The Gap between: Present Farm Yield and the Potential

Major constraints and possible solutions

FIFTH CEREALS WORKSHOP
Algiers, Algeria
May 5-9, 1979
VOLUME II

PRESENT

POTENTIAL

Sponsored by
Ministere de l'Agriculture et de la Revolution Agraire
International Center for Agricultural Research in the Dry Areas
Centro Internacional de Mejoramiento de Maíz y Trigo

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Ministry of Agriculture and Agrarian Revolution, Algeria
International Center for Agricultural Research in Dry Areas—ICARDA, Syria
Centro Internacional de Mejoramiento de Maíz y Trigo—CIMMYT, México

Acknowledgment

The Fifth Regional Cereals Workshop was the result of a combination of interest, dedication and action by many, many persons. The same can be truly said of these two volumes of proceedings of the workshop. Many more persons than can be listed here contributed generously and importantly.

Several played such crucial roles that special acknowledgment must be made: Translations (English to French, French to English) greatly enlarge the reading audiences that can benefit from these papers. Robert Bertram of ICARDA and M. M. Nachit of CIMMYT shared that immense task. Jack V. Mertin, then CIMMYT's science writer/editor for wheat, carried the major editing responsibilities.

Special acknowledgment is due to the Ford Foundation, whose grant enabled participation by persons from Sudan and Jordan and provided for both interpreters and equipment for simultaneous translations.

G. Varughese

FIFTH REGIONAL CEREALS WORKSHOP

Preface

From May 5 to 9, 1979, the Fifth Regional Cereals Workshop met in Algiers, Algeria. During those five days 140 registered participants from 25 countries and five international research groups discussed problems and constraints limiting cereals production in 17 countries. The primary focus was on Mediterranean and Middle East nations with additional attention to Kenya, Afghanistan and Pakistan.

Proceedings of the workshop are presented in two volumes. The first volume offers inaugural addresses and country-by-country analyses of constraints and problems.

Volume II brings together reviews of research results and other literature relevant to attacking leading problems in cereals production in these countries. Summaries of findings and recommendations of nine work-discussion groups are also presented here.

George Varughese
Chairman, Organizing Committee
Wheat Breeder, CIMMYT

CINQUIEME CONFERENCE REGIONALE DES CEREALES

Préface

La Cinquième Conférence de Céréales a eu lieu en Algers, Algerie du 5 au 9 Mai, 1979. Pendant cet période 140 participants en provenance de 25 pays et de cinq groupements internationaux de recherche ont discuté des problèmes et des contraintes que limitent la production des céréales en 17 pays. La discussion a été misse au point sur la Région Méditerraniènne et la Région du Moyen Orient principalement, et aussi on s'a fait attention aux pays suivants: Kenya, Afghanistan, et Pakistan.

Les Mémoires de la Conférence se sont présentées en deux livres. Dans le premier on trouve les discours innauguration et les analises par pays des problèmes et contraintes à la production céréalière.

Dans le deuxième livre, on trouve des résultats de la recherche et d'autre literature importante pour résoudre des problèmes les plus importants pour la production céréalière aux pays cimentionés. Aussi, on a presenté ici les resumés des résultats et recommandations des discussions des neuve groups de travaille de la Conférence.

George Varughese
Président du Comité Organisateur
et Eleveur du Blé, CIMMYT

FIFTH CEREALS WORKSHOP

VOLUME II

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AGRONOMIC YIELD CONSTRAINTS IN RAINFED CEREAL PRODUCTION SYSTEMS

Floyd E. Bolton*

I. Introduction

The world's arable cropland comprises an estimated 1.4 billion hectares. Only about 10 percent is irrigated; the remainder depends on annual rainfall. Nearly 0.6 billion rainfed hectares are considered semi-arid to arid, i.e., receive less than 500 mm of annual precipitation. However, *these low rainfall zones produce a major portion of the world's* cereal crops. In the Middle East and North African regions, the predominance of rainfed versus irrigated lands is shown in Table 1. Cereals, mostly wheat and barley, are the main crops of the region (Table 2). These two crops occupy about 70 percent of the total area devoted to all crops. More than 35 percent of the arable lands is planted each year to wheat and barley (Table 3). The area of wheat and barley in each country is presented in Table 4.

TABLE 1. Arable land and irrigated land for 17 countries of the Middle East and North Africa

Country	Arable Land (1000 ha)	Arable Land % of Total	Irrigated Land (1000 ha)	Irrigated Land % of Arable
Turkey	27,614	35.8	1,939	7.8
Iran	16,153	9.9	5,251	33.7
Iraq	10,163	23.4	3,675	36.8
Afghanistan	7,980	12.3	813	10.4
Morocco	7,505	16.8	265	3.7
Algeria	6,792	2.8	270	4.3
Syria	5,899	31.9	485	8.6
Tunisia	4,510	28.9	80	1.8
Egypt	3,852	2.8	2,852	100.0
Libya	2,521	1.4	125	5.2
Jordan	1,300	13.3	60	5.3
Yemen	1,200	6.2	100	8.3
S. Arabia	1,005	0.5	176	19.3
Cyprus	432	46.8	94	21.8
Lebanon	316	31.6	68	28.3
S. Yemen	252	0.9	252	100.0
Kuwait	1	0.1	1	100.0
Total	96,495	7.9	16,506	17.1

Source: 1973 Production Yearbook, compiled by ALAD.

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TABLE 2. Area in 14 major crops for the Middle East and North Africa

Crop	Area (1000 ha)	% of Region
Wheat	25,173	52.7
Barley	8,962	18.8
Maize	2,311	4.8
Cotton	2,079	4.4
Grapes	1,700	3.6
Food Legumes	1,478	3.1
Rice	1,210	2.5
Vegetables	1,204	2.5
Sunflower	609	1.3
Sugarbeets	412	
Potatoes	395	
Sesame	169	2.3
Sugarcane	83	
Ground Nuts	55	
	47,757	100.0

Source: 1973 FAO Production Yearbook, compiled by ALAD (16 countries).

TABLE 3. Percentages of arable land in 16 countries planted to wheat and barley annually

Country	% of Arable Land in Wheat	Barley	Wheat & Barley
Turkey	32	9	41
Iran	31	9	40
Iraq	11	6	17
Afghanistan	30	4	34
Morocco	29	21	50
Algeria	29	11	40
Syria	22	14	36
Tunisia	25	9	34
Egypt	18	1	19
Libya	5	6	11
Jordan	9	1	10
Yemen	4	12	16
S. Arabia	12	1	13
Cyprus	16	19	35
Lebanon	14	2	16
S. Yemen	—	1	1
Region	26	9	35

Source: FAO 1973 Production Yearbook, compiled by ALAD.

The cereals are of major importance in the economic well-being of these regions because they constitute the main source of food supply for most of the population. A constant, stable supply of cereals would probably have a greater effect on overall development of most of these countries than any other single factor.

Since most of the cereals grown in this region are under rainfed conditions, this paper will address primarily those constraints associated with a variable moisture supply. However, several of the agronomic yield constraints to be discussed apply *equally* to *irrigated* as well as rainfed crop production.

Cereal production under rainfed conditions is confronted by variable climatic conditions from year to year or season to season. These climatic factors, such as precipitation, temperature, humidity, wind, and light intensity, are combined with other factors such as topography and soil type and depth to form a complex environment in which to produce cereals. These factors constitute yield constraints that are beyond the control of the farmer or researcher. Yet each environment under a given set of conditions possesses a certain yield potential. It is in the difference between the "potential" yield and the "actual" yield under a given set of conditions that agronomic yield constraints constitute an important role. If the management system in any environment removes the agronomic yield constraints, the "actual" yield level can be substantially increased.

It should be recognized from the start that all environments have different yield potentials depending on the climatic and topographic features. That we cannot change and must accept. However, the gap between the "actual" and "potential" yield level can be changed if the agronomic yield constraints are removed.

Before proceeding further, we should define the terms "potential" yield, "actual" yield, and "yield gap" more precisely as follows:

Potential Yield: The maximum yield of a crop that is technically feasible within reasonable economic limits in a given environment. The yield limits are imposed by the environment.

Actual Yield: The yield of a crop that is determined by the interaction of its genetic characteristics with the environment in which it is grown and the management practices to which it is subjected. The yield is limited by the production techniques.

Yield Gap: The difference between potential yield and actual yield. This difference may be due to both biophysical constraints and socio-economic constraints.

From the above definitions, it is apparent that the "yield gap" is the aspect that concerns the constraints in cereal production. Socio-economic constraints are to be a major part of

TABLE 4. Area of wheat and barley for 16 countries of the Middle East and North Africa

Country	Wheat (1000 ha)	% of Region	Barley (1000 ha)	% of Region
Turkey	8,915	35.4	2,600	29.0
Iran	5,000	19.9	1,400	15.6
Afghanistan	2,400	9.5	315	3.5
Morocco	2,187	8.7	1,602	17.9
Algeria	2,000	7.9	750	8.4
Syria	1,317	5.2	845	9.5
Iraq	1,156	4.6	600	6.7
Tunisia	1,140	4.5	400	4.5
Egypt	524	2.1	35	
S. Arabia	125		12	
Libya	120		150	
Jordan	113	2.1	19	5.0
Cyprus	67		81	
Yemen	50		145	
Lebanon	45		7	
S. Yemen	—		1	
Total	25,173	99.9	8,962	100.0

Source: 1973 FAO Production Yearbook, compiled by ALAD.

this conference so there is no need to expound on them other than to recognize that unless these constraints are removed, the agronomic constraints will probably not be removed either.

High Yield vs Low Yield Environments

The yield potential varies considerably from one location to another throughout the region. However, cereal production areas can be divided into two general categories for the purpose of discussing agronomic yield constraints. Throughout the region are coastal plains or other areas that are relatively well-watered, i.e., precipitation is adequate during most seasons to produce high grain yields. Even though the annual precipitation varies from season to season, it is not generally the major limiting factor.

Inland from the coastal regions the amount of precipitation decreases until the main factor limiting production is the lack of water. The agronomic constraints can and do change in these two environments. Many of the same yield constraints are present in both environments but may assume a different magnitude or sequence in a yield-limiting situation.

II. Agronomic Yield Constraints

The factors limiting grain yields under rainfed production systems are the same throughout the world, but may differ in severity and sequence in each location. The most common factors encountered in rainfed cereal production systems are:

Weed control (both in crop and fallow land)
Fertilizers (phosphorus and nitrogen)
Varieties (susceptibility to diseases and/or low yield potential)
Seedbed preparation and stand establishment
Planting dates
Tillage and moisture conservation practices
Planting rate and row spacing
Other plant nutrient deficiencies (S, Zn, Fe, Cu, etc.)

Rainfed crop production has been most successful when the "package-of-practices" approach has been used. This means that the best combinations of tillage for moisture conservation and seedbed preparation, selection of adapted varieties, optimum planting rates and dates, fertilizers applied at the proper rates and times in relation to moisture supplies, timely weed control in both fallow and crop seasons and proper harvesting methods are used. The timing and application of the various components of the package is very important and may vary from one locality to another. The proper package of practices must be determined by extensive, applied field research conducted over relatively long periods of time. Each element in the production package must be done in the right sequence or the advantage of the other elements is often lost. For example, if an improved variety is introduced without the addition of weed control or fertilizers or better seedbed preparation, often times the old, local variety will still yield as well or better. If fertilizers are introduced as an improved practice and weeds left uncontrolled, the weeds may respond more to the increased fertility level than the crop, and may in some cases actually reduce yields. If improved initial tillage practices are introduced, but secondary tillage for weed control and seedbed preparation are neglected, the end result may be worse than the traditional method.

The development of a complete production package in the developing countries is not generally possible in the immediate future. Many of the resources (equipment, herbicides, fertilizers, etc.) are not presently available and require considerable time and investment to develop. However, if certain elements of the production package are properly applied and in the right sequence, substantial yield increases are possible. The key to increases in crop yields involves sorting out those practices which give the greatest benefits and can fit into the local traditional systems. As other resources become available and additional field research is conducted, the other elements of the production package can be applied.

An important concept in determining yield constraints was developed over one hundred years ago by Justus von Liebig and is still applicable today. Liebig used this principle to illustrate yield limits due to nutrient deficiencies but it applies equally well to cereal production practices.

Principle of Limiting Factors: "The level of crop production can be no greater than that allowed by the most limiting of the essential plant growth factors."

If one can determine the most limiting factor in a cropping system and then the next, and so on, then it removes the hazard of introducing a new practice that fails to give a yield increase. This requires an extensive and carefully planned field research program.

Agronomic Constraints in High-Yield Environments (water not limiting)

In those areas where a high yield potential exists, generally the first improvement considered is the introduction of a high yielding variety. Too often the result is disappointing, even though some yield increase is achieved. Certainly a high yielding, disease resistant, adapted variety is required to achieve more of the potential yield of the environment, but there are other limiting factors that have to be considered as well. To achieve greater yields in high yielding environments, weed control and fertility levels must accompany the introduction of improved varieties. Appleby, et al. (1976) found that increasing the nitrogen level without controlling weeds did not increase grain yields (Table 5). Apparently, the nitrogen fertilizer stimulated weed growth greater than the crop growth. When the weeds (in this case, weedy grasses) were controlled, grain yields increased with each additional input of nitrogen.

TABLE 5. Weed control vs N fertilization

Nitrogen Level kg/ha	Yield kg/ha Weeds Controlled	Weedy	Grain Yield Reduction %
0	4864	4864	0
40	6098	5009	8
80	6534	5300	19
120	6679	4864	28

In another experiment, they (Appleby, et al., 1976) found that the cultivar, being a significant factor in competition with weedy grasses, was apparently related to plant height (Table 6). The semi-dwarf cultivar Nugaines showed greater reduction in yield due to weed competition that the standard height cultivar, Druchamp. Both cultivars showed reduced yields with increased nitrogen levels. These and other similar studies show that the introduction of a new cultivar and higher fertility levels must be accompanied by adequate weed control, if yield increases are to be achieved.

TABLE 6. Weed control vs cultivar and N fertilization

Cultivar	Nitrogen Level kg/ha	Yield kg/ha Weeds Controlled	Weedy	Grain Yield Reduction %
NUGAINES	50	3070	1920	37.5
(Semi-Dwarf)	100	3570	2000	44.0
	150	3450	1720	50.1
DRUCHAMP	50	3680	2960	19.8
(Tall)	100	3990	3180	20.3
	150	4150	2840	31.6

From: Appleby, et al., 1976.

Other agronomic practices such as seedbed preparation and stand establishment, planting dates, planting rates, and row spacings, and other plant nutrients such as phosphorus, sulphur or micronutrients, may become limiting factors in a high yield environment after weed control, variety, and nitrogen fertilizer needs are met. As each yield constraint is identified and the practice introduced, the yield level can be expected to rise toward the potential yield.

Agronomic Constraints in Low-Yield Environments (water limiting)

Dryland farming revolves around the principle that water is the main limiting factor and to increase or maintain an adequate yield level, one must maximize the water use efficiency for crop production.

There are two things that must occur in order to utilize the limited moisture supply to achieve increased crop production: (1) increase the amount of water stored in the soil and reduce losses due to evaporation and transpiration and (2) make maximum use of the stored water and subsequent precipitation by management of cropping practices geared to the prevalent climatic conditions.

Fallow Efficiency (FE) and Water Use Efficiency (WUE)

These are terms commonly used in the literature and research reports that are often unclear or misunderstood because of different ways used in calculating and defining them. It should be our aim to simplify as much as is possible the terms used in crop production studies so everyone is able to understand and compare their situation with results from any source and any location. The term Fallow Efficiency is quite often used in many ways. It is calculated by using a number of different criteria. In simple, useful terms, Fallow Efficiency is the percentage of total precipitation expressed as *available* water remaining in the soil profile at the planting time within the usual rooting zone of the crop plant.

$$\text{Fallow Efficiency (FE)} = \frac{\text{Available Water}}{\text{Total precipitation during fallow period}} \times 100$$

Determination of moisture storage on fallow efficiency for varying periods during the fallow may be useful for studying various treatment effects. However, in crop management studies, it is the available crop moisture at planting that is important in determining the final yield. This simple formula expresses the success or failure of a fallow management system. The determination of available water of FE is also essential in making calculations for fertilizer (nitrogen) applications that are balanced with the moisture supply. Use of fertilizers in relation to moisture supply is discussed in another section of this paper.

Water Use Efficiency (WUE) is defined as the unit of economic yield produced per unit of precipitation received. WUE is calculated by dividing the total yield per unit area (e.g.,per hectare) by the total precipitation received during the entire period the crop utilized the land (include both fallow and crop periods). For example, if in a fallow-crop rotation, a grain yield of 3.0 tonnes (3,000 kg) per hectare of wheat was produced in an area which received 300 mm precipitation annually, the WUE would be calculated as follows:

$$\frac{\text{Yield per hectare}}{\text{Total precipitation (fallow-crop)}} \qquad \frac{3000 \text{ kg}}{600 \text{ mm}} = 5 \text{ kg/ha-mm}$$

This measure of management skill can be used to compare years and locations and removes the variability of climate in measuring the actual water use efficiency.

The determination and use of FE and WUE can be very useful in evaluating field trial results from crop production studies. FE gives one a measure of the effectiveness of soil management and seedbed preparation in terms of moisture stored in the soil profile. This information can then be used to estimate the probable yield of the succeeding crop. From the estimated yield based on stored moisture in the soil profile and expected precipitation during the crop period, the proper nitrogen fertilizer-moisture balance can be determined. Accurate precipitation records and differential nitrogen fertilizer treatments in a given area can lead to better estimates of nitrogen needs under the prevailing climatic conditions. The calculation of WUE provides a measure of the accuracy of the predicted nitrogen needs.

The use of Fallow Efficiency (FE) and Water Use Efficiency (WUE) can be extremely useful tools to measure progress in a crop production system. The highly variable climatic conditions that are typical of dryland areas of the world cause wide fluctuations in actual crop yields and can be somewhat misleading if only yield levels are considered. There are instances where low precipitation during a season seems to foretell a low yield level, yet the yields are normal or above. In other cases, above average precipitation seems to indicate that above average yields should be obtained and the yield level falls below expectations. If the soil and crop management system is attuned to the prevailing precipitation conditions, then the FE and WUE should remain relatively constant. Improvements in WUE can easily be detected and are not necessarily dependent on favorable climatic conditions.

Dryland Cereal Production and Water Use Efficiency

Yield potential in dryland areas is limited by the moisture supply, but the actual *yield level* obtained is limited by the production techniques. It is generally agreed that yield levels in the dryland cereal regions of the world in both the developed and developing nations can be substantially increased if more efficient use is made of the admittedly limited moisture supply.

There are many factors that affect the WUE in the production of dryland cereal crops. Certain climatic and environmental factors are beyond our control. This includes, in addition to a limited moisture supply, the distribution of and intensity of precipitation, temperature, relative humidity, light intensity, wind velocity, soil type, texture, and depth, and topography of the land. These elements must be considered in the production system and dealt with in the management practices, but essentially they are uncontrollable. There are crop management practices that can be controlled and add greatly to the efficient use of a limited moisture supply. These include:

1. Weed control
2. Stand establishment
3. Plant nutrient-moisture balance
4. Adapted varieties
5. Plant populations and spacings
6. Tillage and moisture conservation

Weed Control and Water Use Efficiency

Although control of weeds is not directly related to management factors affecting water *use efficiency* of the crop plant such as variety, stand establishment, and moisture-fertilizer balance, it certainly has an important role in water availability. Any living organism that uses water (and all do!) and under conditions of limited moisture supply, will reduce the economic yield in direct proportion to the amount of water used. Under adequate moisture levels or irrigation where water is not the major factor limiting the yield potential, some weeds may be tolerated without loss of economic yield.

Generally speaking, the more limited the moisture supply, the more critical adequate weed control becomes. Hepworth et al. (1975) has shown that even under poor soil and crop management, timely chemical weed control resulted in large yield increases. With improved crop management and good weed control practices, the increase in grain yield averaged about 33 percent (Figure 1).

Weed control alone increased the grain yields about 64 percent, but at a yield of only 1.54 mt/ha at a low level of management. Under good soil and crop management, a certain amount of cultural weed control is achieved so that the addition of chemical control during the crop growth period did not show as great a yield increase. However, in total yield, increases due to weed control under improved management averaged 0.8 mt/ha as compared to about 0.5 mt/ha yield increases under poor management.

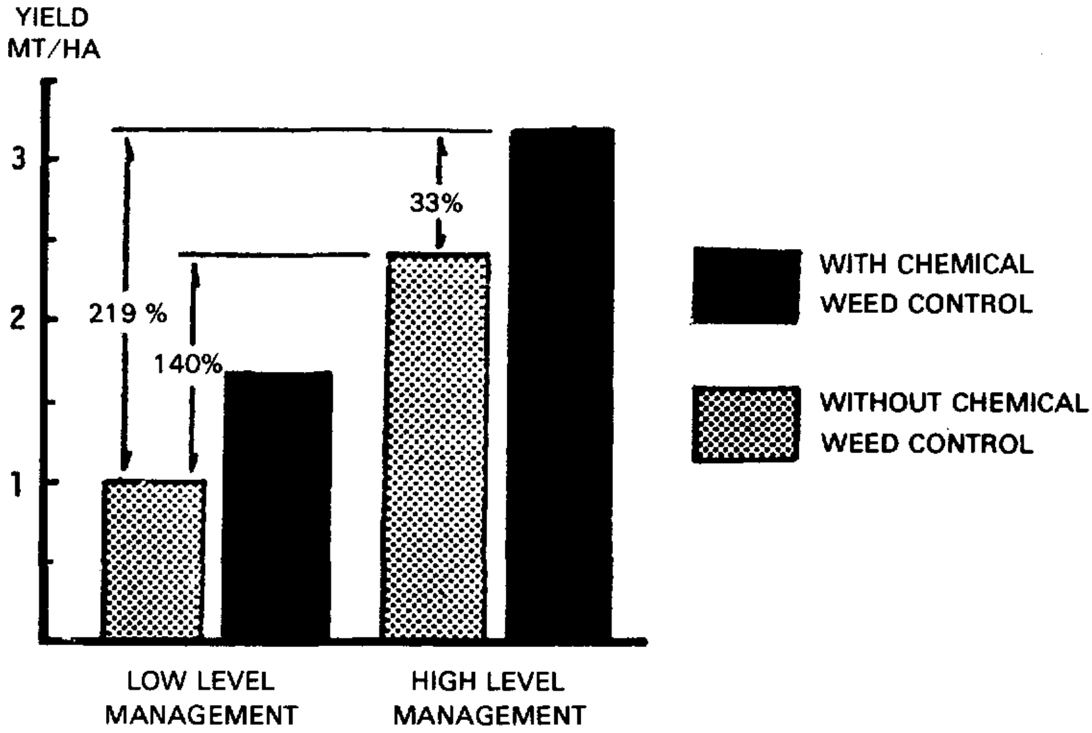


Figure 1. **Effect of weed control and management on yield of winter wheat in Turkey, 1974-1975**

Stand Establishment and Water Use Efficiency

The term "stand establishment" is used in this paper in preference to the commonly used terms such as seeding date, planting date, or date-of-seeding. These latter terms describe the actual time the seeds are placed in the soil, but do not necessarily insure that the following events result in an established stand. Too often a date-of-seeding trial is presented in the literature with no reference to time of emergence, crown root development or the appearance of tillers. All the above events must occur before one can accurately state that a stand has been established.

Time of Stand Establishment

In dryland cereal-producing areas with a winter precipitation pattern, optimum time of stand establishment may have a considerable effect on water use efficiency (in relation to economic yield) by ensuring that the growth of the crop is adjusted to the available soil moisture. The data in Figure 2, which are averages of many trials over a period of years, show the optimum range for stand establishment in eastern Oregon. A number of the early trials reviewed showed no differences in yield due to planting date. Closer inspection of the data showed that in many cases the seeds were placed in dry soil for several days before a significant amount of precipitation occurred. In these cases, the date of seeding may have differed by 2 to 4 weeks but the time of emergence was the same. Since the introduction of deep-furrow drills and the placement of seeds into moist soil from the previous fallow, the data have been more consistent and represented different dates of emergence.

Long-term observations (Bolton 1976, unpublished data) of precipitation in relation to grain yields at 3 locations in the Pacific Northwest have shown that whenever significant rainfall occurred during the period of optimum stand establishment (Sept.15—Oct.15), grain yields were significantly higher. This apparently was the result of adequate soil

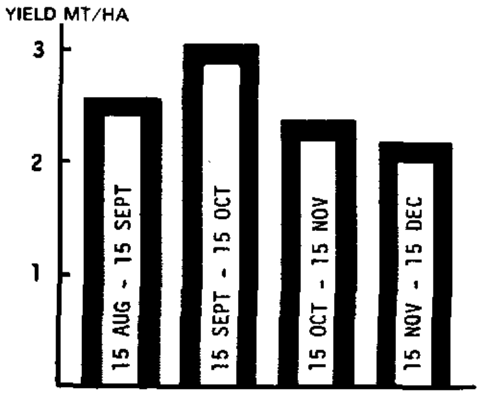


Figure 2. Effect of stand establishment and grain yield in Eastern Oregon (long term average)

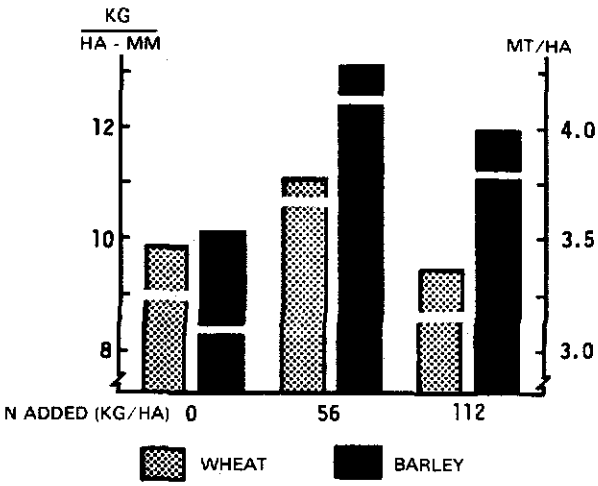


Figure 3. Effect of nitrogen fertilizer on WUE and grain yield (crossbar) of winter wheat and barley at Moro, Oregon, 1975

moisture for emergence and subsequent plant development before low winter temperatures occurred. As soil moisture conservation practices improved and deep-furrow drills were introduced, the seeding into residual moisture became a standard practice. However, there are still seasons when the moisture level for seeding is at too great a depth even for the deep-furrow drill. Often, the time of seeding is delayed beyond the optimum range, waiting for adequate rainfall. In most instances, this results in reduced yields because the plants are not adequately developed before cold weather begins. Pehlivanturk (1975) showed that time from emergence (after adequate moisture was present) to crown root development and tillering was greatly increased after soil temperatures reached a certain range. A critical soil temperature-plant development situation occurs when the mean soil temperature reaches a certain level. This study indicated that when the mean soil temperature at seeding depth dropped below 10ºC, the length of time for seedling development of crown roots and/or tillers was dramatically increased. The number of days from emergence to tillering was 28, 51, and 125 from October 1, October 15, and November 1, respectively. The mean soil temperature at seeding depth for these planting dates was 16, 9, and 5ºC, respectively.

Seeding into dry soil is risky and presents problems with crusting after rains and sometimes with weed control. However, reductions in yield in late stand establishment are well documented and consistent. The risk in reduced yields from crusting or weeds is not predictable. It would seem that timely seeding under dry soil conditions outweighs any advantages in waiting for adequate moisture to wet the seed zone.

Moisture-Fertilizer Balance and Water Use Efficiency

In areas of limited precipitation, a balanced nutrient supply enables the crop to make more efficient use of the available moisture supply (Arnon, 1975, 1972; Olson, et al., 1964). The recommended use of fertilizers is the most economical way of increasing crop-water use efficiency (Viets, 1962, 1967, 1971, 1972). It has been demonstrated that a *nutrient deficient plant, even though it is not growing or growing slowly, is using water at* about the same rate as a nutritionally balanced plant, yet will produce considerably less yield (Asana, 1962; Aspinall, et al., 1964; Brown, 1972; Leggett, 1959). Some recent information by Aktan (1976) has confirmed these findings and indicates that different levels of soil moisture at seeding require different levels of applied nitrogen in order to balance the moisture-nitrogen supply for maximum water use efficiency. An example of this study is shown in Figure 3. These data show that water use efficiency can be decreased markedly by both a deficiency or an over-supply of nitrogen. It is also shown that a barley crop uses both water and nitrogen more efficiently than wheat, at least in this region.

The highly variable moisture conditions that are typical of dryland regions require that fertilizer requirements be tailored to the prevailing moisture supply if the most efficient use of water is to be accomplished. In addition, different soil management methods, such as bare fallow, stubble mulch, minimum tillage or no-till (chemical fallow) systems may require different levels of nitrogen to reference the proper moisture-fertilizer balance (Brown, et al., 1960; Greb, et al., 1967; Koehler, et al., 1967; Oveson and Appleby, 1971). The amount of plant residues left on the soil surface or mixed in the upper few centimeters can have a large influence on the amount of nitrogen available to the crop plant (Leggett, et al., 1974; Smika, et al., 1969; Smika, 1970). Generally, the more surface residues present, the more nitrogen is required to balance fertilizer needs with the moisture supply.

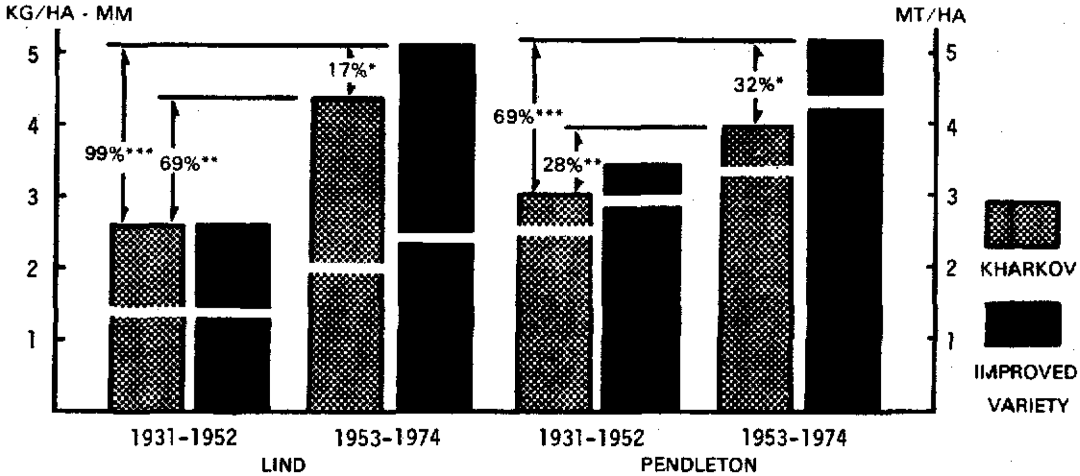
Even though nitrogenous fertilizers receive the major emphasis, other fertilizer elements play an important role in increasing the water use efficiency. Phosphorus, potassium, sulphur, and the other minor elements required for plant growth and development must be present in the proper available amounts or yield levels are reduced (Brown, et al., 1960; Brown, 1972; Gardner, 1964). These other fertilizer elements are not as dependent on the moisture supply as is nitrogen but,unless present in the proper available form and amount, will have a profound effect on the water use efficiency.

Adapted Varieties for Dryland Cereal Production

A key element in increasing the WUE, thereby increasing economic yield, is the use of the best adapted variety which is presently available. All cereal breeding programs have similar goals, i.e., increasing yield potential and quality, maintaining resistance to pests (insects and diseases), lodging, shattering, and other agronomic characters. Resistance or tolerance to drouth and heat is sometimes included among the breeding goals, but are much more difficult to select for.

The selection for varieties with high-yielding potential and resistance to the prevalent crop pests has been very successful in the past two decades. In many cases, the potential for yield under adequate moisture levels greatly exceeds the moisture availability in the dryland cereal regions. Many of the varieties with high-yielding potential under adequate moisture levels have also produced higher yields under limited moisture conditions. Breeders have long recognized that selection for drouth tolerance or heat resistance is extremely difficult because there are no suitable selection criteria presently available. Selection in early generation material under dryland conditions is very risky because of the extreme variability from season to season (Hurd, 1971). As a consequence, many breeders have resorted to testing larger numbers of later generation lines in the dryland areas, hoping to isolate types that are better adapted to drouth conditions. This approach has been generally quite successful in the Pacific Northwest of the United States.

Examples of the progress made in varietal improvement for dryland conditions are shown in Table 7 and Figure 4. These data represent grain yields from standard variety trials grown under a fallow-crop rotation in which the variety Karkov was present as the long-term check variety. The trials were conducted on the Lind Dryland Research Unit, Lind, Washington, and the Columbia Basin Agricultural Research Center, where the annual rainfall averages about 240 and 400 mm, respectively. A standard meteorological station is located at each experimental site. Since improved varieties are constantly changing over a period of years, the grain yields represent those varieties which were the most widely grown commercially during each period of time. For example, at Lind, Washington, during the period 1931 to 1952, the varieties grown commercially in this region were Turkey, Rio, Rex, and Elgin. During the period 1953 to 1974, the most widely grown varieties were Omar, Moro, Gaines, and Nugaines.



Percent increase due to: *improved varieties; **improved management;
***interaction of improved varieties and management
Kharkov: long-term, standard check variety
Improved Variety: variety most widely grown during the indicated period

Figure 4. Efecct of improved varieties and crop management on water use efficiency and grain yield (crossbar) of winter wheat in two locations in the Pacific Northwest

TABLE 7. Grain yield, precipitation, and water use efficiency at two locations in the fallow-crop rotation area of the Pacific Northwest

Dates	Span Years	Yield Tons/ha	(Bu/Ac)	Total Precipitation Mm	(Inches)	Water Use Efficiency Kg/ha-Mm	(Bu/Ac-in)
		Lind, Washington					
1922-1974	54						
Kharkov		1.58	(23.5)	477	(18.8)	3.31	(1.25)
Improved variety		1.71	(25.5)	477	(18.8)	3.58	(1.35)
1931-1952	22						
Kharkov		1.35	(20.1)	518	(20.4)	2.60	(0.98)
Improved variety		1.35	(20.1)	518	(20.4)	2.60	(0.98)
1953-1974	22						
Kharkov		2.01	(29.9)	457	(18.0)	4.39	(1.66)
Improved variety		2.36	(35.1)	457	(18.0)	5.16	(1.95)
		Pendleton, Oregon					
1931-1974	44						
Kharkov		3.03	(42.3)	805	(31.7)	3.76	(1.33)
Improved variety		3.51	(52.3)	805	(31.7)	4.36	(1.64)
1931-1952	22						
Kharkov		2.53	(37.6)	820	(32.3)	3.08	(1.16)
Improved variety		2.84	(42.4)	820	(32.3)	3.46	(1.31)
1953-1974	22						
Kharkov		3.15	(47.0)	800	(31.5)	3.93	(1.49)
Improved variety		4.16	(61.9)	800	(31.5)	5.20	(1.96)

At the Lind site, the increase in WUE for grain yield averaged about 99 percent for the past 22 years when compared to the previous 22-year period. This increase can be separated into three categories: (1) increase due to improved varieties (17 percent), (2) increase due to improved soil and crop management (69 percent), and (3) the increase due to the interaction of improved varieties and improved soil and crop management (13 percent). This region is the lowest rainfall region for cereal production in the United States. The value of improved varieties does not show as great an influence on grain yields as improved crop management, when considered alone. However, when the influence of improved varieties is added to improved crop management (17 percent +13 percent), an overall increase of 30 percent in WUE is achieved. In the more arid cereal-producing regions, it appears that crop management plays a more dominant role than improved varieties. However, to gain maximum benefit, both elements must be incorporated into the production system.

As the precipitation increases, the roles of improved varieties and improved crop management shift in emphasis as shown by the data in Table 7 and Figure 4 for the Pendleton location. The increase in WUE due to improved varieties is almost twice (32 percent vs. 17 percent) that shown for the Lind location. In addition, the effect of improved crop management is less than half (69 percent vs. 28 percent) that of the lower rainfall zone at Lind. This indicates that varietal improvement plays a larger role in WUE under more favorable climatic conditions. The interaction between improved varieties and improved crop management shows about a 9 percent increase in WUE as compared to a 13 percent increase in WUE at the Lind location.

The overall WUE in terms of grain produced per unit volume of water received was about the same for both locations, i.e., 5.20 and 5.16 kg/ha-mm for Pendleton and Lind, respectively. This indicates that both locations are producing at about the same level of WUE but at different yield levels because of the large difference in precipitation. The advantage of using the best adapted varieties for maximum WUE and increased grain yield level is clearly indicated in these data.

Plant Population and Stand Establishment

The optimum number of plants per unit area to obtain maximum economic production varies widely in different environments. Under well-watered or irrigated conditions, the plant population per unit area above a certain minimum number seems to have little or no effect on the subsequent yield (Donald, 1963). With limited moisture conditions, the plant population and distribution can exhibit substantial influence on the water use efficiency and the subsequent grain yield (Harper, 1961).

In cereal crops, adjustments in plant populations and distribution because of the methods of seeding and nature of the crops, must be made either within rows or between rows. Increasing the distance between plants within the rows and reducing the distance between rows to achieve a more uniform distribution over a unit area may defeat its purpose under limited moisture conditions. Brown and Shrader (1959) showed that plants with little competition in the seedling stage tend to produce excessive vegetative growth and deplete soil moisture that could be used for grain production at a later date. Larson and Willis (1957) concluded that to gain maximum benefit of a limited moisture, the intra-row population should be at a level great enough to provide adequate competition in the seedling stages to prevent excessive growth and moisture use, and that the inter-row spaces be adjusted to fit the moisture supply. This proposal is generally contrary to the usual practice in many dryland areas of the world, including both developed and developing countries. Seeding rates and row spacings have been traditionally used for two purposes which are not actually related to the best plant population for maximum yield: 1) Seeding rates within the row are usually greater than necessary in order to provide ground cover for wind and water erosion control; 2) Close row spacings are often preferred to provide greater competition for weeds that may grow between the rows. These concepts may have been partially successful in their purposes, but undoubtedly contribute to reduced grain yields in many seasons. The work of Arnon (1972) and Arnon and Blum (1964) suggests that better use of a limited moisture supply is possible with more careful attention to the plant population and distribution in dryland regions.

Many studies conducted in several different dryland regions of the world have shown that seeding rates can be reduced and row spacings increased without reducing, and many times increasing, grain yields (Alessi et al., 1971; Bolton, 1973; Guler, 1975; Wilson, 1969). Reasons for not using more carefully adjusted seeding rates and row spacings are many and varied but none seem to be related to more efficient use of moisture. There is considerable evidence that varieties differ in their response to seeding rates and row spacing in different climatic zones (Guler, 1975). He found that some varieties had different optimum plant population numbers at each location, while other varieties responded about the same at a given seeding rate over several locations.

Improved Tillage Practices to Conserve Moisture

This element of the production package usually comes first in the sequence of production practices, but it is often the most difficult to introduce in a developing country's program. It involves a very basic change from traditional cultural practices. Also, the full benefits from improved soil management are not realized unless the other production elements, such as weed control, seeding practices, fertilizers, and improved varieties, are combined in the package. Once the latter elements are used in the proper sequence and combinations, then the incentive to practice better soil management is greater. With the proper combination of cultural practices, any additional moisture saved in the soil profile will be reflected in greater crop yields. Therefore, it is listed in a lower priority position in the production package, not because of lack of importance in increasing yields, but because it must be followed by other practices if the advantage of conserved moisture is to be realized. Adequate soil management usually requires a greater amount of farm power than is presently used in most developing countries. Improvement in crop yields need not be delayed until all elements of an improved production package are in place. However, the full yield potential under a given set of climatic conditions will not be realized unless improved tillage practices are used.

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Summary

In the North Africa and Middle East region, rainfed crops, particularly wheat and barley, occupy a majority of the total area devoted to crops. Data for the crops,

area and production for the various countries are given. In addition a number of key terms are discussed and defined.

The region can be divided into two major areas: the coastal plains, where precipitation is high, and the inland areas, where precipitation is limiting. A number of agronomic yield constraints are identified and discussed for these different agroclimatic regions.

Water being the most limiting factor for crop production under dryland conditions, water use efficiency is discussed in detail related to weed control, stand establishment and moisture-fertilizer balance. In addition, the role of adapted varieties, establishment of adequate stand and the needs for improved tillage practices to conserve moisture are discussed.

LES CONTRAINTES DE RENDEMENT AGRONOMIQUE DANS LES SYSTEMES DE PRODUCTION CEREALIERE NON IRRIGUES

Floyd E. Bolton

Résumé

Dans la région Nord-Africaine et de Moyen-Orient les cultures non-irriguées, particulièrement le blé et l'orge, occupent une majorité de la superficie totale destinée a des cultures.

La région peut être divisée en deux zones majeures: les plaines côtières ou la précipitation-est élevée, et les zones centrales ou la précipitation est limitante. Une quantité de contraintes de rendement agronomique sont identifiées et discutées pour ces deux régions agro-climatiques.

L'eau étant le facteur le plus limitant pour la production dans les régions sèches, l'efficience de l'utilisation d'eau est discutée en détail en relation avec le contrôle de mauvaises herbes, l'établissement de peuplement et la balance humidité-engrais. En outre, le rôle des variétés adaptées, l'établissement d'un peuplement adéquat et le besoin des pratiques de labourage amélioré pour conserver l'humidité sont discutés.

Des données pour les cultures, la superficie, et la production pour les différents pays sont données. En outre un nombre de fermes clefs sont discutés et définis.

TRANSFER OF TECHNOLOGY

C. K. Mann*

Many of you at this workshop will remember some results of a survey on the adoption of technology which I presented at the barley workshop in Jordan. The paper I am going to present today really got its start in that same survey work. However, in contrast to the thrust of work by economists in the transfer of technology, the subject I would like to discuss today deals less with economic factors than with the communication processes involved in transfer of technology from researchers to farmers.

During the course of the original survey carried out by Kutlu Somel, me,and our student interviewers, we were struck by the number of cassette tape recorders which we saw in the survey villages. I began to wonder whether or not this might be a valuable medium to use in supplementing more traditional extension techniques. After that survey, any time I was in the field, I made a point of asking farmers how they would feel about receiving technical information in the form of a cassette. The reaction was, in every case, enthusiastic.

During this time Mr. Mansur Bilgec asked whether or not our Wheat Project could import, for use in the extension training programme, a portable video tape recorder. Knowing very little about the subject, Mr. Bilgec and I sought information on both the audio and video tapes from Dr. Clay Volan, who was in Turkey as a project leader of UNDP Communications Project (Family Planning).

Dr. Volan reviewed with us his knowledge of other uses of both media. In contrast to the general tendency to try to use video as a means of communicating from the center out toward the periphery, one of its most effective uses is to capture events occurring at the periphery and bring them realistically to the attention of those at the center. The portable video camera can serve as a sort of field notebook.

As to the audio cassettes, it is generally agreed within the communications profession, that information is most effectively presented embodied in some sort of entertaining context. Therefore, as we began to think about making an experimental cassette, incorporating the Wheat Project recommendations for farmers, we also began to think about something like a play, of the sort that might be written for radio, as a medium in which the recommendations would be incorporated.

In order to get some idea of the potential usefulness of video before committing the Project to financing equipment, Mr. Belgic and I asked Dr. Volan if he would bring his equipment out with us to a typical village, so that we could see the farmer's response to appearing before the camera. To my surprise, while the equipment and the taping process created mild curiosity, it did not seem to interfere with the normal flow of conversation or interview give and take.

Demonstrating the effectiveness of video in the role of field notebook, I was surprised several days later to have a request from some Ministry of Agriculture officials to come to the office to see the tape. The effect of the video as a reporting medium had dramatically more impact than any report one could conceivably write. It began to look as though we were on to something interesting and proceeded to order the basic set of equipment (total cost, $3,000 dollars)

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Returning to the audio cassette project, Mr. Belgic and I had the good fortune to receive an introduction to Mr. Savas Basar, a leading Turkish radio and television personality, and most widely known as Inspector Columbo in the highly popular Turkish version of this series. Mr. Basar not only agreed to provide the needed 'famous voice' but also, as an experienced writer of radio plays, volunteered to write the play which would serve as the vehicle for the technical recommendations. Mr. Belgic supplied him with the recommendations of the Wheat Project for the Anatolian region to be incorporated into the play.

While Dr. Devecioglu, his staff and the extension unit were enthusiastic about this experiment, it was clear that there were substantial pockets of scepticism within the Ministry. We began to think of the video tape as a vehicle for capturing the farmer's response to the tape at the time of distribution.

Given competing demands on everyone's time, it took about a year before the play was ready for review and recording. The script was reviewed by the Wheat Project staff for technical content and adjusted in accordance with their suggestions. Mr. Basar arranged for five other famous radio and television voices to act roles in the play. The action was built around a village feud in which a boy and girl from the opposing sides are in love. Through his education at the agricultural school, the boy brings in new knowledge about how to grow wheat, thereby bringing prosperity to the village and winning permission to marry his sweetheart. The play uses clever devices to ensure a thorough presentation and periodic review of the pertinent technical recommendations.

Once the cassette was recorded, we had some trial runs in nearby villages and incorporated the suggestions of both farmers and technicians. For the experiment itself we duplicated 1500 copies locally. Every element of the process was done using local sources.

Because we had no means of an interview-based follow up to get farmer reactions to this experimental programme, we decided to include in the envelope with the tape a simple questionnaire to get some assessment of reactions. The tapes were intended to go to the village leader (Muhtar in each of the sample villages.

Tapes for each of the 12 provinces were delivered to the provincial extension offices for further distribution through county agents to villages. At the time of distribution to provincial offices, the extension specialist explained the programme to the local staff, and each provincial village was randomly selected in which the tape was played, and the immediate farmer reaction video taped. From about 2 hours of video tape, we have produced a 20 minute 'documentary' of these initial responses.

In addition to the cassette work itself, there were a number of by-products of this project. The farmers were eloquent on their knowledge of new wheat varieties and the problems they faced in obtaining seed on time. The video captured the stark contrast between a county agent's view that there were very few cassette players in the villages and the statement of the Muhtar of a nearby village that there were 80 or 90 cassettes in his village alone. Another technician felt that his greatest handicap was the lack of any relevant films for the 16 mm projectors which the Ministry had recently provided virtually to every county in the country. (There is an excellent locally produced Wheat Project film but it is an 8 mm cassette format).

In about 40 per cent of the villages, the original tape was copied by individuals from the Muhtar's (normally by 5 to 10 people). About 75 percent of the questionnaires reported that the tape had been played 5 or more times, actually with 27 percent of the tapes having been played over 50 times. By the estimates on the questionnaires, some 40,000 farmers heard the tape in the relatively short time between the cassette's receipt and the mailing of the questionnaire, including many from villages outside the original distribution.

Mail questionnaires are not common in Turkey and obviously there is much room for error in these responses. Even discounting heavily for this, the cassette, as a vehicle for transmitting information, seems to have struck a responsive chord. Hopefully, over time, more structured sampling could be arranged to assess the long-term impact of this project.

The visitor to Turkey in the spring of 1979 is powerfully struck by many aspects of a severe foreign exchange crisis. Among other places, this is reflected in the virtual impossibility of using gasoline for the sort of village visits upon which past extension efforts have been based. The time may be coming to re-think the whole notion of transferring technology by people going in person to villages, and to pay more attention to alternative means of communicating recommendations to farmers and of capturing farmer response to such messages. Once one begins to think about alternative possibilities, ideas arise that may be useful in other dimensions of the technology transfer process. For example, the audio cassette might be an efficient medium for international centers, like CIMMYT, to use in conveying up-to-date information to former students. A 30-minute tape by Drs. Borlaug and Anderson, in their own voices, sent out to country programme scientists might be an extremely effective supplement to a written report.

While a cassette is a poor substitute for a personal appearance, the cassette recorder in the middle of a conference table can attract a ready made seminar/discussion of the tape content in a way that no written report can accomplish.

Whilst substantially more complex, there would seem to be also tremendous potential for video tape as a medium for communication between centers and national programmes. I have been struck with the enthusiasm of Turkish economists for audio cassettes of talks by internationally known economists.

I realize this paper is far from the usual economic analysis you expected when you invited me to talk about the transfer of technology. Howevever, I have been constantly reminded in my post in New York of the 'unread reports on library shelves.' Therefore, maybe it is not entirely out of place to talk about such alternative media to convey information contained in some of those reports. The video tape close-up of a farmer's scrawled record of the cost of every input and operation may do more to impress the policy maker that 'farmers calculate,' than any sophisticated analytical report.

In closing, let me tell you what I have learned about the future of our feuding village characters, Cemal Aga and Badi Dayi. Mr. Basar has just agreed with the Agricultural Bank of Turkey to produce a radio series incorporating various technical agricultural information in a serialized, dramatic context. There will be 50 ten-minute programmes, running one a week, over the next year. The characters and dramatic situation he created for the cassette will be the foundation of the series. Cemal Aga, Badi Dayi, Ali and Ayse will go on to new adventures, as Ali develops his agricultural extension agent character. The Turkish radio and television estimates for the programmes a radio audience of 9 to 10 million people. Whether the audio cassette will be added to traditional extension materials remains to be seen. However, I shall be surprised if, among those listeners to Cemal and Badi, there are not at least a few who push the 'record' button on their cassette player when they hear that familiar voice. Collecting the recommendations embodied in that series would give an enterprising farmer quite a technical library from which one does not have to be able to read to benefit. One can think of many ways to enhance the effectiveness of this radio oriented programme - films for the empty projectors, brochures, a cassette series for county agents. Perhaps also their time will come.

TABLE 1. Number of times casette was played prior to return of survey form

1–4 times	106
5–9 times	97
10–19 times	125
20–49 times	58
More than 49 times	27
No response	11

Note: Farmers made 1,005 copies of the cassette.

TABLE 2. Number of farmers who listened to cassette (424 survey forms)

In villages receiving cassette directly	33,318
From other villages	6,467
Total	39,785

TABLE 3. Percentage of survey forms where cassette was rated as:

Extremely useful	50
Quite useful	31
Somewhat useful	16
Of little use	2
Useless	1

TABLE 4. Percentage of villages requesting other information on cassette by subject

Animal husbandry	59
Poultry	40
Orchards	39
Equipment maintenance	38
Vegetables	34
Beekeeping	31
Vineyards	27
Melons	22
Legumes	19
Nothing requested	19

Summary

The theme of the paper is the communication processes involved in transfer of technology from researchers to farmers. The paper discusses the response of Turkish farmers to the use of cassettes containing technical messages in the form of entertainment. Also discussed is the usefulness of using videotape as a means of bringing farmer reactions to the policy makers.

LE TRANSFERT DE LA TECHNOLOGIE

C. K. Mann

Résumé

Le thème de ces documents est le processus de communication engagé dans le transfert de la technologie des chercheurs aux agriculteurs.

Ce document discute la réponse des agriculteurs turques à l'utilisation des cassettes contenant des messages techniques en forme de divertissement. Il a été aussi discuté l'utilité de l'utilisation des bandes vidéo comme des moyens pour transmettre les réactions des agriculteurs aux hommes de la politique.

CEREAL POLICIES AND ECONOMIC CONSTRAINTS

Piero Bronzi*

The invitation to participate in this workshop was most welcome, partly because it provides a respite from the administrative problems that consume too much of the time and energy of a program officer these days, more important because of the opportunity to meet with friends of long standing with whom I have had many long discussions on the issues to which this workshop is dedicated.

My assigned task is to deal with the similarity and diversity of agricultural policies aimed *at increasing cereal production in the Middle East and North Africa*, and to explain the most important constraints that counteract the effective implementation of these policies.

First of all: Why must cereal production be increased? Because the world and in particular the Middle Eastern region is threatened with acute food shortages. Self-sufficiency has become, especially for the Middle East, a strategic necessity, just as self-sufficiency in energy has become a necessity for the Western World.

The goal of national self-sufficiency in food is an old objective that has only come back into vogue in the past 15 years or so. Until about 150 years ago, virtually all populated territories grew the major share of their own food. Colonization, improved transport technology, specialization, comparative climatic advantages, made it feasible and cheaper to move bulk food across long distances.

Unfortunately, our world is not perfect: wars, ideological contrasts, population growth, increased transportation costs have now made many countries — especially the most underprivileged — feel the necessity of one form or another of wheat/food self-sufficiency.

A country with a chronic food deficit can be victimized by international food-price inflation, especially when many countries need to import basic staples in the same year. The country's fragile balance of payments can be fractured quickly by importing food. The consequences are soaring domestic food prices, probably irreversible cost-push inflation and a massive strain on the country's political fabric.

The 18th Session of the FAO Conference (1975) recommended that "developing countries with persistently weak balance of payments should favor wherever possible and appropriate the consumption of food which can be feasibly produced locally or regionally." Unfortunately the most dramatic decline in levels of food self-sufficiency has been registered in Africa and in the Middle East.

Today governments and international research organizations have almost 30 years experience in testing and implementing a wide variety of projects, programs, and strategies. Extensive research has been conducted under a variety of socio-economic and agronomic conditions in most regions of the Middle East and North Africa and in most of the nations of the developing world. Much has been learned, but a great deal remains to be learned.

For example, only recently have national and expatriate scientists, administrators, and professional politicians come to realize the importance that must be given to the productivity and welfare of the small farmer, the subsistence farmer whose contribution to the economic, human and political stability of the whole country is of capital importance.

This cumulative experience has brought us to the stage where we have significantly large areas of consensus within the various disciplines and professions as to what is required, at least from a technical-biological point of view, to achieve a sustained increase in cereal production.

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Despite this consensus and despite some progress, few nations or regions have achieved levels of cereal production that match the levels of domestic demand. In other words, there is a significant gap between the potential and the actual cereal production and — most discouraging — this gap appears to be growing.

Why is this gap growing? There are two basic requirements for achieving sustained agricultural development: the leadership must have a geniune *commitment* to the goal of agricultural development, and it must have an *understanding* of the development process. This is true for all people concerned in agricultural development, whether they work for national organizations or for international assisting agencies.

I do not propose to discuss here the issue of commitment, but only the understanding of the process.

With the exception of Egypt and the Sudan, cereal production is the largest agricultural activity in the Middle East and North Africa. It represents, depending on the countries, between 40 and 60 per cent of the total gross agricultural product, and between 5 and 15 per cent of the total GNP.

Given its importance and its contribution to the formation of the Gross Agricultural and National Products, cereal production can be visualized easily as the most important industry of the primary (agricultural) sector in an input-output table (matrix) of Leontief.

The input-output matrix is one of the basic tools of planning which — together with the macro-socio-economic objectives defined and imposed by the political apparatus of the government — is in turn the basis of the definition of agricultural policy.

The advantages of the input tables are multiple. They show how our industry (cereal production) depends for its inputs on other industries of the same sector (i.e. seeds) or on other sectors (i.e. tractors); and how these inputs are combined with primary inputs (labor, land and capital = value added) and with the imports in order to determine the total supply. They also show how cereal production contributes to the formation of intermediate demand of other industries and sectors (i.e. straw for animal husbandary and paper industries; wheat for bakeries and biscuit industries). This intermediate demand, coupled with the final consumption (or demand) as expressed by the household and Government (wheat home-consumed) determine the volume and therefore — knowing the price — the value of the total output.

But the input-output table can provide us with other valuable information. By looking at the level of integration of the cereal sector within the rest of the economy (i.e. nature and value of the technical coefficients; quality of inputs used in the production process; use of the output whether for intermediate or final consumption) we may define with sufficient precision the relative level of development of the cereal industry in that particular region or country.

The outlook of subsistence farming in Le Kef Tunisia or South of Karak in Jordan is different from that of the socialist cereal sector in Algeria, of the wheat farming sector in the Paris region, North Dakota or South Australia.

These relations and the information we derive from the tables are valid whatever political system prevails in the country, since different political systems are more interested in general in the distributive effects of the result of an act of production than in the input-mix or the technology which is at the base of that product.

The point I would like to make here is that technical coefficients, research, primary inputs, capital, labor, prices, demand, values, all are interconnected elements of the production function. Therefore a policy cannot change the value of a single factor without producing a chain of consequences which — in the end — may have completely different if not opposite effects from those desired.

The provision of short-term credit to farmers in Tunisia in 1970-1971-1972 is an example. Credit was provided to encourage farmers — especially small farmers — to buy inputs, to switch to a higher level of technology, to increase production, and to augment their income. However, those farmers who took the credit were obliged to sell their wheat to the "Office des Cereales" at the official price; they could not sell their wheat surplus —after their home-consumption needs — on the parallel market at a price 10-25 per cent higher than the official one. This procedure *de facto* defeated the program; very few farmers used the credit before 1974 when the Tunisian credit policy was thoroughly revised. The problems of agricultural policies — wheat policy in particular and development policy in general — are most complex in the developing countries, since here policies deal not only with an agriculture which is mostly traditional and subsistence-oriented, but the nation-state itself is — or was in the recent past — in the formative stage. One cannot understand the post-independence development of Algeria without taking into account the dramatic shortage of trained cadres in the 1960's. At independence there were three BS's in Agriculture in the whole Ministry of Agriculture; in 1970 there was only one engineer for the whole sector of large field crops.

Since the services and the functions of the state are crucial in national development —for the successful implementation of an agricultural policy and the elimination of most of the structural and institutional constraints — agriculture cannot be developed very far until the state becomes a stable, serviceable and trusted institution.

As we will see again later, the modernization process requires both capital intensification and an increased involvement in an exchange economy; in a modern agriculture the farmer becomes, to a varying degree, the owner of a firm in which the investment, savings, and managerial decisions are of strategic importance.

Thus, it is the integration of the domestic food-producing agriculture into an investment-oriented, exchange economy which is the basic problem of agricultural modernization. Wheat policy cannot escape from this reality, whatever the socio-political or ideological system that prevails in the particular country.

If we accept market involvement and capital intensification as a shorthand characterization of development, then we must create the conditions necessary for the achievement of these functions. For example, in order to have a good amount of capital investment, the future must be sufficiently secure for farmers to anticipate a reasonable prospect for future rewards. The creation of this climate of security of expectations is the task of the government.

Therefore in a mixed economy — and all the countries of the Middle East and North Africa appear as such from the questionnaire filled out by representatives of the countries participating in this workshop — the creation of a modern agricultural system can be accomplished only if the powers of the state are used in conjunction with — and in support of — the energy, the initiative and the drive of the private farmer. Looking at the traditional agricultural sector — that in which most of the rural population of the Middle East and North Africa still live — it is evident that the private, fundamental motives of both the individual and the family are *security* and *survival*. The social practices through which the survival-security goal is conceived and respected as a major public concern are translated into land tenure arrangements (tribal ownership of land), marriage practices, inheritance laws, the integration of the individual within his own community, and the degree to which these practices are sanctioned by religious and secular authorities (which, incidently, do usually share the same goals).

As agriculture becomes more and more capital intensive and market oriented and the socio-economic and cultural sphere of the farm family becomes larger than the boundaries of the village, other values and other objectives besides survival and security become important. For most, profit — pure personal profit — becomes the primary motor of socio-economic behavior. In the absence of both the old values which have been destroyed as well as of new values which have not yet been assimilated, farmers and rural people in general adopt a very selfish approach to the problem of life, production and development. Bacons statement "homo hominis lupus" (roughly, man acts as a wolf toward other men) expresses well this state of affairs.

Most of the problems of subsistence farming are no longer valid in the industrialized countries. However, the poverty, unrest, riots, and malnutrition of recent migrants to the central-city ghetto — and the problems of alienation that they determine — are forcing a reappraisal of our own so-called developed national policies and in particular of those policies relating to the agricultural sector.

My point here is that a national policy aimed at increasing the output of agricultural products on fewer but larger farms, farms which are kept functional through a series of price stabilization, marketing and credit policies, may not provide optimum conditions of life for the society as a whole. The Rockefeller and Ford Foundations are in the process of defining important programs aimed at studying the problems of food and nutrition. I would not be surprised if the focus of this research soon moves from Harlem to the Appalachians, from Cairo to the 4500 villages along the Nile, from Algiers to the subsistence cereal farmer of the High Plateaux.

The attention of agricultural economists in developed nations, ourselves in particular, is centered on market opportunities for the commodities as well as for the factors of production. In these countries the process of commercialization has run so deeply for so many decades that even future markets and future commodities have come to have definite price dimensions.

Thus, the major and most important aspect of agricultural policy for the last two decades has been *price policy*, and price theory has become the theoretical fulcrum of any market economy.

In the developing world, the economic opportunities do not have such predominant price dimensions. Production systems are not highly efficient and flexible, factors of production are not mobile, there are a lot of market viscosities, market information is far from perfect, and producers are usually neither able nor willing to respond to policy measures imposed on them.

The policies through which governments attempt to increase agricultural production are many; they are different in their application and in their possible consequences. The best known and most widely used is price-policy, and in this category I include policies aimed at subsidizing inputs, outputs and exports. Other policies are land tenure and land reform, acreage allotment, tax policies, input supply programs, credit policies, and collective organization of services (i.e. mechanization, spraying herbicides by plane).

I would like to talk today about price policy in more details.

Price policy has long been considered the most important and most effective tool in production planning. Historically, support prices have been determined mainly with reference to the cost of production of each individual commodity, but little attention has been paid to the relative price levels between commodities. Consequence of this is that in Egypt the price of one ton of straw is higher than that of one ton of wheat.

Most of the times prices have not been used as an effective instrument to encourage the selective expansion of wheat production. As the previous speaker, Dr. Bolton, noted, prices have been declared too late in the year to influence not only the area planted, but also the use of fertilizers, certified seeds, herbicides, and all the other inputs which in the ultimate analysis, determine the yields and the level of national production.

Increasing the level of cereal production requires in most cases making large use of inputs produced outside the agricultural sector. Often governments — which have a vested interest in furthering the adoption of new technologies in order to increase national production — are willing to share costs and provide a subsidy for the inputs they want to be introduced and adopted. In most countries of the Middle East and North Africa, heavy subsidies have been paid on farm inputs, but often these inputs have not been directed toward the production of those high-priority crops for which they were intended. Over the years and in many countries I have seen misallocation of resources, but I have also seen some successful examples of government intervention. The experiments made with Suffix by the Cereal Project in Tunisia showed that this chemical was able to control wild oats, one of the most serious constraints to cereal production increase in rain-fed agriculture. Since the cost per hectare of spraying this chemical was high ($16), in 1973 the Government of Tunisia decided to subsidize at 50 per cent the use of Suffix. The response of the farmers was highly favorable and the participants in the Third Regional Cereal Workshop — which was held in Tunisia in 1975 — were able to see *de viso* the effects of the intervention.

Subsidies are given for specific purposes and should be eliminated as soon as possible; otherwise they become part of the cost structure and are considered by the farmer as a negative tax. In order to introduce HYV in Tunisia the Government in 1979 adopted the practice of exchanging 110 Kg of commercial wheat against 100Kg of certified seed of the variety that was deemed appropriate to be introduced to the farmers. This practice was very effective in changing the pattern of varieties in Tunisia and has contributed to increasing the level of production. However, after 10 years Tunisian farmers should be convinced of the advisability of using HYVs and certified seeds; the practice should therefore be gradually discontinued and market forces be allowed to play.

Output subsidies are generally provided in order to increase the demand of a particular product or to allow the poorest segments of the population to satisfy their need for some basic commodity (wheat, rice, tea, sugar). Subsidies of basic commodities represent, in most cases, an easy burden for the government budget since all the population — rich and poor alike — share in the benefits of this policy.

As an example, I would like to refer to the case of Jordan, which has adopted a very pragmatic position vis-a-vis cereal subsidy policies. As regards consumption of wheat, there are three distinct population groups. The first is represented by the rural population; wheat is generally consumed by those who produce it and by their close relatives, or stored to provide security against weather uncertainty in the following years. Practically, no wheat is sold to the Government, which has the monopoly of trade. The second group consists of the Palestinian refugees, aproximately one third of the total population; in 1975-76 wheat was provided to them through international donations. The third group is the urban sector. This group is fed with wheat imported from abroad — bought on the international market or on concessional terms — at a price that is roughly half that of the locally produced wheat. Moreover, the price of flour is subsidized, with the result that the bread made by the farmers from their own wheat is four times as expensive as that sold in town to the urban consumer.

Subsidies can also produce some important distortions. In Egypt, town bread is seven times cheaper than that made by the poor farmer who has no bakery nearby. For this reason, Egyptian farmers have found it profitable to buy bread in town whenever possible to feed their chickens, rather than give them food produced on the farm.

Price policies designed to increase the aggregate cereal production within the context of a semi-traditional agriculture suffer from two major disabilities. The first is that these policies are usually inconsistent with each other and even with the more basic goals of the economic development of the country. The second is that the appropriate price devices for affecting production increase may be difficult to organize and administer, because the national administrative structures are not yet solid enough.

The conclusion is that in the context of agricultural modernization, cereal policies cannot be conceived as isolated from economic and social incentives for the different segments of the rural population, from national research policies, as well as from input, output, and marketing considerations. Policy makers and planners should be aware of this reality.

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Summary

The paper discusses the similarity and diversity of agricultural policies aimed at increasing cereal production in the Middle East and North Africa. It lists the most important constraints that counteract effective implementation of these policies. The paper emphasizes the need to improve the productivity and welfare of the small farmers. It stresses the importance of commitment on the part of the leaders and their understanding of the agricultural development process. The mechanism of defining agriculture policy is discussed at length, as well as various production functions and their interactions. The paper stresses the need to boost the energy, the initiative and the drive of the private farmer. The role of credit, price policy and subsidy is discussed, with examples from various countries.

POLITIQUES CEREALIERES ET CONTRAINTES ECONOMIQUE

Piero Bronzi

Résumé

Le document discute en détail la similarité et la diversité des politiques agricoles visant à accroître la production céréalière au Moyen Orient et en Afrique du Nord, et classifie les plus *importantes contraintes* qui contrecarrent l'exécution effective de ces politiques.

Le document met l'accent sur le besoin d'améliorer la productivité et le bien-être des petits agriculteurs. Il souligne l'importance d'un engagement sincère de la part du leadership et leur compréhension du processus de devéloppement agricole. Le mécanisme pour définir la politique agricole est discuté en détail. Le rôle de différentes fonctions de production et leurs interactions est aussi discuté. Le document souligne le besoin de prôner l'énergie, l'initiative et le dynamisme de l'agriculteur du secteur privé. Le rôle du crédit, de la politique des prix et de la subvention, avec des exemples de différents pays est discuté.

II. WEED CONTROL

G. B. Baldwin
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A REVIEW OF WEED CONTROL PRACTICES IN CEREAL ROTATIONS IN SOUTHERN AUSTRALIA

G. B. Baldwin*

In reviewing the weed problems of cereal rotations, a good starting point is to ensure an understanding of the nature of the losses that occur; some are obvious, others are not.

The Types of Losses

Weeds reduce crop growth and yield by competing for water, nutrients and light. The competition for water, phosphorus and nitrogen is thought to be particularly important in our Mediterranean environment. Weeds can interfere with harvesting. They can tangle in machinery, cause the crop to lodge, and slow down the harvesting operation. Weed seeds contaminate grain, and may result in taint or discoloration of grain products. They may increase grain moisture and create storage problems, or their presence may down-grade quality and reduce grain value.

Less obvious perhaps, are the losses that occur when measures are taken to control weeds. Herbicides may reduce crop yields if they are used at higher than recommended rates (over-lapping), or if they are mis-timed or are used on "susceptible" cultivars. Cultivation for weed control can destroy soil structure and increase the risk of wind and water erosion. It can delay sowing from the optimum time.

Weeds act as hosts for cereal diseases as well as hosts for diseases of other crops grown in the rotation. *Hordeum* spp. are hosts for the take-all fungus, *Gaeumannomyces graminis.* This is undoubtedly the most important root disease of wheat and barley in southern Australia. Populations of *Heterodera avenae,* the cereal cyst nematode, may increase more rapidly on wild oats, *Avena* spp., than on susceptible wheat or barley cultivars.

It is important not to under-estimate the losses caused by weeds in non-cereal years. Some have a detrimental impact on stock health as well as being able to compete with sown pastures in ley years. Some are serious competitors in other cash crops in the rotation. *Oxalis pes-caprae,* sour-sob, is an example of one such weed in South Australia. This plant competes with cereals, grain lupins, and legume pastures. Its high oxalic acid content makes it poisonous to sheep and careful management of sour-sob dominant pastures is required to reduce the chance of fatal poisoning. Recent reports indicate that two cereal-pasture weeds, *Polygonum aviculare* and *Gasoul crystallinum,* have water soluble compounds in their dry residues which inhibit the germination of annual medic seed and slow seedling medic growth.

Often, when the balance sheet of cost versus extra grain yield is drawn up, the value that weed control has in other years of the rotation is not fully assessed.

Some Notes on Weed Ecology

One could well ask, "What are the characteristics of these plants that are so well adapted to the ecology of our cereal rotations?" The majority are small seeded autumn/winter germinating annuals. Many produce large quantities of seed; 60,000 seeds of annual

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ryegrass, *Lolium rigidum*, per square metre have been recorded in Western Australia (Pearce and Holmes, 1976). Some have dormancy patterns which allow them to survive drought and fallow years; most germinate in the top 2-4 cm of soil. At this depth they are subject to changes in temperature, light and moisture, and are subject to the abrasive action of cultivation machinery. These factors help break seed dormancy, and their variation from season to season, together with the variations in the timing of cultural operations, no doubt contribute markedly to the success of any one species establishing and competing in any crop year. Some cereal weeds make rapid early growth and they seed before crop maturity. Others are mature at harvest and are spread by harvesting machinery or grain. Few are spread by vegetative means. Some are adept at producing seed even when "topped" in pastures or when heavily grazed. Appendix I is a list of important weeds of cereal rotations in South Australia.

Quantifying Losses

What are the economic thresholds (i.e. the weed densities above which significant yield losses occur) for the important weed species? A single value for any one species is thought to be a useful guide for farmers and extension workers to predict crop losses. Such a value can, however, be very misleading. Dew (1972) reported a relationship between the density of *Avena* spp. and grain yield. His formula L = abx (where L = the expected loss, x = the wild oat density per metre squared, b = a crop constant) is an attempt to quantify yield losses. Australian researchers have made similar attempts.

Yield losses caused by weed competition are, however, affected by factors such as sowing rate, soil moisture and soil fertility, i e. factors which affect crop density and vigour. Losses will also be affected by the growth stage of the crop at which weeds emerge and the stage at which they are removed. The wild oat density required to significantly reduce yields in one area of Australia has varied from 11-153 plants/m^2. Weedy species rarely occur in isolation and there are usually two or more species making up the competing flora.

The success of equations aimed at predicting yield losses depends on their ability to define accurately these and other variables.

Cereal growers in southern Australia recognise these variables as those involving the soil, crop density and vigour, and perhaps less readily as those involving weed types. They now recognise that most annual weeds have their greatest impact on yield by competing with crops during their first six weeks of growth. It is not widely recognised, however, that if fertilizer and moisture are adequate, crops may suffer a greater yield loss than if they are grown under stress. Farmer experience indicated that our barley cultivars make more rapid early growth than our wheat cultivars and are able to compete more successfully with weeds. Semi-dwarf wheat cultivars are said to allow better growth of weeds than traditional taller cultivars. Reeves (1977) found differences between cultivars in their competitive ability with annual ryegrass, but he did not associate this directly with semi-dwarf parentage. The seedling vigour and growth habit of cereal cultivars can have an influence on their competitive ability against weeds in our Mediterranean environment.

Different weed species have different competitive abilities. Recent research in Australia has indicated that on a per plant basis, *Buglossoides arvense* has a greater competitive ability than *Amsinckia hispida*, than *Brassica tournefortii* than *Lamium amplexicaule* than *Fumaria parviflora*. Nevertheless, such data requires field interpretation as in South Australia, *Lamium* and *Fumaria* are often more dense in crops than the other species. Different species may compete for the same or different soil nutrients. Research suggests that the species listed above are not keen competitors for nitrogen. Smith and Levick (1974) have, however, shown that competition between annual ryegrass and wheat is mainly for soil nitrogen.

The relationship between yield loss, weed types and densities will always be difficult to determine as the variables influencing competition are always changing. Nevertheless, research is attempting to quantify losses in defined areas with particular crops and weed species. It is the extension officers' role to put the research equations into a simple form so they can be used by the farmer. It is he who has the difficult decision to make when weed densities are low and there are doubts about recovering treatment costs. In Australia at present, trifluralin costs $A3.60 dollars/ha and this is sufficiently low to tempt some farmers to use this herbicide pre-sowing, even though weed densities may not warrant it. Prophylactic treatment is now taking place.

The economic threshold or critical weed density has been defined as the density which will give an increase in crop yield sufficient to cover the cost of the herbicide, the cost of application, and a return on capital invested.

Table 1 after Wells (1978) lists critical weed densities for seven weeds of cereals that occur in Australia. The densities depend on weed type and the cost of the control treatment. Such an approach is one example of how research results can assist farmers to make decisions on the economics of cereal weed control.

TABLE 1. Data on weeds occuring in wheat (after Wells (1978))

Weed Species	Herbicide	Variable Cost $A dollars	Weed-free Yield of Crop in t/ha	Suggested Critical Weed Density/m^2
Emex australis	methbenzthiazuron	5.00	1.4	12
Polygonum convolvulus	bromoxynil MCPA	10.00	1.6	158
Amsinckia hispida	terbutryne	6.50	1.7 - 4.0	18
Fumaria parviflora	terbutryne	6.50	1.5 - 5.5	20
Lamium amplexicaule	terbutryne	*6.50*	*1.6 - 4.4*	*72*
Buglossoides arvense	terbutryne	6.50	0.8 - 3.4	14
Avena fatua	diallate	8.00	2.0	4

The Importance of Cultural Control Techniques

Cultivation, grazing, slashing and burning are used for weed control on cereal farms, although the emphasis today is on chemical weed control in the cropping year. Attempts are now being made to use cultural control techniques to support chemical control. Cultivation is still the major traditional method of weed control.

In reviewing cultural control techniques, it is important to understand how effective they are, to consider their cost, and any impact they may have on the soil.

Cultivation

Fallowing was widely practiced in the southern wheat belt of Australia during the 1940 s and some 70 percent of wheat grown in South Australia was grown on fallow. Fallows were maintained weed-free throughout the year by cultivation, to stop weeds transpiring stored moisture. Herriot (1954) noted that the farmer who ploughed, cultivated and harrowed early in the fallow season usually found he had provided ideal conditions for small seeded weeds to germinate. He had therefore to cultivate again. As a result soil tilth became finer, more weeds were encouraged to grow and a vicious cycle began. Spraying, not tillage, he suggested was the answer. At times farmers worked soils for weed control when they were either too wet or too dry, at high speed. This further aggravated soil problems. Tillage operations are time consuming. As fuel prices rise and labor costs increase, they are becoming more costly.

Pre-sowing cultivations for weed control had a major impact on the soil environment prior to the establishment of legume pastures in rotations in southern Australia. In many areas, soil structure deteriorated and serious wind and water erosion developed. Contour banks had to be constructed and farmers educated to reduce tillage, widen rotations, and build soil fertility by growing legume pastures.

Farmers today still recognize that the mouldboard plough gave them better weed control by inverting weeds and burying weed seeds to a depth of 7-8 cm, than did the disc plough. Tyned implements which have a shuffling action, cut roots and tend to leave plants upright in the soil. They have given poorer weed control than either mouldboard or disc implements; if rain occurs soon after cultivation their percentage weed kill is low. Nevertheless, tyned implements are now widely used to "break-up" and prepare ground for sowing.

Pearce (1973) has pointed out that the key to the cultural control of weeds is understanding the factors which govern the germination of weed seeds. His research has shown that strategic shallow cultivation at the start of the growing season provides the soil cover needed for a fast, even germination of some weed seeds. He recommends that farmers shallow cultivate (skim plough) paddocks before or just after autumn rains to promote a uniform germination of annual ryegrass. Further soil preparation is then delayed for 14 days to achieve maximum annual ryegrass control. Strategic cultivations can greatly assist weed control whereas continual cultivations prevent seed set and stimulate the germination of dormant seeds. The cost and the effect that continual cultivation has on soil structure, however, precludes its use over long periods as a useful method of weed control in our Mediterranean environment. Cultivation for weed control in the past has delayed sowing from the optimum and the cost of such delays must now be compared to the cost of effective weed control with herbicides in the crop.

Grazing

Grazing with sheep will reduce weed growth and seed formation if stocking rates are maintained at high levels during winter and spring. It will allow annual legume pastures to develop optimum leaf area and allow the entry of light into pastures, which in turn aids nitrogen fixation. Farmer experience indicates that some weedy species are preferred by stock, whereas others are unpalatable or become so as they approach maturity. Some species are very adept at producing short or prostrate seed heads, even under a grazing management regime. Few farmers have sufficient stock to keep pastures adequately grazed and grazing pressures of 5-7 Dry Sheep Equivalents (DSE)/ha are often not enough to cope with the spring flush of growth in our Mediterranean environment. Nevertheless, many growers make the attempt and concentrate their stock on areas intended for cropping. When areas cannot be grazed effectively by stock they then "top" pastures for weed control with a rotary slasher.

Slashing

Rotary slashers are used in pasture years of rotations primarily to reduce seed set of grassy and cruciferous weeds, and to minimize the effect of grass seeds on stock health and wool quality. The technique has gained favor with the advent of efficient machines that can slash a wide swath 1-2 cm above the medic canopy. The technique can fail if rain follows slashing and a second slashing may then be necessary to control regrowth. Like cultivation, this practice is labor intensive, and as labor and fuel costs increase some growers are questioning its weed control value if reliable chemicals are available for grass weed control in the burning year.

Burning

Few farmers in South Australia burn for weed control. Many prefer to retain crop and pasture residues on the surface to protect the soil from erosion, or incorporate them to increase soil nitrogen levels. If burning does take place its aim is to remove residues to aid the incorporation of soil applied herbicides, or to prevent blockages in seeding equipment. Burning is not considered a practical weed control technique. It can be effective if weed seeds remain on the flower stalk and there is sufficient residue at ground level to fuel a "hot" fire. The highest temperature in a "grass" fire is reached at a height of 10-20 cm above the ground surface. At the soil surface and 1-2 cm below the surface, temperatures are considerably lower. Seeds shed over a period of time as plants mature may subsequently be trodden into the soil by stock and escape the effects of fire. Cartledge (1973) has noted that in Queensland, stubble burning stimulates wild oat germination. Other reports indicate that wild oat seeds are particularly resistant to heat and stubble burning is ineffective.

The Impact of Rotations on Cereal Weed Problems

Before discussing the impact that rotations have had on weeds, it is necessary to briefly outline our growing season and give a brief history of our rotational practices. The annual rainfall in the cereal region of South Australia ranges from 280-500 mm, of which

200-400 mm falls in the nominal growing season April-October inclusive. Spring wheat varieties are sown mid-May-June and the rain from April onward permits pre-sowing cultivations.

Fallowing land and keeping it free of plant growth for nine to ten months before sowing has long been a feature of wheat growing. Large yield increases were obtained with crops sown on fallow, compared to land given only short preparation (two months). From the early pioneering days fallowing was used to clear land of stumps, control weeds, prepare a seedbed, and increase soil moisture and nitrogen. In the mid-1940's farmers began to change from this exploitive system of close cropping and clean fallows, and a greater emphasis was placed on building soil fertility through wider rotations and sowing improved annual legume-based pastures. Reduced tillage gradually replaced clean fallows and farmers began growing wheat on "grassland." By 1958, French (1963) estimated that the percentage of wheat grown on fallow had fallen from 70 percent to 46 percent. Today it is estimated that this figure is less than 30 percent.

The additional yields from fallows were obtained at extra cost. In some areas the reduction in soil fertility and the breakdown in soil structure caused by continual cultivation allowed wind and water erosion problems to develop. Surface sealing and crusting occurred following heavy rain and crops failed to break through the surface seal. Water needed for crop growth was lost by runoff as soil permeability declined. The need for a critical analysis of fallowing was evident, and French (1978) reported that in South Australia the decision to fallow depends on:

1. The need to promote soil nitrate. With a rhizobial input of approximately 80 kg N/ha/annum from an average legume pasture, the 70 kg N/ha required for high wheat yields could be achieved without long fallow. It was possible if rain followed pasture "break-ups" one to two months prior to sowing, to obtain high levels of nitrate nitrogen (30 ppm) at sowing time without fallowing.
2. The need to store soil moisture. To achieve this, soils need to be of fine texture with more than 20 percent clay in the 15-30 cm sub-soil horizon. Fallowing has to be undertaken before the end of September to minimize evapo-transpiration losses from the pasture and it has to be done in years when 100 mm or more of rain falls in the months of July and August or close to the beginning of the fallowing period.

In the 1950's, emphasis was placed on including annual legume pastures in rotations to build soil fertility. Wheat-fallow rotations were replaced by those that included a period under clover or medic pasture. Rotations, such as pasture, wheat, peas, barley, pasture, wheat, or wheat pasture, barley pasture, came into use. Growers were encouraged to sow annual ryegrass with cereal seed to give "better balanced" pastures.

If land were fallowed early before annual weeds set seed and cultivated after rains to maintain it weed free, then few weed problems developed in the crop year. The problems that did occur were caused by weeds that set seed in the crop year or set seed on fallows that were not maintained weed free. This seed was then buried over the cultivation depth and seed dormancy was an important factor in weed survival. Fallows also had benefits in disease and insect pest control. Meagher and Rooney (1966) reported on their impact on cereal cyst nematode control in Victoria.

With increasing pasture years in rotations, some annual weeds had an opportunity to build a "seed-bank" in the soil. Other weeds were given a selective opportunity to do so in the crop year. It was in the early 1950's that 2,4-D became widely accepted as a herbicide for cruciferous weed control in cereals. Cruciferous weeds flourished in pastures but were controlled in crops at the tillering stage with 2,4-D. Rotations have always been influenced by the value of grain, meat and wool. When livestock became more profitable than grain in the early 1960's, then the number of pasture years in rotations increased. Wheat quotas imposed in the late 1960's had a similar effect.

Pasture years are often not successful weed control years and as soil fertility improved, weeds, and in particularly grassy weeds, such as *Hordeum* ssp.,*Lolium rigidum* and *Bromus* spp. (the latter on the lighter soils), set seed and competed for available nitrogen. Through the 1950's and into the mid-1960's, 2,4-D had its impact on the weed flora. In crops, grasses and 2,4-D-resistant broad leaf weeds were being given a selective advantage. Grass dominant pastures resulted in a resurgence of disease problems in crops. Various grass species hosted disease organisms during non-crop years.

The introduction of soil incorporated herbicides for grass control, and early post-emergent herbicides for 2,4-D-resistant broad leaf weed control in the late 1960's, had a marked impact on the yield of crops grown under the new farming system. Managing weed and disease problems has proved to be an important and under-estimated component of dryland farming.

Developments in Chemical Weed Control

The Past

The last two decades have been referred to as "The Era of Herbicides." Chapman (1978) referring to Table 2 below, noted that although the total pesticide market value had increased by more than fourfold, the predominance of insecticides had been eroded and replaced by herbicides. The increased number of selective herbicides available for weed control in crops has helped contribute to this change.

TABLE 2. The value of the pesticide market at end user level for the world excluding Comecon countries ($M. 1976 money) (After Chapman 1978)

	1957 Market Value	%	1976 Market Value	%
Insecticides	882	54	2,395	34
Herbicides	255	16	3,198	46
Fungicides	370	23	1,086	15
Others	125	7	358	5
Total	1,632	100	7,037	100

From 1950-1965, cereal growers in South Australia relied on 2,4-D or related compounds to control weeds. In 1964-1965, 73 percent of South Australian wheat growers used hormone herbicides. Approximately 50 percent of the crop was sprayed at an average cost of $A00.62/ha treated. The cruciferous weeds controlled were susceptible to 2,4-D and although the rates, the timing and the spray techniques varied (depending on the skill of the operator and quality of his equipment) as 2,4-D was "applicator forgiving" and the weeds were susceptible, results were good. Growers became conditioned to spraying weeds in cereals approximately 2.5-3 months after sowing. Resistant 2,4-D species were given a selective advantage and growers had to use the ester form of 2,4-D at crop tolerance levels (0.56 kg/ha) to check "hard-to-kill" broad leafed species. Grassy weeds completed their life cycle virtually unhindered. Varietal differences in crop susceptibility to 2,4-D did not assume any significance.

A major change occurred in the mid- and late 1960 s. This change began with the introduction of the first two herbicides for grassy weed control, diallate and barban, and the first herbicide, prometryne, for early post-emergent control of 2,4-D-resistant broad leafed species. The cost of these new herbicides was high ($A8.00/ha) compared to the cost of 2,4-D, and their times of application were different. They were also "application sensitive." These three factors resulted in the slow acceptance of the concept of pre-emergent and early post-emergent weed control. Many farmers decided to "wait and see" and they looked "over the fence" at the results of trials or spraying undertaken by the more innovative farmers. "Marginal growers" rightly believed they could not afford such expensive methods.

Farmers also found it hard to believe that the yield increases claimed for these new herbicides were actually being achieved. The yield of spring wheat is determined by the number of heads/hectare, the number of grains/head and the average weight of each grain. Research had yet to establish that weed competition had its major impact on the yield component number of heads/hectare, and that the potential yield of a crop was largely determined within seven weeks of seeding, the period when weed competition is most severe.

In the late 1960 s the technology gap between research, extension and the farmer began to widen. We are still trying to breach this gap today. In the next ten years the following herbicides (in approximate chronological order) were introduced for weed control in cereals — triallate, linuron, bromoxynil, metoxuron, diruon, methbenzthiazuron, terbutryne, alachlor, trifluralin, pendimethalin, diclofop-methyl, difenzoquat, metribuzin and flamprop-methyl. All have or are about to have their impact on cereal weed control; however, trifluralin (introduced in 1972) has had the greatest impact.

The Present

Cereal farmers have learned by experience the problems associated with the use of a wide range of herbicides. Problems have involved soil type, soil tilth, organic matter, sowing depth, rain after spraying, stage of weed growth, seedling weed identification, "escape" species, crop variety, wind strength and humidity at spraying time and the type and quality of spraying equipment. As farmer experience has grown, so too has herbicide usage increased. It is now estimated that in many areas 80 percent of the wheat and barley crop is being treated with pre-sowing applications of trifluralin. This compound has been widely accepted because of its low cost ($A3.60/ha), because it gives excellent control of annual ryegrass and checks the growth of wild oats, and because it controls some seven important broadleaf weed species. Although this herbicide requires effective incorporation and the crop must be sown at a recommended depth and time from treatment, farmer experience has proved trifluralin can give good results when these criteria are not as recommended. Trifluralin too, has its problems. If used alone without follow-up post-emergent treatments, cruciferous weed problems increase. Its present method of use does not fit in easily with minimum tillage systems and a deterioration of soil structure can occur as a result of recommended incorporation techniques. The emergence of wheat can be delayed and trifluralin residues can retard the growth of sensitive crops sown in the following year.

Our weed problems have increased dramatically with changing rotations, but fortunately herbicides have been developed which have been capable of controlling virtually all our annual cereal weeds. Grasses and broadleaf weeds have been controlled by spraying them before sowing the crop, by spraying them immediately after sowing, or by spraying when they first appear in the crop.

The Future

Some workers have predicted that when the weed "seed-bank" in the soil is reduced, we will be approaching weed-free farming systems, I believe to achieve this will require more emphasis on the control of weeds in pastures. It can be argued that weeds are productive and nutritious in pastures. They do not, however, fix atmospheric nitrogen and many compete with those useful plants that do.

With the advent of a wide range of herbicides our attitude to tillage as a weed control practice is changing. This change in attitude has been accelerated by the energy crisis. Tillage for weed control may require ten times the energy input that is required for one application of herbicide to achieve the same end result. Although our most widely used herbicide requires cultivation and incorporation to be effective, research is now concentrating on the benefits of herbicides and mixtures of herbicides in direct drilling systems.

The rapid past growth of the agro-chemical industry suggests that its future growth rate will be slower and that the industry is in a mature phase. It has been forecast that the number of companies participating in herbicide research and development will decrease as economic pressures cause those with few resources to drop out or amalgamate.

The Technology Barrier - Transferring Technology:

The Methods in Use:

Your Committee has asked me to discuss how the new technology has been passed to the end user, the farmer. As a prelude to this discussion, I have listed below a few of the technological messages that have needed transferring to the farmer during the last 15 years in South Australia.

1. Weed control must be considered in all years of a rotation. Control with herbicides alone during the crop year is often insufficient to reduce weed infestations. There are weed control techniques apart from herbicides that can be used to advantage.
2. Weed control early in crop growth (within six weeks of seeding) is essential to maximize yield. Crops with adequate moisture and nutrients will respond better than crops under stress.
3. The boom spray is an important piece of equipment. It needs calibration and maintenance and to be of the correct design.
4. Before selecting a herbicide, it is important to recognize the weed flora present. The ability to identify seedling weeds is essential as is the ability to recognize those species that may escape treatment.
5. Soil moisture and the presence of clods, stones or ridges and crop and pasture residues, can influence the efficacy of soil applied herbicides.
6. Grassy weeds are hosts for cereal diseases and carry over problems in non-crop years. Their control and the control of other weeds in alternate crop years can give benefits in following cereal years.
7. Read the label and follow instructions.

I think this list alone shows the magnitude of the task. Transferring technology requires trained people, organization and dedication. This task is best carried out by people who have a practical knowledge of agricultural systems and a sound knowledge of crop production. This implies a knowledge of agricultural pesticides and a knowledge of weed, insect and disease identification and control. Much of the technology we are transferring requires increased capital input (finance for herbicides). Perhaps this technology is not ideally suited for undeveloped countries where capital is short and labor abundant.

In retrospect, I believe we have done the job poorly. More emphasis has been given to funding, staffing, training and organizing people concerned with noxious weed control when dramatic developments have been taking place in weed control in crops. It is therefore not surprising that farmer acceptance of the technological changes has been slow. Credit must be given to the agricultural chemical industry, as both technical and sales representatives have been readily available to discuss the use of new herbicides with farmers, and member companies have produced excellent technical and sales literature on various subjects.

A discussion on transferring technology must attempt to answer questions such as: Who needs information? How is it to be "put across" to those who need it? How are people to be trained for this work in the future?

Who needs the information? The answer to this question is the 8,000 wheat and barley growers in our State, the industry sales representatives and retailers, the weed control contractors (who contract their services to growers who may be 100 km away from their point of operation) and the Government agronomists, both special and general.

How is information distributed to those who need it? Personal contact is the most effective way of changing attitudes and transferring information. It is interesting to note that most of the 8,000 growers in South Australia can receive a visit from an "expert" within 48 hours of making a request for advice. Group discussion is another useful way of transferring information. Farmer groups (bureaux) are in existence to facilitate this; other "key people," e.g. contractors, have been brought together by marketing companies.

Printed material has also been widely used; it is often colorful and it may contain diagrams and illustrations. Charts are a cheap and acceptable way of transferring tabulated informations and my Department has recently produced its twelfth cereal weed spraying chart.

To attempt to answer the last question, "How are people to be trained for the future?", it is essential to recognize that staff trained in all branches of plant protection are much more useful in the field than those who know all about weeds but cannot tell a root rot from a vascular wilt. Field experience has proved that the broadly trained plant protectionist is a more useful and valuable resource to the farmer than the specialist weed scientist, pathologist or entomologist. My Department is the first in Australia to establish a Plant Protection Section and all staff are regionally based to service agronomists and farmers in country areas. There are, however, few institutions in the world today where staff can receive formal training in plant protection. The training of resellers and contractors has also been a neglected area in Australia. I understand the situation has been reached in the United States where many retailers hold college or university degrees and offer a level of in-depth advice that is unavailable in most areas of Australia.

Technology is dynamic and the transfer of technology is a continual process. We have not been able to rapidly transfer the technological advances that have been made in cereal weed control in the last 15 years. Our research and development work has been at a minimum and we have relied heavily on the agro-chemical industry to do this work and keep farmers informed on new herbicides. The developments now taking place in direct drilling techniques require considerable farmer skill. Once again, much of the resesarch and development work is being left to industry, as is the transfer of the new technology.

Future Prospects - Recent Advances in Weed Control Research:

There are four areas of research which I believe will have an impact on weed control in cereal rotations in the future.

Direct Drilling

Direct drilling methods of crop establishment (i.e. methods that involve minimum soil disturbance prior to sowing and the use of herbicides to control pasture and weed growth prior to and after sowing), have been under investigation for more than ten years in some states in Australia. In one area of Western Australia, 10 percent of farmers use the technique. Experiments in this State have shown that similar yields can be expected from spraying autumn pasture and weed growth and then directly sowing the area with a standard combine (providing weeds, pests and diseases are adequately controlled), as can be obtained from cultivating and harrowing to prepare a seedbed. Research has shown that the triple disc drill, an alternate sowing machine to the standard combine, is better suited to areas where moisture is not limiting, i.e. where the annual mean rainfall is greater than 375 mm. Research has shown that it is easier to direct drill sites previously cropped as implements penetrate these areas more readily, soil tilth is generally better and weed problems are less.

There are many advantages claimed for this new system; some are listed below.

1. It is possible to sow closer to opening rains.
2. There is reduced capital investment needed in large tractors, ploughs and scarifiers.
3. The flexibility of the technique allows for rapid adjustment of the cropping area in any one year. Stock numbers can be maintained on the increased grazing available in autumn.
4. The technique is less damaging to soil structure and erosion risks are reduced.
5. Successful weed control with herbicides (which are an integral part of the technique) is ensured in wet years. In these years cultivations usually transplant weeds.
6. The potential exists for traditional weed problems to decrease under direct drilling. New species adapted to minimum tillage crop production will, no doubt, take their place.
7. Soil fertility, it is claimed, is maintained under direct drilling but declines under conventional cultivation. In soil that is conventionally cultivated organic nitrogen is readily oxidized to nitrate nitrogen, a highly mobile form. It is claimed that after one year of cultivation total soil nitrogen declines.
8. Rovira (1979) has suggested that direct drilling could benefit cereals by reducing the damage caused by cereal cyst nematode and *Rhizoctonia*.

Some of the disadvantages of the system are listed below:

1. Grierson and Allen (1977) recorded lower grain yields in wheat sown under a minimum tillage system compared to wheat sown on ten or three month fallow. The severity of attack by larvae of the insect pest, *Desiantha caudata*, cereal curcurlio, was increased with minimum tillage.
2. In certain years stock numbers are not sufficient to "hard graze" paddocks prior to spraying.
3. It is claimed that mineralization of organic nitrogen to nitrate nitrogen may not take place rapidly enough at sowing and germinating cereals can be nitrogen deficient.
4. Rovira (1979) noted a slightly higher incidence of take-all in direct drilled wheat compared to conventionally sown wheat. He suggests the technique may increase the problem unless steps are taken to eliminate grassy weed hosts.

Direct drilling is now being evaluated and accepted in some instances by cereal farmers in our Mediterranean environment. I forecast that this technique will have a major impact on the weed flora of our cereal rotations.

Controlled Droplet Application (CDA)

The ability to generate uniform sized droplets of spray solutions within the range 150-350 um creates exciting possibilities for weed control in cereals. Wilson and Taylor (1978) suggested an optimum volume rate of between 15-45 L/ha for barban and difenzoquat for the control of *Avena fatua*. Research by Ayres and Merrit (1978) has also shown CDA will allow a reduction in volume per hectare with certain growth regulator herbicides.

The challenge to produce field equipment that will allow us to decrease herbicide rates and total volume applied per hectare, and the challenge to formulate products designed for this method of application have now been accepted by weed research workers. It remains to be proven if this technique will have a useful place in weed control in cereals in our Mediterranean environment.

Herbicide Mixtures

Agronomists often consider making a recommendation which involves mixing two or more herbicides after they have identified the weed flora in a paddock. The use of tank mixtures and mixtures of formulated products is increasing. Mixtures can extend the range of weed growth stages and weeds controlled and reduce herbicide costs. O'Sullivan and Vandenborn (1978) have claimed these advantages from mixing barban and difenzoquat for wild oat control. Research needs to continue to support field recommendations, and perhaps it is the role of the government authorities to lead this research to avoid the conflicts that can occur between companies.

Genotype-Herbicide Interactions - The Use of Safeners

In the last five years we have become conscious of the differences in phytotoxicity that exist in our wheat, barley and oat cultivars to recommend herbicides. Often registration has been approved after considering trial results from America or from Western Europe when only limited research has been available from within Australia to confirm these results. The weakness of this system is that we have assumed our crop cultivars are as tolerant as those on which the overseas research was conducted. My department now accepts some responsibility for evaluating the phytotoxicity of all new herbicides on recommended or potential wheat, barley, oat and certain grain legume cultivars. This service is offered at a fee to the agro-chemical industry.

Chang *et al* (1974) reported on the use of 1,8-napthalic anhydride as a seed dressing to reduce the phytotoxicity of barban to *Avena sativa* when it was used for the control of *Avena fatua*. Perhaps in the future antidotes or safeners will have a role protecting sensitive cultivars from herbicide damage as well as extending the range of crops in which our existing herbicides can be used.

In the Mediterranean regions of Southern Australia, we have seen major changes in weed control techniques in cereals in the past 15 years. There is evidence to suggest that the changes that will occur in the next 15 years will have a dramatic impact on our farm production and cereal weed flora.

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APPENDIX

IMPORTANT WEEDS OF CEREAL ROTATIONS IN SOUTH AUSTRALIA

Annual Grasses:

Family: *Gramineae*

	Common Name
Avena fatua	Wild oat
Avena sterilis	Wild oat
Brachypodium distachyon	False brome
Bromus diandrus	Great brome
Bromus madritensis	Madrid brome

Bromus rubens	Red brome
**Hordeum geniculatum*	Barley grass
**Hordeum glaucum*	Barley grass
**Hordeum leporinum*	Barley grass
**Hordeum marinum*	Sea barley grass
***Lolium ridgidum*	Annual ryegrass
Phalaris paradoxa	Paradoxa grass
**Vulpia bromoides*	Silver grass
**Vulpia megalura*	Silver grass
Vulpia membranacea	Silver grass
**Vulpia muralis*	Silver grass
**Vulpia myuros*	Silver grass

Perennial Grasses:

Family: *Gramineae*

Cynodon dactylon	Couch grass - a minor problem

Annual Broad Leaf Weeds:

Family: *Aizoaceae*

Gasoul crystallinum	Ice plant

Family: *Boraginaceae*

Amsinckia hispida	Yellow burr-weed
Buglossoides arvense	Sheepweed
**Echium plantagineum*	Salvation jane

Family: *Caryophyllaceae*

Stellaria media	Chickweed

Family: *Compositae*

Arctotheca calendula	Capeweed
Carthamus lanatus	Saffron thistle
Onopordon acaulon	Stemless thistle
**Pentzia suffruticosa*	Calomba daisy
Picnomon acarna	Soldier thistle

Family: *Cruciferae*

Brassica tournefortii	Turnip, long fruited
**Capsella bursa-pastoris*	Shepherd's purse
Carrichtera annua	Ward's weed
Neslia paniculata	Ball mustard
Rapistrum rugosum	Turnip, short fruited
Raphanus raphanistrum	Radish
Sinapis arvensis	Charlock
Sisymbrium orientale	Mustard, Indian hedge

Family: *Geraniaceae*

**Erodium botrys*	Wild geranium
**Erodium moschatum*	Wild geranium

Family: *Labiatae*

Lamium amplexicaule	Deadnettle

Family: *Leguminosae*

Melilotus indica	Melilot
Vicia sativa	Common vetch

Family: *Oxalidaceae*

Oxalis pes-caprae	Sour-sob

Family: *Papaveraceae*

Fumaria densiflora	Red fumitory
Fumaria parviflora	White fumitory
Glaucium flavum	Horned poppy
Papaver hybridum	Rough poppy

Family: *Ploygonaceae*

Emex australis	Three corner jack
Emex spinosa	Three-corner jack
Polygonum aviculare	Wire weed
Polygonum patulum	Erect wire weed

Family: *Ranunculaceae*

**Adonis microcarpa*	Pheasant's eye

Family: *Rubiaceae*

Galium tricornutum	Three-horned bed straw
Sherardia arvensis	Field madder

Family: *Scrophulariaceae*

Veronica hederifolia	Ivy leaf speedwell

Perennial Broad Leaf Weeds:

Family: *Caryophyllacae*

Silene vulgaris	Bladder campion

Family: *Compositae*

Chondrilla juncea	Skeleton weed

Family: *Cruciferae*

Cardaria draba	Hoary cress
Diplotaxis tenuifolia	Lincoln weed

Family: *Ploygonaceae*

**Rumex angiocarpus*	Sorrel
Rumex pulcher	Fiddle dock

Family: *Resedaceae*

Reseda lutea	Mignonette, cut-leaf

Family: *Solanaceae*

Solanum elaeagnifolium	Silver-leaf nightshade

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*Primarily weeds of annual pasture
**The annual species in this genus are under investigation

Summary of Species per Family:

Gramineae	19
Cruciferae	10
Compositae	6
Polygonaceae	6
Papaveraceae	4
Boraginaceae	3
Caryophyllacae	2
Geraniaceae	2
Rubiaceae	2
Leguminosae	2
Aizoaceae	1
Labiatae	1
Oxalidaceae	1
Ranunculaceae	1
Resedaceae	1
Scrophulariaceae	1
Solanaceae	1
Total	63

Summary

The nature of the losses caused by weeds in cereal rotations and the variables that make the practical application of economic thresholds difficult are discussed.

The cost, effectiveness and impact on the soil of various cultural weed control techniques is reviewed, and the effect that cereal rotations have had on crop weed problems in South Australia in the last 40 years is described.

The major changes that have occurred in the number of herbicides available for control of cereal weeds are described, and some of the problems associated with transferring the technology associated with their use are listed.

Four areas of research, which it is forecast will have an impact on weed control in cereals in southern Australia in the future, are discussed.

COMPTE-RENDU DES TECHNIQUES DE CONTROLE DES MAUVAISES HERBES DANS LES ROTATIONS DE CEREALES EN AUTRALIE DU SUD

G. B. Baldwin

Résumé

Dans le travaille on présente les thèmes suivants:

Une discussion sur la nature des pertes causées par les mauvaises herbes dans les rotations de céréales et les variables qui font obstacle à l'application pratique de seuils économiques.

L'examen du coût, de l'efficacité et de l'impact sur le sol des différentes techniques culturales de contrôle des mauvaises herbes et description de l'effet des rotations des céréales sur le problème des mauvaises herbes durant les 40 dernières années en Australie du Sud.

La description des changements majeurs intervenus dans le nombre d'herbicides disponibles pour le contrôle des mauvaises herbes dans les cultures céréalières; énumération de certains problèmes associés au transfert de la technologie associée à leur utilisation.

Une discussion sur quatre zones de recherche qui auront à l'avenir un impact prévisible sur le contrôle des mauvaises herbes dans les céréales en Australie du Sud.

CHEMICAL WEED CONTROL AS AN INTEGRATED PART IN CEREAL PRODUCTION

F. Basler*

The definition of a weed says that it is a plant growing in the wrong place at the wrong time!

This is a definition made by man, where he singles out some plants from an otherwise well balanced plant population and ever since he has attempted to remove these unwanted plants by whatever means to benefit from a monoculture, after having realized that they compete with his crop, a new man-made plant population equilibrium was established. Whenever man changed part of his agricultural practices, again another equilibrium established itself. These changes have gone on for thousands of years and will certainly continue to do so, as agricultural techniques will change; this means that, at whichever field we are looking, it has a past history, a present and a future regarding its weed population, and this is in kind as well as in quantity.

The reasons for these adaptations of the weed flora to the various systems lay in the fact that a particular soil contains a vast number and variety of weed seeds, many of them having longevities of decades (Darlington and Steinbauer, 1961) or weeds scantily reproduce under unfavorable conditions for ages, until a suitable environment occurs, permitting them to germinate or to establish strongly. Moreover, weeds are transported as seeds by many means, either by man or by nature from one field to another, sometimes bridging continents.

Naturally we can see normally only the present weed situation of a field, and as long as the same agricultural practices are kept the same, we can assume that it will largely remain as such. However, changes of these practices have been and are being made increasingly often upsetting the weed equilibrium (just think of the introduction of new cultivation techniques and machines, crop varieties, fertilizers, harvesting machines, etc.). Also other-than-agricultural causes can and have influenced the weed equilibrium, notably economical, political and social nature. Many of these changes have affected the weed situation contraproductive to man's aim of crop production, particularly if they were not combined with improved or intensified weed control efforts. And here we are now in many countries of the region; changes have affected the weed equilibrium, but the traditional weed control practices cannot cope with the new problems. In this context, we have to see the use of herbicides in crop production, bearing in mind that these chemicals will also create just another weed equilibrium, since none of them can selectively control all the problematic weed species present in one field, least in a given area. This means also that any recommendation for a certain herbicide will serve only the present situation and cannot last for long, when the practice has to be improved again by using chemicals or other supplementary means and so on.

When and where should herbicides be used?

The ultimate user of a herbicide, the farmer, has many reasons which could make him to decide or force him to change his current, non-chemical, weeding practice, and go for chemical weed control.

The most common reasons are:

- Lack of cheap farm labor to do hand weeding.
- Increase in labor costs for doing hand weeding.

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- Change from subsistence farming to surplus production for sale.
- Higher sale prices for the crop, motivating higher productivity.
- Intensification of the crop rotation system, particularly reducing fallow sequences.
- Government policies to increase indigenous food production to avoid import or production of surplus for export.
- Reduced crop competition effect of newly introduced varieties.
- Use of fertilizer, increasing the weed pressure.
- Presence of grass weeds, which are difficult to identify within a cereal crop; thus they are not removed by manual weeding.
- Frequent rains during manual weeding period.

Where the use of herbicides has to be evaluated with a critical mind is in thosefarming systems in which livestock are integrated, and are fed partially with weeds, either by grazing fallows or by providing them with collected weeds obtained from the cropped land. However, chemicals may be applied for the control of impalatable weeds which often dominate others on account of the selective process of grazing or fodder weed collection by man. Many of these weeds, if left uncontrolled, interfere with harvesting, particularly by using combine thrashers, and in turn, may reproduce heavily by seed shattering either before or during the harvest process.

All these facts should make one believe that herbicides have a role to be employed more and more in the region (where they are not already used), but there are some more problems which have to be overcome first, before particularly the small, poor and uneducated farmer could entertain using the herbicide.

These are:

- Insufficient research and extension work to recommend proper chemicals, rates and times of application.
- Unavailability of chemicals and sprayers within the area.
- Lack of cash or credit to purchase sprayers and herbicides.
- Shortage of hard currency of some governments to import herbicides and sometimes also sprayers.
- Degree of sophistication required to properly apply herbicides.
- Hesitation to take risks, resulting from bad experience of others or from the uncertainty of crop success due to climatic factors.

The benefits of using herbicides:

The world losses of food caused by weeds have been estimated (Parker and Fryer, 1975)

TABLE 1. Estimated losses of food caused by weeds in three classes of crop production[1] (PARKER & FRYER, 1975)

Class of crop production	% of total cultivated area	Relative production per unit area	% of total food production	% loss to weeds in those areas	Loss as % of world food supply M. Tons	Estimated food loss per year
A. Most highly developed	20	x 1.5	30	5	1.5	37,500,000
B. Intermediate	50	x 1.0	50	10	5.0	125,000,000
C. Least developed	30	x 0.67	20	25	5.0	125,000,000
TOTAL:					11.5	287,500,000

[1] Estimates in this table are not based on any firm statistical data but are approximations suggested by the authors. Where food loss is estimated in terms of metric tons this is based on an approximate world total food production of 2,500,000,000 metric tons per year, ref. FAO, Production Yearbook, 1972.

and are given in Table 1, which shows a 11.5 percent loss or 287.5 million tonnes of human food per year. Not included are the secondary losses causes by weeds harbouring pests and diseases, which may affect other crops strongly, as well as the adoption of less productive cropping systems, particularly in the least developed areas, for the sake of reducing the weed pressure. Significant are the relatively low losses of the most highly developed parts of the world, which are the largest herbicide users (5 percent crop loss) against the least developed areas, which lose 25 percent of their yield to weeds. This shows that though other mainly manual weed control practices are used, the efficiency of the current weed control efforts is much lower in the least developed world compared with the highest developed parts, where mostly herbicides are used.

The loss of cereal yield to weeds in this region varies greatly from country to country, and is lowest in Egypt, with an estimated loss of less than 10 percent (Basler, pers. est.), Syria 18.2 percent (ICARDA, 1978), Algeria 50-60 percent (Basler, pers. com.), with an average of 19.4 percent for the Middle East and North Africa (13 countries included by Nelson, 1975), which most likely has increased since, due to reasons mentioned in the previous chapter, Turkey, which between 1966-1975 had an average wheat yield per hectare of 1.15 metric tons, reached for 1977 and 1978 average of 1.64 metric tons country wide, after the introduction of fertilizers and herbicides on just 50 percent of the total area, which is an increase of 42 percent.

Herbicide use strategies for cereals:

The number of different basic herbicides, selective in cereals invented so far are over 40 and the resulting available brands of formulations and mixtures are several hundred. The first criterion should be, and is approached this way by ICARDA: which of these herbicides control the most destructive weeds common in the region, and at the same time are sufficiently selective in the various cereal crops. Hardly any single chemical, however, controls the whole range of weeds that we want to control in a particular ecosystem which necessitates probing mixtures, representing the second stage of narrowing the possible candidates. Thirdly, the decisive criterion is the economic performance of the remaining products, after also probing their possible side-effects within a given cropping system. With this approach one could reach the best answer for a particular field, but never for a larger area, owing to variations of the weed population in kind, the crop varieties grown, the climatic factors, etc. This necessitates testing herbicides in as many locations as required within a certain area (country, province or closely similar ecological zone) to reach a compromise suitable for the average condition. What we therefore always end up with is having a recommendation for several possibilities among which the farmer has the pain to select ultimately.

Keeping in mind that most herbicides developed for cereals are applied post-emergence to the crop and weeds, several guidelines may help to make the choice easier.

Weed control has ideally two ends, i.e. increasing the yield within the crop on which the herbicide is used, and to prevent weeds to propagate.

The earlier that weeds are destroyed within the crop, the more is the resulting yield increase, though some late emerging weeds may reproduce, without harming the crop anymore.

The quicker a chemical kills, the earlier that the competition from weeds is eliminated.

Never use the same chemical over many years in order to prevent weakly controlled weeds from becoming dominant.

Never miss a season to control weeds before they shatter their seeds.

What these points mean can be shown with the following two observations:

(1) In a series of 11 Bread wheat experiments conducted in the cereal belt of Syria (ICARDA 1978) the relative yield increase of early chemical broadleaf control with either bromoxynil or bromophenoxim, over that of unweeded checks, was 17.3 percent, while for a locally recommended herbicide, Banvel-K (2, 4-D Dicamba), also active only on broadleaves, but of slower action and with a need for a later application, only a 5.8 percent increase was recorded. (See Table 2.) The carefully hand-weeded checks with a yield increase of 18.2 percent over those of unweeded

TABLE 2. Mean yield of 11 bread wheat experiments conducted in 1978 in the Syrian cereal belt.

Treatments	Grain yield Kg/ha	Percentage change	S S[1]
Unweeded check	1390.0	100.0	a
Hand weeded check[2]	1643.4	118.2	c
Early Broadleaf killer[3]	1629.9	117.3	c
Late Broadleaf killer[4]	1471.4	105.8	b

1/ Values within columns bearing the same letter are not significantly different according to Duncan's Multiple Range Test at 5 percent level.
2/ Twice handweeded carefully.
3/ Either Bromoxynil or Bromophenoxim early post-emergence (4 leaf stage).
4/ Banvel-K (2, 4-D Dicamba) late post-emergence (post-tillering).

checks, show that almost the full potential yield has been reached by the elimination of broadleaf weeds as early as possible.

(2) The continuous use of the same herbicide 2,4-D has led in many places to particularly a grassy weed problem, which is now only possible to amend at high costs, with high doses of herbicides, which may partially damage to crop (Europe since the sixties, Algeria at present!).

There are few broadleaf weed killers, which can be considered for early post-emergence use in cereals and which are also very selective. These are bromoxynil, ioxinil, bentazone and bromophenoxim. Each of them controls a different range of broadleaf weeds, which would have to be considered for selecting the proper one. The widest range of kill and the quickest kill too has been bromophenoxim, which, however, is quite expensive.

Bentazone is an interesting chemical, which does not control most leguminous weeds, which is of value in cereal/fallow systems, in which fallows are grazed. All these chemicals are also available as mixtures with one or more of the hormones or other chemicals, thereby broadening their spectrum of weed control, but narrowing the selectivity band and application timing.

All of these chemicals and the well-known phenoxy compounds (hormones) like 2,4-D, MCPA and the like, should, however, be stopped being used alone, when grassweeds tend to become dominant. Experience shows that they do take over slowly as major weeds following the use of only broadleaf killers. Generally, the grassweed killers are less selective chemicals in cereals, requiring more accurate timing of spraying and are much more expensive; reasons for not utilizing them from the beginning. But once a grassweed problem is established, there is hardly any other way out, short of intensive fallowing than using such chemicals.

Much focus was given in the past few years to the development of wild oat - (*Avena* spp.) herbicides, with success as we can see from the range of new chemicals now available, like benzoylprop-ethyl, flamprop-isopropyl, difenzoquat and others, which do not substantially control at recommended rates, any other weeds. In addition to these successes, broadspectrum herbicides had been discovered, which control a range of both broadleaves and grasses, such as metoxuron, methabenzthiazuron, isoproturon and chlortoluron. These chemicals, again depending on the species of weeds involved, would be the best choice to follow the purely broadleaf killers as soon as grasses are on the increase. However, they require to be tested on the cereal varieties cultivated in a particular region, since their selectivity is very poor in some varieties, particularly in spring type cereals.

Finally, there is a new, very promising chemical on the market, diclofop-methyl, which controls only grasses including wild oat, and shows a very good selectivity on cereals. This herbicide is therefore an ideal partner to broadleaf killers.

We can now realize that a recommendation for a proper herbicide needs a lot of research and testing, as well as expertise of the scientist involved. There is a lack of sufficiently trained personnel in the region and consequently a lack of sufficient experimental data of the behaviour of herbicides in the dry areas, which to some extent ICARDA tries to improve.

No doubt proper weed control is a must for sufficient food production in the world and using herbicides is the main tool to do so, but not at any cost; we do not want to overkill also, which is not only a waste in money and energy, but it may be harmful to the soil as well. A weak population of small weeds, particularly legumes, not only could help provide the cereal crop with nitrogen, but could also avoid erosion of any kind, as well as add to the crop in competing with really harmful and difficult to control weeds. Therefore, especially in cereal production in the region, we have to think more in terms of weed management, where chemical weed control is a carefully evaluated part of an integrated weed management system —safe, economic and practicable.

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Summary

General thought is given to the dynamics of weed populations in connection with changing agricultural practices of the region. The use of herbicides for increasing cereal production is attempted to be placed in the right context, looking at the constraints of current weed control practices. The food production losses to weeds and the benefits of using herbicides are stressed. A herbicide use strategy for cereals in the region tries to high-light the advantage of early season chemical weed control, not yet practiced in the area,along with suggestions of herbicides for testing in different ecosystems depending on the weed flora. The need for training of weed scientists is stressed, which is the base for reaching proper recommendations for each location, in which herbicides would be an integrated part in the war against weeds to increase cereal production.

CONTROLE CHIMIQUE DES MAUVAISES HERBES COMME PARTIE INTEGRANTE DANS LA PRODUCTION CÉREALIERE

F. Basler

Résumé

La réflexion générale porte sur la dynamique des populations de mauvaises herbes en rapport avec les pratiques culturales variées rencontrées dans la région. On tente de placer l'usage des herbicides en vue d'augmenter la production céréalière dans le contexte approprié, en examinant les contraintes des pratiques courantes de contrôle des mauvaises herbes. On insiste sur les pertes de production alimentaire dues aux mauvaises herbes et sur les avantages de l'utilisation des herbicides. Une stratégie d'utilisation des herbicides pour les céréales dans la région essaie de mettre en pleine lumière les avantages d'un contrôle chimique saisonnier précoce des mauvaises herbes, qui n'est pas encore pratiqué dans la région, ainsi que des suggestions pour tester les herbicides dans différents écosystèmes dépendant de la flore des mauvaises herbes. On souligne le besoin de formation de chercheurs dans le domaine des mauvaises herbes, qui est la base permettant de développer des recommandations appropriées pour chaque emplacement, dont les herbicides seraient partie intégrante dans la lutte contre les mauvaises herbes pour augmenter la production céréalière.

THE ROLE OF CULTURAL PRACTICES ON WEED CONTROL IN THE CENTRAL ANATOLIA

*N. Durutan, M. Güler, M. Pala, I. Unver and M. Karaca**

Wheat is the primary crop of the Central Anatolian Plateau. In this part of Turkey, annual precipitation is too low and irregular for annual cropping; therefore, the fallow system is practiced in order to store part of the moisture of one year for crop use the following year.

The weed flora of this region was mainly of the broadleaf type, for example, *Boreava orientalis, Centaurea* sp., *Cirsium* sp., *Lamium* sp., *Convolvulus* sp., *Salsola kali, Matricaria* sp., *Anthemis* sp., *Chenopodium* sp., *Amaranthus* sp., *Bupleorum* sp. etc. However, in recent years several grassy weeds like *Bromus Tectorum, Aegilops* sp., *Alepecurus* sp. etc., are rapidly increasing and even becoming dominant in certain areas.

The grassy weeds are not controlled in the crop year due to some constraints in herbicide usage. Consequently, fallow tillage operations appear to be the only control measure for these types of weeds. On the other hand, broadleaves are controlled on a large scale in the fallow year. Some, that are escaping the control measures, are eliminated in the crop year by timely 2,4-D spraying.

Weed control is a very important practice on the Central Anatolian Plateau in both the fallow and the crop year, since moisture is the limiting factor in wheat production in the area. Minimizing the moisture loss is the main goal of an agronomy program of such areas. Minimizing the moisture loss, in other words maximizing the moisture storage efficiency during the fallow, can be achieved by controlling the evaporation and transpiration rate.

The way of controlling the transpiration rate is to suppress the weed growth on the fallow land. An unsuccessful weed control in the fallow year is reflected in the crop year. The constraints on the availability of some herbicides effective on certain weeds, eliminate the choice of chemical control within the crop and leave the farmers face to face with an unbeatable weed problem. Therefore, an effective weed control in the fallow year, not only increases the moisture accumulation; it also assures a clean crop the next year.

Weed control is best achieved by tillage during the fallow year since it is an effective, economic and practical method (3). Timely use of the most proper tillage implement is an important factor influencing the success of the weed control. Taking this into consideration, an initial tillage timing trial was conducted on the Central Anatolian Plateau during the period of 1974-78. In this trial, three dates of initial tillage were compared:

I. When the soil is in the first proper condition for plowing.

II. When most of the weeds are emerged; about a month later than the first date.

III. Almost two months later than the first date; plots left weedy.

IV. Almost two months later than the first date; plots kept weed free by using herbicides.

The data in Table 1 indicates that a delay of initial tillage caused yield reductions. On the average, the yield decrease was about 61 kg/0.1 ha when the first tillage was practiced very late. The difference came from the weed growth. Transpiration by weeds even when plants are small can drastically decrease the soil moisture at the surface. Deep rooted weeds transpire water from deeper depths which is the main source of water to the crop the following year.

The yield data indicated that there was no significant difference between the timely tilled plots and the ones kept weed-free by using herbicides for about two months. This shows

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TABLE 1. The yield data obtained from initial tillage timing trial. Haymana, 1974-78

Date of Initial Tillage	Yield (kg/0.1 ha) 1975	1976	1977	1978	Average
I	207 a	209 a	410 ab	272 a	275
II	216 a	215 a	381 bc	245 ab	264
III	109 b	166 b	354 c	226 b	214
IV	214 a	202 a	426 a	269 a	278

that in the experimental area (2-3 percent slope), infiltration was not a problem during the research period.

Soil moisture data obtained from this time of tillage trial (Table 2) indicates rather large differences among the treatments.

TABLE 2. Soil moisture data obtained from initial tillage timing trial

Depth (cm)	Moisture at the time of initial tillage (%)	Moisture at the planting time (%) I	II	III	IV
0-10	-	21.29	21.42	24.57	21.87
10-30	28.62	24.23	20.50	15.80	22.70
30-60	28.25	25.23	22.90	23.15	23.84
60-90	28.58	26.41	26.97	25.74	27.66
90-120	27.71	27.71	27.46	26.14	27.2
Average	28.29	25.78	24.53	23.44	25.30
Total (mm)	373.41	338.59	323.79	309.38	333.97
Loss (mm) [x]		34.82	49.62	64.30	39.44

[x] Amount of moisture (mm) l st in the period of first tillage to planting time.

When the soil was tilled timely, the amount of moisture at the planting time indicated that the loss was about 35 mm and occurred through evaporation. When tillage was delayed almost two months, loss was due to transpiration by weeds and capillary continuity. In other words, the moisture was decreased by evapotranspiration and the loss was about 64 mm.

When herbicide was used to control the weed growth on the plots that were tilled very late, the moisture loss due to evaporation was about 39 mm. In the plots which were tilled at the latest date, the moisture loss difference between the weedy and weed-free plots was 25 mm and was due only to transpiration by the undesirable plant species.

This trial indicates that early tillage gives the best yields since winter wheat emergence and early growth is best assured by the highest amount of moisture conservation during the fallow period due to effective weed control. It also showed that a good weed control practice during the fallow period provides less weed density in the next year. Plots tilled in a timely manner had 35 percent less weeds compared to plots tilled very late and left in a weedy condition.

The farmers of the Central Anatolian Plateau are now beginning their initial tillage as early as possible. This is mainly due to a successful farmer demonstration program which clearly indicated the benefits of early tillage (2).

Weed problems of fallowed land are not solved only by determining the time of initial tillage. The spring and summer tillage implements are other factors influencing a successful weed control program. Research conducted in the region by the Central Anatolian Regional Agricultural Research Institute (3) has revealed that the best tillage method for conserving maximum water through higher infiltration rate, lower evaporation, and control of weed growth is as follows:

Best implement for initial tillage was found to be the moldboard plow used at a depth of 18-20 cm. Sweep and harrow combination was determined as the most beneficial summer treatment when used at 10-12 cm deep.

On the other hand in the region, different systems for fallow tillage are suggested by different sources working on the same subject (1, 3, 4). A three year comparative study has been conducted by the Central Anatolian Regional Agricultural Research Institute since 1977. The systems compared are as follows:

I. Large sweep, beginning from initial tillage till planting time (5-8 cm).
II. Initial tillage with reduced surface sweep and harrow moldboard plow (18-20 cm) followed by sweep + harrow (10-12 cm) for summer tillages.
III. Initial tillage with sweep (18-20 cm) followed by sweep + harrow (10-12 cm).
IV. Initial tillage with moldboard plow (18-20 cm) followed by sweep + harrow for summer tillages at gradually decreasing depths till planting time.

The first yield data obtained from this trial is given in Table 3.

TABLE 3. The yield data obtained from various fallow systems, Haymana, 1978

Fallow Systems	Yield (kg/0.1 ha)
I	201 c
II	266 ab
III	235 bc
IV	303 a

As it is seen from the table, implements that turn over the soil gave much higher yields than sweep type implements, partly due to higher infiltration rates and lower evaporation.

The effectiveness of each system on moisture conservation was determined by taking soil samples at initial tillage time and planting time. Amounts of moisture conserved by tillage systems from the beginning of the operations to planting time (Table 4) revealed that on the Central Anatolian Plateau, the moldboard plow followed by a sweep + harrow

TABLE 4. Soil moisture data obtained from various fallow systems, Haymana, 1977

Depth (cm)	Moisture at the time of initial til. (%)	Moisture at planting time (%)			
		I	II	III	IV
0-10	-	20.58	18.54	21.57	19.69
10-30	24.90	20.08	22.66	19.40	25.44
30-60	26.92	24.11	23.30	24.35	26.75
60-90	26.80	23.02	23.13	23.98	26.30
90-120	27.72	24.93	25.25	25.75	25.72
Average	26.59	23.08	23.24	23.57	25.57
Total (mm)	350.98	304.65	306.77	311.12	337.52

combination is the best system for conserving the highest amount of moisture. The amount of moisture conserved by the sweep was not reflected in the crop year as higher yields; in other words, the crop could not use the advantage of high moisture levels due to a grassy weed infestation.

The higher yields of the moldboard system also depend on the effectiveness of the weed control, particularly that of grassy weeds. During the fallow period, this system helped to conserve more moisture by eliminating the weeds. The performance of each system was reflected in the crop year with different weed densities (Table 5).

TABLE 5. Weed densities in the crop year as influenced by various fallow systems, Haymana, 1978

Fallow Systems	Weed Densities (no. of plant m^2)
I	52
II	20
III	30
IV	16

Moldboard plowing followed by a sweep + harrow combination appeared to be the most effective system in the control of grassy weed species. Many common species that are being found on field edges are an indication that they are present in the area, but properly fallowed fields are largely free of these grassy weeds.

Observations made on farmers' fields and state farms in the region strengthen the idea that sweep type implements, used for the initial tillage, are mostly responsible for the enormous increase in grassy weed species, particularly *Bromus tectorum L.*

Proper weed control is an integrated part of the agronomic package of practices, and successful wheat production depends very much on the cultural practices utilized.

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Summary

On the Central Anatolian plateau of Turkey, the fallow system is practiced where annual precipitation is insufficient. In the past the weed flora was predominantly broadleaves; however, the grassy weeds, due to lack of effective control measures, are increasing rapidly. Since moisture is the limiting factor in this area, weed control is an important practice in reducing moisture loss in both the fallow and crop year.

Since tillage is the most effective practical and economic method of weed control during the fallow cycle, agronomic studies have been intensified to determine the best tillage combination or system. These include time and depth of tillage and

different implements. The objectives are to provide for reduced evaporation rate, better weed control and increased water infiltration rate.

Research conducted at the Central Anatolian Regional Agricultural Research Institute has indicated that initial tillage as early as possible (when the soil is in good condition) helps to conserve maximum moisture through better weed control. The moldboard plow used at 18 to 20 cm depth and followed by a sweep-plus-harrow combination, appears to be most effective. An effective fallow management provides maximum moisture conservation during the fallow year, and it also is followed by a "clean crop" the next year.

ROLE DES PRATIQUES CULTURALES DANS LE CONTROLE DES MAUVAISES HERBES EN ANATOLIE CENTRALE

N. Durutan, M. Güler, M. Pala, I. Unver, M. Karaca

Résumé

Sur le Plateau d'Anatolie Centrale en Turquie le système de la jachère est pratiqué du fait que les précipitations annuelles sont insuffisantes. Dans le passé, la flore de mauvaises herbes prédominante était constituée de plantes latifoliées, bien que les graminées soient en augmentation rapide à cause du manque de mesures de contrôle efficaces. Puisque l'humidité est le facteur limitant dans cette région, le contrôle des mauvaises herbes est une pratique importante pour réduire les pertes d'humidité dans les années de jachère et dans les années de récolte.

Puisque le labourage est la méthode la plus pratique et économique et la plus efficace pour contrôler des mauvaises herbes durant le cycle de jachère, les études agronomiques ont été intensifiées pour déterminer la meilleure combinaison ou système de labourage. Elles incluent la période et la profondeur du labourage et divers instruments. Les objectifs sont de parvenir à un taux d'évaporation réduit, à un meilleur contrôle des mauvaises herbes et à un taux d'infiltration d'eau plus important.

Les recherches menées à l'Institut de Recherche Agronomique Régional d'Anatolie Centrale ont montré que le premier labour aussi tôt que possible (lorsque le sol est en bonne condition) aide à conserver la maximum d'humidité par un meilleur contrôle des mauvaises herbes. La charrue à soc, utilisée à une profondeur de 18-20 cm et suivie par une combinaison canadienne + herse s'avère être la combinaison la plus efficace. Une exploitation efficace de la jachère ne fournit pas seulement une conservation maximale d'humidité en période de jachère, elle est également suivie l'année d'après d'une "récolte propre".

THE ROLE OF ROTATIONS IN WEED CONTROL

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Rotations within the region vary both in alternative crops and the length of the rotational cycle. It is therefore difficult to generalize on the role of rotations in weed control.

In this paper, methods of weed control within the common elements of North African rotations will be discussed and their integration considered.

It is clear that within this region, the highest and most stable yields of cereals are obtained by alternating cereal with clean fallow. The term "clean fallow" should be clearly distinguished from "fallow" which is normally used as a source of grazing. The latter type of fallow is often left until after the weedy species have set seed before tillage commences. The wheat crops which follow are weedy and yields are subsequently lower. For instance, in one test in Algeria in 1975/76, the yield after clean fallow was 26 quintals (Qx)/ha (on 60 ha) as against 18 Qx/ha for a grazed fallow (on 45 ha). Moisture was not a limiting factor in that year, so the difference in yield can be mostly attributed to weed levels in the wheat crop.

Clean fallow-cereal is the simplest rotation to manage. Timing of operations is not particularly critical (within given limits) and the wheat seedbed is more or less prepared during the fallow period.

However, due to a finite arable land surface, greater food requirements by an ever increasing population, and a shift of animals from traditional low rainfall grazing areas to the cereal zone, the clean fallow or fallow are being replaced by more intensive systems of farming.

While this intensification of farming has increased total farm productivity, very often this has been at the expense of cereal yields, due to an increase of weed populations.

Experimental results show that wheat yields after alternate crops are often lower than after clean fallow.

TABLE 1. Wheat yields following various precedents in Algeria (Qx/ha).

	(a) Eastern Algeria 74/75	(b) Western Algeria 74/75	(b) Western Algeria 75/76
After Fallow	16.6	28.7	32.18
After Hay Crop	11.5	24.9	25.2
After Grain Legumes	5.7	22.7	28.2
After Medicago pasture	3.8	23.6	27.5

(a) Data from Programme Recherche et Experimentation - Resultats Campagne Agricole 1974/75. Direction Regionale de Constantine. E.D.G.C. Algerie.

(b) Data from Hadzic, E. (1976). Developpement des Cereales d'hiver et Suppression de la Jachere MARA/FAO/ALG/71/537.

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The results from Eastern Algeria indicate high weed infestations in the wheat following alternate crops. The differences obtained are rather more dramatic than normally obtained in practice. For example, for the farm scale test cited earlier, wheat after Medicago yielded 15 Qx/ha (over 22 ha) compared to wheat following clean fallow, 26 Qx/ha.

The Western Algerian results show less difference between the yields after alternate crops due to lower initial weed populations and careful attention to trial management.

That yields can be almost equal to those obtained after fallow has been demonstrated in Tunisia with regard to the Medicago-wheat rotation.

TABLE 2. Mean wheat yields at three sites (Qx/ha), after *Medicago* and after fallow. 1974/75.

	St. Cyprien	Smindja	Teboursouk
Wheat after Medic (2nd cycle)	18.0	19.1	23.2
Wheat after Medic (1st cycle)	19.5	16.5	18.5
Wheat after Fallow	22.6	20.1	24.7

TABLE 3. Mean yields following *Medicago* of fallow (Qx/ha) at four sites, 1975/76, Tunisia.(a)

	Medjezel Bab	Zaghouan	Medjezel Bab	Pont du Fahs (b)
After Medicago	21.3	19.3	18.3	25.5
After Fallow	20.3	14.0	21.3	39.3

(a) Data from Progress Report, Tunisia, 1975/76.
CIMMYT/Technical Division of Office of Cereals, Tunisia.

(b) At this site, the primary effect of fallow was in moisture storage.

Although these well controlled trials show that high wheat yields are possible after different rotational alternatives, these results are not being translated into the farm or national yields.

While one cannot neglect the effect of fallow on moisture storage (Table 3), it seems that for a large part of this region, the major effect of fallow is that of weed control.

Therefore, we must look to increase our awareness of how weeds can be controlled within the various elements of alternate rotations.

Within rotations, we can exploit and integrate all methods of weed control - cultural, chemical, plant competition, the grazing animal — to reduce the weed population in the cereal crop to an insignificant level.

TABLE 4. Options available for weed control in the common elements of rotations practiced in the region:

	Cultural Control	Chemical Control	Plant Competition	Control by Grazing Animal
Wheat Crop	X	X	X	
Fallow	X			
Hay Crop	X		X	X
Grain Legume	X	X		
Annual Forage Legume	x	(X)	x	X

Cultural Control:

Cultural control discussed here encompasses the traditional control measures — tillage, cutting, hand-weeding, burning.

One must accept the fact that on entering the wheat cycle of a rotation, there is a possibility of higher weed seed levels in the soil than after a clean fallow.

Therefore more attention should be paid to seedbed preparation for the wheat crop. More cultivations between the opening rains and seeding time may be necessary to reduce the weed levels.

For example, in Algerian trials (1) weed populations have been reduced by up to 85 percent, depending of course on the species concerned, by just one cultivation. Under the conditions prevailing in those trials, ryegrass was "controlled" by the first cultivation, phalaris and wild oats by subsequent cultivations, with the broad-leaf weeds proving to be the most difficult to control by sequential tillage.

The important point to remember is that in substituting an alternate crop for fallow, the state of the soil will be different when entering the wheat cycle. This may dictate that traditional seedbed preparation and seeding formulae should be altered.

Tillage also plays a large role in weed control in grain legumes. Properly carried out, inter-row cultivation can achieve a level of weed control similar to that obtained in a clean fallow.

Cutting as a weed control measure can be exploited in hay crops. In principle, the hay is cut and removed before weed seeds are mature. In practice, unfortunately, one sees many hay crops left until the weeds have set seed and during the cutting and baling operation the seed-heads shatter and are left in the field.

Very serious attention should be placed on the timeliness of hay-cutting as a simple weed control tool.

Cutting is also useful in pasture phases of a rotation (top-cutting) for checking the seed set of weeds that have not been controlled by grazing or other means, particularly in the case of brome-grass. It is rarely 100 percent successful, but is one of the many means by which one can *reduce* the total weed level.

Hand-weeding is still common in some countries of this region. Good weed control is possible by this means. However, under some circumstances, selection of weeds for pulling has been noted (9). This is where certain species have greater value for animal fodder than others.

Burning as a weed control measure cannot be highly recommended. Seeds are rarely retained in the seedhead and therefore escape the greatest heat. There is some evidence though, that brome-grass, which very often is retained in the seedhead can be affected by burning.

Chemical Control:

Chemical control should be used in all phases of the rotation where it is required or suitable. Chemical weed control in wheat has been described in a previous paper in this session.

One place for the intervention of chemical control in alternate crops is during the grain-legume phase, particularly where this crop is grown in the modern manner, fully

TABLE 5. Residual effect on wild oat control on wheat variety Siete Cerros (1976), following a Treflan treated lentil crop.

	Treated with Treflan, 1975	Untreated 1975
Wheat spikes/m^2	369	112
Wild Oat spikes/m^2	20	381
Wild Oat seed yield (Qx/ha)	2.76	20.33
Yield Siete Cerros (Qx/ha)	21.83	4.84

mechanized and using narrow row spacings. This system has given very large yield increases of grain legumes.

One should not overlook the residual effect of a treatment such as this (in addition to the *legume yield benefits) on the following wheat crop.*

Herbicides have also been used in *Medicago* to increase seed yield (Table 6). This may be important not only in ensuring the establishment of the *Medicago* rotation (by establishing a large seed store in the soil) but may offer an opportunity (along with grain legumes) to control difficult grassy weeds for which selective herbicides in the wheat crop are not available.

TABLE 6. Effect of herbicide applications on *Medicago*.

	Medic/m²	Weeds/m²	Seed Yield (kg/ha) Medic
No Herbicide	55	91	189.4
Avadex	50	79	265.1
Treflan	52	16	339.6

Data from Annual Report CIMMYT - I.D.G.C., 1974/75, Algeria.

Plant Competition:

The control of weeds by natural plant competition is often neglected. However, depending on the rotation element, it can be a powerful tool.

Plant competition is affected by three main factors - plant vigour, plant type and relative plant densities. Plant vigour and plant type can be utilized as selection criteria. In all sown crops, *relative plant densities can be manipulated.*

Recent research in the region (9) has concluded that tall varieties tend to compete better with weeds than medium height varieties which are more competitive than the short varieties.

One wonders whether this is an effect of plant height per se or whether other factors (early plant habit and viguor) are not associated with the plant height in these examples.

In barley, there appears to be relative independence of plant height on *weed competitive* ability, the important factors being rapid early growth, and a prostrate densely tillering early plant habit. It may be useful to explore this avenue further with regard to the weed competitivity of wheats.

A consideration of plant competition has major importance in annual, self-regenerating forage legumes. One must aim to obtain a large reservoir of seed in the soil so that in each year of *Medicago,* a high density, highly competitive sward is obtained. Regeneration populations have been observed as high as 1600/m² (W.L. Nelson pers. comm.) whereas weed levels are about 2-300/m² (1). Under normal management conditions, a realistic *Medicago regeneration level should be 4-600 plants /m².*

Even at densities lower than these figures, competition can be quite striking.

TABLE 7. Effect of *Medicago* density on botanical composition of a pasture at the end of spring.

Medicago (plants/m²)	58	131	221
Forage	Production		
Medicago (t/ha FW)	21.2	33.6	35.4
Weeds (t/ha FW)	19.1	15.7	8.6

In addition, this competition may be further tilted in the *Medicago* direction by the timing of phosphate application (6). When phosphate is applied before the germinating rains (in the regeneration year) the medic is stimulated ahead of the grassy weeds.

In the program of *Medicago* selection being carried out here in Algeria, particular emphasis is being placed on the plant habit, vigour, seed yield and seed characteristics with a view to obtaining a reliably regenerating highly competitive *Medicago* cultivar.

Table 8 shows some early results from local selection work.

TABLE 8. Winter vigour and seed characteristics of the top lines of the most promising *Medicago* spp., Sidi Bel Abbes, Algeria, 1977/78.

	Winter Vigour	Seed Yield gm/m^2	Regeneration population/m^2
M. polymorpha	14.0	82.7	450
M. truncatula	11.5	151.0	1380
M. scutellata	14.0	183.3	670
M. ciliaris	12.0	223.3	790
M. aculeata	12.7	175.1	540
Check cultivar	10.0	65.8	340

We believe that excellent opportunities exist for increasing the competitivity of *Medicago* with regard to weeds and also for an increase in productivity of the pasture.

The Grazing Animal:

In a rotational system where grazing animals exist, they should not only be looked upon as "meat factories;" they should also be used as a weed control tool.

They can control regrowth following a hay crop, thereby preventing weed increases from that source. (Alternatively, of course, land can be ploughed after the removal of a hay crop.)

In the annual forage legume system, the grazing animal must be manipulated so as to control weeds as far as possible to maintain legume dominance. This is a compromise situation where over-grazing in pursuit of weed control can decrease legume seed yield and may lead to the collapse of the system. Thus, while it is not a complete control, it is an aid to reducing weeds.

Figure 1 shows the effect of grazing pressure on botanical composition at the end of spring (as measured by the Levy Point Quadrat method) of forty-three new sowings of *Medicago* in Western Algeria in 1975/76.

One sees that with minimal grazing, the grass weeds are dominant. As grazing pressure increases, this dominance is reduced. The dominant grass species on the left hand side of the curve were wild oats and annual ryegrass.

As one increases grazing pressure further, grassy weeds, in terms of botanical composition, become more important again. The grass species on the right hand side of the graph were brome-grass predominantly, with occasional annual ryegrass — that is, the grazing animal had a substantial effect on wild oats (and to a lesser extent on ryegrass) if grazing were correctly managed.

Grazing must be started early when the *Medicago* is relatively unpalatable. The animals actively select for the grassy weeds. Grazing pressure should be progressively increased during spring until full-flowering of the medic when attention should be given to adequate seed set. The previous grazing pressure can then be resumed.

The Choice of Rotations:

The choice of alternate crops in the rotation in this region has been largely dictated by financial motives (profitability of one crop or enterprise over another) or by national needs. This, in many cases, has been to the detriment of the agricultural system and,in particular, to wheat yields.

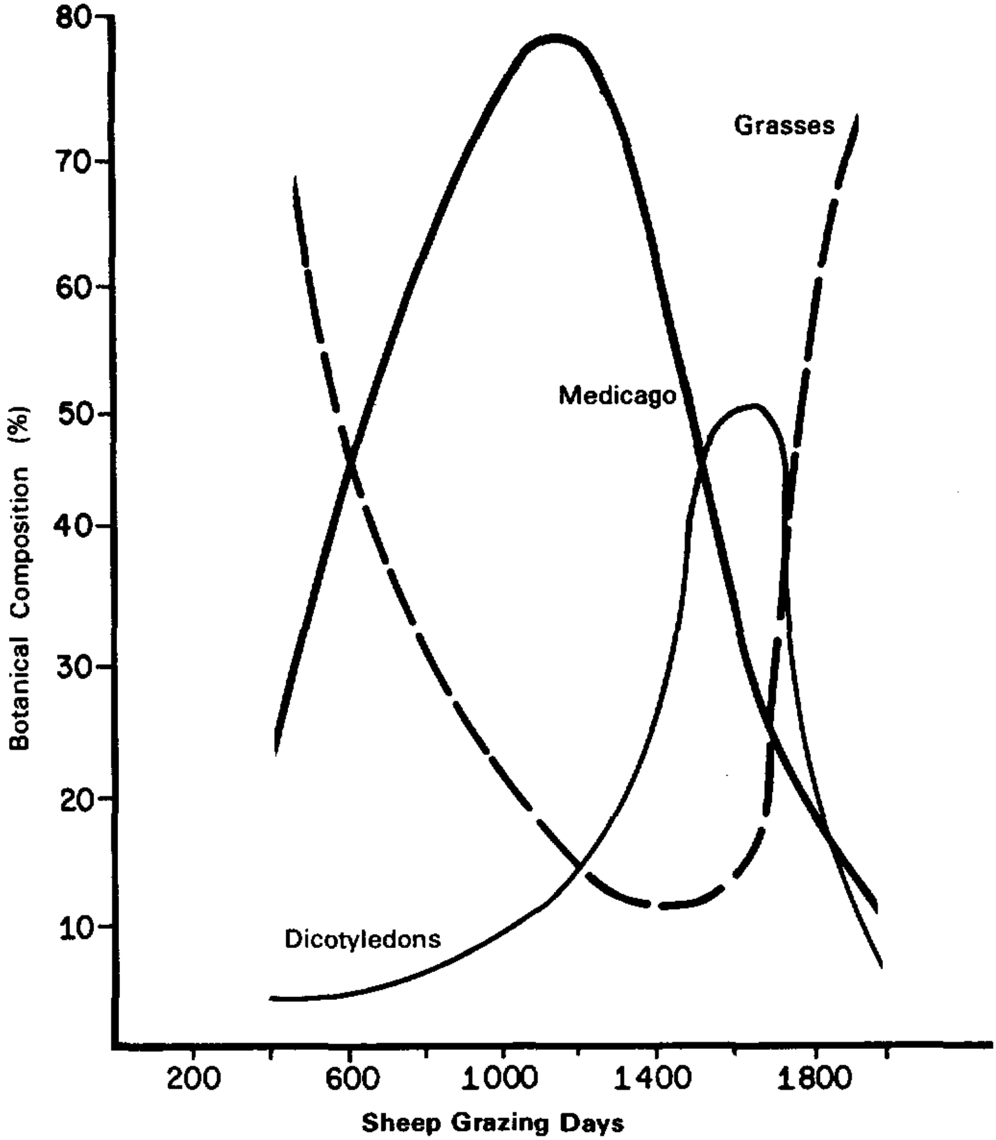

Figure 1. Relationship between botanical composition and grazing pressure, Western Algeria, 1975/76

Weed levels have increased and have been accepted until they have become unacceptable. Chemical control is not the miracle answer, nor is tillage. Rather, the answer lies in an integration of weed control techniques and by judicious choice of rotational elements on an agronomic basis.

For instance, where brome-grass is a problem, one should not sow *Medicago*. Clean fallow should be seriously considered to reduce the brome to a manageable level. Alternatively, a dense hay crop could be sown and cut before the brome matures — or preferably it should be cut as silage (which can be carried out in weather which would be unfavorable for hay cutting) and then the field could be cultivated to control regrowth.

Where brome continues to be a problem, barley may be considered as an alternative to wheat in the cereal year. Barley has proved to be an excellent competitor with brome.

If wild oat populations are high, *Medicago* may be an aid to control only if sufficient sheep are available on the farm to allow properly regulated grazing. In all cases, the area sown to *Medicago* should be a function of the farm flock size.

The easiest and most profitable method of controlling wild oats appears to be that of a wheat-grain legume rotation with treatment in both crops using chemicals. This highly specific weed control will undoubtedly create new problems such as have been reported in Tunisia with *Phalaris* spp. occupying the vacuum left by wild oats.

Thus, the system is extremely dynamic and flexibility must be maintained within the rotations. That is, as weed problems change, so will the rotational elements or pattern.

In conclusion, it is obvious that the means for good weed control are available. These must be integrated into the rotational systems so that individual farm profitability is increased and national objectives are attained.

A high level of weed control (and subsequent high cereal yields) can only be achieved by careful attention to detail and operational timing. It cannot be over-emphasized that weed control within a rotation can only be successful through day to day decisions at the field level.

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Summary

The practice of rotating cereals with another crop, be it another human foodstuff or an animal fodder, is becoming more widespread in the region due to pressure on the available land surface by an ever-increasing population and by the movement of grazing animals from traditional low rainfall grazing land to the cereal areas.

Unfortunately, while this intensification of farming has increased total farm output, very often cereal yields have declined due mainly to weed infestation.

Rotations throughout the region vary in the alternate crops used and the length of the rotational cycle. This paper discusses the possibilities of weed control in the principal rotational alternatives used in North Africa. The principles involved are applicable to the whole region.

It is undoubted that in this region the highest and most stable cereal yields are obtained by alternating cereal and clean fallow. More often than not, the primary effect of a clean fallow is in weed control.

When the clean fallow is replaced by an alternate crop, one must accept the possibility of a higher weed seed level in the soil on entering the cereal phase. We must exploit and integrate all methods of weed control - cultural, chemical, plant competition, the grazing animal-to reduce the weed population in the cereal crop to an insignificant level.

Proper attention must be given to obtaining well-prepared, weed-free seedbeds for all sown cultures (cereal, hay crops, grain legumes); hay crops should be cut before weed

species mature; care should be taken in the hand weeding or inter-row cultivation of grain legumes, and herbicides should be applied in all phases of the rotation to which they are suited.

In the case of a grazed forage legume alternative, one should aim at high plant populations and well regulated grazing to obtain a compromise between weed control and legume seed production. Top-cutting of the pasture should be considered to reduce the seeding of weed species.

A high level of weed control (and subsequent high cereal yields) can only be achieved by careful attention to detail and operational timing. It cannot be over-emphasized that weed control within a rotation can only be successful through day-to-day decisions at the field level.

LE ROLE DES ROTATIONS EN MATIERE DE CONTROLE DES MAUVAISES HERBES

D. A. Saunders

Résumé

La pràtique de rotations de céréales, avec d'autres cultures à caractère d'alimentation humaine ou animale, est devenue très répandue dans la région à cause de la pression exercée par une population toujours croissante et par le déplacement des troupeaux, des zones à pluviométrie insuffisante vers les zones céréalières.

Pendant que se faisait cette intensification, la production au niveau des fermes a certes augmenté, quoique les rendements des céréales aient baissé à cause des adventices particulièrement.

On discutera dans cet papier les possibilités de contrôle des adventices dans les principales rotations adoptées en Afrique du Nord. Les principes admis ici sont applicables à toute la région.

Il est sans nule doute que dans cette région, les rendements céréaliers les plus élevés et les plus stables sont obtenus après une jachère travaillée. Le plus souvent, le principal effet d'une jachère travaillée est le contrôle des mauvaises herbes.

Quand la jachère est remplacée (dans la rotation) par une autre culture, on doit accepter la possibilité d'un niveau de stock de graines d'adventices dans le sol plus élévé et une apparition d'adventices pendant l'année de la céréale.

Nous devons donc exploiter et intégrer toutes les méthodes de contrôle à savoir, techniques culturales, chimiques, compétition par les plantes cultivées, et pâturage par les animaux, afin de maintenir les populations d'adventices à un niveau insignifiant.

Une attention particulière doit être déployée pour l'obtention d'un lit de semences propre (démuni d'adventices) et bien préparé pour toutes les cultures (céréales, fourrages, légumes secs). Les fourrages doivent être fauchés avant que les différentes espèces d'adventices arrivent à maturité. Une prudence particulière doit être observée en matière de désherbage manuel et des binages dans une culture de légumes secs. Les herbicides doivent être utilisés à toutes les phases de la rotation où ils s'avèrent nécessaires.

Dans le cas d'une légumineuse pâturée, on doit viser la notion de densité de peuplement et judicieusement organiser le pâturage afin d'obtenir un compromis entre une production de semences suffisante pour la légumineuse et un bon contrôle de mauvaises herbes.

Des fauches (de mauvaises herbes lorsqu'elles sont plus hautes que la légumineuse) peuvent être envisagées pour limiter la production de graines des espèces d'adventices.

Enfin, un plus haut niveau de contrôle des adventices (donc un rendement ultérieur élevé des céréales) ne peut être atteint que grâce à une attention particulière concernant les techniques de contrôle et les périodes adéquates d'intervention.

On ne peut prétendre à un contrôle efficace des mauvaises herbes dans la rotation qu'à travers des décisions au jour le jour au niveau du champ.

L'ASPECT ECONOMIQUE DU CONTROLE DES MAUVAISES HERBES

G. Logié

Principaux thèmes présentés

1. Introduction méthodologique: L'étude du salissement conduite en milieu producteur permet de raisonner la lutte contre les mauvaises herbes dans chaque zone agro-écologique.*
2. Le manque à gagner sur la production dû à la présence de mauvaises herbes est important dans les zones à bonne potentialité.
3. L'évolution du stock de graines adventices s'observe au cours d'une succession des cultures culturale: elle dépend des techniques appliquées aux différentes cultures de la rotation.
4. L'infestation en mauvaises herbes (nature et quantité) augmente lorsque la jachère diminue: l'intensification doit être progressive et maitrisée.
5. Le raisonnement de la lutte contre les adventices suppose d'abord l'élaboration d'un diagnostic précis par zone agro-écologique et par système de culture.
6. Le choix des moyens de lutte doit tenir compte du mode de fonctionnement actuel de l'unité de production: les comportements techniques des producteurs résultent d'une logique qui ne peut être ignorée ni assimilée à un manque de technicité ou de connaissances.
7. L'élaboration annuelle du plan de culture est l'occasion de définir la complémentarité des moyens de lutte (mécaniques, chimiques, . . .) à mettre en oeuvre. Un ajustement sera nécessaire pour chaque année climatique.
8. La stratégie de lutte contre les adventices nécessite un fonctionnement rigoureux des services apportés aux unités de production: encadrement technique, livraison des produits, travaux culturaux à l'entreprise (CAPCS—Travail Aérien).

THE ECONOMIC ASPECT OF WEED CONTROL

1. Methodological introduction: the weed control study was carried out in farmers' fields in order to understand the problem in each agro-climatic zone.*
2. Production loss due to weeds is greater in the high production potential zones.
3. The evaluation of the weed population can be observed in successive crops. It depends on the techniques applied to different crops in the crop rotation.
4. The weed infestation (species and intensity) increases with the reduction of the fallow system. The intensification is progressive and must be controlled.
5. The program of weed control at first requires a concise diagnosis of the problem for each agro-ecological zone and system of agriculture.
6. The choice of the control methods must take into account the mode of operation of the production unit. The farmer's production techniques are a result of his logic and should not be ignored, nor interpreted as unavailability of techniques or knowledge.
7. At the time of preparing the annual production plan for different crops, the different complementary methods of mechanical or chemical weed control should be defined. An adjustment may be necessary every year, depending on the climatic pattern.
8. The weed control policy needs a rigorous functioning of the different services provided at the unit of production: technical staff, delivery and supply of inputs and cultural practices by the agencies (CAPCS-aerial spraying).

* Travaux menés de 1972 à 1979 par l'I.G.C. dans trois dairate céréalières: Tissemsilt et El Eulma sur les Hauts-Plateaux; Hammam Bou Hadjar sur les zones littorales.

ROLE DES MAUVAISES HERBES DANS LA PRODUCTION CEREALIERE ET LES EFFECT DES DIFFERENTES METHODES

M. Laddada*

La lutte contre les mauvaises herbes revêt un caractère tout particulier, essentiellement d'actualité. Leur présence crée une concurrence vitale qui handicape sérieusement les espèces cultivées, et qu'elles épuisent et infestent dangereusement le sol. En Algérie, c'est l'un des facteurs les plus importants de la limitation du rendement des céréales. Les pertes de production dues aux mauvaises herbes peuvent atteindre selon les années de 30 à 50%.

Les techniques agricoles traditionnelles avaient essentiellement pour but de maîtriser ces adventices parasites: jachère travaillée, assolement, fauchage et coupe de fourrage, pâturage. Ces techniques sont souvent mal appliquées, occasionnant un salissement des terres.

Jachère travaillée: Sous le terme de jachère travaillée, on entend un labour après les premières pluies ou avant le retour de celles du printemps. Les terres sont souvent mal travaillées et favorisent ainsi le développement et la dissémination des mauvaises herbes.

Sur une jachère nue: Les parceles sont pâturées de façon irrationnelle et les mauvaises herbes arrivent à maturité, s'égrenant et infestant les champs.

Dans les assolements: Les cultures en lignes, considérées comme plantes nettoyantes, sont mal travaillées ou desherbées et provoquent ainsi un salissement.

La récolte tardive des fourrages: Favorise l'égrenage des mauvaises herbes et provoque ainsi l'augmentation des stocks dans le sol.

Devant cette situation, et au regard de l'ampleur des pertes de production il devient impérieux d'intensifier et d'améliorer les moyens de lutte contre les mauvaises herbes.

PRINCIPES DE LUTTE:

Pour lutter efficacement et économiquement contre les mauvaises herbes, il faut tenir compte d'un certain nombre de considérations:

—Il est indispensable de bien connaître le cycle végétatif de la plante adventice pour pouvoir déterminer les mesures efficaces destinées à la détruire et les appliquer convenablement.

—Déterminer le stade végétatif le plus favorable au contrôle des adventices.

—Tenir compte du stade végétatif de la céréale.

MOYENS DE LUTTE:

Méthodes agronomiques: Les façons culturales et la rotation des cultures constituent une arme fondamentale de lutte contre les mauvaises herbes. Quelle que soit l'explotation, l'efficacité de la lutte contre les adventices et conditionnées par una bonne préparation du lit de semences.

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Méthodes culturales: Pour être efficace, la lutte contre la végétation spontanée doit être effectuée aux époques voulues d'une façon approfondie et opiniâtre. Les façons culturales doivent être répétées afin de détruire le maximum de jeunes plants avant les semailles.

Rotation des cultures: Les cultures de plantes étouffantes type medics et luzerne sont efficaces contre la lutte des mauvaises herbes à condition d'obtenir une végétation dense et vigoureuse.

Les cultures de plantes annuelles telles que sorgho ou maïs fourrager, cultivées en lignes sont excellentes pour la lutte contre les mauvaises herbes. On obtient cette efficacité en travaillant le sol à plusieurs reprises, en fauchant au stade optimum et en effectuant un labour juste après la récolte.

Les plantes sarclées: L'introduction d'une plante sarclée dans une rotation est un élément favorable dans la lutte des adventices, à condition que cette plante reçoive un certain nombre de façons culturales superficielles mécaniques et manuelles.

Fauchage et coupe des fourrages: Le fauchage ne permet généralement pas de détruire la végétation adventice, mais en l'utilisant en temps opportun, on peut empêcher la production des graines.

Pâturage: En utilisant un pâturage rationnel, on peut détruire ou affaiblir de nombreuses espèces de mauvaises herbes dicotylédones et monocotylédones. Dans ce cas on a recours auxovins qui pâturent les mauvaises herbes au ras du sol, en se déplaçant de manière uniforme.

METHODES CHIMIQUES

Il faut considérer que les desherbage chimique complète mais ne remplace pas les façons culturales bien exécutées. Les pertes de rendement causées par les plantes adventices dans les céréales varient en fonction des espèces qui les constituent, du taux d'infestation, etc.

Des campagnes de desherbage ont été entreprises chaque année sur une grande échelle. Dans un premier temps, seul le 2.4.D. était employé. Ce desherbant bien connu a permis le contrôle d'une bonne partie des adventices, mais il n'a d'effet que contre les dicotylédones et épargne même un certain nombre de ces dernières, particulièrement les gaillets (*Gaillum* sp.).

Son prix, très bas, et sa facilité d'emploi ont encouragé son emploi massif. Après plusieurs années de lutte chimique au 2.4.D., la flore non détruite par ce produit s'est considérablement développée, c'est ainsi que les gaillets mais surtour les monocotylédones (ray grass, folle avoine, phalaris, brome) sont devenus les principales adventices nuisibles aux cultures.

Compte tenu de cette évolution, d'autres produits spécifiques ont été testés.

A partir de la campagne 1972/1973, des essais ont été entrepris sur les diverses régions de l'Algérois où se développe pratiquement l'ensemble de la flore adventice, pour tester des produits polyvalents à large spectre d'activité et applicables à un stade précoce de la céréale.

Dès la campagne 1975/1976, les problèmes de desherbage ont commencé à être mieux cernés. Les trois campagnes précédentes avaient permis d'orienter les recherches sur un certain nombre de voies:

Recherche de produits herbicides présentant les qualités suivantes

—large spectre d'activité en relation avec la flore adventice observée;
—souplesse d'emploi quant au stade de la céréale et des adventices;

—action à un *stade précoce* (2.4.D. et benzoyl *propéthyl s'emploient* fin tallage début montaisson de la céréale; à ce moment, la concurrence des mauvaises herbes vis-à-vis de la céréale est déjà sévère);
—facilité pratique d'utilisation (les poudres mouillables sont d'un emploi délicat, la préparation des bouillies demande un très grand soin) exemple: Métoxuron-Isoproturon;
—efficacité et phytotoxicité;
—régularité dans les effets herbicides dans les conditions différentes (climat, sol).

Etude economique sur la rentabilité de la lutte chimique

—Quelle doit être la quantité minimum récoltée en plus pour payer l'application?
—Peut-on utiliser des produits relativement coûteux dans les zones agro-ecologiques où la prévision de récolte est limitée ou lorsque les conditions climatiques laissent prévoir une mauvaise récolte?

Etude des associations des spécialités

Dans le but d'élargir le spectre d'activité de l'herbicide on associera le plus souvent un anti-dicotylédone à un anti-monocotylédone, ou un produit spécifique avec un autre produit plus polyvalent.

Bilan des actions engagées

Campagnes désherbages: L'analyse des bilans des précédentes campagnes montre clairement que les opérations de désherbage ne sont pas appréciées à leur juste valeur. Sur un objectif annuel d'environ 500.000 hectares, le taux de réalisation n'a jamais dépassé 40%. Cet objetif n'est pas atteint pour certaines raisons:

—Conditions climatiques défavorables
—Insuffisance en matériel
—Manque de produits au moment de l'application
—Produits *utilisés 2.4.D application tardive, courte période d'application*
—Manque d'expérience au niveau des unités de production

Devant cette situation et au regard du pourcentage de réalisation très insuffisant, conscients de ce problème et de l'ampleur des pertes de production, il a été décidé d'augmenter les superficies traitées en fixant comme objectif un million d'hectares, en 1977-78.

Cette nette amélioration a fait intervenir plusieurs services et une parfaite coordination des activités. La programmation d'une campagne de désherbage est conditionnée par une préparation minutieuse des interventions:

—Choix et *localisation des zones à désherber*
—Date d'application
—Matériel de traitement
—Produits phytosanitaires
—Vulgarisation et formation: cette dernière est la plus importante. Tous les moyens de formation et d'information sont mis en oeuvre afin de sensibiliser les agriculteurs.

Des séminaires regroupant des techniciens et les producteurs sont organizés au niveau daïra, les moyens audio-visuels sont largement utilisés avec l'appui des techni*ciens spécialisés.*

Ces objectifs amélioreront d'avantage notre potentiel de production nationale en mettant à la disposition de l'agriculteur au niveau des Unités de Production des produits à:

—application précoce (à partir de la troisième feuille)
—application tardive (plein tallage)

Les enquêtes "Folle avoine" effectuées au cours des campagnes 75-76 montrent que l'infestation des emblavures et les dégâts provoqués par ce parasite atteignent un seuil alarmant. Afin d'empêcher cette propagation, des mesures ont été prises, l'opération anti-folle avoine ainsi déclenchée a été subventionnée.

Parallèlement, des parcelles de démonstration ont été installées dans les régions céréalières; des journées de vulgarisation ont été organisées à l'intention des producteurs. Les objectifs en repport avec la superficie à traiter ont été augmentés des 6,000 ha en 1975-76 à 43,000 ha en 1978-79. On a atteint ces objectifs à niveaux de 80 à 100%.

Legumes secs

Traditionnellement, les cultures de légumes secs plantes sarclées, sont dites nettoyantes pour la culture suivante. Ces observations faites pendant plusieurs années à Mahdia, Wilaya de Tiaret, montrent que les adventices jouent un rôle important dans la chute de rendement.

Le tableau suivant montre l'influence des mauvaises herbes sur le rendement qui semble très dépendant du nombre de graines au m^2 les adventices agissant plus particulièrement en limitant le développement végétatif.

Tableau 1. Tests effectués a Mahdia en 1976

Degré d'infestation en mauvaises herbes	1	2	3	4	5
Rendements en gr/m^2	94, 62	82, 99	74, 46	62, 65	57, 1
Nombre grain/m^2	2,484	2,202	1,934	1,704	1,750
Poids 400 grains	15,3	14,9	15	14,6	13

Au moment des entretiens de la culture un déficit important en tracteurs et bineuses et un manque total de main-d'oeuvre empêchent la réalisation correcte des opérations de lutte contre les adventices. Les cultures sont alors complétement infestées et la récolte compromise.

Des recherches sont alors entreprises pour limiter l'effet d'infestation des mauvaises herbes. Nous disposons d'une gamme de produits herbicides efficaces et rentables. Actuellement, nous pensons qu'une généralisation de la culture des légumes secs mécanisée est souhaitable, ce n'est que quand cette technique sera bien maitrisée que l'on pourra à nouveau envisager une extension des surfaces.

Essais d'herbicides

On a faites 26 essais d'herbicides dans trois cycles depuis 1975-76 jusqu'à 1977-78. La majorité des essais ont été réalisés comme "macro-tests" et les traitements appliqués avec un pulvérisateur agricole normal. Les essais ont nous permis éliminer rapidement toutes les substances que n'avaient pas produit des bons résultats; aussi travers les tests nous avons bien connus des produits et commencé faire una recherche sur la association des différents substances chimiques spécialisées pour augmenter le spectre d'activité d'autres substances.

CONCLUSION

L'expérience acquise en matière de désherbage chimique des céréales nous permet de conclure qu'il y a souvent intérêt à employer de tels produits qui dans la majeure partie des cas permettent une augmentation substancielle du rendement à l'hectare.

La gamme des spécialités que nous avons étudiées jusqu'à présent en ce qui concerne le désherbage chimique des céréales, ne comporte que des produits utilisés en post-émergence. Il serait peut être plus judicieux d'utiliser des produits chimiques de contrôle de mauvaises herbes en pré-émergence.

Ce type de désherbage a déjà donné d'excellents résultats sur les légumes secs et le maïs. Il est évidemment séduisant de traiter au moment des semis car le traitement est efficace, aucune concurrence n'aurait lieu entre la plante cultivée et les adventices.

L'emploi d'herbicides très élaborés est une affaire de jugement et d'expérience *à acquérir; ces qualités impliquent donc un effort important de formation des utilisateurs éventuels.*

L'expérimentation ne doit pas s'arrêter sur ces quelques résultats qui sont positifs, l'utilisation de ce genre de produits peut entrainer des déplacements de flore et certaines espèces peuvent acquérir une certaine tolérance si les mêmes spécialités sont employées pendant de longues périodes.

La mise au point constante de nouveaux produits dont l'utilisation doit obligatoirement comporter une période de testage au préalable, ne doit en aucun cas faire oublier que ces produits sont des remèdes et que la meilleure manière d'avoir des cultures propres est d'améliorer les techniques culturales.

Actuellement, le facteur le plus important ayant une influence sur le rendement est la folle avoine qui se présente dans les zones à hautes potentialités, les meilleures techniques pour le désherbage chimique de la folle avoine sont les suivantes:

En cas d'infestations faibles ou moyennes, la technique la plus importante qui permet un gain de rendement plus élevé repose sur l'utilisation du Chlortoluron + Diclofop Méthyl; Isoproturon + Diclofon Méthyl; Métoxuron + Nitrofène; Diclofop Méthyl.

En cas de fortes infestations, la technique la plus sûre consiste à adopter des traitements à base de Chlortoluron, Isoproturon, Diclofop Méthyl utilisé au stade très jeune de la céréale, 4 à 5 feuilles, qui sera suivi par une application tardive à l'aide du *Benzoyl Prop Ethyl au stade de début montaison de la céréale.*

L'importance de la lutte contre la folle avoine est une opération délicate qui repose sur la bonne réussite d'une bonne application des différents herbicides s'employant sur les céréales et d'autres cultures (betteraves, légumes secs, etc....).

La réalisation d'une application peut paraître onéreuse actuellement mais elle présente l'intérêt d'améliorer le degré de propreté des champs et de limiter la propagation.

Le désherbage chimique ne doit pas faire négliger une bonne préparation des terres en donnant une certaine sécurité, une culture exempte de mauvaises herbes dès sa mise en place a certainement plus de chance de donner de meilleurs résultats.

Résumé

En Algérie les mauvaises herbes concurrencent dangereusement les variétés à haut potentiel de production. C'est le facteur limitant le plus important par rapport au rendement des céréales d'hiver et d'été; les pertes peuvent atteindre selon les années de 30 à 50°/o.

MOYENS DE LUTTE:

La solution la plus confortable consiste à employer des techniques culturales; cette forme de lutte est subordonnée à:

— une bonne préparation du lit de semences,

— au respect de la rotation des cultures (graminées, légumineuses);

— l'utilisation en cas de besoin de jachères travaillées et de cultures intercalaires.

Lutte chimique: le désherbage chimique complète mais ne remplace pas les façons culturales bien exécutées. L'emploi du 2,4-D a permis le contrôle d'une partie

des adventices, mais aucun effet sur les monocotylédones. A partir de 1972 des essais ont été entrepris afin de tester des produits polyvalents à large spectre d'activité.

L'analyse des campagnes de désherbage montre que les opérations de lutte contre les mauvaises herbes ne sont pas appréciées à leur juste valeur. En effet, la superficie désherbée à chaque campagne, quoique en progression, est encore relativement faible malgré un programme d'information et de formation dans ce domaine assez important.

L'expérience acquise en matière de désherbage chimique nous permet de conclure qu'il y a souvent intérêt à employer de tels produits qui dans la majeure partie des cas permettent une augmentation substantielle du rendement.

L'expérimentation ne doit pas s'arrêter sur ces quelques résultats; l'utilisation de ce genre de produits peut entraîner des déplacements de flore. La lutte contre la folle avoine est une opération délicate qui repose sur la bonne réussite des applications herbicides et des techniques culturales sur les différents types de culture.

ROLE OF WEEDS ON CEREAL PRODUCTION

AND THE EFFECT OF DIFFERENT METHODS OF CONTROL

M. Laddada

Summary

In Algeria, weeds compete extensively with high-yielding varieties. Weeds are the most important limiting factor to production of winter and summer cereals—the loss can range from 30 to 50 percent.

CONTROL METHODS

The best solution is the use of different cultural practices. The different steps are: good seedbed preparation, correct use of crop rotations (cereals and grain legumes), and where necessary, the use of a well-kept fallow or mixed cropping.

Chemical control cannot completely replace well-executed cultural practices. The use of 2,4-D allows control of breadleaf weeds, but has no effect on the monocotyledons. Since 1972, a large number of trials have been conducted to evaluate a wide spectrum of polyvalent products (chemicals). The examination of farmers' weed control programs show that weed control operations are not well-appreciated. In fact, the area which has been weeded in each season is increasing but is still relatively small in spite of the information and training in this field. The experience and results gained from chemical control work have shown that often it is beneficial to use herbicides, and in most cases it produces substantial increase in yield.

The experimentation should not stop with a few results. The use of chemicals can alter the structure of the flora. The control of wild oats is a delicate operation, and its success depends on the proper use of herbicides, cultural practices in the different crops, and crop rotations.

III. TILLAGE

Homer M. Hepworth
M. Güler et al

EFFECTIVE TILLAGE AND CEREAL PRODUCTION

Homer M. Hepworth*

Introduction

Since the dawn of agriculture many thousands of years ago, man, or more probably woman, has been tilling the soil in one manner or another. No doubt in the beginning it was a great deal more exciting to be the big hunter and let the little woman do the "dirty" work. Recently, the scene has changed slightly, at least in some areas. We now find that man has taken over a large share of the farming work. He still loves to grab his musket and charge off into the wilds on hunting trips. But, he has taken over the less menial, more enjoyable part of the soil management process. Note that it has become soil management and tillage systems — not "dirty" work. Why has this phenomenon occurred? Because farming has in many ways become less physically demanding and more psychologically rewarding. There are many areas where men supervise or actually do the "man's" work, but the basic situation still remains; women do the weeding, picking, and back bending labor. Man drives the animals, he operates the machines, and especially nowadays his ego is really massaged. He can sit on a huge tractor in an air conditioned cab with radio and even television, while he tills his fields. He is really lord and master.

Tillage

For purposes of this discussion, tillage is defined as any physical manipulation of the soil to enhance plant growth. This definition no doubt produces very different mental images in our minds, depending upon our experience and training. In order to set some parameters on these images we can include as tillage implements everything and anything from a sharp stick or table fork to a one-hundred-foot-wide cultivator. There are literally hundreds of tillage implements from hand tools or a donkey or oxen to a 600-horsepower Steiger-Tiger tractor. This tractor would require a corn planter 560 feet wide to utilize all its power.

Objectives of Tillage

There are several major objectives of tillage. Some of these are:

1. to prepare a seedbed
2. to manipulate plant residue
3. to manage water
4. to control weeds
5. to establish a surface layer which prevents wind and water erosion
6. satisfaction; psychological fulfillment

Each of these objectives is of great importance when considering their effects on wheat production and they deserve brief discussion.

Preparing a Seedbed

Characteristics of a desirable seedbed are:

1. a weed-free soil which prevents the loss of precious water and fertilizers for production of weeds;
2. a granular soil structure which allows close contact of the seed,and later the plant roots, with the soil particles. It also factilitates penetration of air and water. Obviously different soil types require different management to produce a seedbed of desirable tilth;
3. a soil free of compacted layers which reduce air and water penetration and inhibit root development; and

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4. a generally level surface which allows for planting seeds at a uniform depth and is especially important in irrigated fields for proper water management.

Obviously, there is an almost unlimited number of methods of seedbed preparation. The crop involved, the soil type, and the size and kind of equipment available are all factors influencing seedbed preparation. Certainly, available time is a major factor. As the number of acres farmed by one man enlarges and the cropping intensity increases, there is an increasing demand for more efficiency in management and tillage. This adds up to mechanization.

Manipulating Plant Residue

In some areas virtually all of the plant residues —straw, fodder, and even the roots— are utilized for animal feed or fuel. However, with some crops there is a good deal of residue and this can become a problem. Nearly everyone agrees upon the benefits of adding organic matter to the soil: (a) increased fertility, (b) increased water penetration and holding capacity and (c) more favorable soil microflora. The problems of how and when to handle crop residues must be faced. We know that decaying organic matter can tie up the nitrogen supply for a time. Thus, additional chemical fertilizer may be required. The physical presence of straw or crop residue can cause mechnical problems in wheat farming. The trash clogs tillage tools and drills. Machines have been specially designed to handle this problem. But in many areas this same surface trash helps prevent wind and water erosion.

Controlling Weeds

For many centuries little was done to control or eliminate weeds. A lot of backbreaking, discouraging hand labor was devoted to weed control, but with little success. The mechanical age, even with animal powered implements, ushered in a new era of weed control. Now we have a large assortment of tillage implements, designed specifically to control weeds. And finally during the last 25 to 30 years we have come into the chemical age. There are well over 100 different chemicals used commercially for control of weeds.

Water Management

In areas which can be irrigated, tillage plays an important role. Fields must be level and smooth with proper slope and drainage. Sometimes, beds are created for growing the wheat crop. This allows for both irrigation and drainage.

Where wheat is produced under rainfed conditions, which includes vast semi-arid areas of the world, water management is even more critical. Limited moisture for crop growth is often the major factor constraining yields. Over the years rather successful tillage systems have been developed specifically for these low rainfall areas. Again, a large array of tillage implements has been developed. Since dryland farming often involves large areas of open land, this is the area where huge machines are most efficiently used.

Since these semi-arid lands are often most subject to wind and water erosion, we should remind ourselves of the objectives of tillage. It is too easy to think only of the immediate future and forget that once the soil is lost to erosion, it cannot be replaced. Any acceptable tillage system must provide for erosion prevention and control.

Minimum Tillage

According to our original definition, tillage is any physical manipulation of the soil. This would include seeding operations.

Recently a lot of interest has evolved around the so-called conservation tillage or minimum-tillage concept. Using our definition, I cannot think of any system of wheat production which would be correctly called no-tillage. However, minimum tillage may involve only one operation: seeding. It seems logical that man would have always performed the minimum number of tillage operations required to produce a satisfactory crop. But, with increasing knowledge of plants and soils and greatly increased sophistication of agricultural implements, the required number of tillage operations has been reduced.

Energy and Population

Two other very important factors continue to cast an ominous shadow on agriculture. One is the ever-increasing problem of energy supplies. Petroleum supplies continue to decrease while the demand and the price continue to increase. The other is the constantly increasing world population. Each year millions of acres of our best agricultural lands are lost to housing developments and highways. Meanwhile,population continues to grow at an alarming rate. I certainly cannot predict when or how, but I do believe that the energy-food-population equation will be balanced. One can only hope that as the situation becomes increasingly dismal, mankind will have the insight and the courage to make the most judicious use of soil and energy resources. The alternative is not pleasant to consider.

Some Specific Effects of Tillage on Wheat

A large volume of scientific literature is available on how tillage affects wheat production. This literature indicates that tillage directly affects many elements of the biological complex in which the wheat plant grows. There are:

1. effects on soil moisture
2. effects on soil temperature
3. effects on soil structure
4. effects on soil micro-organisms
5. effects on soil nutrients and uptake
6. effects on diseases and insects
7. effects on wind and water erosion.

This list could certainly be expanded. It isn't considered to be definitive nor is there any attempt to enumerate in order of importance. We must also keep in mind the fact that in a biological system all of these factors and others are functioning in very complex interrelationships. A change in any one of these factors results in a change in all of the others. For example, the soil temperature-soil water relationship, although not clearly understood, clearly has an effect upon seed germination, root growth, and tillering of wheat plants.

1. Effects of Tillage on Soil Moisture

Tillage systems have been developed to facilitate water penetration into the soil, control weeds and increase the amount of water retained for later crop use. Many variations of water conservation, stubble mulch, erosion control systems are used. Table 1 illustrates the effects obtained from one of these systems.

TABLE 1. Wheat yields and water use efficiency at Akron, Colorado

Time	Tillage System	Average Rainfall mm/yr	Wheat Yields kg/ha	Water Use* Efficiency kg/ha/cm
1916-30	Shallow plow-harrow	435	1068	1.22
1931-45	One-way disc-rod weeder	402	1162	1.44
1946-60	Disc, begin mulching w/ sweep and rod weeder	424	1700	2.00
1961-72	Stubble mulch, begin w/ fall weed control	375	2049	2.73

*Water use efficiency kg/ha/avg pptn x 2 (fallow and crop year)

It is unfortunate that many farmers do not understand the concept of moisture conservation tillage and/or they do not have the equipment required to do the job properly. All too often the net result is that after several tillage operations the soil contains not more but less water and the physical structure is broken down. This prevents water infiltration and encourages erosion.

It is important at this juncture to re-establish a few basic principles. First, we are dealing with a concept —that of ideal growing conditions for the wheat plant. Second, it matters not to the plant how we achieve these ideal conditions. It is problems of time, resources, and economics that dictate the methods used. Recall that I said anything goes from a table fork to Steiger-Tiger. Third, there is a critical time for completing tillage operations. *When* the job is done may well be more important than how it is done, providing we achieve the proper soil condition. We are all familiar with what we refer to as "lunch" soils. They are given this name because they are too wet to work in the morning and too dry in the afternoon. The only time they handle properly is during the lunch hour. Incidentally, there is another non-scientific but very important term that we should discuss —"handle." Perhaps we are combining science with art, but farmers who live, or die, with the soil learn to handle it. It's a method of talking with the soil; the same as he talks with his plants. In fact the plant may be the interpreter between man and the soil.

2. Effects of Tillage on Soil Temperature

Research has shown that different tillage systems result in differences in soil temperature. For example, straw or stubble mulch systems usually decrease soil temperature. This may be an advantage in the fall, allowing earlier seeding and promoting profuse tillering of wheat. It may be a disadvantage in the spring when seeding would be delayed or when the growth of fall-seeded wheat would be retarded.

3. Effects of Tillage on Soil Structure

Tillage directly affects the roughness and bulk density of the soil. These factors in turn directly affect such things as water infiltration, crusting, wind erosion, and compaction, which in turn affect seedling emergence, root development, nutrient uptake, and so on. This again illustrates the close relationship of all these factors.

4. Effects of Tillage on Soil Micro-organisms

As stated by Somus and Biederbeck (8), "Soil micro-organisms control and maintain the productivity of agriculture lands by continually recycling and regenerating essential plant nutrients from crop residues, humus and other forms unavailable to plants." Consequently, if tillage effects temperature and moisture and manipulates crop residues, it will certainly affect soil micro-organisms.

5. Effects of Tillage on Soil Nutrients and Uptake

Probably nitrogen is the nutrient most affected by tillage, although both phosphorus and potassium are also influenced. Incorporation of organic matter and changes in the amount and location of soil water are the factors which cause most of the fluctuaton in nutrients. The effects can be either positive or negative for a given time and condition. Warm moist soils have greater micro-organic activity which results in greater mineralization of nitrogen which can result in greater nitrogen uptake by plants (9).

6. Effects of Tillage on Diseases and Insects

As with all of the other factors discussed, the disease and insect situation is complex. Crop residues left on or near the soil surface provide favorable conditions for diseases and insects. Residues may be the main source for the carry-over of pathogens from one season to the next. It is the old case of "damned if you do and damned if you don't." Tillage of the soil to bury wheat stubble greatly reduced the incidence of take-all (*Ophiobolus graminus* Sacc.). However, the incidence of eyespot (*Cercosporella herpotrichoides* Fron.) was much less in non-tilled, direct seeded wheat (1). Little work has been done to study how tillage effects the wheat-insect relationship.

7. Effects of Tillage on Wind and Water Erosion

Again we face the paradox. Tillage causes erosion from wind and water; tillage reduces erosion from wind and water. Concern over loss of top soil and resultant deleterious effects to the environment has resulted in legislative action (15). In the United States, under the far-reaching Environmental Protection Agency legislation, farmers who exceed certain minimal rates of soil erosion are liable to legal action. No one who lives by the soil, as do wheat farmers, needs to be reminded of the value of our soil nor of its irreplaceable nature once it is lost. Still the demands of an ever-increasing hungry world population force us to farm for maximum food yields and to farm many acres of land where the erosion risk factor is extremely high.

Let us now briefly summarize this important subject. A few key points can be stated:

a) Tillage manipulates crop residues.
Crop residues on and in the soil surface help to increase water infiltration, reduce runoff, and prevent and control erosion.
b) Tillage affects soil structure.
Rough surfaces containing clods from 1/2 cm up to 5 cm help to control both wind and water erosion. Tilling too much destroys structure. Handling soils at the wrong time may result in an extremely rough, cloddy surface —more like bricks than soil.
c) Choose the proper implement.
Several tillage implements and systems have been designed to accomplish the conditions stated above. The farmer must determine which system best fits his own soil and climatic conditions within his economic limitations.
d) Tillage is an art: learn to handle the soil.
Certainly there is a great deal of scientific research to provide guidance on soil management. But there is no substitute for experience in really handling the soil.

I would like to cite one further example of the results that can be achieved through imporved farming practices. I am fully aware of the fact that tillage is only one facet of this picture; that improved varieties, use of fertilizers, and control of weeds all are equally important parts of the production package. However, particularly in the vast semi-arid regions, a tillage system which results in conservation of more water for plant use is a critical step toward increasing wheat production.

Here is an example of the result which can be achieved when the package is properly put together. Table 2 indicates the yield increase obtained in Turkey after improved technology was applied.

TABLE 2. Comparison of wheat yields from farmer fields and improved farming systems, Turkey, 1973-74

Year	Yield kg/ha Farmer Fields	Improved System	Percent Increase
1973	1170	1960	67
1974	850	1370	61

The happy part of this story is that Turkish farmers have been able to utilize the improved technology to increase wheat production nationwide. Production has risen from roughly 9 million tonnes in 1974-75 to roughly 15 million tonnes in 1977 and 1978. Certainly tillage is not the only factor involved, but considering the many effects of tillage on wheat production, we can conclude that we must continue to learn more about tillage and its effects.

Let us constantly remind ourselves that we are dealing with a variable concept, that of ideal plant growing conditions, a complex biological system and two of the world's most precious resources —the soil and energy supplies. Let us use them wisely.

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Summary

Since the dawn of the agricultural age, tillage of the soil has been practiced to aid plant growth. A vast array of implements and tools is available for soil tillage. Effects of tillage are both favorable and unfavorable. Wind and water erosion and soil compaction can result

from improper tillage practices. Well-managed tillage operations assist in preparing a desirable seedbed, managing plant residues, controlling weeds, managing water and preventing erosion. Tillage affects soil moisture, temperature, structure, micro-organic life, nutrients uptake and diseases and insects. All of these factors directly affect cereal production. Constantly increasing world population and food needs, coupled with ever increasing prices but decreasing supplies of petro-chemical energy, demand that we exercise our best judgement and technology to achieve optimum food production and also prevent waste of the soil and energy.

LABOURAGE EFFICACE ET PRODUCTION DE CEREALES

H. Hepworth

Résumé

Dès l'aube de l'agriculture, le labourage du sol a été pratiqué pour favoriser la croissance des plantes. Une vaste gamme d'instruments et d'outils est disponible pour le labourage du sol. Les effets du labourage sont à la fois favorables et défavorables. L'érosion par le vent et l'eau et le tassement du sol peuvent résulter de techniques de labourage inadaptées. Des opérations de labourage bien conduites facilitent la préparation d'un bon lit de semences, l'exploitation des résidus de plantes, le contrôle des mauvaises herbes, une exploitation judicieuse de l'eau et permettent d'éviter l'érosion. Le labourage affecte l'humidité du sol, sa température, sa structure, la vie micro-organique, l'assimilation des substances nutritives, les maladies et les insectes. Tous ces facteurs affectent directement la production des céréales. L'augmentation constante de la population mondiale et des besoins alimentaires jointe à des prix sans cesse croissants, mais aussi à une fourniture décroissante d'énergie pétro-chimique, exigent que nous exercions notre meilleur jugement, et mettions en oeuvre notre meilleure technologie en vue d'obtenir une production alimentaire optimale et d'éviter le gaspillage du sol et de l'énergie.

THE FALLOW SYSTEM AND CEREAL PRODUCTION IN THE DRYLAND AREAS OF TURKEY

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Introduction

Successful cereal production in Central Anatolia requires farmers to practice the fallow-crop rotation system. This is due to the very different environmental and ecological *conditions encountered.* This system aims not only at a good seed bed preparation but more important factors which are:

1. Conservation of soil-water by decreasing runoff or by increasing infiltration;
2. Effective weed control;
3. To supply and conserve optimum soil characteristics by controlling wind and water erosion.

In this region the amount of rainfall is insufficient with great variabilities in its distribution. Fallow-crop rotation is the only effective system for crop production by the farmers. The main goal in practicing fallow-crop rotation is to conserve the maximum amount of water in the soil in the fallow period for the crop to use during the cropping period and to supply the optimum soil conditions for crop to grow. The objectives of our research programme were to determine the optimum fall, spring and summer tillage implements for the wheat fallow areas of Central Anatolia.

Materials and Methods

Soils:

The soils of Anatolian Plateau are in the brown, red-brown and red great soil groups. The depths are between medium and shallow. The slopes of the soils vary from flat to steep. The pH varies between 6.8 and 8.3. The soils are high in clay and lime, high in potash, low in available phosphorus and have been affected by wind and water erosion. They are low in organic matter and some areas have problems with salt and drainage.

Climate

The average annual rainfall is 390 mm. Of this rainfall 35 percent occurs in the spring, 14 percent *in the summer,* 18 percent *in the fall,*and 34 percent in the winter. The average relative humidity is 63 percent and the minimum relative humidity occurs in August (38 percent) and maximum in December and January (82 percent). The average temperature is 10.7º C. Maximum temperature occurs in August,and the minimum in January.

Experimental Design

Strip-split block with four replications in five different locations.
Main plots: Fall tillage: Chisel (20-22 cm depth)
Moldboard plow (20-22 cm depth)
Control (no tillage)

* Cereal Agronomists, Ankara, Turkey.

Sub plots: Spring tillage; Moldboard plow (18-20 cm depth)
Offset disc (18-20 cm depth)
Sweep (18-20 cm depth)

Sub-sub plots: Summer tillages: Rodweeder
Sweep + harrow
Sweep + rodweeder
Chemical

In the first three summer tillage systems, tillage operations were performed at a 10-12 cm depth, and the final tillage at 7-9 cm depth. Contact herbicides were applied as chemical fallow at the times when the other tillage operations were conducted. Summer tillages were performed 2-3 times according to the crust and weed situation of the soil or field.

Results and Discussion

The fall, spring and summer tillages were evaluated separately since no significant interactions were found.

Fall Tillage

The effect of fall tillage for accumulating rainfall by means of increasing the infiltration rate was investigated. The chisel and moldboard plows were compared with non-tilled plots.

Among the 16 experiments conducted in five years, only the experiment harvested at Gozlu State Farm in 1973 showed a significant difference among the fall tillage treatments. No significant differences were found among fall treatments in the other 15 experiments.

There was a difference of only 11 kg/1/10ha among the fall treatments (Figure 1), and that difference mainly comes from the results on one experiment harvested in 1975, which was not statistically significant (Figure 2).

In this region winter rainfall intensities are relatively low, but the soil infiltration capacities are much higher. According to the results of our experiments conducted over a five year period, it was determined that fall tillage had very little effect on increasing yields, was not economic, and was not necessary in the Central Anatolian region.

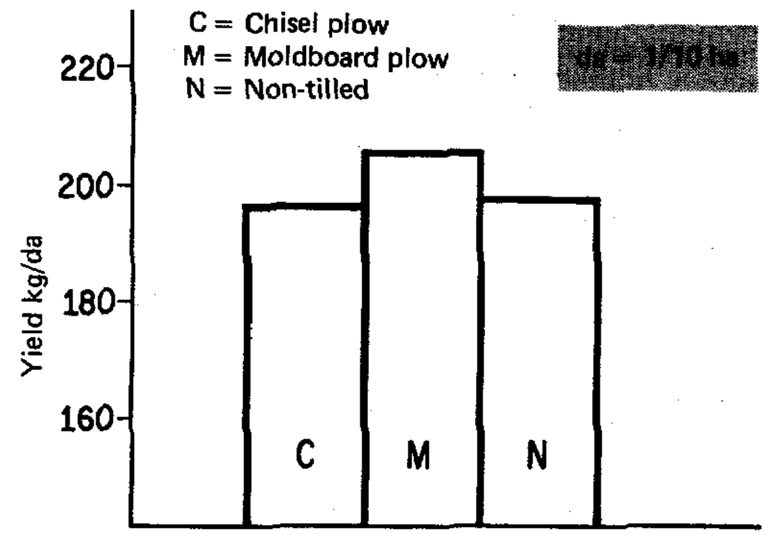

Figure 1. The average yields of fall tillage systems in tillage research, 1972-76.

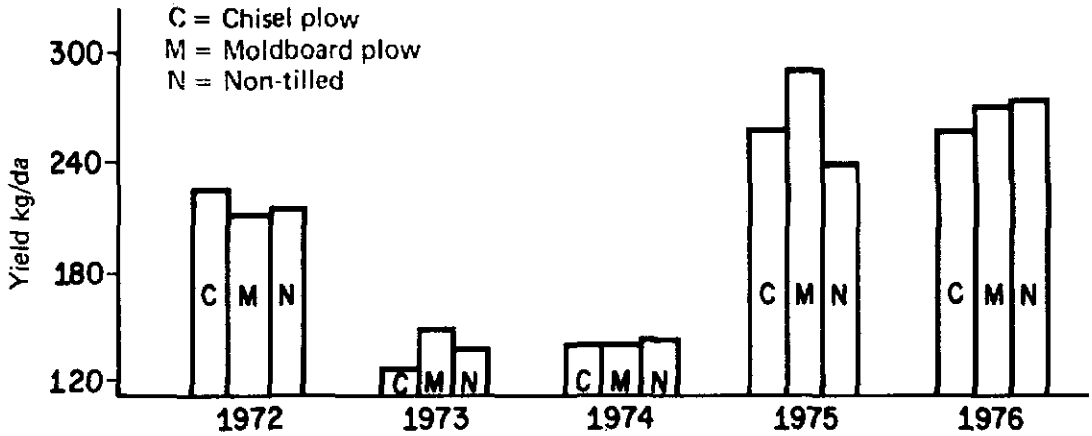

Figure 2. The average yields of fall tillage systems in different years in tillage research,1972-76.

Spring Tillage

In the region, rainfall with high intensities occurs in the spring, mainly in April and May. The main objectives of spring tillage are:

1. To increase the aeration, water holding capacity, and the infiltrations rate of soil; to stop water accumulation and evaporation on the soil surface and minimize the runoff;
2. *To control weeds and volunteer wheat which use most of the water during the fallow;*
3. To begin preparing the soil for conserving moisture through the use of a soil mulch during the rest of the fallow cycle.

In the selection of the spring tillage implements, the different functions of the implements in soil have been taken into consideration. The spring tillage implements used throughout the research were offset disc, sweep and moldboard plow. The time of tillage was when the soil was at its proper condition for tillage.

The implements were compared from different standpoints. The description of of the performances of different implements are:

(a) The offset disc was observed to turn the soil into a finer structure. Because of the over disintegration of soil surface particles, the soil became subject to wind and water erosion. The offset disc also needs more power than the other implements and because of its heaviness, it caused some compaction under the tillage depth;

(b) The sweep plow, as a spring tillage implement, was not sufficient for tilling at the desired depth. This was because of the higher resistance of soil to tillage and the amount of plant residue and weeds on the soil surface. There was also an increase in the grassy weeds in these plots and the sweep flow was unsuccessful for controlling the perennial weeds. At the same time, when rainfall occurred just after tillage, it was observed that annual weeds regained their viability.

(c) The moldboard plow appeared to be the most effective implement in increasing the infiltration rate and the water holding capacity of soil. It also controlled the annual and the perennial weeds much better, including the grassy weeds, which are the main problem in fallow areas of the region.

It has been claimed by many researchers that the moldboard plow fails in erosion control. However, it was observed that timely tillage with the moldboard plow at the proper soil moisture conditions resulted in a granular structure with small clods on the surface which were not subject to wind and water erosion under normal conditions.

Spring tillage using moldboard plow can be performed at the direction suitable for the farmer or if possible parallel to contour lines at the slopes between 0.1 and 3 percent.

The fields having a slope more than 3 percent must be separated into two parts. In fields having a slope of 3-8 percent, the tillage direction must be parallel to contour lines. By this way of working the soil, it is possible for the furrows to act as terraces. If tillage along the

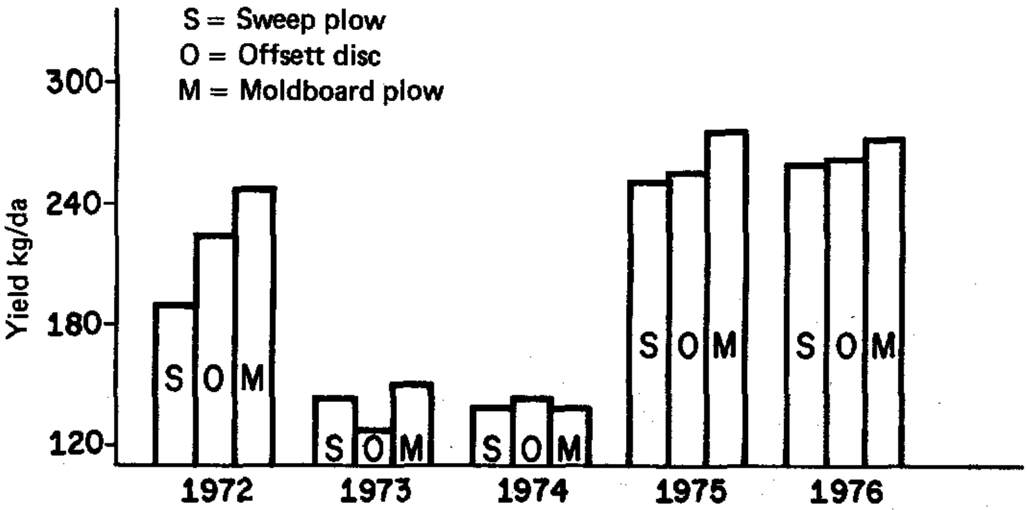

Figure 3. The average yields of spring tillage implements in different year in tillage research, 1972-76.

contour is not practiced, gullies and extensive erosion often occur. It is very difficult to control water erosion in a crop-fallow rotation in fields with a slope more than 8 percent. In such areas, crop production must be left to other practices or systems.

Among the 15 of 16 experiments conducted over the five year period, the moldboard plow was in the highest yielding group, the offset disc and sweep were only six times in this group. In the 1973 and 1974 harvest years, which had lower than the average rainfall, the yield levels of the moldboard plow, offset disc and sweep plots were in the same statistical group. In the harvest years of 1972, 1975 and 1976, which had much better rainfall, the highest yields were found in the moldboard plow treatments and they were statistically significant (Figure 3).

Although there were no significant differences among the yields of spring tillage implements in 1973 and 1974 harvest years, the yields of moldboard plow were 16 kg/1/10ha higher than offset disc and 23 kg/1/10ha than sweep (Figure 4).

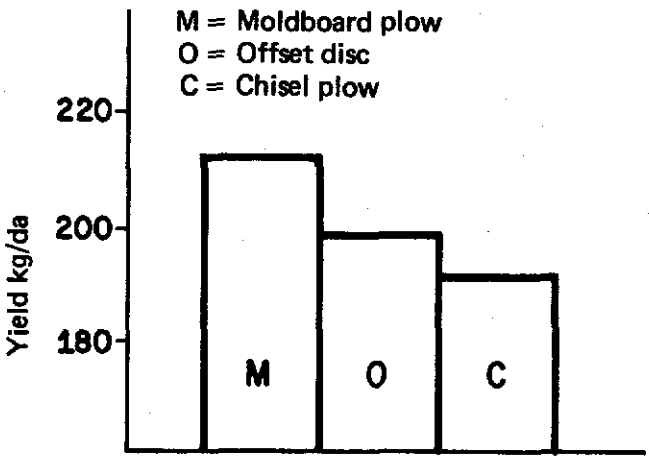

Figure 4. The average yields of spring tillage implements in tillage research, 1972-76.

The economical analysis showed that the cost of the moldboard plow and the sweep treatments were 15 TL/1/10ha and 6 TL/1/10ha, respectively. According to the yield average of 16 experiments, the moldboard plow was found to be 60 TL/1/10ha more profitable than the sweep as an initial spring tillage implement.

The yield averages, statistical and economical analyses, and performance evaluations showed that in the region, the moldboard plow is the most suitable implement for spring tillage and must be used on land with less than 8.0 percent slope. Fields with a slope of more than 8 percent are not suitable for fallow-crop rotation because of the water erosion hazard.

Summer Tillage

In the region, intensive spring rains are followed by a hot and relatively dry summer season. The objective of summer tillages is to conserve the accumulated water by decreasing evaporation. The heavy textured soils of the region are subject to capillary water movement which results in high water loss by evaporation.

In dry soils, cohesion between the soil particles and adhesion between soil particles and water is relatively low. This makes the capillary tube diameters larger which results in slower capillary movement. Secondly, in an expanded soil, the number of capillary tubes are less than in undisturbed soil. It is difficult for water in the lower zones to move upward to the expanded soil having lower volume density. A 10-12 cm thick, dry and expanded soil zone on the surface (dust mulch) affects the evaporation by slowing down capillary movement. This application is also effective in controlling weeds and preparing a good seedbed.

Four summer tillage systems were compared to test the adaptability of these theories to the region and to find the optimum summer tillage system.

The first three summer tillage systems are based on having a mulch layer 10-12 cm thick in the initial summer tillages and 7-9 cm in the final tillage before seeding. The fourth system was aimed at controlling weeds by contact herbicides. Herbicides were used at the times when the other three implements were used. The rodweeder was used for the last treatment (chemical) because of the seeding difficulties which arose in the plots.

The results of the 16 experiments indicated that the rodweeder was 12, sweep + harrow was 13, sweep + rodweeder was 13 and chemical was 11 times in the highest yielding group which were statistically significant.

The average yields of the summer tillage systems showed some differences by the years (Figure 5), but the average of all experiments showed a difference of only 5 kg/1/10ha among themselves (Figure 6).

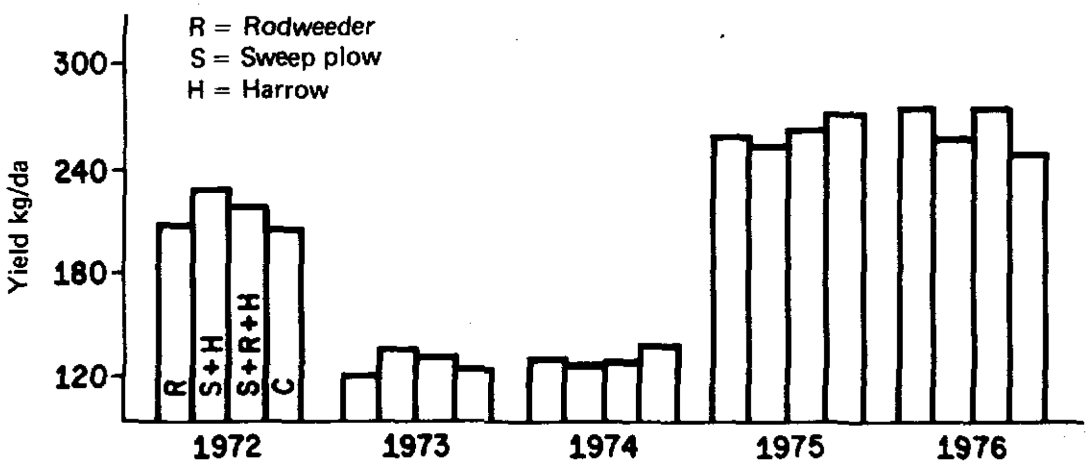

Figure 5. The average yields of summer tillage systems in different years in tillage research.

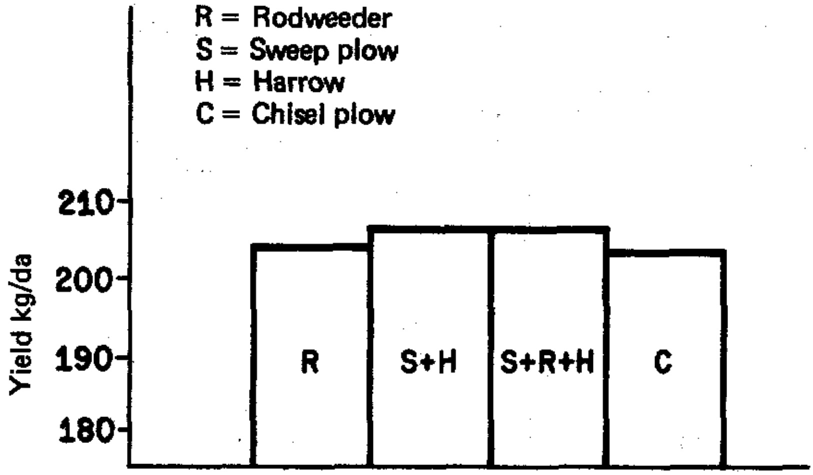

Figure 6. The average yields of summer tillage systems in tillage research, 1972-76.

It was impossible to decide the proper summer tillage systems by their levels of yield. But when the problem was taken from the point of view of application and economy, it was possible to make a conclusion.

The observations on the application of these systems showed that:

When a rodweeder was used as the first summer tillage implement and when pF was lower than 3.5, the moisture level of the soil prevented the rodweeder from functioning properly. The connection parts of rodweeder stopped turning when filled with wet soil. Under the above mentioned conditions, it was very difficult to get into the desired depth. In most cases, it was impossible and it caused soil compaction below the tillage layer. When the upper soil layer was dryer, the rodweeder functioned properly by keeping the soil mulch layer, controlling weeds and preparing a good seed bed.

The sweep + rodweeder combination had the same disadvantages as rodweeder alone when working in soils below 3.5 pF. Chemical fallow resulted in an unproper seedbed with lots of plant residues on soil surface. This situation caused problems in seeding with a drill. The rodweeder was used in the plots before seeding, where chemicals were applied. Contact herbicides were effective in controlling annual weeds. Controlling perennial weeds in the fallow areas was impossible by using contact herbicides.

The sweep + harrow combination seemed to be the proper summer tillage implement for mulch and seedbed preparation and for weed control.

The economic comparison of the summer tillage systems tested is shown in Table 1.

TABLE 1. The comparison of summer tillage systems with chemical by net income

	Yield kg/1/10ha	Yield Difference kg/1/10ha	Costs TL/1/10ha	Difference in Cost Compared with Chemical TL/1/10ha	Yield Value Difference TL/1/10ha	Net Income Difference TL/1/10ha
Chemical	197		38.45			
Sweep + harrow	202	5	6.49	31.96	16.25	48.21
Rodweeder	199	2	5.00	33.45	6.50	39.95
Sweep + rodweeder	202	5	9.95	28.50	16.25	44.75

Economical analyses showed that chemical fallow was the most expensive and sweep + harrow combination was the cheapest system. When the summer tillage systems were compared from the practical economical points of view, the sweep + harrow combination seemed to be the ideal implement for summer fallow. A rodweeder can be used when the soil moisture is above 3.5 pF and it is the most proper summer tillage implement for the last summer tillage. The compaction caused by it results in increasing the water level in the soil at seeding time.

From the results of tillage research, the recommendations for the Central Anatolian region can be summarized as follows:

I. To till the soil in fall is unnecessary; however, for the areas where a plow layer is a problem, it would be necessary to till in the fall every 4-6 years with a subsoiler type implement at a depth of 30-35 cm.

II. The moldboard plow must be used as the spring tillage implement. The direction of tillage must be the direction available for the farmer for the slopes between 1-3 percent and parallel to contour lines for the slopes between 3-8 percent.

III. Summer tillages must be performed by the sweep + harrow combination. The tillage direction must be parallel to contour lines if there is a hazard of erosion. If not, the direction must be perpendicular to spring tillage. The rodweeder seemed to be the best implement for the final summer tillage aimed specially on seedbed preparation.

Adaptive Research

Adaptive research trials were conducted on farmers' fields in five provinces on the Central Anatolian Plateau. These trials were conducted jointly by the wheat research

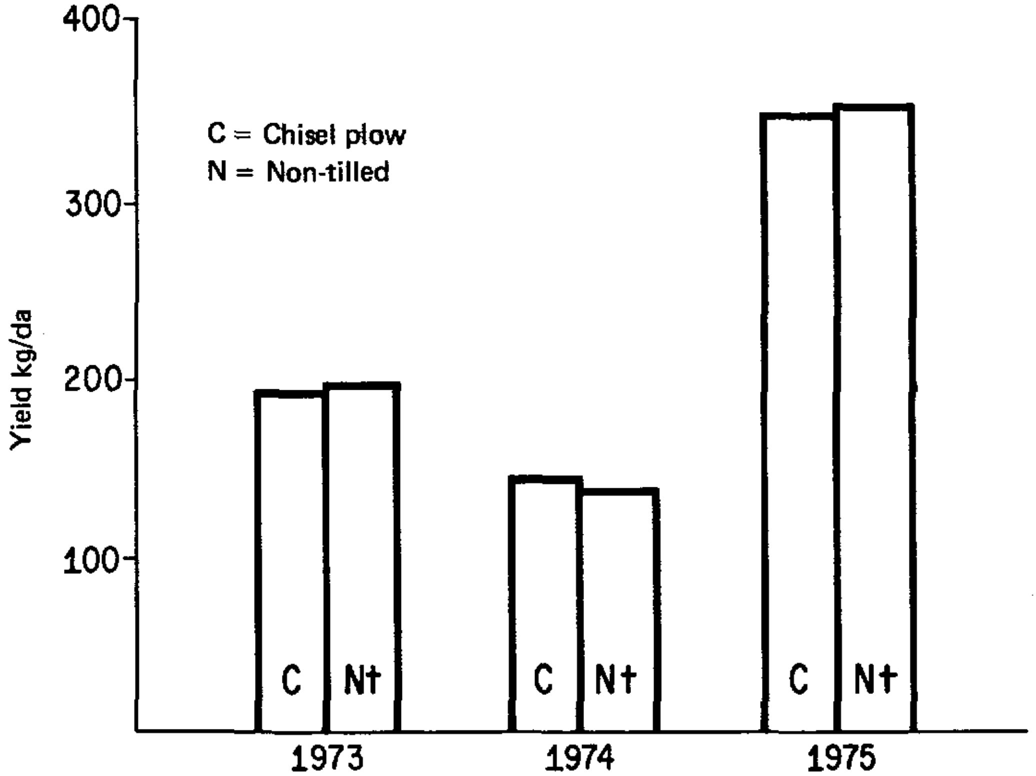

Figure 7. The average yields of fall tillage systems in adaptive research, 1973-77.

project and the regional extension organization. The objectives of the adaptive research programme can be summarized as follows:

a. To demonstrate the improved wheat production techniques;

b. To determine the adaptation to farmer conditions of the results obtained from previous experiments;

c. To determine the yield situation and potential of the region.

In the first three years fall, spring and summer tillage implements were tested. The experimental design was then changed and only spring tillage implements were tested for the last two years.

Fall tillage:

The chisel plow was compared with "no tilled" plots. As can be seen from Figure 7, no difference was found between these treatments.

Spring tillage:

The moldboard plow and sweep were tested for five years at all locations. In the first three years, the offset disc and during the last two years, the chisel plows were also tested.

The yield averages for spring tillage implements are shown in Figure 8. The moldboard plow gave the highest yields.

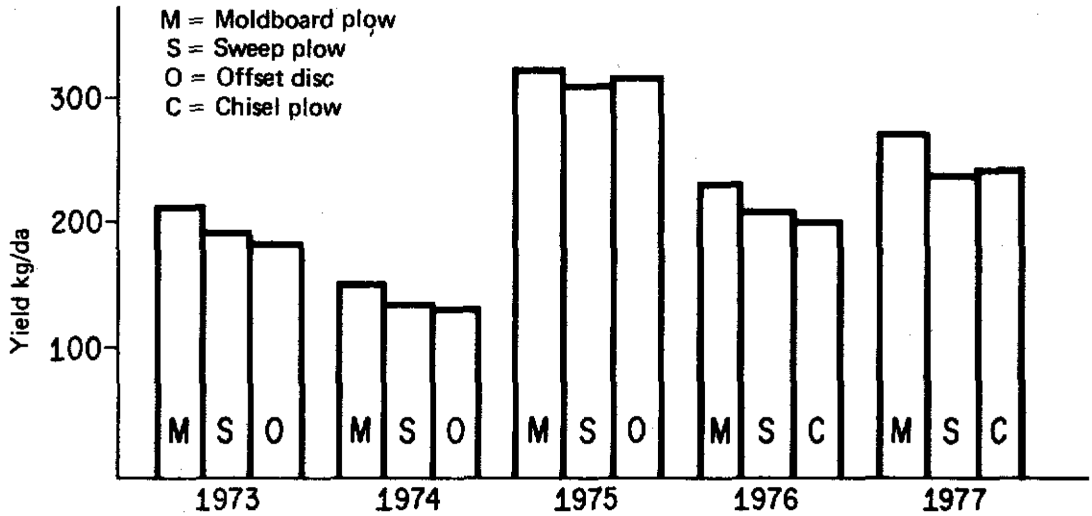

Figure 8. The average yields of spring tillage implements in different years in adaptive research.

Summer tillages

Sweep + harrow, sweep + rodweeder and rodweeder alone were tested as summer tillage implements. The results obtained from summer tillage implements are shown in Figure 9.

Although the yield averages between these three implements did not differ greatly, the observations on the applications of these implements showed that the sweep + harrow combination was the most suitable implement for establishing a soil mulch.

Comparisons of Adaptive Research Averages with Farmer Fields

Adjacent farmer fields to the adaptive research trials were harvested throughout the research period in order to determine the differences and yield potential of the region. The

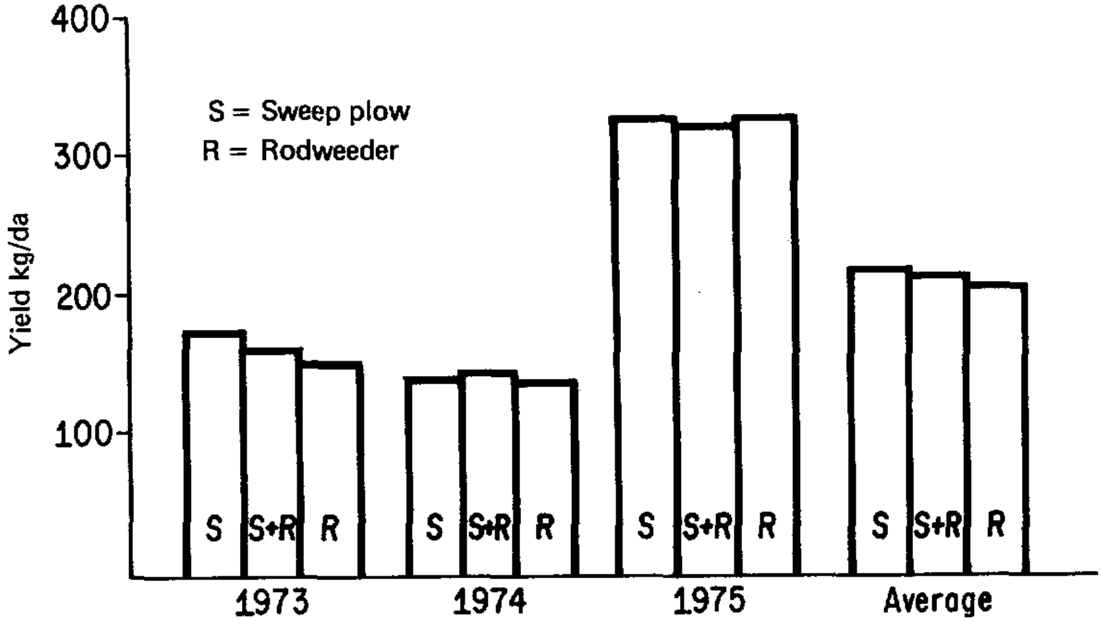

Figure 9. The average yields of summer tillage systems in different years in adaptive research.

adaptive research yield values indicate the yields obtained by the use of improved wheat growing techniques when the tillage implements were not taken into consideration. These improved techniques included timely tillage operations, high yielding cultivars, proper seed and fertilizer application, weed control, etc.

The yield average of adjacent farmer fields and adaptive research trials are shown in Figure 10. These results indicate that, even when the tillage implements are not taken into consideration, it is possible to increase the yields 79 percent by improved growing techniques.

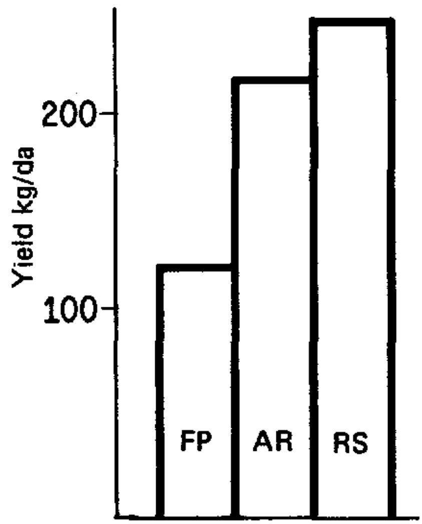

Figure 10. The yield averages of farmer practices (FP), adaptive research (AR) trials and recommended system (RS) in adaptive research, 1973-77.

According to the results of adaptive research and basic research, in the fallow tillage system the best system for soil preparation appears to be:

- Fall tillage is unnecessary
- Moldboard plow for spring tillage
- Sweep + harrow combination for summer tillages

The recommended system and its comparison with adjacent farmer fields at five different locations over a five year period and the averages are shown in Figures 11 and 12. The recommended system resulted in 88.0 percent higher yields over the traditional system (Figure 10).

The adaptive research studies indicate that the yield potential of the region has not been achieved and that it is possible to increase wheat production substantially by the application of the improved techniques.

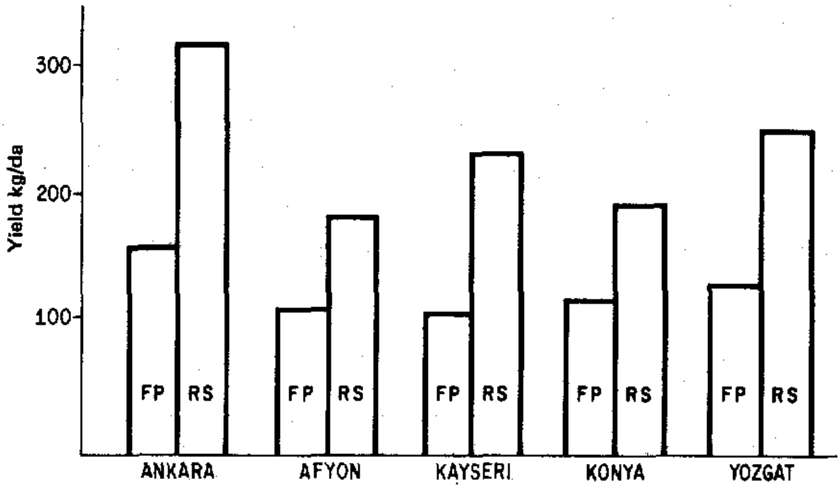

Figure 11. The comparison of the average yields of farmer practices (FP) with recommended system (RS) in five locations in adaptive research, 1973-77.

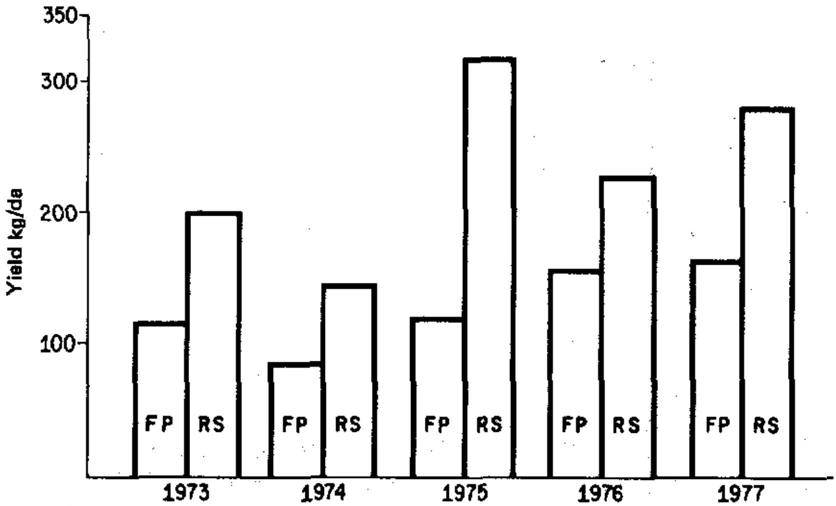

Figure 12. The comparison of the average yields of farmer practices (FP) with recommended system (RS) in different years in adaptive research.

Summary

Experiments were conducted at different locations under dryland conditions and included the brown and the red brown soil groups of Central Anatolia. The experiments were conducted in order to verify the best tillage method to conserve the maximum available water in the soil during the fallow. The experiments were conducted in the period of 1970-76.

The various tillage treatments compared were:

Fall

Moldboard plow (20-22 cm depth)
Chisel (20-22 cm depth)
No tillage

Spring

Moldboard plow (18-20 cm depth)
Sweep (18-20 cm depth)
Offset disc (18-20 cm depth)

Summer

Sweep + harrow (10-12 cm depth)
Rodweeder (10-12 cm depth)
Sweep + rodweeder (10-12 cm depth)
Chemical (contact herbicide application)

The fall treatments did not show any significant effects on wheat yield. Of the spring tillage treatments, the moldboard plow gave the best results.

The differences between summer treatments were very small as far as yield is concerned, but the sweep+harrow combination seemed better on a practical and economic basis.

Adaptive research trials were also conducted on farmers' fields in the Central Anatolian Plateau Region. The objective of these trials were:

1) to demonstrate the improved wheat production techniques,
2) to determine the adaptation of the results obtained from previous experiments,and
3) to estimate the yield potential of the region. At each location the average yields from the adaptive research trials were compared to those from adjacent farmers' fields.

Similar results were also obtained in the adaptive and the basic research trials at the main research station for the Central Anatolian Plateau. The comparisons showed that the wheat yields from adaptive research trials were 79 percent more than wheat yields in adjacent farmers'fields. The system recommended by our institute resulted in 88 percent higher yields from those of farmers'.

These results indicate that it is possible to increase wheat production substantially by the application of the improved techniques in the Central Anatolian Plateau of Turkey.

LE SYSTEME DE LA JACHERE ET LA PRODUCTION CEREALIERE DANS LES REGIONS SECHES DE TURQUIE

M. Guler, I. Unver, M. Pala, N. Durutan, M. Karaca

Résumé

Des expériences ont été effectuées dans diffèrentes zones soumises à la sécheresse, incluant des groupes de sols bruns et bruns-rouges d'Anatolie Centrale. Ces expériences ont été menées dans le but de déterminer la meilleure méthode de travail du sol pour conserver le maximum de l'eau stockée dans le sol durant la jachère. Les expériences ont été effectuées durant la période de 1970 à 76.

Les différents traitements de travail du sol comparés étaient:

Automme

	Charrue à soc	(20-22 cm de profondeur)
	Charrue à dents	(20-22 cm de profondeur)
	pas de labourage	
Printemps		
	Charrue à soc	(18-20 cm de profondeur)
	Canadien	(18-20 cm de profondeur)
	Charrue à double-brabant	(18-20 cm de profondeur)
Eté		
	Canadien + herse	(10-12 cm de profondeur)
	Sarcleuse	(10-12 cm de profondeur)
	Canadien + sarcleuse	(10-12 cm de profondeur)
	Chimique	(contact application d'herbicide)

Les traitements d'automme n'ont pas eu d'effets significatifs sur le rendement

Parmi les outils comparés au cours des labours de printemps, la charrue à soc a donné les meilleurs résultats.

Les différences entre les traitements d'été ont été minimes en ce qui concerne le rendement, mais la combinaison canadien + herse a semblée mieux sur une base pratique et économique.

Des essais dans la recherche d'adaptation ont également été effectués dans des pareilles d'agriculteurs de la région du Plateau d'Anatolie Centrale. Le but de ces essais était:

1)de faire connaître les techniques améliorées de production du blé,

2)de vérifier l'adaptation des résultats obtenus à partir des expériences précédentes, et

3)d'estimer le rendement potentiel de la région.

A chaque emplacement les rendements moyens des essais d'adaptation ont été comparés à ceux des champs adjacents des agriculteurs.

Des résultats similaires ont également été obtenus lors des essais d'adaptation et des recherches de base menés à la station principale de recherche du Plateau d'Anatolie Centrale. Les comparaisons ont montré que les rendements en céréales obtenus lors des essais de recherche d'adaptation étaient de 79°/o supérieurs aux rendements en céréales des champs adjacents des agriculteurs. Le système recommandé par notre Institut a eu pour résultat des rendements de 88°/o supérieurs à ceux des agriculteurs.

Ces résultats indiquent qu'il est possible d'augmenter substantiellement la production céréalière par l'application des techniques améliorées dans le Plateau d'Anatolie Centrale en Turquie.

IV. CROPPING SYSTEMS AND CONSTRAINTS

T. Samios
Mahmoud Duwayri
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A. Alameddine
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CROPPING SYSTEMS AND CONSTRAINTS IN CYPRUS

T. Samios*

Rotation Trials and Cultural Practices in Cyprus

Rotations

Since the establishment of the Agricultural Research Institute a number of cereal rotation trials have been initiated at various locations of different agroclimatic conditions. The purpose of these trials was to investigate (a) whether fallow is a necessary practice in dryland areas and (b) whether fallow could profitably be replaced by preferably a leguminous fodder crop.

In 1963, a rotation trial was initiated in an area where the average annual rainfall is about 500 mm. In this trial, an attempt was made to introduce a short-term ley into a cereal rotation and to compare its effect on cereal yield with the effect of annual vetch and fallow. The following five rotations were tested:

- Continuous wheat
- Fallow - Wheat
- Vetch - Wheat
- Subclover - Subclover - Wheat - Wheat
- Subclover - Subclover - Subclover - Wheat - Wheat - Wheat.

The results obtained showed consistently that wheat following a three year subclover ley produced the highest grain yield. The average yields of grain wheat obtained in the period 1963-1974 are shown in the table below.

The favourable effect of the subclover ley is most probably due to the enrichment of the soil with nitrogen and organic matter.

Grain Yield of Kyperounda Durum Wheat under Various Rotations in kg/ha

Rotation	Average for 1963-1974
Kyperounda continuous	792
Kyperounda following fallow	1100
Kyperounda following common vetch	1407
Kyperounda following a two-year subclover (Clare) ley	1767
Second year Kyperounda following a two-year subclover ley	1436
Kyperounda following a three-year subclover ley	2101
Second year Kyperounda following a three-year subclover ley	1592
Third year Kyperounda following a three-year subclover ley	1423

Soil analyses carried out during the trial showed a marked increase in organic matter and soil nitrogen in plots where a subclover ley was grown. A marked increase in soil moisture retention was also recorded at the depth of 30-60 cm as shown below:

* Agricultural Research Institute, Nicosea, Cyprus

Effect of Rotation on Soil Organic Matter (O.M.) and Soil Moisture

Rotation	O.M. per cent in 4 years 0.04	Soil moisture per cent (w/w) October 1970 0-15 cm	15-30 cm	30-60 cm
1. Wheat continuous	0.10	7.2	9.1	15.0
2. Fallow-wheat	0.21	7.8	12.0	14.3
3. Vetch-wheat	0.24	8.5	13.1	18.3
4. Two years sub ley				
Wheat 1	0.79	9.7	15.4	20.9
Wheat 2	0.29	8.1	10.6	14.0
5. Three year sub ley				
Wheat 1	0.85	9.7	12.3	20.8
Wheat 2	0.79	8.8	13.2	17.8
Wheat 3	0.20	8.4	10.9	17.4

Apart from this trial, a series of rotations was established in areas of 200-350 mm annual rainfall. In these trials the following eight rotations are compared:

- Cereal continuously
- *Cereal continuously with additional nitrogen fertilization*
- Cereal - Fallow
- Cereal - Cereal - Fallow
- Cereal - Forage Cereal
- *Cereal - Cereal - Forage Cereal*
- Cereal - Vetch
- Cereal - Cereal - Vetch

Although valuable data have been recorded from these trials no conclusive results were obtained as, for reasons beyond our control, the trials were abandoned prior to their completion. Therefore, in 1975 trials comprising the same rotations were initiated at three new locations.

In addition in 1973 in one location,and in 1975 in another three locations, similar but more simplified trials were initiated in order to obtain results in a short period. In these trials, the following five rotations were compared.

- Barley continuously
- Barley continuously with additional nitrogen fertilization
- Barley - Fallow
- Barley - Forage Barley
- Barley - Vetch

The trial which was initiated in 1973 was completed in 1978. Results have varied from season to season. Generally the highest grain yields were obtained from barley that *followed vetch. The lowest yields were obtained from continuous barley cropping without* increased N-fertilization. The table below shows the average yield of barley, from 1974 to 1978, in the various rotations:

Grain Yield of Athenais Barley under Various Rotations, in kg/ha.

Rotation	Average for 1974-1978
Barley continuous	1785
Barley continuous with increased N fertilization*	2151
Barley following Lana (Woollypod vetch)	2211
Barley following fallow	2121
Barley following farras (barley forage)	2009

* About 10 kg N/ha in addition to normal dosage, applied as a top dressing.

Finally, a trial in which a cereal/Medicago rotation is compared with a cereal/fallow one was initiated in 1975.

Apart from following up the yield performance of the crops in each rotation,every effort is made to record the effect of each rotation on important soil parameters such as moisture, nutrient status and structure. This was proved to be a very difficult task due to the lack of adequate instrumentation which could facilitate a more thorough investigation of the above parameters.

Cultural practices

Rainfall in semi-arid dryland regions is seasonal. Though in general it occurs during a few months, followed by drought periods, in some regions it may occur at a time unsuitable for crop production. In both cases, it is essential to complete field operations in a short period so that moisture accumulation, by tillage,or good seed germination and plant growth by timely sowing, can be achieved.

Timeliness in dry farming is a critical factor. Mechanization has improved timeliness by speeding up field operations. Equipment which was made to suit high rainfall conditions has been modified, and advanced agricultural engineering has produced new machines to meet the requirements of dry farming systems.

However, successful mechanized dryland farming should be based on two major considerations —a thorough study of the economics of a farming enterprise, and the adaptation of new agrotechniques.

In Cyprus where a traditional cereal-fallow rotation is practiced, farmers believe that the larger the number of ploughings of the fallow, the better for the succeeding crop, as ploughing controls weeds and conserves moisture. Work in other countries suggests that this may not be so under dryland conditions, if the ploughings are not properly timed and related to soil tilth and growth stage of weeds.

Fallow in the dry cereal growing regions of Cyprus lasts for 17 months. After harvest, the straw is usually collected for animal feeding and the crop residue is grazed by flocks. The land is ploughed up in autumn after the first rains and is left open throughout the rainy season. Ploughing is repeated three or four times up to the end of rains in late April. These operations are not necessarily justified and excessive ploughings result in soil pulverization and an increase in production costs.

Trials aiming at finding out the most effective and economic method of seed bed preparation, by comparing the number and time of cultivations during the fallow year, were carried out by the Cyprus Agricultural Research Institute from 1963 to 1971.

Each of these trials needed two seasons to be completed. The treatments and barley grain yields of these trials are shown in the next table.

Time and Number of Ploughings in a Cereal-Fallow Rotation. Atheaais Barley Grain Yields, in kg/ha.

Treatment	1963-1965 Athalassa	1964-1966 Prastio	1956-1968 Prastio	1968-1970 Kondemenos Dromolaxia (mean)	1969-1971 Prastio, Gypscu Dromolaxio (mean)	1963-1971 Mean of 8 trials
A. One ploughing in autumn after the rains	3683	2084	777	2600	4445	2719
B. Two ploughings (autumn + spring)	4908 –	2704	1591	3033	4848	3414
C. Two ploughings (autumn + late spring)	4587	2538	844	2988	4519	3093
D. Three ploughings (autumn + early spring + late spring)	4295	2532	777	2719	4631	2988
SX	84.4	35.1	145.7	73.2	80.7	
Precipitation (mm) Fallow leg	220	371	436	Kond. 620, Prast. 240	Prom. 547, Gypsou 222	Dromol. 314
Precipitation (mm) Crop leg	356	233	273	316, 267	314, 373	388

* At Prastio and Gypsou, it was not possible to carry out the third (late spring) ploughing.

From the table it is clear that two cultivations, one in autumn and one in spring,produce a better seed-bed for the following crop. The timing of the spring cultivation is the most critical. It should be timed so as to effect proper weed control and to create proper soil conditions for moisture conservation and maximum rainfall intake. Late spring cultivation results in excessive weed infestation and thereby in excessive moisture losses.

Soil sampling for percent moisture determination was done in nearly all trials. This determination showed that plots of treatment conserved about 3.0-5.0 percent more moisture than plots of the other treatments.

In order to investigate the effect of chisel ploughing in dryland farming and to compare various techniques of tillage, such as minimum tillage and zero tillage, new trials have been initiated at various locations in 1971. In these trials, the following tillage practices and implements are compared:

Autumn/Winter	**Spring**
Mouldboard Ploughing	Mouldboard Ploughing
Deep Chiseling	Shallow Chiseling
Chemical Weed Control	Spring Tyne Cultivator
No Cultivation	Disc Ploughing

No cultivation, chemical weed control throughout.

All autumn/winter treatments are cross-cultivated with spring treatments producing 16 combinations. These are compared with the zero tillage/chemical weed control/press drill sowing techniques. Though no conclusive resuts are as yet available, there is evidence that autumn mouldboard ploughing so far produces higher yields, independent of the spring tillage operation. The data obtained from zero tillage have not been consistent; in some seasons and locations the results were excellent while in others, disappointing.

Apart from relating cultivation treatments directly to yields, a study is also necessary on the soil conditions induced by these treatments. Therefore, an attempt was made at the initial stages of the trials to measure bulk soil density, porosity, infiltration rates and soil moisture, as affected by cultivation treatments. Due to the unavailability of the appropriate instrumentation for quick measuring methods, most of this work had to be abandoned and was restricted to soil moisture determinations, where soil sampling is done annually.

Parallel to "minimum tillage" practices, press drills for direct sowing in uncultivated fallow have been developed, in order to avoid moisture losses that occur in seed bed preparations; thus more moisture for seed germination and early plant growth is made available.

Trials comparing the conventional, the deep-furrow and press drills have started since 1969. Studies continue.

In the coming season a study will be undertaken to investigate the best way of seed bed preparation in a cereal-cereal cropping pattern. Treatments in this study will include stubble burning, stubble burying, stubble mulching and stubble seeding. This work was interrupted as it involves the study of the soil factors, mentioned when discussing the tillage trials, which required appropriate instrumentation.

Past and Present Cropping Practices Applied in the Rainfed Cereal Growing Areas of Cyprus

In the old days, cereal growers were generally applying the cereal-fallow rotation. Occasionally in areas with sufficient rainfall, fallow was replaced by a grain legume or an industrial crop such as *Ervum ervilia, Lathyrus sativa,* flax, cotton and tobacco.

Later on with the initiation of chemical fertilizer application and the use of weedicides, the fallow-wheat-barley rotation pattern was introduced, on a relatively small scale. Moreover, the developments in agricultural mechanization which made possible timely operations and the implementation of techniques for soil moisture retention encouraged the application of other cropping patterns than the traditional cereal-fallow rotation.

The major crop rotations used nowadays are:

a) Fallow-cereal: still practiced but becoming less important due to the introduction of more remunerative rotations and the loss of the major part of the cereal growing area.

b) Continuous cereal growing: this became possible with the introduction of mechanization, *chemical weed control and chemical fertilization.*

c) Cereal-forage (cereal or legume): this cropping system is becoming very important due to the needs of the expanding livestock industry. The government encourages this system by means of a subsidy paid on hay production. Barley is used for cereal hay production while a local variety of vetch is used for legume production. The leguminous crop has the additional advantage of benefiting the subsequent cereal grain crop.

d) Cereal-grain legume rotation: this is a very recent development. In the last three years, food legumes and especially chickpeas have become popular in replacing fallow, due to their high price in the international market.

e) Fallow-wheat-barley: an intermediate practice between the old cereal-fallow rotation and the continuous cereal cropping which is applied on a rather small scale.

Naturally all these cropping patterns are subject to changes depending on climate variations and socio-economic factors. It can also be said that the whole picture of cereal cropping practices might entirely change when efforts made for the investigation of the fallow problem end in a clear and responsible answer to the question of whether or not fallow is a necessary practice in the low rainfed areas.

Generally, apart from the land scarcity and precipitation factors, both of which cannot be controlled by man, there are no serious constraints for the cereal grower in Cyprus.

Summary

*Different rotations, cultural practices and use of equipment have been de-*scribed. In regions where the rainfall is 500 mm per year, the highest yielding rotation has been wheat after three years of subterranean clover. Soil analyses have shown noticeable increments of organic matter and nitrogen soil content. The moisture conservation was increased in the 30-60 cm depth zone.

The crop rotations in the 250-350 mm rainfall zones were variable, but the best results have been obtained with barley after vetch.

The numbers of cultural practices carried out in the fallow-barley rotation were compared. Auturm ploughing with a mouldboard, followed by a second ploughing in the spring, has produced the best results. Comparison studies between the minimum tillage and sowing practices are under way.

SYSTEMES D'ASSOLEMENTS AND CONTRAINTES AU CHYPRE

T. Samios

Résumé

Les différentes rotations, pratiques de labourage et l'usage d'equipment ont éte étudiés. Dans les régions ou il y existe 500 mm de précipitation, la rotation au plus haut *rendement a été le blé après tois années de trêfle souterraine.* Les analyses de sol ont montré des augmentations marquées dans la matière organique et l'azote du sol. La conservation de l'humidité augmentait dans la zone de 30-60 cm.

Les rotations dans les zones de 250-350 mm de précipitation étaient variables, mais les meilleurs résultants étaient obtenus de l'orge après la vesce.

Le nombre des pratiques de labourage dans le système jachère-orge étaient comparées. Le labourage avec la charrue au versoir en automne suivit par le labourage à temps en printemps a donné les meilleurs résultats. Des études comparant le labourage minimum et les pratiques de semer sont en cours maintenant.

CROPPING SYSTEMS AND CONSTRAINTS IN JORDAN

Mahmoud Duwayri*

It is estimated that 870,000 hectares can be classified as agricultural land in Jordan. The average area under cultivation is estimated at 530,000 hectares, of which 490,000 are under rainfed conditions and 40,000 hectares are under irrigation, mainly in the Jordan Valley. Data concerning the agricultural land are presented in Table 1.

TABLE 1. Agricultural Area, Private and Government Ownership in the East Bank, 1977* (Area in 000 dunums).

	OWNERSHIP		
GOVERNORATE	*Private*	*Government*	TOTAL
Amman	1,705	681	2,386
Balqa	604	252	856
Irbid	2,752	183	2,935
Karak	1,225	636	1,862
Ma'an	505	169	674
Total	6.791	1.921	8,712

* Source: Agriculture Statistical Yearbook and Agricultural Sample Survey, 1978.

The average area planted to annual crops during the period 1969-1977 is estimated at 267,000 hectares. Wheat and barley occupy 81 percent of this area. The land use pattern in Jordan for the year 1977 is presented in Table 2.

TABLE 2. Land Use by District in the East Bank, Excluding the Ghors, 1978 (Area in 000 dunums)

	Land Under Cultivation					*Cultivable*		
Governorate	Fruit trees	Vegetables	Field crops	Total	Uncultivable	Forest	Un-used	TOTAL
Amman	78	35	689	802	19	146	14	981
Balqa	36	4	47	87	4	22	11	124
Irbid	241	66	866	1,173	76	457	128	1,834
Karak	26	6	352	378	7	115	15	525
Ma'an	6	3	95	102	1	64	-	167
Total	381	111	2,050	2,542	107	814	168	3,631

Source: Agriculture Statistical Yearbook and Agricultural Sample Survey, 1978.

Crop rotation in Jordan

Wheat occupies the largest area planted to a single crop in Jordan. The area and production fluctuate from year to year based on the amount and distrubition of annual rainfall. It is estimated that wheat is planted on 190,000 hectares in the five rainfall zones in Jordan (Table 3).

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TABLE 3. Estimated Area and Production of Wheat in the Different Rainfall Zones in Jordan.

Zone	Rainfall mm	Area 1,000 hectares	Production 1,000 tonnes
Desert	150-250	42	17
Eastern Area	250-300	69	44
Western Plain Area	300-400	61	49
Upland Area	400 and above	18	19
Ghor Area	Irrigated	5	7
Total		195	136

The crop rotation followed in Jordan varies from one zone to another and therefore will be discussed according to the zone.

1. The Desert Zone: A successful wheat crop may be obtained from this zone once per 5-10 years. There is no definite crop rotation in this zone and farmers plant almost every year when early rains fall.

2. The Eastern Zone: Annual rainfall (250-300 mm). A two year crop rotation is being followed.

(I) Wheat - fallow
(II) Wheat - legume (lentils or vetch)
(III) Wheat - summer crop

The wheat - fallow rotation in this region is in practice in about 50 percent of the area in this zone. It is not a planned rotation and depends mainly on early rains. The wheat - summer crop rotation is being practiced on 10 percent of the wheat area of this zone.

3. The Western Plain Area (Annual rainfall - 300-400 mm).

The rainfall pattern is reliable, and therefore well planned crop rotations are being followed. There are three types of crop rotation in this area:

(I) Two year crop rotation which is mainly wheat - legume
(II) Wheat - summer vegetable
(III) Wheat - legume - summer vegetable

The third type is being practiced in some villages near Irbid.

4. The Upland Area (400 mm rain).

A two year crop rotation is dominant in this zone. Wheat is followed either by legumes or a summer vegetable.

5. Ghor Area (Irrigation)

Wheat is included in the crop rotation based on the weather conditions and prices of the various crops.

The Jordan Wheat Project:

This project was started in 1967 by the Government of Jordan and the Oregon State University with the objective of increasing domestic wheat production through the introduction of advanced dryland wheat production techniques. These techniques are basic to dryland wheat production in the low rainfall areas of the Pacific Northwest. They include clean summer fallow, fertilization, dryland grain drilling, and chemical weed control.

Clean fallowing typically includes a sweep cultivation and two or three row weeding operations during the fallow year.

Annual demonstrations were used in areas receiving sufficient rainfall to support an annual cropping pattern. The impact of this project in terms of numbers of adopters of the introduced technologies appear minimal.

Schmisseur, W.E., found that the adopters of the technology in Amman and Kerak Governorates would incur losses in about one in every four years. In the Irbid Governorate, the incidence of loss appears to be one in every two years. He also found that the minimum annual yield response required to recoup annual technology adoption cost was 50 kg/dunum.

Source: Schmisseur, W.E. 1976. *Economic Evaluation of Dryland Wheat* Technologies in Jordan Wheat Research and Production-Final Report. Contract No. AID/Sa. c-1024.

Constraints of the cropping systems in Jordan

Though the cropping rotation in Jordan has been outlined, there is a great deviation from what has been reported and it is difficult as a matter of fact to have a definite pattern. This could be attributed to many factors some of which are:

(1) *Environmental Factors:* These include the dry weather or the fluctuation of the rain distribution and amount from one year to another. In spite of the fact that the total rain could be enough to produce a wheat crop, many farmers will not plant if the rains are delayed. In other words, though in some years the average amount of rain is received, the area cropped may be quite different.

(2) *Agronomic Factors:* In Jordan, there are not enough data to show the amount of soil moisture which could be stored in the soil if a proper summer fallow is practiced. Demonstrations in summer fallow areas have shown increases in wheat yield, but the extent of soil moisture stored was not measured. Also research data to support the advantage of deep and early planting is not complete and therefore there is not much confidence in getting a crop if farmers are to plant early before rainfall in October.

Farmers believe in the advantages of the crop rotation, wheat followed by legumes. However, many of them are raising questions about their wheat after lentils in this sequence. This is becuase they have observed poor wheat growth in this rotation. Proper tillage equipment for soil moisture preservation in a fallow system has also not been identified for Jordan conditions.

(3) *Availability of Inputs: Some of the tillage equipment which has been recommended* is not available in enough quantities. Examples of this are unavailability of chisel plows and grain drills.

In the wheat/legume crop rotation, lentil harvesting is becoming costly mainly because of the cost of hand pulling by laborers. Since combines for lentil harvesting are not available, not many farmers are encouraged to plant this legume.

(4) *Economic Factors:* In spite of the fact that prices for wheat in Jordan are higher than the international market, the acreage of wheat is being reduced. This is due to the higher cost of inputs and perhaps the high cost of living in Jordan.

The lack of policy concerning wheat production and its prices is the main reason, and this is certainly affecting the wheat acreage and thus the cropping systems.

Summary

On average, wheat and barley are grown on 81 percent of the annually cultivated land. The total cultivated area varies considerably from year-to-year due to rainfall variation. In general, there are five well-known zones. In each zone, a different rotation is practiced, according to the available moisture. Many farmers refuse to sow wheat when the rains start late.

For several years, the Jordanian Wheat Project has carried out demonstrations of technologies to cultivate dry lands. The data from these demonstrations have established costs and incomes related to the recommended technologies, and document the constraints to adoption which still exist. The soil humidity storage capacity is still unknown and the rotation with lentils seems to reduce the yields. The necessary equipment for tillage operations and for harvesting is not readily available, and the hand labor for harvesting lentils is expensive. Due to these economical and environmental circumstances, the area cultivated with wheat is decreasing.

SYSTEMES D'ASSOLEMENTS ET CONTRAINTES EN JORDANIE

M. Duwayri

Résumé

Le blé et l'orge occupent environ 81°/o de la superficie annuelle cultivée. La superficie totale varie beaucoup d'une année à l'autre à cause de la précipitation variable. En général, cinq zones sont connues. Chaque zone pratiquera une rotation différente selon l'humidité disponible. Dans les années de précipitation tardive, un grand nombre d'agriculteurs refusent de semer le blé.

Le projet jordanien de blé effectuait des demonstrations sur les techniques de cultures des terres sèches pour plusieurs années. Des resultats établissaient le coût et les revenus, mais un nombre de contraintes restent. La capabilité d'émmagasiner l'humidite du sol est inconnue et la rotation avec les lentilles paraît réduire les rendements. L'équipement de labourage et de récolte n'est pas aisément disponible et la main d'oeuvre pour récolter la lentille devient chère. Dû aux caprices économiques et environmentaux la superficie ensemencée en blé est au déclin.

LES SYSTEMES D'ASSOLEMENTS EN TUNISIE

A. R. Maamouri*

Dans les pays à climat sec et irrégulier les assolements ont été toujours considérés comme l'un des problèmes les plus importants de la production. En Tunisie ce problème a préoccupé depuis très longtemps aussi bien les agriculteurs que les chercheurs et continue encore à nous préoccuper.

C'était l'une des premières questions qui s'était posée aux colons depuis leur installation dans le pays. Les travaux qui ont été effectués à l'époque ont abouti à la mise au point de quelques types d'assolements. Dans ces travaux le blé était considéré comme la production principale et tout visait à l'obtention d'une production maximum.

L'assolement biennal jachère–blé était certainement le plus pratiqué; il était devenu la règle dans toutes les zones où la pluviométrie était inférieure à 500 millimètres (c'est à dire sur les 80% environs de la superficie emblavée en céréales). Pendant l'année de jachère les agriculteurs appliquaient au sol les façons culturales permettant d'y conserver le maximum d'humidité malgré les chaleurs de l'été. Les labours préparatoires étaient effectués d'abord au printemps, puis en hiver et même dès l'été précédent (labours de 18 mois). Ces labours étaient suivis de façons superficielles effectuées avec divers appareils: herse, polydisques, cultivateurs. . . entretennant la superficie du sol parfaitement meuble et propre.

Dans les zones à plus de 500 millimètres, la jachère nue perd son objectif principal qui est d'emmagasiner de l'eau. Elle a été remplacée par des cultures dites améliorantes: fèves, feveroles et pois-chiches en particulier.

Ces assolements laissaient peu de place aux pâturages et à la culture des fourrages. Les agriculteurs ayant un cheptel à entretenir réservaient une partie variable de leur terre (en général près de la ferme et dans les mauvaises terres) pour pratiquer un assolement biennal fourrager (vesce-avoine en première sole suivie d'une culture d'orge ou d'avoine pour le grain).

Enfin dans les terres considérées déjà bonifiées par la pratique de l'assolement biennal un troisième type d'assolement était pratiqué par quelques agriculteurs dans les zones à plus de 400 millimètres de pluviométrie: c'est l'assolement triennal: fèves–blé dur–blé tendre.

En 1960 c'est à dire immédiatement après l'indépendance et à la veille de l'élaboration du premier plan de développement les services de la production végétale du Ministère de l'Agriculture ont pensé que les assolements pratiqués étaient très extensifs et très onéreux du fait que le sol n'était exploité qu'une année sur deux. Ne disposant pas de résultats de travaux d'expérimentation ils ont chargé une société d'étude d'effectuer une étude complète du Nord de la Tunisie et de proposer des types d'assolements adaptés aux divers milieux physiques et aux objectifs de production définis par le plan décennal.

Parallèlement ils avaient chargé l'Institut National de la Recherche Agronomique et l'Office des Céréales d'entamer des travaux d'expérimentation concernant des types d'assolements intensifs.

Divers assolements ont été proposés et appliqués dans les coopératives de production du Nord. Cela s'est traduit par une régression sensible de l'assolement biennal blé-jachère au profit d'assolements triennaux plus intensifs faisant ou non intervenir la jachère en troisième sole.

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* INRAT, Tunisia

Ces assolements ont été adoptés et acceptés par les coopératives de la zone subhumide bien que cela s'était traduit par un envahissement des terres de mauvaises herbes (de graminées en particulier) et par de faibles rendements des blés en deuxième paille (blé après blé).

Dans les zones à plus faible pluviométrie les coopératives ont fait de fortes objections aux assolements proposés.

Quant aux agriculteurs privés ils étaient restés attachés à leurs anciens assolements.

Situation actuelle:

1/ Zones où la pluviométrie est inférieure à 400 mm

L'assolement le plus utilisé est actuellement l'assolement biennal: jachère—blé. Les agriculteurs commencent les façons culturales à la fin de l'hiver—début du printemps.

Cependant dans cette zone, beaucoup d'agriculteurs sont en même temps éleveurs d'ovins et il est assez fréquent de voir des agriculteurs labourer en Mai-Juin après la pâture complète de la jachère.

Un autre biennal: fourrages (vesce-avoine)—blé est assez couramment pratiqué depuis quelques années. Les résultats que nous avons pu observer au cours de nos tournées sont mauvais sur la sole blé surtout que les agriculteurs fauchent leurs fourrages trop tard.

Signalons enfin les deux biennaux: jachère engrais vert—blé et medicago annuel—blé pratiqué par quelques agriculteurs. L'introduction récente des medicagos rend toute conclusion un peu aléatoire à l'heure actuelle. Quant à l'assolement jachère—engrais vert—blé nous avons pu observer des résultats très positifs chez certains agriculteurs pratiquant cet assolement depuis quelques années.

2/ Zones où la pluviométrie est supérieure à 400 mm

Un premier type d'assolement intensif est pratiqué dans les zones de Béjà et de Mateur sur 20.000 hectares environs; il s'agit de l'assolement betteravier; assolement quadriennal en général où la culture entrant dans la rotation varie en fonction des besoins de l'agriculteur.

On rencontre soit: Betteraves—blé dur—céréales secondaires-fourrages.
Betteraves—blé dur—blé tendre, légumineuses

Un autre assolement triennal intensif est pratiqué par les coopératives et par quelques agriculteurs privés. Les cultures entrant dans la rotation différent aussi suivant les agriculteurs. On peut rencontrer:

Blé—céréales secondaires—fourrages
Blé—blé—légumineuses
Blé—orge en vert—fourrages

Cependant le type d'assolement le plus encore pratiqué dans cette zone est l'assolement biennal. Le blé est associé à plusieurs autres cultures: féveroles, poischiches, fourrages, bersim...... et quelques fois jachère lorsque les terres sont très sales. En général d'ailleurs la sole précédent le blé est divisée en plusieurs parcelles sur lesquelles on rencontre les différentes cultures citées.

Ce type d'assolement est le plus pratiqué par les agriculteurs du fait qu'il est plus facile à mener et ne nécessite pas de gros moyens pour une intervention rapide; les mauvaises herbes sont en particulier plus facilement controlées dans cet assolement biennal.

Peut-on parler d'avantages de tel type d'assolement par rapport à un autre?

Malheureusement il m'est difficile de répondre à cette question. Cet aspect est actuellement un peu négligé; on dispose de peu de résultats d'expérimentation et à ma connaisance on ne dispose pas d'analyses économiques comparant tel type d'assolement par rapport à un autre. Or ce dernier aspect du problème est très important.

Résumé

Le document décrit les anciens systèmes d'assolement en Tunisie et ceux favorisés au présent. Dans toutes les zones les céréales jouent un rôle majeur, et dans les zones de 400 mm de précipitation ou moins, un système de blé-jachère est communement pratiqué. Le manque d'une culture fourragère dans un tel système a conduit à l'utilisation d'une culture avoine-vesce (fourrage) alternée avec le blé. Cela a abaissé les rendements de blé; la rotation introduite de medic-blé se révéle très promettrice. *Dans des zones recevant plus de 500 mm de précipitation ou plus, un nombre de* rotations son faisables. La rotation la plus commune pratiquée est le blé suivi par une autre culture, souvent une légumineuse d'alimentation, et après encore une fois le blé.

CROPPING SYSTEMS AND CONSTRAINTS IN TUNISIA

Summary

A. R. Maamouri

The paper describes the early cropping systems practices in Tunisia and those currently in favor. In all of the zones the cereals have a major role, and in areas of 400 mm of rainfall or less, a wheat-fallow system is commonly practiced. The lack of a fodder crop in such a system has led to the use of an oats-vetch (fodder) crop rotated with wheat. This has depressed wheat yields. The introduced rotation of medic-wheat looks very promising. In zones receiving 500 mm of rainfall or more a number of rotations are feasible. The most common rotation practiced is wheat followed by another crop, often food legumes, and then wheat again.

CROPPING SYSTEMS AND CONSTRAINTS IN LEBANON

A. Alameddine*

In a very densely populated country like Lebanon, multiple cropping has gained a prominent place among the cropping systems used.

Multiple cropping consists of the growing in sequence of more than one crop per year on the same piece of land. It is a system of agriculture that allows for more efficient use of agricultural land.

The potential of this system is not yet well explored in the world, particularly in the Middle East. It is gaining more importance in Lebanon both in Akkour Plain to the north and in the Bekaa valley.

Seven double cropping practices were studied on a winter fallow plot in northern Lebanon. The differences in yields were significant among all cropping practices:

1. Corn for silage after corn for grain (5620 kg/du)
2. Corn for silage after soybeans (3300 kg/du)
3. Corn for silage after sunflower (3170 kg/du)
4. Corn for silage after safflower (2400 kg/du)
5. Corn for silage after onions (1850 kg/du)
6. Corn grain after field beans (736.365 kg/du)
7. Corn grain after potatoes (587.87 kg/du)

The data suggest that in the Lebanese Akfar plain, corn for silage be planted after corn for grain, whereas corn for grain be planted after field beans.

The Bekaa Valley

Eighteen single, 56 double and triple cropping practices were agronomically and economically evaluated under the Bekaa conditions (average annual rainfall of 450 mm). Several double and triple cropping practices were superior in net returns and production to most of the single crops. The most economical single crops were sugar beet, onion and sudax (sorghum x sudan grass) with a net profit of 6908, 3583 and 2683 LL/ha respectively.

Among the double and triple cropping practices:
Wheat/cucumber (7492 LL/ha), onion/corn silage (4530 LL/ha)
Potatoes/corn silage (4298 LL/ha), lentils/potatoes (4091 LL/ha)
Field beans/corn silage (3520 LL/ha), barley grain/field beans (3414 LL/ha),
Barley + vetch silage/field beans/corn silage (3216 LL/ha),
Corn silage/corn silage (3133 LL/ha), lentils/corn grain (3080 LL/ha),
Lentils/field beans (2928 LL/ha),
Barley + vetch silage/corn silage/turnip (2923 LL/ha),
Barley + vetch silage/corn silage/corn silage (2711 LL/ha),
Barley + vetch silage/sunflower (2699 LL/ha),
Safflower/corn silage (2589 LL/ha) and
Barley grain/corn grain (2528 LL/ha)

It is worth mentioning that crops after legumes yielded more than those after cereals when occupying the same period of growth.

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Conclusion:

With the exception of sugar beet as a single crop, several double and triple cropping practices exhibited superiority over the singles in both production and net returns. Such practices include forage crops, cereal grains, grain legumes, oil crops, and other food crops such as onions, potatoes, cucumber and turnip.

It can be concluded that certain double and triple cropping practices can be successfully grown under the Bekaa conditions of Lebanon and similar semi-arid and temperate climates of the world, provided water is not a limiting factor. Also, the wide variety of field crops present in the successful cropping practices allows the farmer a large selection of crops that meet his needs. Moreover, such an intensive cropping system will result in better farm income, more efficient utilization of land, water and light resources as well as more world food output.

Summary

The multiple rotation pattern is increasing in the plain of Akkar, on the north coast, and in the Bekaa valley. In a trial of seven double rotation systems in the plain of Akkar, silage corn after corn for grain after field beans, was significantly better than other combinations.

In the Bekaa valley, the best simple crops were: sugar beets, onions, and sudax (forage). Wherever the double or triple rotation was possible, a number of profitable rotations have been established.

SYSTEMES D'ASSOLEMENTS ET CONTRAINTES AU LIBAN

A. Alameddine

Résumé

L'assolement multiple est en accroissement dans la plaine d'Akkar su la côte du nord et dans la vallée du Bekaa. Dans un essai avec sept systèmes de double assolement dans la plaine d'Akkar, le maïs de silo après le maïs de grain et le maïs de grain suivant la fève étaient significativement mieux que d'autres combinaisons.

Dans la vallée du Bekaa les meilleures simples cultures étaient le betterave sucrière, les oignons, et le sudax (fourrage). Là où le double ou le triple assolement étaient possibles, un nombre de rotations étaient établies qui sont profitables.

CROPPING SYSTEMS AND CONSTRAINTS IN PAKISTAN

M. Tahir*
H.M. Hepworth**

Basically there are two main approaches available for increasing agricultural production: (a) extending the area under cultivation and (b) increasing the yield per unit of land. In most countries, especially in Pakistan, the first possibility is already exhausted to a large extent as very little additional land is now available for bringing under the plough. In the years to come we will have to depend mainly on increased crop yields from the land already under cultivation for meeting the growing food need of a rising population. Improved agronomic management practices including the use of modern scientific inputs like chemical fertilizers, control of diseases, pests and weeds, efficient management of soil and water, and selective mechanization of agricultural operations constitute a major component of the strategy for increasing the per hectare agricultural production. However, the traditional crop varieties which have been in cultivation for centuries have not been selected for response to these improved cultivation techniques, and do not fit into the new cropping pattern (rotations) essential to enhance per unit area agricultural production.

Agricultural production has increased substantially during the second half of the sixties but does not match the resources committed to agriculture. Per capita incomes of rural communities remain far below than that of urban inhabitants and in fact are decreasing. The urban-rural disparity in income has increased over time.

Agricultural output is the result of the decisions of millions of cultivators regarding the nature of production, the type and level of various inputs, selection and combination of various enterprises. Some farmers through trial and error have been able to combine their farm resources judiciously. They have selected a suitable combination of farm enterprises and are able as a consequence to obtain high dividends. Unfortunately the majority of farmers has not been able to attain the same level of returns.

The prevailing traditions in the art of agriculture and artificial support do make it possible to raise crops other than those which are best adapted to a given locality. But this happens only at the cost of economic efficiency to eliminate waste and attain the goal of optimum output per unit of resources. Choice of crop must be in accordance with the law of comparative advantage.

Factors/Variables Determining Cropping Pattern

The cropping pattern is the result of a complex of numerous acting and interacting factors. These factors can be listed under two major groups:

1. *Natural factors*
   Climate and rainfall, natural topography and land forms, soil texture, and location of the farm.
2. *Other factors*
   a) *Physical factors*
   Development of water resources, water table depth and changes thereof, soil salinity and alkalinity, irrigation and drainage practices, motive power, land tenure and farm size.
   b) *Economic factors*
   Industrial development, financial resources of the cultivators, credit facilities, input availability, market prices, trade policies.
   c) *Social factors*
   Population density and growth, the availability of labour, and advancement of agriculture.

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Land Utilization

Before going further it will be worthwhile to give the land utilization statistics of Pakistan (Table 1).

TABLE 1. Land Utilization Statistics of Pakistan.

Years	Geographical area	Total area reported	Forest area	Not available for cultivation	Culturable waste	Cultivated area	Current fallow area	Net area sown	Area sown more than once	Total cropping area
1976-77	196.72	133.44	7.03	51.12	26.27	49.02	11.75	37.23	7.18	44.45
1975-76	196.72	133.25	7.17	51.67	26.27	48.14	11.58	36.56	7.55	44.11
1974-75	196.72	133.24	6.92	50.21	27.29	48.32	11.81	36.51	6.43	42.94
1973-74	196.72	133.21	7.05	50.72	27.55	47.89	10.34	37.55	7.64	45.19
1972-73	196.72	132.81	6.91	51.21	27.40	47.25	12.47	34.78	7.08	41.86

Source: Agriculture Statistics of Pakistan, 1977, Ministry of Food & Agriculture (Planning Unit), Islamabad.

Land Use Intensity and Cropping Patterns in the North West Frontier Province (NWFP) and the Punjab

The NWFP due to its typical soil conditions and limited water supply has a low land use intensity. It increased from 52 percent in 1947-50 to only 61 percent in 1975-76. The cropping intensity approached a figure of 100 percent which is higher than that achieved in the provinces of Sind and Baluchistan. Season-wise the analysis reveals a contraction in the cropped area as a percentage of cultivated area in the rabi season from 67 percent in 1947-48 to 62 percent in 1975-76. On the other hand, in the kharif season, the corresponding figure for cropped area showed only a small increase during 1947-76 from 31 percent to 36 percent.

Changes that took place in the allocation of land among different crops during 1947-76 have been mainly in favor of cash crops, viz. sugarcane and tobacco. Sugarcane and tobacco's average annual acreage registered big increases of 97 percent and 64 percent respectively during this period.

In the Punjab, cropping intensity was about 89 percent in 1947-48 and rose to 103 percent in 1964-65. Later on however, the intensity did not show any clear-cut increase remaining around 100, and touched a peak of 110 percent during 1973-74. This clearly reveals that the provision of enhanced water supplies through canals and tubewells was mostly used for bringing culturable waste under cultivation rather than using it on the existing cropped area. Thus cropping intensity increased only by about 14 percent during the last 27 years.

EXISTING CROPPING PATTERNS

Ecological Zones	Areas	Cropping Pattern
A. N.W.F.P.		
1. *Northern Hilly Regions*	*Chitral, Dir, Swat, Northern and Southern part and central part of Hazara Division*	*Kharif:* Maize, Millet, pulses, potatoes & vegetables, fodder, paddy and sugarcane. *Rabi:* Wheat and barley.

2. Peshawar valley	Mardan and Peshawar excluding Neelab valley of Nizam	*Kharif:* Maize, millet, paddy, pulses, sugarcane.
		Rabi: Wheat, barley, gram, pulses, oilseed, sugar cane.
3. Kohat hilly tract	Major part of Kohat Dist. except Kark Tehsil	*Kharif:* Maize, millet, oilseed, and pulses.
		Rabi: Wheat, barley, gram, oilseed and pulses.
4. Bannu Basin	Bannu and major part of Kohat Tehsil	*Kharif:* Paddy, maize, millet, pulses, sugarcane.
		Rabi: Wheat, barley, gram, tobacco, oilseed.
5. Sulaiman Piedmount	Indus river, east Sulaiman ranges, D.I. Khan	*Kharif:* Maize, millet, pulses, oilseed.
		Rabi: Wheat, gram, oilseed, tobacco.
6. Potwar Upland	Tehsil Haripur	*Kharif:* Maize, millet, groundnut, lentil.
		Rabi: Wheat mixed with gram and pulses.
7. Southern Hilly Regions	North-South Waziristan Agency	*Kharif:* Maize, sugarcane, rice and pulses.
		Rabi: Wheat and barley.
B. PUNJAB		
1. Southern Zone	Multan, Vehari, Bahawalpur, Rahimyar Khan, and parts of Muzaffargarh, D.G. Khan and Bahawalnager	*Kharif:* Cotton, fodders and fruits.
		Rabi: Gram, wheat and fodders.
2. Central Zone	a) Faisalabad, Sahiwal, parts of Sargodha, Jhang, Sheikhupura, Jehlum & Bahawalnagar	*Kharif:* Cotton, maize, sugarcane.
		Rabi: Wheat, fodders and fruits (citrus and mango).
	b) Gujranwala, Lahore, parts of Sheikhupura, Kasur	*Kharif:* Rice, maize, sugarcane.
		Rabi: Wheat.
3. Thal Zone	Khushab, Leiah, Kot Addu	*Kharif:* Ground nut.
		Rabi: Gram.

4. Submountain Plains	Parts of D.G. Khan	*Kharif:* Sorghum, millet and little acreage of cotton. *Rabi:*
5. North Eastern Zone	Sialkot, Gujrat and part of Jhelum	*Kharif:* Rice, groundnut, millet, fruits like guava, citrus. *Rabi:* Wheat, berseem.
6. Pothwar Plateau	a) Rawalpindi and parts of Attock	*Kharif:* Groundnut, millet, maize, rape and mustard. *Rabi:* Wheat, lentil.
	b) Parts of Attock, Jhelum and Mianwali	*Kharif:* *Rabi:*
7. Northern Zone	Murree	Fruits, vegetables and maize.
8. Cholistan desert	Desert area of Bahawalpur and Rahimyar Khan	On bushes grown in this area.

Changes in the Cropping Pattern

During the last 28 years in the Punjab, only minor changes have come about in the cropping schemes despite considerable up-surge in the supply of inputs considered to be instrumental in changing the cropping pattern of an area. Important changes have however been taking place within different ecological zones due to agro-climatic and economic factors.

Some of the crucial factors are discussed here:

1. *High Yielding Varieties and Ensured Water Supplies*

Introduction of tubewells which ensured flexible water supplies produced a radically different cropping pattern. These results are even evident in the areas where year round canal supplies were available. Gotsch and Falcon (1975) observed that the improved varieties in wheat and rice have a significantly lower unit cost than the local wheat and rice. The water constraint dominated the allocation of land among crops so that the cropping pattern remained virtually unchanged. However, the combination of tubewells and high yielding varieties resulted in a cropping pattern contrasting the combination of traditional wheat varieties and tubewell irrigation.

2. *Tractors*

The tractor farmers (Bashir 1972) irrespective of ownership of a tubewell, grow more acreage under high value crop such as wheat and cotton as compared to bullock farmers. The tractor farmers are able to overcome the seasonal peak power constraint of those high value crops. Bullock farmers grow relatively more maize and gram.

3. *Credit*

Attempts to explore the relationship between the size of farm, technological changes and ability to accumulate is affected by the government policies regarding agricultural credit, interest rate and product prices. Studies carried out by Nasim (1971) indicated misallocation of resources when domestic prices diverged from world market prices. There is evidence that fair and equitable prices for the commodities can result in food autarky.

The cropping pattern approach is essentially a farm planning and budgeting technique. It focuses attention on the entire farm business and helps in developing such enterprise combinations which ensure optimal utilization of available resources resulting in sufficient net profit for the farm family. As such, the primary consideration of a scientific cropping pattern is sustained with maximum production from the land as the goal. It has to fit into the economic outlook of the country in terms of raw material for food and fibre. Therefore, a *desirable cropping pattern would have, among others, the following qualifications:*

i) It should fit in the textural features of the soil and maintain the fertility.
ii) Ensure protection of land from salinization and erosion.
iii) Ensure most efficient utilization of scarce resources such as water.
iv) It should be feasible with the farmers' resources.
v) The farmer should get the highest possible net income.
vi) National requirements of food and fibre should be provided for.

Crop Rotations

Some of the crop rotations which are followed by the farmers in different regions are described below:

Rainfall

One year

1. Summer fallow - Wheat, oilseeds or chickpea.
2. Groundnut, maize, sorghum, millet, soybean - winter fallow.
3. Wheat - fallow - wheat - fallow.

Two years

1. Groundnut, maize, sorghum, millet or soybean - winter fallow - summer fallow wheat, oilseeds or chickpeas.
2. Groundnut, maize, sorghum - winter fallow - groundnut, maize, sorghum, etc. - winter fallow.

In the rainfed areas the major source of water is precipitation during summer from the monsoon rains. So far the major crop of rainfed areas has been wheat which is planted on the conserved moisture. Summer crops such as maize are also grown successfully. The cropping intensity can be increased in the rainfed areas by developing earlier maturing varieties of maize or soybean which can then be followed by wheat or winter oilseeds like rape and mustard. However, to increase cropping intensity there are certain pre-requisites such as proper moisture conservation, suitable crop variety, availability of agricultural machinery and fertilizers.

Irrigated areas

One year rotation

- Summer fallow - wheat
- Summer fodder - wheat
- Green manuring - wheat
- Summer vegetables - wheat
- Cotton - winter fallow
- Rice - winter fallow
- Maize, sorghum or miller - winter fallow
- Maize, cotton or rice - wheat
- Maize, cotton or rice - winter fodder.

Farmers will double crop land to grow a fodder crop in the rabi season if (a) there is enough water retained from the kharif season or (b) they will grow a shallow rooted rabi crop of fodder following a deep rooted crop in the kharif season. This way they feel they are regaining the fertility of the soil.

In the recent years with the availability of appropriate varieties of rice, wheat and maize and additional supplies or irrigation water and fertilizer, a rotation of maize, cotton or rice followed by wheat has become quite popular.

Two year rotations

- Wheat - wheat
- Wheat - cotton

- Wheat - summer fodder - wheat
- Wheat - mung/mash - wheat
- Wheat - cotton - fodder
- Wheat - coarse grain
- Wheat - sugarcane.

The last rotation, i.e. wheat - sugarcane, has become quite popular with the farmers in certain areas of the Sind and NWFP. In this case, the farmers while planting wheat in October also plant sugarcane in the same field. Sugarcane sets buried in the soil remain dormant during winter and sprout in the month of February. After the harvesting of wheat, interculture is done. This practice has certain advantages, such as the small farmers have more crops per unit of land, and frost damage to the sugarcane field kept for seed, is avoided.

Three year rotations

- Wheat - cotton - sugarcane
- Sugarcane - fallow - wheat
- Wheat/summer fodder - winter fodder - cotton
- Wheat - oilseed - cotton
- Wheat - maize - sugarcane
- Wheat - oilseed - sugarcane

It has been observed that the acreage seeded to wheat varies directly with the amount of available fertilizer. The supply of available irrigation water has a greater effect on wheat acreage than on any other food crop. This means that farmers try to utilize increased water and fertilizer for increasing wheat acreage.

On land which is fallow for one year (current fallow), the relationship with wheat is mixed. When there is more land in current fallow, the wheat acreage decreases. But when there is less land in current fallow, the acreage may go to wheat or it may go to sugarcane or cotton.

High yielding varieties of cotton, rice and maize which respond to fertilizer have helped to make a rotation system with wheat more popular. Besides the increase in cropping intensity the farmers receive economic benefit, as the following wheat crop utilizes residual phosphatic fertilizer applied to the previous crop. Wheat is in the most advantageous position since the other competing crops such as chickpea, oilseeds, barley and oats do not provide an economic incentive for the farmers to substitute these crops for wheat. Therefore, the increase in wheat acreage with the adoption of this rotation by more farmers is inevitable.

In summary, Pakistan has a vast potential for increasing production by increasing per acre yields and cropping intensity. To achieve these increases mechanization appears necessary, as well as developing shorter season crop varieties and the use of improved production technology.

Acknowledgement

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Summary

This paper provides statistics on land use, and summarizes the factors affecting crop rotation models in Pakistan. The change in land use and the different available crop rotation models in the Northwest Province and in the Punjab are briefly described. Critical factors affecting the crop rotation models, and the rotations themselves, are also described.

SYSTEMES D'ASSOLEMENT ET CONTRAINTES AU PAKISTAN

M. Tahir and H. Hepworth

Résumé

Ce document pourvoit des statistiques sur l'utilisation de la terre et résume les facteurs affectant les modèles d'assolement au Pakistan. Le changement dans l'utilisation du sol et les différents modèles d'assolement disponibles dans la province du nord ouest et le Punjab, sont décrits en détail. Les facteurs critiques affectant les modèles d'assolement et les rotations sont aussi discutés.

V. FERTILIZER EFFECTIVENESS

D. W. Bray
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FERTILIZER EFFECTIVENESS
UNDER LOW RAINFALL CONDITIONS

D.W. Bray*

Crop production involves a complex of limiting factors. Any student of agronomy knows that the best cultivar for an environment is the one which is able to compensate for the stresses placed by these limiting factors, achieving a high yield in spite of the difficulties. Agronomy students also know that another way of increasing crop yield is to alleviate the recognizable limiting factors, thus allowing the "best" cultivar to give even higher yields, until unrecognized factors limit further increases. From the farmer's view, economics must not be omitted from the list of limiting factors. For example, if all the limiting factors were alleviated, yield could be increased with more and more alleviation, until the costs of these and other inputs became so great that they could not be covered by the increased yields.

Farmers producing rain-fed cereals are known to be faced with many of these limiting factors. Much work has been done to study these factors, with more effort recently devoted to looking at the system of factors as they interact with each other and the environment, to limit crop yields.

In the region of interest to us the obvious limitations to the production of cereal crops are water, nitrogen, phosphorus, and other nutrients, as well as a host of other physical, social, and economic realities of life. It is unlikely that much can be done to alleviate rainfall deficiencies, although cloud seeding experiments done elsewhere would bear watching. Though we may not be able to do more than talk about moisture deficits, there are many things to be done to use effectively that which is received, by understanding the interactions of this deficiency with deficiencies (as well as excesses) of the other factors mentioned.

In addition to the physiological interactions of these factors, there are many physical interactions with which agronomists and agricultural mechanization people grapple.

Let us remember that the cultivar with the best possible potential for yield must achieve this potential in the real world. And this agricultural world has, most commonly, deficiencies of available nitrogen (N) and phosphorus (P). Other elements are often deficient, but in this region, where rainfall is often *the* determining factor, factors other than N and P are usually not of much concern.

Crops are fertilized to supply the nutrients that are limiting the attaining of maximum potential yield because they are not present in the soil in sufficient quantities. An adequate fertilizer program should supply on a sustained basis, the amounts of nutrients that will provide maximum net return. Crop and soil characteristics, expected yield, and the cost of inputs versus sale price of the crop are factors that must be considered in determining the kind, the rate, and the place of application of the fertilizer (14).

The rain-fed areas of the region have been farmed more or less exhaustively for hundreds (some for thousands) of years. Each crop has removed its share of N and P, and of course of all the other nutrients. Very small amounts of these nutrients have been returned to the soil by the farmers. Indeed, not only the nutrients, but most of the organic matter (OM) essential to a productive stable soil system have been depleted with at present, little attempt at replenishment. A serious result of this (other factors contribute also) is erosion of the soil itself, down to exposed rock in many areas. This is also evidenced by the excessive amount of small to large stones in many otherwise arable fields.

* ICARDA, Amman, Jordan

FERTILIZER EFFECTIVENESS

UNDER LOW RAINFALL CONDITIONS

D.W. Bray*

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In arid regions, the weathering of soils and subsequent leaching of the soluble minerals are minimal. The annual precipitation is not enough to accomplish any appreciable amount of weathering and leaching. In these regions, OM in the soil is dependent on plant cover, but as this is normally sparse, the existing OM is limited, and that deposited each year may simply disappear through rapid oxidation caused by the high temperatures. The decomposition of the OM present, however, may be delayed because of the dryness of the soil; thus the release of its N may be delayed. Under extreme dry conditions, the availability of P may be reduced even more than is that of N. This allows time for the P to become fixed in the clay fraction of the soil, and thus remain unavailable to crop plants for a very long time. Boron may also become deficient under such conditions (14). There, N and P are usually the important factors limiting yield in arid areas. Usually P is deficient, and that which is applied is fixed rapidly as mentioned. Adequate amounts of potassium are found normally, although this may not continue to be the case. As higher yielding cultivars come into general use and the addition of N and P stimulate increased growth, the potassium (and other nutrients) now thought to be in adequate, if not abundant, supply, may become limiting.

Nitrogen reactions in the soil

Nitrogen, as fertilizer, is commonly added to the soil in the nitrate (NO_3^-), ammonio (NH_3), or ammonium (NH_4^+) forms. Since NO_3^- ions are negatively charged, they do not adhere to the soil surfaces which are also negatively charged. Instead, they are subject to diffusion and transport in the soil solution. Transport is mostly leaching to lower levels in the soil profile, there being little lateral movement of water and its solutes (1). Diffusion is important in NO_3^- movement to replenish the "sink" effect established in the rhizosphere by the root hairs, although such movement probably does not exceed one half centimeter (14).

When NH_3 is added to soil most of it will change to NH_4^+ through reaction with soil water. Some becomes NH_4^+ by reaction with hydrogen ions adsorbed on clay surfaces and some is held, by hydrogen bonding, to the clay surfaces. The ammonium in the soil solution is subject to some loss through leaching. Some of the NH_4^+ formed is held in the tissues of the soil microflora. Ammonium ions, similar in size to potassium ions may get into the clay lattices and remain locked between their sheets. Thus fixed, this NH_4^+ will not be available to the crop plants.

There are two important biological or enzymatic N reactions in the soil: nitrification and denitrification. In nitrification, ammonium becomes nitrite which in turn becomes nitrate. The organisms responsible are the autotrophic bacteria *Nitrosomonas* and *Nitrobacter*. Denitrification is accomplished by many forms of bacteria, mainly facultative anaerobes. Nitrate is used as a terminal hydrogen acceptor, when oxygen in the soil is at a low concentration, as might occur when the soil is water logged, or where there is rapid decomposition of soil organic matter. Denitrification results in the release of gaseous nitrogen, or oxides of nitrogen. Thus what was available nitrogen, is lost to the atmosphere. Denitrification occurs most rapidly in soils which are acidic, water logged, and/or high in OM. One might infer from this that denitrification would not cause serious losses of N in the calcareous, arid, low OM soils of the region (1).

Phosphorus reactions in the soil:

Fertilizer phosphorus is readily available to plants immediately after incorporation into the soil. However, with time, the P becomes less and less recoverable (1). This is usually referred to as "fixation," and is mainly the result of the formation of insoluble compounds with calcium, under alkaline soil conditions. In soils where fixation occurs, only a small portion, perhaps 15 percent, or less, is recovered in the crop to which the P was applied. This does become available in subsequent years, as has been reported by many authors.

In our experiences in Lebanon 200 kg per hectare of P_2O_5 had been applied to irrigated crops for several years. When the cost rose dramatically in 1974, and then when the fertilizer became difficult to obtain during the civil war, applications were stopped. There was no appreciable decrease in yield over the subsequent three years.

Fertilizer forms available, or used, in the Middle East

Nitrogen:

Ammoniacal N fertilizers have an advantage in arid regions in that the NH_4^+ ion is less liable to be leached, being held in the colloidal fraction of the soil. The most commonly used such fertilizer in the region is ammonium sulphate (20.5 percent N, 23.5 percent S). The acidifying effect of the sulphate is of little concern in the calcareous soil, and the sulphur may have some benefit as a nutrient itself (1, 3).

There is some risk. When NH_4^+ salts are applied to the surface of calcareous soils, the unstable ammonium carbonate which forms, decomposes readily to release free NH_3. Thus, to be effective, N applications into calcareous soils must be made so that the crop roots have access to the available N, that is, at, or near to, planting time (11). If split applications are made, care must be taken where high rates of N are applied. The seeding time increment may result in a high concentration of soluble salts in the soil solution in which the seed is placed. In this condition aluminum and iron from the clay fraction go into solution, with toxic effects on some seedlings (14). Care must also be taken with the spring increment to ensure that the NH_4^+ form is not applied to a wet soil surface. Such application often results in a very serious loss of N, as the NH_4^+ becomes a carbonate which readily breaks to gaseous NH_3. Losses up to 50 percent of the N applied have been reported (4). This loss is exacerbated by high temperatures and soil drying.

TABLE 1. *Barley vetch silage.* **Nitrogen fertilizer trial. Yields expressed as tons silage per hectare. Rainfed conditions.**

Amounts of N per hectare, and dates applied	Yield
100 kg N all applied in March	10.0
100 kg N all applied in November	10.7
150 kg N all applied in November	11.1
50 kg N in November + 50 in March	11.9
150 kg N all applied in March	12.2
75 kg N in November + 75 in March	13.6
50 kg N in November + 100 in March	14.1
100 kg N in November + 50 in March	15.5

Urea (46 percent N) is advantageous because of its high N content. In the soil it is rapidly transformed to NH_3 and thus behaves as the NH_4^+ sources of N (1).

Liquid forms, anhydrous ammonia (82 percent N) and aqua ammonia (20 or more percent N), have become popular in other regions of the world, chiefly because their cost per unit of N to the farmer is about half that for the N in ammonium nitrate. They require sophistication in equipment and use (1).

Phosphorus:

The superphosphates are the most used forms of fertilizer P. Triple superphosphate (44 to 52 percent P_2O_5) has the highest content of P. It is granular, is easy to handle, and the fixation of the P is somewhat retarded (1).

Fertilizer Application:

When fertilizers are applied to the soil their nutrient availability to the crop depends on the presence of water in the region of the soil where the fertilizers are placed, on the solubility of the nutrients in the soil solution, and on the ability of the root system to absorb the dissolved nutrients (1).

Fertilizer Placement:

It is important that the fertilizer be placed so as to be accessible to the root system, yet not so near to the seeds that deleterious salt effects hinder germination. If soil moisture is deficient, as little as 10 kg N/ha can reduce wheat germination. Banding of P near the seed row in acid soils commonly gives best recovery of the applied fertilizer. In calcareous soils this may not be so helpful in recovery of the P (10). When ammonium sulphate is applied in a band, mixed with a soluble P fertilizer, there is a great proliferation of roots in the band and a greatly increased uptake of P by the plant (14).

In arid regions it would be preferable to place the fertilizer in the soil zone where water will be retained for the greatest part of the growing season. Deeper placement gives greater uptake of N under dry conditions, but has no benefit when there is no water deficiency (14). Uptake of P, in contrast, may show no response to depth of placement since it is so quickly fixed (1). Nutrient levels in the field are normally greatest near the soil surface, but this is the first part of the soil to become dry under moisture deficit, leaving the nutrient content there unavailable to the crop. Any roots that penetrate deeply may find available nutrients, except that the nutrient level there tends to be low (2).

The volume of soil that is in intimate contact with crop roots varies over a range of 0.1 percent to 5.0 percent of the whole. Thus placement is especially important for P because it is fixed so rapidly and therefore is low in mobility compared to N. If both N and P are placed together in a narrow band, near but not in contact with the seeds or seedlings, certain advantages can be noted. Damage to the developing seedlings from high concentrations of dissolved nutrients is avoided. The soluble N and P dissolve more slowly since the concentration in the soil solution reaches an equilibrium at the periphery of the band, hence less loss from leaching or fixation occurs. In addition, there is a great proliferation of roots in and around this band enhancing uptake of the nutrients, but with little apparent damage from the high concentration of the nutrients. Experimentation has shown that this band should be about 5-7 cm to one side, and 5 cm below the level where the seeds are deposited in the drill furrow. Equipment that will band the fertilizers and deposit the seed at appropriate levels simultaneously, has been developed. It requires considerable capital to purchase and sophistication to operate (1).

Where sophisticated banding equipment is not available, the broadcasting of fertilizers over the surface, then plowing to incorporate the fertilizer with the soil is often practiced with good results. This is especially important when high rates of fertilizer are being applied, in order to avoid seedling damage. For summer crops, living on the winter's accumulation of rain, deeper incorporation may be extremely important in order to keep the nutrients down in the moisture levels of the soil, and thus available (1, and see Fig. 1). As stated earlier, application of NH_4^+ fertilizers to a wet soil surface should not in any case be done (4).

Fertilizer Effectivity

One problem of rain-fed agriculture is the adjusting of crop growth and development to utilize but not waste the available water. That is, to reach maximum yield just as the water reserves in the soil are exhausted. Under semi-arid conditions, crops are subject to periods of moisture stress between rains, or to increasing moisture stress as the accumulated winter precipitation is depleted. In Washington State in the U.S.A. (380mm of rain) a winter wheat crop left no available water in the top six 25-cm layer of soil. Some water was left in the next three 25-cm layers. It was estimated that 100mm of water was required to produce the plant, and then the yield of grain was 175 kg/ha/cm of rain received, when no fertilizer had been applied. When 90 kg N/ha had been applied, grain yield was 200 kg/ha/cm of rain received (15).

Under conditions of limited water supply the vigorous vegetative growth resulting from early heavy applications of N may lead to depletion of soil moisture too early, with reduction in grain yield, as compared to lower levels of N. Similar effects of P applications were reported (2).

Absorption of N by plants is slow during seedling establishment, but it accelerates to a maximum at full growth, remains steady for several days during which around 4 percent of the final total N content of the plant is absorbed per day. For example, a good maize crop accumulating 175 kg N/ha over the season will at its peak period, absorb about 7 kg N/ha/day (5).

The timing of fertilizer application is a crucial aspect of N management. Applying N at seeding time often stimulates excessive fall and early spring vegetative growth. This leads to excessive moisture depletion in years of insufficient late winter and early spring rains. Delayed, spring applications should therefore lead to more efficient use of water in achieveing potential grain yield (10). Thus the recommendations concerning split applications of N fertilizer are based on sound theory. Yet the ultimate of this principle - repeated small increments at frequent intervals - increases the total cost of the fertilizer. It is doubtful whether more than two such applications to one crop can be justified. Since P is fixed so rapidly in the soil, it is not likely that repeated applications could be beneficial (1).

TABLE 2. Effect of N and P on the yield and return of two wheat cultivars grown near Amman, Jordan. 1976-77. Yields in kg grain per hectare, returns in Jordan Dinars.

	Yield and return ascribed to fertilizer			
Treatments	Yield		Net return	
	F8	Stork "S"	F8	Stork "S"
1. control	1370	1790	—	—
2. P(200 kg/ha)1/	1370	1900*	-0.560	+0.392
3. N(300 kg/ha2/	1850	2440*	+4.055	+4.004
4. N P3/	2020	2680*	+2.050	+5.467

* Significant at 5 percent level of significance.
1. expressed as kg P_2O_5 per hectare.
2. expressed as N per hectare.
3. N and P together at same rates as treatments 2 and 3.

From: Mahmoud Duwayri, Akram Steitieh, and Talal Thalji, 1978. A study of the economics of applying fertilizers to different wheat varieties grown under dryland conditions in Jordan, 1978. Accepted for publication in Dirasat.

TABLE 3. Effect of N fertilization on grain yield and protein percent. Means of 10 varieties 1/ and 2 sites 2/ near Amman, Jordan.

N rate kg/ha	Grain yield kg/ha	Protein %
0	2240c 3/	9.96 c
20	2480bc	10.32 b
40	2660ab	10.74 a
60	2860a	10.92 a

1. The durum varieties were: F8, Deiralla 2, Cocorit 71, Stork S, D. Dwarf, and Jori 69. The breadwheats were Barouk, Mexipak, University Queen, and Arz.
2. The sites were Jubeiha and Hisban.
3. Means, within a column, having the same letter do not differ significantly at the 5 percent level (DMRT).

From: Mahmud Duwayri. Effect of nitrogen fertilization on yield and quality of grain of different wheat varieties, 1976. Accepted for publication in Dirasat.

Spring application (prior to tillering) of N to winter wheat in Kansas in the U.S.A., resulted in maximum increases in grain production and minimum effects on the protein content of the grain. Later applications of N had lesser effects of yield, but more on the protein content of the grain produced. Application of N at heading time had all of its effect on grain protein content (13).

In summary of this section it is clear that cereal production is a matter of balancing several limiting factors in such a way that maximum possible yield is obtained.

Excess alleviation of any one, or of several, of the limiting factors will not substitute for those not so alleviated, indeed, more damage than good may be the result. Judicious choice of fertilizer formulation and rate, timely application, and careful placement in the soil can maximize water use efficiency and concomitantly maximize economically, crop yields.

TABLE 4. Summary of fertilizer experiments on wheat, 1951-76, in Jordan. Data expressed as Response: positive (+), no response (0), negative (-), to nitrogen fertilizer, at various locations in the rain-fed wheat production area.

Year	Amman	Rabba	Irbid	Description, rate/ha, etc.
1951-52	0		0	0,25
1952-53	0			0,25,50
1953-54	0			0, 25
1954-55	0			0, 40
1957-58		0	+	0, 50
1959-60	0		0	methods of applic.
1968-69	+	0		0, 40, 80
1969-70	+	-	-	0, 40
1973-74		+		0, 20, 40
1973-74		0		urea spray in March
1974-75			0	0, 20, 40, 60, 80
1974-75		+		0, 60
1974-75 (UJ)[1]	+	0	0, 30, 60	
1975-76 (UJ)	0/-	+/0		0-100; 20-50/60-100
1975-76 (UJ)		+/-		0-50; 20-30/40-50
1975-76 (UJ)	+	0		0, 20, 40, 60

1. University of Jordan, Faculty of Agriculture research data. Otherwise data from Ministry of Agriculture research.

From: Mahmoud Duwayri and Ibrahim Saket. 1976. Discussion Paper No. 1. Response of wheat to fertilizer in Jordan: Twenty-five years of experiments: Studies of Dryland Agriculture. Sponsored by the Ford Foundation, Amman, Jordan.

Research Data from the Region:

In Lebanon, under 450 mm of rain, a non-replicated field scale trial was done to determine the effects of split applications of N on a mixture of barley and vetch for silage. The N source was ammonium sulphate. From the data in Table 1 it seems that split applications did increase silage yield. The data are from the 1971-72 crop year, but similar results were observed over a period of 2-3 years.

As mentioned earlier, crop, or even cultivar, as well as fertilizer influences yield. In Table 2 the effects of N and P on yield and return from two cultivars grown near Amman, Jordan are shown. It may be seen that the variety Stork was able to respond to the addition of N and P, and that the levels of N and P used resulted in a high benefit/cost ratio.

Similarly in Table 3, the effect of N, although not evaluated economically, was significant on grain yield and protein percent of the grain. In both of these experiments, the N source was ammonium sulphate.

A summary of 25 years of fertilizer-on-wheat research in Jordan is presented in Table 4. It is not inclusive, but it serves to point to the need for more comprehensive research in this field. In addition, the strong effect of climatic (primarily precipitation) variation is amply evidenced. It is clear that responses to low levels of N are more likely than are responses to higher levels. A similar table showing research reported on effects of P, and of N and P together, could have been included. Similar conclusions would be evident. More comprehensive work is needed, and lower levels of P are more likely to result in yield increases.

The Future

All of the difficulties related to fertilizer choice, rate, time, and method of applications, and ultimately the uptake or recovery of the nutrient by the crop plants can be coped with in one way or another, using the help of crop breeders, crop physiologists, agronomists, soil scientists, and others, but is there some panacea-like treatment that could alleviate many of our fertilizer problems in one blow? It seems the answer is yes. There may well be one approach that helps to solve many of these problems. This is the use of "slow-release" fertilizer formulations. If the fertilizer granules could be coated with something that delayed the solubilization of the nutrient(s), many of the problems referred to above would be alleviated, if not solved.

According to long term field and lysimeter trials it seems that little more than 50 percent of applied fertilizer N is recovered in the crop to which it is applied (4). Crop uptake of P is much worse, generally reported to range from 5 to 25 percent. This low recovery is *related to rapid solubilization* of the N and P applied, the resulting high concentrations in the soil solution often affecting, in the case of N, nutrient mobility into and out of the soil-plant system, and in the case of P the maintenance in the soil-plant system of a form available to the plants. Fertilizer forms of N are readily soluble and the resulting ion concentrations in the soil solution often reach levels damaging to seed germination and seedling development. Or, in some cases the N in solution may be lost through denitrification or leaching. The fertilizer forms of P are also readily soluble, but the P remains in the soil solution for a relatively short time before being fixed into forms or physical states, that are unavailable, at least to the crop to which the fertilizer was applied.

In recent years concerted efforts have been made toward developing what are known as "slow-release" forms of fertilizer (7). Such forms would help avoid many of the problems referred to above. These fertilizer formulations are designed so there is a steady release of the nutrients to the soil solution at a rate that is utilized but not wasted by the crop. Thus the crop is able to express its genetic capacity for yield, with a better balance of limiting factors. This ideal may be difficult of achievement, because of the varying need for most nutrients, as determined by the cultivar, its ontogeny, and variations (regional as well as seasonal) in soil, moisture, climate, etc. But the problem of fertilizer formulations with rapid release and subsequent loss or non-availability, can probably be much relieved via some method of release control.

There are several ways of accomplishing slow-release fertilizers, but the one seemingly most practicable is a water soluble nutrient source, the dissolution of which is controlled by a coating on the particles, acting as a physical barrier. Many coating materials have been tested; in 1907 a patent was issued in the USA based on this principle, but only in the last 20 years have serious efforts been made to develop a suitable coating for a soluble nutrient, thus effecting a true slow-release fertilizer. Many substances have been tested for their use as a coating. Two main problems are (1), the coating must be thin, or it occupies too large a portion of fertilizer volume (even a relatively thin shell will amount to 40 percent of the fertilizer volume), and (2) the *coating must be uniform and free* of imperfections, not an easy accomplishment on the rough, irregular surfaces of most fertilizers (7).

Sulphur has proved useful as a coating agent. It is low cost, can be sprayed on in a molten form, and has value as a nutrient itself. It is mainly used on urea because of the high N analysis and the physical properties. Extensive research by the Tennessee Valley Authority in the USA has used sulphur, a soft wax sealant, and a microbicide. The sealant slows water vapour transfer through the sulphur coating and the coal tar microbicide slows the rate of decomposition of the sealant (7). The material is sprayed over pre-heated urea granules. Release rates of N can be varied by controlling coating weights which range from 15-25 percent sulphur, plus about 5 percent sealant and conditioner. The product contains from 32-37 percent N (6). The rate of release of N from urea coated with sulphur is reported to be controlled by the thickness of coating, microbicide, temperature, placement, and time in contact with the soil (12). Surface applications of this product result in very little N loss. At low rates the main advantage of sulphur coated urea (SCU) is uniformity of plant growth throughout the growing season. At high rates, luxury N consumption is prevented resulting in greater yield and less N loss (6). If the sulphur is properly applied to compose about 15 percent of the coated granules, N release would continue for about 50 days (9).

The rapid diffusion of N into the soil solution during the first 24 to 48 hours is from the imperfectly covered granules. Thereafter, the release rate tends to be linear with time, and may be controlled to nearly 1 percent per day for 100 days in alkaline soils, slightly faster in acid (6).

Some interest has been shown in coated fertilizers containing P, or in combination with N, but developmental work is waiting for demonstrated need of such products.

Although TVA manufacturing costs are kept low, SCU still costs from 25-50 percent more than urea (on a N content basis). One of the main advantages to SCU is that high rates can be applied, with no fear of deleterious effects on existing vetgetation (7, 12).

Conclusion:

Of the several advantages attributed to SCUs, reduction of nutrient loss through water movement, avoidance of nutrient fixation, reduction of seedling damage, better seasonal distribution of growth and concomitantly more efficient use of water, economy of application (single versus split), seem most important. If crop needs and responses were well enough understood, one could visualize mixtures of fertilizers in "timed release" sulphur coatings. In this way there would be a steady release of nutrients in amounts appropriate to the ontogentic stages of the crop plants. Even flushes of nutrients could be timed for release when flushes of growth require greater release. The ultimate in flexibility and efficacy seems attainable.

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Summary

Crop production involves a complex of limiting factors. In arid regions the deficiency of water tends to over-ride all other deficiencies. Under rainfed conditions, amelioration on nutrient deficiencies brings into play interactions and responses that are sometimes difficult to predict. Application of N and P fertilizers, under arid conditions is fraught with difficulties. High solubility of some of them results in high concentrations in the soil solution, with possible seedling damage, may lead to loss through leaching, or fixation into the colloidal fraction of the soil.

Slow release fertilizer formulations, in particular sulphur coated urea (SCU), seem to hold promise. Its manufacture adds cost to the fertilizer, but avoiding some of the hazards of fertilizer applications to rainfed cereals may much more than off-set these additional costs. Since dissolution of the fertilizer is slowed, high concentrations in the soil never occur, leaching and seedling damage are not problems, and single applications are sufficient, saving the expense of split applications. Finally, these types of fertilizer could be applied (banded) directly into the drill furrow, in contact with the seeds, with little fear of damage, and with the advantages of having the nutrients in the rhizosphere of the crop plant.

EFFICACITE DES ENGRAIS DANS DES CONDITIONS DE FAIBLE PLUVIOMETRIE

D. W. Bray

Résumé

La production végétale implique un complexe de facteurs limitatifs. Dans les régions arides, le déficit en eau tend à l'emporter sur tous les autres déficits. Dans des conditions de forte pluviométrie, l'amélioration des déficits en sustances nutritives met en jeu des interactions et des réponses parfois difficiles à prévoir, L'application d'engrais azotés et phosphatés dans des régions arides présente de grosses difficultés. La forte solubilité de certains d'entre eux aboutit à de fortes concentrations de la solution dans le sol pouvant causer des dommages aux plantules, et peut entraîner des pertes par lessivage, ou fixation dans la fraction colloidale du sol.

Des formulations d'engrais à dissolution lente, en particulier l'urée enrobée de soufre (S.C.U.) semblent prometteuses. Sa fabrication ajoute au coût de l'engrais, mais le fait d'éviter certains risques lors des applications d'engrais aux céréales bien arrosées, fait plus que compenser ces coûts additionnels. Puisque la dissolution de l'engrais est ralentie, il n'en résulte jamais de fortes concentrations dans le sol, le lessivage et les dommages causés aux plantules ne font pas problème et des applications uniques sont suffisantes, épargnant la dépense d'applications fractionnées. Finalement, ces types d'engrais pourraient être appliqués (groupés) directement dans le sillon, en contact avec les semences, avec peu de risques de dommages, et avec l'avantage d'avoir les substances nutritives dans la rhizosphère de la plante.

FERTILIZER RESPONSES UNDER HIGH RAINFALL CONDITIONS

Elpis A. Skorda*

The actual level of yields obtained from grain crops is the net result of the interaction between the potential yield and the effect of environmental conditions, which can be classified into three main groups.

1. Natural conditions which are usually not under human control (climatic conditions).
2. Agricultural conditions that are affected by the farmer's action such as the level of soil nutrients.
3. Diseases and pests that are partially affected by farmers.

A program for raising yield levels is a continuous process involving increasing the potential yield of growing varieties with wide adaptation, improving agricultural conditions, especially soil fertility, and protecting the crop from diseases, pests and other injuries.

However, any improvement in soil fertility results in increased yields up to the point where the potential yield, or lodging, becomes the limiting factor. Further increases in yield will be obtained only by introducing varieties capable of utilizing to a fuller extent, the *greater soil fertility and improved agricultural* practices. Fortunately such varieties are available in most countries, world wide. After the development of high yielding varieties, the widespread and judicious use of fertilizer has perhaps contributed more than any other factor to increasing crop yield and production since 1945. In Greece, as in most Mediterranean countries, much of the cultivated areas have been under cultivation for centuries and essential plant nutrients have been extracted from the soil by repeated crop harvesting without a fallow or legumes in the rotation. As a result most of the cultivated area is now deficient in one or more essential plant nutrients. Nitrogen deficiency is present in almost all the country; phosphorus deficiencies are not so widespread. Potash supply is enough for the present time. In some areas, manganese deficiency limits yields. The only way to correct these nutrient deficiencies is by the application of the proper dosage of the right fertilizer.

Wheat is grown on soils varying in chemical and physical characteristics. Therefore, the *proper use of fertilizer should be determined by studying the yield responses to fertilizers in* different soils and regions. More research has probably been carried out on fertilizer management practices in wheat, than in any other crop. It is essential to use nitrogen fertilizers properly because they are highly susceptible to losses by leaching and denitrification processes. Proper use of fertilizers can result in large increases in wheat production without causing water pollution. It has been estimated that not more than 20-50 percent of fertilizer nitrogen is recovered by arable crops (Cooke, 1967). Correct timing of nitrogen application is important for its most efficient utilization. With phosphates which are highly immobile and easily fixed in the soil, correct placement is important. Recovery by the crop in a single season has been estimated to be only 10-16 percent (Cooke 1967).

Efficient fertilizer practice aims at maximizing the utilization of applied fertilizer by the crop in the most economic way for optimum crop production. This calls for quantitative information on how the actual amount of fertilizer taken up by a crop varies with the different practices involved in fertilizer application (rates, time, and frequency of application, method of placement, nature of the fertilizer etc.) and the soil and climatic conditions

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under which the crop is grown. Therefore, field experiments based on crop yield and quality as well as other agronomic characteristics have been conducted for many years for each of the principal soil types, on which wheat is grown. From these quatitiative data, suitable fertilizer recommendations are formulated each year which permit increased yields of cereals. Field experiments by isotopic labelling of nutrient elements in the fertilizer have also given some useful information (Apostolakis 1971). Other soil fertility studies by the Soil Institute have contributed to the subject.

A large amount of data from fertilizer experiments conducted at the Cereal Institute and Experimental Stations of the country has provided the following information:

Fertilizer Rates

Nitrogen deficiencies occur throughout the cereal growing area. Phosphate response is variable and economic responses to applications have been obtained with low P rates (Boudonas 1975). Wheat and barley do not respond to potassium nor to micro-elements, with the exception of manganese in one or two regions.

1. *Wheat*

The first recommendations were 30-60 kg/ha N and 30-60 kg/ha P_2o5. They remained at this level because of the limiting factor of lodging until semi-dwarf varieties were introduced when the recommendations were increased to 90 or 120 kg/ha N. Lodging of the double dwarf varieties now limits yield. Triple dwarf varieties require 150-180 kg/ha N. The recommended rates for N and P_2O_6 at different locations in Greece are shown in table 1. Thus when changing varieties, it is necessary to manipulate all the other factors necessary to increase yields, especially fertilizers. However, with the introduction of heavy fertilizer dosages the microclimate in the denser stands in the fields becomes more favorable for diseases, e.g. mildew, which can cause severe losses. Sources of fertilizer, time of application and other different combinations help to change the microclimate in the grain field.

Improving soil moisture conditions by irrigation has not increased the efficiency of fertilizer-nitrogen, up to 90 kg/ha under the weather conditions of a three year experiment (table 2).

2. *Barley*

Fertilizer requirements for barley are less than those for wheat. In the more humid regions, barley generally responds to nitrogen and phosphorus. On poor soils, this crop often benefits from top dressing with nitrogen.

Barley has not responded to applications of nitrogen with phosphorus in all soil areas of Greece. Most varieties need no more than 70 kg/ha N because of the danger of lodging. The variety Georgia gave the highest yield per hectare with 90 kg N/ha.

TABLE 1. Recommended rates of N and P_2O_5 at Different Locations in Greece.

Location	Rainfall	Rates-Kg/ha				Cost of Fertilizers		Yield Increase	
	35 Years Mean	1967-72		1973-78		Wheat Kg/ha		Wheat Kg/ha	
		N	P_2O_5	*N*	P_2O_5	1967-72	1973-78	1967-72	1973-78
Thessaloniki	469	60	30	150	40	166	357	1120	2470
Halkidiki	450	90	60	150	40	273	357	960	1200
Nea Zoi	600	60	30	150	40	166	357	1000	
Serres	572	150	60	180	80	390	481	2430	2710
Ioannina	1195	120	0	120	80	234	365	1230	1590
Larisa	518	90	30	90	40	224	240	1030	850
Boiotia	616	90	60	150	0	273	292	960	1370
Lamia	600	-		120	80	-	365	-	2430
Tripolis	809	120	60	120	80	332	365	1440	1760
Xanthi	992	90	30	-	-	224	-	1650	-

Nitrogen was the primary nutrient that limited barley yields, even on productive land. The yield from the complete fertilizers was about 500-1000 kg/ha more than the treatment without nitrogen.

On manganese deficient soils, yields are dramatically increased by applying 10-20 kg/ha manganese suplhate, (table 3).

More nitrogen is applied to forage barley.

TABLE 2. Wheat Yield Responses to Three Nitrogen Rates in Relation to None, One and Two Irrigations.

		Grain Yield (Kg/ha)			
Irrigation	Fertilizer Rate	1973	1975	1978	Mean 3-Year
Nil	9-5-0	4770	4120	1690	3520
	12-5-0	4580	4480	1790	3620
	16-5-0	4720	4240	1130	3360
Mean		4690	4280	1540	3500
One Irrigation	9-5-0	5160	4560	2850	4190
	12-5-0	5050	4360	2730	4050
	16-5-0	5320	4480	2320	4040
Mean		5180	4440	2630	4080
Two Irrigation	9-5-0	5320	5190	3670	4730
	12-5-0	5450	4950	3990	4800
	16-5-0	5450	4800	3550	4600
Mean		5410	4980	3740	4710
LSD (0.05)					
Irrigations		359	557	424	
Fertilizers		N.S.	N.S.	244	
Interaction		N.S.	N.S.	N.S.	

TABLE 3. Grain Yield Response (Kg/ha) of Bread Wheat, Barley and Oats to the Application of Manganese Sulphate.

Variety	Manganese	Sulphate	(Kg/ha)
	0	10	20
Wheat			
Generoso	0	1167	940
Gallini	386	1847	1407
38290	1573	4600	2907
Niki	767	3360	3073
G-0893	0	953	2067
G-84865	1167	2740	2940
Barley			
Beka	2373	3547	3260
Zephyr	2747	2840	4987
Oats			
Kassandra	2280	5233	5173

Source of Fertilizers

In general, field experimentation in different locations in Greece has shown all sources of nitrogen to be equally effective on wheat yield and quality, if properly applied.

Many comparisons of phosphate sources have been made. There seems to be no best source for all field conditions (table 4). Ammonium phosphates are becoming popular for use in winter wheat and barley. A larger portion of the starter fertilizer now used is one of the ammonium phosphates.

Ammonium sulphate and ammonium nitrate have generally been more commonly used as sources of nitrogen followed by sodium nitrate. However, Spratt and Gasser (1970) have reported that under conditions of adequate water, wheat produced more dry matter and grain from nitrate nitrogen. When water limited growth, ammonium nitrogen was found to be as good or better than the nitrate form.

TABLE 4. Response of Wheat to Different Sources of Phosphates Over a 2 Year Period.

Treatment	Rate	Grain Yield Kg/ha					
		Thes	Niki	N. Zoi	Serres	Mean	%
1. Check (Without fertilizer)	0-0-0	1760	2415	1490	2890	2120	100
2. Ammonium Phosphate+Ammonium nitrate	6.2-4-0	3160	3380	3100	3385	3210	151
3. Superphosphate Ammonium + sulphate + nitrate	6.2.4-0	3060	3080	3020	3930	3190	150
4. Ammonium phosphate + Ammonium Nitrate	9.4-8.0	3330	3485	3440	3230	3380	159
5. Superphosphate Ammonium sulphate + Nitrate	9.4-8-0	3160	3350	3331	5245	3590	169
LSD (0.05)		**329**	**513**	**308**	**585**		

Time of Application

Cereal grain yield per unit area consists of various components, which are determined at the various stages of the crop development. Adverse conditions prevailing at the time of determining a certain component, will also limit the other components that are determined at later stages of growth, unless compensation exists between these components (such as between the number of plants per unit area and the extent of tillering). On the other hand, the effects of favorable environmental conditions during early growth stages will be fully expressed only if advantageous conditions also prevail during the later stages.

Hence the timing of nitrogen applications is very important in order to provide the necessary available nitrogen at various stages of crop growth to obtain increased grain yields without excessive yields of straw. The latter are obtained when heavy applications of nitrogen are made at sowing time and weather conditions are favorable. The merit of late, or split applications of nitrogen for increasing yields seems to be largely dependent on the season and soil conditions. However, results of numerous experiments on different soils and weather conditions have shown that split nitrogen applications with half applied in the fall and the other half topdressed in the spring, produced the same yield as if all the nitrogen were applied in the fall, except in one region (table 5). Similar results have been reported from India, Australia and other countries. In Britain most experiments have shown that winter wheat uses nitrogen more efficiently when it is applied in the spring, rather than in the autumn, at or before seeding (Cook, 1967). For small rates (60 kg N/ha), a single application in the spring has been reported to be preferable to two split applications in the autumn and the spring. However, for higher rates (120 kg N/ha) a split application of 60 kg in the autumn and 60 kg in the spring gave better results. Split nitrogen applications have generally not enhanced production. The interaction of soil type on time of nitrogen application has been reported by Clapp (1973). Johnson et al (1973) found significant increases both in yields and in grain protein content in winter wheat, when ammonium nitrate was applied in the spring.

Terman et al (1969) found that soil moisture levels played an important part in the effect of nitrogen applications on increasing both yields and grain protein contents. The work of Mehrotra et al (1961), who found that with adequate N and P fertilization, wheat took up nearly 45 percent of its total N by the tillering stage, 25 percent during stem extension and slightly more than 25 percent during grain formation, supports the above observations from field experiments on the need for available nitrogen at various stages of growth.

Soluble phosphate fertilizer should be applied as close to seeding time as possible. Wheat exhibits a great starting response from added phosphorus, perhaps because it needs large quantities during early stages of growth. Therefore, planting or preplanting applications have been the most beneficial. Like phosphorus, potassium should be applied at preplanting or at seeding, when it is required.

TABLE 5. Response of Bread Wheat to Time of Application of N in Greece - Grain Yield (Kg/ha) of Three Years' Trials.

Time of N Application (Kg/ha)		Locations								
Fall Pre-Sowing	Tillering Early Late	Thes PBI	Niki U.F.	N. Zoi	Gian Nitsa	Lari Sa	Ser Res	Ptole Mais	Kil Kis	Mean
90	0	3720	4680	3670	5000	3660	3710	4160	2710	3870
40	50	3930	4640	3950	4700	3650	3460	4120	2810	3840
40	30 + 20	3770	4780	4020	4680	3820	3550	4160	2850	3930
0	50 + 40	3850	4780	3790	4620	3760	3230	3960	2800	3820
0	90	3900	4480	3720	4660	3780	3440	4000	2750	3810
LSD 0.05		N.S.	N.S.	N.S.	N.S.	N.S.	181	N.S.	N.S.	N.S.

Application Methods

Placement depth is relatively unimportant for mobile nutrients such as nitrogen and sulphur, because these nutrients move in the soil and can be carried into the root zone by rainfall. Relatively immobile nutrients such as phosphorus, and potassium, must be placed in the root zone.

Wheat is commonly sown and fertilized satisfactorily with the combination drill, which places the fertilizer in contact with the seed. Because wheat is commonly seeded in 14 cm rows and usually into moist soil, and the amount of fertilizer in each band is small, fertilizer contact is not injurious at conventional rates.

Research conducted throughout Greece has shown that the placement of starter amounts of nitrogen, 40 kg N, plus 50 kg P_2O_5 per hectare, directly with the seed by drilling, had similar effects on yield and yield components as did an application 2-3 cm below the seed or by broadcasting the same amount on all the surface of the field, (table 6).

These results indicate that it is of no advantage to sideband or under sow fertilizers, which are more expensive operations than drilling fertilizer with the seed. However,

TABLE 6. Response of Wheat to Three Methods of Starter Fertilizer Placement.

Treatment	Grain Yield (Kg/ha)					
	Thessaloniki		N. Zoi	Larisa	Serres	Mean
Check (Without fertilizer)	2550	1560	2930	2580	1990	1680
Broadcast to the soil surface	3110	2070	3340	3280	2670	2390
Drill with Seed	3030	2120	3560	3100	2605	2400
Below the Seed, 3 cm	3090	2020	3390	3320	2460	2410
LSD (0.05)	194	145	297	368	493	358

caution must be exercised if high amounts of fertilizers are placed directly with the seed in order to avoid seedling injury. Nitrogen and potassium salts can be injurious to germinating seeds depending on soil moisture and other factors.

According to Bland (1971) the drilling of fertilizers directly with the seed is the most economical method of application. In India, deep side-placement is recommended as superior to drilling with the seed, under conditions of limited moisture.

Grain Quality

The grain protein content of wheat varieties is usually increased by the application of 60-120 kg N/ha compared with a check, but there was not always a response to the higher N rates. In general, the protein content of wheat varieties does not increase with an increase in fertilizer N application until the N rate exceeds that required for maximum yield. The same results were found by Koehler, 1961; Hunter et al., 1961.

When fertilizer N was applied to a growing crop near heading, the grain protein content was increased, but yields were not affected. Excess N fertilization to increase protein content is not economical. Moreover, continued fertilization for high protein content is a potential threat to nitrate pollutions of ground water (Mourkidis 1978). Hence, nitrogen application as a foliar spray for increasing grain protein content is the most efficient use of the N when applied to wheat. Significant increases in grain protein content were obtained when urea was used as a foliar spray on wheat before flowering, but this application gave no significant increase in grain even under optimum conditions. One spraying of urea at flowering, increased the protein content of grain by 7.0 percent, but this protein has a slightly lower biological value (Valtadoros 1970).

Increased nitrogen content of wheat grain does not necessarily mean an improved quality of the grain for bread making purposes, but an increase in nitrogen percentage resulting from nitrogen fertilization has improved the flour quality of the varieties studied, when the grain was heat treated.

The same is true for durum wheat in which the percentage of vitreous kernels may be increased by nitrogen fertilization.

Yield Components

Fertilization of wheat, especially with nitrogen and phosphorus, has a marked influence on the relative expression of yield components (number of fertile heads per/m^2 and seeds per head, and average weight per seed). In numerous trials at 12 locations in Greece using different wheat varieties and four N levels and three P_2O_5 levels it was found that, with the addition of nitrogen, heads per/m^2, seeds/head and seed weight were significantly higher.

Conclusions

It is difficult to predict the amount of available nitrogen that a given soil will furnish to a cereal crop. The only significant storehouse for nitrogen in the soil is the organic matter.

However, most of the wheat growing areas are very poor in organic matter. On the other hand, the efficiency with which available rainfall is used can be greatly improved through proper fertilization. Wheat generally responds to the direct application of commercial fertilizers, where the annual precipitation exceeds 500 mm.

In Greece, numerous field experiments on fertilizers applied to wheat were conducted over a 12 year period. Under nearly all conditions, a starter fertilizer when applied at a rate not exceeding 60 kg N and 40 kg P_2O_5 per hectare was the most desirable. A supplemental application composed chiefly or solely of nitrogen at 30-60 kg/ha was generally needed in the spring, before March 15. Late applications after the tillering period were generally ineffective for yield increases, but a foliar application of urea close to flowering increases the protein content of the grain.

Relatively small amounts of fertilizer phosphorus are often needed, while high amounts of nitrogen may be applied to produce maximum yields.

Farmers realize the benefits of fertilizers, but they use higher rates than the recommended rates. Therefore, the annual consumption of fertilizer for the ten year period, 1969-1979 was increased dramatically in Greece, as indicated in table 7.

About 60-65 percent of these fertilizers were used in cereals, and the remainder in cotton, sugar beets and other crops. These quantities are expected to increase even more with improvements in cultural practices. However, such increases may be a waste of money and increase the pollution of streams, rivers and lakes. It is well known that the use of both nitrogenous and phosphatic fertilizers can greatly contribute to the pollution of rivers and lakes.

TABLE 7. Total Consumption of Mineral Fertilizers in Greece (Metric Tons of Nutrients).

Year	Nitrogen	Increase Percent	P_2O_5	Increase Percent	K_2O	Increase Percent	Total	Increase Percent
1969-70	190,117	-	118,580	-	17,560	-	326,257	-
1970-71	201,960	6.2	128,588	8.4	17,530	-0.1	348,078	6.6
1971-72	205,700	8.1	123,788	4.2	17,377	-0.2	346,866	6.3
1972-73	211,732	11.3	129,570	9.2	20,576	17.2	361,878	10.9
1973-74	243,076	27.8	145,864	23.0	22,416	27.6	411,356	26.0
1974-75	251,525	32.3	150,204	26.6	24,586	40.0	426,315	30.6
1975-76	257,728	35.5	156,927	32.3	25,240	43.7	439,895	34.8
1976-77	282,615	48.6	167,856	41.5	32,454	84.8	482,925	48.0
1977-78	294.244	54.7	175,376	47.8	35,859	104.2	505,579	54.9
1978-79	342,750	80.3	195,689	65.0	45,606	159.7	584,045	79.0

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Summary

Soil fertilizer is the most limiting factor in cereal production all over the world under high rainfall conditions. Improved varieties with high yield potential express their productivity when they are grown on properly fertilized soil. Numerous studies have been conducted comparing different levels of fertilizers, nitrogen and phosphorus sources, methods of application and the effect of irrigation on fertilizer utilization under different soil and climatic conditions.

Increased grain yields, due to the addition of nitrogen occurred in almost all of the experiments conducted over 12 years of testing. In most instances, these yield responses were quite dramatic and clearly illustrate the need of fertilizer nitrogen for obtaining maximum yield and economic production of wheat and barley. The grain nitrogen percent was also generally increased by the addition of nitrogen, especially from foliar spraying close to flowering. The application of potash was found to be entirely unnecessary. Phosphate was beneficial in many cases. There was evidence that phosphate was sometimes necessary to obtain the full effect of nitrogen. Manganese deficiency has been observed in one region of Greece. Fertilizer requirements for barley are less than those for wheat and the benefits obtained are less.

In most experiments, split applications of nitrogen are not superior to a single application at planting as far as grain yield increase or grain protein content is concerned, even though increased efficiency in nitrogen uptake from split application on nitrogen was observed by isotopically labelled fertilizers. The placement of starter amounts of nitrogen directly with the seed, or broadcast in the whole surface, had very similar effects on yields and yield components as did a band application 2-3 cm below the seed, of the same amount. The effectiveness of ammonium nitrate and ammonium sulphate as fertilizer sources of nitrogen as well as ammonium sulphate plus superphosphate for wheat were remarkably similar. Improving soil moisture conditions by irrigation did not increase efficiency of fertilizer nitrogen up to 90 kg/ha.

EFFETS DES ENGRAIS EN SITUATION DE FORTE PLUVIOMETRIE

E. A. Skorda

Résumé

Dans le monde entier, l'engrais est le facteur le plus limitatif dans la production céréalière. En situation de forte pluviométrie, les variétés améliorées à haut potentiel de rendement expriment leur productivité lorsqu'elles sont cultivées dans un sol correctement fertilisé.

De nombreuses études ont été réalisées comparant les différents niveaux d'engrais, les sources d'azote et de phosphore, les méthodes d'application et l'effet de l'irrigation sur l'utilisation des engrais dans différentes conditions de sol et de climat.

Des rendements céréaliers accrus dus à l'addition d'azote ont été obtenus dans presque toutes les expériences menées au long des douze années d'expérimentation. Dans la plupart des cas, ces effets sur les rendements étaient vraiment dramatiques, illustrant clairement le besoin d'engrais azoté pour obtenir un rendement maximum et une production économique de blé et d'orge. Le pourcentage d'azote dans les céréales était également augmenté d'une façon générale par l'addition d'azote, particulièrement en pulvérisations foliaires peu avant la floraison. L'application de potasse était tout à fait inutile. Pareillement, le phosphate est bénéfique dans de nombreux cas. Il était évident que le phosphate était parfois nécessaire pour la manifestation du plein effet de l'azote. Un déficit en manganèse a été observé dans une région de Grèce. Les besoins en engrais pour l'orge étaient moins élevés que pour le blé et le bénéfice est moindre.

Dans la plupart des expériences, l'application fractionnée d'azote n'est pas supérieure à une application unique au moment de la plantation, en ce qui concerne l'augmentation du rendement des céréales ou la teneur en protéines des céréales, même si on a observé une efficacité accrue dans l'assimilation de l'azote au moyen de l'application fractionnée, en utilisant des engrais marqués par des isotopes. Les effets sur le rendement et les composantes du rendement étaient presque similaires, que l'on place au départ une quantité d'azote directement avec la semence, ou à la volée sur toute la surface, ou que l'on mette la même quantité groupée à 2 ou 3 cm sous la semence.

L'efficacité du nitrate d'ammoniaque et du sulfate d'ammonium comme sources d'engrais d'azote ainsi que le sulfate d'ammonium + superphosphate ou phosphate d'ammonium pour le blé étaient presque similaires. L'amélioration de l'humidité du sol par irrigation n'a pas augmenté l'efficacité de l'engrais azoté jusqu'à 90 kg/ha.

FERTILIZER RESPONSE UNDER IRRIGATED SITUATIONS

M. Tahir* and H. M. Hepworth**

In Pakistan responses from application of fertilizer to wheat grown under irrigated conditions differ from area to area depending upon soil type, climate and management conditions. To assess the nutrient needs of the wheat crop, a large number of fertilizer experiments have been conducted at various locations on both research farms and cultivators' lands for the last several years. The results obtained are summarized below:

1. The data reveal a significant response to added nitrogen in all varieties of wheat. The yield of wheat under irrigated conditions increases as the fertilizer dose increases up to 130 kg/ha nitrogen in loamy to clay-loam soils. Beyond these levels, yields remain almost the same or respond at a diminishing rate of return.

2. With high yield potential, semidwarf varieties, yield is invariably low from nitrogen alone, when compared to its use in combination with other essential nutrients (especially phosphorus) provided these are applied in balanced proportion and in adequate amounts.

3. Response to N and P applications at lower doses of 80 kg N and 40 kg P is lower than that obtained under higher doses viz, 120 and 60 kg of N and P, respectively. The data reveal a significant difference with NP application over N alone.

4. Response to potassium is not economical except in pockets with low potash contents, particularly in sandy loam soils and rice tracts of Punjab Province. The addition of potassium increases the yield by about 8 to 20 percent in certain areas but it is not usually found to be remunerative for adoption as a recommended practice.

5. In long corn field trials being conducted at Tandojam (Pakistan) for the last 20 years, it has been observed that potash application to wheat not only increases the grain weight and yield per acre but also the protein and starch content of wheat.

6. If double the amount, by weight, of farmyard manure is mixed with phosphorus source, the availablility of phosphorus to the wheat plant is enhanced.

7. The response of N application decreases with increase in salinity level. However, the salinity level does not affect the response to phosphatic fertilizer.

8. The total fertilizer use on 16 million acres of wheat crop during 1978-79 was 372, 600 nutrient tons (N 298.8, P 92.1 and K 1.7 thousand nutrient tons). The average NPK application per acre comes to about 53 lbs with an N to P ration of 3:1 compared to the recommended dose of 120 lbs of N and 60 lbs of P_2O_5.

The lower rate of fertilizer application in unbalanced form indicates the gap between the recommended dose and actual rate of application. The increased and balanced use of nitrogenous and phosphatic fertilizers according to the research findings will enhance wheat production, not only making the country self-sufficient, but providing significant quantity for exporting to the food deficit areas of the world.

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REPONSE AUX ENGRAIS DANS DES SITUATIONS D'IRRIGATION

M. Tahir and H. Hepworth

Au Pakistan des réponses à l'application des engrais au blé cultivé sous des conditions d'irrigation varient de région à région dépendant du type du sol, du climat et des conditions d'exploitation. Pour évaluer les besoins nutritifs de la culture du blé, un grand nombre d'essais d'engrais *ont été menés* à des locations différentes et sur des fermes d'essais et sur les terres des cultivateurs pendant les dernières années. Les résultats obtenus sont resumés si dessous:

1. Les données révelent une réponse *significante à l'azote dans toutes les variétés* de blé. Le rendement de blé, sous les conditions irriguées, augmente quand la dose d'engrais augmente jusqu'à 130 kg d'azote par hectare dans des sols de terreau à argile-terreau. Au-delà de ces neveaux les rendements restent presque les mêmes ou répondent d'un taux de rentrées diminuant.
2. Avec le potentiel de haut rendement, des variétés semi-nains, en utilisant seulement le nitrogèn le rendement reste invariablement bas comparé à son utilisation en combinaison avec d'autres nutritifs essentiels, particulièrement le phosphore, pourvu que ceux soient appliqués en proportion équilibrée et en quantités adéquates.
3. La réponse aux applications de N et P aux doses inférieurs à 80 kg N et 40 kg P est inférieure à celle obtenue sous des plus grandes doses, c'est à dire 120 and 160 kg of N and P respectivement. Les données révelent une différence significante des applications de NP sur N seul.
4. La réponse au potassium n'est pas économique sauf dans des poches de bas indices de potasse, en particulier dans des sols de terreau sablonneux et dans des régions de riz de la Province de Punjab. L'adjonction du potassium augmente le rendement d'environ 8 à 20 pour cent dans certaines zones, mais en général elle n'est pas *trouvée d'être rémunératrice* pour être adoptée comme pratique conseillée.
5. Dans des longes essaies de champs de céréales qui ont été menés à Tandojam (Pakistan) pendant les dernières 20 années, on a observé que l'application de la potasse *au blé n'augmente pas seulement* le poid de graines et le rendement par hectare mais aussi l'indice de protéine et d'amidon du blé.
6. Quand on mélange deux fois la quantité, par poid, de fumier avec du phosphore, *la disponibilité du phosphore au blé est rehaussée.*
7. La réponse à l'application de N diminue avec l'augmentation du niveau de salinité. Pourtant, le niveau de salinité n'a pas d'effet sur la réponse à l'application des engrais phosphatiques.
8. L'utilization totale d'engrais sur 16 million d'hectares de cultures de blé pendant 1978-79 était de 372,600 tonnes de nutritifs (N 278.8, P 92.1 et K 1.7 mille tonnes de nutritifs). L'application moyenne de NPK par hectare *vient à 53 livres environ, avec la* proportion N et P de 3:1 à l'opposé de la dose recommandée de 120 livres de N et 60 livres de P_2O_5.

Le taux inférieur d'application d'engrais dans une forme non-équilibrée montre clairement le grand écart entre la dose recommendée et le réel taux d'application. L'utilization augmentée et equilibrée des engrais azotiques et phosphatiques conformément aux résultats de recherces vont intensifier la production du blé non seulement pour rendre le pays auto-suffisant mais une quantité significante de blé excédentaire sera disponible pour exporter dans des régions du monde qui sont déficitaires en aliments.

PRICES, TECHNICAL RESPONSE, AND THE BENEFITS AND COSTS OF FERTILIZER APPLICATION

J.B. Fitch, A.A. Goveli, M. El Gabely and S. Imam*

Optimum use of fertilizer in cereal production —or in the production of any other crop— depends upon both technical and economic factors. Even though a farmer applies the amount of fertilizer which is recommended and thought to be economically justified, he may get low returns because he has poor technology or lack of know-how. On the other hand, recommendations, and allocations of fertilizer made by the government are at times determined without fully considering whether they make economic sense to the farmer. There may be no relationship between a government's price and allocation policy and its system of developing recommendations for fertilizer use.

The economic principles upon which optimum fertilizer application levels can be determined are relatively simple. They rest on the assumption of profit-maximizing behavior by the farmer. This overlooks the fact that farmers may have objectives other than maximizing profit or that the uncertainty of the environment in which the farmer operates can also have a significant impact on behavior. Nevertheless, to maximize profit, the farmer should apply fertilizer up to the point where the benefit of an additional unit of fertilizer is just equal to the cost of that unit. In economic jargon this is abbreviated to the statement "the marginal benefit equals the marginal cost". This rule is perhaps more clearly stated as: "the value of the marginal product of the fertilizer equals the cost of the fertilizer". These conditions are illustrated in Figure 1a.

These optimal conditions or rules involve *both economic and technical considerations*. The underlying technical relationship is the fertilizer response surface (Figure 1b) from which the marginal product relationship may be derived.** Note that the optimum level of fertilizer (F_0), which is derived by taking both economic and technical factors into account, is *less than* the amount of fertilizer (Fm) which would maximize the crop yield based on technical considerations alone. The additional benefit (i.e. the value of the additional yield) obtained from increasing fertilizer from F_0 to Fm, would be less than the additional cost. The optimum level of F depends on both crop prices and fertilizer prices. If crop prices rise, F_0 is increased. If fertilizer prices rise, F_0 is lowered.

To the extent that government policy influences or controls crop and fertilizer prices, this will naturally influence the benefits and costs which farmers receive from fertilizer use, and the farmer's optimum level of use will be influenced accordingly. Government price policies are designed for a variety of purposes. The government can decide to influence crop prices upward to increase the incentive to produce; this will give the farmer incentive to use more fertilizer in the process. Crop prices, especially those for staples such as grains, can also be held down by policies designed to provide cheap food for consumers; this will give the farmer less incentive to produce and reason to use less fertilizer. Governments also can and frequently do influence or control fertilizer prices, and this also influences fertilizer use and crop production. Controls on a crop price have their main

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** If y = f (F) is the response function and Pf and Py are the prices of fertilizer and crop, respectively, then the optimal conditions are written:

$$Py \frac{dy}{dF} = Pf$$

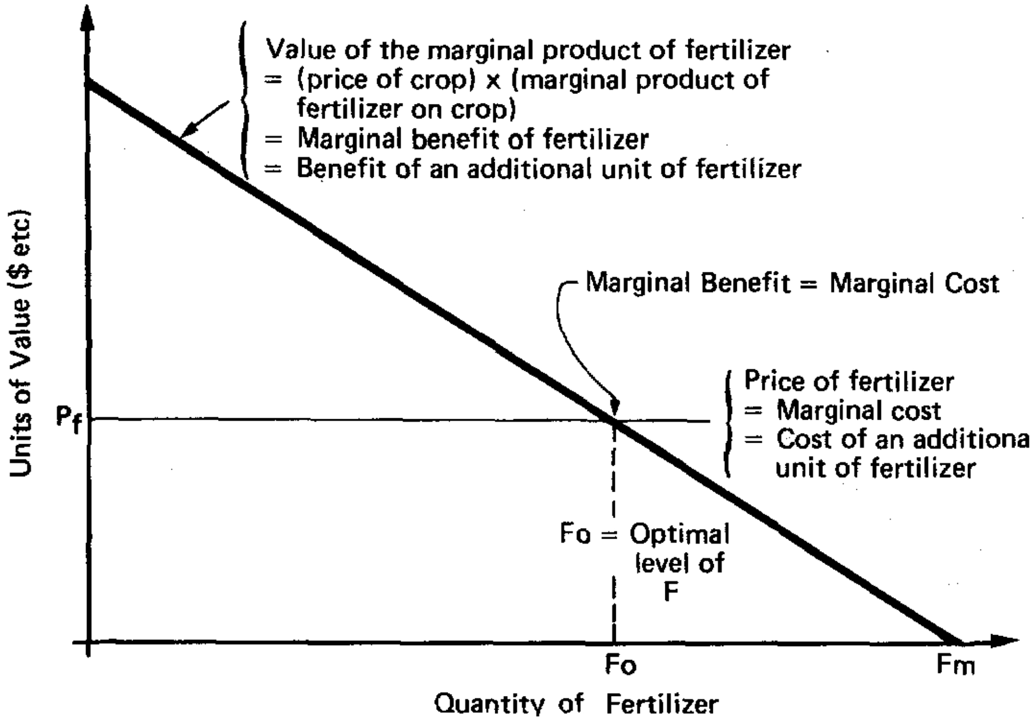

Figure 1a. The Profit Maximizing Conditions: The Economic Basis for Developing Fertilizer Recommendations.

influence on production and fertilizer use for that crop. Fertilizer price controls, on the other hand, influence fertilizer use and production for all crops simultaneously. Both crop and fertilizer price controls are common in the grain producing countries of the Middle East.

Government controls on crop prices can run into direct conflict with attempts to stimulate fertilizer use and crop yields. Gotsch showed that in Jordan there was a relative decline in (controlled) wheat prices, with respect to fertilizer prices, just at the time that a new technology package depending on larger fertilizer inputs was being promoted. In his opinion this probably had a direct bearing on the failure of farmers to adopt the new package.*

Controls to keep fertilizer prices low can be very costly** and are often difficult to justify on economic grounds. Nevertheless, if controls are maintained, the government must take special measures to insure that enough fertilizer is produced or imported to meet the high demands that will result. Otherwise, shortages will result and it may not be possible for farmers to obtain all of the fertilizer that they would like to use at low prices. Under these conditions, it is normal for "black" markets to arise. Recent maize and wheat surveys conducted in cooperation with CIMMYT in Egypt show that black market prices for nitrogen fertilizers are often twice as much as the official controlled rates. As yet, there is no evidence to show just how much fertilizer is sold at the higher free market prices.

* See Gotsch, C.H., "Wheat Price Policy and the Demand for Improved Technology in Jordan's Rainfed Agriculture", Discussion Paper No. 2, Studies in Dryland Agriculture, The Ford Foundation, Amman, Jordan, 1976.

** For example, the cost to the Egyptian government for maintaining fertilizer subsidies in 1975 was LE 72.8 million, according to A. Mostafa, "An Economic Study of Egyptian Agricultural Policy", Ph.D. Dissertation, Cairo University, 1978.

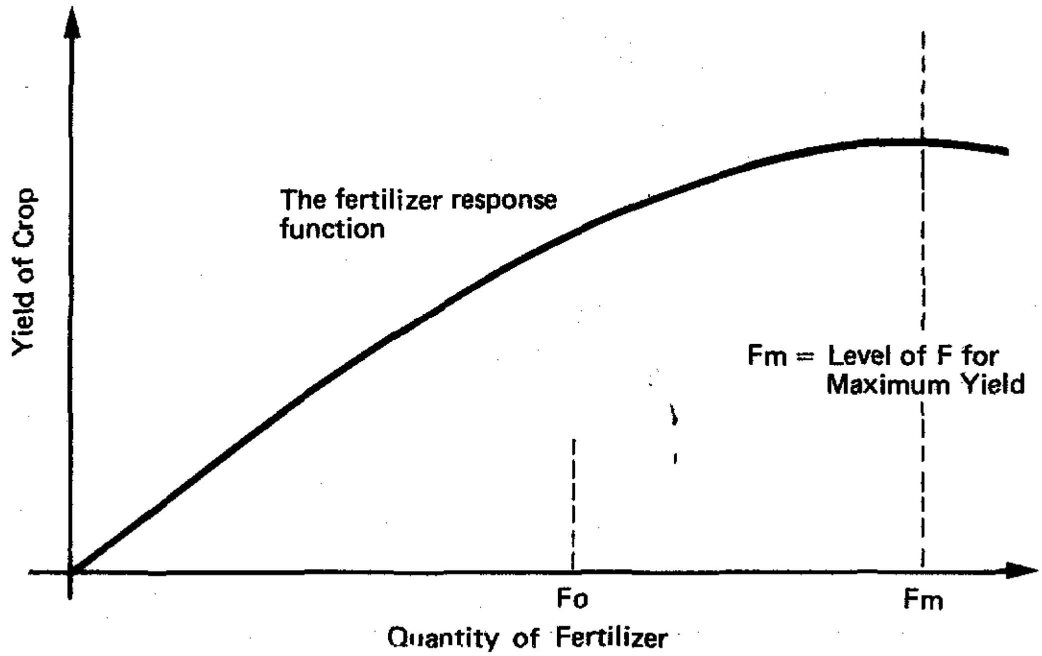

Figure 1b. The underlying Technical Relationship: The Fertilizer Response Function

To make recommendations to farmers and to help estimate how much fertilizer will be required to meet farmers demands, government research agencies are frequently required to provide *norms* for fertilizer use. The norms simply state the normal or recommended amounts of each type of nutrient to be applied to each crop. If they are based on both the technical and economic principles discussed above, norms can provide useful guidelines*. However, norms which are not well founded can be very counter-productive. If a farmer goes by a bad recommendation —i.e. one which is not based on good technical information about fertilizer response and not evaluated in economic terms by consideration of both fertilizer costs and likely crop prices— he can lose money.

Egypt has had a system whereby norms developed within the Ministry of Agriculture have become not only a basis for recommendations to farmers, but also the basis for the amounts of fertilizer allocated by the government and made available to farmers through the village banks.** The system for developing norms involves evaluating data on fertilizer response, based on experimental trials conducted by the Agricultural Research Center. At times, economists have been critical of this system of developing norms because it was felt that the economic dimension —i.e. the farmer's benefit-cost calculus described earlier— was not given proper attention. Nevertheless, if one follows the norms which have been used over the past decade, they do seem to relate to the changing economic situation.

* Nevertheless, it is doubtful whether estimates of national demands based on aggregates built up from per hectare norms for each crop would ever be accurate enough to rely on as the sole basis for projecting a country's supply or import needs. It is preferable to look at estimates derived from other types of analysis, such as *estimates of aggregate fertilizer demand functions and trends of past use.*

** Until 1978, the government-supervised farmer cooperative system was used as the distribution channel.

This can be shown by referring to two statistical regression studies which provide estimated nitrogen response functions for wheat, maize, and other crops.* These studies were based on data from experiment station field trials conducted in different areas of Egypt. The first study, by Goueli and Habashy, estimated nitrogen response functions for wheat, cotton and rice based on experimental data from the early 1960's. The later study by Mansour, *et al.*, estimated nitrogen response functions for two zones, Northern and Middle Egypt, for cotton, wheat, maize and rice, based on experimental data from 1971. The authors' response equations for wheat and maize are given in Appendix A. These were solved for the economic optima, based on prices prevailing for each of the years 1970-1977, as also explained in the Appendix. The results are shown in Figure 2.

Taking the case of wheat (Figure 2a), in particular, it is to be noted that the optimum levels based on Goueli and Habashi's study of early sixties data are substantially lower than the Mansour *et al.* study based on early seventies data. There is a clear indication that Egypt had developed varieties which were far more fertilizer responsive by the seventies. It is because of this, perhaps, that national average wheat yields did increase between the

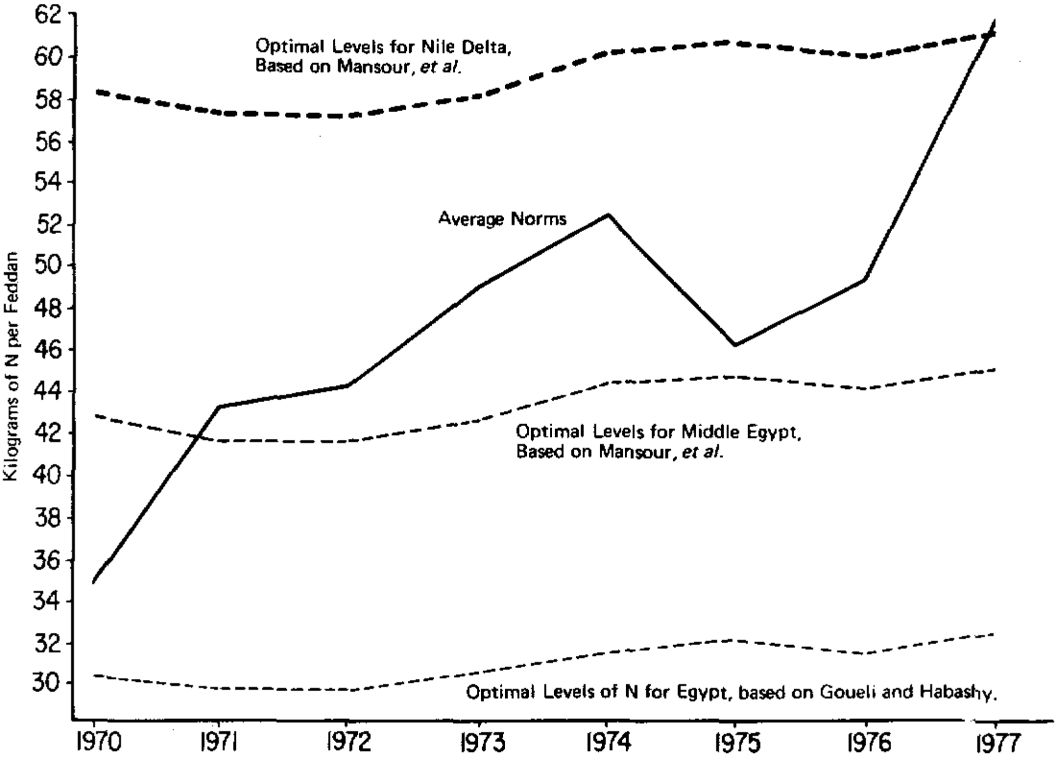

Figure 2a. Nitrogen Application Levels for Wheat: Official Norms Compared to Optima, 1970-77.
A *feddan* = 1.04 *acres* = 0.42 hectares
Source: Based on Data and Calculations shown in Appendix A.

* See Goueli, Ahmed A., and Nabil T. Habashy, "Estimation of Fertilizer Production Functions for Some Major Crops in U.A.R. Agriculture and it's Economic Implications", The Fourth Statistical Conference Proceedings, Cairo, April 1968. Also see Mansour, Mahmoud E.I., *et al.*, "An Economic Analysis of the Application of Chemical Fertilizers to the Production of Cotton, Wheat, Maize and Rice", Research Bulletin No. 1, Agricultural Research Center, Agricultural Economic Research Institute, Cairo, 1974.

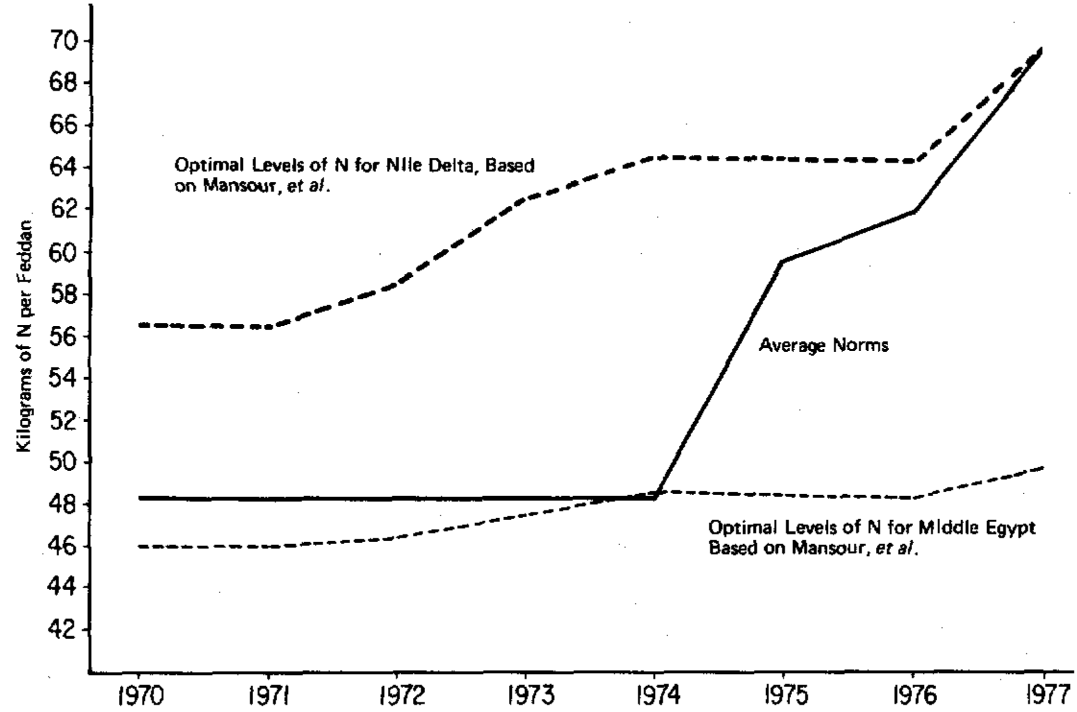

Figure 2b. Nitrogen Application Levels for Maize: Official Norms Compared to Optima, 1970-77.
A feddan = 1.04 = 0.42 hectares
Source: Based on data and calculations shown in Appendix A.

two periods, from about 2.6 to some 3.2 tonnes per hectare. It is clear that by 1977, the official norms for both wheat and maize were high compared to economic optima derived from early seventies response data. This is not to say that the norms are out of line, however. To determine this, it would be necessary to look at data from later response trials.

It is one thing to consider norms and optima which have been developed from experimental trials, and quite another to consider farmers' actual practices. To take a look at actual farmer practices in Egypt, some surveys of wheat and maize producers have recently been conducted by economists from Zagazig University and the Institute of Agricultural Economic Research working in cooperation with the wheat and maize programs in the Agricultural Research Corporation.* With regard to nitrogen application levels, some rather revealing findings are now being obtained from analysis of the data. In particular, it is noteworthy that while the normal or recommended levels of N for maize farmers in the Middle Egypt region are currently in the 60-70 kg per feddan range, the average** for 185 farmers sampled from this region in 1977 was 96 kg. per feddan. What was even more striking, however, is that applications ranged from less than 2 kg of N per feddan to over 250 kg! Expected yields ranged from 2 ardebs (380 kg) to 18 ardebs (2420 kg) per feddan.***

* These surveys were financed by CIMMYT and were assisted by technical guidance and logistic support from the Ford Foundation.

** This average is, in fact, biased downward since it contains a disproportionate number of large farmers and since large farmers tend to use somewhat less N than small farmers.

*** A feddan is 1.04 acres or 0.42 hectares.

Wheat presents a somewhat different picture. A 1978 sample of 99 Middle Egypt wheat growers averaged just 65 kg of N per feddan, which was only slightly higher than the norm for that crop. Nevertheless, the sample range was from 23 to 126 kg per feddan.

In general, Egyptian yields for wheat and maize are high by international standards, but the quantities of N applied to both crops are high, too. Average wheat yields have been about 3.4 tonnes per ha in recent years whereas those for maize are 3.7 tonnes. Survey data indicates that farmers are applying averages of 150 kg of N per ha for wheat and more than 225 kg to maize to obtain these yields. This leads one to suspect that N efficiency is rather low and that there are problems with techniques for applying or using N.

How is it that farmers can act so differently from the way that experiment station trials and cursory economic logic suggest they should act? One obvious answer is that farmers often operate under very different conditions from those existing on experiment stations. Not only do they experience quite different agro-climatic conditions, at times, from those which exist on experiment stations, but they also face different circumstances in terms of labor availability and management, in available motive power and mechanical technology, and in availability of key inputs. It is possible for *all* of these factors to *cause technical* differences in response. In other words, the farmer probably has a different fertilizer response curve from that which applies for experimental conditions. Add to this the fact that the farmer may also face different economic conditions from those assumed in deriving the national or regional optima shown in Figure 2.

The survey data are very revealing in terms of identifying some of the differences in farmers' conditions as well as in showing differences in their techniques and farming practices. Planting methods and seedbed preparation are a case in point. For wheat, the standard experiment station practice for trials in Egypt is to plough the (dry) field with a tractor, seed with a drill, and then irrigate. Among farmers, however, there is a common practice of irrigating seven to ten days prior to soil preparation, so that soils may be worked with an animal drawn plow. This system is called *heraty*. Almost half of the wheat farmers in the Middle Egypt survey were found to use heraty. Furthermore, only 1 of the 99 farmers sampled used a seed drill. The remainder used hand broadcasting. (Incidentally, the same thing occurs in dryland wheat production in North Africa and the Fertile Crescent, where most if not all of the small farmers still hand broadcast, while virtually all experimentation is done with drill-seeded plots.)

There is a similar but somewhat more complicated situation in the case of Egyptian maize. The experiment station practice is to plough dry ground, work the land into ridges, and then seed with a drill. Of the 185 maize sample farmers, however, some 27 percent were found to use no tillage whatsoever following the preceding crop. Evidently to save time, they prefer to go in directly after the preceeding crop is cleared and just make holes or chop up the ground into hills with a hand hoe. Only 47 percent were found to plant in ridges. The remainder planted on flat ground and/or used the no-tillage method.

Most experiment stations have a good, reliable and easily controlled supply of water. Not so for many Egyptian farmers. Reliability of water supply can potentially be a real factor in nitrogen use efficiency if, as is the typical case in Egypt, the fertilizer is applied on top of the soil and temperatures are high. Under these conditions nitrogen from some forms of nitrogen fertilizer can volatilize and be lost in the air, unless water is applied quickly. In the wheat survey, it was found that 51 percent of the farmers interviewed experienced delays of 12 hours or longer in getting their plots irrigated after nitrogen was applied (Table 1). Of those experiencing such delays, half waited longer than 24 hours. If such delays are the general rule and if they are leading to volatilization, this could be a cause of low nitrogen efficiency.

It is especially remarkable that farmers who experience the longest delays appear to be those who rely on motorized pumps rather than on gravity or one of the more traditional pumping methods. The survey enumerators had an explanation for this. Pumps are used in the tails of the canals where water supply is the least reliable and where pumps are preferred because they can pick up smaller volumes of water more effectively. Because of this, the pumps, which are usually rented, are in very high demand and heavily worked. Even though a farmer feels that he has one scheduled in advance, delays frequently occur.

TABLE 1. Timing of Irrigation Following Nitrogen Application for Middle Egypt Wheat Farmer Survey, 1978.

Type of irrigation system or device		Time Until Irrigation, Following Fertilizer Application, for Each Wheat Parcel 0-6 hours	6-12 hours	12-24 hours	24 hours or longer	Totals
	No.	3	3	2	1	9
Gravity	(Percent)	(33.3)	(33.3)	(22.2)	(11.1)	(100)
	No.	4	2	3	2	11
Water wheel	(Percent)	(36.4)	(18.2)	(27.3)	(18.2)	(100)
	No.	10	4	10	20	44
Motorized Pumps	(Percent)	(22.7)	(9.1)	(22.7)	(45.5)	
	No.	15	9	5	2	31
Persian Screw	(Percent)	(48.4)	(29.0)	(16.1)	(6.5)	(100)
	No.	-	-	-	2	2
Artesian well or balance	(Percent)				(100)	(100)
Motorized Pumps in combination with other devices.	No.	7	4	12	7	30
	(Percent)	(23.3)	(133.3)	(40.0)	(23.3)	(100)
Other combinations	No.	7	5	6	5	23
	(Percent)	(30.4)	(21.7)	(26.1)	(21.7)	(100)
Totals	No.	46	27	38	39	150
	(Percent)	(30.7)	(18.0)	(25.3)	(26.0)	(100)

In contrast to the motor pumps,the Persian screw appears to be a more reliable device.This explains why farmers are often reluctant to give up the screws and why there is still a relatively large number of this type of device.

At times, farmers may use methods which are technically superior to experiment station methods. In an effort to explain why some maize farmers are using such high levels of nitrogen it was found that many farmers have the practice of splitting up their nitrogen applications on maize to a far greater extent than is typically done in experimental trials. On average, sample farmers were found to make 2.77 separate applications of N, and some apply in as many as six separate doses. The standard experimental trial procedure is to make two applications. Upon further investigation, it was found that there is a very direct relationship between number of applications and quantity of fertilizer used. Furthermore, simple cross-tabulations showed that the farmers which report a high number of applications are the ones who report high expected yields.

In an attempt to take into account a number of factors that appear to be influencing farmer maize yields and fertilizer response simultaneously, survey data was used to estimate an analysis of covariance model. Farmers' normal or expected maize yields were the dependent variable, and the total amount of N applied, the number of separate N applications, the type of planting method, and the preceding crop were used as explanatory variables or factors. Preliminary results of this analysis are given in Appendix B.* This preliminary analysis only explains 25 percent of the variation. However, it shows that, in

* The analysis is now being expanded to include such factors as phosphate level, type of irrigation system, and maize variety, along with the variables which have already been included. In this way it is hoped that a significantly greater amount of the variance yields can be explained. While number of applications is significant in the current version, there is a problem with the fit of this variable.

TABLE 2. Optimum levels of N Application to Maize, Based on the Farmer's Response Relationship, as Derived from 1977 Farmer Survey Data.

"Technical Conditions	N Fertilizer Prices a/	Application Costs b/	Optimal Level of N Per Feddan
	High	High	29.18
Preceding Crops: Broad beans	High	Low	37.87
Planting Method: "wet", no ridges	Low	High	66.19
	Low	Low	85.92
	High	High	73.37
Preceding Crops: Crops other than beans: wheat, berseem	High	Low	93.97
Planting Method: *No tillage*	Low	High	164.11
	Low	Low	213.11

Note: For explanation, see Appendix B. In each case the maize price is assumed fixed at L.E 7.09 per ardeb, equal to the average farm level price for the three years prior to 1977.

a/ High is the typical black market price of L.E. 0.25 kg of N, whereas low is the official price of L.E. 0.13.

b/ High costs were assumed to be L.E. 1.26 per application, the survey average. Low costs were assumed to be L.E. 0.50 to reflect a condition of surplus family labor.

addition to the level of N itself, the number of applications, certain preceding crops (broad beans) and some types of planting method ("wet", no ridges) can have a significant impact on yields. As a consequence, the other factors also affect N response. The estimated response relationship was solved for the optimum level of N, depending upon a variety of alternative economic and technical scenarios. Table 2 gives the optimum levels of N, depending on these alternative conditions or assumptions about the farmer's situation.

The range of optimal N levels shown in Table 2 is quite wide, depending on the conditions which the farmer faces. Naturally, when fertilizer costs are low (i.e. when the farmer is able to buy what he needs at the low official price) and when application costs are low (e.g. when there is abundant, under utilized labor in the farm family), it pays to put on more fertilizer. It also pays to apply more when certain technical conditions are favorable, however, such as when the maize is following a particular preceding crop or when the farmer is able to use a better planting system.

The exact technical causes for the higher response are not clear from the analysis. Why do farmers who use the "wet" (heraty) planting systems get lower yields? Is it because the heraty method is used by farmers who rely on animals for tillage and because animal drawn ploughs are less effective? These are subjects which may well merit further research, both on experiment stations and in farmers' fields under actual farming conditions.

The points raised in this paper may be summarized as follows. The benefits and costs of fertilizer use are influenced by a number of technical and economic factors. While the principles of determining the most beneficial or optimum level of fertilizer use for the farmer are simple, in practice many factors must be taken into account. The optimum level of use can be influenced by government policies for both crop and fertilizer prices. In Egypt, the levels of N recommended for maize and wheat by the government seem to correspond roughly to the economically optimal levels which are derived from experimental trials, using official fertilizer prices. However, when farmer survey data are used as a basis for estimating technical response functions, and when differences in farmer technical conditions and technique are taken into account, there is a wider range of response than exists in experimental fertilizer trials, and this leads to a very wide range of possible optimal applications.

The information presented here suggests that it is indeed worthwhile to go beyond the bounds of the experiment station to obtain information about the benefits and costs of fertilizer use. The farmer survey is one means of doing this, but certainly not the only one. In Egypt, plans now call for moving into a phase where economists will work together with plant breeders and agronomists in order to help monitor on-farm trial farmers and survey adjacent farmers. This system will permit researchers to gather at least five types of information simultaneously: (1) trial farmers' opinions about the feasibility and acceptability of the trial package of practices, (2) adjacent farmers' opinions about the package, (3) a description and contrast of adjacent farmer practices, (4) response to trial practices, and (5) response to the regular practices of adjacent farmers. This information will be useful in determining fertilizer response, among other factors, under a wide variety of conditions.

Appendix A. Determination of Optimal Nitrogen Application Levels, Based on Experimental Plot Data.

	1970	1971	1972	1973	1974	1975	1976	1977
Pn, Official Price, kg of N	.13	.13	.13	.13	.13	.13	.13	.13
Pw, Farm Gate Price, Ardeb of Wheat	5.80	5.31	5.26	5.72	2.04	7.70	7.07	8.12
Pm Farm Gate Price, Ardeb of Maize	4.69	4.68	5.15	6.31	7.11	7.12	7.04	10.66
Pn Pw Nitrogen/Wheat Price Ratio	.0224	.0245	.0247	.0227	.0185	.0169	.0184	.0160
Pn Pm Nitrogen/Maize Price Ratio	.0277	.0278	.0252	.0206	.0183	.0183	.0185	.0122
Optimal N level for Wheat, Egypt (1)	30.5	29.8	30.4	31.8	32.4	31.8	32.7	
Optimum N level for Wheat, Nile Delta (2)	58.3	57.3	58.2	60.3	61.1	60.3	61.5	
Optimal N level for Wheat, Middle Egypt (3)	42.8	41.9	41.8	42.6	44.4	45.0	44.4	45.4
Optimal N level for Maize, Nile Delta (4)	56.6	56.5	58.7	62.5	64.4	64.6	64.3	69.5
Optimal N level for Maize, Middle Egypt (5)	46.0	46.0	46.6	47.7	48.3	48.3	48.2	49.7

Notes: Yw 9.96 + 0.114N - 0.0015N^2; MP 0.114 - 0.0030N Pn/Pw; N (0.114-Pn/Pw)/0.0030.
(2) Yw 5.50 + 0.139N - 0.0010N^2; MP 0.139 - 0.0020N Pn/Pw; N (0.139-Pn/Pw)/0.0020.
(3) Yw 9.35 + 0.125N - 0.0012N^2; MP 0.125 - 0.0024N Pn/Pw; N (0.125-Pn/Pw)/0.0024.
(4) Ym 10.66 + 0.0956N - 0.0006N^2; MP 0.0956 - 0.0012N Pn/Pm; N (0.0956 - Pn/Pm)/0.0012.
(5) Ym 11.30 + 0.221N - 0.0021N^2; MP 0.221 - 0.0042N Pn/Pm, N (0.221 - Pn/Pm)/0.0042.

(1) Is taken from Goueli and Habashy, *op. cit.* Their data was from 1962.
(2), (3), (4), (5) are taken from Mansour, *et al., op. cit.* Their data was from 1970-71.

Appendix B. Determination of Optimum Nitrogen Application Levels for 1977, Based on Farmer Response Function Estimated from 1977 Middle Egypt Maize Survey.

1. The Response Function, Estimated with Analysis of Covariance.

Dependent Variable: Expected Maize Yield, Ym*

Explanatory Variable or Factor		Estimated Coeficient	Standard Error	F to Delete
Total Nitrogen Applied	XN*	0.1643/a	0.0831	3.91
Number of N Applications	XL*	0.1852/a	0.1047	3.13
Preceding Crop Dummy Variables:				
Berseem Clover	C	-0.0853		0.794
Wheat	W	-0.1155		1.203
Broad Beans	B	-0.2930		7.286/b
(Control: Other crops)				

continued **APPENDIX B**

Planting Method Dummy Variables:			
Dry tillage, no ridges	D^2	0.0489	0.440
No tillage	D^3	0.0533	0.600
Wet, with ridges	W^1	-0.2332	2.038
Wet, no ridges	W^2	-0.2442	6.428/b
(Control: Dry w/ridges)			
Constant term		1.4694	

a/ Significant at 95 percent level of confidence, based on test.
b/ Significant at 95 percent level of confidence.
Number of observations: 141
R-Squares: 0.2450
Fa, 131 for overall significance of relationship 4.72.
* Variable in logarythmic Form.

2. The Farmer's Demand for Nitrogen:
Response Function: Ym A XN X L

Demand for fertilizer and fertilizer applications:

3. Alternative technical and economic scenarios:
   a. Preceding crop and maize planting method:

   Low: Beans; wet with no ridges

A e 2.540 (1.469 - 0.2930 - 0.2242)

   High: Other crops; No tillage

A e(1.469 + 0 + 0 (.0533) 4.585

   b. Maize prices:
   Expected prices average of preceding three years prices.

Pm 7.09
(no alternative considered)

   c. Fertilizer prices:
   Low: Official price, PN 0.13
   High: Typical black market price, PN 0.25
   d. Labor costs per application of N:
   High: Average costs for survey, PL 1.25
   Low: Surplus family labor, PL 0.50

4. Fertilizer demands for the alternative scenarios:

Technical Factors:	Fertilizer Costs	Application Costs	Kg. of N per Feddan, optimal
Low	High	High	29.18
Low	High	Low	37.87
Low	Low	High	66.19
Low	Low	Low	85.92
High	High	High	73.37
High	High	Low	93.97
High	Low	High	164.11
High	Low	Low	213.11

Summary

Optimum use of fertilizer in cereal production - or in the production of any other crop - depends upon both technical and economic factors. Even though a farmer applies the amount of fertilizer which is recommended and thought to be economically justified, he may get low returns because of faulty technique or lack of know-how. On the other hand, recommendations and allocations of fertilizer made by the government are often determined without fully considering whether they make economic sense to the farmer. There is often no relationship between a government's price and allocation policy, and its system of developing recommendations for fertilizer use.

A farmer seeking to maximize his net returns should use fertilizer up to the point where the cost of an additional unit of fertilizer just equals the value of the additional crops (grain + straw) which the fertilizer will produce. That is, the level of fertilizer used will depend upon both crop and fertilizer prices. If prices change, the optimum fertilizer level will change. In Egypt, the prices of fertilizers have been held almost constant by the government throughout the 1970's. As a result the government has had to undertake a costly fertilizer subsidy program. Grain and straw prices have fluctuated considerably, meaning that to maximize net returns, farmers have had to increase levels of fertilizer applied. Government recommendations and quantities of fertilizer distributed have increased, however, apparently taking the changing circumstances of the farmer into account.

Surveys of Egyptian wheat and maize farmers conducted in cooperation with CIMMYT show that farmer yields and fertilizer application levels vary widely. A sample of 185 maize farmers from Middle and Upper Egypt were found to be applying about 35 percent more nitrogen, on average, than the government recommends and allocates for the crop. A sample of 99 wheat growers from Middle Egypt showed them to be using amounts of fertilizer which were very close to the government recommentadion for that crop. In both cases, however, usage fluctuated widely about the mean.

Although Egyptian yields for wheat and maize are hgh by international standards, the quantities of N applied to both crops are high, too. Average wheat yields have been about 3.4 tonnes per ha in recent years whereas those for maize are 3.7 tonnes. Survey data indicate that farmers are applying an average of 150 kg of N per ha for wheat and up to 200 kg to maize to obtain these yields. This leads one to suspect that N efficiency is rather low and that there are problems with techniques for applying or using N. The wheat survey revealed that over 50 percent of farmers interviewed waited 12 hours or longer from the time of applying N until irrigation water could be applied. This leads to the speculation that there may be substantial N loss through volatilization. The delays in application appear to be associated with the water distribution and pumping facilities.

In some cases, farmers may use techniques which are advanced by comparison with experimental methods. The Egyptian maize survey shows that some farmers expect to obtain yields as high as 6 tonnes per ha and that these appear to be associated with levels of N which are abnormally high by experiment station trial standards. Some farmers are applying more than 400 kg of N whereas experimental trials in Egypt typically deal with levels of 150 to 200 kg and seldom if ever more than 300 kg. Farmers who apply high levels of N were found to resort to split applications, with some applying N in as many as six separate doses. The typical experimental trial technique is to make two applications.

By estimating fertilizer response functions based on farm survey data and by taking farmers' differing technical and economic circumstances into account, it was found that the optimum level of N under actual farm conditions could vary widely, from as little as 70 to over 400 kg. of N per hectare. Although these results are only tentative, they are nevertheless suggestive of the need for more research which examines fertilizer response under farmers' actual conditions.

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PRIX, SAVOIR-FAIRE TECHNIQUE, BENEFICES ET COUTS DE L'APPLICATION D'ENGRAIS

J. B. Fitch, A. A. Goueli, M. El Gabely, S. Imam

Résumé

L'utilisation optimale d'engrais dans la production céréalière—ou dans la production de toute autre culture—dépend à la fois de facteurs techniques et économiques. Même si un agriculteur applique la quantité d'engrais qui a été recommandée et qui est censée être justifiée économiquement, il se peut qu'il obtienne des rendements bas en raison d'une technique défectueuse ou d'un manque de savoir-faire. Par ailleurs les recommandations et attributions d'engrais par le gouvernement sont souvent décidées sans avoir complètement examiné si elles ont une signification économique pour l'agriculteur. Il n'y a souvent aucune relation entre le prix et la politique d'attribution du gouvernement et son système de recommandations pour l'utilisation des engrais.

Un agriculteur cherchant à maximiser ses rendements nets devrait utiliser l'engrais jusqu'au point où le coût d'une unité supplémentaire d'engrais est égal à la valeur de la récolte supplémentaire (grain + paille) produite grâce à l'engrais. C'est-à-dire que le niveau d'engrais utilisé dépendra à la fois de la récolte et des prix des engrais. Si les prix changent, le niveau optimal d'engrais changera. En Egypte, les niveaux d'engrais recommandés pour le blé et le maïs, de même que les prix des engrais, ont été maintenus constants par le gouvernement depuis 1970. Les prix du grain et de la paille ont considérablement fluctué, cependant; ainsi pour maximiser son revenu net, l'agriculteur devrait changer les niveaux d'engrais appliqués. En clair, les recommandations du gouvernement et les quantités d'engrais distribués n'ont pas tenu compte des réalités économiques de l'agriculteur. Les agriculteurs semblent avoir amplement raison de ne pas se fier aux recommandations du gouvernement.

Des enquêtes auprès de producteurs égyptiens de blé et de maïs, réalisées en coopération avec CIMMYT montrent que les rendements et les niveaux d'application des engrais varient énormément. On trouva un échantillonnage de 185 producteurs de maïs en Moyenne Egypte et en Haute Egypte appliquant, en moyenne, environ 35% d'azote de plus que ce que le gouvernement recommande et attribue pour cette culture. Un échantillonnage de 99 producteurs de blé de la Moyenne Egypte utilisaient une quantité d'engrais très proche de la recommandation du gouvernement pour cette culture.

Bien que les rendements égyptiens en blé et en maïs soient élevés par rapport aux niveaux internationaux, les quantités d'engrais azoté appliquées aux deux cultures sont également élevées. Les rendements moyens du blé ont été d'environ 3,4 tonnes/ha ces dernières années, tandis que ceux du maïs sont de 3.7 tonnes par ha. Les éléments de l'enquête indiquent que les agriculteurs appliquent une moyenne de 150 kg d'engrais azoté par hectare pour le blé et jusqu'à 200 kg pour le maïs pour obtenir ces rendements. Ce qui amène à suspecter l'efficacité de cet engrais et les problèmes que posent les techniques d'application ou d'utilisation de l'engrais azoté. L'enquête sur le blé a révélé que plus de 50% des agriculteurs entrevus ont attendu 12 heures ou plus à compter du moment d'application de l'engrais azoté avant de procéder à l'irrigation. Ce qui permet de supposer qu'il y a probablement une perte substantielle d'engrais azoté par volatilisation. Les retards dans l'application apparaissent associés à la distribution de l'eau et aux possibilités de pompage.

Dans certains cas, les agriculteurs peuvent utiliser des techniques qui sont avancées en comparaison des méthodes expérimentales. L'enquête égyptienne sur le maïs montre que certains agriculteurs comptent obtenir des rendements de 6 tonnes

par hectare et que ceux-ci paraissent associés à des niveaux d'engrais azotés anormalement élevés par rapport au niveau des essais réalisés dans les stations expérimentales. Certains agriculteurs appliquent plus de 400 kg d'engrais azotés tandis que lors des essais en station expérimentale en Egypte on utilise des niveaux de 150 à 200 kg et rarement, en cas de besoin, plus de 300 kg. Les cultivateurs qui appliquaient de hauts niveaux d'engrais azoté avaient recours à des applications fractionnées, certains appliquant l'engrais en 6 doses. La technique expérimentale typique lors des essais est de faire 2 applications.

VI. VARIETAL ADEQUACY

J. P. Srivastava and G. Varughese
E. E. Saari et al
G. C. M. Sage

VARIETAL ADEQUACY FOR THE DIFFERENT AGROCLIMATIC CONDITIONS OF THE WEST ASIA AND NORTH AFRICA REGION

J.P. Srivastava* and G. Varughese**

The title of this workshop "The gap between the present farm yield and the potential: major constraints and possible solutions" calls for an examination of the varietal adequacy for the different agroclimatic conditions prevalent in the Western Asia and the North African regions. The population of this region at present is approximately 370 million with an annual growth rate of 2.9 percent and can double in less than 30 years. About 50 percent of the population is dependent on agriculture. Only seven percent of the 1,500 million hectares of which the region is comprised is arable land. More than 80 percent of this arable land is dependent on annual rainfall for crop production. Wheat and barley occupy over 65 percent of the area devoted to the food crops. Thus rainfed wheat and barley are the most important crops of the region.

Wheat is grown on 27 million hectares with an annual production of 31 million metric tons, averaging about 1.2 metric tons per hectare. Barley is grown in 10 million hectares with an annual production of 9 million metric tons, representing an average production of less than one metric ton per hectare. The import of cereals to this region has more than doubled during the past decade and the present import level is close to 14 million metric tons. Thus the challenge to increase the crop production through all available means is very urgent.

Before we look into the details of varietal adequacy it is essential to have a general background of the crop growing conditions of the region. The cereal areas can be grouped into two major zones based on topography and climate patterns: highlands or continental climate areas where the crops are long duration and at times approaching winter habit, and lowland areas bordering the Mediterranean and extending inland and having a Mediterranean climate. The moisture stress at different stages of crop development is variable from year to year and also the crop can at times be subject ot hot dry winds at the time of flowering and grain filling under both types of environments. The total rainfall received is also highly variable ranging from as high as 1000 millimeters to below 200 millimeters. The majority of the cereal crops are grown in a range of 200-500 millimeters with wheats in the higher range and the barley in the lower range. The crop management in general in the region is poor and can be classified as moderate to poor input technology under high rainfall and irrigated conditions, and low input technology under the majority of low rainfall conditions. Under the high rainfall conditions the main cereal crop is bread wheat and is followed by durums and some forage barley. Improved local varieties and semidwarf bread and durums are quite common in this area. In areas around 350 millimeters of rainfall and below, the predominant crop is barley followed by durums and some bread wheat. Local improved varieties, selections from land races, and land races, are the main cultivars of this climatological region. These varieties have low yield potential, suffer from most of the major cereal diseases and in general are late, but many of them have good survival ability under moisture stress caused by erratic rainfall patterns.

In the fifties before the introduction of the semi-dwarf varieties, 2.5 tonnes/ha under irrigation and 1 t/ha under rainfed conditions were considered good yields. However, in the seventies under irrigation or high rainfall conditions, a crop of less than 5 t/ha is

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considered unsatisfactory. In our opinion this change occurred mainly due to the introduction of high yielding nutrient responsive varieties and the use of better management practices. In one of the recent CIMMYT reviews, it is reported that high yielding semi-dwarf varieties at present occupy about 40 percent of the good irrigated or high rainfall area. However, the extension of these varieties to the remaining 60 percent of the crop area is very slow.

One of the factors can be the extensive use of poor cultural practices and there may not be enough economic return in using the better varieties. If we look at the statistics of this region we will find that in the lower rainfall areas the yield has not changed in the last 25-30 years. As a matter of fact, in some cases it has gone down. If we look country by country at the varietal releases during the past decade, we will find that very few varieties were released for the low rainfall areas. In contrast, many new varieteis were introduced in the high rainfall and irrigated areas. Explanations to these trends is evident in the data reported by Dr. Bolton in an earlier paper at this workshop where he reported that between 1931 and 1952 and from 1952-74, at a site in the north west USA with an average rainfall of 242 millimeters, improvement due to varieties was 17 percent, crop management 69 percent, and a combination of the two was 100 percent. That means a 15 percent gain due to the interaction. In another location with an average rainfall of 400 millimeters between the same period the improvement due to varieties was 32 percent, due to crop management 28 percent, and the combination of the two gave 78 percent. In this case the interaction due to the combination of improved variety and crop management was 18 percent. It is evident that under both low and moderate rainfall it is important to have a combination of improved varieties and good management. The magnitude of gain due to good crop husbandry increases with decreasing rainfall while the gain due to the use of improved varieties is greater with increasing rainfall. The situation in this region of west Asia and North Africa is very similar. There is no doubt that the yield potential of this region can be increased even in the low rainfall areas if we use improved varieties coupled with appropriate cultural practices and inputs.

The adequacy of varieties should also be reviewed in light of their ultimate use and farmers' requirements. The varietal requirement depends on whether it will be used for grain production alone, or for grain production and straw for feeding the animals. If it is barley under low rainfall, will it be used for grazing or will it be a combination of grazing and grain production? The varieties also should be adapted to the crop rotations prevalent in its area of cultivation and also to the limitations imposed by climatic patterns of the location where it will be grown and to some extent the level of crop management under which the crop is going to be grown. If we develop varieties without taking into account these requirements and farmers' circumstances, the varieties probably will not be widely accepted.

The degree of improved varieties available for the different agroclimatic patterns of the region for the different cereal crops is highly variable. The research input for the varietal improvement and the crop management for the low rainfall barley crop is minimal at present. The potential to increase the barley production through a combination of varietal improvement and crop management is excellent. Since the early seventies, high yielding durums and semi-dwarf durums started coming into production in this region. However, the high yielding durum area is much more limited at present in comparison with the high yielding bread wheats. Taking into account that durum wheat is the main wheat of this region, if more attention is given in developing high yielding varieties with better drought tolerance, quality and disease resistance, they will extend themselves into large areas of cultivation. Among the three crops, the bread wheats are in a better situation, because they have received maximum attention in the past. However, this advantage is mainly exploited in the comparatively better environment in which they are grown. Varietal adequacy of bread wheats for low rain fall and low production potential areas still need additional attention.

Weeds constitute one of the major limiting factor in cereal yields in the region. Controlling them through cultural practices or through chemicals or a combination of the two are the best. But, under low production potential where the yield potential is below 2 t/ha, the use of herbicides may not be as economical as it might be for higher yield potential conditions. Development of high yielding varieties with profuse early growth habit like barley, may increase the competitiveness of wheats with the weeds. This is a challenge for the breeders.

It has been suggested by some people that the semi-dwarfs have not been as successful under rainfed conditions as they have been under irrigated and high rainfall conditions. However, results of on-farm demonstration trials in Algeria 1972 (Table 1), farmers' field verification trials in Syria, during the past two years (Table 2), analysis of on farm demonstration trials in Tunisia by Purvis in 1973 and the adaptation analysis done by Laing and Fischer on grain yield data (1977) of the 6th and 7th ISWYN, all indicate that despite the greater regression slope of new high yielding varieties, the best yielders under almost all conditions including the lowest yielding (driest) conditions were certain high yielding new varieties. In contrast other genotypes of similar mean yields, plant height and phenology were not well adapted to the drier conditions. Thus it seems fairly well established that under diverse conditions a number of genotypes have been adapted or are yielding well under better, as well as adverse, conditions and on the other hand there are several which are very specific to the better conditions only.

TABLE 1. Yield of New Improved Varieties Compared With Local Checks. Algeria 1972-73 (CIMMYT Wheat Report 1973).

	Trials averaging less than 2 t/ha			Trials averaging 2 t/ha or more		
Variety	Number of locations	Yield t/ha	% of local check	Number of locations	Yield t/ha	% of local check
Strampelli	9	1.45	107a	9	3.07	146c
7 Cerros 66	9	1.37	100a	10	2.89	133c
Soltane	9	1.59	117a	10	3.04	146c
Tobari 66	8	1.43	100a	8	2.76	134c
Cajeme 71	8	1.28	96a	7	2.88	141c
Inia 66	-	-	-	5	2.77	143c
Zaafrane	-	-	-	5	3.40	156c
Cocorit 71	8	1.37	123b	10	2.84	131d
Jori 69	6	1.15	125b	10	2.92	134d
Inrat 69	6	1.10	113b	10	2.46	113d
Capeiti	7	1.30	125b	8	2.70	116d

a = Florence Aurore, b = Oued Zenati or Mohamed B. Bachrir, c = Mahon Demias or Florence Aurore, d = Oued Zenati

A common practice at present is to grow the breeding nurseries under moderate to optimum conditions and some people may argue that this may not permit the selection of types for low moisture and low input conditions. However, the experience so far indicates that some of the best varieties identified for the low rainfall and low input areas are varieties with high yield potential and wide adaptation. Selections for yield potential under low and variable moisture conditions are highly undependable and unreliable. On the other hand, selections for yield potential can be done with relative ease under moderate to optimum conditions. If appropriate germplasm is used in crosses and the selections are screened for their performance under low input and optimum conditions, then lines can be identified which will perform well under adverse environment as well as can provide a better harvest if good climatic conditions prevailed.

TABLE 2. **Farmers' Field Verification Trials Syria. Average for Two Years Under Low Rainfall.**

		1977-1978*				1978-1979*			
Crop	Variety	Mean yield kg/ha	Rank	Freq**	% of check	Mean yield kg/ha	Rank	Freq**	% of check
Bread wheat	Haramoun	1867	2	7	102	1288	2	7	110
Bread wheat	Arvand	2019	1	8	110	1322	1	8	113
Bread wheat	Mexipak	1835	3	3	100	1185	3	3	101
Bread wheat	Fl. Aurore	-	-	-	-	1170	4	4	100
Durum wheat	D.Dwarf S15-Cr"S"	1918	2	9	125	1339	1	10	113
Durum wheat	Cr"S"xT.dic Ver-GII"S"	1931	1	10	126	1345	2	10	114
Durum wheat	Hourani	-	-	-	-	1185	3	3	110
Durum wheat	*S. Capelli (check)*	1536	3	2	100	-	-	-	-
Durum wheat	Farmers Field***	1210				874			

* Average rainfall 1977-78 1978-79 193 mm.

** The number of times a variety ranked in the top 2 for grain yield.

*** Six samples in 1977-78 and 10 samples in 1978-79.

In conclusion, the varietal needs of the region of west Asia and North Africa are diverse. Excellent progress has been made in the irrigated and high rainfall regions where high inputs are in use. The progress in low input and low rainfall areas so far has been slow and in some areas negligible. Germplasm in general is available. If this potential germplasm is properly selected and appropriate technology in crop production is used, many of the present food deficit nations can easily become surplus countries.

Summary

Wheat and barley are the two most important crops of this region and they are grown on more than 65 percent of the cereal land area. The average wheat yield is 1.2 t/ha, while that of barley is less than a one metric ton per hectare. Cereal importations in this region has more than doubled during the last decade. Currently, this region imports near 14 million of metric tons.

Most cereals are grown in the zones with rainfall varying from 200 to 500 mm per year, with wheat grown in the most favored areas and barley in the drier ones. The farm technology in the region could be calssified as medium-to-poor.

During the last 20 to 25 years, there has been little change of yields in the low rainfall areas (less than 300 mm) and few new varieties have been released. However, yield improvements have occurred in the higher rainfall areas (above 350 mm) and the irrigated zones. The availability of improved varieties for the three crops is as follows: good for bread wheat; passable for durum wheat; and poor for barley.

The data from Algeria, Tunisia, and Syria indicate that the varieties that produce the best yields under almost any conditions, including the conditions of moisture stress, are the improved high-yielding varieties.

In general, it can be said that if the available improved germplasm is properly utilized, and if adequate technology is applied to the crops, many of the countries in this region that currently import food, could actually become food surplus countries.

CONVENANCE DES VARIETES POUR DES CONDITIONS AGROCLIMATIQUES DIFFERENTES DE LA REGION D'ASIE OCCIDENTALE ET D'AFRIQUE DU NORD

J. P. Srivastava et G. Varughese

Résumé

Le blé et l'orge sont les deux plus importantes cultures de cette région occupant plus que 65°/o de la superficie consacrée aux cultures d'alimentation. Le rendement moyen de blé est environ 1.2 tonnes métriques par hectare en tant que le rendement moyen de l'orge est moins qu'une tonne métrique. L'importation des céréales dans cette région a plus que doublé pendant la dernière décade, le niveau actuel d'importation étant près de 14 millions de tonnes métriques.

Le plus grand pourcentage de la culture céréalière est cultivée entre 200 et 500 mm de précipitation, le blé dans la partie favorable et l'orge dans la partie la plus sèche. La technologie de l'exploitation de culture dans la région peut être classifiée, en général, comme moyen à pauvre.

Pendant les 20 à 25 années passées, il y avait peu de changement dans le rendement moyen dans les régions de basse précipitation (moins de 300 mm), et relativement peu de variétés ont été lancées. Cependant, cela n'est pas vrai pour l'agriculture de précipitation élevée (plus de 350 mm) et d'irrigation. Le degré de la disponibilité des variétés améliorées pour les 3 cultures est variable, dans l'ordre suivant: le blé tendre bien, le blé dur passable et l'orge pauvre.

Des données de l'Algérie, de la Tunisie et la Syrie indiquent que malgré la plus grande pente de régression des nouvelles variétés à haut rendement, celles qui donnent un haut rendement sous presque toutes les conditions, incluant les conditions de bas rendements (les plus sèches) étaient certaines variétés eminaines de haut rendement.

En général, de bon germ-plasme est disponible. Si ce potentiel germplasme est proprement sélectionné et une technologie appropriée dans la production de culture est utilisée, un grand nombre des nations actuellement deficitaires en alimentation, peuvent facilement devenir des pays de surplus.

THE SIGNIFICANCE OF DISEASES AND INSECTS IN CEREAL PRODUCTION

E.E. Saari,* J.M. Prescott,** A.H. Kamel***

Diseases and insects are considered to be the biological variables most frequently encountered as an important production factor in the wheat and barley crop, once weeds are brought under control. Even in situations where weeds are not being well managed, diseases, insects, nematodes and other animals are often encountered as a significant problem. To some degree, the relative importance of the different pests can be measured by the amount of time spent on the various methods available for control. Since weeds are a subject that is being covered separately in detail at this conference, we will restrict our comments to the "other" pests.

Regarding insects, there is generally either very little or no time spent in breeding for resistance. Only in a few places, in other parts of the world is breeding taken into consideration. For example, there are breeding programs for resistance to aphids, Hessian fly and Cereal Leaf Beetle in the United States, and for sawfly in Canada. By and large, in this region of the world the control of insects is dependent on the use of insecticides and their timely application. This usually means that some sort of awareness or monitoring system must be developed if the insecticides are to be effectively and economically applied. All too often, insecticides are applied as a reaction to a crisis situation which has gone beyond the economic realities of successful control.

If one contrasts this situation with breeding for disease resistance, almost every program involved with wheat and barley improvement takes into consideration one or more diseases. The CIMMYT breeding program in Mexico, for example, concentrates a great deal of its efforts on disease resistance and this involves a number of diseases. The diseases which continue to receive major emphasis are the three rusts followed by *Septoria tritici* and *Helminthosporium* species. Other diseases are of concern but the methods for adequate screening and testing have not been established on a regular basis. Some national and other international programs do take into consideration some of these other diseases.

When one reviews the international nursery reports of CIMMYT, it is possible to develop some appreciation for those diseases which are regularly reported. In reviewing the past few years of nursery reporting for the International Spring Wheat Yield Nursery (ISWYN) and the International Durum Yield Nursery (IDYN) for this region of North Africa and the Middle East, there were only five diseases reported and there were no insect infestations recorded. Listed in Table 1 are the five diseases and the frequency of their occurrence. Leaf rust *(Puccinia recondita)* of wheat would be considered by far the most important disease, particularly in the Middle East, followed by yellow rust *(P. striiformis)* and stem rust *(P. graminis). Septoria tritici* was considered the next most important wheat disease of bread wheats in the Middle East, yet no reports were received from North Africa, the traditional problem area for this disease. Only one report on durum wheat was received. We suspect that this is partially a reporting anomaly, or it could also indicate the level of awareness and recognition of this disease. The other disease reported was powdery mildew *(Erysiphe graminis)*. It was reported in the Middle East but not from North Africa.

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Again, the possibility exists that either there is a reporting anomaly or the nursery sites were not representative. The diseases on bread wheat appeared to be more important and frequent than those reported for the durum wheats. This would not be in complete agreement with our experience and our data base from other nurseries. This can be seen in Table 2 when we compare the levels of rust resistance from the RDISN nursery grown in this region in the world. The bread wheats generally possess a higher level of resistance to the rust diseases than do the durum wheats.

TABLE 1. Summary of the Wheat Diseases Reported in the International Spring Wheat Yield Nursety (ISWYN) 1973 to 1977 and the International Durum Yield Nursery (IDYN) 1969 to 1977 from the Middle East and North Africa.

	Middle East		North Africa	
Disease	ISWYN	IDYN	ISWYN	IDYN
Leaf rust	24	7	6	6
Yellow rust	12	8	0	5
Stem rust	10	6	4	1
Septoria tritici	9	0	0	0
Powdery Mildew	3	1	0	0
Total Nurseries Reporting	37	34	20	19

TABLE 2. Frequency of Wheat Lines Falling into Different Groups Based on the Average Coefficient of Infection (ACI): Resistant 0-5, Moderately Resistant 5-10, Moderately Susceptible 11-20 and Susceptible 20+. Data from Regional Disease and Insect Screening Nursery 1976-1977.

	Disease and Percent of Entries in each A.C.I. Grouping					
	Leaf Rust		Stem Rust		Yellow Rust	
A.C.I.	BW	DUR	BW	DUR	BW	DUR
0-5	4.5	40,8	33.8	55.1	63.0	35.3
5-10	15.2	8.3	18.5	15.7	17.1	13.5
11-20	21.7	39.0	23.3	29.7	15.7	14.8
20+	27.8	48.2	17.4	20.8	12.1	8.7

BW Bread Wheat
DUR Durum Wheat

Leaf and yellow rust were reported more frequently, but stem rust is still one of the potentially most serious disease problems. The decline in the number of stem rust epidemics probably reflects the use of varieties with a broad base of genetic resistance, which has been developed over a period of years. Because of the seriousness of this disease, many man-years of research has gone into the breeding for stem rust resistance. The effort will far exceed the efforts on all of the other diseases. This, coupled with the earlier maturing varieties which are now available, results in a partial escape mechanism for stem rust infection. These two factors have reduced stem rust as a serious problem in many areas and we have not experienced a major epidemic of stem rust with the semi-dwarf wheats in this region. Stem rust is a disease which must not be forgotten, and we must continue to select for resistance.

Another means of measuring the importance of diseases and insects would be to analyze the country reports presented on the opening day of this conference. Out of the 17 reports presented by the countries, there were 12 reports which considered diseases as a significant factor to production and seven considered insects as a problem. The importance of insects should not be under-estimated because when they do become a problem they have the potential to be devastating. They are, however, variable in their occurrence.

The insects which are most often encountered in barley seem to be the aphids, as a group. Based on reports, the insects listed in Table 3 are considered to be the major insect pests attacking barley. The order of listing should not be taken as a ranking of importance.

In the case of the insects that attack wheat, aphids are the most often reported. There are a number of others which are frequently mentioned. In Table 4 the species of insects found attacking wheat are similar to those reported on barley, but there is a greater number listed. This may be indicative of the rainfall areas where wheat is being grown in relationship to barley.

TABLE 3. Insects Attacking Barley (*Hordeum vulgare*) and Reported as Important or as Occasionally Being of Significance to Production in the Middle East and North Africa.

IMPORTANT	SIGNIFICANT
1. *Aleia* spp.	Armyworm
2. Aphids	Barley fly
3. Ants	*Cephus* spp.
4. *Eurgaster* spp.	Cereal leaf beetle
5. Frit fly	Cereal leaf miner
6. Locust	Gout fly
7. Stem borer	Grasshoppers
8. Termites	Hessian fly

TABLE 4. Insects Attacking Wheat (*Triticum aestivum* and *T. durum*) and Reported as Important or as Occasionally Being of Significance to Production in the Middle East and North Africa.

IMPORTANT	SIGNIFICANT
1. *Aleia* spp.	Armyworm
2. Ants	Cereal leaf miner
3. Aphids	Frit Fly
4. *Cephus* spp.	Gout fly
5. Cereal leaf beetle	Grasshoppers
6. Cutworm	Leafhoppers
7. *Eurgaster* spp.	Mites
8. Hessian fly	Stem borer
9. Locust	Thirps
10. Termites	Wheat bulb fly
11. White grubs	Wheat midge
12. Wireworms	Wheat stem maggot

As previously mentioned, the cereal rusts occupied the predominant position in regard to disease importance. One of the reasons is their ability to evolve and the losses they can cause over a large area.

The foliar disease *Septoria tritici* was mentioned earlier. The extensive *Septoria* attacks that were encountered in a number of countries in the Mediterranean basin in the late 1960's, have not re-occurred to the same degree. One should not forget, however, that when a susceptible variety is widely grown and excessive rainfall occurs throughout the growing season, the attacks of *Septoria* can be very severe. Algeria, Morocco, Tunisia and Turkey experienced epidemics of *Septoria tritici* in the 1969-71 period.

The other foliar disease reported was powdery mildew. We have little understanding or regard for the damage that this disease causes. The damage caused by it appears to be slight in this region. We know that in the Northern European climates, powdery mildew is considered a major disease, capable of causing serious losses. It is possible that the damage caused by it is dependent on the duration of the host-parasite relationship. In many cases, a fall infection occurs in the northern countries of Europe. In the Mediterranean area and in much of the Middle East, the infections frequently do not occur until spring or after the wheat plants are fairly well developed.

The other foliar disease which has come to our notice over a period of time is *Helminthosporium tritici repentis (Pyrenophora tricostoma).* This is a disease which has always been present but it has not been recognized or appreciated. We are becoming increasingly aware of the fact that it is widely distributed throughout this part of the world and severe attacks do occur.

The least appreciated disease appears to be the bunts caused by *Tilletia* species. They are extremely important in large areas where colder weather prevails, and winter habit wheats are grown. This includes much of the Turkish plateau and the higher elevations of Iran, Iraq and Afghanistan. It is also common in the hills and mountains of India and Pakistan, and it can be found in portions of North Africa. In Iraq, bunt is considered the major disease, and in Turkey it is possibly the most economic disease. Seed treatment is regularly employed in Turkey becuase of the seriousness of bunt.

Loose smut is commonly encountered, but it is not very often considered important. This probably reflects some level of resistance plus the environment in which wheat is grown. Loose smut infection occurs only at flowering time. This would limit loose smut build-ups in this part of the world because of the dry climate at flowering time. This disease, however, should be considered important, and highly susceptible varieties should be avoided.

Root rots collectively are considered important but we have no ranking as to their seriousness. They are, by all consideration, grossly under-estimated. *Fusarium* spp., *Ophiobolus graminis (Gaeumannomyces) Helminthosporium* spp., and sometimes *Pseudocerosporella* are recognized as being the principal fungi involved with the root diseases. The area in which any one of these diseases would be considered important will vary a great deal because of the differences in topography, the environmental conditions and the crop rotations practiced.

The diseases caused by bacteria are not generally found in this region. There have been a few cases of *Xanthomonas translucens* recorded, but it has not been encountered as a serious problem. The lack of bacterial pathogens probably reflects the somewhat dry atmosphere that prevails in this region.

It is interesting to note, that virus diseases have been recorded but their prevalence is limited and as a result their economic importance appears to be minor. It seems strange to find so few viruses in the center of origin. This is in spite of many man-years of looking and recording. We are aware of only the example of wheat striate virus and barley yellow dwarf virus on wheat being reported as serious in Egypt. The aphids that transmit barley yellow dwarf virus are common and widespread but we have not been aware of any other epidemics. We have observed what appears to be a yellow type virus of wheat but it has not been identified. It seems to be particularly severe on fall sown durums. In this area we need the assistance of a virologist for the identification of viruses.

Nematodes are encountered in a few instances. We have observed the cyst nematode, *Heterodera avenae,* as a serious problem in some fields of North Africa, India and Pakistan.

Barley seems to be very susceptible to the cyst nematode. The other nematodes are not often encountered; however, *Anguina tritici,* the gall nematode, can be found when farmers maintain their own seed stock improperly.

Other pests such as birds and animals are a problem of varying degrees, depending upon the location and the year. These pest problems are primarily a management issue. Some would argue that birds are a problem for the scientists to resolve, but to date our ability to effectively control them has been limited.

The reliable quantification of disease and insect losses is lacking in most countries. There are few estimates of loss due to the pests for wheat and barley since Carmer published his estimates in 1967. He placed the losses from potential wheat production in Africa from diseases and insects at 24 percent. The loss caused by diseases and insects in Asia was placed at 17 percent. The loss values for Europe and North America, where more extensive cultivation of disease resistant varieties and more intensive insect management are practiced, were placed at 10.1 and 16.4 percent, respectively. There have been no estimations presented since the introduction of the semi-dwarf wheats into this part of the world. The FAO of the United Nations has been trying to establish a system of loss assessment, but this is a program in its early stages of development. This type of measurement and the quanitfication of the importance of various diseases and insects should be encouraged.

In spite of the introduction of semi-dwarf wheats and the concentration of rust resistance we have experienced some epidemics in the last few years. For example, in Algeria, yellow rust on the variety Siete Cerros has been epidemic in the eastern part of the country for the past three years. In Turkey the reduction from potential wheat production by yellow rust was substantial in 1976. A record crop was realized but the reduction from potential approached 2 million tonnes. The quality of the wheat harvested was also affected, and consequently must be considered in any loss calculations. More recently, a yellow rust and leaf rust epidemic occurred in Pakistan during the 1978 season. The losses realized were in the area of 15-20 percent which resulted in an excessive importation of between 1.2 and 1.5 million tonnes of wheat. This can be translated into a cost of at least 200 million U.S. dollars, just for the wheat purchases alone. The sad comment is that in the above case the loss should have been avoided.

In 1978, Spain and Portugal also experienced an outbreak of yellow rust. The outbreak was sufficiently serious that the Government of Spain requested CIMMYT to review the situation. The epidemic of yellow rust occurred on two varieties. Fortunately, neither variety occupied a major acreage and the national average was not substantially affected. It did, however, point out the dangers and potentials of a rust epidemic. The yellow rust epidemic occurred in the first year of increase of one of the varieties. If the epidemic had not occurred, and if the variety had become popular with the farmers, an epidemic at some later date could have been disastrous.

We are still confronted with the problem of quantifying the magnitude of such attacks. When there are no planned loss trials available, the use of variety yield trials presents an interesting possibility for developing loss estimates. One can use the nursery mean and compare it with the susceptible variety, which would probably give a conservative measurement. Another way to develop an estimate would be to compare a resistant and a susceptible variety. The logical comparison involves the use of varieties that are known to be of equal or similar yield potential under disease free circumstances. The Ministry of Agriculture, Madrid, supplied data from a number of yield trials throughout the area of Cordoba and Sevilla where the yellow rust was particularly severe. In Table 5, the calculations are based upon the most predominant resistant variety, Cajeme 71, and the average of three resistant varieties. The two means are compared with the average yield of the newly released variety, Mahissa - 1, and Siete Cerros. Based on these calculations the losses ranged between 30-50 percent. This is probably a reasonably valid comparison, because Mahissa - 1 was released on the basis that its yielding ability was equal or greater than Cajeme 71. The varieties Anza and Yecoro 70 are also known to be in the same yield class. The variety Siete Cerros also has been considered to be near these varieties in yield potentials.

TABLE 5. The Calculated Reduction in Wheat Yields Caused by Severe Yellow Rust (YR) in the Cordoba, Spain Area in 1978. Calculations are Based on the Comparison of Resistant and Susceptible Wheat Varieties Known to have Similar Yield Potentials. (Average of Four Yield Trials; Data Courtesy of the Ministry of Agriculture, Madrid.)

Variety	YR Score**	Aver. yield Kg/ha	Percentage difference Caj.	X
Mahissa - 1	VS	3138	-41.4	-41.2
Siete Cerros	VS	3259	-39.1	-38.9
Cajeme 71 (Caj)	VR	5333		- 0.4
Mean 3 Vars. (X)*	VR	5353	+0.4	

* Average yield of the varieties Cajeme 71, Yecora 70 and Anza
** VS = Very Susceptible
VR = Very Resistant

Another way to measure yield losses is through the use of 1,000 kernel weights. This is a very sensitive measurement and many factors can affect the kernel weight. However, it does provide some calculated figures upon which judgments can be made if there are no loss trial data. The use of kernel weight can be considered a conservative measurement, since it does not always reflect all the components of loss that occur under severe rust attack. The 1,000 kernel weights of the yield trial tend to be in agreement with the losses in yield (see Table 6.). The loss estimates calculated from the yield trials and the 1,000 kernel weights should not be taken as absolute, but they can be considered as guidelines when no other measurements are readily available.

TABLE 6. The Calculated Reduction in Kernel Weight Caused by Severe Yellow Rust (YR) in the Cordoba, Spain Area in 1978. Calculations are Based on the Comparison of Resistant and Susceptible Wheat Varieties Known to have Similar Yield Potentials. (Average of Four Yield Trials, Data Courtesy of the Ministry of Agriculture, Madrid.)

Variety	YR Score**	1,000 kernel wt. -g.	Percentage difference Caj.	X
Mahisse - 1	VS	31.0	-40.4	-33.0
Siete Cerros	VS	26.5	-49.0	42.8
Cajeme 71 (Caj)	VR	52.0		+12.3
Mean 3 Vars. (X)*	VR	46.3	-11.0	

* Average yield of the varieties Cajeme 71, Yecora 70 and Anza.
** VS = Very Susceptible
VR = Very Resistant

Needless to say, the additional and further quantification of disease and insect losses is desperately needed. If we are going to assign priorities and resources to breeding for resistance, there needs to be some valid estimates developed if we are to defend our use of scarce resources and manpower.

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Summary

A review of the regional and international nursery data provides us with some idea regarding the importance of different insect and disease problems of wheat, barley and triticale. Insects would be considered of minor importance if measured by the number of reports. Experience and discussions with trained entomologists indicate a substantial amount of damage caused by insects but it it either overlooked or unappreciated except in extreme cases. The relatively small effort devoted to breeding for resistance to insects would tend to attest to the sporadic nature of insect attacks. With little or no resistance being incorporated for insects there remains only chemical control procedures in the case of serious infestations. Except for major outbreaks the use of insecticides is not a common practice in wheat and barley cultivation even in most developed nations.

Diseases are much more important as judged on the amount of reporting from nursery data. The rust diseases of wheat continue to be the predominant disease reported. Leaf rust (*Puccinia recondita*) is the most frequently encountered disease followed by yellow rust (*P. striiformis*). Stem rust (*P. graminis*) is still potentially a serious problem. The decline in stem rust epidemics probably reflects the use of earlier maturing varieties (escape mechanism) along with better resistant varieties in the higher rainfall situations.

Other foliar diseases of wheat have been regularly recorded but their importance are regarded as much more cyclic. The extensive *Septoria tritici* attacks experienced in a number of countries in the late 1960's have not been encountered since to the same

extent. It is, however, the most frequently reported disease after the rusts. Our awareness of other diseases has also increased over this same period of time. *Helminthosporium tritici-repentis (Phrenophora trichostoma)* is now recognized to be widely distributed and an important disease-causing organism throughout the region.

The bunt diseases caused by *Tilletia* spp. are still the most serious disease in large areas where colder weather prevails and winter habit wheats are grown. Loose smut is a consistent problem extracting a systematic loss each year. In certain areas powdery mildew (*Erysiphe* spp.) is considered important.

A number of other diseases are encountered but do not rank at the same level of importance. The root rots, collectively, are grossly underestimated. Certainly, *Fusarium, Helminthosporium, Cercosporella* and sometimes *Ophiobolus* are recognized as being important root rots.

In the case of barley diseases leaf rust, scald, Helminthosporium (three different species) and powdery mildew are considered the major diseases. Because barley is often grown in the marginal rainfall areas, disease potentials are greatly reduced or avoided.

The reliable quantification of disease losses is lacking in most cases. Trials designed to measure the amount of disease losses are not available in most situations. In cases where the yield potentials of standard varieties have been established an estimated loss can be calculated from variety yield trials. In the past few years, several yellow rust epidemics have been recorded in different areas in the region. The use of yield trial data offers a promising avenue by means of which we can generate some loss estimates that will have some basis.

Other pests such as nematodes, rodents and birds are not well documented and losses caused by them are at best broad estimates at this time. The subject of weeds is of major importance and this topic is receiving individual attention at this conference.

CONSEQUENCES DES MALADIES ET PARASITES DANS LA PRODUCTION CEREALIERE

E. E. Saari, J. M. Prescott, A. H. Kamel

Résumé

L'examen des données des centres régionaux et internationaux de sélection nous donne une certaine idée de l'importance des différents problèmes des insectes et maladies du blé, de l'orge et du triticale. L'importance des insectes serait considérée comme mineure si on la mesurait au nombre de rapports. L'expérience et les discussions avec des experts entomologistes indiqueraient qu'une quantité substantielle des dommages est causée par les insectes, mais on les néglige ou on les méconnaît, sauf dans des cas extrêmes. L'effort relativement restreint consacré à la sélection de résistance aux insectes tendrait à attester la nature sporadique des attaques par les insectes. En incorporant peu ou pas de résistance aux insectes, il ne reste que les procédés chimiques de contrôle dans les cas d'infestations sérieuses. Sauf en cas de manifestations majeures, l'usage des insecticides n'est pas une pratique générale dans la culture du blé et de l'orge, même dans les nations les plus développées.

Les maladies sont bien plus importantes à en juger la quantité de rapports faits à partir des données des centres de sélection. Les rouilles du blé continuent à être signalées comme maladies prédominantes. La rouille brune (*Puccinia recondita*) est la maladie recontrée le plus fréquemment, suivie de la rouille jaune (*P. striiformis*). La rouille noire (*P. graminis*) constitue encore potentiellement un problème sérieux. Le déclin des épidémies de rouille noire reflète probablement l'usage de variétés à maturation précoce (mécanisme échappatoire) en même temps que de variétés plus résistantes dans les situations de plus fortes précipitations.

D'autres maladies foliaires du blé ont été régulièrement signalées, mais leur importance est considérée comme bien plus cyclique. Les attaques étendues de *Septoria tritici* expérimentées dans un certain nombre de pays vers la fin des années 60 ne se sont plus présentées depuis avec la même ampleur. C'est pourtant la maladie le plus fréquemment signalée après les rouilles. Notre connaissance d'autres maladies s'est également accrue durant cette même période. On reconnaît maintenant que *Helminthosporium tritici-repentis* (*Phenophora trichostoma*) est largement répandue et est un organisme responsable d'importantes maladies dans toute la région.

Les caries du blé causées par *Tilletia* spp. sont encore la maladie la plus sérieuse dans de vastes régions où prédomine un temps plus froid et où l'on cultive des blés d'hiver. Le charbon nu est un problème de taille qui provoque des pertes systématiques chaque année. Dans certaines régions, le blanc des graminées (*Erysiphe* spp.) est considéré comme important.

On trouve un certain nombre d'autres maladies, mais elles n'atteignent pas la même niveau d'importance. La cercosporellose collectivement est grossièrement sous-estimée. Certainement, *Fusarium, Helminthosporium, Cercosporella* et parfois *Ophiobolus* sont reconnues comme d'importantes cercosporelloses.

Dans le cas de l'orge, la rouille brune, les brunissures, *Helminthosporium* (3 espèces différentes) et le blanc des graminées sont considérées comme les maladies majeures. Du fait que l'orge est souvent cultivée dans les régions à précipitations marginales, les possibilités de maladies sont grandement réduites our supprimées.

Dans la plupart des cas, on manque d'une quantification fiable des pertes dues aux maladies. Les expériences destinées à mesurer le montant des pertes dues aux maladies ne sont pas disponibles dans la plupart des situations. Dans les cas où les potentiels de rendement de variétés standard ont été établis, on peut calculer une perte approximative à partir des expériences de renderent variétal. Ces dernières années, plusieurs épidémies de rouille jaune ont été signalées dans différentes zones de la région. L'utilisation des données des expériences de rendement offre une voie d'accès prometteuse au moyen de laquelle nous pouvons avancer certaines estimations de pertes qui auront une certaine base.

Il n'y a pas de bonne documentation sur d'autres parasites tels que les nématodes, les rongeurs et les oiseaux, et les pertes dont ils sont responsables sont a au mieux des estimations grossières à l'heure actuelle. Le sujet des mauvaises herbes a une importance majeure et bénéficie d'une attention individuelle à cette conférence.

THE EXPLOITATION OF SPRING WHEAT POTENTIAL

G.C.M. Sage *

Physiologists at the Plant Breeding Institute have calculated the potential yield of grain obtainable under ideal conditions in the UK, from the best wheat and barley varieties now available (Austin, 1978). The method used for the calculation was to estimate the potential photosynthesis during the grain filling period from anthesis until maturity, deduct respiratory losses, add the estimated contribution made to grain weight from photosynthesis before anthesis, and to express the resulting weight on the usual basis of 15 per cent moisture. The calculations assumed average values of daily solar radiation appropriate to the grain filling period in eastern England, which is where the bulk of cereals are grown, that disease was absent throughout, and that throughout growth, temperature and water and nutrient availability were non-limiting. It was also assumed that the numbers of grains set and their capacity to fill does not limit the attainment of maximum yield.

It was realized that these assumptions would be valid only in very favorable years and only over a very small proportion of the total area devoted to cereal growing. However, the calculations resulted in maximum potential yields of between 11.4 and 12.9 t/ha for wheat and 9.8 and 11.1 t/ha for barley, depending on the figures used for maximum leaf area indices and respiratory loss of photosynthate. Now these figures are extremely close to the record yields of winter wheat and spring barley that have been grown in the UK, which are about 12 and 10 t/ha respectively, so it would seem that in Britain our rare record high yields are already at the level of the calculated maximum potential yields, given present varieties. Since currently the national average yields obtained by our farmers are about 4.7 t/ha for wheat and 4.0 t/ha for barley it can be said that nationally we achieve less than half our current potential.

The reason for this discrepancy, and others like it round the world is, of course, that in most situations environmental factors severely limit crop performance. The factors assumed to be non-limiting in the calculation of potential maximum yields, and which were apparently non-limiting in the record crops, that is incidence of disease, temperature, water and nutrient supply, are all to a greater or lesser extent beyond the farmer's control and in practice, they limit plant growth because they do not usually occur at optimum levels at the optimum time. The major objective of studies in agronomy and crop husbandry is to identify and try to reduce the effects of environmental factors which cause variation in yield and the extent to which they are successful determines to a large extent, the strategy available to plant breeders.

In those situations where a very high degree of environmental control is available to farmers in terms of such things as timing of husbandry operations, fertilizer use and irrigation, the environment can be closely defined and reliably reproduced. In these circumstances breeders can seriously consider aiming for varieties in which the potential maximum yield itself is increased by such innovations as, for example, increased maximum rates of photosynthesis. Such varieties would be even more dependent than current varieties on the occurrence of optimum environmental circumstances at the right time and would have a very narrow adaptation.

In most dry land situations, however, where climatic conditions are unpredictable, fertilizers expensive and irrigation unavailable, farmers have relatively little control over most environmental factors. In these circumstances the breeder's objective is not so much to extend the maximum yield potential of his crop, but to close the gap between practice and current potential. To do this he must aim to produce varieties which can function well despite variations in environmental circumstances, in other words varieties that are

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environmentally resistant. Such varieties would be expected to raise yields by roughly similar percentages in all fields in all years and consequently would have to have a very wide adaptation.

In the early days of the CIMMYT programme a number of spring wheat varieties were produced, such as Pitic 62, Siete Cerros and other varieties derived from the 8156 population, which had very remarkable world-wide adaptation. They grew well in the UK, in the absence of disease, and their exploitation in the Plant Breeding Institute spring wheat breeding programme has begun to change the adaptation of UK spring wheats.

Spring wheat breeding in the UK is of much more recent origin and has been on a much smaller scale that has the breeding of winter wheat. Before the advent of semi-dwarf types, British spring wheat breeding depended heavily on Scandinavian, Dutch and German varieties and did not have a very wide genetic base. Thus at that time it was probable, although we had very little evidence, that spring wheats in the UK were less well adapted to British conditions than winter wheats. Our response was to use the CIMMYT wheats with wide adaptation as parents in the hope that we would broaden the genetic base of our material and improve adaptation.

Subsequent research has in fact indicated that UK spring wheats are less well adapted to British weather conditions than other longer established crops (Sage, 1979). This conclusion arises from analyses I have carried out of the relationship between national yields and national average values of simple weather factors such as temperature, rainfall and daily sunshine hours. I chose national average figures for the analysis because I hoped that by using these coarse figures, local interaction between crops and weather would be averaged out, and that I would thus get more reliable general comparisons between crops.

I took as my yield data, the national average yields of winter wheat and spring barley, as published by our Ministry of Agriculture, for the years 1948-1976 and, in addition, for the same period I calculated the annual mean yield of all the varieties of winter wheat, spring wheat and spring barley in the national trials system run by our National Institute of Agricultural Botany (NIAB). I thus had yields for five crops over a 29 year period. However, to remove from my calculations the effect of the steady increases in yield, which occurred during this period, I expressed yield not in absolute terms but as deviations from the fitted linear trend.

The weather data I used were the English national average figures for monthly mean air temperature, monthly rainfall and monthly mean number of sunshine hours per day for each of the months covering the major part of the growing season from February to August. I thus had seven monthly figures for each of three components of the weather, giving me 21 weather factors in all, for each of the 29 years. Using this data I carried out, for each crop, a stepwise multiple regression of yield deviations on the weather factors, dropping out successively those factors which contributed least to the regression mean square.

The results are presented graphically in Figure 1. Here the percentage effect on yield of the average variation found in the most influential weather factors are shown as bars. Solid bars indicate temperature, open bars sunshine hours and hatched bars rainfall. If there is a bar present, it shows that the weather factor was important in influencing yield, and its size shows just how important, with positive effects being drawn above the line and negative effects below.

Fig. 1. Most important weather influences on yield in five UK cereal crops.

FEB MARCH APRIL MAY JUNE JULY AUGUST

National Average Wheat NIAB Winter Wheat NIAB Spring Wheat

National Average Barley NIAB Spring Barley

Percentage effect on yield expected from a one standard deviation change in those weather factors involved in the most significant multiple regressions.

In all the crops, the yield benefits from warm temperatures before anthesis which occurs in June, presumably because this results in bigger canopies and bigger ears, but at and after anthesis cool temperatures promote yield presumably because these extend leaf area duration. In June or July, sunny weather promotes yield in all the crops presumably by increasing the net amount of photosynthesis that occurs while the grains are filling.

These results are reasonable because of the consistency of pattern of response between crops and because this pattern corresponds to expectations from our knowledge of crop physiology. They are, however, slightly surprising in one respect, and this is that around the anthesis period in early June, temperature is shown to have a greater influence on yield than rainfall, the major effects of which are confined to the end of the growing season where rainfall has a negative effect on all crops, presumably because it causes lodging. Water supply is known to be a major influence on crop development around anthesis and I suspect that the predominant influence of temperature rather than rainfall in these results arises because of the very generalized nature of my data. It is quite possible that when dealing with national average figures, temperature is a better measure of the level of water available to crops than is a measure of the actual precipitation, and that the temperature effects noted here are mediated as far as the plants are concerned, via the plants' water relations.

Whatever the nature of the actual physiological response, spring wheat appears to be more sensitive than either winter wheat or spring barley to the prevailing temperatures around anthesis in May and June, which means that it is likely to meet its ideal growing conditions far less frequently than either of the other two crops and consequently is less well adapted. These results seem to pinpoint May and June temperatures as a major restriction of the expression of potential yield in spring wheat in the UK, and consequently, as a major element in this crop's relative lack of adaptation to British growing conditions.

In fact, as shown in Figure 2, for spring wheat most of the extreme deviations from the linear trend of yield that have occurred during the last 20 years were associated with extremes of the ratio of national average May to June temperatures. The four largest positive deviations occurred in years with warm Mays and cool Junes. Of the five largest negative deviations, three occurred in years with the three lowest May to June temperature ratios, that is years with relatively cool Mays and hot Junes, and the two exceptions, which occurred in 1958 and 1978, were years where yield was restricted because of very late sowing in cold soil and wet harvests. Thus, growing temperatures around the anthesis period do seem to be of crucial importance for the expression of high yield in spring wheat in the UK.

Fig. 2. Most extreme positive and negative deviations from the linear trend of NIAB spring wheat trial yields and national May/June temperature ratios.

Year	Deviation from linear trend (T/ha)	National average May temperature/ June temperature	Ranking of temperature ratio
1964	+0.841	0.95	1st highest
1971	+0.744	0.95	2nd highest
1977	+0.577	0.84	4th highest
1972	+0.485	0.90	3rd highest
1975	-0.324	0.68	1st lowest
1978	-0.572	0.82	6th highest
1958	-0.582	0.83	5th highest
1968	-0.597	0.69	2nd lowest
1976	-1.073	0.71	3rd lowest

During the last four years, 1975-1978, all of which were years of extreme yield deviation from the trend, the highest yielding variety in the *National Institute of Agricultural Botany* trials grown all over England and Wales has been a variety called Highbury. This variety is the most successful selection from the crosses that we made at the Plant Breeding Institute between European lines and the widely adapted CIMMYT derived lines. Highbury is a selection from the cross between a breeding line, derived from the European spring wheats Svenno and Jufy I, and the Indian variety Sona 227 or Kalyansona, which was selected in India from the 8156 population developed in Mexico. Highbury has now been officially recommended to farmers, is beginning to be grown comercially, and has introduced a radically new phenotype, compared with all other commercially used spring wheat varieties, because, like Sona 227 its parent, it is a semi-dwarf type and it is awned.

Its performance in national trials over the last four years is shown in Figure 3. Relative to the control varieties, Maris Dove and Sappo, the yield of Highbury was best in 1975 and 1976, years which were unusually hot, sunny and dry in the later part of the growing season. Its yield advantage fell off somewhat in the very high yielding conditions of 1977, which was a cool, dry, but reasonably sunny year, and was almost non-existent in 1978, which had a very late cold spring, and thereafter was cool, very overcast, and later on, very wet. Highbury thus appears to thrive, relative to the conventional types, when yield is restricted by hot, dry conditions, but is only as good as the conventional types when yield is restricted by cold sunless and damp conditions. Thus, in respect of hot dry conditions at least, Highbury appears to be more environmentally resistant than other varieties and thus to have, in this one respect, a greater breadth of adaptation.

Fig 3. NIAB Spring Wheat Trial Yields and Climatic Conditions 1975-78.

		Year			
		1975	1976	1977	1978
Yield per cent of	Mean of controls t/ha	3.89	3.18	4.90	4.05
Controls	Variety (mean + sd t/ha)				
	Maris Dove (3.90 ± 0.59)	97	100	94	100
	Sappo (4.11 ± 0.83)	103	100	106	100
	Highbury (4.61 ± 0.70)	119	126	114	104
Mean air temperature	1941-1970 averabe, C				
per cent of 1941-1970	April ,ay 10.2	92	101	91	90
average	June July 15.5	105	115	94	94
Mean daily sunshine	1941-1970 average, hours				
hours, per cent of	April May 5.79	93	96	112	89
1941-1970 average	June July 6.34	126	132	89	81
Mean rainfall, per	1941-1970 average, mm				
cent of 1941-1970	April May 62.5	94	68	82	79
average	June July 67.0	65	37	81	117

At first, I suspected that Highbury's particular advantage in hot dry conditions was due to greater drought resistance, resulting largely from its unique possession of awns. In fact, this is very likely to be at least part of the reason for Highbury's performance in 1975 and 1976, since a separate research project at the Institute has shown that awns do confer a yield advantage in the UK under the kind of drought conditions that prevailed in those years (Olugbemi *et al.*, 1976). However, the possession of awns, which Highbury derived from its exotic parent Sona 227, is not necessarily the only, or even the most important, element of drought resistance and since Sona 227 was selected in both Mexico and India under irrigated conditions there is no reason to suppose that it conferred any other elements of drought resistance to its derivative Highbury.

However, Sona 227 was selected under considerably hotter conditions than prevail in the UK, so it is possible that it has conferred on Highbury a greater tolerance of, or resistance to, high temperatures than is possessed by conventional European spring wheats. If this is so, and since the multiple regression results I referred to earlier indicate that over a long period of years high temperatures during grain filling have been particularly detrimental to yield in spring wheat, then the exploitation of Sona 227 in the production of Highbury may be a significant step in the direction of widening the adaptation of British spring wheats, and hence in closing the gap between practice and potential.

However it must be remembered that the higher yields of the new variety Highbury are likely to be the result of better adaptation improving the realizable potential of the crop rather than of improvements in its maximum potential. In practice, spring wheat is grown on only about 5 percent of the wheat area in the UK and in general, yields 20 percent less that winter wheat. Thus the national average yield of spring wheat, at 3.8 t/ha, is even further below the theoretical maximum wheat yield of about 12 t/ha than the current overall wheat national average yield. Obviously many other constraints to yield, besides response to growing temperatures, need to be identified and overcome, either by agronomic or genetic means, before yields approaching the maximum potential become widespread.

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Summary

Physiologists in the UK have calculated that the maximum potential yield of wheat and barley obtainable under ideal conditions in Britain is about 12 t/ha for wheat and 10.5 t/ha for barley. The highest yields ever recorded in farmers' fields are close to these figures. However, since the national average yields obtained by our farmers are 4.7 t/ha for wheat and 4.0 t/ha for barley, it can be said that nationally we achieve less than half our theoretical potential. This discrepancy must be due to adverse environmental factors.

Multiple regression analyses have indicated that temperature levels both before and after anthesis are of great importance for the expression of high yield and that spring sown wheat is more sensitive than either winter wheat or spring barley to the temperatures prevailing at this time. This means that spring sown wheat is likely to meet its ideal growing conditions far less frequently than either of the other two crops and consequently is less well-adapted.

An example of how this constraint to high yield might have been partially overcome by breeding is the new UK spring wheat variety Highbury. Highbury was derived from the Indian varieta Sona 227, which was itself derived from the CIMMYT 8156 population as was Siete Cerros and several other widely adapted varieties.

Highbury has yielded best, relative to other European spring wheat varieties, in hot dry conditions and only as well as other varieties in cool damp conditions. This wider adaptation of Highbury may well be due to factors derived from its non-European parent which was selected under considerably hotter conditions than prevail in the UK.

L'EXPLOITATION DU POTENTIEL DU BLE DE PRINTEMPS

G. C. M. Sage

Résumé

Les physiologistes du Royaume-Uni ont calculé que le rendement potentiel maximum du blé et de l'orge que l'on puisse obtenir dans des conditions idéales en Grande-Bretagne est d'environ 12 tonnes/ha pour le blé et 10,5 tonnes/ha pour l'orge. Les plus hauts rendements jamais signalés dans les champs des agriculteurs sont très proches de ces chiffres. Cependant, puisque la moyenne nationale des rendements obtenus par nos agriculteurs est de 4.7 tonnes/ha pour le blé et de 4,0 tonnes/ha pour l'orge, on peut dire que sur le plan national nous réalisons moins de la moitié de notre potentiel théorique. Cette contradiction doit être due à un environnement défavorable.

De nombreuses analyses de régression ont indiqué que les niveaux de température avant comme après la floraison ont une grande importance pour l'obtention de hauts rendements, et que le blé semé au printemps est plus sensible aux températures qui règnent à cette époque que n'importe quel blé d'hiver ou orge de printemps. Cela signifie que le blé semé au printemps est bien moins fréquemment susceptible de trouver des conditions idéales de croissance que les deux autres cultures; par conséquent, il est moins bien adapté.

La nouvelle variété britannique de blé de printemps Highbury est un exemple de la manière dont on aurait pu, par la sélection, partiellement venir à bout de cet obstacle à un rendement élevé. Highbury était dérivé de la variété indienne Sona 227, elle-même dérivée de la population CIMMYT 8156, tout comme Siete Cerros et plusieurs autres variétés largement adaptées.

Highbury a eu le meilleur rendement par rapport à d'autres variétés européennes de blé de printemps dans des conditions de chaleur sèche, et au moins aussi bon que d'autres variétés dans des conditions froides et humides. Cette plus large adaptation de Highbury peut bien être due à des facteurs dérivés de son parent non-européen qui a été sélectionné dans des conditions considérablement plus chaudes que celles qui règnent au Royaume-Uni.

VII. SEED PRODUCTION

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CEREAL SEED PRODUCTION IN TURKEY

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The area sown to cereals in Turkish agriculture in 1977 was over 46 per cent of the total cultivated area. Including fallow land used for cereals, the figure reached almost 75 per cent. Wheat leads in importance, with barley second.

Seed production has been closely related to cereal production. The area in cereals in 1950 was 7.2 million ha, with production of 6.7 million t. By 1955 the area had increased to 10.7 million ha and production of 10.9 million t. By 1965 the respective figures were 11.8 million ha and 13.1 million t.

Demand for seed increased with this rapid expansion in area. The first stage of a seed industry was organized in this period. Existing state farms were combined in 1950 under the Directorate of State Farms and concentrated on seed production. The need for seed certification was evident by 1953. Several agronomists studied seed technology abroad, and a department of seed certification was established in the Ministry of Agriculture after their return. A seed testing laboratory was established in the agronomy department at Ankara University, and between 1956 and 1959, seeds were analyzed in this laboratory. An Institute for Seed Testing and Certification was established in Ankara in 1960. A member of the International Seed Testing Association since 1962, the institute is authorized to issue international certificates. The institute is supported by a station at Yesilkoy-Istanbul and laboratories at Izmir and Tarsus-Adana. A law of registration, control and certification of seeds was enacted by the National Assembly in 1963.

During this period seed production was 50,000 to 70,000 t, with some years up to 100,000 t. Emphasis was given to seed production by private seed companies and farmers contracted through the state farms.

An intensified campaign was undertaken to expand cereal production through increased yield per unit area. The campaign was based on a package including large quantities of seed of high yielding varieties, new technology, a dynamic extension service to transfer the technology, supply of production inputs, credit, coordination, etc. By 1976 the area sown to cereals was 12.6 million ha, and production had increased to 22.5 million t. Between 1970 and 1976, the increase in wheat yield was 69 per cent and for all cereals, 43 per cent. The country became self-sufficient in cereals, with several million tons available for export.

Seed multiplication was one of three cereals projects organized at the start of this intensive campaign. Its objective was to increase seed production and distribution capacity. The General Directorate of State Farms has 22 farms located in different regions, with about 200,000 ha in area. Half is planted to cereals and half is left to fallow. The production capacity of the farms has reached 100,000 t annually. Seed processing and storing capacity on the farms was increased to 300,000 t. Through the contracted seed production activity of the state farms, larger quantities of certified seed can be produced. Cereal seed production and distribution is at a level of about 200,000 t.

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HOW THE SEED INDUSTRY FUNCTIONS

The nature and functions of the seed industry in Turkey include the following:

A. Seed legislation, regulations and quality control

Certified seed activities are regulated by law. Among objectives and activities are: control of varietal purity and physical characteristics; registration, control and certification of seeds produced, sold and distributed within the country or imported or exported; control and inspection of private and official organizations that deal with seeds; Ministry of Agriculture decisions on cultivars, seeds of which are produced, distributed, sold, imported and exported. (Seed exchanges between farmers are not under provisions of the law, since they are not regarded as seed trade.)

Cultivars are registered under a system of the Ministry of Agriculture. Cultivars of foreign origin are registered under their own names after adaptation tests have been made in the country. A developer of a new cultivar gives material to the testing organization for test at three locations for three years. New superior cultivars are registered, named and released. After publication in the official gazette, a new cultivar is included in the certified seed production program.

Four classes are recognized in seeds for cereals: breeder seed; foundation seed; registered seed; and certified seed.

Cereals are required to be multiplied through two generations for each seed class. Some years certified seed is multiplied one more generation to fulfill the need for certified seed. For certification, field inspection, laboratory testing and analysis are required. Certified seeds are sealed and labeled, with most distributed in 50-kg cloth bags.

Many scientists involved in variety improvement in the national cereal research project believe now that some regulations limit the rapid increase of new cultivars. Variety development is a team effort now, involving different disciplines—a dynamic function with countrywide organized testing. Existing regulations delay the new cultivar in its availability to farmers.

B. Seed production

The four classes of seed are produced by the following: Breeder seed—by the originating or sponsoring plant breeder or institute; Foundation seed—by the research institute under control of the breeders; Registered seed—by the state farms; Certified seed—by the state farms and contracted farmers.

The state farm contract with a farmer indicates that he will grow certified seed. Credit is available to the contracted farmers. When the crop is at the right stage, certification experts apply their controls. After harvesting and processing, seed samples are sent to a laboratory for test and certification. The state farm buys the seed from the farmer, paying the premium for certified seed.

It is expected that contracted farmers will be organized into cooperatives of grower organizations, which will play an important role in certified seed production.

The cereal grower is expected to obtain certified seed once in a 5-year period. It is thus planned that the industry will produce 400,000 t of certified seed.

C. Seed price

Seed prices are not subsidized. Price is determined by these elements: highest price of the crop at the Soil Products Office; premium for growing certified seed; and expenses of processing, storing, transporting, etc.

D. Seed distribution

Seed requirements for each province are determined from reports of the extension office. The General Directorate of Agriculture then allocates the available seed, identifying the source to each province. The provincial extension office organizes further distribution. Farmers can get credit for seed from the Agricultural Bank; special arrangements through this bank are possible to provide credit to small farmers—the extension office is involved.

E. Coordination and policy decision

A *coordination council* provides high-level coordination among various seed committees.

The *project application committee* coordinates actions among various organizations responsible for seed production, determines annual seed requirements for each seed class—according to targets of the Five-Year Developmental Plan and Annual Programs; divides tasks of seed production and distribution among the related organizations; announces seed requirements to producing organizations; examines programs of the producing organizations and submits them to the state planning organization; provides for application of programs after approval; makes decisions on credits, premiums and seed prices in the market; submits its decisions on premiums to the coordination council, and after approval provides for their application.

The *National Seed Advisory Committee* acts in an advisory capacity to the project application committee.

In addition to the certified seed production system, producers are aided by seed processing facilities at convenient locations. There are now 1,300 such units with a total capacity of 2,000 t per hour. The number is to be increased to 6,000 units as soon as possible.

Seed is one of the important inputs in the country's program for intensified cereal production. A strong seed multiplication program is needed for more rapid use of results from the cereals research program. Our emphasis on seed multiplication will continue so that new cultivars can have a favorable impact on cereal production.

Summary

Cereals are the most important food crops in Turkey, covering 46.1 percent of the cultivated land. Between 1950 and 1965, the area cultivated with cereals has increased from 7.2 to 11.8 million hectares. An increase in the national seed production capacity has been an essential factor in production increases. In 1950, all state farms were placed under the same administration and given the responsibility for national seed production. During the 1953-1962 period, the seed production industry developed very fast,from seed production a base of 50 to 70 tons per year.

Despite these production increases, the country still needed to import wheat in the early 1960s. As result, the government initiated a campaign to intensify wheat production in the latter part of the 1960s. Total cereal production has increased from 13.1 million tons in 1965 to 22.5 million tons in 1976.

A major factor that contributed to this success was the availability of large quantities of good quality seed of high-yielding varieties. Nowadays, the state farms produce 200,000 tons (as a mean) of seed per year for distribution.

Turkish seed legislation recognized four classes of seed: breeders' seed, foundation seed, registered seed, and certified seed. In order to keep good purity standards, cereals are required to be multiplied through two generations for each seed class. In some years, when the seed is scarce, the certified seed might be multiplied one

more generation. This massive and strictly controlled seed multiplication system allows Turkey to produce large quantities of good seed of the new varieties in a short time.

The paper briefly describes the different seed classes, national seed legislation, prices and distribution systems, as well as the role of the coordination council in the decisions related to seed regulations.

PRODUCTION DE SEMENCE CEREALIERE EN TURQUIE

Basri Devecioglu

Résumé

Les céréales sont la plus importante culture en Turquie et elles couvrent 46.1% de la terre cultivée. Dès 1950 à 1965 la superficie sous la culture céréalière a augmentée de 7.2 millions d'hectares à 11.8 millions d'hectares. Une augmentation de la production de semence est devenue essentielle et en 1950 toutes les fermes d'état étaient soumises à une seule administration et on leurs donnait la responsabilité de ae concentrer sur la production de semence. De 1953 à 1962 l'industrie de semence s'est développée très rapidement et durant la période la production annuelle de semence était 50-70 milles tonnes.

Malgré ces accroissements, le pays nécessitait toujours de l'importation de blé. Comme resultat, le gouvernement, à la fin des années 60, a initié une campagne pour l'intensification de la production de blé et durant les dernières dix années la production céréalière totale a augmenté de 13.1 à 22.5 millions de tonnes.

Un des facterus majeurs conduisant à ce succès était la disponibilité de grandes quantités de semence à bonne qualité des variétés à haut rendement. A présent les fermes d'état produisent environ 200,000 tonnes de semence annuelles pour la distribution.

La législation de semence reconnaît quatre classes de semence. Il y a la semence de sélectionneur, la semence de fondation, la semence enregistrée et la semence certifiée. Afin de maintenir une bonne purité, chaque classe de semence n'est autorisée a avoir que deux générations de multiplication. Dans quelques années de manque, la reproduction de semence certifiée est permise pour une année de plus. Ce système de multiplication massive sous un contrôle strict permet à la Turquie de produire de large quantités de bonne semence de plus nouvelles variétés dans un très court.

Le document donne des descriptions détaillées des differentes classes de semence, la législation, les prix et la distribution de semence et le rôle du conseil de coordination en décidant sur les régulations de semence.

SEED PRODUCTION AND CERTIFICATION IN TUNISIA

A.R. Maamouri *

Varietal improvement work was started in Tunisia at the beginning of this century. Starting in 1926, selection within local populations, followed by hybridization, has resulted in many pure lines.

To put these new lines at the disposal of the farmers, the need to multiply cereal seeds, especially wheat, and to have it under proper control, was realized. This objective was attained because a few years later, these new varieties covered almost all the cereal area.

However, the seed production rules have been revised many times to rectify defects.

Taking into account new developments in research on varieties of high productivity, new legislation was enacted in 1971 to cover all aspects of the seed industry in Tunisia, such as: official varietal catalogue, production, conditioning, storage, the marketing of certified seeds and the control of seed quality.

The actual organization of seed production and certification in Tunisia is as follows:

The National Agronomic Institute of Research (INRAT), the only official organization in charge of the creation and experimentation of new varieties maintains the official cereals catalog. An official commission meets periodically to add to or to delete varieties from the official list. Only the varieties appearing in the catalog can be marketed.

The multiplication of pre-base seeds is carried out by two cooperatives on two farms under the direct control of INRAT, which enforces the technical aspect of multiplication and assists in the choice of plots and the control of the different generations.

The basic seeds are produced from pre-base seeds by the cooperatives. Production is subjected to certification procedures. The certified seeds are produced from the basic seeds.

One or more inspections are made during the growth cycle of the crop by inspectors of the Ministry of Agriculture to check the varietal purity and disease incidences. Samples are taken from the seed processing stations, and laboratory analyses of seeds samples are made, seed lots are labelled and sealed.

There are also post controls to verify the functioning of the system and to check for varietal purity, identity and disease incidences. To be certified, the seeds must meet certain norms which are defined by the law.

Despite a few problems, the seed production program in Tunisia has provided sufficient quantity of quality seeds. There has been good collaboration between the different agencies involved in the program. The emphasis has been on the multiplication of high yielding varieties which the farmers have demanded.

To encourage farmers to adopt the new varieties, the government has instituted a system of seed procurement in exchange of commercial wheat. This is done especially to favor the small farmers. In addition, bank credit was established to assist as many farmers as possible.

For example, during the year 1977-78, 200,000 quintals (Qx) of seeds were produced, consisting of 76 percent durum wheat and 24 percent bread wheat. More than 95 percent of this is represented by the new varieties. About 147,000 Qx of seeds were sold, consisting of 117,000 Qx of durum wheat and 30,000 Qx of bread wheat, which represent an adoption of about 22 percent and 29 percent of the durum wheat and bread areas, respectively. This estimation covers only northern Tunisia. Due to this program and the

* INRAT, Tunisia

encouragement of the government, the new varieties covered more than 300,000 ha in northern Tunisia, in a total of 640,000 ha. As a consequence, the use of fertilizers, nitrogen fertilizers in particular, has increased proportionately.

It is difficult to estimate the increase in production due to the utilization of certified seeds. Tunisia is still deficient in wheat production. The use of new varieties has definitely allowed Tunisia to increase its wheat production.

PRODUCTION DE SEMENCES ET CERTIFICATION ET SES IMPLICATIONS SUR LA PRODUCTION DES CEREALES: UNE ETUDE DE CAS SUR LA MANIERE DONT CELA REPOND AUX BESOINS DES AGRICULTEURS TUNISIENS

A. Maamouri

C'est au début de ce siècle que l'amélioration variétale des céréales a commencé en Tunisie. La sélection à l'intérieur des populations locales puis l'hybridation ont permis dès 1926 la réalisation de plusieurs lignées pures.

Pour mettre ces nouvelles lignées à la disposition des agriculteurs, on a éprouve la nécessité à peu près à la même époque d'organiser la multiplication de semences céréalières, particulièrement du blé, de la contrôler et de la réglementer. L'objectif souhaité était atteint, puisque quelques années plus tard ces nouvelles variétés couvraient la quasi totalité des superficies emblavées en céréales.

Cependant la législation réglementant cette production de semences a été à plusieurs reprises remaniée compte tenu des lacunes qu'elle comportait.

Ce n'est qu'en 1971 et étant donné l'importance prise par la recherche en matière de blé et la mise au point de nouvelles variétés productives qu'une nouvelle législation a été élaborée englobant tous les aspects de "l'industrie de semences tunisienne", à savoir: catalogue officiel des variétés, production de semences mères, production, conditionnement, stockage et commercialisation des semences certifiées, contrôle de la qualité des semences.

L'organisation de la production et de la certification des semences en Tunisie est actuellement la suivante:

— L'Institut National de la Recherche Agronomique, seul organisme officiel chargé de la création et de l'expérimentation des variétés, tient le catalogue officiel des variétés de céréales. Une commission officielle se réunit périodiquement et décide de l'inscription ou de la radiation des variétés. Seules les semences des variétés inscrites dans ce catalogue peuvent être commercialisées.

— La multiplication des *semences-mères (ou semences pré-bases)* est effectuée par les deux coopératives dans deux domaines sous le contrôle direct de l'I.N.R.A.T. qui impose le schéma technique de multiplication, participe au choix des parcelles et contrôle à plusieurs reprises par an les différentes générations.

— Les semences de base sont produites à partir des semences mères par les coopératives. Elles sont soumises à un processus de certification.

— Les semences certifiées sont produites à partir de semences de base. Elles sont soumises à un processus de certification qui comporte plusieurs étapes.

— Une ou plusieurs inspections au champ en cours de végétation par les agents contrôleur du Ministère de l'Agriculture et ce en vue notamment de la pureté variétale et de l'état sanitaire.

— Echantillonnage des semences à la station de conditionnement.

— Analyse au laboratoire des essais de semences.

— Etiquetage et plombage des emballages.

— Enfin contrôle postérieur au champ en vue de contrôler la bonne marche du système et de contrôler encore la pureté et l'identité variétale ainsi que l'état sanitaire.

SEED PRODUCTION IN THE SYRIAN ARAB REPUBLIC

Yassin Swiedan *

Wheat is the most important agricultural crop in Syria because of its economic value and its nutritional value. An expansion of production can come from increasing the area of cultivated land, but this factor is limited by the quantity of available water (rain and irrigation). Increasing yield (kg/ha) is another factor which offers the main scope to increase production by improving varieties, genetics and the proper use of environmental factors.

Varietal improvement work started in Syria at the beginning of this half century with selection within local varieties and recently in Mexican varieties.

Responsibility for seed multiplication

The Directorate of Agricultural Research is the official organization in charge of the creation and experimentation of new varieties and the multiplication of nucleus seed. This seed is given to another commission which is responsible for other stages of seed multiplication, that is the General Agency of Seed Multiplication (GASM), which started work in 1975-76.

Stages of seed multiplication

1. Nucleus seed stage. Seed is produced from breeder wheat under the direct control of the breeder himself.
2. Foundation seed stage. Seed is produced from nucleus seed under the direct control of GASM which enforces the technical aspects of multiplication.
3. Registered seed stage.
4. Certified seed stage.
5. Improvement seed stage for distribution of seeds to farmers.

Field inspection

One or more inspections are made during the growth cycle of the crop, by technical persons from the Directorate of Agricultural Research and GASM to check varietal purity, distance between fields, agronomy, freedom from weeds, other varieties, diseases, etc. After harvest seed samples are taken for analyses in the laboratory.

Number and times of inspection

Three inspections are made—the first in January, the second in March and the third in May.

* Director of agricultural Research, Damascus

Inspection report

The report of inspection includes the farmer's name, address, location, area, variety, rate of seeding, date of seeding, date of harvesting, rate of fertilizers, weed and disease contents, agronomy, etc. There is also another report which includes information on the inspection of stores and the analysis of seed.

Seed Production

The Ministry of Agriculture supports these seed multiplication agencies and it hopes to cover all cultivated areas with improved seeds annually. So the agency of seed multiplication dealt with production of the following quantities through three years ago. Seed production statistics in tonnes are:

1976	1977	1978
1,458	3,846	22,397

It is planned to produce 50,000 tonnes in 1979 in order to cover the whole of the irriagted area and 50 per cent of the First Zone (high rainfed).

Constraints

There are several constraints, such as the non-availability of highly trained agronomists, administrative staff, credit, transport, stores and seed cleaning equipment.

The Varieties

Varieties which have been multiplied include Senator Capelli, Hourani, Shihani, Jori 69, Jaziarat, Florence Aurore, Mexipak and Siete Cerros. These varieties have been evaluated and released since 1973.

Distribution of certified seeds

To encourage farmers to adopt the certified seeds, the Cooperative Agricultural Bank assists farmers with low prices, which in the 1978-79 season were about 1000 Syrian pounds/tonne.

PRECONCEPTION

The Cereal Department in the Directorate of Agricultural Research works to find new varieties by breeding and selection. Research workers and extension personnel try to guide farmers to use certified seed. The methods used are established extension fields, training methods, field days, radio, television, farm meetings and visits. These methods encourage farmers to adopt the certified seeds. In the near future, we hope to cover all our cultivated land with improved seeds.

Summary

Wheat is the most important food crop in Syria. Further expansions in production through increasing the area of cultivated land are limited by the availability of water (rain and irrigation). Thus, production expansions have to come mainly from yield increases. The utilization of improved varieties is one of the most important factors to reach this objective. The paper describes the seed production system in Syria. The major identified constraints in successful seed production and distribution are the lack of properly trained scientists, lack of administrative personnel, lask of credit, lack of transportation, storage, problems with seed purity, and facilities for seed conditioning. The Syrian program hopes to produce a mean of 50,000 tons of certified seed during 1979. This will cover 100 percent of the irrigated land and 50 percent of the land with adequate rainfall.

LA PRODUCTION DE SEMENCE EN SYRIE

Y. Swiedan

Résumé

Le blé est culture d'alimentation la plus importante en Syrie. L'expansion de la culture aux superficies nouvelles est limitée par le manque de précipitation adéquate ou irrigation. Donc, l'augmentation de la production doit venir de l'augmentation du augmentation de rendement par unité de superficie. La disponibilité et l'utilisation de semence de qualité des variétés ameliorées est l'un des plus importants facterus dans l'accomplissement de ce but. Le document décrit le système de production de semence en Syrie. Les majeures contraintes identifiées sont le manque du potentiel humain entrainé, des facilités adéquates de personnel administratif, de crédit, de transport, d'emmagasinage et de purification et de conditionnement de semence. Le programme syrien espére produire environ 50,000 tonnes de semence certifiée durant l'année 1979. Cela couvrera 100 pourcent du domaine irrigué et environ 50 pourcent de celui sous précipitation elevée.

STRUCTURES DE LA PRODUCTION DES SEMENCES DE CEREALES EN ALGERIE

Kadra Nourredine et O. Ait Amer *

Au lendemain de l'Indépendance, alors que notre pays se trouvait confronté aux difficultés de remise en exploitation des terres coloniales récupérées, le problème d'un approvisionnement régulier en semences de bonne qualité s'est posé de façon cruciale.

Jusqu'alors, la production de semences, d'ailleurs fort peu importante était pratiquement réservée à une minorité de grandes exploitations qui, à partir d'achats annuels réduits, produisaient elles-mêmes les semences qui leurs étaient nécessaires. Ces exploitations rétrocédaient parfois une partie de leurs excédents mais, dans leur grande majorité les fellahs devaient se contenter d'utiliser des semences quelconques appartenant le plus souvent à des populations locales hétérogènes.

En 1962, aucun contrôle des multiplications n'ayant été réalisé par les services agricoles de l'époque, la pénurie était d'autant plus grave que les variétés cultivées dans notre pays étant des selections locales, inconnues hors de nos frontières, aucune importation de semences n'était possible.

En 1963, les services du Ministère de l'Agriculture et de la Révolution Agraire entreprenant une vaste campagne de repérage des parcelles susceptibles d'être retenues pour la production de semences, la collecte des récoltes était organisée, les triages et conditionnements effectúes. Pratiquement et jusque 1973, la quasi totalité des exploitations ont utilisées des semences d'origine incertaine, presentant un minimum de garantie.

Une réorganisation en profondeur, tenant compte des nouvelles orientations agricoles du pays et de ses besoins réels s'imposait. Ce fut, en matière de production de semences, l'un des grands mérites du Plan Quadriennal 1973/77 de:

a) Fixer avec précision les objectifs de production à atteindre

b) Ordonner la création d'une Réglementation Semences qui garantisse les utilisateurs et soit en même temps alignée sur les textes extrêmement sévères, en vigueur dans les pays étrangers partenaires commerciaux habituels de notre pays.

c) Prévoir les moyens humains et materiels nécessaries à la bonne réalisation d'objectifs ambitieux.

Dès lors, une véritable industrie des semences pouvait s'organiser sous l'égide du Ministère de l'Agriculture et de la Révolution Agraire et les structures nouvelles et adéquates pouvaient être installées.

L'ORDONNANCE No.74-90 DU 1er. OCTOBRE 1974

Portant création de l'Institut de Développement des Grandes Cultures dont elle fixait les attributions, devait en fait lancer les bases d'un système nouveau de production de semences, mieux structuré et plus efficace.

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* Institute of Development of the Important Crops.
El Harrach, Algeria

L'IGC était chargé, en étroite collaboration avec les D.A.R.A.W. de:

1o. Organiser l'intégralité de la production des semences sur l'ensemble du territoire, d'en fixer le programme annuel de telle sorte que, tenant compte de la demande des agriculteurs et d'une constante et nécessaire évolution vers des types plus productifs et mieux adaptés à l'amélioration des techniques, chaque wilaya puisse finalement produire, sur son propre espace agricole, les semences finales qui lui sont nécessaires.

2o. Produire, selon la méthode de Selection Généalogique l'ensemble des Semences de Base nécessaire à la bonne réalisation du plan national annuel de production. Cette production très spécialissée est réalisée par les 7 stations Expérimentales relevant de l'IGC.

3o. Proposer une réglementation globale de la production des semences tenant compte des besoins particuliers et des contraintes spécifiques tout en l'harmonisant avec les législations étrangères et particulièrement avec celles des pays ayant des relations commerciales avec notre pays.

4o. Contrôler la bonne application des textes réglementant la production et la distribution des semences et assurer l'ensemble des opérations conduisant à la Certification des semences.

5o. Gérer la production des semences mères à tous les niveaux, assurer l'encadrement et la promotion technique des multiplicateurs.

STRUCTURES INTERNES DE L'IGC

Mener à son terme un programme de production aussi ambitieux nécessitait, on le conçoit, bien une organisation nouvelle et efficace, ainsi que des moyens parfaitement adaptés. Le Département "Semences" de l'IGC qui a la charge de réaliser les objectifs. "Semences" est dirigé par un ingenieur spécialisé responsable de la coordination des différentes services implantés, à trois niveaux:

AU SIEGE DE L'IGC

A—Un service "Programmation-Gestion" de la production chargé de l'élaboration des Plans de Production et de leur réalisation. Un fichier central regroupe toutes les informations concernant les cultures de multiplication et l'utilisation de chaque lot de semences qu'il soit destiné à la multiplication ou utilisé comme semence finale.

B—Un service "Contrôle" et "Certification" travaillant plus spécialement les semences destinées à la multiplication et travaillant à la S.C.E.S.

DANS CHAQUE REGION

Dans chaque Direction Régionale de l'IGC (Oran—Alger—Constantine) se trouve un service "Semences" prolongement des Services Centraux. Un laboratoire de Contrôle est installé dans chaque Direction Régionale et assure le contrôle et la Certification des semences finales. Chaque responsable régional semences a autorité sur les responsables semences de wilayate et daïrate qui assurent l'encadrement rapproché des multiplicateurs.

LES STATIONS IGC

Chacune des 7 *Stations Expérimentales de l'IGC (Guelma—Constantine—Setif—*Oued Smar— Tiaret—Sidi Bel—Abbès—Saïda) a en charge une partie du Plan de Production des semences de base G4.

Aucune ne disposant des surfaces nécessaires, chaque station s'est associé quelques producteurs particulièrement compétents qui, sous contrôle permanent de l'IGC, assurent les multiplications G3 voire même parfois G2. L'ensemble formé par une station IGC et ses producteurs spécialisés constitue un "Centre Régional de Production" progressivement doté de moyens matériels spécialisés (matériel agricole, locaux, installations spéciales de triage, etc.....)

LES METHODES DE SELECTION

Toutes des semences de base produites par les stations de l'IGC le sont selon le principe de la Selection Généalogique ou pédigrée. En règle générale le materiel végétal de départ est fourni par le Département "Recherche–Amélioration" de l'IGC.

LE PLAN NATIONAL DE PRODUCTION

Une fois arrêté avec les D.A.R.A.W., le plan national de production est publié annuellement sous forme d'une Circulaire Ministérielle. Il précise par variétés les surfaces à mettre en application au niveau de chaque wilaya de telle sorte que tenant compte de la demande réelle des producteurs et des orientations données en matière d'utilisation des variétés nouvelles chaque wilaya arrive progressivement à un auto-approvisionnement total en semences finales.

Les responsables des wilayate qui relèvent de l'IGC sont chargés de la mise en application du Plan National de Production, les attributions de semences-mères à chaque multiplicateur étant faite nominativement par les services de l'IGC. Ainsi peut-on à l'issue de chaque période de semis connaitre avec exactitude la situation exacte de chaque multiplicateur: localisation et lot de semences-mères utilisé. Cette parfaite connaisance permet d'organiser le contrôle en végétation des parcelles de multiplication.

CONTROLE ET CERTIFICATION

Le contrôle en végétation est effectué par l'ensemble des techniciens participant à la production semences. Il s'exerce à trois niveaux:

1) Contrôle au 1er degré réalisé par les Services "Grandes Cultures" des Daïrates et wilayates lesquels sont chargés avec la participation des techniciens semences des coopératives locales de suivre les multiplications, d'ordonner telle ou telle mesure particulière (désherbage, manuel complèmentaire, épuration, détourage, etc....) d'attribuer après deux visites (pré-contrôle puis contrôle) l'Agréage provisoire des cultures. Cet agréage donne lieu à la délivrance d'un Certificat d'Agréage provisoire ou CAP).

2) *Contrôle régional.* S'exerce par sondage aussi nombreux que possible et a surtout pur but de vérifier la bonne technicité des contrôleurs au 1er Degré et la bonne réalisation des opérations qui leur sont confiées.

3) Contrôle National: S'exerce lui aussi par sondage ou sur demande des contrôleurs régionaux. Il est particulièrement axé sur la production des semences de base considéré comme facteur primordial de la bonne réalisation des objectifs.

Après Triage et Conditionnement des semences issues de cultures détentrices d'un Certificat d'Agréage Provisoire, un échantillon représentatif de chaque lot de semences finales est analysée par les laboratories de l'IGC. Un certificat d'Agréage Définitif délivré pour chaque lot conforme.

LES NORMES CEREALES

Le faible taux de multiplication des semences entre deux générations oblige à maintenir provisoirement au moins un nombre de générations anormalement élevé soit trois ans après les semences de base G4. On peut cependant prévoir d'ores et déjà une réduction à 2 ans pour certaines espèces plus faciles à multiplier (orges notamment) our même pour certaines variétés de faible diffusion.

En règle générale sont certifiables:

R1 Produit par multiplication de semences G4
R2 Produit par multiplication de semences R1
R3 Produit par multiplication de semences R2

La pureté variétale minimum est de:

99.9°/o pour les générations G4 et les générations anterieures G3-G2
99.7°/o pour les générations R1 et les générations anterieures
99.0°/o pour les générations R2 et les générations anterieures
97.0°/o pour les générations R3 et les générations anterieures

Sans doute est-on encore assez loin des exigences minimum ayant cours dans les pays de céréaliculture intensive. Il ne faut cependant pas perdre de vue qu'une pureté variétale très élevée n'a de sens que lorsque tous les autres facteurs de productivité sont mis en oeuvre. Dans nos régions où l'importance de la récolte dépend souvent plus de conditions climatiques incontrôlables et où la maitrise totale des techniques ne peut encore être assurée, en il eût été dangereux de succomber a une "perfection exagérée". Nous avons plus à attendre d'un usage généralisé de semences à 97.0°/o que d'une utilisation limitée de semences de pureté presque absolue.

PURETE SPECIFIQUE, FACULTE GERMINATIVE ET ETAT SANITAIRE

A l'inverse et pour ce qui concerne la pureté spécifique, la faculté germinative et l'état sanitaire, il est apparu nécessaire de fixer des normes très élevées. La qualité des récoltes peut être gravement compromise dans le cas de semences contaminées ou contenant des semences de plantes adventices contre lesquelles la lutte est si difficile ou encore lorsque le taux de germination est insuffisant. De ce triple point de vue, les normes algériennes sont identiques et aussi rigoureuses de celles des pays d'agriculture intensive.

LA LEGISLATION SEMENCES

Les grandes orientations: objectifs, méthodes, responsabilité de la production, étant contenues dans le Plan Quadriennal 73/77, il était primordial de redéfinir en toute priorité les règles précises de la production en complètant et en synthétisant les nombreux testes anciens, souvent insuffisants, parfois contradictoires.

Publié par l'IGC en 1975 sous forme d'un "Règlement Technique, de la production, du contrôle et de la Certification des Semences", les différents points de ce règlement ont été élargis à la production des semences de légumineuses alimentaires et fourragères. Ils sont donc maintenant pleinement applicables et servent de référence pour tout ce qui concerne les agréages. La publication en 1974 d'une monographie des différentes variétés de céréales cultivées en Algérie permet aux techniciens de disposer d'un outil de référence pour le contrôle variétal.

D'autres textes complèmentaires ont été présentés et sont en cours d'étude soit au niveau du Gouvernement soit du Ministère de l'Agriculture et de la Révolution Agraire. Ils concernent:

1o) La création d'un catalogue algérien des Espèces et variétés de grande culture et les Règlements techniques d'Homologation des varitétés.

2o) La réglementation du commerce des semences.

3o) La certification obligatoire des semences et plants etc.....

Sans doute est-il nécessaire de mettre au point une législation globale; il est remarquable pourtant de constater, c'est l'une des forces de notre système, que la parfaite communauté d'objectifs des différents échelons interéssés aux problèmes de semences et leur habitude de travail et de prises de décisions en commun font qu'il est toujours possible d'entreprendre toute action d'ensemble visant à améliorer les systèmes dépassés ou inadaptés et ce dans recourir comme dans de nombreux pays aux instances suprêmes.

Il y a donc un début de réalisation de ce programme, cependant il reste beaucoup à faire.

Dans la pratique nous nous sommes rendus compte très souvent que la production de semences généalogiques était très mal comprise, tant par les producteurs que par les techniciens.

La durée de production de semences était la cause (six ans entre la Go et la R2) de nombreux mélanges et de confusion; il nous faudra songer à raccourcir ce cycle de façon à concentrer les premières générations uniquement au niveau de l'IGC et mettre directement à la disposition du producteur les semences de 1er et 2ème générations.

—en renforc,ant l'équipement des stations et centres régionaux de production tant en materiel qu'en formation des producteurs et des techniciens.

—une concentration de la production sur un nombre très restreint de Xème année, ce qui permettra une augmentation de rendement et une reduction des charges d'encadrement et de contrôle.

—des progrès certes, ont donc été accomplis ces dernières années, il faudra cependant être réaliste et tenir compte du degré de technicité des producteurs.

Résumé

A cause de l'indépendence et de l'occupation des terrains qu'avaient été sous le domain colonial, la production des semences de bonne qualité a devenu un facteur crucial pour la production céréalière de l'Algerie. Pendant le temps de la colonie, la production des semences était controlée par quelques exploitations agricoles coloniales. Les "fellahs" et les petits fermiers avaient eu d'être satisfaites d'user quicon que semence comerciale que fut disponible ou de semer celles très hétérogènes des populations locales. Donc, en 1962 il n'y avait pas aucun programme pour la production des semences et non plus pour leur contrôle. En 1963, le Ministère de l'Agriculture développait un programme pour identifier des bons terrains appropiés pour la production de semences et les retenir pour y produir les semences necessaires. Les semences y produites ont été processées et distribuées. Jusqu'à 1973 cet système etait l'unique en production dans le pays. Dans le plan à quatre années, 1973-1977, on a determinée une politique nouvelle de productions des semences en Algerie.

Le programme de production des semences est basé sur les principes genealogiques; les semences sont produites en commençant pour Go et en continuant jusqu'à R_3. Les semences basiques sont produites dans sept stations experimentales de l'IDGC. Des générations plus avancées sont contractées en grandes fermes de production des semences sous la surveillance technique de l'IDGC. Tous les aspects commerciales de l'industrie de production des semences sont surveillés par l'OAIC.

Dans cet travaille on décrit les details de l'industrie de semences, les rôles des différentes agences, le status de la législation aux semences, le plan national et les projections sur la production des semences, aussi que les normes de qualité pour des différentes semences.

Le problème, le plus important qu'ont trouvé pour la production des semences est la longueur du période necessaire pour passer de Go jusqu'a R_1. Il y a aussi un autre problème important, il s'agitte des mélanges que peuvent être produites n'importe à quelle étape ou dans plusières, à cause du manque de personnel eduqué. On fait des suggestions pour résoudre les problèmes déjà mentionnés.

SEED PRODUCTION STRUCTURE IN ALGERIA

N. Kadra and O. Ait Amer

Summary

With independence and the reoccupation of the colonial lands, production of good quality seed became a crucial factor in cereal production in Algeria. Up to that time seed production was controlled by a few large colonial farms. The "fellahs" or the small farmers had to be content to use any commercial seed available or use local hetrogeneous populations. There was no seed multiplication program or control in 1962. In 1963 the Ministry of Agriculture undertook a program of identifying good production fields and retained them as seed fields. The seed harvested from these fields was processed and distributed. Until 1973, this was the only system in operation. The 4-year plan of 1973-1977 set the stage for a new seed production policy.

The seed production program is based on genealogical principles. Beginning with Go and continuing up to R3, the basic seeds are produced at the seven experimental stations of the IDGC. More advanced generations are contracted on big seed producing farms under the technical supervision of the IDGC. Commercial aspects of the seed industry are carried out by the OAIC.

The paper gives the details of the seed industry, the role of different agencies, status of the seed legislation, national plan and projections for seed production, and quality standards for the different classes of seed.

The major problem encountered in seed production is the length of time it takes to pass through from the Go to R1 and the problems of seed mixture, which can occur at any one or more of these numerous steps due to the lack of trained manpower. Suggestions are made as to how these problems may be solved.

PROBLEMS IN SEED PRODUCTION AND DISTRIBUTION IN LEBANON

A. Alameddine*

Presently, a seed production project, financed through FAO ($466,100) and executed by the Agricultural Research Institute is under way at Tel Amara. It started in March 1979 and is expected to be completed in 2 1/2 years.

The long term objectives of this project are:

* To contribute to the intensification of agriculture, and in particular to cereals, by the generalized introduction of certified seed produced locally and in a regular fashion.
* To cover the national needs of certified wheat and barley seed.
* To produce and disseminate certified seed of wheat and barley to cover the whole cereal area in Lebanon. This area was 52,000 ha of wheat yielding 57,000 tonnes of seed—1.1 t/ha—in 1975. Half of this area exists in the Bekaa Valley.

The short term objective is to produce, starting in 1979, 200 tonnes of elite (basic) seed and 4,000 tonnes of certified seed of wheat and barley, in accordance with international rules for seed testing.

Problems of seed production and distribution

1. The modernization of materials of production and the preparation of elite or basic seed.
2. Completing the equipping of a laboratory for seed testing. The equipment includes a moisture tester, grain tester, sieves for purity tests, seed scale, seed blower, double chamber germinator, constant temperature oven, etc.
3. The reinforcement and reorganization of the control of increase (roguing) and of the laboratory for certified seed.
4. Training of responsible technicians for selection, production and seed testing (at least six should be available).
5. Recommendation of steps to take for the improvement of the plant breeding department personnel of the Agricultural Research Institute.
6. Setting up a program of evaluation, adaptation and yield trials of cereals in the traditional agricultural zones covering the northern and southern portions of the country.

The Lebanese Government is conscious of the importance of wheat growing for social and food security reasons. It supports financially the local wheat production. Harvests are purchased at the bonus price by the Cereal Office which equally interferes

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with the national production of certified seed. Wheat growing is not ready, however, to disappear from Lebanon. The requirements of the net returns push towards a continued intensification of cereal culture.

Before 1975, Lebanon was practically self-sufficient, producing 2000 tonnes of certified wheat seed (1975). The events of 1975-76 have stopped this production. Barley culture is not supported by the government, and is maintained at 7,500 ha (1975). It is important in the arid regions toward the north (Kfordane, Hermel, etc.).

The traditional farm sector in Lebanon, principally localized in the northern and southern portions of the country, has never used certified wheat seed for various reasons. The main reason is the inefficiency of the system of extension and distribution of seeds. A considerable effort remains to be done for the identification, production and dissemination of more productive varieties. In this connection, the assistance of ICARDA is desired to attain this goal in a moderate time span.

Summarized the objectives of the Lebanese government are:
Short term: starting in 1979 and continuing in 1980 on a regular basis to produce 3,000 tonnes of certified seed of wheat and 1,000 tonnes of barley complying with international certification rules.
Medium term: introduce the use of certified seed in the traditional agricultural zones of wheat and barley (5,000 tonnes of wheat and 1,000 tonnes of barley).
Long term: develop the export of certified seed and produce this seed for a wide range of agricultural zones.

The production of certified seed of wheat and barley

Four partners share the responsibility of certified seed production:

1. The Agricultural Research Institute. It selects the varieties and produces the basic seed.
2. The Cereal and Sugar Beet Office. It buys the basic seed and takes responsibility for its mutiplication and sale to farmers at cost price, as certified seed.
3. The private sector (2-3 firms). It takes over from the Cereal Office the responsibility of increasing, harvesting, etc. the certified seed.
4. The Ministry of Agriculture. It is responsible for the technical control of contracts for the multiplication and certification of seed.

1. The Agricultural Research Institute possesses the experience to select a great number of wheat and barley varieties adapted to the different cultural conditions of Lebanon. The Institute possesses the plant material, the personnel and the necessary installations. Some reinforcement of means remain indispensable:

a. The recruitment of at least one specialist in plant selection.
b. The reinforcement of a laboratory for quality testing of seeds of wheat and barley.
c. The replacement of testing, cleaning, threshing equipment, etc. by more modern equipment.
d. Make available 120 ha of fields for variety trials and production of basic seed.

2. The Cereal and Sugar Beet Office:

a. Participates in financing all control operations (field roguing, etc.) directed by the Ministry of Agriculture.

b. Accelerates all procedures of adjudication, of buying and reselling of certified seed.

3. The Ministry of Agriculture is responsible for the delicate operations of control and seed certification. Here, three facts present themselves:

a. Recruitment and training of qualified controllers with satisfactory salaries.

b. Increase the means of transport.

c. Re-equipment of the seed testing laboratory.

The coordination of operations

The following should be completed:

1. The project of a seed production and sale of certified seed law, which was prepared by the Ministry of Agriculture but is not approved yet by the parliament.
2. A "Committee of Seed" should be appointed to decide each year the production programs and varieties tonnages, and to orient research at the *Agricultural Research Institute*.
3. Seed multiplication in farmers' fields should be improved both from the Cereal Office and the Ministry of Agriculture aspects.
4. Seed trade should be under the joint control of the Cereal Office and the Ministry of Agriculture.

One of the objectives of ICARDA in the region should be to stimulate this cooperation among the various parties.

In spite of all the difficulties present in Lebanon, the setup of seed production is not bad. The plant material is available, the trained personnel are there, the technology is around, the organization is acceptable and the institutions still exist. A relatively moderate assistance from ICARDA and CIMMYT should speed up the program of production of quality seeds.

Summary

Lebanon grows, as an average, 52,000 ha of wheat, each year with a mean yield of 1.1 t/ha. Half of this area is located in the Bekaa Valley. Before 1979, Lebanon produced 2,000 tons of certified seed. In 1979, a new project was initiated with the help of FAO to extend the certified seed production. In 1979, the project administrators hope to produce 2,000 tons of basic seed and 4,000 tons of certified seed. The paper discusses the national seed production mechanism, the problems, and propositions for the future.

LES PROBLEMES DANS LA PRODUCTION ET LA DISTRIBUTION DE SEMENCE AU LIBAN

A. Alameddine

Résumé

Le Liban cultive, en moyenne, 52 mille hectares de blé avec un rendement moyen de 1.1 tonnes par hectare, la moitié de cette superficie est dans la vallée de Bekaa. Avant 1979, le Liban produisait 2000 tonnes de semence certifiée. Durant 1979 le Liban initiait un projet nouveau avec l'aide de la FAO pour étendre la production de semence certifiée. Durant 1979, les administrateurs du projet espérent produire 2000 *tonnes de semence de base et 4000 tonnes de semence certifiée. Le* mécanisme de la production de semence, ses problèmes et ses propositions pour l'avenir sont discutés.

THE CONTROL AND MULTIPLICATION OF SEEDS IN MOROCCO

Ouassou Abdallah*

The Direction of Agricultural Research (DRA) is the official organization concerned with an official catalogue of species and varieties; the production of basic seeds of the principal cultivated species; and the control and certification of seeds.

For the inscription of varieties, a national commission was formed to add new varieties to the official catalogue and to eliminate certain others. The multiplication of basic seeds is being done on an experimental level by the DRA. Certified seeds of the first and second reproduction are being produced from the base seeds between the DRA and selected seed growers.

Control and certification of seeds is being carried out according to established procedures in the field and the laboratory. In the field, DRA technicians make two visits relating to varietal purity, sanitary state and crop maintenance. In the laboratory, the controls concern varietal and species purity, per cent of grain to weeds, germination percentage and the sanitary state.

The Present Seed Situation

The varieties which occupy the largest planted area with selected seeds are Kyperounda *(durum wheat)*, *Nasma (bread wheat)*, *Brasserie Maroc* (barley).

The present production of seeds is still low, currently being 400,000 quintals which is only 25 per cent of the needs. Production is inversely proportional to the importance of the area sown. The sown area percentage of selected seeds during the period 1973-77 of each cereal group was: durum wheat 7; bread wheat 29; barley 0.1 per cent. The higher yields of bread wheat rouses the demand for such seeds. A greater effort is required to improve the yield of durum wheats.

Main Constraints

Constraints include the shortage of better varieties of durum wheat, the price paid for the multiplication of barley and a global lack of seeds.

Two constraints have developed. The state wants to create the National Society for Commercialization of Seeds (SONACOS), leaving control to the DRA which will plan the long term needs and production quality. Contracts will be arranged directly with the farmers and the state society, and there will be large scale commercialization of sales in different regions.

* *Assistant Professor, Rabat*

In order to encourage farmers, especially the small farmers, the state has agreed to subsidize them 30 per cent and to provide more credit facilities.

Also steps are being taken to increase the barley seed production.

The objectives for 1981 seed production are as follows:

Species	Proportion
Durum Wheat	25 per cent
Bread Wheat	33 per cent
Barley	10 per cent

CONTROLE ET MULTIPLICATION DES SEMENCES AU MAROC

Ouassou Abdallah

La Direction de la Recherche Agricole (DRA) est la organisation officielle concernée avec le catalogue des espèces et varietés, avec la production des semences basiques des espèces les plus importantes, et le avec contrôle et la certification des semences.

Pour l'enregistrement des varietés, c'est formé une commission national que peut additionner des nouvelles varietés et éliminer quelques autres. La multiplication des semences basiques est faite au niveau experimental par la DRA. Les semences certifiées de la première et de la deuxième generations sont produites a partir des semences basiques entre la DRA et des producteurs selectionés.

Le contrôle et la certification des semences son faites d'accord aux procédés établis, pour la campagne et le laboratoire. À la campagne, les techniciens de la DRA font deux visites pour regarder la pureté varietal, l'état de santé des plantes et l'entretien du culture. Au laboratoire, on fait le control pour la pureté varietal et de l'éspèce, le pourcentaje de grain-males herbes, le pourcentage de naissance et l'état de santé des semences.

La situation des semences au present

Kyperounda (blé dur), Nasma (blé tendre), Brasserie Maroc (orge) sont les varietés qu'occupaient la majeur partie des terres semées avec des semences selectionées.

La production des semences est encore basse, 400,000 quintaux, qu' est le equivalent à une quatrième partie des besoins. La production des semences selectionées est proportionelle à l'inverse, à la importance de la superficie semée. Le pourcentage des terres semées avec des semences selectionées pendant 1973-1977 a été, par group des céréals: blé dur 7, blé tendre 29, orges 0.1 pour cent. Les rendements plus hauts du blé tendre font aumenter la demande des bonnes semences, tandis qu'il est necessaire faire un effort pour améliorer des rendements du blé dur.

Contraintes à la production

Les contraintes les plus importantes pour la production sont la dissete de meilleures varietés de blé dur, le prix des semences de multiplication de l'orge, et un manque de semences en général.

Il y a aussi deux contraintes developpées; l'Etat veut créer la Societé Nationale pour la Commercialisation des Semences (SONACOS), sous le contrôle de la DRA, laquelle fera les plans des besoins futures des semences et de qualité de production. Les contrats seront arrangés avec des fermiers et la societé d'état, et il y aura des grandes ventes in différentes régions.

Pour encourager les agriculteurs, spécialement des petits fermiers, l'état a accordé les donner un subside du 30 pour cent et plus des facilités de crédit.

Il y a aussi des preventions pour augmenter la production des semences d'orge.

Les objectives de la prodution de semences amèliorées exprimés en forme de pourcentage des terres sous la culture respective pour 1981 sont:

Espèce	**Proportion**
Blé dur	25 Percent
Blé tendre	33 Percent
Orge	10 Percent

PANEL REPORTS

- AGRONOMIC CONSTRAINTS
- TRANSFER OF TECHNOLOGY
- ECONOMIC CONSTRAINTS
- WEED CONTROL
- CROPPING SYSTEMS
- FERTILIZER RESPONSES
- VARIETAL DEVELOPMENT AND DISEASE AND PEST MANAGEMENT
- SEED PRODUCTION

AGRONOMIC CONSTRAINTS

Chairman: F. E. Bolton
Committee members: N. Kadra, A. Golusic, A. Alemeddine

1. The actual yield level is well below the potential yield in most countries of the region, in both the high and the low yield environments.
2. Varieties are not a major constraint if currently available materials are used. However, there may be specific areas with disease problems which would require a varietal change.
3. Weed control is considered a major constraint throughout the region in all environments and research should be increased to determine the cultural, mechanical and chemical control methods.
4. In high yield environments, the major constraints in order of priority are: (a) weed control, (b) nitrogen fertilizer, (c) responsive disease resistant varieties. The above constraints are followed by others such as (d) seedbed preparation, (e) planting date, (f) seed rate, and (g) in some cases other nutrient deficiencies such as S, Mn, Zn, Fe, etc.
5. In low yielding environments (water limiting) the major constraints are: (a) weed control, (b) phosphate fertilizers, (c) seedbed preparations, (d) planting date, (e) tillage and moisture conservation practices, (f) nitrogen fertilizer, (g) varieties, and (h) other nutrient deficiencies such as S, Mn, Zn, Fe, etc.
6. A knowledge gap exists in determining the sequence of factors to be introduced in the package of improved practices. Teamwork with economists is needed to determine acceptable practices for each class of farmer.
7. A knowledge gap exists in determining the response to nitrogen under low rainfall and seasonal variability that usually accompanies the limited water supply. More research is needed in this area.
8. Agronomic constraints under dryland conditions require extensive and carefully planned field experimentation because of the extreme variability that exists. Relatively long term experiments are required to sample adequately the seasonal variations in order to develop accurate recommendations.
9. Agronomic or production research cannot be conducted in a vacuum. It requires close cooperation with breeders, pathologists, economists, soil scientists and government planners working together as a team to research, demonstrate and introduce improved practices to farmers. We need to keep reminding ourselves that our mission is to serve the producer and not the opposite.
10. The committee and the working group expressed a common opinion that in this region, the potential exists for nearly every country to become self-sufficient in cereal production if we combine our efforts among all disciplines and government agencies to remove the constraints that now exist.

TRANSFER OF TECHNOLOGY

Chairman: C. K. Mann
Committee members: R. Bertram, M. Benzaghou, H. Halila

The committee recognized the broad scope of the topic. This includes the issues of the transfer among countries, particularly from developed to less developed countries. Especially significant are issues of licensing, commercial arrangements and the distribution of benefits between the source firm or country and the recipient country. In view of the broad nature of these issues and the limited time available, the committee decided that it would be most productive to limit the discussion to the transfer of technology within countries from the research-extension organizations to the farmer.

By transfer of technology, the committee means the process of communication to farmers of research results and recommendations, which have been investigated and developed by national or regional research programs. The objective of this process is to increase the productivity of the farmer and his farm. It was stated at the beginning that the transfer of technology is not an isolated process dealing only in terms of cereal production. Rather it should have a broad scope, taking into account the effects and the interests of producers and consumers and social well being as a whole. This is best achieved by a combined effort of several specialists—plant breeders, agronomists, extension officers, economists, pathologists and social scientists.

It is important to investigate and understand the wealth of information found in the farming community. All those involved in the transfer of technology benefit from familiarity with the knowledge accumulated through many years of experience in the farming community. Often farmers posess keen insights about their environments and the performance of crops within them. There is a need for workers involved in research, extension, economics, etc. to be aware of and understand the knowledge and information available from the farmer and a need to understand accurately the farmer situations. This results in a modification of the traditional diagram of an agricultural extension program:

Models for technology transfer to farmers:

1. Traditional Model:

Research/Extension

Farmers

2. Improved Model:

Research/Extension

Farmers

It is important to point out that although goals and ideas may be the same, the actual program and applications of technology may be specific to an individual country or locale. Each situation will be different, and techniques will need to be suited to that situation. The size of the area, number of farmers to be involved, commercial orientation of the farmers, and their confidence in the existing research/extension structure are all factors which determine the type of program and techniques to be considered.

An important requisite for successful transfer of technology is the existence of a personnel base dedicated to this goal. At the research level, this means having researchers (breeders, agronomists, economists, etc.) who work towards the development of a suitable and appropriate system of cereal cultivation and one adapted to the area they serve. It requires people who discuss and evaluate their programs and goals with experts in other important disciplines. And, perhaps most important, it requires people who want to see their useful research findings applied on the farm and so are willing to vigorously pursue the extension of accumulated knowledge.

It is on the extension level that decisions to transfer information about innovative practices are made. But after a decision is taken, there must be support for the extension team. They should be well trained and convinced of the efficiency and improvement offered through the technological measures which they advocate. They should be provided with mobility so that they are able to meet the farmers, run demonstrations and see the crop growing. Their frequent presence is an important step in building the credibility required for extension programs, as well as helping to ensure their familiarity with the farmers' problems and capabilities.

Suggestions for successful transfer of technology.

It is important that what is said to the farmer is based on good, well-planned research, and that the recommendations derived have been tested and found to be sound and worthwhile on the production level. If the recommendations include the use of new varieties, fertilizers, etc., it is imperative that adequate supplies of seed and materials be made available to farmers. Government participation can be crucial in helping to make an extension program work. An appropriate policy/economic incentive is a key element in an agricultural development strategy. Other supports might take the form of credit or subsidies designed to assist the farmer in implementing new practices.

Methods of technology transfer.

1. Research/Extension—Farmers

(a) Demonstration plots designed and planted by the extension service in conjunction with researchers are valuable tools in technology transfer. These plots should be located on a piece of land typical for the area, preferably where as many farmers as possible will be able to see them.

Suggestions included the use of separate components of an overall package being demonstrated individually or in combinations (e.g. weed control, drilled seed, herbicide, fertilizer, etc.). This could be of use when some farmers are unable or unwilling to adopt an entire package of practices, allowing them to choose those practices they deem most valuable and within their capabilities to implement. Moreover, seeing the effect of certain individual practices might induce the farmer to make the investment required to implement a particularly favorable practice (seeder, sprayer, fertilizer, etc.).

(b) Training films and literature—these aids produced specifically for technology transfer are valuable in communicating new production practices to the farmers.

(c) Media campaigns—radio and television now have the ability to reach a large number of people, including many who would not be reached by printed material.

(d) Innovations such as the use of cassette tapes distributed over a wide area is an example of another way of reaching a large audience.

(e) Field days—these special sessions provide a setting where a two-way flow of information can take place. Also, by bringing the farmer into closer contact with researchers and extension agents, a greater degree of credibility can be established for the national program.

2. *Farmer to Extension/Researchers*

In the contest of receiving feedback from the farmers, farm level surveys play a key role in providing both researchers and policy makers with accurate information on farmer circumstances. Portable field videotape equipment provides a particularly dramatic possibility of bringing farmers' insights and perceptions to the attention of policy makers. Often the duties of these officials limit their first hand contact with farmers. Even if they do go to the field, their rank and status often removes spontaneity from farmer interviews. In contrast, video used as a field notebook by survey takers does not have such an effect. As noted above, farmer demonstrations and adaptive research trials provide extremely useful opportunities for research/ extension/farmer exchanges of perceptions and ideas. On both sides of the technology transfer process—the research-extension side and the farmer side, there is great value in first hand observations.

ECONOMIC CONSTRAINTS

Chairman: P. Bronzi
Committee members: P. Marko, L. Hachemi, K. Feliachi

Since the fundamental political systems and aspirations of the countries are different, the analysis of economic constraints should only aim to define the necessary ways and means by which the cereal production can be increased.

On this subject, it has been notably recommended that the efficiency of the development effort should be tightly bound to the exact knowledge of the micro-type and macro-economics in the starting situation.

The exact knowledge of the medium should be reverberated to the level of planification, following the economic structures faithfully so that the transformation of the given different levels in a language relative to their function might not entail distortions between reality at ground level and the decision center.

The criteria following the aforesaid domain leads to the necessity of providing precise and efficient information. This advocates the effect that specialists in different disciplines might be able to participate in the elaboration of the information.

Passage from the initial situation to a better situation is difficult and depends upon a cumulus of experiences in the considered country. It may be that the better situation is unknown. Incidentally, this cannot be defined in quantitative terms. It is not a matter of how to pass from one phase to another by blind adoption of models which have been proved in the considered country under consideration, but it is the opposite, by the bias of a progression which would be stable from the initial situation by internal experience, the assimilation, the interpretation and the judicial choice of the existing brute information on an international scale, and capable of being original new itineraries.

The relative effort to the proceeding development which has been drafted should permit the elimination of a great number of constraints, notably those which concern the adecuacy between production factors, their availability and the biological cycle of the plant, their precise requirements in time and space.

Finally, the committee has approached the relative problems to the equilibrium of the exchanges between the agricultural sector and the other economic sectors. It has noted the importance of the impact that the constraints which these exchange terms impose on the agricultural sector.

WEED CONTROL

Chairman: S.A. *Qasem*
Committee members: N. Duratan, Ladada, D.A. Saunders

The session on weeds and their control has focused once again on this important agronomic constraint in the production of wheat in various parts of the world, and especially in this region. Research efforts and experiences in weed control were presented and discussed, especially those in Southern Australia, Algeria, Turkey, and by ICARDA and CIMMYT.

The presentation and discussion highlighted the following points:

1. Weeds are still considered a constraint in wheat production in the region with varying degrees of importance, being of major importance in several countries like Algeria.
2. The integrated approach should be followed as much as possible, but chemical control seems to be an option which is imperative to take in many situations and for many years to come.
3. There is a big gap between what is known and what can be done on the one hand and what is being practiced by the farmers and the actions being taken by governments on the other hand to deal with this problem.
4. More information is needed in several areas which include:

(a) When weeds should be considered as a pest necessitating control, and what level of infestation is either potentially or actually harmful and should be checked.

(b) More attention should be given to monocotyledonous weeds especially those species of Bromus. Species should be identified so that effective means of control can be applied to each species.

(c) There is great promise in the use of herbicide mixtures in the chemical control of weeds. More information is needed on granular herbicides and their application.

(d) When cultural practices are used, especially crop rotation, more studies are needed on the economic and agronomic feasability of the various options.

5. Availability to farmers of the inputs to control weeds should be given more attention. Coordination between various agencies concerned in the registration, acquisition, distribution and the application of herbicides, should be consolidated.

CROPPING SYSTEMS

Chairman: A. Hadjichristodoulou
Committee members: Saidani, M.M. Elghouri

Cropping systems in the Near East and North Africa vary greatly with agroclimatic conditions and other socio-economic factors. In general, there are two classes of cropping systems:

(a) Irrigated or higher rainfall areas

Under these conditions, the farmer has many choices of cropping systems to follow, as moisture is not a limiting factor. Land is cropped every year, and in some cases two or more crops are harvested each year. Along with cereals (wheat, barley, maize, etc.), vegetables (watermelon, tomatoes, potatoes, etc.), industrial crops (cotton, oilseed crops) and other crops follow each other in different patterns depending on the needs of the country and market demands.

(b) Low rainfall rainfed regions

Under these conditions , the most limiting factor is soil moisture. In the past, the most predominant farming system was cereal-fallow. Fallow covered the period from soon after harvesting the cereal crop and through summer, winter, spring and summer of the following year until autumn—that is, around 15 months to over a period of 2 years. Land was kept free from weeds throughout the period by several cultivations. Or natural vegetation was grazed for some time and then the land was cultivated and kept free from weeds until sowing. It was believed that fallow stores moisture and increases nutrient availability, thus making it possible for a more successful crop during the following year.

Another advantage of fallowing in dry areas, which is also important, is that the seed bed is much better prepared than by growing a cereal crop continuously. By securing a better stand establishment, the farmer may increase the chances of getting good yield, even without the other advantages of fallowing.

Under relatively higher rainfall conditions, the fallow is replaced by a dryland food legume (chickpeas, lentils, etc.) or a dryland forage crop (legume or cereal) or by summer vegetables (watermelons, tomatoes, etc.).

In the past, when agriculture was not mechanized and nitrogen fertilizers or chemical weed control were not available, fallowing was a necessity because (a) the farmer did not have enough time to sow and harvest all his land within the time limits imposed by the climate and (b) fallow was one of the few options open to the farmer to improve soil fertility and control weeds.

Today, soil fertility and weed control can be improved by chemical means. Seed beds can also traditionally be better prepared by the use of modern equipment than by ploughs pulled by animals. However, nothing can be done to increase rainfall, and better crop management therefore remains the only way to increase moisture availability.

Experimental data on the effects of fallow in the dry areas of the region are limited. Moisture storage during the fallow year would depend on the soil depth, soil type, temperature and other climatic factors. In the Northwest USA, there is evidence that out of 400 mm rainfall, water equivalent to 100 mm is stored in the soil and 300 mm are lost. The stored moisture may contribute significantly to the success of the crop in the following year. Data from Turkey showed that the cereal yield after fallow was significantly higher than under continuous cropping. On the contrary, data from Cyprus showed that the yield of barley grown after barley, but with additional nitrogen fertilizer, was higher than under barley following fallow (with normal nitrogen fertilizer).

A number of speakers pointed out that any comparison of different cropping systems must take into consideration the economic evaluation of the data.

Salinity problems may be faced under certain conditions (Pakistan, Canada), if the wrong cropping system is followed.

In general, the discussion stressed the point that rotation systems are complex to study because of the many interacting factors involved. Agronomic and other biological factors should be studied in combination with climatic factors, economic and social conditions in each environment. Improving the existing farming systems will become possible when more reliable data become available. Priority might be given to studies on the effects of fallow and leguminous crops (food or forage crops) in a cropping system with grain cereals.

FERTILIZER RESPONSES

Chairman: S. Benfreha
Committee members: W.L. McCuistion, H. Ketata

The workshop session on fertilizers examined their use under various rainfall conditions and their economic efficiency.

In low rainfall conditions, water is the most limiting factor in production. For fertilizers to be efficient under these conditions, they must be balanced with the level of rainfall. A large dosage of nitrogen, for example, could lead to an exagerated development of vegetative growth at the beginning of the vegetative cycle, thereby causing an inbalance between the later development of plants and grain. Slowly diffusing fertilizers are recommended for lowering losses and for increasing the efficiency of the fertilization.

In high rainfall conditions (500 mm per year), cereals generally respond better to fertilizers. The application of nitrogen fertilizers in two stages during plant development, combined with an early application of phosphate fertilizer seems to give the best results in the majority of cases. Late applications of nitrogen do not seem to affect the yield, but they increase protein in the grain.

The yield levels increase with the increase in fertilizer dosage. In general it is not necessarily the case that the maximum dose is the optimum dose.

When discussing fertilization, one must not lose sight of the economic aspects. In studying the need for fertilizers, one should take into account their manner of utilization by the farmer. To determine the quantity and types of fertilizer to recommend, the investigator should take into account the technical, social and economic conditions in which the farmer uses the fertilizer to increase production.

VARIETAL DEVELOPMENT AND DISEASE AND PEST MANAGEMENT

Chairman: N. Kadra
Committee members: J.R. Burleigh, C. Fontan

Varietal adaptation for different agroclimatic conditions is the same as a constraint on the increase of cereal production. The lack of rainfall or the abundance of water, frost or heat, especially during the flowering of plants, are also factors which lead to research for different genotypes. If in an irrigated medium, progress in cereal production is attained, then in dry zones the new varieties hardly give the same hopes for increasing yield, especially with hard wheat and barley. In fact, the potential of these varieties cannot be realized fully on an international scale.

The adaptation of a variety, in a given country, notably in North Africa or the Middle East, depends upon the needs of the farmer who, for example, might not exclusively need grains of a short straw variety, or of grains and straw. The latter is necessary for feeding animals. At this moment, research on a long straw variety would be preferable. Another all important aspect in varietal adaptation is the required and variable time duration between planting and harvesting (90 days in Sudan and 8–9 months in Turkey). Therefore selections are guided by the improvement of yield and the study of drying mechanisms. The question is to find the lines which utilize water and nutritive material to the best advantage so as to increase cereal production.

Diseases are also a constraint on increasing cereal production. The struggle has been carried on principally by plant pathologists but varietal selection should also take into account the resistance to diseases. Reports from different participants have not mentioned any specific diseases that have badly damaged crops, but it must not be forgotten that state endemic centers exist. The main worry in the fight against diseases is centered at the moment around rust which is a supple and adaptable disease, and where the epidemic potential is important. Moreover its development is rapid. Other diseases such as *Septoriose, oidium,* rots and smuts do not seem to present any particular problem. At this moment, the importance of losses due to diseases in cereals is unknown. In the past, it has been estimated as being about 10 per cent of production. Also, insects, rodents and other animals contribute to quantitative losses in cereals.

SEED PRODUCTION

Chairman: W.L. McCuistion
Committee member: A.A. Goma, O. Ait Amer

Developments in the area of seed multiplication could be compared to advances made thus far in weed control. Progress is being realized; however there is still much to be accomplished.

For the region of North Africa and the Middle East generally, there is still a great need for trained people, coordination at the national level and equipment to better process the seed.

Seed laws legislation in most countries has occurred within the last 20 years. In many cases, these laws are still being evaluated and have not been initiated. However, several countries have well developed legislation.

There has been a substantial increase in the area under multiplication in most countries during the past ten years. Multiplication of certified seed in Turkey and Tunisia has occurred for the past 50 years and for at least 30 years in Morocco.

Newly developed varieties and/or introductions into the country must be tested in experimental trials for 3–4 years in most countries before registration and release. In some cases, the old systems of multiplication hinders the rapid increase of new cultivars.

Semi-dwarf varieties have only been included in the various country multiplication programs during the past 6–8 years.

The system of multiplication is much the same between countries. The terminology is the main difference, i.e., Breeders, Foundation, Registered and Certified or G_0, G_1, G_2, G_3, G_4, etc. Most countries need to multiply the advanced generations of seed for several years to meet the demands. The basic seed (first two generations) classes are controlled by the research institutes; however the third, fourth and subsequent generations are handled through national seed societies, cooperative efforts of institutes, or directly at the state farm level. Most countries report the presence of systems for field and laboratory seed control, that is, roguing, harvesting and sampling for laboratory analysis. Several countries such as Algeria have regionalized the control of seed. Farmers generally have accepted the new cultivar seeds and replaced the old cultivars when encouraged by the seed organizations. A large percentage of the seed in the countries reporting is being produced on large size cooperatives and/or state farms. Standards of varietal purity are high in those countries reporting. This guarantees good quality seed to the farmers. It must be stated, however, that extremely pure seed requirements must not stand in the way of moving new cultivars into the production channels.

Various countries have well-defines short and long-term goals.

Some general problem areas indicated were:

(1) Lack of adequate trained personnel control to properly the registered and certified seed classes.

2) Lack of sufficient yield on those fields under seed increase. This problem is normally a function of poor management practices.
3) Need for additional processing equipment, storage and transportation for the movement of field personnel.
4) Modernization of present laboratories.
5) Development and coordination of a seed committee.
6) Most countries are not yet meeting the demands of the agricultural sector for improved seeds.

THE FIFTH REGIONAL CEREALS WORKSHOP
GENERAL SUMMARY ON THE WORKSHOP

R. G. Anderson*

Regional workshops of this type are not a new development. In the early days of international organizations, FAO organized and conducted a number of workshops throughout the region; all of us owe a great debt of gratitude to their concerned officials for the past and continuing efforts to assist the different countries with their agricultural programs.

The present meeting in Algiers is the fifth in this series. The first was held in Lebanon, the second in Turkey, the third in Tunisia and, two years ago, the fourth was held in Jordan.

I have been fortunate to be present at all of these five meetings, and I have seen a great evolution. In the earlier years, these meetings were attended primarily by administrators of programs rather than the technical personnel. With each succeeding workshop, more technical people have become involved. This is a reflection of the rapid growth of scientific manpower in the region as a whole. It is a healthy development, and it has been a pleasure for me as a colleague to be associated with this group.

When the organizing committee first came together to discuss what might be the theme of this meeting, a number of topics were considered. It was decided that constraints to production was the single most important interest to all. Constraints were certainly recognized in the past, but their effect has become increasingly apparent as better varieties have become available. The rapidly increasing population and heavier demands for food have made it mandatory that agriculture advance in production. Agronomic constraints are undoubtedly a prime barrier to that advance. Superimposed on these agronomic factors are many additional constraints; these were woven into the program. In retrospect, I can say it has been a rewarding experience to me personally to have had the opportunity of listening to the presentations during the week.

The presence of the Minister of Agriculture at our opening session is a measure of the importance which Algeria places on agricultural development. It was heartening to all of us to have had him officiate.

In the opening session of the workshop, I stated that agriculture is a complex activity, that it combines a mixture of science, a lot of art and heavy doses of common sense. Further, it is a mixture of a great many interactions of biological, soil, climatic, and economic phenomena. The scope of the subject matter, discussed this week, makes apparent that agriculture is indeed a complex subject. We must also remember that many second-level constraints were not included in the deliberations, and they add more complexity. However, we may hope that for those constraints considered, new light has been shed on how they may be removed or diminished.

We have had the various country reports. They provided a background, not only of constraints, but also the present agricultural position in the countries, the importance of various crops and that constellation of problems impinging on production in each.

Weeds, as might be expected, are one of the major constraints to yield in most of the countries. The problem varies. In those countries where rainfed agriculture is

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practiced, weeds are a greater source of variability in cereal yield and production than any other single factor. In a dry year, with moisture limiting, weeds are even more important than in a wet year. Although they rob the fertility in a wet year, they do not compete as heavily for moisture; in the dry year they appear to have a real competitive advantage over the crop in removing water from the soil. In the case of the broadleaf weeds, the tap root system and leaf shading undoubtedly account for much of this advantage. For the grassy weeds, the prolific seed production, which falls to the ground, plus tillering capacity provides the advantage. One may readily see the effect by observing a grain crop in a dry year after a fallow season where large weeds were allowed to grow. Where each weed stood, we can see holes and depressions in the growth of the cereal crop in the succeeding year. In developing its growth the weed removed both fertility and moisture.

Transfer of technology is a real problem. I believe that much of the difficulty stems from the fact that the researchers have not taken time to provide their relevant results to the extension people. There is a crying need to have these disciplines brought together in most countries. In the more sophisticated countries, where research and extension have been conducted for a long time, the division has become wide. Extension specialists are taught in the universities the methods of "how to extend" but are not provided the information they are to extend. The snobbery of discipline may keep them from admitting this and they often avoid trying to find out what is happening in research. We must look for ways to bridge this gap. Training programs must be established within countries in which research results are transmitted to extension. There must be a training officer who will look after the physical logistics and interpolate research results to the extension specialist. Such a transfer program should be organized at the major research centre(s) within the country; the farm demonstration should be used as a part of the techniques by which this transfer is made. We have heard from different persons of various techniques used for technology transfer. Of significance was the concensus that information should flow from the farmer to the extensionist and to the researcher. Research may need to be reorganized to be relevant to the farmer and providing the extension specialist with information that is acceptable to the farmer. This hypothesis of information flow is based on the fact that the farmer is a rational person who acts in such a way that, under his present conditions, maximizes his return consistent with his understanding of the risks involved. An understanding of the conditions under which the farmer operates is essential if one is to help him with means to change those conditions and move to new levels of production. It may be, for example, that he is unable to adopt a likely improvement because he has insufficient money to buy the inputs. Credit facilities would seem to be warranted, with a minimum of paperwork for its procurement. The farmers may be growing a weedy fallow on which he feeds his sheep. We might substitute a medic forage crop for that season, and in this way eliminate the detrimental effect of weeds on the following cereal crop. In other words we change his condition so a different avenue is open with advantages that are obvious to him.

Let me turn now to economics, a field in which I am but poorly versed. May I say that the recent coming together of the agronomist and economist to look at farm problems is a move in the right direction. These joint activities must be complementary rather than competitive. There are two levels of economics which must be considered. The first, that which most directly affects the technical group, is the farm-level economics in which it is paramount that we understand what the farmer does, how he does it and why he does it. Such studies seek to find in what ways his circumstances may be changed so that change can be effected. The second level, which in my opinion has been neglected, deals with the macro level—the policy decision area. This is where biological realities interact with planning commission policies. It is unfortunate, but usually true, that planning level decisions are made in a near-vacuum of knowledge of the biological possibilities. This lack of biological knowledge is often the result of school systems which fail to teach anything about agriculture. Decisions may be adverse to the country's well-being simply because of ignorance of the needs and limitations. It is time that biologists become involved in planning decisions to assit in interpreting the effect of policy issues on eventual production improvement. For example, this is necessary so that the right fertilizer is purchased at the right time and in the required quantity, that the proper machinery is ordered for the soil type and so forth. Countries cannot afford the luxury of ignoring these basic considerations. Ministries of agriculture and ministries of planning must integrate their efforts.

Cropping systems were discussed during the workshop. Like agronomy, cropping systems tend to be location-specific, they must be fitted into a structure concerned with all of the problems with which we have been dealing in the past week. However, the form will vary according to the political structure of the country involved. It seems likely then that cropping systems research will have to be largely approached within a country as opposed to research being conducted primarily at a central international location. A cropping system brings together the knowledge of many crops and the many disciplines represented here. The challenge is to put them together into a functioning whole, maximizing the return to the farmer and minimizing his cost in reaching that goal.

These are the guiding principles. Where irrigation is practiced, as it is in a limited part of the Mediterranean area, or where rainfall is high, one may use some form of multiple croppping, with more than one crop per year. Even in such systems where water is not a limiting factor, one can encounter difficulties in that pressure is put on the soil to give high yields and more than one crop per year.

In cases where heavy fertilization with the major elements is practiced, the soil simply may be unable to supply the increased micro elements required, and yields tend to go into decline. Increasingly we will need to monitor the status of minor elements in the soil if production is to be maintained. We should develop a set of indicator plants which can be grown in widely placed geographic locations to provide a picture of the need for additional applications of elements. This is already a serious problem in certain areas of the world. Zinc shortages in northern India and copper shortages in many countries of East Africa exemplify the problem. Failure to stay abreast of the need for these minor elements can lead to the erroneous conclusion that the major elements are not helpful.

The discussion of cropping systems for shallow soils is particularly appropriate in the Mediterranean region. Some soils with appreciable depth lend themselves to the fallow–cereal system. Others with less depth perhaps should not grow wheat; barley, or a similar short season annual crop, might be grown.

We discussed varieties as a limiting constraint. It seems generally accepted that varieties are available which will provide adequate yiels in many of the countries. This does not infer that improvements cannot be made for greater drought resistance or other characters which adapt the variety to specific environments. I am convinced that the breeding must be conducted under ideal conditions to establish genetic superiority. Those lines shown to have this advantage should then be tested under limited rainfall to establish which among this high-yielding group fit the location and provide high yields at the moisture level and input level available. Of course, one continues to incorporate parent material with drought tolerance in crosses. But the advantage of this approach lies in the proven ability of the variety to respond in years of better moisture and also that it can do well when years are less favoured.

Semidwarf varieties in a weedy situation are often at a disadvantage compared to the tall varieties; unless agronomic practices can be improved to remove weeds, they should not be recommended. Such a course should not be followed indefinitely improving cultural practices through removal of weeds. In water stress conditions, the semidwarf shortens at a much slower relative rate than do the tall varieties. This is due to the fact that the dwarfness is the result of non-response to the growth hormone, gibberellic acid.

Evidence was presented to show that yields in the United Kingdom can be increased by breeding for specific adaptation. On a restricted area, this can undoubtedly be done, particularly where water is not limiting. Such tailor-made varieties can provide superior yields in such conditions, possibly on a sustained basis.

Unfortunately, in most countries the climate is variable from year to year so stability of yield is provided by the broadly adapted variety as determined by its superior yield over a wide diversity of environments in a single year. Because of its demonstrably good buffering capacity to maintain yields over the broad geographic range, the broadly adapted variety can be expected to perform well across fluctuations of the environment. A further advantage of this type of variety is shown when the seed industry in one location can supply seeds to other countries where seed production is poorly developed.

The most important constraint we considered is the poor seed production capabilities in most countries. This constraint prevents the reproduction of varieties that may be produced at great expense in the country's breeding program, and in this way diminishes the breeding and selection efforts of the plant breeders. The need for seed production is evident, but how much seed should be produced is an open question. Varying estimates have been put forward of the percentage of seeded area that should be supplied with certified seed. In many countries 15 percent is considered a suitable level, in others a change of seed every five years is considered best. In my opinion, most of the countries would be wise to establish a moderate level of seed replacement. It would seem better to spend money on facilities where farmers can clean their own grain for seed at market centres, with only a few well placed centres for processing certified seed. In this way farmer-to-farmer sales of seed can be effected, extending the seed industry.

I would like to refer briefly to the question of seed laws. It is unfortunate that most of the knowledge has evolved in developed countries with long histories in the seed industry. Farmers have been educated to the use of seed, and laws have become more and more rigid with the passage of time, culminating in the rigid laws including the royalty system of the private seed firms. These restrictive laws can work in such an environmental. However, it is discouraging that this is the type of law being promoted in the developing countries by "experts" from the developed nations.

Seed laws need to be flexible where a seed production program is being initiated in a country already short of trained personnel. What is needed is a system where farmers are supplied with relatively pure seed of high germinability to produce a good field stand. The law must be sufficiently flexible so that in years of seed shortage caused by natural calamities or poor growing conditions, seed may be processed although not as pure as the provision of the law. This is common sense. Without question seed production laws tend to be a major constraint.

Several times during the week, oblique references were made to the shortage of trained manpower. The increase in scientific manpower in the region as a whole over the past 10 years has been phenomenal, but the need continues. This is particularly true in the area of extension and seed production and almost as much in research and all phases of the agricultural industry. International centres, such as ICARDA and CIMMYT, continue to struggle with the problem. We are doing our utmost within our capacity to provide training. May I suggest, however, it would serve well each country represented here to establish by policy a fund to provide training internally or externally at the engineer or bachelor's level and for advanced degrees. Certain countries, such as Libya, have moved rapidly to develop a strong scientific cadre trained inside and outside the country. Algeria has moved aggressively to turn out large numbers of graduates. There are many others, where priority for agriculture is so low that each year only a handful are graduated. They cannot reach the demand levels for the trained people needed for production. *We need active government support. It is almost impossible for us in the international centers to generate funds for graduate training.* The costs of scholarships have risen rapidly leaving governments as perhaps the only sources of the necessary funds.

Let me reiterate the need to have strong interactions of disciplines—particularly biology with economics at both micro and macro levels. It is also essential that bureaucratic roadblocks are lessened or removed. Often, everyone knows what needs to be done, but decisions are avoided, issues are handed from one person to another and are sometimes lost before action is taken. I point no finger at any particular country. All are guilty of these bureaucratic roadblocks to a greater or lesser degree. It should be one of the things that rational human beings can remove.

The other day it was stated that more than a million mounths a week are added to the world demand for food. It will soon be two million. We are going to have to work *overtime, double time and triple time to stay even with the geometric increase* of the human time bomb. So far we have failed to stop this juggernaut. We are not helped by those who proclaim that the world can feed 40 or more billions. This is a pernicious pipe-dream.

I have every hope that through dedicated work we will be able to produce enough food to feed the next doubling, to eight billion. The technology discussed here this week has the potential for production to feed twice the present numbers. Each of us must meet the challenge to make our homeland as self-sufficient as possible. Self-sufficiency is not possible in all countries, particularly where water shortages exist, but *in most the good husbanding of resources can add materially to the food supply.* We need to grow wheat, barley, triticale, maize, rice, pulses, etc., not wild oats and wild rye grass.

Mr. Chairman, in closing, add my personal thanks to all of the people who have attended this seminar. Its success is a credit to all of those in the organizing group. Their efforts have been extraordinarily successful. The officials of the Government of Algeria are to be commended on the importance they have given to food production. It is an important pursuit, the challenge is with us, and on our joint success in meeting the need will depend the future of our countries.