues, indicating a positive effect of nitrogen on the plant metabolism of P. The same trend was observed in the other three species of medics. The nitrogen content in the shoots of all medics at all levels of P ranged between 2% and 3% and was not affected by P or either mineral or symbiotic nitrogen. Similarly, root nitrogen contents varied between 1.5% and 2.1%, but not significantly.

Field experiments. I. Tel Hadya. The experiment was planted on 27/11/91, on a field having the following characteristics: pH = 8.36, P (Olsen) = 11.5 ppm, NH_4 = 1.56 ppm, NO_3 = 7.84 ppm, mineral

N = 9.4 ppm and a moisture value of 11.7%. Four species of medics (M. rigidula sel. 716, M. rotata sel. 2123, M. polymorpha ecotype Tah and M. truncatula cv Jemalong) were inoculated with strains of Rhizobium meliloti ICARDA M3 and M53. Uninoculated controls were included, with and without nitrogen. The mineral nitrogen dose was 90 kg N/ha, applied in the form of urea and split into three applications. The design of the experiment was a split-split-split plot, having the four inoculated treatments as main plots, the four species as subplots and the five P-levels as sub-sub plots with three replications. The experiment was also replicated, using a pot experiment in the plastic-house (see above). The area of the plots was 4 m². Plants were observed for herbage and nodulation responses and harvested on 11/5/92.

Because of unusual temperatures and weather conditions throughout the growing season (e.g. snow and freezing temperatures), all species of medics grew under stress. M. polymorpha and M. truncatula were affected by the frost, producing yields lower than 2 tons/ha, whereas M. rigidula and M. rotata were able to produce herbage yields ranging between 4 and 5 tons/ha. There was no marked effect due to inoculation and P-levels, or any significant interaction detected in these combinations. A reason may be that, although the soil was low in P (8.36 ppm), the soil matrix was saturated to such an extent that the plants were not able to benefit metabolically from the P content in the soil. Concentrations of N and P in the tissues of the shoots were no different from those detected in the plastic-house pot experiment, using the same soil.

Field experiments. II Ramtha Experimental Station (Jordan).

The soil here had the following characteristics at planting: pH = 8.4, P (Olsen) = 7.45 ppm, NH₄ = 5.74 ppm, NH₃ = 1.69 ppm, mineral N = 7.43, total N = 8.16% and moisture = 11.7%. Four species of

medics (*M. rigidula* sel. 716, *M. rotata* sel 2123, *M. polymorpha* ecotype Tah and *M. truncatula* cv Jemalong) and *R. meliloti* strains M3 and M53 were tested for symbiotic response. Uninoculated controls included mineral nitrogen as 90 kg/ha in the form of urea. The urea was split into three applications during the growing season. Methodology for P-levels and plot design was the same as for the experiment in Tel Hadya (see above section).

Because of unseasonal weather, including freezing temperatures and snow, *M. truncatula* and *M. polymorpha* suffered severe damage and their data, therefore, were not included in the analysis. Herbage dry matter yields produced by these species were approximately 1 to 1.3 tons/ha. Results for the remaining species of medics indicated marked responses to rhizobial inoculation and mineral nitrogen application (Figures 2.10, 2.11). *M. rotata* responded to inoculation with strain ICARDA M53: inoculated plots produced 2.48 times more herbage yield (2513 vs 1013 tons/ha) compared with uninoculated plots. Mineral nitrogen application to the uninoculated plots of *M. rigidula* combined with phosphorus produced higher herbage yields at P levels higher than 10 kg P/ha (Table 2.12).

Concentration of P in the shoots in all medic species tended to be constant. The percentage of P ranged between 0.4 and 0.5. In contrast, N concentration in shoots of *M. rotata* nodulated by strain ICARDA M53 was significantly superior to all other means from all treatments and ranged from 2.98 to 3.31%. Uninoculated plants had N percentage values ranging from 1.54 to 2.08. We conclude that, despite the general trend of negative response of most of the treatments within each species for P levels, more experimentation is needed on this important topic. We surmise that the lack of response was due to the relatively high concentration of phosphorus in the soils at both field trials. Variation may occur in laboratory analysis in determining the amount of phosphorus in the soil samples

(e.g. experimental error or inaccurate sampling techniques). It would be desirable to use soils with concentration lower than those used in these two experiments. - **L. Materon and M. Zaklouta**

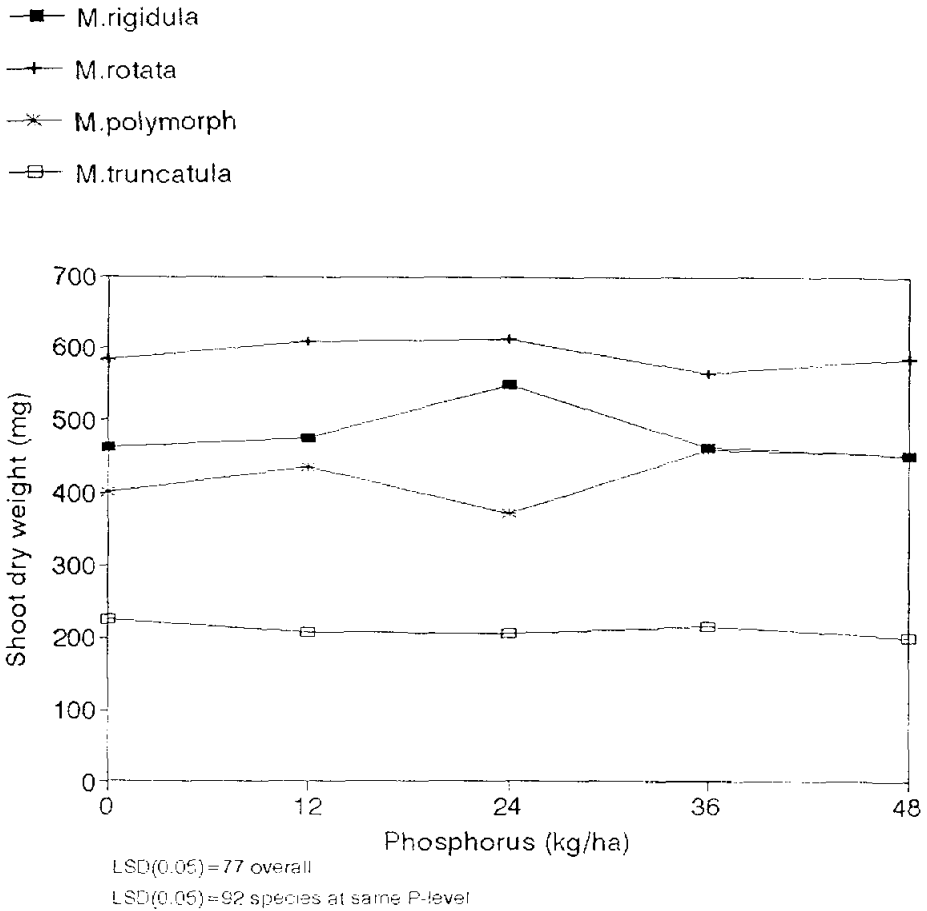


Figure 2.8. Shoot dry weights of annual Medicago species as affected by phosphate application to the soil.

Table 2.12. Phosphorus levels and inoculation affecting the herbage yields of medic at Ramtha Experimental Station, Jordan, 1991-1992. Dry matter herbage yields (tons/ha)

P Level	Inoculant treatment										
	ICARDA M3			ICARDA M53			Uninoculated N ^r			Uninoculated N ^r	
	rig	rot		rig	rot		rig	rot		rig	rot
0	2127	1250		1383	2569		1921	1623		1025	798
12	1707	1101		1573	2158		2065	1501		1023	1012
24	1966	928		1702	2649		2417	1226		1472	1211
36	1937	1300		1098	2478		2551	1396		918	745
48	1581	1251		932	2714		2197	1193		1342	1298

LSD (5%) for P-level at the same level of strain or species = 3.31

rig = M. rigidula

rot = M. rotata

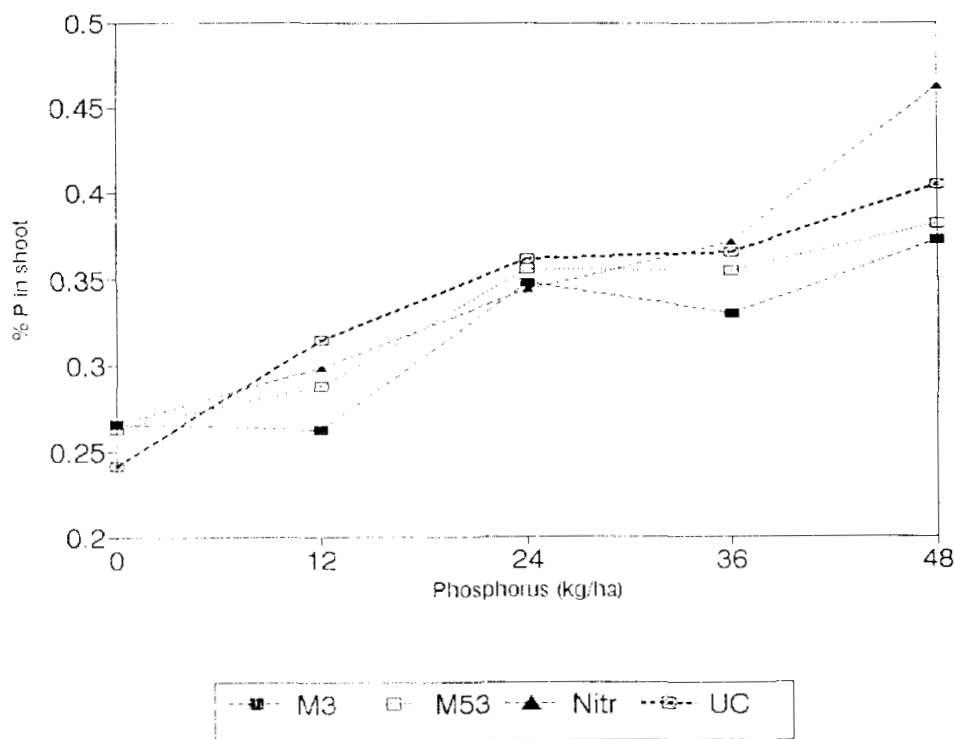


Figure 2.9. Phosphorus concentration in shoot tissues of *M. polymorpha* as affected by increasing concentrations of phosphate in the soil

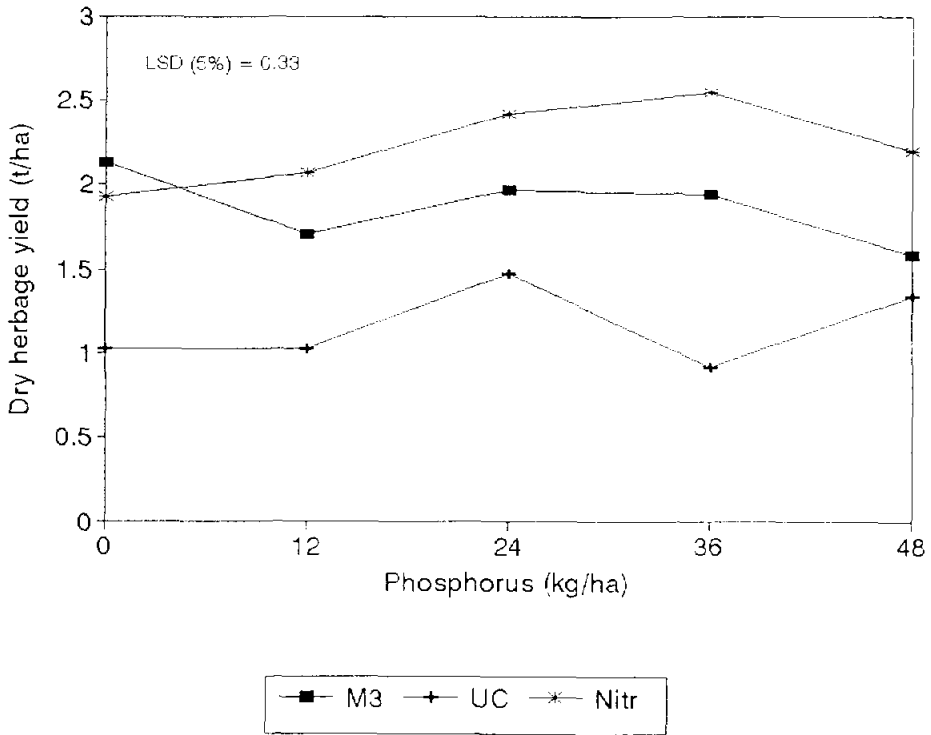


Figure 2.10. Dry matter production of *M. rigidula* and as affected by inoculation with *Rhizobium meliloti* strain ICARDA M3 and increasing concentrations of phosphate at Ramtha Experiment Station (Jordan) in 1991-1992

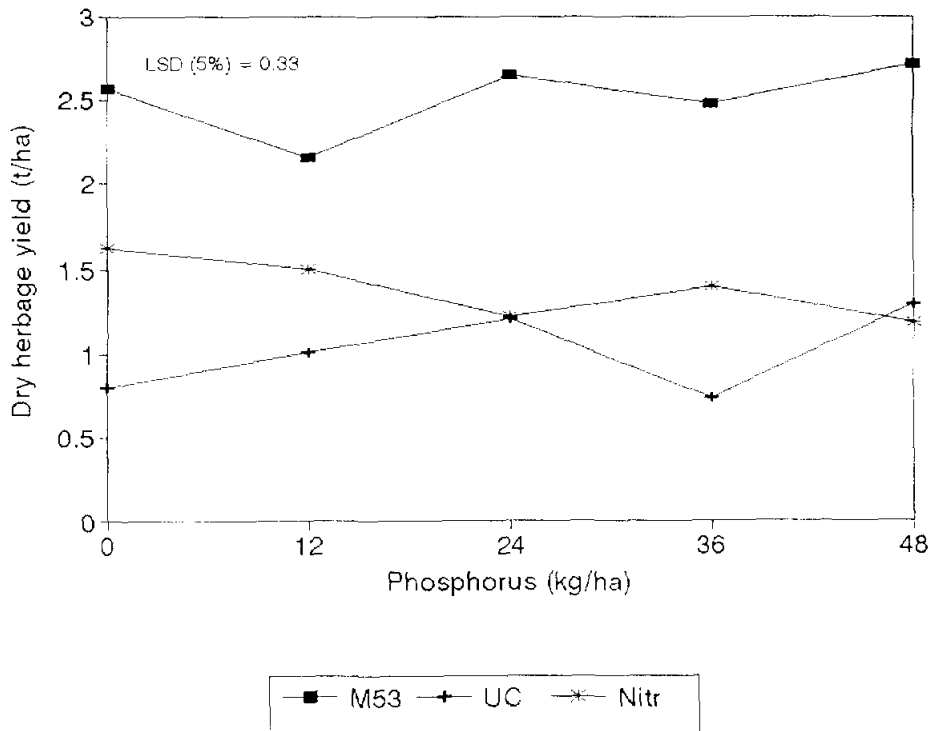


Figure 2.11. Dry matter production of *M. rotata* and as affected by inoculation with *Rhizobium meliloti* strain ICARDA M53 and increasing concentrations of phosphate at Ramtha Experiment Station (Jordan) in 1991-1992

2.6 Survey of crop/livestock systems in Zones 1-3, Hassakeh Province in northeast Syria

Introduction: Hassakeh Province in NE Syria possesses many of the elements needed for successful adoption of integrated crop/livestock systems. In order to work in the 'Jezira' of Syria we needed to ask where we should work, which farmers should be involved, how representative were the households compared to the community as a whole, how they fed their animals and what constraints they faced. To obtain answers to these questions, SMAAR and ICARDA, through the Directorate of Agriculture in Hassakeh Province, interviewed 214 farmers living in Agricultural Stability Zones 1-3 (see Endnote p.170 for definitions). The survey took place in July 1992: the map (Figure 2.12) shows the areas surveyed and the general location of Hassakeh Province, Syria.

The objectives of the survey were twofold:

1. To define key economic characteristics affecting pasture, forage and livestock production systems in selected areas within agricultural stability zones 1, 2 and 3 of Hassakeh Province.
2. To fill the gaps in data on other crops, on farming constraints and prices, to allow whole-farm economic analysis of existing and new crop/livestock systems.

SMAAR staff in El Hassakeh identified 9, 27 and 13 villages from Zones 1, 2, and 3, respectively. The villages selected for interviews had livestock and were located near roads for easy access. The number of questionnaires completed per village was proportional to the size of the village and respondents were randomly selected from a list of farmers in each village. Questions were asked concerning the 1991-1992 agricultural year.

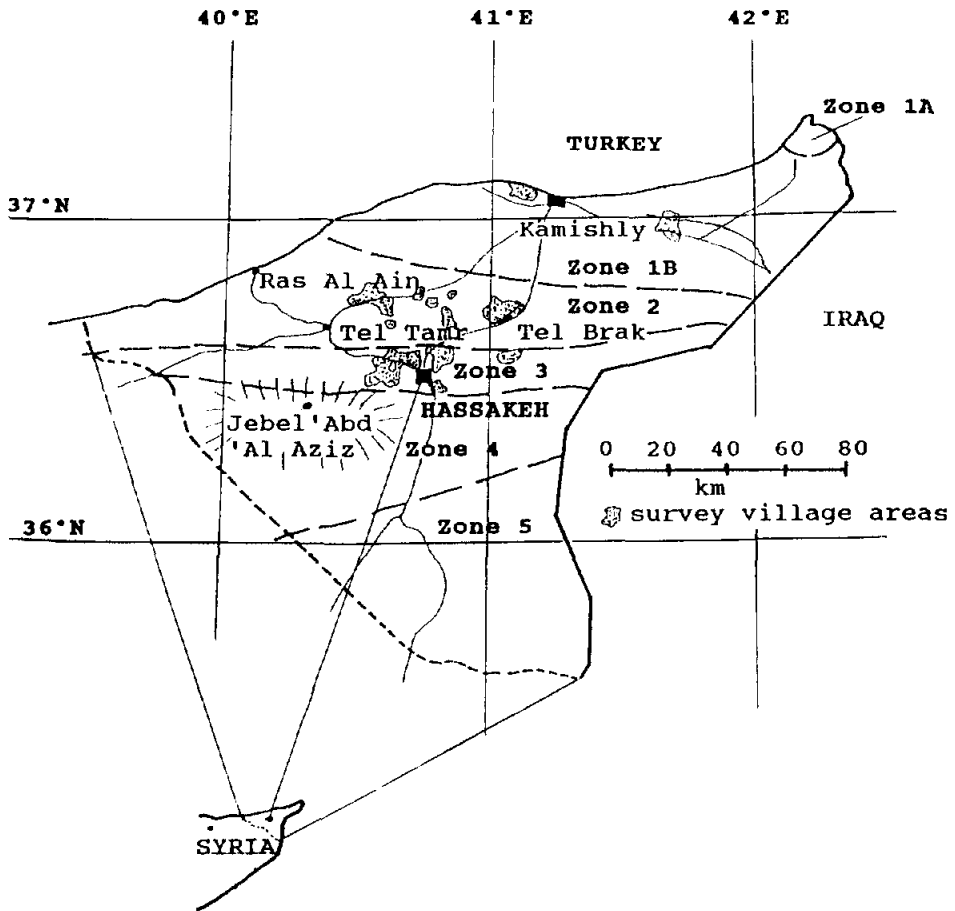


Figure 2.12. Map of the project area showing the villages in Agricultural Stability Zones 1-3 where the survey took place in July 1992. A total of 50, 91 and 73 farmers were interviewed in Zones 1, 2 and 3, respectively. The map is an incomplete sketch and is no authority on international boundaries.

EL HASSAKEH SURVEY SUMMARY

Table 2.13. Crop areas

Crop	Zone 1		Zone 2		Zone 3		Study Area	
	ha	%	ha	%	ha	%	ha	%
Wheat	684	61	869	50	101	8	1654	40.0
Barley	285	25	788	46	1147	92	2220	54.2
Lentil	85	8	5	0.3	0	0	90	2.2
Chickpea	8	1	0	0	0	0	8	0.2
Vetch	18	2	0	0	0	0	18	0.4
Fallow	0	0	65	3.7	0	0	65	2.0
Other	46	4	0	0	0	0	46	1.0
TOTAL AREA	1126	100	1727	100	1248	100	4101	100
TOTAL FARMS	50		91		73		214	
AVG FARM SIZE	18(ha)		19(ha)		17(ha)		19(ha)	
AVG PARCEL NO	2.28		2.30		2.40		2.33	

Table 2.14. Crop average harvest yields - tons/ha

Crop	Zone 1	Zone 2	Zone 3
Wheat grain	1.72	1.01	0.56
Wheat straw	0.37	0.20	0.25
Barley grain	1.40	1.05	0.65
Barley straw	0.20	0.27	0.19
Lentil grain	1.22	0.30	0.00
Lentil straw	0.97	0.20	0.00

Table 2.15. Individual rotations - Number (N) of fields.

Rotation	Zone 1		Zone 2		Zone 3		Study Area	
	(N)	(%)	(N)	(%)	(N)	(%)	(N)	(%)
Barley-Barley	10	19	38	31	51	66	99	39
Wheat-Wheat	7	13	28	23	6	8	41	16
Wheat-Barley	17	32	49	39	12	16	78	31
Lentil-Wheat	12	23	0	0	0	0	12	5
Others	7	13	9	7	8	10	24	9
TOTAL FARMS	53	100%	124	100%	77	100%	254	100%

Table 2.16. Ewe inventory - Number (N) of farms in each class

Ewe Number	Zone 1		Zone 2		Zone 3		Study Area	
	(N)	(%)	(N)	(%)	(N)	(%)	(N)	(%)
1 - 10	10	29	21	30	10	46	41	33
11- 20	14	41	15	22	2	9	31	25
21- 50	7	21	21	30	3	14	31	25
51-100	3	9	6	9	3	14	12	9
> 100	0	0	6	9	4	18	10	8
Total farms	34	100%	69	100%	22	100%	125	100%

Results and Discussion

A total of 214 farmers were surveyed, with 50, 91 and 73 respondents from Zones 1, 2 and 3, respectively. The total area of land used by these farmers was 4101 ha; mean farm size was 19 ha and the average number of parcels per farm was 2.33. Ninety three percent of the land was sown to cereals. Lentil represented 8% and vetch 2% of the land planted in Zone 1 and only 5 ha of legumes were found among the 164 farms surveyed in Zones 2 or 3 (Table 2.13).

Grain and straw yields were low and could improved with better management. Considerable amounts of stubble remain in the field for summer grazing, straw yields therefore, reflect only amounts of collected straw (Table 2.14).

Few farmers practised a legume-cereal rotation; a third of all farmers, however, practised a wheat-barley rotation, because this permits some protection against a total crop failure when years are too dry for wheat. In Zone 1, lentil-wheat represented 23% of rotations, but lentil was sown on only 8% of the cultivated area: lentil fields are small and limited by the labor available to harvest by hand. Fallow is still used on about 10% of the land in Zone 3 (Table 2.15).

The average size of ewe flocks in Zones 1-3 was 20, 39 and 58 ewes,

respectively. In Zone 1, 34 of 50 farmers kept ewes and 77% of the flocks were comprised of fewer than 20 head. More than half of the flocks were smaller than 20 head in Zone 3. Overall, only 10 of 125 livestock owners with ewes had flocks bigger than 125 head (Table 2.16).

Of 48 farmers who had cows, sheep or goats in Zone 1, only two of the farmers took their animals off the farm to find grazing. More than half of these livestock owners devoted a small portion of their land to green grazing of cereal crops, indicating a need for forage or grazing resources. More farmers who live in Zones 2 and 3 move their flocks to the mountains or steppe in the spring, because there are government regulations requiring departure of flocks larger than 50 head from the cropping zones.

Feeding and grazing data were collected in 180 interviews where farmers owned sheep. Interview and data summary methods for the analysis of feeding calendars are described by Nordblom et al. (1993).

The most important hand-fed feeds were barley grain, barley straw, wheat straw, wheat bran, lentil straw, cottonseed cake, dairy concentrates and weeds pulled from wheat and cotton fields. The most important grazed feeds included green cereal crops, unharvested barley crops, green legume crops, legume stubble, cereal stubble, weedy fallow, native pastures (common grazing and steppe grazing), cotton residues and sorghum residues. Vetch grain, cottonseed hulls, maize residues, bread and alfalfa (fasa) are omitted from the summary tables as their use is insignificant.

The flock diets are dominated by hand fed wheat and barley straws (see Figure 2.13). Nonetheless, seasonal shifts in diet are apparent in each zone. The grazing of sown crops contributes a small but high-quality fraction of diets in winter and has an increased role in spring. In the same period, there is grazing of common

pastures on roadsides and non-arable or vacant areas near the villages. Some grazing of weedy fallow land is also reported at this time. Use of open steppe grazing is limited to the spring season and mainly to the larger flocks in Zone 2.

Lambing is in late winter and sheep are milked through the spring in March, April and May. It is for this period that research is needed on sown pastures, which provide forage or grazing as lower cost substitutes for hand-fed concentrates.

By June, milking has largely ceased and the harvest of cereal crops has begun, opening up stubble fields for low-cost grazing. Hand feeding and other sources of grazing drop to low levels or stop through July, August and September. Zone 3 is an exception, in that some hand feeding occurs in summer and continues into September (Figure 2.13).

Low levels of cottonseed cake and cotton seed, a protein supplement, are fed in summer in all three zones. Trials at ICARDA have confirmed the benefits to cereal stubble/straw digestibility that can be gained by modest dietary supplementation with cottonseed cake, and related work has shown a positive response in ewe fertility, with rising body condition at mating in mid-summer (F. Bahhady, personal communication). If the quality of mid-summer diet is as poor as suggested in our survey (Figure 2.13), there may be opportunities for economically beneficial increases in protein supplementation which would be reflected in improved ewe fertility.

Irrigated cotton fields are grazed after harvest in October and November. There is no chemical defoliation prior to hand harvest, so cotton leaves and weeds can be grazed. Grazing cotton fields after harvest increases in importance from Zones 1-3 (Figure 2.13). Hand feeding in this period comprises a major part of the diet.

A shift in the diet calendar occurs in December, away from grazing to 90% hand-feeding. The December increases in concentrate

feeding coincide with the ewe production cycle as lambing draws near. Concentrate feeds, such as barley grain, wheat bran, cottonseed cake or cottonseed, supplement diets comprised largely of cereal straw. Lentil straw was fed occasionally in Zone 1 where a small area of lentil is grown. In Zones 2 and 3, the survey found little or no lentil production and no feeding of lentil straw.

Diet calendars vary from place to place and year to year, according to season and resulting costs of feed (Thomson et al. 1989). Our results show that, from 1991-92, about half the annual sheep diet was supplied by hand-feeding in Hassakeh Province, Zones 1-3, compared to about a third hand-feeding in marginal dry farming and steppe areas of Aleppo and Hama Provinces (Wachholtz et al. 1993). Typical diets will vary among agro-ecological zones according to the natural resources available, including the season's rainfall, and the way these resources are managed.

Research plans

With such high proportions of the diet supplied by hand-fed materials and little access to grazing, there may be cases of mineral and micro-nutrient deficiency which can be satisfied with low-cost supplements. Economic benefits may be found through increased lamb health and survival.

Forage crops, such as vetch or lathyrus, grown and harvested cheaply, could have an economic role in substituting for purchased concentrate feeds in the winter and spring months, by providing higher-protein supplements in mid-summer, and by improving cereal yields in legume-cereal rotations as compared to continuous cereal cropping.

The diet calendars found for Hassakeh Province indicate a wide variety of seasonally available feeds. Research hypotheses on winter nutrient deficiencies, mid-summer protein supplementation, and the

introduction of sown forage crops and pastures will require hard data and economic analysis. The next step will be to plan on-farm trials that build upon information collected in the present survey.

- T.L. Nordblom, K. Dendal, H. Sawmy Edo, S. Nasser, F. Shomo, F. Bahhady and S. Christiansen

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TABLE Detailed sheep diet calendars for Zones 1, 2 and 3 in Hassakeh Province, NE Syria: 1992 survey results

SYMBOL	FEEDS	1991 AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	1992 JULY
Zone 1													
Hand fed													
B	Barley grain	1	5	14	16	21	22	21	18	9	7	+	+
-	Barley straw	.	1	3	2	4	5	5	4	1	1	.	.
-	Wheat straw	3	17	48	52	56	60	58	54	27	22	2	2
W	Wheat bran	.	1	2	2	3	3	3	3	1	1	.	.
L	Lentil straw	.	+	7	5	8	7	7	5	3	1	.	.
N	Cotton s.cake	.	+	2	1	2	2	2	2	1	1	.	.
N	Dairy concn.	1	1	+	1	1	1	2	3	14	15	.	.
d	Weeds of c,w	.	.	.	.	.	.	.	.	.	.	.	.
Grazed													
U	Green cereal	.	.	.	.	.	.	1	5	13	11	.	.
U	Un har. barley	.	.	.	.	.	.	.	2	3	2	.	.
U	Green legume	.	.	.	.	.	.	.	.	2	2	.	.
I	Legume stubb.	.	.	.	.	.	.	.	.	.	2	1	+
I	Cereal stubb.	95	75	20	1	.	.	.	.	.	9	97	98
Y	Weedy fallow	.	.	.	.	.	.	1	9	8	.	.	.
C	Common graz.	.	.	.	.	.	1	3	15	16	.	.	.
S	Steppe graz.	.	.	.	.	.	.	.	2	2	.	.	.
R	Cotton resid.	.	.	4	20	5	.	.	.	.	.	.	.
R	Sorghum resid.	.	.	.	.	.	.	.	.	.	.	.	.
TOTAL (%)		100	100	100	100	100	100	100	100	100	100	100	100
Zone 2													
FEEDS													
Hand fed													
B	Barley grain	1	2	13	16	18	18	18	18	13	8	1	1
-	Barley straw	+	+	18	23	27	27	27	26	21	16	.	.
-	Wheat straw	+	5	26	31	37	37	36	30	24	16	+	+
W	Wheat bran	.	+	2	2	4	4	4	3	2	1	.	.
L	Lentil straw	.	.	.	.	.	.	.	.	.	.	.	.
N	Cotton s.cake	+	+	2	2	3	3	4	3	1	1	.	.
N	Dairy concn.	1	1	1	1	1	1	1	1	1	1	1	1
d	Weeds of c,w	.	.	1	+	+	+	+	+	1	1	.	.
Grazed													
U	Green cereal	.	.	2	2	7	9	10	11	13	10	.	.
U	Un har. barley	.	.	.	.	.	.	.	.	.	.	.	.
U	Green legume	.	.	.	.	.	.	.	.	.	.	.	.
I	Legume stubb.	.	.	.	.	.	.	.	.	.	.	.	.
I	Cereal stubb.	98	91	3	+	.	.	.	.	.	6	98	98
Y	Weedy fallow	.	.	1	+	+	+	.	1	3	15	.	.
C	Common graz.	.	1	+	.	.	.	+	2	5	10	.	.
S	Steppe graz.	.	.	.	.	.	.	.	7	17	15	.	.
R	Cotton resid.	.	.	31	23	2	1	.	.	.	.	.	.
R	Sorghum resid.	.	.	.	.	.	.	.	.	.	.	.	.
TOTAL (%)		100	100	100	100	100	100	100	100	100	100	100	100
Zone 3													
FEEDS													
Hand fed													
B	Barley grain	2	3	4	5	6	6	6	5	5	4	2	1
-	Barley straw	.	2	3	3	4	4	4	4	3	3	.	.
-	Wheat straw	17	41	43	39	60	60	60	55	50	47	17	15
W	Wheat bran	4	9	8	8	12	13	13	12	11	9	4	3
L	Lentil straw	.	.	.	.	.	.	.	.	.	.	.	.
N	Cotton s.cake	2	6	6	6	9	9	9	8	8	6	2	2
N	Dairy concn.	2	3	2	3	4	4	4	4	4	3	2	2
d	Weeds of c,w	3	2	+	+	.	.	+	1	2	2	2	3
Grazed													
U	Green cereal	+	3	2	2	3	3	3	5	5	6	+	+
U	Un har. barley	.	.	.	.	.	.	.	.	+	4	.	.
U	Green legume	1	+	+	.	.	.	.	.	.	.	1	1
I	Legume stubb.	1	.	.	.	.	.	.	.	.	.	1	1
I	Cereal stubb.	65	22	.	.	.	.	.	.	.	2	66	67
Y	Weedy fallow	3	5	2	+	+	+	+	1	3	4	3	4
C	Common graz.	+	1	1	1	1	1	1	5	7	8	+	+
S	Steppe graz.	.	.	.	.	.	.	.	.	2	2	.	.
R	Cotton resid.	.	1	28	33	1	.	.	.	.	.	.	.
R	Sorghum resid.	+	2	1	.	.	.	.	.	.	.	.	1
TOTAL (%)		100	100	100	100	100	100	100	100	100	100	100	100

NOTE: Percentages greater than or equal to 0.5 were rounded up to the nearest whole number; those less than 0.5 are shown as traces (+); cases where no one reported use of a feed are shown as a point (.). Symbols for some feeds are shared in diet calendar graphs.

Figure 2.13. Sheep diet calendars for zones 1, 2 and 3 in Hassakeh Province, NE Syria: 1992 survey results

Endnote Definitions for agro-ecological zones by the Syrian Ministry of Agriculture and Agrarian Reform are based on precipitation only; five Agricultural Stability Zones are identified, the first of which is divided into two sub-zones (Watson, 1979). SAR (1990) refers to these as Agricultural Settlement Zones:

Zone 1a

Average precipitation over 600 mm. A wide range of crops may be grown here. Fallowing is not necessary.

Zone 1b

Average precipitation between 350 and 600 mm and not less than 300 mm in two thirds of the years surveyed. The main crops are wheat, pulses and summer crops.

Zone 2

Average precipitation between 250 and 350 mm and not less than 250 mm in two thirds of the years surveyed. Two crops are normally planted every three years. Barley, wheat, pulses and summer crops are grown.

Zone 3

Average precipitation over 250 mm and not less than this in half the years surveyed. One or two crops will yield in every three years. Barley is the principal crop but some pulses can be grown.

Zone 4

Average precipitation between 200 and 250 mm and not less than 200 mm in half of the years surveyed. Barley is grown. The area is also used as grazing land.

Zone 5

Covers the rest of the country. This desert and steppe land is not suitable for unirrigated agriculture, but parts of it offer winter pasturage.

Section III Native Pastures and Rangelands

3.1 Effects of residual phosphate on marginal lands

An experiment was started in 1984/85 to test the hypothesis that the application of superphosphate to non arable lands, (also called marginal lands, because grazing is the only possible use), which contain annual legumes, stimulates the legumes, eliminates the nitrogen deficiency, and so leads to increased herbage production. Phosphate fertilizer was applied in small quantities (11 and 26 kg/ha P) every year for seven years. The treatment has resulted in improved pasture productivity (Osman et al. 1990; Osman et al. 1991; Osman and Cocks 1993), and in improved productivity of sheep grazing the pasture (Bahhady, Osman and Russi 1988). Results also indicated that annual applications of 11 and 26 kg/ha of P raised Olsen-P values in the soil from approximately 7 mg/kg to about 20 to 40 mg/kg, respectively, at the end of the seventh season (July 1991). No more fertilizer was applied and the experimental plots were used to study the effects of the residual phosphate on pasture and grazing animals. Since residual phosphate may contribute significantly to pasture and animal production in the following years, such a contribution must be included in the final economic analysis of the study. Significant effects of residual P have been reported on succeeding crops in many countries of the Mediterranean basin (Kacar 1972; Orphanos 1988; Abdel Monem et al. 1990). The present report summarizes the results in 1992.

The experiment was conducted at Tel Hadya on undisturbed native grassland whose predominantly annual vegetation included a few low shrubs, perennial grasses, and herbs. The soils are calcareous, pH ranges between 7.8 and 8.4. and soil organic matter and available phosphorus averaged 3.5% and 5.8 mg/kg, respectively. The slope is moderate (3.7° to 7.2°), 30-40% of the ground is covered with stones and the soil depth varies from 1 to 50 cm. Three rates of triple

superphosphate, supplying 0 (referred to as P_0), 11 (P_{11}) and 26 (P_{26}) kg/ha of P annually in September, and two stocking rates, low (0.8 sheep/ha per year) and high (1.7 sheep/ha per year), were tested. The experimental design was a randomized complete block with three replications, and the total area of the experiment was 85.5 ha.

Animals were introduced at the beginning of the second season (1985/86), following completion of fencing. Initially, 90 Awassi ewes were allocated to groups, with five ewes aged two to six years old. Each group was permanently assigned to plots of 6.5 ha or 3.0 ha, representing the low and high stocking rates respectively, in each of the fertilizer treatments. At the beginning of the fifth season (1989/90), two more ewes were added to each flock, 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. Sheep were fed a supplement of barley grain during pregnancy and early lactation, and in July and August each year, in preparation for mating. Barley and hay were also provided whenever the liveweight of individual ewes fell below 43 kg. Each year, the oldest ewe was replaced with a two year old ewe, and sick and barren ewes were also replaced. The lambs were weaned when eight weeks old. No fertilizer was applied after September 1990, but all other treatments of grazing remained the same.

Table 3.1 Available phosphorus in the soil¹ (mg/kg) recorded in May in each of two seasons⁽¹⁾ at Tel Hadya in northern Syria.

Season	Phosphate rate ² (kg/ha P)			SEM
	0	11	26	
1990/91	6.5	20.8	40.1	1.56
1991/92	7.3	23.4	38.2	2.07

(1) Each value is an average of two stocking rates. There was no significant phosphate x stocking rate interaction.

(2) The last phosphate application was September 1990.

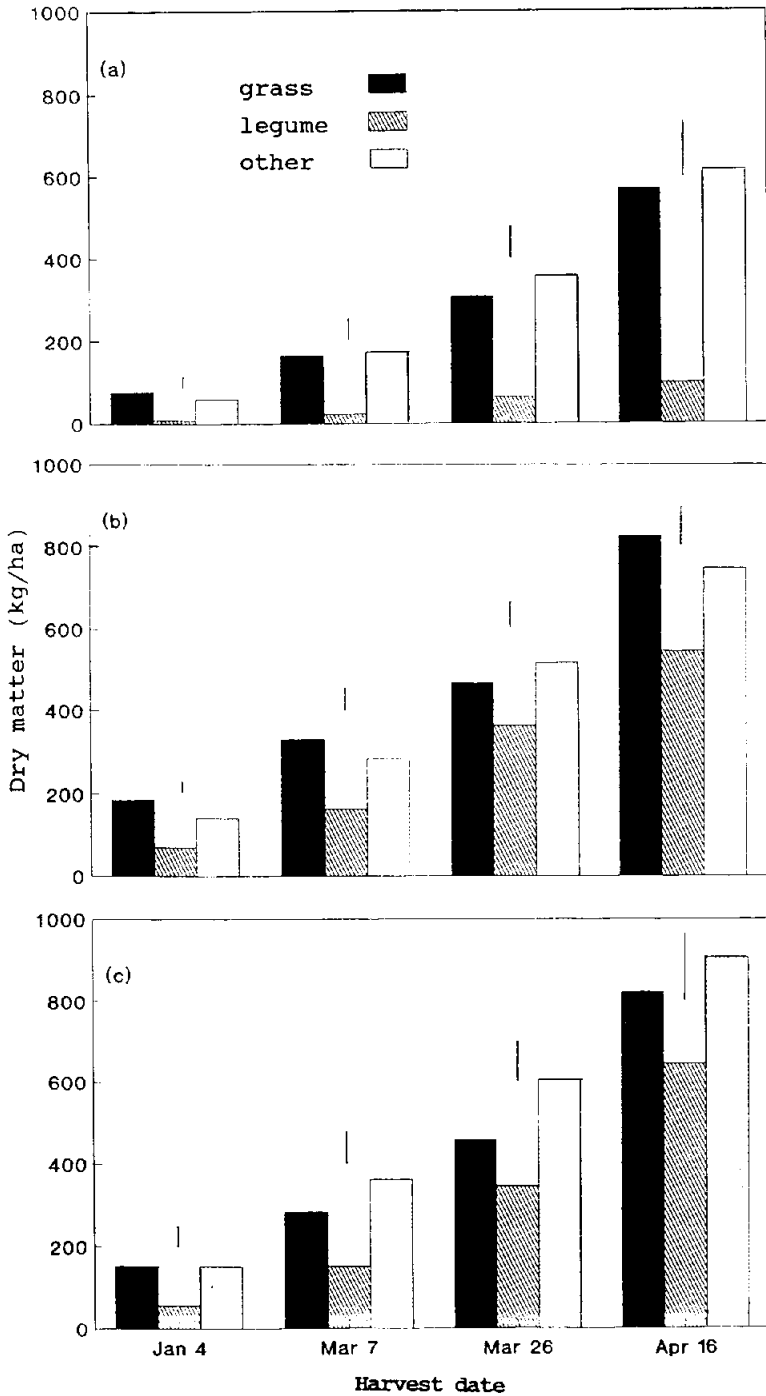


Figure 3.1. Cumulative herbage yield of grass, legume and other species at (a) 0, (b) 11 and (c) 26 kg P/ha during 1991/92 at Tel Hadya. Bars on histograms represent SEND.

Available phosphorus

There were small changes in the level of soil phosphorus in June 1992, 18 months after the last fertilizer application, compared with June 1991, 6 months after the last application. These were slightly higher for P_0 and P_{11} and slightly lower for P_{26} in 1992, compared with 1991 (Table 3.1). Plots which received phosphate fertilizer (P_{11} and P_{26}), remained significantly higher ($P < 0.01$) in available phosphorus over the control (P_0).

Botanical composition

Under P_0 treatment, legume comprised between 5% and 8% throughout the season (Figure 3.1), while it ranged between 17 and 27% under P_{11} and between 15 and 27% under P_{26} .

Herbage and seed yield

The total herbage yield of legume and all species (Figure 3.2) shows the same trend as in previous seasons: a higher accumulation of biomass at both P_{11} and P_{26} over the control, the difference being significant ($P < 0.01$) throughout the season. There were no significant differences between P_{11} and P_{26} . The number and mass of legume seeds harvested in June at P_{11} were, respectively, 8 and 9 times the amounts at P_0 . While at P_{26} , these were 8 and 8 times, respectively. In September, seed number and mass were greatly reduced in all treatments, but the phosphate treated plots were still 7 to 9 times greater in seed mass and 5 to 6 times in seed number over the control (Table 3.2). The seed mass at the low stocking rate was approximately twice the amount of the high stocking rate in June and 3 times in September, while the seed number was 1.2 times higher than in June and 2.3 times higher than in September.

Table 3.2. Mass of legume seeds in the top 1 cm of soil (g/m^2 and number of seeds/ m^2) as the result of residual phosphate from previous phosphate application, at three rates of phosphate¹ and two stocking rates in June and September 1992 at Tel Hadya.

Phosphate rate (kg/ha P)	June		September	
	mass	number	mass	number
0	0.82	1060	0.51	882
11	8.04	8657	3.58	4506
26	6.74	8553	4.85	5673
SEM	1.08	1178	0.77	921
Stocking rate (Sheep/ha per year)				
Low: 1.1	6.93	6703	4.57	5084
High: 2.3	3.47	5477	1.39	2250
SEM	0.88	962	0.63	752

1. Last phosphate application was in September 1990.

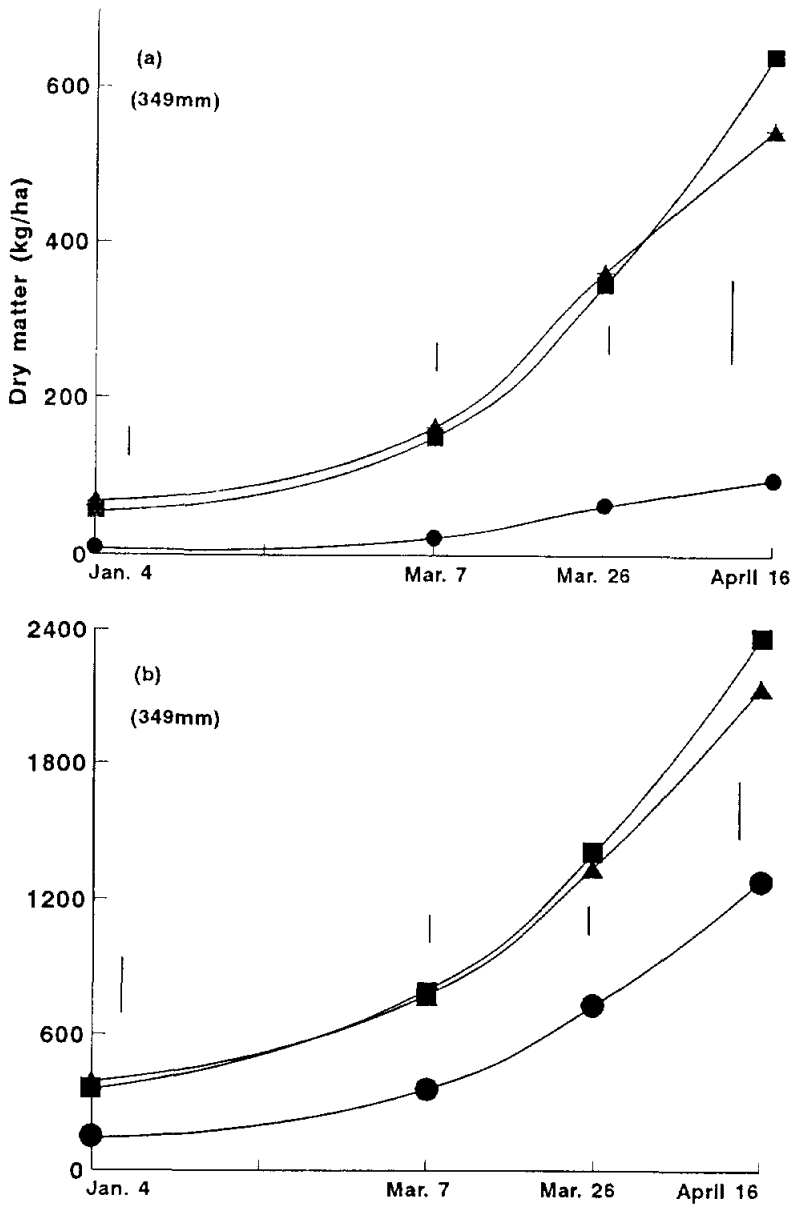


Figure 3.2. Total herbage yield of (a) legume and (b) all species during 1992 on grassland at Tel Hadya, for 0, 11 and 26 kg P/ha. Bars represent LSD at 1% level. Total rainfall in parenthesis.

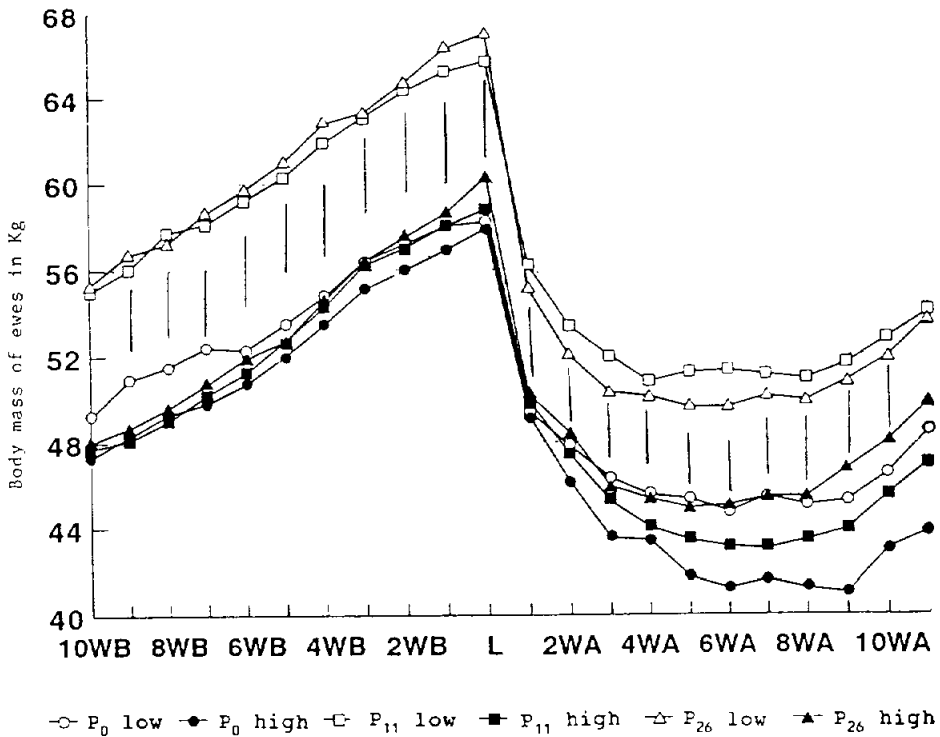


Figure 3.3. Body mass of sheep grazing on grassland under different levels of phosphate and stocking rate treatment combinations at Tel Hadya, ten weeks before (WB) and eleven weeks after (WA) lambing (L) during 1991/92 season. Bars are LSD at 5% level.

The high stocking rate treatment showed a 60% reduction in seed mass and a 59% reduction in number in September, compared with values for June. Respective values for low stocking rate were only 34% and 24%. Such a reduction can be attributed to grazing by animals as well as to collection by ants. A survey in November 1992 indicated an average of 40 colonies of ants/ha (the range was 28-48 colonies/ha) on the experimental plots. The impact of these ants on the seed bank needs further study.

Effects on livestock

(a) Body mass of ewes

Figure 3.3 summarizes ewe body mass 10 weeks before lambing and 11 weeks after lambing. For the weeks before lambing as well as the first four weeks after lambing, the six treatment combination (fertilizer x stocking rate) can be arranged into two groups: (a) consisting of P_{11} low, and P_{26} low, treatments and (b) of P_0 low, P_0 high, P_{11} high, P_{26} high. Treatments in (a) are significantly greater than those in (b), but the differences between treatments within each group were not statistically significant. Body mass after lambing and from the fifth week, can be divided into three groups consisting of (a) as above, (b) P_0 low, P_{11} high, and P_{26} high, treatments, and (c) P_0 high. Group (a) was the highest and group (c) was the lowest, in body mass. The differences between the three groups were significant, at 5% level.

(b) Body mass of lambs

The phosphate and stocking rate treatments acted separately (no interaction) with regard to the body mass of lambs. From week 8 through 10 after lambing, the treatment P_{26} resulted in significantly higher body mass over the control (Table 3.3). The differences between P_{26} and P_{11} and between P_{11} and P_0 were not significant. Low stocking rate, on the other hand, resulted in significantly higher ($P < 0.05$) body mass over high stocking rate, in weeks 6 through 10.

(c) Milk and wool yield

The highest commercial milk yield (i.e., excluding milk suckled by lambs), was produced under P_{26} , the difference being significant over the control only (Table 3.4). Milk yield under P_{11} was higher than the control, although the difference did not reach statistical significance. The stocking rate treatments did not result in any

significant differences in milk yield. Similarly, wool production in 1992 was not affected by either phosphate or stocking rate treatments.

Table 3.3. Body (kg) mass of lambs on marginal land under different levels of phosphate¹ recorded during the week of lambing (L) and in 9 weeks after lambing (WAL) during 1991/92 season.

Date of record	Phosphate rate (kg/ha P)			LSD at 5%	Stocking rate	
	0	11	26			
Lambing	4.9	4.8	4.7	NS	Low	4.8
					High	4.7
					LSD (5%)	NS
2WAL	5.8	5.8	5.9	NS	Low	5.8
					High	5.8
					LSD (5%)	NS
3WAL	7.7	7.7	7.8	NS	Low	7.8
					High	7.6
					LSD (5%)	NS
4WAL	9.7	9.7	10.0	NS	Low	9.9
					High	9.7
					LSD (5%)	NS
5WAL	11.8	11.7	12.3	NS	Low	12.2
					High	11.7
					LSD (5%)	NS
6WAL	13.8	13.9	14.6	NS	Low	14.5
					High	13.7
					LSD (5%)	0.61
7WAL	15.9	16.2	16.9	NS	Low	16.9
					High	15.8
					LSD (5%)	0.72
8WAL	18.2	18.5	19.4	1.02	Low	19.4
					High	17.9
					LSD (5%)	0.84
9WAL	20.4	20.7	21.9	1.12	Low	21.8
					High	20.2
					LSD (5%)	0.92
10WAL	22.4	23.0	24.2	1.17	Low	24.0
					High	22.4
					LSD (5%)	0.96

1. Last phosphate application was in Sep. 1990.

(d) Supplementary feeding

The treatment combination P_0 high required the highest amounts of supplementary feeding (MJ/month per ewe) throughout the season (Figure 3.4). The least supplementary feeding was under P_{26} low and was needed during lambing and early lactation (January-March). This was followed by treatment P_{11} low, from October to the end of the season, and then P_0 low, for the same period. Figure 3.4 also suggests that the native pasture on marginal land can contribute significantly to the energy requirements of the grazing ewes almost all the year round, provided that the soil phosphorus deficiency has been corrected and/or the stocking rate maintained at a low level, such as the one tested in this study. Under P_0 high, the pasture appeared to have contributed very little to the monthly requirement of the ewes for energy, except during April-July.

Table 3.4. Total commercial milk yield in kg/ewe per lactation (90 days) and total wool production (kg/ewe), during 1992, at three rates of phosphate¹ and two stocking rates.

Phosphate rate (kg/ha P)	Milk	Wool
0	41.5	2.4
11	43.5	2.5
26	52.7	2.4
SEM	2.94	0.08
Stocking rate (sheep/ha per year)		
Low: 1.1	45.6	2.5
High: 2.3	46.2	2.3
SEM	2.40	0.07

1. Last phosphate application was in Sep. 1990.

Conclusions

The results reported here suggest that annual application over several years of small quantities of phosphate fertilizer to undisturbed native grassland will continue to improve pasture

productivity beyond the seasons of actual application. Animals grazing on pastures with a history of phosphate application had greater body mass and required less supplementary feed than animals on native unfertilized pasture, especially at a high stocking rate.

- A.E. Osman and F. Bahhady

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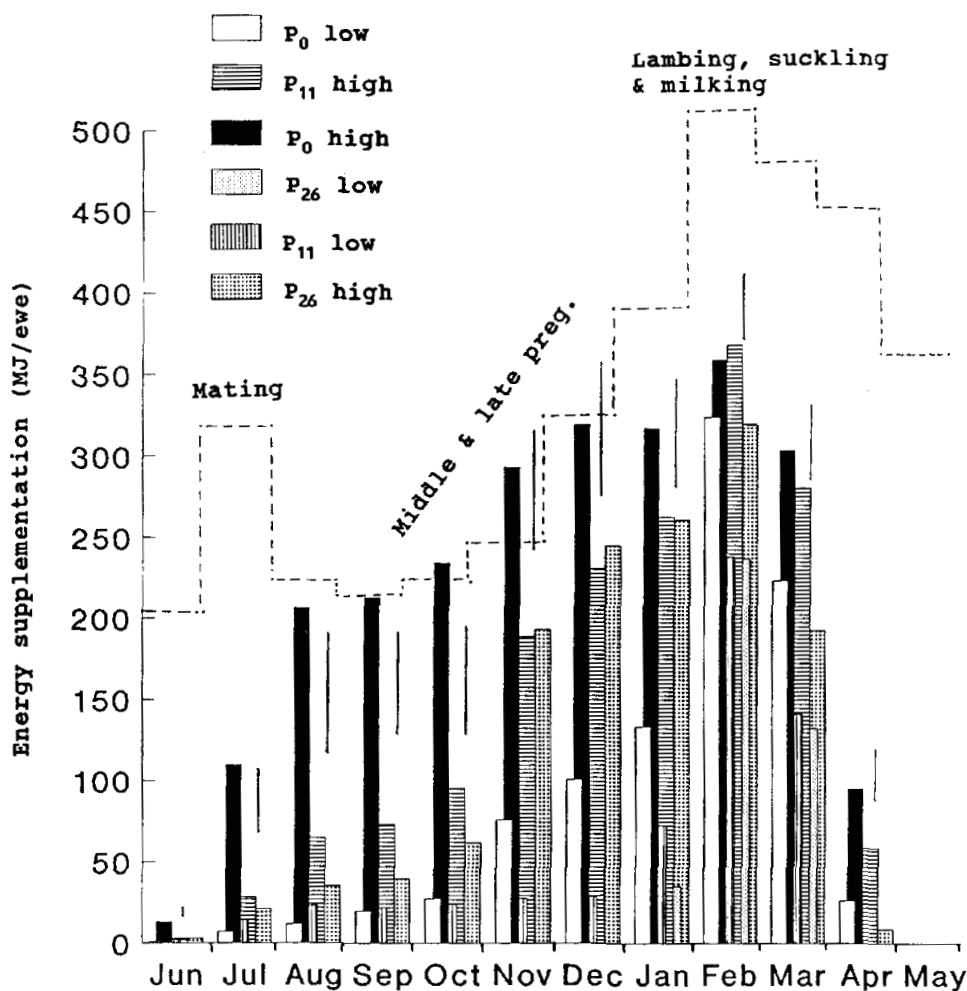


Figure 3.4. Energy supplementation in MJ metabolizable energy/ewe on monthly basis as the result of different levels of phosphate (P) and stocking rate treatment combinations, at Tel Hadya during 1991/92. Bars are LSD at 5% level. The broken line is an estimate of metabolizable energy requirement of a productive ewe during the season (Nordblom et. al, 1992).

3.2 Use of edible shrubs in pasture improvement on degraded marginal lands

Out of 18.5 million ha, the total area of Syria, 10.2 million are considered rangeland. This rangeland has no more than 200 mm of rainfall and is unsuitable for cultivation, but supports native pasture which is utilized by increasing numbers of livestock (sheep in Syria were estimated at 13.3 million heads in 1988 compared with 4.3 million in 1963). It is estimated (Syrian Ministry of Agriculture) that 75% of the total sheep population use the rangeland during part of the year. Syria is like many countries of west Asia and north Africa, where rangelands have suffered considerable deterioration over the years. The well known factors, uncontrolled grazing, increased livestock numbers, uprooting of shrubs, and the encroachment of cereal cultivation, have all prevailed. In addition another important factor since the 1950's has been the increased availability of trailers and water tankers (Treacher, 1991). This allows the livestock owners to transport sheep, feed and water, reach remote areas and stay longer on the range, thus accelerating its destruction.

Rangelands in Syria which originally supported woodland and shrub vegetation (Emberger 1956), now support only low growing grasses and herbs and, occasionally, small populations of legumes. This degradation is often accompanied by severe soil erosion. They produce on average <400 kg/ha of herbage per year (PFLP 1992), in contrast with the expected yield of 1,200 kg/ha per year of mediterranean rangelands in general (Le Houerou and Hoste 1977). In Libya, with similar rainfall, yields amounting to 2,000 kg/ha dry matter per year have been reported (Gintzburger 1986).

Range rehabilitation

An extensive program of range rehabilitation was started in Syria in

1986. At first, the activity was focused on the use of seedlings of imported species such as Atriplex nummularia and A. canescens. Later work has shown that the native shrubs A. halimus and Salsola vermiculata perform even better than the imported species. They can be established from direct seeding and, more importantly, they are self-reseeding. The total area of shrubs planted from seedlings (all government reserves), is estimated, to date at 48,000 ha. In addition, there are 14,000 ha established by direct seeding. The latter method is expected to gain importance over the seedling establishment method because of the limited cost involved. In a recent study (Abo Shalla 1992), involving two provinces (Hama and Aleppo), the cost of establishing shrub seedlings on one hectare ranged from 2,225 to 2,300 Syrian pounds (1 USD = 42 SL), while the cost of using the direct seeding method on the same area was 200 to 345 Syrian pounds.

Management

Although shrub plantations have not been put to systematic use for livestock production, except on experimental plots, the main use being for seed production, during two drought years, 1989 and 1990, one of the reserves (Maragha, Aleppo Province) was opened for grazing from June to November (165 days in the first year and 100 days in the second). During these periods, the shrub reserve (6,500 ha) was used by a government flock of 11,000 sheep.

To obtain detailed information on pasture improved with shrubs, a joint field study was started in 1989/90 at Maragha (120 km south east of Aleppo, annual rainfall 200 mm) by ICARDA, the Syrian Ministry of Agriculture and the Arab Center for Studies of the Arid zones and Dry lands (ACSAD). The study was carried out on 100 ha land improved by direct seeding of S. vermiculata and A. halimus, and 100 ha of native unimproved pasture. The objectives were to

determine the productivity of rangelands improved by seeding with edible shrubs, to monitor the effects of three stocking rates on biomass production and on sustainability of livestock production, and to measure the economic return. Three stocking rates, one sheep/2.25 ha, one sheep/1.5 ha and one sheep/0.75 ha, on both improved and unimproved areas, were achieved by grazing eight ewes/plot, with plot sizes of 18, 12, and 6 ha. Each treatment was replicated three times. The plots were fenced.

Animals were introduced into the experimental plots on February 1, 1990. Thereafter, the ewes grazed the plots from early morning to sunset, and were sheltered at night. Animals on both pastures were supplemented with barley, cotton seed cake and hay, when body weight was not sustained by grazing, and in late pregnancy and early lactation. Good quality water was provided on a continuous basis for all animals. The first two seasons were reported in PFLP (1992). The present report covers 1991/92 season.

Table 3.5. Effects of stocking rate and type of pasture on grazeable forage and total biomass in April 1992 at Maragha.

	Low	Stocking rates ¹		Mean
		Medium	High	
		Grazeable forage ²		
Type of pasture				
Native	602a	315bc	239c	386
Improved	447ab	491ab	327bc	422
Mean	524	403	283	
		Total biomass		
Native	602	315	239	386a
Improved	1038	1143	800	994a
Mean	820a	729ab	520b	

1. Low = 2.25; medium = 1.5 and high = 0.75 ha/sheep per year.

2. Means with different letter(s) are significantly different at 0.05 level by Duncan's multiple range test. Where there is a significant interaction, significant differences between main effects are not shown. Where there is no significant interaction, significant differences between main effects only are shown.

Table 3.6. Effects of stocking rate and type of pasture on grazeable forage and total biomass in October 1992 at Maragha.

	Low	Stocking rates ¹		Mean
		Medium	High	
Type of pasture		Grazeable forage		
Native	356cd	222cd	82d	220
Improved	734b	1054a	472bc	753
Mean	545	638	277	
		Total biomass		
Native	818	583	378	594a
Improved	1559	1836	870	1422a
Mean	1188a	1211a	624b	

1. Low = 2.25; medium = 1.5 and high = 0.75 ha/sheep per year.

2. Means with different letter(s) are significantly different at 0.05 level by Duncan's multiple range test. Where there is a significant interaction, significant differences between main effects are not shown. Where there is no significant interaction, significant differences between main effects only are shown.

Table 3.7. Number of seeds/m² of herbaceous species on the top 3 cm of soil at two pastures and three stocking rates recorded June or September 1992 at Maragha.

	Low	Stocking rates ¹		Mean (SEM)
		Medium	High	
Type of pasture		June		
Native	31923	22873	28327	27708
Improved	7593	7049	4481	6374
Mean (SEM)	19758	14961 (3062)	16404	(730)
		September		
Native	9340	4774	2658	5591
Improved	3064	2277	1027	2123
Mean	6202a	3526b	1842b	

1. Low = 2.25; medium = 1.5 and high = 0.75 ha/sheep per year.

2. Means with different letter(s) are significantly different at 0.05 level. Interaction of pasture x stocking rate is not significant.

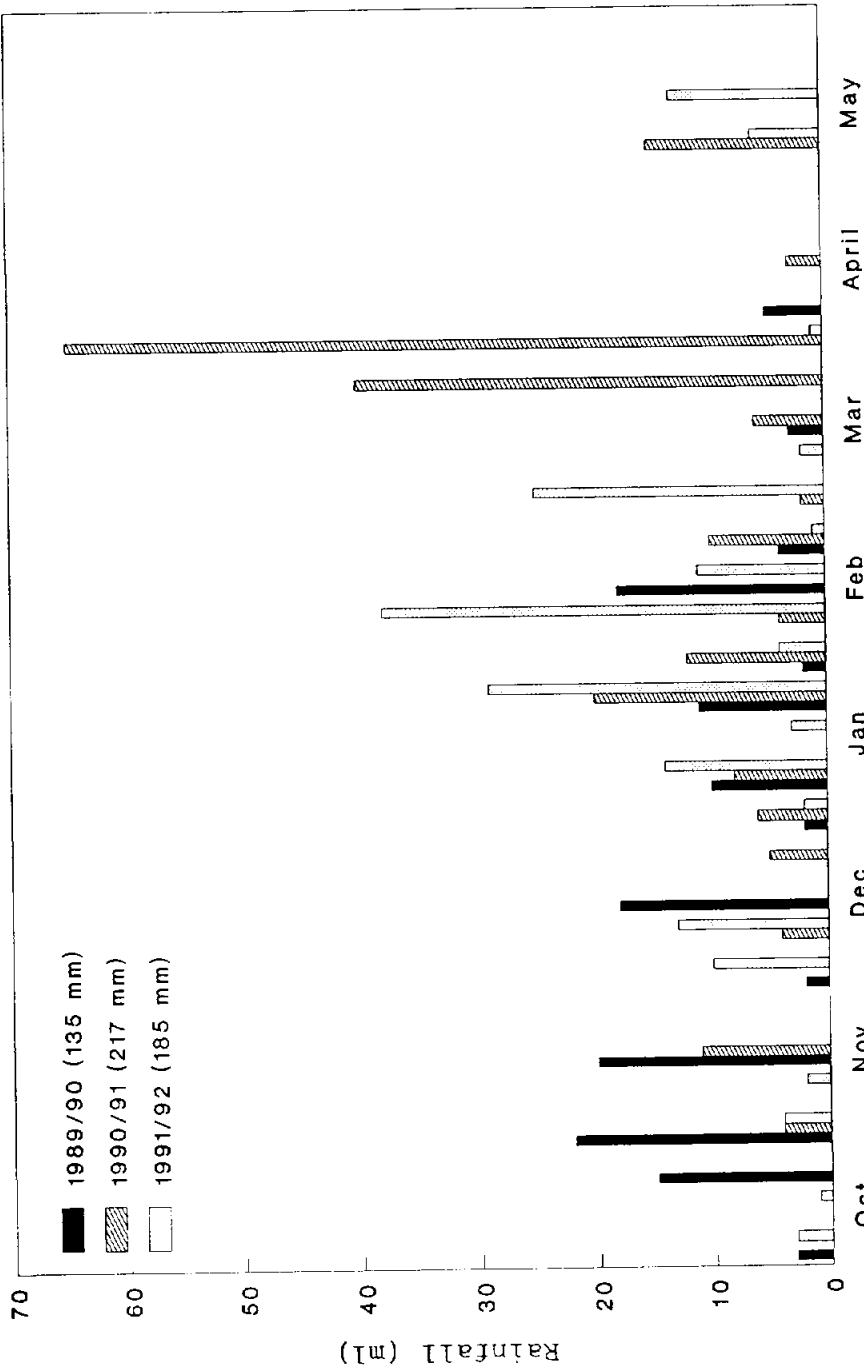


Figure 3.5. Mean weekly rainfall in mm during three seasons at Maragha, northern Syria.

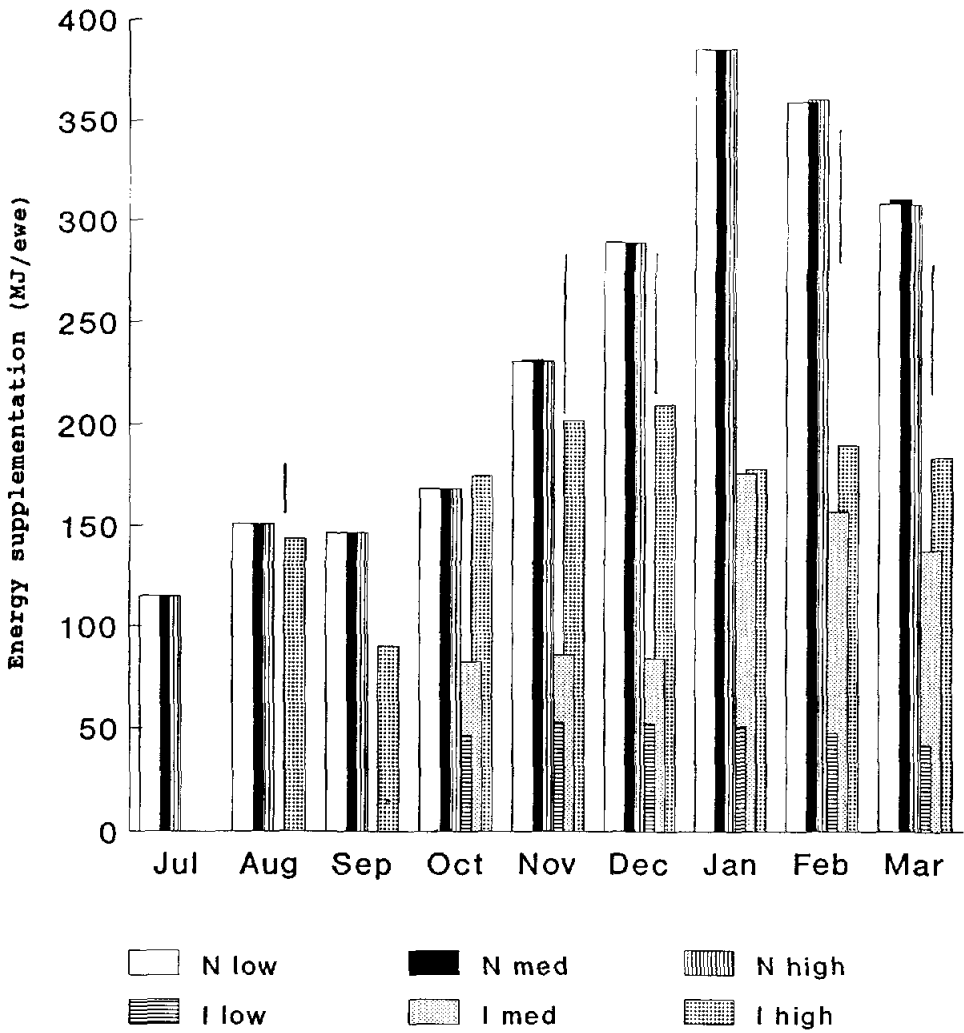


Figure 3.6. Energy supplementation in MJ metabolizable energy/ewe on monthly basis on native (N) and improved (I) pastures at different stocking rates at Maragha during 1991/92 season. Bars are LSD at 5% level.

Results

Forage and seed yield

Rainfall at Maragha in 1991/92 was only 185 mm, but it was well distributed throughout the season (Figure 3.5). Grazeable forage (any plant or part of+ plant eaten by animals) and total above-ground biomass on native and shrub-seeded pastures are shown for April and October in Tables 3.5 and 3.6. The shrub-seeded pasture gave consistently higher yields at all times over the native pasture. The difference was greater in October, suggesting that the shrubs had made their maximum growth and contribution to grazeable forage during the summer. For example, on the native pasture, the grazeable forage in October was 57% of its level in April, while on the shrub seeded pasture it was 178%.

Comparing the stocking rate treatments (there were significant interactions of pasture x stocking rate) in April, the maximum grazeable forage was recorded on native pasture at a low stocking rate, which was significant over all other treatments except the improved pasture, when grazed at low or medium stocking rates (Table 3.5). The improved pasture when grazed at low or medium stocking was significantly better in grazeable forage than the native pasture treatments in October (Table 3.6). It must be noted that the herbage yield of grasses and forbs in the spring was much better on the native than on the shrub seeded pasture, especially under low stocking. This can be attributed to soil disturbance, using a duck foot cultivator, at the time of seeding the shrubs, which probably resulted in partial loss of the seed bank on the shrub seeded pasture. Data on the seed bank (Table 3.7) indicated that the native pasture contained more than four times the number of seeds/m of herbaceous species over the shrub seeded pasture in June and more than twice in September. The high stocking treatment resulted in a significant reduction of seeds in September, compared with the low

stocking treatment (Table 3.7).

Live weight and supplementary feeding

Body mass of ewes, recorded from the 10th through the 2nd week before lambing, was slightly higher on the native than on the shrub seeded pasture, but this difference was not statistically significant. After lambing and up to week 6, weights were higher on the shrub seeded pasture, although not statistically significant. The low stocking rate treatment produced consistently higher body mass over the other two stocking rates, both before and after lambing (Table 3.8). The data presented in Figure 3.6 show significantly higher supplementary feeding on native pasture over shrub seeded pasture throughout the season. It is also shown that the lowest feed supplementation was given on improved, shrub seeded, pasture when grazed at low stocking (I low), followed by medium (I med), then high (I high) stocking rate treatments. It can be concluded that animals on the native unimproved pasture were able to sustain their body weight during 1991/92 season, at the level shown in Table 3.8, mainly by supplementary feed, while animals on the shrub seeded pasture attained the same level of performance with smaller amounts of supplementary feed. - **A.E. Osman, N. Hassan, N. Murad and F. Bahhady**

Table 3.8. Body mass of ewes grazing on native (N) pasture and on pasture improved (I) by sowing edible shrubs, at different stocking rates at Maragha, several weeks before (WB) and after (WA) lambing during 1991/92 season.

Date of record	Type of pasture		Low	Stocking rate ¹		SEM
				Medium	High	
10WB	N	54.0				
	I	51.9	54.0	52.7	52.2	1.03
	SEM	0.95				
9WB	N	54.2				
	I	52.3	54.7	52.8	52.3	1.03
	SEM	0.68				
8WB	N	54.4				
	I	52.3	54.7	53.2	52.3	0.97
	SEM	0.95				
7WB	N	54.3				
	I	52.6	54.8	53.2	52.3	1.00
	SEM	0.76				
6WB	N	54.9				
	I	52.6	55.0	53.2	53.0	1.10
	SEM	0.62				
5WB	N	55.2				
	I	54.0	56.0	54.0	53.8	1.10
	SEM	0.83				
4WB	N	56.1				
	I	54.7	56.7	54.8	54.7	1.03
	SEM	0.83				
3WB	N	57.0				
	I	55.4	57.5	55.7	55.5	1.07
	SEM	0.89				
2WB	N	57.0				
	I	56.4	58.0	56.5	55.7	1.07
	SEM	1.11				
1WB	N	57.1				
	I	56.4	58.0	57.0	55.8	1.08
	SEM	1.31				
1WB	N	57.1				
	I	57.1	58.5	57.0	55.8	1.08
	SEM	1.31				
1WB	N	57.1				
	I	57.1	58.5	57.0	55.8	1.08
	SEM	1.31				

Lambing	N	57.0				
	I	57.4	58.8	57.0	55.8	1.11
	SEM	1.52				
1WAL	N	48.7				
	I	49.0	50.3	48.5	47.7	1.22
	SEM	1.08				
2WAL	N	47.4				
	I	48.2	49.8	47.3	46.3	0.95
	SEM	0.68				
3WAL	N	46.0				
	I	46.6	48.3	46.2	44.3	1.00
	SEM	0.95				
4WAL	N	44.7				
	I	45.7	46.8	45.0	43.7	0.83
	SEM	0.62				
5WAL	N	43.8				
	I	44.8	46.2	44.2	42.5	0.91
	SEM	0.47				
6WAL	N	43.0				
	I	43.6	45.3	43.5	41.0	1.12
	SEM	0.72				
7WAL	N	42.6				
	I	42.1	44.7	42.2	40.2	1.21
	SEM	0.49				
8WAL	N	42.3				
	I	41.6	44.5	41.3	40.0	1.23
	SEM	0.49				
9WAL	N	42.7				
	I	41.0	43.8	41.8	39.8	1.25
	SEM	0.71				
10AL	N	42.9				
	I	41.2	43.5	41.5	41.2	1.22
	SEM	1.31				
11WAL	N	43.3				
	I	41.7	43.7	42.3	41.5	1.18
	SEM	1.03				

1. The interaction pasture x stocking rate was not significant.

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3.3 Native shrubs in sheep diets

Natural rangelands in countries of west Asia are heavily degraded owing to uncontrolled grazing, increased livestock numbers, uprooting of shrubs, and the encroachment of cereal cultivation (see Section 3.2). Ongoing research at ICARDA is assessing the establishment of native shrubs, Atriplex halimus and Salsola vermiculata, on native unimproved pastures in both Syria and Lebanon.

A collaborative project was started in 1991 between the American University of Beirut (AUB), Lebanon and PFLP, ICARDA, to study the botanical composition of sheep diet, using faecal microhistological techniques. Faecal and plant samples were collected in August and November 1992 and sent to AUB. Each time, the faecal samples were collected from seventy two ewes grazing the shrub seeded plots in the Maragha project. Plant samples were collected from all treatments in the experiment. At AUB, the faecal samples were dried and ground through a Willey screen and a composite prepared for each ewe. Plant samples were dried, ground and stored. Faecal and plant materials were soaked, rinsed and mounted on slides with Hoyer's solution. The botanical composition of the composites was then determined on five slides per sample. This was done by examining twenty random fields per slide under the microscope. Undigested plant fragments were identified, recorded and estimated as percentage of diets. Dietary similarities between groups were calculated using similarity index.

Results

Preliminary results indicate that reseeding of marginal lands with native shrubs such as the ones tested here, may provide sheep with green feed when other vegetation is dry. During the dry season, in August, about half the sheep diet (46%) was contributed by edible

shrubs, with equal proportions of Atriplex and Salsola species (Table 3.9). Increasing the stocking rate, from low, one ewe/2.25 ha per year to high, one ewe/0.75 ha per year, resulted in more Atriplex being consumed, 16.7% and 25%, respectively. The grass component in the pasture did not respond to the stocking rate effect (average 31%). Consumption of Salsola was lower under the high stocking rate. It was also noted from the August sample that about 23% of the diet was contributed by shrubs and forbs other than Atriplex and Salsola.

During the autumn, in November, the sheep ate very little Atriplex, irrespective of the stocking rate (Table 3.10). Other shrub species, Salsola spp. and Noaea macronata, represented 20% of the diet, with the greatest contribution coming from Noaea mucronata. About 15% of the diet was contributed by Artemisia herba alba. - S.K. Hamadeh and A.E. Osman

Table 3.9. Botanical composition of sheep diet under three different stocking rates (August) on rangelands improved with shrubs.

Species	LOW MEAN STOCKING TRT 1	MEDIUM MEAN STOCKING TRT 2	HIGH MEAN STOCKING TRT 3	S.E.	GRAND MEAN
Grasses	27.02	30.33	28.38	0.085	31.176
Atriplex sp.	16.65	24.34	25.20	0.078	24.071
Salsola sp.	23.57	22.22	15.29	0.060	22.211
Other species	20.82	23.19	18.62	0.069	22.776

Table 3.10. Botanical composition of sheep diet under three different stocking rates (November) on rangelands improved with shrubs.

SPECIES	LOW MEAN STOCKING TRT 1	MEDIUM MEAN STOCKING TRT 2	HIGH MEAN STOCKING GG TRT 3	S.E.	GRAND MEAN
Artemisia herba alba	12.87%	10.65%	18.88%	0.049	14.33
Atriplex leucoclada	0.00%	0.00%	0.25%	0.004	0.08
Ephedra alata	0.00%	0.00%	0.00%	0.000	0.00
Gossypium barbadense	0.00%	0.07%	0.06%	0.002	0.04
Hordeum (grain)	13.47%	10.29%	9.37%	0.047	11.20
Hordeum (straw)	22.75%	21.74%	22.69%	0.074	22.71
Noaea mucronata	11.47%	17.86%	11.22%	0.049	13.71
Salsola inermis	3.15%	10.02%	4.38%	0.042	5.93
Salsola spinosa	0.88%	2.86%	3.02%	0.033	2.28
Other species	30.63%	26.41%	29.65%	0.076	29.30%

3.4 Rhizobial populations of Trifolium spp. as affected by season, soil phosphorus concentration and animal stocking rates

Clovers (Trifolium spp.) are common plants found in marginal lands in most of the WANA region, with a precipitation mean ranging from 300 to 400 mm/year. They provide nitrogen to the soil, thus improving its fertility, and are also a source of feed for animals. Previous investigations conducted in the Program have indicated that phosphorus applications increase the herbage yields of several species of clovers. Phosphorus is an essential element for the metabolic processes involved in nitrogen fixation and is usually found in relatively high concentrations in the nodules of legume plants. Preliminary investigations have been started to determine the effect of phosphorus on the indigenous Rhizobium trifolii (clover rhizobia), present in some soils of marginal lands in Tel Hadya, Syria, and on their symbiotic characteristics.

Populations of rhizobia indigenous to a marginal land site in Tel Hadya (experiment ML2) were determined throughout the growing season. The soil supported an experiment which consisted of three applications of phosphorus, 0, 25 and 60 kg of P_2O_5 /ha. Each phosphorus treatment had a low and a high sheep stocking rate. For the purpose of enumerating the clover rhizobial population native to this site, soil samples were collected at three different dates during winter and spring (21-11-91, 29-3-92 and 22-4-92). The sample for rhizobial enumeration analysis was made by mixing each sample taken from each of the three replications plots within a phosphorus and animal stocking rate treatment. A total of 18 samples was kept in plastic bags, sealed tightly to prevent cross contamination, and refrigerated for analysis.

The most probable number technique (MPN) was used to enumerate rhizobia present in the soil samples. The 'trap' species of clover was Trifolium stellatum. The plants were grown in glass tubes

containing a 1:1 sterile mixture of vermiculite and gravel and a nitrogen-free mineral solution to support plant growth. Serial 10-fold dilutions of the soils were prepared by mixing the suspensions vigorously for 10 minutes in a reciprocating shaker. A volume of 1 ml from each dilution level was taken to inoculate the rhizobium-free clover plants. Plants were evaluated for presence or absence of nodules after four weeks of growth in a plastic-house. Scores were used to determine the most probable number of rhizobia found in the amount of soil used for the initial suspension. The numbers of rhizobia were then determined by using the appropriate statistical tables available for this purpose. The test included uninoculated plants, with and without mineral nitrogen. Plant vigor, number and quality of nodules, dry weight of shoots and roots were also recorded.

Results indicated that sampling time had a marked influence on numbers of clover rhizobia present in the soil and was not related to the presence of animals (Table 3.11). Actual rhizobial numbers in autumn were six to seven times lower than those found in the second and third sampling taken during the spring. There were no significant correlations between the presence of the animals within and between phosphorus treatment. There were however, higher rhizobial numbers in soils which were treated with phosphorus, as more substrate or energy sources became available to bacterial populations in the soil.

Herbage production of clovers inoculated with indigenous bacteria from these soils produced effective nodulation on Trifolium stellatum regardless of phosphorus application and animal stocking rates. Plant vigor scores, number of nodules and herbage dry weight on a plant basis appeared constant at each sampling date (Table 3.11). Differences in plant yield during the autumn were due to environmental factors (e.g. temperature) in the period of the test.

The abundance of rhizobia and their symbiotic relationships with several species of clovers growing in marginal lands are topics that need further investigation. - L. Materon M. Zaklouta and A. Osman.

Table 3.11. Shoot dry weights of *Trifolium stellatum* nodulated by indigenous *Rhizobium trifolii* present in soils amended with phosphorus and grazed by animals in marginal soils of Tel Hadya (northern Syria). Values are in mg fresh tissue per plant.

P level	Autumn		Spring 1		Spring 2	
	P rate		P rate		P rate	
	high	low	high	low	high	low
0	7.9	7.2	17.7	18.5	15.6	17.8
25	6.9	7.3	17.2	19.4	18.3	21.4
60	6.4	6.8	12.9	17.8	18.4	18.6
s.e.m	1.8		4.6		5.7	

Autumn sampling on 21-11-91; spring 1 on 29-3-92;
spring 2 on 22-4-92

3.5 Research on Fourwing Saltbush (*Atriplex canescens*) in Balochistan (Pakistan)

Introduction

Highland Balochistan is generally defined as those areas above 1000 m altitude (Figure 3.7 - shows map of Balochistan). The climate is harsh, with annual rainfall increasing from 200 mm at the southern end of the highlands to over 400 mm in the northeast of the province. Most of this rain falls in winter, although, in the north, up to 40 percent can fall as monsoon rain in summer. Winters are cold, with mean minimum temperatures in January close to zero, although absolute minimum temperatures can fall to -15°C. Since 1985, the Range Section at the Arid Zone Research Institute (AZRI) in Quetta has focused on range vegetation surveys, and on assessing the potential of exotic grasses and fourwing saltbush (*Atriplex*

canescens). 1992 has seen a narrowing of the focus of the Section, partly because it has only three scientific officers and partly because fourwing saltbush appears to be the most promising technology emerging from the research efforts of the Section.

The research on exotic grasses has completely stopped, since they showed only a limited adaptation to the conditions of highland Balochistan, with the exception of weeping lovegrass (Eragrostis curvula), which has shown good persistence at Tomagh due to the summer rainfall at that site (AZRI/ICARDA, 1991). Furthermore, it seems most unlikely that farmers in Balochistan will reseed rangeland, because of the cost, the need to import seed, the lack of control over marauding flocks and the management requirements needed to ensure good persistence of exotic grasses.

It is also emerging that fourwing saltbush, a perennial chenopod native to the arid south-western states of the USA, is well suited to growing on land marginal for cultivation, where there is some soil but low plant cover. The former is important for the storage of water, which helps the seedlings survive through the first summer, and the latter is necessary since competition from native shrubs appears to severely reduce growth of saltbush. This information is being taken into account when selecting sites for demonstrating forage reserves.

It should not need mentioning that on-farm testing of saltbush with full participation of farmers is an essential part of the research process and that such activities need to be accelerated at AZRI. A forage reserve was established near Miangundi in March 1992 and two further sites will be added in 1993.

Focusing on just one species to provide feed from rangeland and land marginal for cultivation has obvious weaknesses. For this reason, another perennial forage shrub, Salsola vermiculata, which can be propagated direct from seed, is being multiplied in the AZRI

nursery from seed provided by the Pasture, Forage and Livestock Program of ICARDA, in spring 1992. Research is likely to begin in 1993, when enough seed is available. - **Sarwat N. Mirza: Head, AZRI and Range Section and Euan F. Thomson: ICARDA Advisor**

Benefits of fertilizers, manure and micro-basin water-harvesting

Plant density, the possible benefits of fertilizer and manure application, and two different methods of micro-basin water-harvesting, are being investigated in this trial. It began with the planting of nine-month old seedlings at Quetta (AZRI) and Tomagh, in June 1990. At AZRI, the saltbush seedlings were planted on a site where few other perennial plants grow, whereas at Tomagh the seedlings were planted among the native bunch grasses, Cymbopogon schoenanthus and Chrysopogon aucheri. The three treatments were:

- fertilizer: manure, N plus P, and no fertilizer (three levels)
- plant spacings: 2.5 and 2.0 m (two levels)
- water-catchment system: saucer-shaped, V-shaped (two levels)

These treatments combine to give 12 treatment combinations in a factorial design with two replicates. The fertilizer was applied to each plant as a single dose, equivalent to 11.5 kg nitrogen and 11.5 kg phosphorus/ha, as Nitrophos (23.23.0, 50 kg/ha). Manure was applied to each plant at a rate equivalent to 1 t/ha. A single irrigation of 15 l/plant was applied at planting. The saucers have a diameter of nearly 2 m and the Vs have arms of 2 m length at 90° to each other. Measurements of plant survival, height and crown diameter are being made every month on the same five, individually tagged plants in each plot. The experiment will end in June 1993, when the biomass of leaves and wood of plants will be determined, using destructive methods.

Markedly contrasting growth patterns of saltbush have been seen at AZRI and Tomagh, which have different levels and distributions of

rainfall, as well as soils (Figure 3.7). The total rainfall during the period from July 1990 to June 1991 and from July 1991 to June 1992 was 391 and 332 mm at Quetta AZRI, respectively, and 424 respectively, at Tomagh. The distribution, however, at the two sites is different: at Quetta, rainfall is concentrated during winter and spring, whereas at Tomagh, rainfall during the summer monsoons makes a significant contribution to the annual total. (Figure 3.7). The mean minimum temperatures at Quetta and Tomagh are also different (Figure 3.7), even though the altitude at Quetta (1680 m) is slightly lower than at Tomagh (1800 m).

At Quetta, the plants are growing on soil that was transported in and placed over the underlying gravel beds that form the base of the AZRI research station. The soil is thought to be fairly fertile, although no analyses have been made. In contrast, the soils at Tomagh are very shallow, with a calcareous hardpan 15 to 20 cm below the surface. This would affect root development, as can be seen in the next experiment on different water-harvesting methods.

The clear effect of climate on the pattern of growth of saltbush is reflected in the increasing crown diameter of plants growing at AZRI and at Tomagh (Figure 3.7). Following planting in June 1990, seedlings at AZRI showed little growth during the autumn, when moisture, but not temperature, was the limiting factor, and during winter, when temperature, but not moisture, was limiting growth. Growth started again in March 1991, when temperatures began to rise, and was rapid until June, when lack of moisture probably started to limit growth again. A period of dormancy followed, until April 1992, when growth started again. Even though growth, expressed as crown diameter, was less in the second summer 1992 than in 1991, it continued until October 1992, as compared with July in 1991. This may have been because more moisture was stored, following excellent rain (132 mm) in April 1992 at AZRI.

Legend:

- Manure, V-shape
- +— N+P, V-shape
- *— Manure, Saucer shape
- N+P, Saucer shape
- x— o N+P, V-shape
- o N+P, Saucer shape
- △— Monthly rainfall

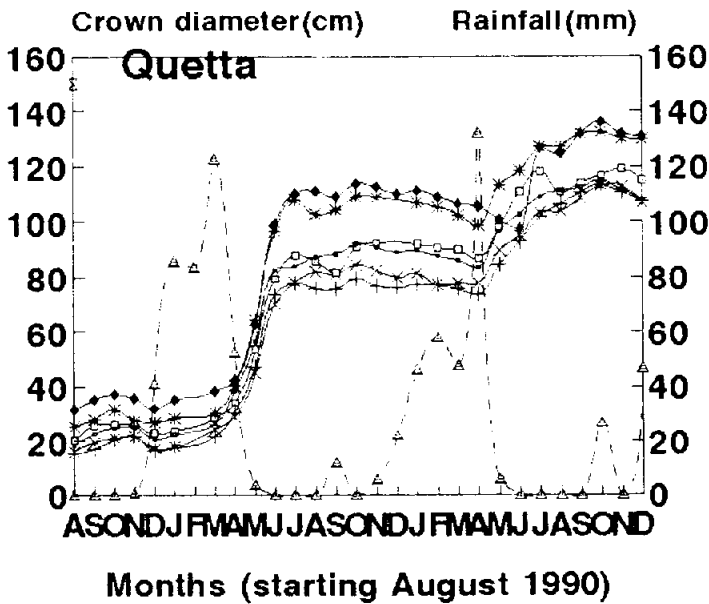


Figure 3.7. Effects of two methods of micro-basin water-harvesting and fertilizer on crown diameter of saltbush at Tomagh and the AZRI station. (Only shows 2 m plant spacing.)

At Tomagh, a different growth pattern was seen and the plants were, in general, smaller than at AZRI (Figure 3.7). Crown diameter remained fairly constant from November 1990 until February 1991 and then increased rapidly, owing to rising temperatures and good rainfall. Marked contrasts in growth, however, were seen between treatments, which are discussed below. The decrease in crown diameter in June 1991 may have been a measurement error that affected all treatments. From July 1991 until the end of the experiment, in December 1992, growth continued at a steady rate, even during winter. This suggests that winter temperatures were not low enough to stop growth and that sufficient moisture was generally available. Indeed, the good rainfall during the winter 1991/92 accelerated the growth of the plants from October to December 1991, especially of those receiving fertilizer and manure. After a short period of relative dormancy, in January and February 1992, growth continued throughout the summer of 1992 and only slowed during the period September to December 1992, when lack of moisture may have been the limiting factor.

Only the main effects of fertilizer application on crown diameter were statistically significant at Tomagh, and these effects persisted, even when adjusted, using crown diameter in November 1990 as a co-variate. This effect can be seen in Figure 3.7. The benefits gained from added plant nutrients at Tomagh, but not at AZRI, suggest that the soils at Tomagh are low in fertility, compared to the soils at AZRI. This suggestion needs to be confirmed, using the chemical composition of the soils.

At AZRI, treatment effects on crown diameter were similar during the autumn and winter dormant period, but effects began to emerge during the period of rapid growth in the spring of 1991. The increased crown diameter from harvesting water in saucer-shaped basins as compared with V-shaped catchments was generally highly

significant ($P < 0.001$), with the statistical significance of the main effects of plant spacing and fertilizer on crown diameter being somewhat lower over the period August 1990 to December 1992. During the 10 months after June 1991, the plants growing in saucers with no fertilizer or with manure tended to have larger crown diameters than the plants in the other treatments. This difference persisted through to December 1992. When the initial differences, however, in crown diameter were removed, using the crown diameter in August 1990 as a covariate, the significance of the main effects were seldom statistically significant ($P > 0.05$). There were no significant interactions between plant spacing, fertilizer application and water-harvesting design.

The conclusion drawn from this preliminary analysis of the data is that, at AZRI, growth of saltbush plants was similar under the two water-harvesting designs and that adding inorganic fertilizer or manure had little beneficial effect. In contrast, inorganic fertilizer and manure enhanced plant growth on the infertile and shallow soils at Tomagh. At both sites the height of the plants and crown diameter responded similarly to the various treatments. -
Principal investigator A. Hussain

Comparisons of different methods of water-harvesting

Ways have to be found to ensure that saltbush establishes quickly after planting, without the need for additional watering. This reduces the amount of work to be performed by farmers and should make them more willing to adopt the technology. Planting has to be completed before the long, dry period in summer, and, even during the planting season from December to late February, rainfall can be insufficient for plant growth and survival. It is, therefore, important to harvest as much water as possible close to the plant.

The four ways of harvesting water being investigated in the trial are:

- saucer catchments; each saucer has a 2 m diameter,
- V-shaped catchments: the Vs have 2 m arms at 90° to each other,
- contour furrows: at 2 m spacing, and
- ripping: at 2 m spacing.

Six-month old seedlings were planted in June 1990 at Zarchi and Tomagh³ in native range dominated by C. schoenanthus and C. aucheri. A single irrigation of 15 l/plant was given. The trial is laid-out as a randomized complete block design with four replicates. Survival rate, crown diameter and plant height are measured every month on the same tagged plants. Only the results from Tomagh are reported here, since growth of saltbushes at Zarchi in all trials has been poor, except where they are irrigated. This suggests that Zarchi, with a mean annual rainfall of 200 mm, is too dry compared with Quetta, which receives annually about 220 mm rainfall. The soils where the trials are laid out are also quite shallow and stony with little water-storage capacity. These arguments are supported by the good growth of bushes at a site below Zarchi station, where the soils are better, some water can run on to the site (known as the sailaba system) and there is no competition from sagebrush (Artemesia maritima).

During the first four months after transplanting, there was some growth, expressed as crown diameter (Figure 3.8). During this period, soil moisture was available and minimum temperatures were above 10°C. Thereafter, the crown diameter of plants decreased until

³The trial at Mastung was abandoned since poor seedlings with a single shoot were used and many of them were damaged by a heavy infestation of rodents.

January, probably due to leaf-drop and damage by rabbits which are common in the area. Beginning in January 1991, no increase in crown diameter was seen until March. This is difficult to explain since, even though low temperatures may have limited growth until April, this would not have been the case thereafter, when moisture was adequate. By July 1991, a period of steady growth had begun and continued for 18 months, until December 1992. This is the same finding as in the other experiment at Tomagh reported above. It suggests that, once the bushes are established, they can continue to grow through winter at a rate similar to the summer period.

There were no statistically significant ($P>0.05$) effects of the different water-harvesting designs on crown diameter, although the bushes planted in furrows tended to be larger. This may be related to the better catchment of water in the furrows rather than breakage of the hardpan, since, although it is likely that the ripper would have broken the hardpan too, the bushes there were smaller.

It is difficult to conclude from this study at Tomagh that one water-harvesting or land preparation treatment is better than the other, since it is not known what role the hardpan plays in determining plant and root growth. Furthermore, the magnitude of the effect of competition from the bunch grasses is also unknown. From a practical standpoint, however, ploughing would be the land-preparation method of choice, since it can be mechanized and appears to result in the largest plants among the treatments compared. Indeed, saucers and V-shaped catchment designs would appear to be impractical because of high labour costs. These costs have to be very low to give range improvement technologies a chance of being accepted by government agencies, let alone farmers. - **Principal investigator A. Hussain**

Legend:

- + Rainfall (mm)
- × Saucer shape
- ✦ V-shape
- △ Ripper
- ▢ Plough (furrow)

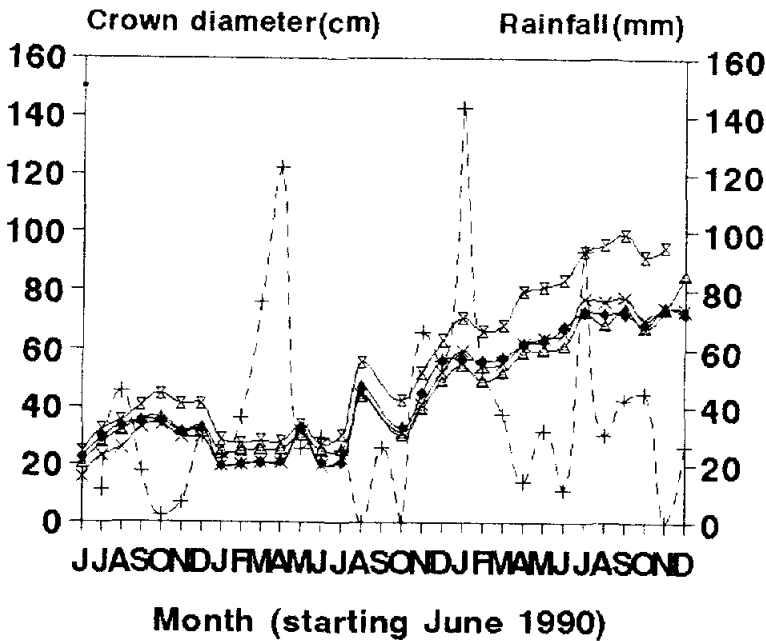


Figure 3.8. Effects of two methods of water-harvesting (saucers, V-shaped catchments) and two methods of land-preparation (ripping, ploughing) on crown diameter of saltbush at Tomagh. Total monthly rainfall also shown.

Effects of plant density on growth

Experience with forage reserves of saltbush at AZRI has shown that, if stands become too dense, they are poorly utilized by sheep and goats. The purpose of this study is to find the optimum plant density that maximizes carrying capacity. It is anticipated that the closer plant spacing will make better use of the scarce rainfall, because more will be used by the plants rather than lost as evaporation. The life-span, however, of closely spaced plants may be shorter, because of competition effects. This will be less serious, provided the plants remain small as a result of grazing.

The study is being conducted at two locations; AZRI station, Quetta, and Karkassa National Park near Quetta (Forestry Department, Govt. of Balochistan). At each location, two blocks (replicates), each of 3000 m² and differing in their soil types, were planted with six-month old seedlings in February and March 1991. The three plant spacing treatments being applied within each block are: 1 x 1 m (10,000 plants/ha), 2 x 2 m (2,500 plants/ha) and 3 x 3 m spacing (1,111 plants/ha). Every two months, data are collected on survival rate (mortality), plant height and crown diameter. Plant biomass was estimated from the regression between plant biomass, which ranged from 0.0018 to 2.9942 kg, and plant height and crown diameter, which ranged from 15 to 110 cm and 10.5 to 135 cm, respectively, ($P < 0.001$, $n = 27$, $r^2 = 0.90$).

Apart from ground cover, there were no statistically significant effects of plant spacing on the various parameters measured and estimated plant biomass. The expected trends, however, are sufficiently interesting to deserve comment (Table 3.12). Individual plant volume doubled, but plant volume per hectare decreased by about 75 percent, as plant density decreased from 10,000 to 1,111 plants per hectare. This resulted in a four-fold difference in individual plant biomass, much better ground cover and a higher

rainfall-use efficiency in closely spaced plants. Survival rate was similar across the spacing treatments.

Table 3.12. Plant dimensions, volume, biomass, ground cover, rainfall-use efficiency and survival at the November 1992 sampling, at three plant spacings (S) and two locations (L), AZRI and Karkassa

Plant spacing (m)	Sign. 1x1	2x2	3x3	SL	SED	
Plant height (cm)	58	62	67	10.3	ns	ns
Crown diameter (cm)	58	63	78	16.9	ns	ns
Plant volume (m ³)	0.11	0.16	0.24	0.104	ns	ns
Plant volume (m ³ /ha)	1065	409	268	268.3	ns	ns
Biomass (kg DM/ha/2 yrs) ¹	2922	1123	735	-	-	-
Ground cover (m ² /plant)	0.27	0.35	0.51	0.189	ns	ns
Ground cover (percent)	26.7	8.7	5.7	10.7	*	ns
Rainfall-use efficiency ²	4.18	1.61	1.05	-	-	-
Survival (percent)	95.1	95.0	90.6	2.79	ns	ns

¹Estimated from regression between biomass and plant volume.

²kg dry matter (DM)/mm rainfall/ha. Based on rainfall (698.6 mm) between October 1990 and October 1992.

In regions where rainfall is so low that efficient use of moisture is a priority, these preliminary results indicate that rainfall-use efficiency can be markedly improved by using close plant spacing. During the coming season, however, the effects of inter-plant competition should become apparent, especially in the closely spaced plants, which could make high plant density less attractive. Indeed, it is generally considered that a plant population of 1000 per hectare is closer to the level that allows persistency of the population. It is also unlikely that farmers will consider planting well over 1000 plants per hectare, because of the high costs involved. It is planned to graze half of each plot in 1993, so that the further development of both ungrazed and grazed plants can be studied. - **Principal investigator J. Afzal**

Grazing potential of saltbush

It is essential that grazing studies be conducted to investigate the carrying capacity of saltbush and its persistency. It can withstand moderate to heavy grazing pressure (Rumbaugh *et al.*, 1982), but, without suitable grazing management, sustained production is not maintained (Jefferies and Pitman, 1986). Utilization of saltbush by animals is generally recommended after 18 to 24 months of growth (Ueckert, 1985). The adoption potential, however, of saltbush is likely to be reduced if farmers have to wait this long. Therefore, some of the saltbush planted on farm land in March/April 1992 was grazed in December 1992. It remains to be seen how well the saltbush recovers.

A new grazing study on saltbush at AZRI, which also serves as a training exercise, is investigating the persistency, offtake and carrying capacity of saltbush under different grazing regimes. Since the study started late in the growing season, only a simple comparison was made between the potential of saltbush grazed in a continuous (set-stocked) and a deferred regime. The latter involved twice the grazing pressure as in the continuous regime, but for half the duration. Moreover, grazing in one of the deferred plots ended eight weeks before grazing in the other deferred plot and in the continuously grazed plot. This could affect the level of root reserves in plants entering the winter period and, ultimately, the persistency of the plants. The trial used Balochi and Harnai yearling rams. They were offered a basic diet of wheat straw, since it was anticipated that the saltbush alone could not maintain the liveweight of animals during the autumn period, when plant growth diminishes, owing to a lack of soil moisture.

Two adjacent blocks (replicates) of saltbush, one of 35 x 152 m and the other of 41 x 143 m, established in the early summer of 1987 at AZRI, were used. Each block was divided into three plots

and, starting in July, one plot in each block was grazed continuously by five sheep for 16 weeks, at a stocking rate of 28.3 sheep/ha. Grazing by 10 sheep in one of the other two plots in each block started on the same day and continued for eight weeks. The sheep were then moved to the other plot for eight weeks. Thus the mean stocking rate in these two plots was also 28.3 sheep/ha, but one was grazed later into the autumn than the other.

At the start of the study all leaves from seven plants in each plot were removed, weighed, and dried to determine biomass available at the start of the study. Eight plants in the continuously grazed plots were protected by 1.5 x 1.5 m cages and the biomass of leaves on them measured at the end of the study. The leaf biomass of other plants exposed to grazing in each plot was determined at the end of grazing. This made it possible to estimate the amount of leaf available at the start and end of grazing, and the amount apparently removed by the sheep. Plant height and crown diameter were also measured on 50% of the plants in each plot, before the start of grazing.

Sheep grazed from 8.00 to 12.00 h and were then returned to pens for water and chopped wheat straw, which was offered at a daily rate of 500 g/sheep. Samples of straw were taken for dry matter analysis. Sheep were weighed at the start of the trial and at weekly intervals afterwards, until the trial ended. It will continue in the spring of 1993, after plants have been pruned. The weight of the prunings will be measured.

The preliminary results from the trial are shown in Table R2. There are unlikely to be statistically significant differences between the two grazing regimes, with sheep in both treatments gaining 13 to 18 g daily. About 1100 kg dry matter (DM)/ha leaves were on offer at the start of the trial, and intakes of leaves and wheat straw were the same in the two treatments. Total intake was

about 20 g DM/kg liveweight or 47 g DM/kg metabolic body weight, which was higher than that of pen-fed sheep offered some wheat straw in the trial reported below (Table 3.13).

These results indicate that, in the autumn, sheep grazing saltbush need to be supplemented with wheat straw to allow modest liveweight gains. The saltbush could have provided a higher proportion of the diet at a lower stocking rate, but the duration of grazing would have been shorter. Currently, it is not known how farmers will manage their saltbush reserves and, therefore, it is important to expand the area and number of reserves on farms, so that these can be grazed. Meanwhile, grazing studies are needed, which will give researchers the information necessary to advise farmers on grazing regimes that allow good offtake from saltbush reserves, without jeopardizing the persistency of the plants.

Table 3.13. Grazing days, liveweights and average daily gains of sheep, grazing offtake of saltbush leaves, and intake of saltbush leaves and wheat straw in a continuous and deferred grazing regime.

	Continuous	Deferred
Initial liveweight (kg)	29.8	27.8
Final liveweight (kg)	31.8	29.3
Average daily gain (g)	18	13
Offtake of saltbush (kg/head)		
Initial Biomass	20.0	20.0
Final Biomass	2.8	3.0
Offtake	17.2	17.0
Intakes (g DM/day)		
- saltbush leaves	154	152
- straw	466	429
- total	620	581

Establishment of saltbush forage reserves on farms

The on-farm testing of a technology puts it to its greatest test, since, if it is not adopted by farmers, the preceding research is of little value. This is especially the case in developing countries, where the research resources of national programs are desperately low. For this reason, AZRI started establishing saltbush forage reserves in 1988 at Zarchi and Kovak. In 1990, it planted saltbush in the buffer zones of its water-harvesting trials and, in 1991, started inter-cropping studies at two sites in Spezand. No fencing is used at the sites established in 1991 and 1992, since the technology must succeed without it, and no rent is paid for the use of the land.

A new site, at Miangundi, was added in 1992. Since it is close to the main migration route of nomads, a guard is employed to protect the saltbushes from grazing. In late March/early April 1992, about 2000 seedlings were planted on sloping, deep soil, largely free of range vegetation. Ridges with 4 m spacing were prepared along the contour with a disc-plough and seedlings were planted on the uphill side of the ridge at 1 m intervals. A further 8000 seedlings were planted at the same intervals directly into 25 x 40 cm shallow pits on adjacent sloping rangeland, which supports a good stand of Artemisia maritima. The survival rate only of the plants is being monitored.

Approximately 100 mm rainfall fell in April, resulting in good plant establishment. Growth was better than expected and, by December, sheep and goats from local herds were allowed to graze the shrubs until most of the leaf had been removed. No record was taken of grazing days. Grazing was allowed because farmers are more likely to establish their own saltbush reserves if they can be grazed during the first winter. Whether saltbush can tolerate this grazing pressure is a subject for detailed studies: further forage reserves

will be established on farm land in 1993. - **AZRI Staff: B. Chaudhry (Extension Section), M. Islam (Agronomy Section)**

3.6 Characterization of year-round sheep feeding and grazing calendars of bedouin flocks in the NW Syrian steppe

Introduction

Economic and biophysical studies on livestock-pasture-cropping systems benefit from information on the local calendars of animal nutrition and production. This is particularly so where livestock are a main feature of the system, for example in understanding the management of flocks by agro-pastoralists or fully nomadic people (McIntire et al, 1992). Here we discuss the diet calendar results from a recent large survey of flock owners in the marginal dry farming and steppe areas of Syria, between the towns of Aleppo and Palmyra (see sampling groups 1, 2 and 3 in Figure 3.9). The results are compared with those of past surveys which focused detailed attention on the hand-fed portions of sheep diets. We also explain the need for detailed, year-round sheep feeding and grazing calendars, showing the feed sources appropriate for use in economic evaluations of improved pasture systems that provide grazing at certain times in the year.

Methods

The general sampling, interview, data summary and graphic presentation methods for sheep diet calendars are described elsewhere in this volume by Nordblom et al (1993a). Several points specific to our survey, completed in 1992, should be highlighted. It was a single-visit survey of 128 bedouin households in the winter and spring of the 1991/1992 season.

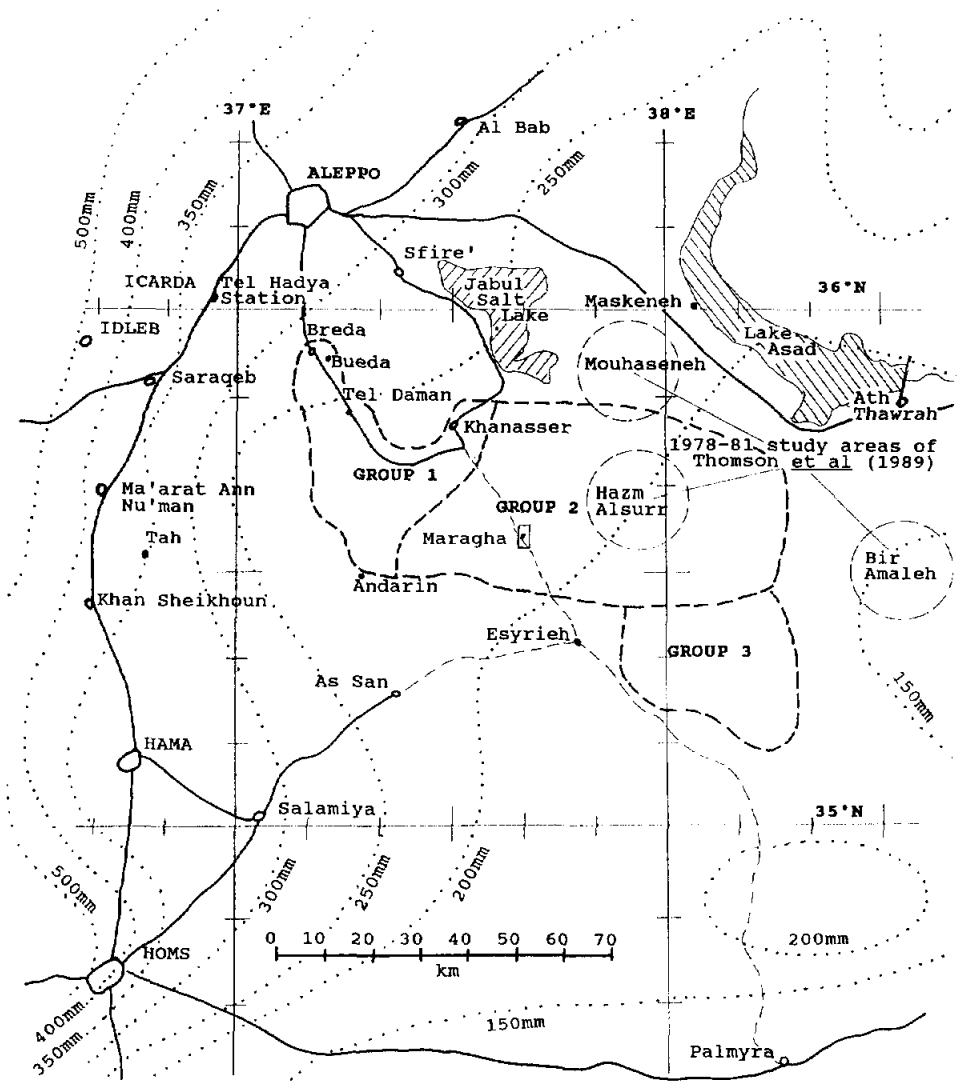


Figure 3.9. Groups of winter/spring sampling areas for survey of bedouin production systems in NW Syria: (1) sedentary agropastoralists, (2) semi-sedentary agropastoralists and (3) nomadic pastoralists.

These are defined in three groups (Figure 3.9): **Group 1** - Sedentary / semi-sedentary agro-pastoralists in marginal areas, including the villages of Breda, Bueda and Khanasser, on the edge of the steppe; 39 bedouin households owning flocks were interviewed.

Group 2 - Semi-sedentary agro-pastoralists cultivating barley and grazing their sheep in the steppe in winter and spring; 57 bedouin households with flocks were interviewed.

Group 3 - nomadic pastoralists grazing their sheep in the steppe in winter and spring, but grazing and feeding crop residues and by products from elsewhere for the remainder of the year; 32 bedouin households were interviewed. This group was omitted in the earlier surveys in the margins of the steppe reviewed below.

The map in Figure 3.9 shows the locations of the sample areas in relation to main towns, annual average precipitation isohyets and to the sites of other studies. The villages studied by Thomson *et al* (1989) are in the same area. Coordinates of main towns, roads, etc., follow GEOprojects (1987) map of the Syrian Arab Republic. One of the authors (Wachholtz) gave approximate boundaries of the three survey sampling groups. The isohyets were drawn from the Climatic Atlas of Syria (SAR, 1977). Coordinates of the Maragha station are from Takahata and Osman (1992).

The diet calendar questions were part of a questionnaire covering most aspects of bedouin livestock and crop production, including land tenure and access to grazing. A second round of interviews, focusing on productivity, marketing and gender roles, will be completed in 1993. Here we report only on the diet calendar results of the first round of interviews, finished in 1992.

In the livestock part of the questionnaire, several sets of questions were asked prior to those on month-by-month diet proportions. First came questions on flock inventories and changes in numbers in the year December 1990 to November 1991. Second were

questions on the annual patterns of flock movement and grazing and third on the total annual consumption of feeds from various sources, purchased, produced by household or grazed free of charge. These questions on inventories, movements and total feed use set the stage for those on month-by-month identification of feeds used and their proportions in the diet.

Results

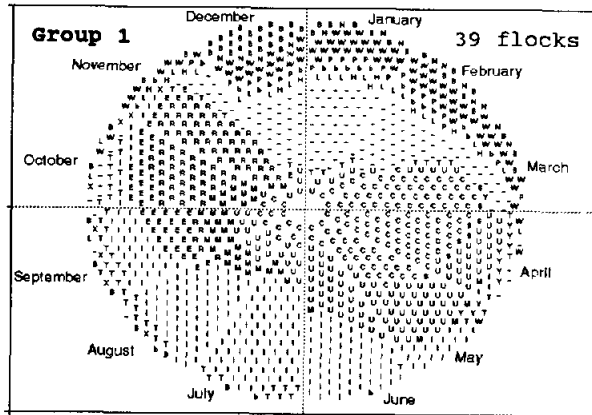
Detailed diet calendars for Group 1, Group 2 and Group 3 bedouin flocks are summarized in Tables 3.14, 3.15 and 3.16 respectively. Seventeen feedstuffs, which were reported only at trace levels, or for four months or less at the one-percent level, were left out of the summary tables. These minor feeds were: soybean residue, lathyrus straw, bran mixed with broken lentil or maize, soybean straw, turnip, bean straw, pressed grape residue, bean residue, sorghum seeds, medicago, maize seeds, wheat, broken wheat, lentil and broken lentil, and potato leaves. Feeds reported at levels higher than these by one or more of the three groups of bedouins, are listed separately in each of the tables (3.14, 3.15 and 3.16).

Data for feedstuffs recorded under 18 different names were combined under seven names to reduce the size of the tables:

<u>combined name</u>	<u>reported names</u>
barley, whole plant	<= barley whole + immature or green barley.
maize, whole plant	<= maize whole + immature maize.
sunflower residues	<= sunflower residues + s. straws + s. hulls.
melon residues	<= watermelon residue + melon residue.
orchard weeds	<= pomegranate orchard + weeds of orchard.
cotton residues	<= cotton residues + cotton res.
sugar beet residues	<= sugar beet + sb. tails, heads or stubbles.

In addition to the eight combined names shown above, 24 other, often more important, feeds are listed in the tables. This degree of detail may seem excessive until one considers two points: (1) such information is either not available or confounded by aggregation in reports from earlier studies, and (2) it is important to quantitatively document the diversity in sheep diets over the full course of a year, to know which are the appropriate substitute feeds for use in economic evaluations of pasture or diet improvement scenarios.

The detailed tables are most valuable for archival documentation which will allow different levels of aggregation for different subsequent uses. For better comprehension of annual diet calendars, a graphic display, such as that in Figure 3.10, is useful. In Figure 3.10, we have aggregated the 32 feeds in Tables 3.14, 3.15 and 3.16 into 18 classes of feeds and grazing sources and, through shading the grazed materials, into two classes, hand-fed and grazed. We have, for example, combined wheat and barley straws in the class of "cereal straws", grazing of unharvested wheat, barley and legume crops in the class of "unharvested crops", and grazing of several crop residues and weeds in the class of "other residues". Results in Tables 3.14, 3.15 and 3.16 show that wheat straw is never very important as a feed source in this study area, a barley/livestock zone. In contrast, wheat straw appears to be the single most important feed source for sheep, aside from wheat stubbles, in NE Syria (Nordblom et al, 1993b). Revealed in each of the summary tables, and in Figure 3.10, is a strong seasonality in diets, with major shifts into and out of the various components. The seasonal patterns show the bedouins' flexible use of a wide variety of hand-fed and grazed materials to feed sheep in the cheapest ways, but with obvious concern to provide adequate nutrition to match the annual reproductive cycle of their sheep.



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

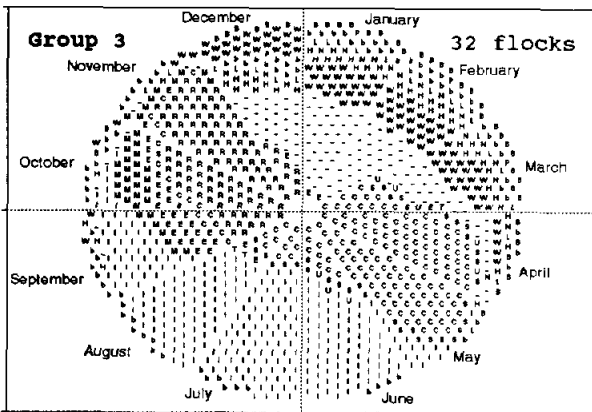
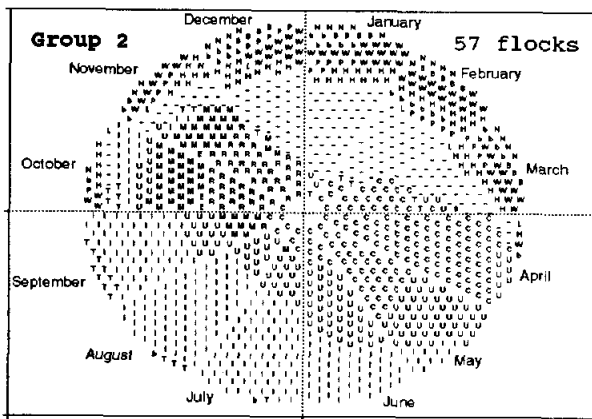


Figure 3.10. Sheep diet calendars for Bedouin groups 1, 2 and 3 in Aleppo and Hama Provinces, NW Syria: 1991/92 survey results.

Relatively expensive feed grains and other concentrates are hand-fed with chopped cereal and legume straws in the winter months, before and during lambing and early lactation. These feeds are not used in the summer months, when ewes are not lactating and are able to survive on cheaper crop residues.

Flock mobility makes these flexible diets possible. Sheep grazed crop residues, particularly cereal stubbles and cotton residues, in summer and autumn, and depended almost totally upon hand-fed feeds in the winter months of December, January and February. Only in March, April and May does grazing of native pastures provide significant proportions of sheep diets. While not every feed is used by all the flocks in a group, the largest feed proportions clearly identify major feed sources.

One or two flocks using a large amount of an unusual feed source would thus be reflected as a small proportion in the group average, just as if all flocks used small proportions of that source. This is an expected result of aggregation within a sample group which has diverse characteristics. The remedy is to distinguish clusters of bedouin households with like conditions and practices and repeat the diet calendar analysis for the clusters of main interest.

Comparisons with Past Studies

In January 1979, a 33-month-long study began, in which sheep husbandry practices of some 30 semi-sedentary agro-pastoral bedouin households at three sites in the cultivated margin of the NW Syrian steppe (Figure 3.9) were monitored on a monthly basis (Thomson et al, 1989; Bahhady, 1981). A number of households dropped out of the survey, owing to departure from the area, death of family head, unwillingness to cooperate, or other reasons, so that data from a total of 17 households were analyzed across years. The study provided benchmark data on feed production, sales, purchases,

stocks, etc., and many other bedouin production activities. Here we focus only on the study's results on use of feedstuffs. The percentages of various materials in the hand-fed part of winter diets, for three winters (1978/79, 1979/80 and 1980/81), are given in Table 3.17, based on feed-per-head data of Thomson et al (1989).

The monthly monitoring of practices over several years brought depth to the understanding of the agro-pastoral systems under investigation and identified large year-to-year and site-to-site variations in feed (Table 3.17) and, by implication, pasture conditions. Such variations were also documented in a survey by Nygaard et al (1982), covering 79 members and 14 directors of sheep and range cooperatives across seven provinces in Syria.

Results of Nygaard et al (1982) show that the length of the period during which sheep were hand-fed varied between provinces, rainfall zones within provinces, and between years: a five-province average for cooperative members in the dry cropping zones was 4.7 months in the winter of 1977/78 and 6.4 months in 1978/79; four-province averages in the steppe (rangeland) zones were 5.6 and 7.5 months for the two winters, respectively. Longer periods of hand-feeding were associated with poorer dryland crops and shorter range-grazing seasons, and vice versa. Members of cooperatives in the dry cropping zones expected 3.8 months of range-grazing in a good year, 2.4 months in an average year and 1.4 months in a poor year. Those based in the steppe rangelands expected 5.0, 3.4 and 2.0 months of grazing, respectively. Insufficient details are given to evaluate the importance of grazing in the remaining months of the year, except to remark that crop residues were used, chiefly those of cereal crops.

A third survey was carried out in 1984/85, 1985/86 and 1986/87, in conjunction with on-farm trials of vetch, pea and lathyrus forage

Table 3.17. Hand-fed feedstuffs in winter diets of sheep in flocks of semi-sedentary agro-pastoralists, according to early multiple-visit surveys in NW Syria.

Components	percent compositions of hand-fed materials								
	winter totals for three seasons in the steppe and on its margins, from Thomson, <i>et al</i> (1989)			typical-month levels in a dry farming area near the steppe (Breda/Bueda), from Jaubert and Oglah (1985)					
	1/			2/					
	78/79	79/80	80/81	Nov/Dec	Jan	Feb	Mar	Apr	
Cereal straw	50.0	38.4	38.1	.	.	.	.	.	
Barley straw	.	.	.	50.0	43.0	44.6	38.0	.	
wheat straw	.	.	.	3.0	.	.	.	.	
Lathyrus straw	.	.	.	3.0	6.5	0.4	6.0	.	
Barley grain	23.5	18.8	30.9	36.0	36.0	35.2	39.0	56.0	
Lathyrus grain	.	.	.	.	0.3	1.0	.	.	
Wheat bran	3.1	3.6	4.2	3.0	4.5	7.4	3.4	44.0	
Cottonseed	0.9	5.1	3.6	.	.	.	.	.	
Cottonseed cake	7.9	5.8	4.8	3.0	4.5	8.0	6.6	.	
Cottonseed hull	4.9	5.8	4.8	0.7	2.6	.	.	.	
Sugar beet pulp	6.2	14.5	10.7	1.3	2.6	3.4	7.0	.	
other feeds 3/	3.5	8.0	3.0	.	.	.	.	.	
Hand-fed diet	100	100	100	100	100	100	100	100	

Sources

1/ Thomson, Bahhady and Martin (1989) p. 88. cf Table 2.

2/ Jaubert and Oglah (1985) p. 47. cf Table 1.

3/ other feeds: compound, wheat grain, bread flour, sorghum grain, lentil straw, and bread.

crops with phosphate fertilizers in the Breda/Bueda area (Thomson *et al*, 1992), within what we now define as our Group 1 sampling area (Figure 3.9). The area supports dryland barley cultivation and grazing by sedentary and semi-sedentary agro-pastoralists (Jaubert

and Oglah, 1985 and 1987; Thomson et al, 1985; Maerz, 1990). Repeated visits to sample farmers over the three year period made possible the accurate recording of winter feeding patterns. The hand-fed diets recorded by Jaubert and Oglah (1985) are expressed on a monthly basis in Table 3.17. Again, little quantitative information is available on the sources of spring, summer and autumn grazing; as in the other studies, detailed data are only given on the hand-fed part of sheep diets.

The multi-year monitoring studies (Thomson et al 1989; Jaubert and Oglah, 1985) gave each farm household the virtual status of a case study and gave the opportunity to follow up with new questions and to resolve discrepancies in understanding. Where on-farm trials are being carried out, repeat visits are needed and a concurrent monitoring survey is cost-effective.

Our Group 1 sampling area overlaps the Breda/Bueda sub-area which was the focus of field work and surveys by Jaubert and Oglah (1985, 1987) and the 1986 survey of Maerz (1990). Our Group 2 sampling area overlaps the 1979-81 survey area of Thomson et al (1989), but includes none of the bedouins who participated in that survey; the latter are the subject of a follow-up multi-visit survey by Marina Leybourne in ICARDA's Farm Resource Management Program (Leybourne, 1992a, 1992b). Full nomads in our Group 3 sampling area were not represented in the other studies.

Our results are generally consistent with reports of earlier studies, showing the importance of hand-fed supplementary feeds from December through March (Jaubert and Oglah, 1985, 1987; Thomson, 1987; Thomson and Bahhady, 1983a, 1983b; Thomson et al, 1985; and Thomson et al, 1989; Nygaard et al, 1982; Tully, 1984). Barley straw was an important ingredient in the winter diets of all three groups in our 1990/91 survey. It comprised over 40 percent of the December, January and February diets for sheep of Group 2, the semi-

sedentary agro-pastoralists of the steppe (Table 3.15). This is comparable with the three-year average of 42 percent cereal straw recorded by Thomson *et al* (1989) in winter sheep diets among similar bedouin households (Table 3.17).

Our survey indicates greater proportions of wheat bran than barley grain in winter sheep diets (except in December 1990 by Group 1, Table 3.14). This conflicts with all earlier studies, but may be explained by the government's release of large stocks of cheap wheat bran during that winter. Coincidentally, barley prices were quite high, owing to the dry 1989/90 growing season. Normally, such quantities of wheat bran would not be available and this level of substitution of wheat bran for barley is thought to be temporary.

Other minor components of winter diets were reported in all the surveys; sugar beet pulp, cottonseed (whole, cake and hulls), wheat straws and legume straws. Bread was reported as a minor feed by Thomson *et al* (1989) and by bedouins in our survey: never more than 12 percent in a few months for Group 3 (Table 3.16).

Among the Group 1 households in our survey, (Table 3.14), use of barley straw was lower by several percentage points than reported in the same area by Jaubert and Oglah (1985) for the December - March period (Table 3.17). The two surveys agree that barley grain and wheat bran comprised roughly equal proportions of the hand-fed part of the diet in April. Our survey shows, however, that each comprised only about two percent of the diet. The rest of the diet was mainly from grazing standing barley crops (26%) and native pastures (52%).

A difference in the two surveys is seen in November: Jaubert and Oglah (1985) reported that sheep were hand-fed virtually their entire diet, while our survey estimated 50% of the Group 1 sheep diet was from grazing of cotton residues and another 15% from other crop residues (Table 3.14). This difference could be due to an expansion in cotton cultivation in nearby districts over the seven

years between the surveys; it is also within the normal range of year-to-year variations as quantified by Nygaard *et al*, (1982) and Jaubert and Oglah (1985).

Jaubert and Oglah (1985) found that bedouin farmers consider wheat straw to be of lower quality than barley straw which they collect and store for winter feeding; wheat stubbles are mainly used in summer and early autumn grazing. These observations on timing of use are confirmed and quantified in our survey of Group 1 bedouins in the 1990/91 season. Wheat stubble grazing in this area (Table 3.14) was reported to provide greater proportions of summer and early autumn grazing than barley stubble. Low amounts of wheat straw in winter diets, at three to four percent levels, are shown by both surveys (Tables 3.14 & 3.17).

Results of our survey in the Group 3 sampling area (Table 3.16) are thought to provide the first quantification of year-round sheep diet calendars for the fully nomadic bedouin flocks. These people have no crops and are on the move through much of the year, following the feed. The general logic and patterns of nomadic flock movements have been described by Bahhady (1981) and Chatty (1986) and are consistent with those found in the new survey.

An important difference can be noted between diets of the fully nomadic flocks (Table 3.16) and those of the sedentary and semi-sedentary agro-pastoralists (Tables 3.14 and 3.15), in the grazing of whole barley plants. This was a very minor part of the nomadic flock diet, but was a major feed source for bedouins growing barley for their own sheep (Group 1 and Group 2). The grazing of standing barley crops in lieu of harvesting has been well documented (Nordblom, 1983a, 1983b; Mazid and Hallajian, 1983; Somel *et al*, 1984; Tully, 1984), but this finding that fully nomadic flocks make little use of this source, is new.

Grazing of native pastures (mountain, village/site and open

steppe) was concentrated chiefly in March, April and May of the dry 1990/91 season. This made up a relatively minor proportion of the annual sheep diets of the three sampling groups: 12, 13 and 18 percent for the agro-pastoral Groups 1 and 2 (Tables 3.14 and 3.15) and nomadic Group 3 (Table 3.16), respectively. These are, perhaps, the first quantitative estimates of native pasture contributions from recent years in Syria. They reflect the extent to which native pastures have decreased their contribution to sheep diets since the 1950's, when little, if any, winter supplement feed was used (Bahhady, 1981; Chatty, 1986; Lewis, 1987).

It is remarkable that native pastures in open-access steppe areas provide such a small proportion of the reported annual sheep diets, less than one percent for the agro-pastoralists' flocks and only three percent for the nomadic flocks. Of secondary importance was native pasture grazing in mountain areas with higher rainfall. More important are the village grazing areas in the dry farming zones and grazing areas in the steppe, where native pastures are used in common by local bedouin households, but less by outsiders' flocks. There are indications, however, that outsiders' flocks may enter these areas after the local bedouins have moved their flocks away to higher rainfall zones in spring or summer. This raises serious questions about the economic viability of rangeland improvements where access is uncontrolled for any part of the year.

The distinction between open-access grazing and common grazing is recognized (Bromley and Cernea, 1989). Our survey suggests that full, open-access, grazing is of little importance in terms of quantities of feed contributed, although the land areas so used may be quite large. The best grazing lands appear now to have been claimed by barley cultivation and the settlements of agro-pastoralists, with little feed left over for scavenging flocks when the home flocks depart for better seasonal pastures.

The feed calendars (Tables 3.14, 3.15 and 3.16) represent a particular year (1990/91). Patterns will vary from year to year according to weather, crop and rangeland productivity, and price and availability of other feeds. Thomson *et al* (1989) demonstrated large year-to-year differences in winter diet compositions (Table 3.17), attributing these to differences in weather. Likewise, Jaubert and Oglah (1985) and Cooper *et al* (1987) reported effects of the 1983/84 drought, which forced changes from the normal calendar: extended use of supplementary feeds, reduced use of native grazing, earlier and increased grazing of standing barley crops, and earlier movement of flocks to higher rainfall areas. It is clear that demand for the various feed and grazing sources varies from year to year according to the weather, crop areas sown, and sheep and grain prices (Mona, 1986).

Conclusions

The sheep diet calendars generated from single-visit surveys of large numbers of bedouin households match reasonably well with those obtained through multiple-visit surveys in the same areas. The latter have provided quantitative estimates of quantities and proportions within the hand-fed parts of the diets, but none of proportions in the diet from the various grazing sources. The timing and importance of grazed feeds in the diet should be understood by those wishing to improve sheep diets and grazing resources.

Bedouins have been able to locate and use available grazing resources and cheap feeds through the annual cycle of cropping and breeding seasons. This is to be taken into account in proposing and evaluating possible alternative grazing or feed sources. The principle of "opportunity cost", the price of the cheapest substitute feed at a given moment, becomes useful only when one is aware of the options facing the bedouins. The rapid survey technique

provides a way to quantitatively assess such options and understand their relative importance to livestock owners.

From early summer through early winter, grazed residues of dryland and irrigated crops provide much more feed than spring use of native pastures in the study area (Tables 3.14, 3.15 and 3.16; Figure 3.10). These crop residues are the cheapest sources of nutrition when native pastures have dried up. This raises questions about the appropriate time of use for any improved pasture and, especially, about the value of the feed it provides at a particular time of the year. The cheapest available substitute for pasture at a given time will provide the appropriate economic value to use for pasture offtake at that time. The same principle holds for improved pastures, (1) sown in rotation with crops, (2) on non-arable lands in the cropping zones, and (3) on rangelands. For example, in the evaluation of summer grazing provided by experimental shrub plantations, the appropriate substitute feed cost would be that of cereal stubble and not barley grain.

Our detailed quantifications of spring, summer and autumn grazing patterns show the ability of bedouins to make use of many seasonally available crop residues and by-products. These are substitute feeds which must be considered in any economic evaluation of improved pastures. The issue of sustainability of substitute feed sources is of concern, since feeds and grazing sources which appear cheapest in the short run, (eg. from barley cultivation in the steppe), may lead to loss of native vegetation and of soil in the longer run. - R. Wachholtz, T.L. Nordblom and G. Arab

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Table 3.14. 1990-1991 Sheep feed and grazing calendar for Group 1, sedentary and semi-sedentary agro-pastoralists in a dry farming area of NW Syria (summary of 39 flock-owners' estimates on percentage compositions of monthly diets).

Description	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
HAND-FED MATERIALS												
barley straw	30	37	34	20	2	+	+	+	1	2	5	13
wheat straw	3	3	4	1	.	.	.	.	.	.	.	+
lentil straw	4	5	4	2	1	1	+	+	+	1	2	3
chickpea straw	.	.	.	.	.	.	.	.	.	.	2	2
wheat bran	18	22	20	11	2	1	.	.	.	.	2	7
barley grain	25	7	7	3	+	.	.	1	2	3	2	2
sugar beet pulp	5	7	6	2	+	.	+	+	+	.	+	1
bread	4	5	5	2	+	+	1	1	1	.	+	3
cotton seeds	2	2	2	1	+	+	.	.	.	.	.	.
cotton seed cake	2	2	2	1	+	+	.	.	.	.	+	+
cotton seed hull	2	3	2	1	+	+	.	.	.	.	+	3
cotton residue (bagged)	.	.	.	.	.	.	.	.	.	.	+	+
peanut residue	.	.	.	.	.	.	.	.	1	3	.	.
GRAZED MATERIALS												
native past, mountain	.	.	.	.	17	13	4	.	.	.	.	..
native past, vill/site	.	.	.	5	27	34	22	3	3	3	4	3.
native past, steppe	.	.	.	2	5	1	.	.	.	.	.	.
barley stubble	.	.	.	.	3	12	33	33	26	12	4	3
wheat stubble	.	.	.	.	.	5	27	42	38	19	3	.
maize stubble	.	.	.	.	.	.	1	4	6	12	9	2
barley, whole plant	3	2	4	5	26	45	32	6	6	6	1	1
wheat, whole plant	.	+	.	.	1	1	1	1	.	.	.	.
maize, whole plant	.	.	.	.	1	3	.	.	3	.	1	.
cotton residue (grazed)	.	.	.	.	.	.	.	1	4	37	50	.
sunflower residues	.	.	.	.	.	.	+	+	1	8	10	3
melon residues	1	+	.	.	.	.	.	.	1	13	7	3
fallow land	.	.	.	1	7	3	.	.	.	.	.	.
sugar beet residue	1	1	1	1	.	.	1	6	6	2	.	+
vegetable residue	.	.	1	3	3	2	.	1	1	4	3	2
orchard weeds	.	.	.	.	.	.	.	1	1	3	3	.
onion and onion residue	.	.	.	1	.	.	.	.	1	+	3	11
weeds of irrigated land	.	.	.	.	.	.	.	.	1	3	.	.
Atriplex	.	.	.	.	.	.	.	.	.	.	.	.
MONTHLY TOTAL (%)	100	100	100	100	100	100	100	100	100	100	100	100

Note for Table 3.14.

Percentages greater than or equal to 0.5 were rounded up to the nearest whole number those less than 0.5 are shown as traces (+), cases where no one reported use of a feed are shown as a point (.).

Due to rounding error and unlisted minor feeds (see test for these), values may not total exactly 100 percent.

Table 3.15. 1990-1991 Sheep feed and grazing calendar for Group 2, semi-sedentary agro-pastoralists in the NW Syrian steppe (summary of 57 flock-owners' estimates on percentage compositions of monthly diets).

Description	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
HAND-FED MATERIALS												
barley straw.....	40	45	43	32	4	.	.	.	.	.	5	18
wheat straw.....	1	1	1	.	.	.	.	.	.	.	.	.
lentil straw.....	+	+	1	1	+	.	.	.	.	.	+	1
chickpea straw.....	.	.	.	.	.	.	.	.	.	.	.	+
wheat bran.....	14	17	16	12	1	.	.	.	.	+	3	8
barley grain.....	4	4	5	3	+	.	+	+	.	.	+	1
sugar beet pulp.....	5	6	5	4	+	.	.	.	.	.	1	4
bread.....	6	6	6	5	+	.	.	1	1	.	1	2
cotton seeds.....	+	1	1	1	+	.	.	.	.	.	.	+
cotton seed cake.....	3	4	4	3	+	.	.	.	.	.	+	+
cotton seed hull.....	4	4	4	3	+	.	.	.	.	.	1	2
cotton residue (bagged).....	9	9	8	8	1	.	.	.	.	.	4	7
peanut residue.....	.	.	.	.	.	.	.	.	.	.	.	.
GRAZED MATERIALS												
native past, mountain...	.	.	4	9	15	7	.	.	.	.	.	.
native past, vill/site..	.	.	.	13	69	29	7	3	2	2	+	.
native past, steppe.....	.	.	+	.	.	.	.	.	.	.	.	.
barley stubble.....	.	.	.	.	.	11	38	56	61	49	15	4
wheat stubble.....	.	.	.	.	.	2	14	23	21	13	3	+
maize stubble.....	3	+	.	.	.	.	.	1	.	9	28	20
barley, whole plant.....	.	2	+	3	8	50	40	14	12	15	11	2
wheat, whole plant.....	.	.	.	.	.	+	1	+	+	+	+	.
maize, whole plant.....	.	.	.	.	.	.	.	.	.	.	.	.
cotton residue (grazed).....	8	.	.	.	.	.	.	.	.	1	19	26
sunflower residues.....	.	.	.	.	.	.	.	.	.	+	1	1
melon residues.....	.	.	.	.	.	.	.	.	.	+	1	.
fallow land.....	.	.	.	.	.	.	.	.	.	.	.	.
sugar beet residue.....	1	1	2	2	.	.	.	+	+	6	1	1
vegetable residue.....	.	.	.	.	.	.	.	+	2	1	+	.
orchard weeds.....	.	.	.	.	.	.	.	.	.	1	2	.
onion and onion residue.....	.	.	.	.	.	.	.	.	.	+	+	1
weeds of irrigated land.....	.	.	.	.	.	.	.	.	.	.	.	.
Atriplex.....	.	.	.	.	.	.	.	.	.	2	1	.
TOTAL (%)	100	100	100	100	100	100	100	100	100	100	100	100

Note for Table 3.14.

Percentages greater than or equal to 0.5 were rounded up to the nearest whole number those less than 0.5 are shown as traces (+), cases where no one reported use of a feed are shown as a point (.).

Due to rounding error and unlisted minor feeds (see test for for these), values may not total exactly 100 percent.

Table 3.16. 1990-1991 Sheep feed and grazing calendar for Group 3, fully nomadic pastoralists based in the Syrian steppe (summary of 32 flock-owners' estimates on percentage compositions of monthly diets).

Description	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
HAND-FED MATERIALS												
barley straw.....	20	23	23	16	7	+	.	.	.	1	2	2
wheat straw.....	9	10	9	6	5	.	.	.	.	1	2	2
lentil straw.....	5	5	5	4	2	1	+	+	+	+	+	2
chickpea straw.....	.	.	.	.	.	.	.	.	.	.	.	.
wheat bran.....	24	25	25	23	5	1	1	.	.	2	2	3
barley grain.....	6	8	8	8	5	1	.	+	+	.	2	.
sugar beet pulp.....	1	1	1	1	+	+	.	.	.	.	.	.
bread.....	11	12	12	7	3	2	4	6	8	8	8	7
cotton seeds.....	+	1	1	1	1	.	.	.	.	.	.	.
cotton seed cake.....	3	3	4	3	1	+	.	.	.	.	.	.
cotton seed hull.....	3	4	4	3	1	+	.	.	.	.	.	.
cotton residue (bagged).....	7	7	7	6	2	1	.	.	.	3	1	1
peanut residue.....	.	.	.	.	.	.	.	.	.	.	.	.
GRAZED MATERIALS												
native past, mount.	.	.	.	2	2	.	.	.	.	.	.	.
native past, vill/site..	.	.	.	10	57	65	9	6	6	6	6	5
native past, steppe.....	.	.	.	5	7	12	5	3	3	.	2	.
barley stubble.....	.	.	.	.	.	12	53	56	52	31	7	.
wheat stubble.....	.	.	.	.	.	3	25	28	28	13	2	.
maize stubble.....	.	.	.	.	.	.	.	.	.	7	23	9
barley, whole plant.....	.	.	.	3	2	.	3	.	.	.	.	.
wheat, whole plant.....	.	.	.	.	.	.	.	.	.	.	.	.
maize, whole plant.....	.	.	.	.	.	.	.	.	.	.	.	.
cotton residues.....	8	.	.	.	.	.	.	.	.	12	35	67
sunflower residues.....	1	1	1	1	.	.	.	.	2	3	7	2
melon residues.....	.	.	.	.	.	.	.	.	.	13	2	.
fallow land.....	.	.	.	.	.	.	.	.	.	.	.	.
sugar beet residue.....	.	.	.	1	.	.	.	.	2	.	.	.
vegetable residue.....	.	.	.	.	.	.	.	.	.	.	.	.
orchard weeds.....	.	.	.	.	.	.	.	.	.	.	.	.
onion and onion residue.....	.	.	.	.	.	.	.	.	.	.	.	.
weeds of irrigated land.....	.	.	.	.	.	.	.	.	.	.	.	.
Atriplex.....	.	.	.	.	.	.	.	.	.	.	.	.
TOTAL (%)	100	100	100	100	100	100	100	100	100	100	100	100

Note for Table 3.14.

Percentages greater than or equal to 0.5 were rounded up to the nearest whole number those less than 0.5 are shown as traces (+), cases where no one reported use of a feed are shown as a point (.). Due to rounding error and unlisted minor feeds (see test for for these), values may not total exactly 100 percent.

3.7 Evaluation of natural populations of medic rhizobia in the highlands of Turkey

As cereal-legume integrated systems have been considered recently for introduction into the highlands of west Asia, the Ministry of Agriculture and Rural Affairs of Turkey has requested a collaborative investigation into interactive factors of the environment, rhizobia and medic host, to determine the necessity for the inoculation of medics in the highlands. The scope of the project has also been expanded to include chickpeas, lentils and Vicia, in a joint project with the Legume Program. This investigation will also provide valuable information on the relationship between the indigenous populations of soil rhizobia, and the environment and soil characteristics.

To date, a total of 105 soil samples has been collected from the first 0-20 cm portion of the profile, placed in thick plastic bags and sealed tightly to reduce the chance of cross contamination. Sampling sites were selected to be within 10 km of meteorological stations with long-term temperature, rainfall, elevation, latitude and longitude records of data of the area. The soil samples have been analyzed by the Soil and Fertilizer Research Institute of Ankara. The chemical characteristics included pH, CaCO_3 , P_2O_5 , K_2O , organic matter content and total salts. Following chemical analysis, the samples were sent to ICARDA and kept refrigerated for further analysis. The soils are currently being used for the enumeration of medic rhizobia, expressed as the number of viable rhizobia per gram of soil. The system of enumeration is a statistical procedure based on the presence of nodules induced by the last rhizobial cell present at the extinction dilution level of the soil. Four medic species (M. rigidula, M. noeana, M. aculeata and M. minima) are used as 'trap species' and will also reflect whether the rhizobia in the soil are compatible, for symbiosis or effective association with the host for nitrogen fixation. If the level of symbiosis is high and produces effective nodulation then we may infer that the region

where the soil sample was taken requires no inoculation for that particular host. If the plant produces parasitic nodulation, then the medic rhizobia in the soil are considered ineffective and agronomists and extensionists will be warned of the need to inoculate or change the medic for a more compatible one to avoid nodulation failure. Preliminary results have indicated that the soils contain bacteria which are both compatible and incompatible in forming effective nodulation in either species of medics. It has also been found that a proportion of rhizobia produced effective nodulation in both species of annual medics.

Data will be subjected to multivariate analysis and will be fully presented in the next annual report. Using the same samples and approach, we will attempt to evaluate clovers and Lathyrus. This investigation will be expanded to the highlands of other countries within the ICARDA region, providing cooperation for soil sampling and analysis is available. - L. Materon and D. Keatinge.

3.8 Rangeland resource evaluation for conservation and management

Introduction

Ecosystems found in many dryland environments are susceptible to human impact, e.g., grazing, cultivation and fuel harvesting. Because of the pressure of increase in human population, the degradation of natural resources, such as soils and vegetation, prevails.

There is a lack of geographical information on natural resources, especially on their degradation, and a corresponding lack of geographically specific identification of natural resources problems, especially on the subject of land use and management. This limits the ability of policy makers, land planners and land users to coordinate immediate and long-term measures to protect resources from over-exploitation and to facilitate sustainable land use.

Evaluation of natural resources in the context of land productivity versus degradation risk enables guidelines to be made available prioritising to scientists and land planners for research, fine-tuning land use policy, and planning sustainable land use.

Cartographic presentation of land productivity and the risk of degradation can enhance understanding of the magnitude of the problems. For such purposes, maps are better than presentation by text and tables. Technological evolution of remote sensing and geographical information systems (GIS) has improved satellite images. Both technologies have outstanding advantages in their cartographic presentation: clear and precise positioning, the facility for merging both satellite images and digitized maps, and for incorporating modelling with many parameters for predictive scenarios with various combinations of factors.

The Land Resource Evaluation Project

The development of sustainable dryland management relies heavily on the availability of basic information on current resources and the assessment of agricultural potential.

Rangeland resource conservation and management can be assisted by the provision of map information on natural resources.

Project components

The land resource project falls into two major sub-projects over two years, 1992/1993, within the framework of the cooperative project between ICARDA and TARC, on the development of sustainable rangeland management in WANA.

1. **Sub-project 1** is based on collaborative research activities with the General Organization of Remote Sensing (GORS), the Syrian Government and SMAAR's Soil Directorate on land resource evaluation of Jabal Abdel-Aziz, using a feasibility study

conducted in 1989 and an aerial photosurvey conducted in 1981, on which the 1:25,000 scale topography maps of the area are based. This study also aims to demonstrate that land evaluation is possible, using remote sensing and GIS.

2. **Sub-project 2** highlights the history of barley cultivation encroachment in the steppe, using sequential satellite images and early aerial photographs to analyze land use changes. For the aerial photo analysis and field survey, collaboration between GORS and ICARDA is necessary.

Rangeland resource evaluation study of Jabal Abdel-Aziz

The objectives of this study are to identify the resources of an area in thematic maps of vegetation, soil, hydrology, topography, etc., and to classify each land unit, based on soil, topography and vegetation, by level of degradation, productivity and potential use.

Methods

1. Acquisition of maps (base maps and thematic maps derived from the 1989 study) and early aerial photographs taken in 1981.
2. Interpretation of aerial photographs to produce a preliminary survey map.
3. Land degradation survey and delineation of a degradation status map.
4. Satellite image analysis (classification of vegetation types and land use) and field survey for land characteristics such as soil, vegetation, land use, stoniness, slopes, etc.
5. Assessment and classification of each land unit according to agricultural use, i.e., grazing, horticulture or cropping.
6. Definition of decision-making processes on land use/protection according to local experience.

7. GIS analysis, using derived decision processes and delineation of land resource management maps for the test area.

The geographical location of the test zone is shown in Figure 3.11. Selected areas in aerial photographs taken in 1981 which cover the central part of Jabal Abdel-Aziz, (Figure 3.12), were interpreted visually by stereoscope to detect drainage patterns, roads, settlements (Figure 3.13), and classified for level and type of soil degradation (Figure 3.14).

Several reconnaissance surveys were made to check the general trends in topography, soils, vegetation and soil degradation.

The project is expected to produce:

- An inventory of natural resources.
- Two thematic maps on land productivity and degradation risk.
- A resource management (land use and conservation) map, essential for planning improvements in land use.
- A demonstration of the projected land evaluation approach, using remote sensing and GIS.
- A pilot project to apply GIS methods and appraisal to other areas of west Asia and north Africa.

History of the encroachment of barley cultivation on rangelands:

The objective of this study is to provide basic information for resource enhancement/degradation studies by examining the development of barley cultivation in part of the Syrian rangeland, relating it to socioeconomic factors and soil degradation and using multiscale remote sensing and GIS.

A part of this study might be incorporated into a proposed research activity on the sustainable development of dry areas in Syria and into a project, using remote sensing to identify detailed land use changes and their relationship with climatic and socioeconomic factors. The study area will be southeast of Aleppo and north of Palmyra, in a region that has experienced

drastic land use change in the last forty years, from tribal grazing to open grazing and barley cultivation, and where socioeconomic studies are currently being carried out in conjunction with rangeland experiments.

The study consists of the following activities.

1. Acquisition of early aerial photographs of the region and identification of the steppe/cultivation lines at that time.
2. Assessment of changes in land use in a time series using Landsat MSS images and delineation of a barley cultivation development map in the region.
3. Satellite image analysis on vehicle tracks, settlements, wells and cisterns.
4. Assessment of detailed changes in land use in small areas of rangeland or cultivation, using recent Landsat TM images.
5. Analysis of the relationship between changes in land use, climatic and socioeconomic factors.

Expected outputs from the study are:

- A series of small-scale maps of cultivated areas and steppe, projecting a whole transect of the test fields.
- Sequential cultivation/steppe patterns in a GIS time series representing a shift in land use.
- A clear understanding of both small and large scale changes in land use in relation to climatic and socio-economic factors. - **H. Fujita, T. Nordblom and G. Gintzburger**

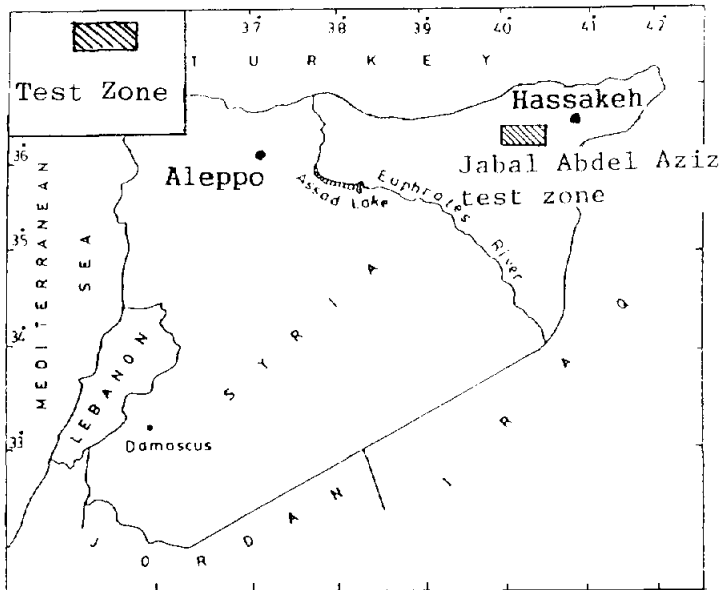


Figure 3.11. Geographical location of test zone

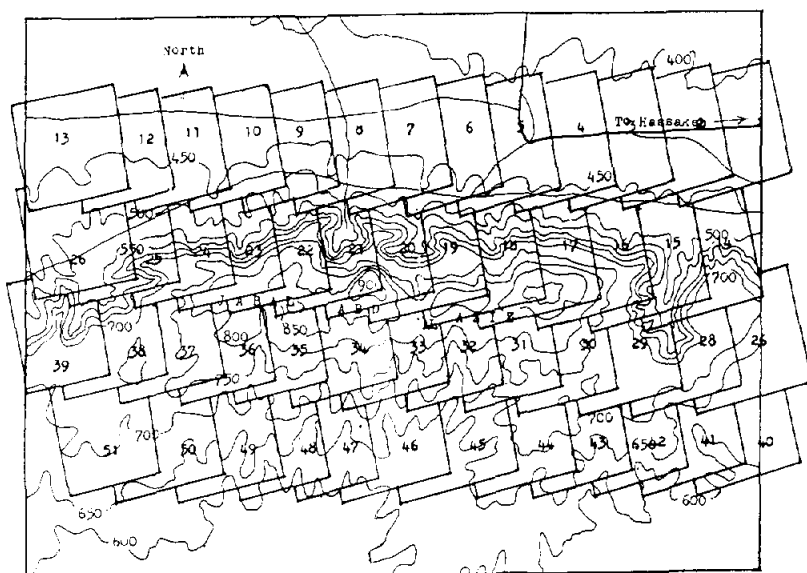


Figure 3.12. Aerial photograph index on topographical map.

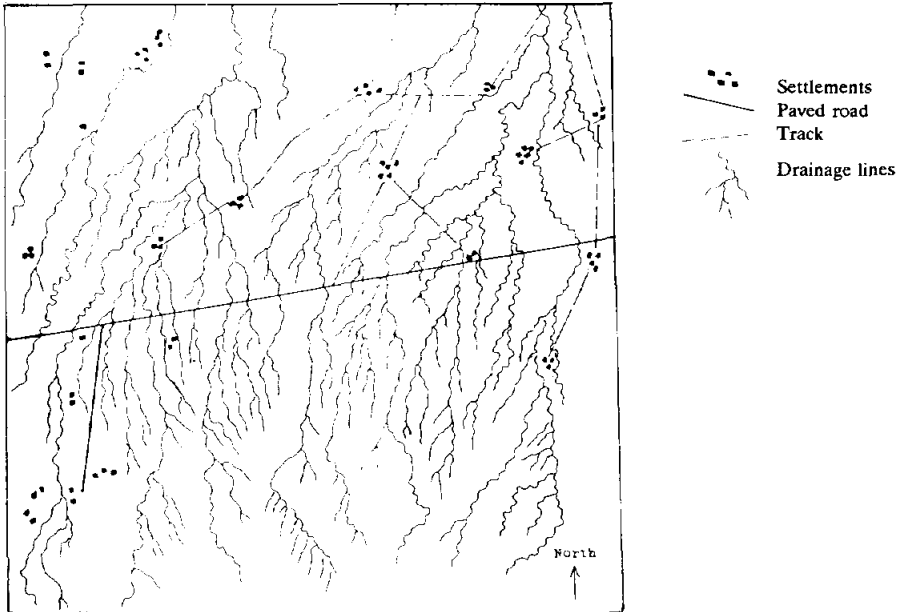
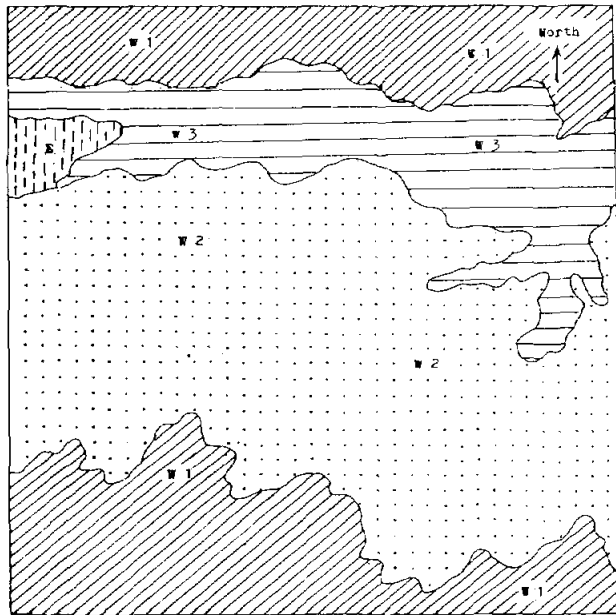


Figure 3.13. Topo-base thematic map as interpreted from aerial photo No.1 shown in Figure 3.12



- W 1 = Low degradation (Water erosion)
 W 2 = Medium degradation
 W 3 = High degradation
 E = Wind degradation (Eolian erosion)

Figure 3.14. Soil degradation thematic map as interpreted from aerial photo No.16 shown in Figure 3.12

Section IV Economic analysis: The Whole Farm Model 1992

The first economic analysis of medic pasture in WANA

Sown pastures of self regenerating medic (Medicago spp., collected from the WANA region) have been grown in rotation with cereal crops on a wide scale in South and Western Australia since the 1940's. Attempts to transfer Australian ley-farming (pasture-cereal) techniques to the WANA region have been made since the 1960's with little permanent success.

Reasons offered by technical scientists include lack of adapted species, poor nodulation, poor management (especially of grazing management and tillage), inadequate research into the components of the system, and into the system as a whole.

Until now, there has been no comprehensive investigation into the economics of ley farming at any site in the WANA region, because of a lack of reliable field and livestock data on the comparative performance of the pasture-cereal system and traditional rainfed crop rotations. ICARDA has made breakthroughs recently on both these crucial points (reliable systems data and economic analysis) and in finding solutions to some of the technical problems.

How it was done

A large field trial was established at ICARDA's Tel Hadya Station, near Aleppo, in the 1985/86 season. Besides medic-wheat, four traditional two-year crop rotations with wheat were studied: lentil, watermelon, fallow and vetch. Results from the first six years of the trial provided yield and pasture offtake data as the physical basis for the first whole-farm economic analysis of the pasture-cereal system anywhere in the region. Average wheat grain yields were highest (about 2.1 t/ha) after watermelon or fallow, and about 500 kg/ha lower after lentil or vetch; a further 200 kg/ha reduction was associated with medic pasture, due, apparently, to greater water use in the pasture phase of the

rotation.

In the trial, local farming practices were followed for the traditional crop rotations. Accurate records of grazing days from the trial were used in the economic analysis, together with local information on seasonal sheep diets, management and productivity. Farm and market surveys provided appropriate production cost and price data, as well as information on family labor and land availability. Farms in this part of Syria are very small by Australian standards: over 50% have 20 ha or less. The economic analysis considered family farm sizes of 16, 32 and 64 ha in a whole-farm optimization model. The economic analysis determined **whole farm income**: returns to family land, labor, capital and management, above family subsistence expenses and net of all costs of material inputs and hired labor.

Results for a spot in NW Syria

Results across all three farm sizes (Figure 4.1a) show that the medic-wheat rotation does not compete well with any of the traditional rotations in terms of whole farm income, given the standard price relationships holding for the trial period (1985-91). Rotations with labor intensive crops (lentil and watermelon) are dominant, both in the results of the economic model and in the neighborhood of the study site. The low wheat yields associated with medic pasture, and the rather low pasture offtake levels in terms of grazing days, are causes for concern.

The question of how far wheat yields and pasture productivity would have to improve, before the medic-wheat system became competitive with traditional crop rotations, was answered through a sensitivity analysis which considered increments of grain yield and pasture offtake (Figure 4.1a). In the case of the small (16 ha) farms, grain yields would have to increase by 600 kg/ha **and** pasture offtake increase to double (200%) the levels found in the trial, before medic-wheat became more profitable than the best of the traditional rotations, lentil-wheat.

For 64 ha farms, however, a 600 kg/ha increase in grain yield alone would be sufficient, with no need for increased pasture offtake, for medic-wheat to give the highest whole-farm income. On the other hand, a 50% increase in pasture offtake accompanied by a 400 kg/ha boost in wheat grain yields would have a similar effect (see Figure 4.1a). These results present a considerable challenge for biologists in terms of plant productivity increases. Further, the results enable us to predict that few if any farmers facing prices and growing conditions similar to those depicted in the model will wish to adopt the medic-wheat system. But these conditions are unlikely to hold for all farms, in all other farming districts of Syria or other countries of the region, or for all future years.

Examples with higher labor costs and lower straw sales prices

Under conditions as shown in Figure 4.1b) where hired labor costs are doubled, from about 2 to 4 USD/day, where there is no opportunity for off-farm work for family labor and straw prices are halved (approximating to the case of Syrian farms distant from main population centers), medic pasture becomes competitive on larger farms (64 ha), but remains the poorest option on small farms (16 ha). Sensitivity analysis shows that smaller productivity increases are needed for medic-wheat to be the best economic choice on 32 and 64 ha farms: either a 200 kg/ha increase in wheat grain yield **or** a 50% increase in pasture offtake (Figure 3.16). An in-between combination would have the same effect.

Wheat grain prices were nearly double the world market price in the study period (Figures 3.15, 3.16). This places a premium on crop rotations giving the highest grain yields and penalizes those, like medic-wheat, with lower grain yields. Whether the current level of grain price subsidy is maintained is a complex question. The subsidies are tied to land reforms and aimed at encouraging farmers with small land holdings. Such questions are

strictly the domain of the national authorities.

Targets

Productivity-increase targets for the medic-wheat rotation are functions of input and output prices (eg. for labor and straw), but prices will vary from location to location, and particularly from country to country, as will the relative performance of different crop rotations or crop-pasture systems. This is why the results presented here cannot be said to represent the WANA region as a whole. They do, however, confirm that economic arguments will have a role in explaining or predicting the adoption of new practices.

It should be mentioned that, to date, no Syrian farmer has been able to buy seed of locally adapted medic; none has been released and none has been tried by farmers on an economically viable scale. Remedies for these and other technical problems have been identified and are being pursued in collaboration with NARS of Syria, Morocco and Algeria. For example, locally adapted lines and mixes of medic seed have now been identified in each of these countries and large-scale on-farm trials are in various stages of progress.

The economic model can be used for other locations, given appropriate adjustments in yields, prices and other parameters. Detailed documentation of the model and the economic results presented here are provided in Nordblom et al. (1992). - **T. Nordblom, S. Christiansen, N. Nersoyan, F. Bahhady (PFLP) and D. Pannell, University of Western Australia**

Reference

- Nordblom, T.L., S. Christiansen, N. Nersoyan and F. Bahhady.
1992. A whole-farm model for economic analysis of medic pasture and other dryland crops in two-year rotations with wheat in northwest Syria. ICARDA-066. ICARDA, Aleppo. 100 pp.

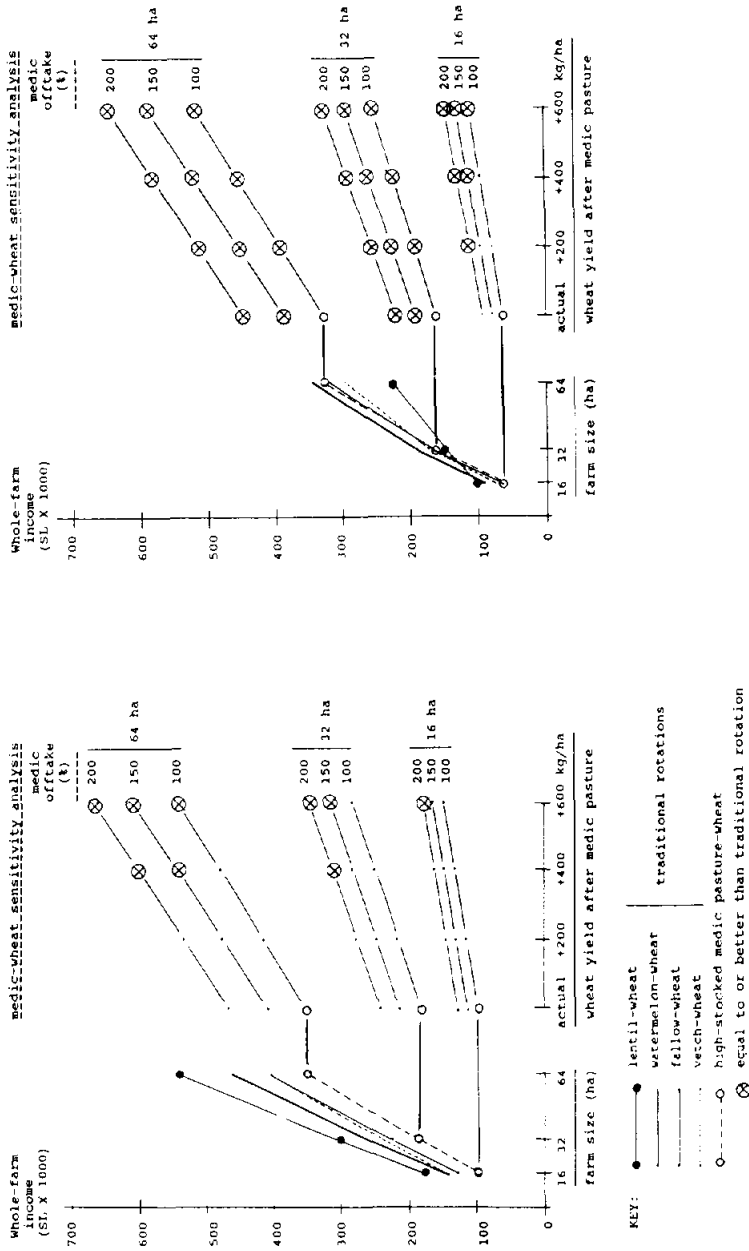


Figure 4.1 a & b Whole-farm income comparisons of five crop rotations, with sensitivity analysis on medic pasture and wheat grain productivity: a) under standard price assumptions, and b) with doubled wages of hired labor, half price for straw sales and no off-farm work opportunities for family members.

Section V Outreach and Networking

5.1 INONET: Inoculation network experiments

An international series of experiments is necessary in order to understand the interaction of rhizobial strain, medic species, and environment. Without such a series, recommendations emanating from Tel Hadya are likely to be misleading when applied, for example, in the highlands of Algeria or Turkey. Such an international network will also increase awareness in national programs of possible inoculation problems in pasture and forage legumes.

The International Inoculation Network (INONET) has been operating since 1986, following a recommendation on regional need-to-inoculate experiments from a workshop organized by ICARDA and UNDP. The objectives of INONET are to form closer links between national programs and to use the limited resources available to microbiologists as efficiently as possible. The network also enables ICARDA to evaluate its strains throughout west Asia and north Africa. Furthermore, it will help spread information on how to conduct research on strain selection, host specificity, inoculant production, seed inoculation, and other related topics.

As an example of the activities conducted through the network this year, we report on one experiment, conducted with the Ministry of Agriculture at El-Khroub Experimental Station in Algeria, information from which our colleagues from the Institut Technologique des Grandes Cultures (ITGC) have allowed us to use for statistical analysis and interpretation. A similar experiment was conducted at Setif Experimental Station, but results are not presented in this report.

The objective of the trials was to determine whether ICARDA selected medic strains of Rhizobium meliloti were superior in fixing nitrogen and contributing to higher biomass production than the indigenous rhizobia present in the soils at both

locations. Another objective tests the null hypothesis of no specificity between the medic species and their rhizobial partner. In addition, potentially important annual medic species, both those imported from Syria and some Algerian ecotypes, were selected at El-Khroub for each of the locations, and ICARDA supplied the strains of medic rhizobia in peat bags. The peat inoculants had a concentration of approximately one thousand million rhizobia per gram. The results of the trial are briefly summarized as follows:

The experiment was conducted at El-Khroub Experiment Station in northern Algeria, east of the city of Constantine. Three local medic species (*M. aculeata*, *M. ciliaris* sel 80 and *M. scutellata*) and three Syrian medic species (*M. rigidula* sel 716, *M. noeana* sel 2351, *M. rotata* sel 2123) were inoculated with *Rhizobium meliloti* strains ICARDA M3, M15, M29 and M53. Gum cellulose was used as the sticker ingredient in the slurry. Uninoculated treatments, with and without mineral nitrogen fertilization, were also included. It was assumed that the indigenous populations would fully nodulate those plants in the uninoculated controls and partially nodulate, depending on their ability to compete, those originating from inoculated seed. The experiment consisted of a split-split plot design with three replications. The main plots were inoculation treatments and the subplots were assigned to medic species. The size of the plots was 3.0 x 0.7 m, with four linear rows in each plot. The experiment was planted on 3/11/91 and samples for herbage and nodulation analysis were taken on 10/3/92 (data on harvest was not provided). The accumulated precipitation at planting time was 88.3 mm. Five plants were collected from each plot and assessed for quantity and quality of nodulation, and for herbage production after flowering.

Results from the analysis of variance on the split-plot model indicated that no significant differences ($P>0.05$) in herbage yield production were detected among all the inoculation

treatments within each medic species, when compared to those plants nodulated with the indigenous rhizobia. Marked differences among the means of herbage yields of medic species were detected ($P < 0.0001$), but this was due to the intrinsic genetic characters of the plants. A significant variability between the three blocks ($P < 0.0055$), and a high coefficient of variability (39.3%) showed that a more rigorous experimental protocol should have been implemented for this trial. Furthermore, statistical precision was concentrated on the subplots (species) instead of the inoculation treatments.

When data were analyzed by species in a randomized complete block (RCB) design, the null hypothesis on the equality of the herbage means was tested, using a different statistical model from the split plot design. In doing so, significant interactions between the species and inoculation treatments became evident. Results however, should be treated with caution. Orthogonal comparisons detected that *M. ciliata* responded positively to inoculation with strain ICARDA M15, *M. rigidula* with strains ICARDA M3 and ICARDA M29, and *M. rotata* with strain ICARDA M3. Experimentation on annual medic-rhizobial strain specificity and inoculation response will be conducted in the Algerian highlands to test the effect of low temperature. - **M.S. Mellouhi, K. Feliachi and L. Materon**

5.2 Dryland Pasture and Forage Legume Network Coordination Meeting for the Highlands Subregion, 20-22 October 1992, Ankara, Turkey. The University of Ankara, the Turkish national program and ICARDA hosted the meeting.

The group made progress in organizing the priorities of highland research among ICARDA's pasture, forage, livestock and crop researchers and their national counterparts in the countries of Turkey, Pakistan and Iran.

The meeting concluded with the evident desire of all participants for additional active collaboration within the context of a project called RANGELAND REGENERATION IN THE HIGHLANDS. It was envisaged that the Network could eventually expand to other countries with similar ecological conditions. Strengthening of links between countries and organizations was seen as a major impact of the Network.

Below is a summary of the final session.

Synthesis of concluding discussion

RANGELAND REGENERATION IN THE HIGHLANDS was the title given to describe the focus of collaborative research projects to be supported by the national committees of Turkey, Iran, Pakistan and ICARDA. Improved forage production was recommended as an additional priority area. It was felt, however, that National Agricultural Research Systems (NARS) were already making a large contribution to forage production research while support for rangeland research in the region was urgently needed.

We attempted to define a framework for future work that was sufficiently broad to accommodate the interests of all three countries. Attention was given to strategic areas of work where ICARDA has experience and can best complement the national programs. RANGELAND REGENERATION IN THE HIGHLANDS, as a theme, was divided into the following parts:

1. Socio-economic and/or policy research
2. Germplasm resources
3. Seed production
4. Revegetation methods and techniques
5. Management of revegetated areas
6. Livestock feeding

The complexity of the problems associated with improving animal feed supplies in a sustainable manner and in avoiding the abuse of environmental resources was evident from all participating countries. Thus, the need for research with a strong interdisciplinary systems approach was recommended.

The Network participants indicated that there was ample scope for, and a strong desire to implement, international collaborative research in highland areas on animal feed from forage, pasture and range sources. Each country agreed to submit a short proposal concerned with one or more of the topics listed. ICARDA's job will be to identify common themes that can be used in project proposals. If we make a successful start from a simple set of complementary activities in each of the three countries it will be easier to broaden our effort within each country and expand the work to other highland countries of West Asia and North Africa. - S. Christiansen, G. Gintzburger, N. Nersoyan and D. Keatinge

5.3 A project for improved integration of sheep, cereal and pasture in rainfed farming systems of north Africa

Introduction: The goal of this project is to provide recommendations based on economic analysis for the selection of profitable dryland rotations by north African farmers who raise sheep and cereal. In this project, ICARDA's collaboration in north Africa bridges the National Agricultural Research Systems (NARS) of Morocco and Algeria. North African NARS are ready to undertake systems-oriented research and ICARDA's research programs have experience directly related to the task.

This proposal of NARS and ICARDA in the Maghreb provides links that cut across national boundaries. Project activities in Morocco are based on the production of pasture legume seeds outside the commercial seed sector. Researchers will benefit because they need enough seed to sow pastures that can be realistically compared with other forms of land use.

An on-station wheat based rotation trial has begun in Algeria, where enough locally adapted seed was produced in 1991 so that a pasture treatment could be compared to other crops in rotation with wheat: clean fallow, weedy fallow, wheat after wheat, vetch/oats forage mixture, chickpeas and medic. The medic and weedy fallow pastures are grazed by Ouled Djellal sheep. The experiment is planned to last for 8 years.

This project began with cooperation among north African NARS and ICARDA and was recently supported with funding by the French Government.

Pasture seed production in Morocco: Millions of hectares of north Africa are degraded and the majority of this land is not cultivated because rainfall is too low or the soil too rocky for crops. These areas have traditionally served to feed a large portion of the region's livestock, which generate about 30-40% of the region's agricultural income. For the marginal lands in arable zones and rangelands, virtually no local seed production capability exists for reseeding degraded sites.

Pasture species for use in rotations with cereal crops are virtually unknown because of the lack of seed, and imported seed has been ill-suited for much of the region.

The objective is to develop a practical method of producing and harvesting at least one ton of pasture legume seed per seed processing unit per year, using small-scale machinery, namely a seed/pod collector, thresher and scarifier. These units are designed to be managed by groups of farmers or researchers. Two processing centers will be started in the first year of the

project.

Guidelines for the study: project outputs would include a manual of recommendations for land preparation, seed crop agronomy, fertilization, weed control, machine maintenance, pre-harvest field preparation, harvest and storage techniques. Farmer cooperatives will be provided with machines, adapted pasture germplasm and training on how to produce their own seed and how to use it in reseeding operations or rotations.

This is a cooperative project between ICARDA, INRA, IAV-HII, MARA/DPV, and MARA/SE.

Crop rotation studies in Algeria: The objective of this project is to introduce legumes and provide sheep and cereal farmers with economic comparisons for selection of dryland crop and fodder rotations in Algeria. The project is divided into two four-year-long phases, at El Khroub Research Station in northeastern Algeria, in a rainfall zone of approximately 400 mm.

Medic research in Algeria began in the 1970's with the selection of locally adapted genotypes. During the 1980's, local medics were collected and evaluated in collaboration with ICARDA and French scientists; then, in the 1990's, several ecotypes were increased by ITGC-Guelma and ICARDA. This provided seed for inclusion of medic in the rotation experiment.

Many of the local farming districts are considered to have conditions similar to El-Khroub. The Wilayate surrounding the project site include Mila, Constantine, Guelma, Oum El Bouaghi, Tebessa, Khenchela and Batna. Relatively unproductive weedy fallow occupies about 460 thousand ha or about 32% of this area. It is a traditional practice to graze the weedy fallow. Often the fallow fields contain a diversity of adapted annual legume germplasm. Therefore, we wish to use phosphate fertilizer and grazing management to stimulate the native legume component of weedy fallows. Water relations, nitrogen cycling and changes in organic matter status of the soil will be monitored in the medic

and weedy fallow pastures and the results will be compared with results obtained from the continuous wheat, clean fallow, forage mixture and chickpea.

It is estimated that there are 15 million sheep in Algeria, with 2 million in the project zone. After harvest of cereals it is hypothesized that sheep numbers double because graziers come from other regions to graze their livestock on cereal stubble. This project seeks to quantify sheep performance, using the pasture and cereal portions of the medic and weedy fallow rotations with wheat. We will measure sheep meat production, supplemental feed consumed, ewe fertility, lambs weaned and duration of grazing.

Monitoring of market data and conduct of farm surveys in the zone will provide the data necessary to analyze the trial, make recommendations to farmers and classify farms for extension of results. ICARDA has developed a method for analyzing the profitability of rotation systems by combining market prices and production costs from farmers with controlled on-station experimental data. Linear programming techniques can then be used to provide a profit ranking of rotations. The effects of changes in labor costs, grain prices, farm size, etc can also be tested.

This is a cooperative project, that includes, at this time, ITGC, ITEBO and ICARDA (PFLP, FRMP). Other organizations are expected to cooperate in future. - S. Christiansen and G. Gintzburger

Section VI Technology transfer, extension and training

6.1 Pasture legume pod sweeper is ready for production

For the past three years, ICARDA has been developing a simple but robust pasture 'seed sweeper' that can be used in village, or researcher, seed increase programs. Diagrams will be available, so that if farmers or NARS find the machine useful they may make the machines locally.

Most of the forage and pasture legume researchers in the region are working with plants they collected and evaluated themselves, which may exhibit excellent performance in terms of herbage and seed production. The seed production bottleneck posed by increasing several grams or a kilo of seed up to the quantities needed to sow a pasture has been difficult to overcome until now.

The pod sweeper, which has no engine, is pushed by hand. A brush assembly, rotating about a horizontal axis against the direction of travel, sweeps light materials from the soil surface into a removable catch basket. When attention is paid to land preparation the sweeper can collect pods very efficiently. For example, last summer, two teen-age girls at the Qatanieh State Farm, in northeast Syria, swept up almost a ton of pods in two weeks on a 2 ha field that was fairly well leveled. Lines of promising germplasm can be grown in strips, separated by cereals, to prevent the mixing of seeds, on a prepared field, to achieve a much greater harvest efficiency.

One advantage of this machine to farmers is that they can sow pods directly, thus minimizing the risks associated with the establishment year of a pasture. Each medic pod, for example, is Mother Nature's equivalent to a 'Jiffy Pot' -- the peat pots used in greenhouses to establish seedlings. They absorb water, provide insulation from the elements and give a cozy niche for the Rhizobium needed to inoculate the legume seedling.

Pods of Medicago rigidula, for example, contain about 30%

seed by weight. Newly produced seed is approximately 95% impermeable to water (hardseeded) in the first autumn after the seed is formed. This means that, when 100 kg/ha of pods are broadcast and barley sown over it, only about 3 kg of the medic seed in pods will germinate to compete with the barley. With the barley crop eventually ripened and harvested, medic pods on and in the soil will be exposed to fluctuating summer temperatures, creating a further softening of the seed in the pod. When rains begin in the autumn, another 20% of the medic seed can be expected to germinate, i.e., almost 6 kg/ha, which should be nearly adequate as a seeding rate for pasture establishment under normal conditions. Current work is focusing on the quantity of pods actually needed to establish a reasonably dense pasture.

- S. Christiansen and P. Eichhorn

6.2 Training and Technology Transfer

Training and technology transfer are seen as vital mechanisms for:

a) Improving the ability of scientists and technicians in the national agricultural research programs in the region to conduct independent and collaborative research into the rapidly changing needs of their country or region. b) Increasing their technical knowledge and skills, so that they can identify and overcome constraints on pasture, forage and livestock production. c) Helping them understand the process of technology transfer and how farmers reach the decision to adopt or reject new technologies. PFLP focuses its training efforts on relevant and practical courses linked to its research projects and activities, which are used as working demonstrations.

During 1991/92, PFLP staff were involved in training 60 participants, from different WANA countries, on a variety of research activities summarized by projects in Table 6.1, and outlined in subsequent sections.

Table 6.1. Training activities related to PFLP research projects, 1992.

Title	No of participant	Country
Small ruminant production and management		
1. Straw digestibility	1	SYR
2. On-farm forage and grazing trials at al-Bab.	1	SYR
3. Animal nutrition.	1	SYR
4. Animal nutrition (MSc & PhD).	2	ICARDA
Sown pasture and forage production		
1. Food and forage legume harvest mechanization.	12	WANA
2. Pasture and forage legumes.	12	WANA
3. Medic seed harvest.	3	ALG/SYR
Native pastures and rangelands		
1. Pasture, range and livestock.	7	MOR/SYR LIB
2. Rehabilitating marginal land and steppe.	1	SYR
3. Marginal land development (MSc & PhD)	2	SYR
Other activities		
1. Training on survey techniques.	8	SYR
2. Economics (1PhD, 2MScs, 1Diploma).	4	GER/SYR
3. Computer applications.	6	SYR/LIB
Total	60	

Group training

Headquarter courses

In-country courses

Individual training

Specialized short courses

Non degree related training

Research fellowships

Senior research fellowships

Degree related

Other activities

Postdoctoral fellowships

Field days in Lebanon

Field visit.

Assessment of training needs

The production of training materials

Group training

Headquarters courses

Food and forage legume harvest mechanization course. This short course was conducted jointly by the Legume Program (LP) and PFLP at Tel Hadya from 10 to 22 May 1992, and included lecturers from the Farm Resource Management Program (FRMP) and Station Operations (SO). It was attended by 12 participants from Iraq (Abdul Zahra Mohsin Shai), Pakistan (Mohamed Ali Akbar), Cyprus (George Angelis Alexandrou), Iran (Abbas Moradi, Manuchehr Massahi, Manuchehr Salimi Ashtiani, Hossain Sabghpoor, Galal Rastegar, and Hasan Ali Abedi) and Syria (Khaled Omar Sali, Mohamed Ahmed Hindawi, and Fayez Farhan Al-Anbar). The purpose of the course was to demonstrate systems of legume production and mechanization and included both lectures and practical sessions related to harvest machinery, such as mowers (self-propelled and tractor-drawn), combine harvesters and a lentil puller. Lectures were focused on the following topics: mechanization of harvesting of different legumes, breeding, agronomy, seed-bed preparation, economics, and techniques for interviewing farmers and for on-farm trials. In addition, trainees explained legume production and mechanization in their own countries.

Pasture and forage legume course. This course was conducted at Tel Hadya from 20 April to 3 May 1992, and attended by 12 participants from: Algeria (Meriem Mantoliche, Korichi Mohamed Larbi and Sonia Hamrit), Lebanon (Ahmed Kobaissi and George Malouf), Libya (Soliman A. Abdul Khader), Syria (Halim Ammuo, Ahmed Mohamed Ahmed, Ahmed Itah, Ghiris Eldin Jazey, and Sufian Sleibi) and Tunisia (Mohamed Dhaoui). The course dealt with

germplasm conservation (collection, identification, evaluation and documentation), resource management, grazing management, pasture ecology, seed bank sampling, seed multiplication harvest and processing, surveys and economics, livestock management and nutrition, and nitrogen cycling and fixation. The course program also included visits to research projects at Breda, Teh, and Al-Bab. This was the first time that an integrated pasture and forage legume training course had been offered by ICARDA. It was organized by PFLP in collaboration with Genetic Resources Unit (GRU) staff.

In-country courses

Survey of livestock feeding systems in Hassakeh province. This short training course, held in Tel Hadya from 20 to 25 June, was offered to eight collaborators (Meheyden El-Hammoud, Hisham Heiyo, Jamal El-Saleh, Mohamed Qarmo, Abderaouf Ramadan, Jassem El-Kassem, Radwan Daoud and Elias Baho) from Hassakeh province, Syria, on conducting a survey of livestock feeding systems in that province. Topics discussed included survey objectives, random sampling of villages, definition of interview schedules and team responsibilities, development and pretesting of questionnaires, definition of other information needs, and coordination of data.

Individual training

Specialized short courses

Range and pasture management. A short course on range and pasture management was held at Tel Hadya from 19 to 30 April 1992. One Moroccan (Khalooki Lrabi Omar), three Libyans (Ali Yousef Abo-Hamid, Ahmed Shimakhi and Mohamed Al-Idrissi), one Turk (Suliman El-Abuikar), and two Syrians (Kareem Diaoub and Faisal Hinedy Al-saleh) attended. The emphasis was on practical management aspects of the marginal land project at Tel Hadya and the shrub utilization project at Maragha. Plant identification, grazing and

livestock management, supplementary feeding and animal nutrition were also covered.

Data management and computer applications. Three Libyans and two Syrians who participated in the Range and Pasture Management course continued on two weeks training on computer softwares, including MS-DOS, LOTUS, Harvard Graphics and MSTAT-C.

Computer applications for livestock economics. A Sudanese (M. Ahmed Abdul-Gabbar), from the Department of Planning and Agricultural Economics at the Rahad Agricultural Corporation, received four weeks individual training in August on computer applications for livestock economics. He worked on data entry and analysis of the PFLP/SMAAR survey of 215 farmers in Hassakeh province.

Straw digestibility. This specialized individual training was offered to a Syrian researcher (Ali Badran), from 2 February to 31 March 1992, and concentrated on the effect of processing methods on the nutritive value of barley straw and the interactions between particle size (chopped or coarsely milled) and chemical treatment (ammonia derived from urea).

Medic seed harvest. An Algerian (Mohamed Zighem) and a Syrian (Ghiris Eldin Jazey) attended this practical short course, from 5-16 July, at the state farm in Qahtanieh, 30 km east of Kamishly, in Hassakeh province, on medic seed increase inside and outside Tel Hadya. Twenty hectares of medic fields were harvested, using the Horwood-Bagshaw vacuum harvester.

Non degree related training

Research fellowships

On-farm forage and grazing trials at Al-Bab. This six months fellowship was granted to a Syrian researcher (Mohamed ali

Nahhas) for training on the following: 1) Recording information on crop yields, soil fertility, and sheep performance. 2) Investigating the effect of the preceding forage crop on the subsequent barley yield, and the effect of nitrogen fertilizer on barley yield. 3) Analyzing data and writing a final report.

Animal nutrition. A nine months research fellowship was given to another Syrian (Omar Ankouz) to undertake a research experiment on the effect of mineral supplements on intake of barley straw and the growth of Awassi lambs. Different mineral supplements were studied, blood and faeces samples were collected for analysis, and statistical analyses were made.

Senior research fellowships

Rehabilitating marginal land and steppe. From 2 February to 31 October 1992, a Syrian researcher (Marwan Abo-Shalah) with the Steppe Directorate, was granted this senior fellowship to review the literature on rehabilitating marginal land and steppe in Syria. His main focus was on the use of edible shrubs and, more specifically, the economic costs of direct seeding as opposed to transplantation. The study included data from Aleppo, Hama, Homs, Hassakeh, and Deir Ezzor provinces. At Adhami nursery, near Maragha, in Aleppo province, the cost of growing Atriplex or Salsola and the total cost of establishing shrubs by transplanting were estimated and compared with the costs of direct sowing.

Degree related

During 1991/92, PFLP continued to attract postgraduate students for theses research projects. Currently, the program scientists are supervising 6 theses; 3 Ph.Ds, and 3 M.Sc.s. 4 students, 1 Ph.D, 2 M.Sc.s and 1 diploma, completed their studies during 1992 (Table 6.2).

This type of training, supported by ICARDA's Graduate Research

Training Program (GRTP) and other funding sources, is expected to increase: PFLP has received several requests from Sudan, Syria, Algeria and Morocco. PFLP is also seeking special funding to support two members of staff for M.Sc's on animal nutrition and applied plant taxonomy.

Other activities

Post-doctoral fellows. Post-doctoral fellows, from both inside and outside the WANA region, carried out research, using ICARDA's facilities and in collaboration with PFLP staff. During 1992, a post-doctoral fellow (Dr Peter White) conducted research on nitrogen cycling (soil/animals). Another (Aletor Valentine) completed work on the evaluation of Lathyrus and Vicia species seeds for anti-nutritional factors, including tannins, trypsin inhibitors and the neurotoxin B-N-oxalyamino-L-alanine (BOAA).

Field days in Lebanon. On 6-7 May, two field days were organized in Hermel and Qah, for 24 farmers, local television staff, journalists, and municipal leaders. The objective of this activity was to draw farmers' attention to the use of shrubs, especially Atriplex, in addition to pasture plants such as medics and clovers.

Field visit. This one day visit was organized for 15 Syrians from the Steppe Directorate to acquaint them with the program activities, especially on a practical and integrated approach to pasture, forage and livestock management.

Assessment of training needs

Assessment of needs can define training goals, priorities, topics and materials. A previous, preliminary, attempt was made within PFLP concerning ley farming systems. The current survey study, organized by the program Training Scientist, is dealing with all PFLP research projects: small ruminant production and management,

sown pasture and forage production, native pastures and rangelands as well as other cross-disciplinary activities such as agroenvironmental land resource evaluation and conservation, socioeconomic studies and microbiology and nitrogen fixation. It involves two groups: NARSS (real needs), and PFILP scientists (perceived needs). Arabic and English versions of the questionnaire were tested in 1992.

Preliminary results from NARSS in Tunisia, Algeria, and Morocco showed that seed production and processing, germplasm enhancement, range and pasture management, and feeding quality analysis received high demand ratings. Edible shrubs, pasture and forage rotations with cereals and microbiology were in medium demand. On-farm livestock trials, resource evaluation by aerial photography, pasture phosphate application, mechanical harvesting of forage legumes, sheep management and nutrition, farm economics and surveys, and internal and blood parasites were in low demand. Further studies with other NARSS of the WANA region will be conducted.

The production of training materials

Lecture notes on different aspects related to sown forages and pastures have been produced on the following topics: 1) Germplasm collection, characterization and documentation. 2) Isolation, manipulation and application of Rhizobium. 3) Contribution of Pasture and Forage Legumes to the N Nutrition of Cereals. 4) Ecological factors influencing management of pastures. 5) Pasture and crop management. 6) Forage legumes. 7) Technology transfer and extension. 8) Medic seed production. 9) Harvesting of medic seed. Materials on other topics are in the course of preparation.

W. Sarraj

Table 6.2. Degree related training in PFLP, 1992.

Name	Topic	Country	Degree	University	Up to
S. Nasser	crop/livestock systems in Hassakeh	Syria	M.Sc	Damascus, Syria	Oct93
S. Rihawi	Animal nutrition	Syria	Ph.D	Reading, UK	1994
R. Wachholtz	Economics	Germany	Ph.D	Hohenheim, Germany	Apr 93
G. Khattach	Marginal land	Syria	Ph.D	Giessen, Germany	Jul 93
S. Filo	Animal nutrition	Syria	M.Sc	Aleppo, Syria	1993
A. Pape	Economics	Germany	M.Sc	Hohenheim, Germany	Apr 93
A. Haloubi	Marginal land Development	Syria	M.Sc	Aleppo, Syria	1992
K. Heylen	Economics	Germany	Diploma	Leipzig, Germany	Dec 92
E. Carter	Animal nutrition	English	Ph.D	Reading, UK	Oct 92
N. Lahrash	Microbiology	Morocco	M.Sc	Moulay Ismail, Morocco	June 92
F. Ghassali	Marginal land	Syria	M.Sc	Amman, Jordan	Postponed

Staff List

Gustave Gintzburger	Program Leader (appointed September 1992)
Zuka Mousattat	Secretary
Sonia Noaman	Secretary
Kamal Kaddah	Technician
Wahid Hamo	Technician (resigned December 1992)

Improvement of small ruminant production

Timothy Treacher	Livestock Scientist (Acting PL May 1991-March 1992)
Anthony Goodchild	Ruminant Nutritionist
Hiroaki Nishikawa	Veterinary Consultant, (JICA-Japan)
Massimo Giangaspero	FAO Consultant (August 1992)
Faik Bahhady	Asst. Livestock Scientist
Sadallah Filo	Research Assistant
Hisham Hreitani	Research Technician
Adnan Termanini	Research Assistant
Abdul Karim Ferdawi	Research Assistant
Safouh Rihawi	Research Associate
Ibrahim Saeed	Research Assistant
Mohamed Heilani	Technician
Ahmad Sawas	Technician
Saleh Agha	Shepherd
Mahmoud El Razzouk	Shepherd

Improvement of sown pasture and forage production

Scott Christiansen	Grazing Management Scientist
Nerses Nersoyan	Research Associate
Hanna Sawmy	Research Associate
Akram Semaan	Senior Technician
Abdulhamid Antar	Research Assistant (resigned December 1992)

Walid Bou Moghlebey	Senior Technician
Marwan Jabboulieh	Research Assistant
Alaa Badenjki	Technician

Improvement of native pasture and rangeland

Ahmed Osman	Pasture Ecologist (Acting PL March-August 1992)
Amin Khatib Salkini	Research Assistant
Fahim Ghassaly	Research Assistant
Faour Ahmed	Technician (resigned October 1992)
Ali El Rajab	Technician
Adel Nassar	Senior Technician
Ghuffran Kattach	PhD Student (Aleppo University, Syria)
Rukoz Abu Nakad	Technician

Agroenvironmental land resource evaluation and conservation

Haru Fujita	Resource Information Scientist (TARC-Japan)
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Socioeconomics

Thomas Nordblom	Livestock Economist
Farouk Shomc	Research Associate
Shebab Nasser	GRTP Scholar (Syria)
Rolf Wachholtz	Research Fellow (BMZ-GTZ) (Hohenheim University, Germany)
Andrea Pape	Research Fellow (BMZ-GTZ) (Hohenheim University, Germany)
Georges Arab	Consultant
Nejude Sallah	Consultant

Microbiology and nitrogen fixation

Luis Materon	Microbiologist
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Monika Zaklouta	Research Associate
Elias Khoudary	Research Assistant
Bakri Abu Dan	Research Assistant
Sahar Sabbouni	Technician

Training

Walid Sarraj	Training Scientist
Mohamed Touna	Training Assistant

Publications

1. Papers in refereed journals

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2. Papers to conferences, Symposia and Workshops

- Goodchild, A., Ceccarelli, S., Grando, S., Hamblin, J., Treacher, T., Thomson, E., Rihawi, S. 1992. Breeding for cereal straw quality. International conference on Manipulation of Rumen Micro-organisms to Improve Efficiency of Fermentation and Ruminant Production, Alexandria, Egypt, 20-23 September 1992.
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- Nordblom, T.L. "Land Tenure, Social Systems and Institutions for Dryland Farming," paper prepared for the Seminar on Natural Resources and Environmental Management in the Dry Areas, sponsored by EDI/World Bank, ICARDA and AOAD, at ICARDA, Aleppo, Syria, 16-27 February 1992.

- Osman A.E. and Cocks, P.S. 1992. Effects of phosphate and stocking rate on mediterranean grasslands in northern Syria. Proceedings of XVII International Grassland Congress, New Zealand and Queensland, Australia 8-22 February 1993 (in press).
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- Treacher, T., Goodchild, A., Bahhady, F. and Filo, S. 1992. Nutritional strategies for improving the performance of Awassi flocks. Mashreq Project Workshop, Amman, Jordan, 13-15 December 1992.
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- Treacher, T., Goodchild, A., Bahhady, F. and Filo, S. 1992. Nutritional strategies for improving the performance of Awassi flocks. Proceedings of FAO workshop on the strategies for the development of fat-tail sheep in the near East. October, Cukurova University, Adana, Turkey (in press).
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Abdelmagid, Salah A. 1992. The Economic Impact of Faba Bean Introduction in Smallholdings: A Case Study of the Gezira Scheme, Sudan. PhD Thesis, Institute of Agricultural Economics and Social Sciences in the Tropics and Sub-Tropics, University of Hohenheim, Stuttgart, Federal Republic of Germany. Published by Wissenschaftsverlag Vauk, Kiel, as Vol. 13 in the series: Farming Systems and Resource Economics in the Tropics, W. Doppler, editor.

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المركز الدولي للبحوث الزراعية في المناطق الجافة

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