ICARDA RESEARCH HIGHLIGHTS

1984

International Center for Agricultural Research in the Dry Areas (ICARDA)

Profile of ICARDA

The International Center for Agricultural Research in the Dry Areas was established in 1977 to undertake research and training relevant to the needs of developing countries and specifically for the agricultural systems of West Asia and North Africa. The Center's general objective is to help increase agricultural productivity and food supplies, thus improving economic and social living standards.

ICARDA focuses primarily on rainfed agricultural systems in areas with limited, winter rainfall. Research extends into irrigated areas when logical and cost effective, but the Center's research priority is problems of the rainfed sector which research has previously neglected.

ICARDA is designated a world center for barley, lentils, and faba beans, and a regional center for improving bread wheat, durum wheat, triticale, chickpeas, pasture and forage crops, and farming systems.

Governed by an International Board of Trustees, the Center is organized into four scientific programs: Farming Systems, Cereal Crops Improvement, Food Legumes Improvement, and Pasture, Forage, and Livestock Improvement. Other key divisions include Genetic Resources, Training, Communications and Documentation, and Computer Services.

Principal financing for ICARDA is arranged by the Consultative Group on International Agricultural Research (CGIAR). Support for ICARDA's programs in research and training in 1984 was provided by many countries and organizations. The principal donors are listed on page 90.

Headquarters for the Center, including its principal research station, is at Tel Hadya, Syria (about 30 km south of Aleppo on the Damascus-Aleppo highway). Land for the 948-hectare site was granted to ICARDA by the government of the Syrian Arab Republic. ICARDA also has a sub-station in Lebanon and works in many other countries of the region in collaboration with national research programs.

Cover: The background of the cover is an actual photograph of the soil taken from an experimental field at ICARDA's headquarters.

ISSN 0255 - 643X

Correct Citation: ICARDA (International Center for Agricultural Research in the Dry Areas). 1985. Research Highlights for 1984. Aleppo, Syria.

Contents

4 **Foreword**

Food Legumes

6 *Farmers' Results with Faba Bean Pilot Production/Demonstration Plots in Northern Sudan*
9 *Weed Control in Faba Beans in Egypt's Nile Valley*
12 *Development of Determinate Faba Bean Lines*
14 *Multiple Disease Resistance in Faba Beans*
16 *Economic Approach to Insect Control in Lentils and Faba Beans*
19 *Nematode Infestations of Food Legume Crops in the Dry Areas*
23 *Selection of Superior Lentil Cultivars by Ethiopia*
24 *Improvements in Lentil Dehulling*
25 *Breeding Kabuli Chickpea Lines with Larger Seeds, Better Yields, and Resistance to Blight*
27 *Role of Supplemental Irrigation to Improve Chickpea Yields*
29 *Tackling the Problem of Ascochyta Blight of Chickpeas in Pakistan*
32 *National Programs Select Kabuli Chickpea Genotypes*

Cereals

34 *Improved Varieties of Barley and Wheat for West Asia and North Africa*
38 *Stability and Heritability of Cereal Quality Characteristics*
42 *Identification and Development of Bread Wheat with Stress Tolerance*
45 *Screening Wheat for Resistance to Septoria Leaf Blotch*
48 *Breeding Barley for Low Rainfall Areas*
50 *Better Triticale Yields and Improved Quality*
52 *Extending Cereal Research to Farmers' Fields in Syria*

Pastures, Forage, and Livestock

54 *Measuring Biological and Environmental Constraints to Increasing Productivity of Marginal Grazing Lands*
56 *Winter Growth of Annual Pastures: Species vs. Density*

58 *Flower and Pod Loss in Annual Medics*
60 *Value of Crop Residues as Summer Grazing for Breeding Ewes*
63 *Predicting Feeding Value of Barley Straw for Sheep*
65 *Sheep Feeding and Grazing Trials: Palatability of 20 Pea and Vetch Genotypes*

Farming Systems

68 *Enhancement of Biological Nitrogen Fixation in Legume Crops*
72 *Effect of Crop Rotation on Fertilizer Response in Barley Growing Areas of Syria*
77 *Feasibility of Annual Sown Forage Legumes in Barley/Livestock Systems*
79 *Evaluating Existing and Alternative Fallow/Crop Rotations*
83 *Farming Systems Research Project Initiates On-Farm Trials in Tunisia*
84 *Predicting How Wheat Yields Respond to Climatic Factors: A New Computer Program Named SIMTAG*

Seed Health Laboratory

86 *Limiting the Risk of Spreading Pests and Pathogens*

Building Program

88 *Update on ICARDA's New Buildings*

90 *ICARDA Donors*
91 *Board of Trustees*
92 *Senior Staff*
96 *ICARDA Addresses*

Foreword

In this fourth edition of our Research Highlights you will find recent examples of the work of scientists to enhance agricultural production, stability, and profitability in West Asia and North Africa, particularly in the rainfed lands that cover more than 70% of the region's cultivated acreage. The results of their work are an investment in the present and in the future for a very large, complex region with a fast growing population and an increasing demand for food.

The gap between food production and consumption is rapidly widening with costly imports now meeting more than half of the food needs. One of the reasons for the decline in food self-sufficiency in the region is that too little agricultural research is being undertaken in countries of the ICARDA region. The tragic famines in Ethiopia, Sudan, and other parts of Africa are striking evidence of the result of a lack of clear focus of research on basic food crops, the degradation of land resources, and man's mismanagement of his crops and animals. Some of the research reported here is aimed at helping prevent similar deterioration already becoming evident in other parts of North Africa and in several parts of West Asia.

Our scientists are making progress to develop practical and economical ways to use millions of hectares of fallow land for pasture and forage crops as an alternative to destroying marginal areas. They have identified productive strains of native species of medics which could greatly increase the supply of feed for sheep—the main source of income for many of the poorest farmers. Also, we now have proof that with new improved varieties and cultural practices, production of certain basic food crops can be increased 50% or more—not only on experimental plots but on farmers' fields. During 1984, more ICARDA and national program research than ever before moved to on-farm trials in several countries. Hundreds of farmers became active partners in research—not just passive bystanders. For example, in Syria, our principal host country, more than 300 cooperative trials were conducted during the 1983/84 season at 14 research stations and in almost 100 farmers' fields. Two wheat varieties released the year before (Sham 1 and Sham 2) performed well, as did two new bread wheat lines. Various advanced cereal lines have been selected and released by as many as 17 countries in the region.

In Egypt and Sudan, farmers participating in the unique Nile Valley Project (now in its sixth year) reaped faba bean yield increases of 30, 50, and 100% and more. Scientists in both countries speak enthusiastically about the lessons they have learned from farmers. Recently the Sudanese National Research Program presented this project to an international organization as the best project model so far experienced in that nation. The Arab Conference for Agricultural Research on Basic Food Crops recommended that it serve as a model for application in similar countries. Ethiopia has asked for it to be extended there in 1985, and this will be done.

ICARDA is now developing a nucleus of activities in collaboration with the national program in Tunisia. The newest project, started in 1984, involves farming systems. It will emphasize on-farm trials with the aim of developing technology components or practices which can be adopted piecemeal by small farmers. ICARDA scientists posted in Tunisia not only work with their

counterparts in the national system but also form the nucleus for the Center's activities with the North African sub-region as a whole. From this base, contacts increased during 1984 with scientists in Morocco and Algeria.

We continue to place great emphasis on our training activities. More persons have been trained in the past two years than the previous five. Increased emphasis is being put on in-country training. Also, we cooperate with universities to have graduate students work on their thesis research at ICARDA.

We express our deepest gratitude to our donors who number nearly 30 governments and organizations. Without their backing ICARDA's research and training would draw to a halt.

For additional information about the Center's activities, please do not hesitate to write to us. A fuller account of our work is available in the 1984 Annual Report.

Mohamed A. Nour
Director General

Left, farmers in Sudan irrigate faba bean fields (in the background); right, a Sudanese technician and a national scientist talk with a farmer in one of the faba bean pilot production demonstration plots in the Zeidab scheme in the Nile Valley Project.

Farmers' Results with Faba Bean Pilot Production/Demonstration Plots in Northern Sudan

In the Nile Valley Special Project, on-farm research provides a network in which farmers, extension personnel, and national program researchers work together to improve faba bean (*Vicia faba*) yields in Sudan and Egypt. This on-farm research is managed at three levels:

- **Researcher-managed trials.** Different combinations of test and farmer practices are compared in small replicated areas. Farmers participate in these trials by following their own traditional practices for the variables under study on certain plots. Researchers apply test practices to other plots.
- **Farmer-managed trials.** When the researcher-managed trials have proved the success of a test practice, this is compared with the farmer's method on larger areas. The farmer manages both the test and his own traditional practice areas under the supervision of researchers.
- **Pilot production demonstration plots.** The farmer alone then tests on a larger scale the recommended technologies which have proved successful in farmer-managed trials. Involvement of scientists

and extension workers is limited to advice on the recommended technologies and to monitoring the physical and monetary results.

Farmer-managed trials conducted at Zeidab and Aliab schemes in Sudan in 1982/83 showed that the recommended package of early planting, more frequent irrigation, and pest control resulted in significant yield gains and was profitable to farmers. (See 1983 edition of *Research Highlights.*) Thus, the recommended package was evaluated on larger plots in Zeidab scheme entirely managed by the farmer. This pilot production/demonstration program was the third step in the on-farm research process.

In the 1983/84 season, 21 plots were selected from the different sections of the Zeidab scheme in northern Sudan to evaluate the recommendations. These larger test plots ranged from 1.3 to 18.3 hectares with a total area of 139.5 hectares; 77 farmers participated.

Results in Table 1 show that consistently throughout the Zeidab scheme faba bean

Table 1. Faba bean grain yield of pilot production/demonstration plots compared with neighboring farmers' fields in the Zeidab scheme in Sudan (1983/84).

Section	Pilot Production/Demonstration Plots					
	No. of farmers	Total area (ha)			Yield increase over neighboring farmers	
					(t/ha)	(%)
Northern	3	6.9			0.7	51
«	4	6.6			0.7	31
«	6	7.8			1.4	80
«	13	18.3			0.3	16
Abu Selaim	3	4.9			0.9	76
«	2	5.0			1.5	198
«	2	3.6			0.5	25
«	1	1.3			2.0	263
«	2	2.9			2.4	218
Section 4	5	8.6			2.2	153
«	4	5.5			0.7	70
«	3	3.5			0.7	74
«	2	1.9			0.5	55
«	1	1.8			1.2	108
«	4	12.6			1.3	276
«	7	11.5			1.0	100
«	5	8.4			0.4	29
Southern	1	2.5			0.6	64
«	5	13.2			0.6	34
«	1	3.8			0.5	43
«	3	8.9			0.4	29
Mean					0.9	75.4

yields of the individual pilot production/demonstration plots were considerably higher than those of neighboring farms (general practices). The yield gap ranged from 0.3 to 2.4 t/ha, with an overall mean of 0.9 t/ha. This is equivalent to a yield increase ranging from 16 to 276% with an average of 75%. The economic analysis showed that the participating farmers realized an increase of Sudanese £119/ha in net benefits over those of non-participating farmers.

This research is part of the Nile Valley Special Project now in Phase II and supported financially by the International Fund for Agricultural Development (IFAD). The project is unique because it places the responsibility for leadership, coordination, and actual execution of the work with the national programs in Sudan and Egypt and involves the farmers themselves in the research process. ICARDA plays a catalytic and research backup role.

Left, a Sudanese farmer displays his local faba bean seeds in his hands; right, one of the 10 Sudanese farmers who received awards for the highest faba bean yields in the Nile Valley Project leaves for his farm on his donkey carrying a certificate and sprayer he won in the 1984 competition.

Weed Control in Faba Beans in Egypt's Nile Valley

Non-parasitic weeds in Egypt in recent years have reduced faba bean yields by 24 to 30% and the parasitic weed, *Orobanche*, by 5 to 24%. Hand labor — the traditional method of weed control in Egypt— has become expensive. Therefore, chemical weed control looks like an increasingly economic alternative.

Results of non-parasitic weed control experiments conducted at several experiment stations in Egypt over the past five years as part of the cooperative national/ICARDA Nile Valley Project have proven that weeds should be controlled early--not later than six weeks after sowing. Two hand hoeings at 5 and 10 weeks after sowing effectively controlled the weeds (Table 2).

The effectiveness of herbicide applications depended on the type of weed population. Terbutryn (Igran) at a rate of 2.5 kg a.i./ha gave effective weed control (Table 2), as did the same rate of terbuthylazine (Topogard) application in certain locations. If the weed population included *Ammi* sp., effective control was obtained by terbutryn (Igran) followed by one hand hoeing. Post-emergent application of fluazifobutyl (Fusilade) at the rate of 0.5-1.0 kg a.i./ha gave good control of grassy weeds.

Other trials were conducted on farmers' fields. At each site, hand hoeing as normally done by farmers was compared with chemical weed control. Terbutryn (Igran) was applied after sowing, before

Table 2. Effect of different treatments on weed control and faba bean seed yield at three locations in Egypt.

Treatment	Rate	% Weed reduction			% Seed yield		
	(kg a.i./ ha)	Sakha	Mallawi*	Shandaweel**	Sakha	Mallawi	Shandaweel
Weedy check	—	0	0	0	100	100	100
Weed free	—	100	94	100	187	143	363
Hoeing once	—	79	49	20	154	121	131
Hoeing twice	—	90	61	47	184	121	204
Terbutryn (Igran)	2.0	92	69	14	173	130	[illegible]
Terbutryn + hoeing once	—	97	79	53	183	[illegible]	[illegible]
Terbuthylazine (Topogard)	2.0	89	77	14	141	[illegible]	[illegible]
Fluazifobbutyl (Fusilade)	2.5	—	—	44	—	—	136
Av. yield of check (t/ha)	—	7.8	6.7	2.3	1.34	2.3	1.0

Ammi spp. as troublesome weeds predominated at Mallawi.

***Cynodon dactylon* as perennial grass was prevalent at Shandaweel.**

emergence, at the rate of 2.5 kg a.i./ha. The seed yield increase due to chemical weed control averaged 9.3%.

Scientists have developed a new faba bean variety—Giza 402—tolerant to *Orobanche*, and it is being multiplied on more than 6000 hectares in the 1984/85 season for distribution to farmers in Egypt. Also, they have tested integrated strategies to control *Orobanche* in faba bean fields by combining genetic resistance and chemical applications. Different treatment combinations involving the growing of Giza 402 (tolerant) and Giza 2 (susceptible) were tested at three naturally infested sites in Minia Governorate.

The faba bean genotype Giza 402 produced an average seed yield increase of 18.4% and 24.1% for straw over the cultivar Giza 2 with no glyphosate spray (Figure 1). However, Giza 402 with no glyphosate application produced almost as much seed as Giza 2 with two spray treatments. This demonstrates the tolerance of Giza 402 to *Orobanche* infestation.

Mid-November sowing reduced the parasite infestation and increased seed yields for both varieties compared with mid-October. Sowing in a non-tilled soil also decreased the parasitic infestation rate. Over the three sites, Giza 402 sown without tillage in mid-November and sprayed twice increased seed yields 88.1% or 2.4 t/ha.

Three on-farm trials on *Orobanche* control were also conducted in Minia in naturally infested fields during 1983/84 to test four combinations involving the use of Giza 402 and Giza 2 cultivars with a test package. It consisted of a large population, heavy fertilizer application, and the use of glyphosate in contrast to the traditional farmers' package. The seed yield increases were 119, 33, and 7% with the test package for these *Orobanche* infested fields; the parasite infestation in the last two locations was less than at the first one.

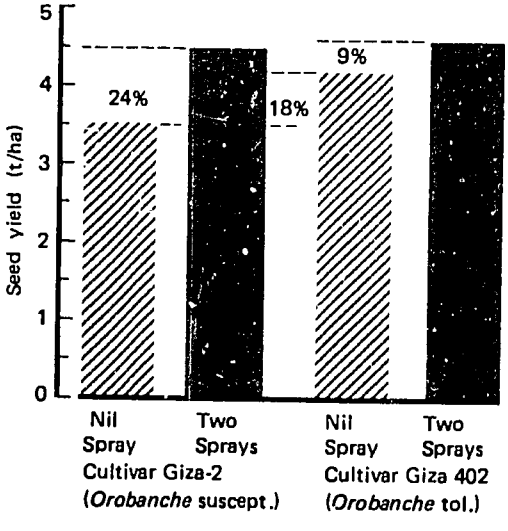


Figure 1. On-farm trials with and without glyphosate herbicide applications for control of the parasitic weed *Orobanche* in faba bean fields at El Minia, Egypt. The faba bean cultivar Giza 402 shows its tolerance to *Orobanche*.

Orobanche (with the beautiful flowers) is a parasitic weed which sucks the life from faba bean plants and may devastate a crop in one year. A heavy infestation can lead farmers to drop production entirely.

A new faba bean variety— Giza 402— developed by national scientists in Egypt is tolerant to *Orobanche*. The plot on the left, not treated with a herbicide (glyphosate), gave far better yields than traditional varieties in spite of some infestation.

The field of faba beans on the left, treated with a herbicide (Igran), shows good weed control compared with the untreated plot on the right.

Development of Determinate Faba Bean Lines

Discovery several years ago of a «topless» faba bean mutant excited the interest of breeders and physiologists. They thought it might offer the possibility of controlling excessive vegetative growth believed to reduce grain yield by using nutrients otherwise available for floral development and grain growth.

However, one major weakness of the original «topless» mutant was a low number of pod-bearing nodes per plant. It also had a greater young pod abortion rate than indeterminate types. Furthermore, the «topless» mutant, developed in northern Europe, is poorly adapted to the Mediterranean environment and produces small seeds.

To overcome these problems, ICARDA initiated a crossing program with the determinate mutant in 1979, selecting and backcrossing with Mediterranean types each year to improve the adaptability and increase the seed size and podding nodes per plant.

In 1983, scientists made 197 crosses and 323 in 1984 involving determinate parents. Each year since 1979 the best determinate selections were used as the determinate parents in the crosses. In this way the determinate gene was transferred and most of the undesirable genes of the original mutant discarded.

Yield evaluation of determinate lines started in the 1982/83 season at ICARDA when 75 of these lines were yield-tested. The best determinate line yielded 2.4 t/ha compared with 4.7 t/ha for the indeterminate check. In the 1983/84 season, 93 determinate lines with one additional backcross were tested. In general, for all trials in 1983/84, yields were reduced from the previous year because of a poor growing season due to less than average rainfall. But the comparison against the standard indeterminate check used for all trials showed 10 determinate lines not significantly different in yield than the indeterminate standard (Table 3). Some selections were made from these lines for large seed size and a larger number of podding nodes.

These results are encouraging compared with the first determinate lines developed. As a further step to increase yields, these determinate lines will be crossed in 1985 with another set of mutants that have a very low flower drop because each of their flowers has its own vascular system.

Table 3. Performance of determinate faba bean lines and a standard indeterminate check (ILB 1814) in preliminary determinate yield trials grown at Tel Hadya, Syria (1983/84).

Line	Grain yield (kg/ha × 000)	100 seed weight (g)	Plant height (cm)
S82223-2	2.12	55	43
S82226-37	2.50	80	33
S82229-38	2.18	85	50
S82229-35	2.02	75	44
S82236-4	2.14	65	40
S82237-31	2.40	90	52
S82237-50	2.34	90	45
S82238-38	1.98	90	40
S82238-40	2.57	100	41
S82238-45	2.53	90	38
ILB 1814	2.79	230	64
LSD (5%)	0.645	—	6.9

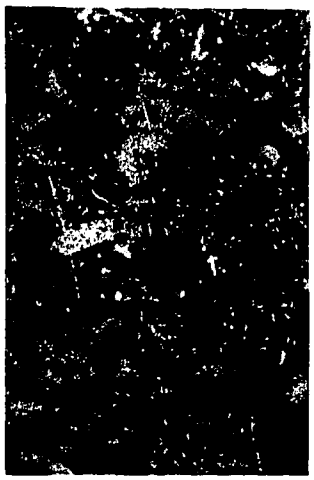
Two stages of development of new faba bean lines with variations. Left, determinate faba beans with small pods and large seeds; right, with large pods and large seeds. Plant breeders make repeated backcrosses to develop new lines.

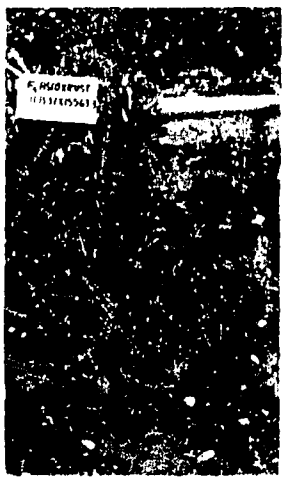
Multiple Disease Resistance in Faba Beans

Chocolate spot *(Botrytis fabae)*, Ascochyta blight *(Ascochyta fabae)*, and rust *(Uromyces fabae)* — among the most important diseases of faba beans throughout Asia, North Africa, and Europe— are rarely found separately in nature. Most often they overlap and interact to create complex pathological conditions. Although these diseases may be destructive individually in faba bean fields, when two or more act in concert their combined pathogenic effect becomes much greater.

Faba bean fields in different production regions frequently have been affected by combinations of chocolate spot and rust, Ascochyta blight and rust, or by chocolate spot and Ascochyta blight, and suffer severe damage. Therefore, scientists at ICARDA have focused on developing faba bean cultivars with multiple disease resistance for cultivation in production regions known to suffer from such complex disease problems. Based on disease distribution patterns throughout these regions, genes for resistance to major diseases were combined and progenies tested at ICARDA's sub-site in Lattakia, Syria.

These efforts resulted in faba bean lines with simultaneous resistance to two or three diseases (Table 4). At present, F_6 progenies from these studies are being evaluated in preliminary yield trials and also used in ICARDA's breeding program. New sources of multiple disease resistance have also been identified in ICARDA's pure line collection (BPL's) for use in development of broad-based disease resistant cultivars for different areas (Table 5).





Left, rust and chocolate spot diseases on a faba bean plant; center, a combination of Ascochyta blight and rust; right, a new line of faba beans with multiple resistance to blight and rust compared with a local check which is susceptible to both.

Table 4. Multiple disease resistance of F_4 faba bean families to Ascochyta blight, chocolate spot, and rust compared with certain local cultivars.

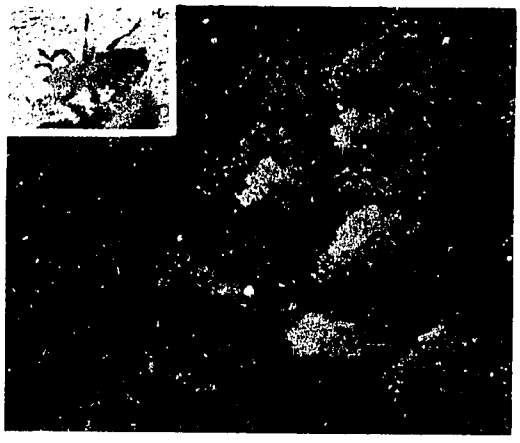
Families and local cultivars	Disease reaction*			
	Ascochyta blight	Chocolate spot	Rust	Recommended for:
L82003	R	R	NT	Northern Africa and Europe
L82004	R	R	NT	« »
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
L82010	NT	R	R	Egypt and North Africa
L82011	NT	R	R	« »
L82012	R	NT	R	North Africa and Middle East
L82013	R	NT	R	« »
[illegible]	[illegible]	[illegible]	[illegible]	

*Disease readings were recorded on ICARDA's scale where: R = resistant; MR = moderately resistant; S = susceptible; HS = highly susceptible; NT: not tested.

Table 5. Sources of multiple disease resistance in faba beans based on evaluation in 1982/83 and 1983/84 at ICARDA's sub-site at Lattakia, Syria.

Accessions	Disease reaction*				
BPL	Rust	Sremphyl-ium	Alternaria	Ascochyta	Chocolate spot
74	NT	NT	NT	***	**
472	NT	NT	NT	***	**
[illegible]	***	***	***	NT	***
[illegible]	**	***	***	***	***
274	**	**	**	NT	**
470	*	**	**	NT	*
710	***	**	***	NT	***
1055	*	NT	**	NT	**
1058	*	NT	**	NT	**
1179	***	***	***	NT	***
1196	*	NT	***	NT	***
1278	**	NT	**	NT	***
1543	*	NT	**	NT	**
1544	*	NT	***	NT	**
1547	**	NT	**	NT	**
1548	*	NT	*	NT	**
1550	**	NT	**	NT	**
1763	*	NT	*	NT	**
1821	*	NT	*	NT	**

*Moderately resistant; **Resistant; ***Highly resistant.
NT: Not tested.



The notches on the leaves of the young lentil plant show the initial damage of the adult *Sitona* weevil (inset).

Once the nodules on lentil roots are heavily infested by larvae of the *Sitona* weevil, there is no recovery.

Economic Approach to Insect Control in Lentils and Faba Beans

An array of insects attacks lentils and faba beans in the Middle East and North Africa, causing varying degrees of damage and yield losses. To quickly suppress insect populations and help prevent these losses, ICARDA scientists are using and testing insecticides which will be integrated with host plant resistance and other non-chemical protection methods. They use the insecticides only for those insects which cause definite yield losses and weigh their benefits against costs. Benefit/cost ratios should be clearly in favor of chemical applications before being used.

To identify the key pest or pests affecting lentils and faba beans, research aimed at partitioning yield losses among crop growth stages and insect species has been conducted at the Center. Results of several experiments indicate that the leaf weevil (*Sitona* spp.) is the most important insect pest on lentils in Syria, with foliar insects such as *Apion*, aphids, thrips, bruchids, and pod borers less important. Average

yield increases of lentils obtained through selective control of these groups of insects are shown in Table 6. Black aphids are the main pest on faba beans. In outbreak years, highly selective control of aphids can increase yields by 60% (Table 7).

Application of insecticides substantially reduced yield losses but were the control measures economical? To answer this question, different alternatives of control were compared in terms of their efficiency to suppress the insect populations and their economic profitability. Depending on lentil yield levels, *Sitona* control with insecticides can be a profitable practice. A comparison of different alternatives is shown in Figure 2. Clearly, a single application of a granular insecticide (heptachlor or carbofuran) would be the most profitable practice. Research underway is attempting

Table 6. Insecticidal regimes and resulting yields of lentils with different levels of insect control at Tel Hadya, Syria (1982-84 seasons).

Kind of protection	Yield	
	(kg/ha)	(% increase)
None	2109	—
Against *Sitona**	[illegible]	[illegible]
Against foliar insects**	2274	7.8
Complete	2696	27.8

*With a granular insecticide at planting.
**One spray with methamidophos.

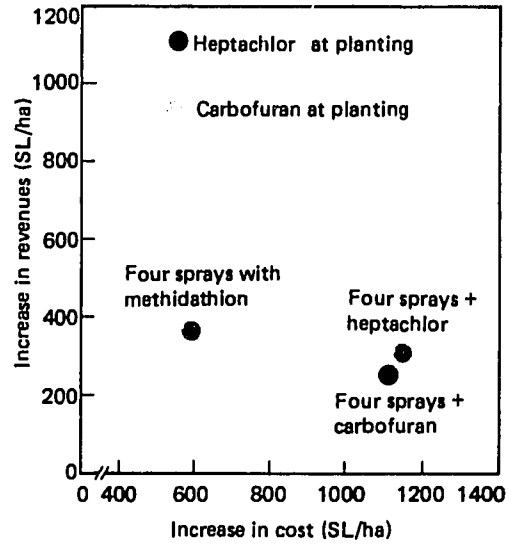
Table 7. Insecticidal regimes and resulting yields of faba beans with different levels of insect control at Tel Hadya, Syria (1982-84 seasons).

Kind of protection	Yield	
	(kg/ha)	(% increase)
None	1396	—
Against *Sitona**	1786	27.9
Against aphids**	[illegible]	[illegible]
Complete	2552	82.8

*With a granular insecticide at planting.
**One spray with a highly selective insecticide (pirimicarb).

Black aphids are the main pest on faba beans, but they can be economically controlled. Shown here is heavy infestation of black aphids feeding on a plant's stem, leaves, and flowers.

Figure 2. Cost-benefit relationships for five alternatives of chemical control of *Sitona* weevils in lentils. (SL = Syrian lira.)



to find even cheaper, safer, and easier methods of control of *Sitona* weevils.

Economic control of aphids on faba beans can be attained by timing the applications according to the level of damage caused by the insect and the crop growth stage. Thus, a single spray at the pod filling stage (Figure 3), when damage levels were 2 in a 1 to 4 visual damage score (1 = no damage, 4 = very severe damage), was the best alternative in terms of yield response and economic returns (Figure 4).

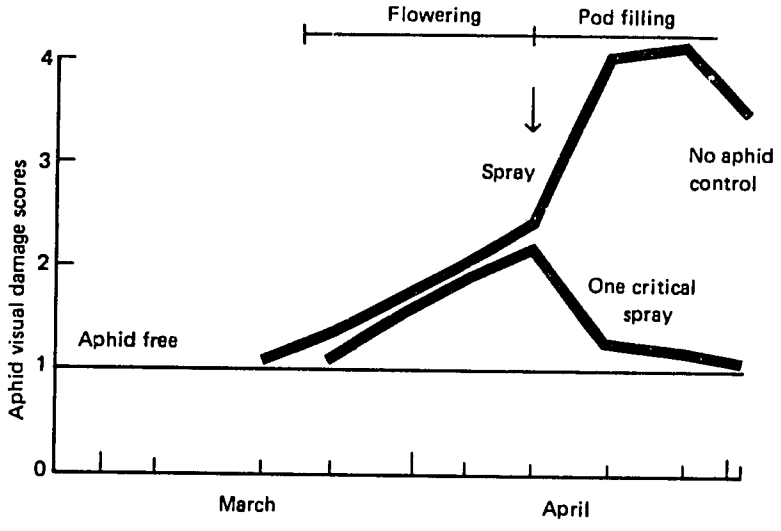


Figure 3. Effect of one critical spray with pirimicarb on the levels of damage caused by faba bean aphids. (Visual damage scores: 1 = no damage, 4 = very severe damage.)

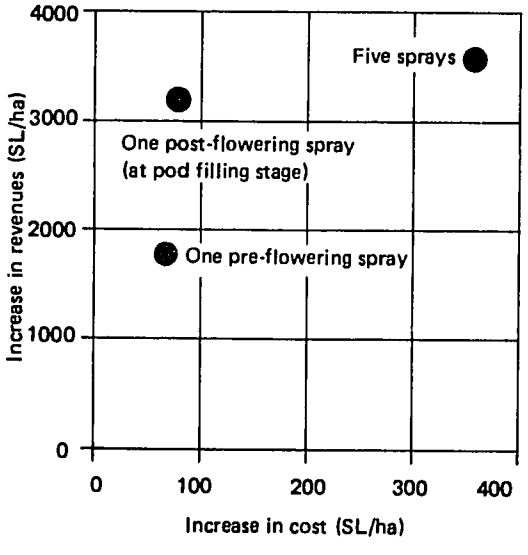
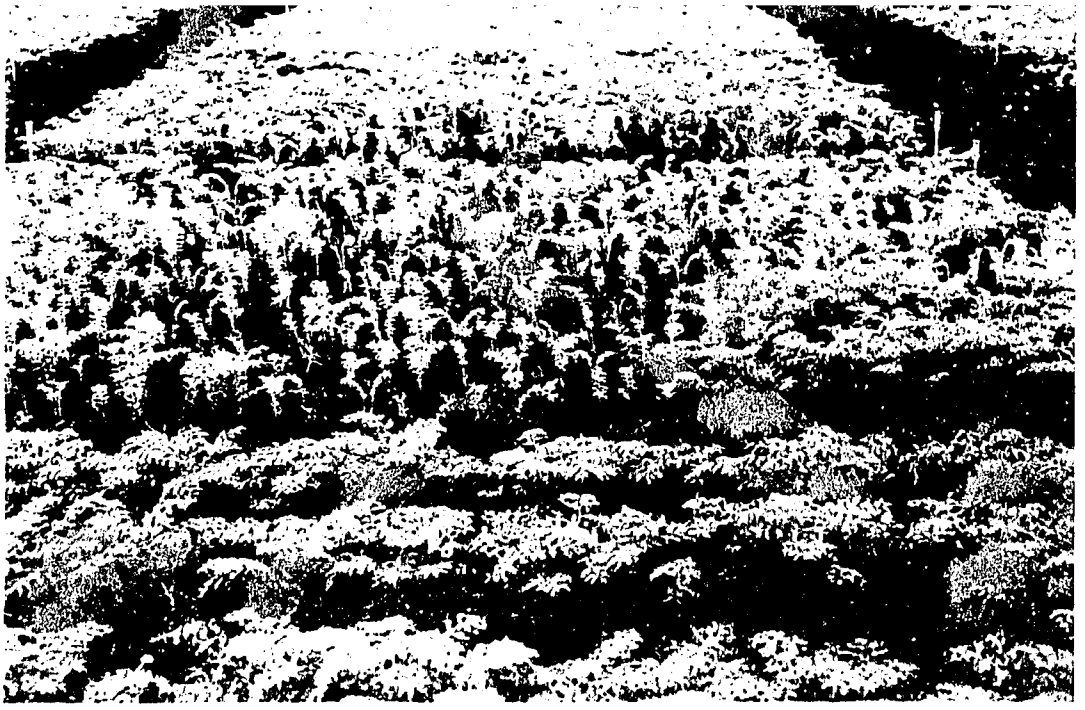


Figure 4. Cost-benefit relationships for three alternatives of chemical control of faba bean aphids. (SL = Syrian lira.)



A chickpea plot (center), with patches of yellow and stunted plants, is infested with root knot nematodes.

Nematode Infestations of Food Legume Crops in the Dry Areas

Little is known about the nematode species affecting food legume crops in the dry areas of West Asia and North Africa and the extent of the losses caused by these plant parasites. During the 1979-80 season, ICARDA scientists found an infestation of root-knot nematodes in chickpea plots at its principal experimental farm at Tel Hadya, Syria, and the problem became worse over the next season. A survey on farmers' fields also revealed the presence of nematodes.

To begin to find some answers, the scientists initiated a research program in 1982 involving chickpeas and lentils in collaboration with Italy's Instituto di Nematologia Agraria. Its main objectives are to identify various species of nematodes affecting these crops, their distribution, production losses, and the possibility of controlling them through host-plant resistance or tolerance.

Surveys conducted in Syria during the 1982-83 season gave an indication of the seriousness of the problem. Scientists found 12 nematode genera occurring in soil and root samples. Among them *Heterodera*, *Meliodogyne*, *Paratylenchus*, *Ditylenchus*,

and *Aphelenchoides* are usually considered of more economic importance. Also present were the genera *Pratylenchoides*, *Helicotylenchus*, *Tylenchorhynchus*, and *Xiphinema* that have been reported as causing damage to several crops. Genera of less economic importance were *Paratylenchus*, *Trophurus*, and *Tylenchus*.

Cyst nematodes infested 24% of the chickpea root samples. Chickpea plants in infested fields grew poorly and their foliage was yellowish. This resulted in poor yields. Peas appeared to be less susceptible and faba beans were resistant or a non-host. All of the nematode populations detected in the infested fields showed morphological features of the *Heterodera trifolii* group and were close to *H. rosii* Duggan *et* Brennan.

Pratylenchus thornei (root lesion nematode) was detected in 60% of the samples, including chickpeas, faba beans, and alfalfa. Chickpeas seemed to be heavily damaged by attacks of *P. thornei*, and 74% of the samples were found infested with this parasite. Many lesions were found on the roots of infested chickpeas, and growth was retarded.

Root-knot nematode, identified as *Meliodogyne artiellia*, was detected in 12% of the samples, and infested fields showed patches of yellow and stunted plants.

Among other nematodes, *Tylenchorhynchus* spp. occurred in 73% of the sample, *Tylenchus* spp. 60%, *Helicotylenchus* spp. 50%, *Pratylenchoides* spp. 6%, *Trophurus* spp. 6%, *Aphelenchiodes* spp. 4%, *Pratylenchus* spp. 4%, and *Xiphinema* spp. 2%. Most of these nematodes are ectoparasitic in habit and were found on the roots and in the rhizosphere of several plants. However, no symptoms of damage associated with their presence could be found.

While root-knot and root lesion nematodes seem to be sporadic on winter-sown chickpeas, cyst nematodes are more common on the spring-sown chickpeas and are also widely prevalent in farmers' fields.

Forty-six crop species common to the Mediterranean region were tested to determine which are hosts to cyst, lesion, and root-knot nematodes (Table 8). Scientists observed cyst nematodes only on chickpeas, lentils, *Lathyrus*, peas, soybeans, lupines, *Phaseolus* beans, medics, and vetch, indicating that these nematodes are confined to legumes. However, they did not infest faba beans. Lesion nematodes infested most of the legumes and cereals. *Lathyrus*, was one of the exceptions. Also, root-knot nematodes infested most of the legumes and cereals, but not cowpeas, lupine, and corn.

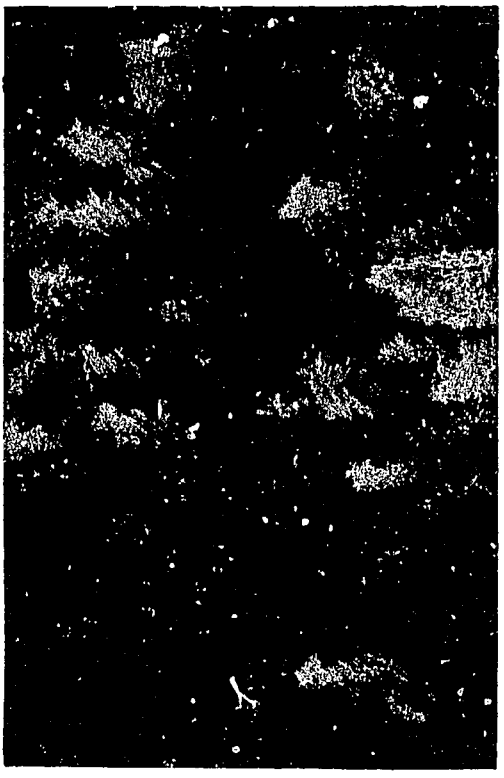
Crop	Cyst	Root-knot	Lesion
	(Nematodes per gram of roots of host plant)		
Faba beans	0	46	111
[illegible]	[illegible]	[illegible]	[illegible]
Lentils	60	5	73
Peas	12	41	222
Soybeans	4	14	0
Phaseolus beans	100	0	0

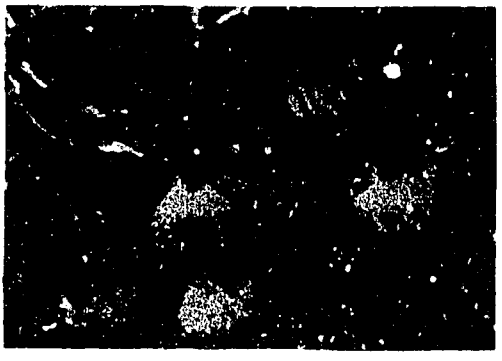
Table 8. Relative susceptibility of important food legumes to cyst, root-knot, and lesion nematodes.

In a preliminary evaluation, 290 chickpea genotypes were screened in the pots in the greenhouse for resistance to cyst nematodes. They were mainly Ascochyta blight resistant lines made up of kabuli and desi germplasm accessions and newly developed kabuli lines. Of these, 27 lines were rated tolerant to resistant: ILC 196, -197, -446, ICC 6306, FLIP 82-20C, 82-40C, 82-110C, 82-129C, 82-144C, 82-167C, 82-191C, 82-197C, 82-215C, 82-221C, 82-245C, 83-7C, 83-8C, 83-11C, 83-29C, 83-32C, 83-36C, 83-65C, 83-74C, 83-78C, 83-82C, 83-85C, and 83-91C.

One hundred Ascochyta resistant lines consisting of kabuli and desi germplasm accessions and newly developed kabuli lines were evaluated for resistance in a field plot infested with root-lesion nematodes. Very little difference in the extent of root necrosis was observed between the genotypes. The number of nematodes and the yields differed significantly, but there appeared to be no relationship between them.

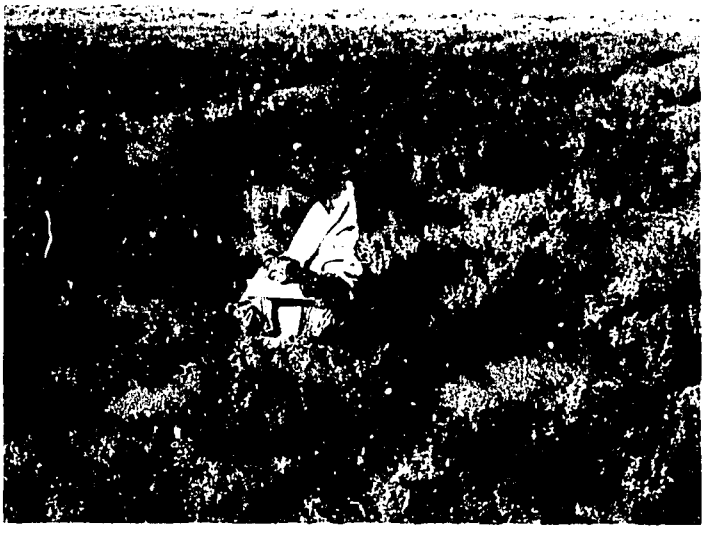
Surveys similar to the one in Syria need to be made in other countries in West Asia and North Africa to gather data on the magnitude of the problem. Scientists believe it may be possible to select for host plant tolerance to cyst and root-knot nematodes.





Mature female cyst nematodes are the small white attachments on the chickpea roots (top photo); round swellings in the lower photo are root knot nematodes. Scientists are working on selection for host plant tolerance to both types of parasites.

Left, an Ethiopian scientist and former training participant at ICARDA examines a new rust tolerant cultivar, NEL (ILL) 358, at Addis Ababa University's Debre Zeit Agricultural Research Station; right, a new trainee from that country records information on lentils in one of ICARDA's experimental fields.



The new lentil line, NEL (ILL) 358 (center), shows a high level of rust tolerance in Ethiopia compared with the local susceptible variety on the right.

Selection of Superior Lentil Cultivars by Ethiopia

Until the mid-1970s, Ethiopia was the second largest lentil producer in the world but now ranks only eighth. Furthermore, lentils at one time were second only to chickpeas among important pulse crops in that country but have dropped to fourth after faba beans, chickpeas, and field peas. Among the reasons for the decline are relatively poor economic returns to farmers because of low yields and government price support for lentils in contrast to other food legumes.

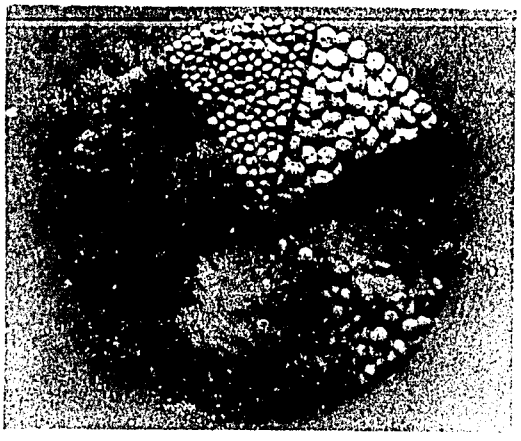
Lentils are grown mainly in the central parts of the Ethiopian highlands—Shoa, Gojam, South West Wollo, South Begemdir, and Eastern Wolleaga—at an altitude of 1800 to 3000 m with 950 to 1500 mm average annual rainfall. Compared with faba beans, peas, and chickpeas, lentils have the advantage of tolerating drought and thus can be grown without irrigation. Also, they require the fewest plant protection measures.

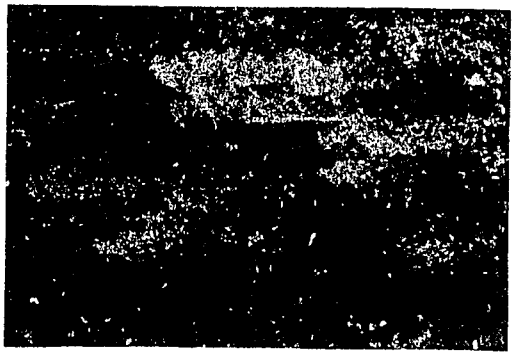
Following extensive testing by the Highland Pulse Team of Ethiopia, lentil variety NEL (ILL) 358 was recently identified for release in the highland areas. It went to Ethiopia among several other lentil materials supplied by ICARDA for initial testing at the Debre Zeit Agricultural Research Station. Promoted by the Ethiopian National Variety Trial, this line yielded over 50% more seed than the local check (Table 9). It is resistant to lentil rust *(Uromyces fabae)*, an important local pathogen, and has seed characteristics suitable for consumption either locally or abroad.

Other selections from ICARDA germplasm, such as ILL 4605 (Precoz) with a larger-seeded yellow cotyledon, have been selected by Ethiopian scientists at Debre Zeit for yield and tolerance to *Ascochyta lentis* and are being promoted to National Yield Trials.

	Akaki	Kulumsa	Robe	Location mean
1981		Yield (kg/ha)		
NEL (ILL) 358	1930	4239	2547	2905
Local check	200	539	1609	782
1982				
NEL (ILL) 358	2610	2970	2780	2786
Local check	1800	2280	2900	2326
1983				
NEL (ILL) 358	2444	2345	2256	2348
Local check	335	1557	784	892

Table 9. Seed yield (kg/ha) of lentil variety NEL (ILL) 358 and the local check in National Yield Trials in Ethiopia at three highland region sites during 1981-83.





Above, different sizes and colors of lentils. Below, the criterion of successful dehulling is the percentage of cleanly dehulled and intact lentils recovered. The best example shown here is on the left side of the lower row.

Improvements in Lentil Dehulling

Small-grained lentils are by far the most widely grown type of lentil in Syria with 90,000 to 100,000 metric tons produced each year. Moreover, this country is the second largest exporter of lentils in the world, and when the small-grained lentils with orange cotyledons are dehulled, split, and exported, they are annually worth over US$25 million to Syria. The lentil factory in Aleppo is one of the largest in the region, and there are plans for erecting a new and even larger facility.

ICARDA's food legume quality laboratory recognizes the dehulling characteristics of lentil cultivars as an important aspect of quality and has developed a laboratory-scale dehuller based on similar equipment used in the Aleppo lentil factory. Lentils are dehulled industrially by adding water to loosen the hull. Then they are immediately drained and dried for about 30 minutes, using warm heated air in

Minutes in water after immersion	Air temperature used in drying			
	Cold air (22°C)		Warm air (41°C)	
	Minutes between draining & air-drying			
	0	30	0	30
	% dehulled lentils recovered			
0	70.6	76.1	78.5	79.5
1	74.0	77.7	78.8	78.9
5	77.1	77.9	77.7	78.5
10	76.8	76.8	77.9	79.7

Table 10. Influence of wetting time, standing time between draining and air-drying, and air temperatures used in drying on percent of dehulled lentils recovered.

the winter and natural warm air in the summer months. The criterion of successful dehulling is the percentage of cleanly dehulled lentils recovered. The residual material consists of hull (about 10%) and both intact and broken lentils (about 5% each). At ICARDA the lentils are dehulled and separated by suction and sieves into the various fractions.

A recent study of the wetting and air-drying process carried out at the Center showed that:

- Warm air drying was more effective in dehulling than cold air (Table 10).
- Introducing a standing period between wetting and drying with warm air increased recovery of dehulled lentils by 1%. (An increase in recovery of 1% translates into an increased revenue of US$214,000 per year at current prices for dehulled lentils.)

Breeding Kabuli Chickpea Lines with Larger Seeds, Better Yields, and Resistance to Blight

Large seeded kabuli chickpeas (40g/100-seed weight) are preferred by consumers and bring a premium price in various parts of the world. But currently they are low yielding, short statured, and susceptible to Ascochyta blight disease. Major emphasis in the ICARDA/ICRISAT joint research program is directed at solving these problems.

Although blight resistant chickpeas developed so far through this program have been tall and good yielding, the seeds are round and small (30g/100-seed weight). Also, the cultivars are late maturing types which do well in winter sowing but not in spring sowing because of the short season and moisture stress.

Following a pedigree method of breeding, scientists are making progress in developing kabuli-type and large seeded, tall stature (more suitable for mechanical harvesting), and Ascochyta blight resistant types. They make crosses at ICARDA's main station at Tel Hadya, Syria during the main season (November-June). The F_1s are grown in off-season sites in Syria and Lebanon (July-October) under extended daylight, and F_2s and F_4s in the main season in the Ascochyta blight screening nursery. F_3s and F_5s are grown in the off-season under normal conditions (decreasing day length), and the photoperiod sensitive types are eliminated. Yield testing in F_6 is

done in Syria and Lebanon and then through an international testing program in areas growing large seeded types.

So far, 20 chickpea lines combining large seed, high yield, and Ascochyta blight resistance have been bred, and 10 lines are shown in Table 11. Irrespective of their yield performance, lines combining large seed and blight resistance should encourage the introduction of winter sowing which has a great potential in many areas of West Asia, North Africa, and South Europe.

A number of lines combining tall stature, high yield, blight resistance, kabuli-type seed and large seed size have been developed for the first time (Table 12). Additional emphasis is being put on the development of early maturity types having these traits.

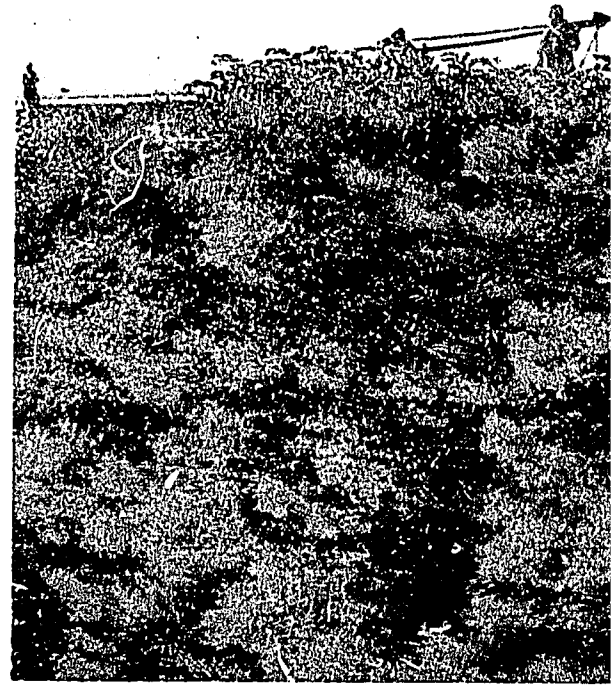


Table 11. Seed weight of some of the newly bulked large seeded and blight resistant kabuli chickpea lines at Tel Hadya, Syria (1983/84).

Parentage	100-seed weight (g)	Blight reaction*
ILC 470 × ILC 2956	46	R
ILC 2950 × ILC 3279	42	R
ILC 191 × ILC 262	49	R
ILC 202 × ILC 256	42	R
ILC 112 × ILC 191	42	R
ILC 112 × ILC 191	50	R
ILC 202 × ILC 3355	44	R
ILC 3279 × ILC 3355	44	R
ILC 3279 × ILC 3355	46	R
ILC 72 × ILC 1922	43	R
ILC 464 (check)	46	S

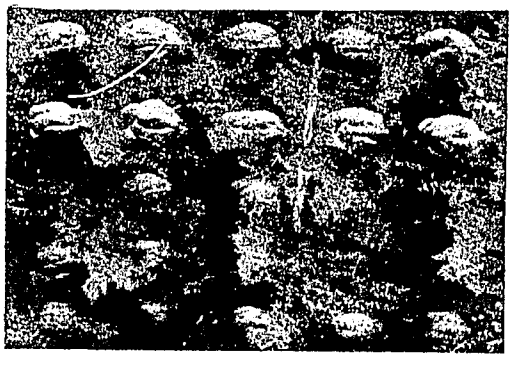
*R = Resistant; S = Susceptible.

Table 12. Seed weight of some of the newly bulked tall and blight resistant kabuli chickpea lines at Tel Hadya, Syria (1983/84).

Parentage	Plant height (cm)	100-seed weight (g)
ILC 610 × ILC 72	65	33
ILC 1920 × ILC 2956	65	34
ILC 1920 × ILC 2956	70	35
ILC 1920 × ILC 2956	60	32
ILC 72 × ILC 482	60	32
ILC 72 × ILC 482	65	32
ILC 72 × ILC 484	60	31
ILC 72 × ILC 484	70	35
ILC 72 × ILC 484	65	31
ILC 72 × ILC 73	70	38
ILC 3279 (check)	67	28

Role of Supplemental Irrigation to Improve Chickpea Yields

Tall, early, blight resistant, and large seeded kabuli chickpeas (right) compared with the traditional spreading type on the left.



Different sizes of kabuli chickpea seeds. The large ones are preferred by consumers and bring premium prices in various parts of the world.

Chickpeas which are cultivated in West Asia in the spring under low management practices depend for growth on a diminishing moisture supply stored in the soil from winter rainfall. As a result, yields are low. Supplemental irrigation is possible in many chickpea growing areas of the ICARDA region, and because of the high price of chickpea due to an increased market demand, farmers may adopt the practice if economic yield increases could be demonstrated.

A study was initiated at ICARDA's main station at Tel Hadya, Syria using the late maturing chickpea cultivar ILC 3279 sown in winter to investigate the effect on yields of supplemental irrigation, increased plant population, inoculation with *Rhizobium cicer*, phosphate fertilizer application, and nematicide use. The chickpeas were irrigated at three stages: before flowering, at flowering, and at the pod filling stage. Figure 5 shows the results.

Because of low rainfall (230 mm) and rather unfavorable distribution at the experimental sites, the yields of rainfed chickpeas were only about 600 kg/ha. The dominant role of supplemental irrigation was clearly indicated because it alone gave a 105% increase in yields. Smaller increases were obtained only when other inputs were applied or when a higher plant density was used (44 plants/m^2).

The size of the yield increase obtained with supplemental irrigation makes the additional cost worthwhile. Therefore, farmers can consider supplemental irrigation as a means of increasing and stabilizing their chickpea yields and economic returns in the low rainfall areas of this region.

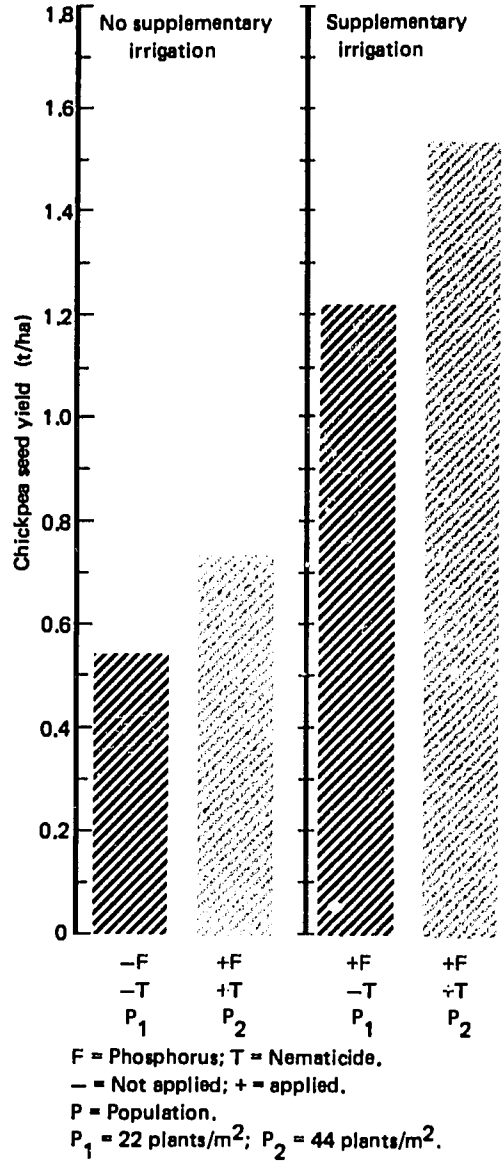


Figure 5. Influence of supplemental irrigation and management practices on seed yield of the winter sown chickpea cultivar, ILC 3279.

Tackling the Problem of Ascochyta Blight of Chickpeas in Pakistan

Ascochyta blight has been a serious threat to chickpea production in Pakistan since it was first reported in 1918. Three recent and consecutive epidemics of the disease (1980, 1981, 1982) have cut production by one half, causing a loss of US$150 million annually and requiring the importation of chickpeas. This severe setback to chickpea production by Ascochyta blight prompted Pakistan to tackle the problem on a crisis basis.

To reduce the losses caused by this disease, the nation correctly put the main emphasis on the development of resistant/tolerant cultivars. But the lack of sufficient resistant sources and the presence of a large variability in the blight fungus made its control difficult. The only resistant source available to plant breeders in the past was variety F_8 which has now lost its resistance because of the appearance of new races of the disease fungus. The clue to solving the problem of Ascochyta blight lies in identifying diversified and long lasting sources of resistance to the disease,

Pakistani and ICARDA scientists inspect Ascochyta blight damage in chickpeas near Islamabad, Pakistan.

identifying the variability present in the blight fungus, and sustained and continued efforts to develop resistant chickpea cultivars.

National and international efforts during the past five years suggest that the disease may be controlled through host plant resistance. Through mutation breeding work at the Nuclear Institute of Agricultural Research in Faisalabad, a few varieties such as CM72 and CM68 which tolerate some isolates of *A. rabiei* in Pakistan were identified. These varieties, especially CM72, are an improvement over the earlier released resistant varieties such as F_8 and C12/34, and they need to be multiplied and made available to farmers in areas where their performance has been good. But because CM72 does not have a high level of resistance and is also susceptible to some isolates, scientists are attempting to develop varieties with better and broader based resistance (Table 13).

The joint efforts of Pakistan Agricultural Research Council (PARC), ICARDA, and ICRISAT have resulted in some progress toward a solution to the problem of Ascochyta blight. A large scale evaluation of the world collection of germplasm (both desi and kabuli types) found lines such as ILC 72, ILC 195, ILC 3279, ILC 3346, and ILC 3856 to be resistant for several seasons in various locations in Pakistan. Interestingly, all lines showing high and broad-based resistance in Pakistan were late-maturing kabuli types and unadapted to Pakistan conditions. But because blight resistant desi types are the need of the hour, efforts are underway to use the kabuli source of resistance to develop desi blight resistant varieties.

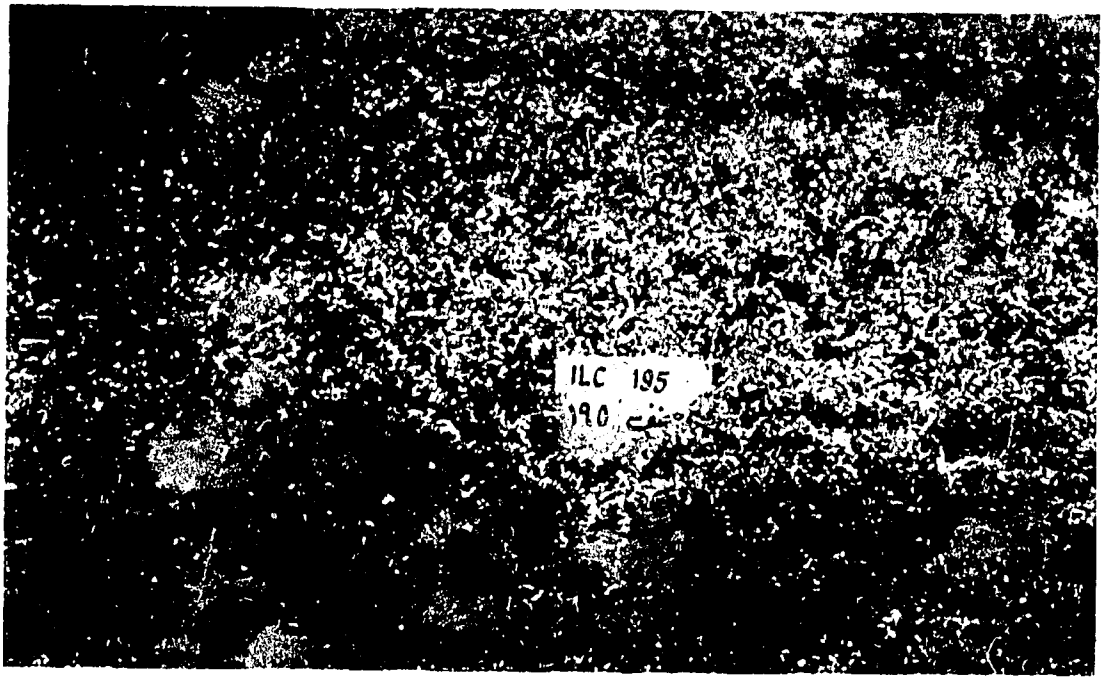
The infrastructure to achieve this objective is already in place in Pakistan. Laboratory and field screening techniques have been standardized, trained researchers hired, and in-country training conducted. Pakistani officials expect that Ascochyta blight will be controlled in the near future. In cooperation with ICARDA and ICRISAT, their plan of action calls for a centralized screening program involving a mixture of all existing races and isolates of the fungus by artificially induced epidemics at one location such as Islamabad; then yield testing of the resistant materials in various locations under natural conditions.

Ascochyta blight resistant lines should not be susceptible to other diseases such as wilt, root-rot, and pea leaf-roll virus which severely damage chickpea crops in certain pockets of the country. Testing of the blight resistant lines for wilt and root-rot can be done at Faisalabad where multiple disease-sick plots are being developed.

Race of Ascochyta blight fungus	Chickpea genotypes				
	C-727	RC-32	C-44	CM-72	C-141
1	S	S	S	R	S
2	S	S	S	R	R
3	S	R	S	S	R
4	S	S	R	R	R
5	S	R	R	R	R

S = Susceptible; R = Resistant.

Table 13. Reaction of some of the chickpea genotypes to different physiologic races of *Ascochyta rabiei* in Pakistan.



This kabuli chickpea genotype shown here in an on-farm trial proved to be resistant to all five races of Ascochyta blight fungus for several seasons in various locations in Pakistan.

Present research to identify foliar and seed dressing fungicides for control of blight is being continued to support the resistance breeding/selection work. Producing blight-free seed for farmers, which can be done in blight-free Sind Province, is a necessary final step.

National Programs Select Kabuli Chickpea Genotypes

Nine national programs in Syria, Jordan, Lebanon, Cyprus, Egypt, Tunisia, Morocco, Pakistan, and Oman have selected improved kabuli chickpea genotypes from the international nurseries (Table 14). Also, many other lines have been provided for their use in a hybridization program and for further evaluations at principal experiment stations.

Materials supplied to national programs under the cooperative ICARDA/ICRISAT chickpea improvement program include elite germplasm and newly developed breeding lines in early and advanced generations. Scientists have combined blight resistance, large seed size, and tallness—characteristics of special interest to the national programs in the region. Out of the materials developed at ICARDA and supplied to the different national programs, a large number of genotypes were found to be superior to local checks and will be used either in on- farm trials or in multi-location testing.

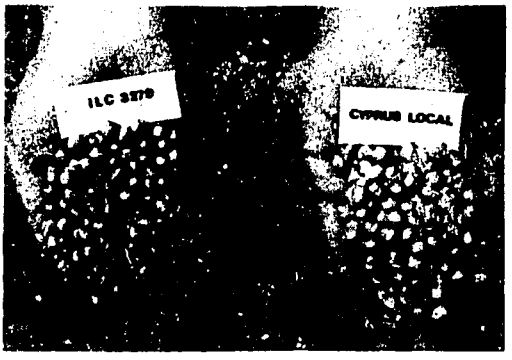
Chickpea cultivar ILC 3279—a selection made from an introduction from the USSR—has produced consistently high yields during winter sowing in Cyprus. This cultivar is resistant to Ascochyta blight—the common disease during the winter season—and tolerant to cold. Tall in stature, it is best suited to mechanical harvesting—an important factor in the Cyprus national program.

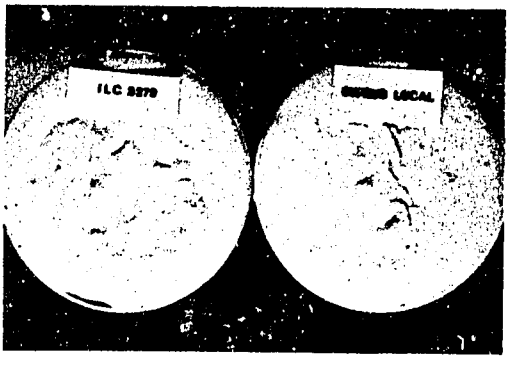
This cultivar is on a par with the Cyprus local variety for certain characteristics such as cooking quality, swelling capacity, and hydration capacity. It is slightly better in «hommos bitihineh» (West Asian salad dip) and protein content but has slightly smaller seed size than the Cyprus local (Table 15). Seed has been multiplied by the Cyprus national program for release to farmers.

Country	Cultivar
Syria	ILC-72, 195, 202, 3279, 620, 629, FLIP 82-64C, FLIP 82-236C
Jordan	ILC-484, 202
Lebanon	ILC-482
Cyprus	ILC-3279
Egypt	ILC-195, 482, 484
Tunisia	ILC-482
Morocco	ILC-195, 482, 484
Pakistan	FLIP 82-8C, FLIP 82-52C, FLIP 82-69C, FLIP 82-5C, FLIP 82-43C
Oman	ILC 3279, FLIP 80-5

Table 14. Promising chickpea lines included in multi-location or on-farm trials by national programs (1983/84).

Four countries have selected the chickpea cultivar on the left and three the one on the right. (See Table 14.)





Chickpea cultivar ILC 3279 has been rated slightly better for "hommos" (a West Asian salad dip shown in the lower photo) and for protein content than the Cyprus local variety.

Preparation/trait	Cyprus local
"Hommos bitihineh"*	
Texture**	3.9
Odor	3.6
Color	3.8
Taste	3.6
Cooking time (min.)	115
Swelling capacity (%)	151
Hydration capacity (%)	117
Protein content (%)	20.03
100-seed weight (g)	29

*West Asian salad dip.
**Excellent = 5; Good = 4; Fair = 3; Poor = 2; Very poor = 1; evaluated by a taste panel.

Table 15. Mean values of some quality parameters of chickpea cultivars ILC 3279 and Cyprus local.

Improved Varieties of Barley and Wheat for West Asia and North Africa

Every year ICARDA disseminates improved new barley and wheat germplasm to countries in the region for evaluation and possible use in their national programs. The nurseries involve crossing blocks, segregating populations, advanced lines for observation, and elite lines for yield testing. From these materials scientists in the national programs make their own crosses and selection, as well as test and release lines that perform consistently well under their own conditions.

Within the past few years, more than 20 new varieties of wheat and barley have been identified and released by national programs in the region from the international nurseries. This achievement is a product of collaborative research by national programs, ICARDA, and the Centro Internacional de Mejoramiento de Maize y Trigo (CIMMYT).

These varieties were released by national programs after they had performed consistently better than the highest yielding varieties over several seasons and locations in their countries. This means that not only do these varieties possess high yield potential and stability, but they withstand environmental stresses such as heat, cold, or drought and diseases and insect pests better than existing commercial varieties. Also, they have good seed and flour quality.

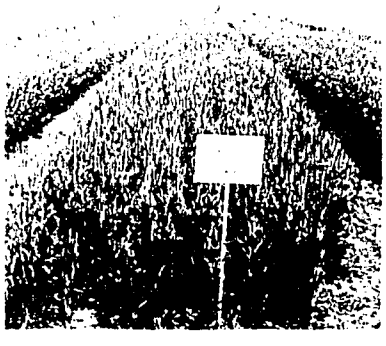
Table 16. Barley varieties released in the region.

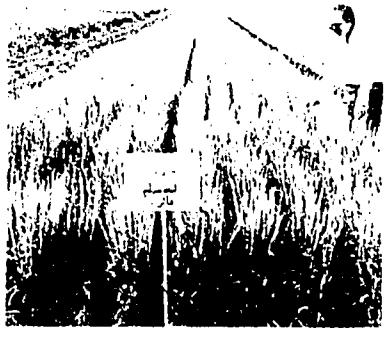
Country	Variety
Cyprus	Kantara = Roho
Iran	Val Fajr
Morocco	Asni
	Tamellalt
	Tissa
	Gulf = Arivat/Athenais
Qatar	Harma
Tunisia	Faiz = ER/Apam
	Roho
	Taj = WI 2198

Ten new barley varieties (Table 16) have been released from five countries in the region—Tunisia, Morocco, Qatar, Cyprus, and Iran. The three varieties released in Tunisia—Faiz (= ER/Apam), Roho, and Taj (= WI 2198)—were developed through a collaborative project between ICARDA and Tunisia. Their yield potential and stability of performance were confirmed again in the 1983/84 season at a range of locations in central and northern Tunisia (Table 17). The three varieties are all the early heading, medium short, and lodging resistant two-row type with resistance to net blotch, stripe disease, and powdery mildew. ER/Apam was developed at ICARDA and has consistently performed well, not only in Tunisia but in the region as a whole over the last four seasons. Roho and WI 2198 are characterized by large kernels. (In addition to these countries, three barley varieties have been released in Portugal which in some areas has environmental stresses similar to countries in the ICARDA region.)

Eleven new durum wheat varieties have been released from five countries in the region (Table 18). Of special importance is Waha—a high yielding, relatively early line with excellent stripe rust resistance and good buffering capacity against en-

Looking for disease resistant cereal varieties in Tunisia.





Left, Tunisia and Cyprus have released the barley variety Roho (named Kantara in Cyprus); right, ER Apam has been released as Faiz in Tunisia

Table 17. Grain yield (kg/ha) of the newly released barley varieties in Tunisia (1983-84).

Line or variety	Location					
	Tedjerouine	Boulifa	Beja	Koudiat	Siliana	Oueslatia
Roho	2544	4222	2889	3423	3190	1230
WI 2198	3072	4044	2664	3562	3140	1180
ER Apam	2255	3544	2500	3692	3040	1190
Martin (check)	2111	3105	2378	2976	2030	830
Ceres (check)	2022	1967	2131	1334		

vironmental fluctuations. It has been released in Syria under the name of Sham I, in Cyprus as Karpacia, and as Celta in Portugal. It is also under final testing in other important durum growing countries, including Morocco, Jordan, Tunisia, Turkey, Libya, and Spain.

Also in the pipeline are other newly developed durum lines such as Sebou, Korifla, Belikh, and Khabour. Under final testing in several countries of the region, they have shown outstanding performance over several seasons, especially in the lower rainfall areas of Syria, Jordan, Cyprus, Morocco, and Tunisia. These lines with early maturity and large and vitreous kernels are tolerant to drought and frost.

Ten bread wheat varieties have been released from six countries in the region: one each from Iran, Pakistan, Sudan, Syria and the People's Democratic Republic of Yemen, and two from Morocco (Table 19). All of these varieties were released because of their yield potential, disease resistance, and consistent performance in several years of testing in farmers' field verification trials in these countries. An example of this is the bread wheat variety Ahgaf recently released in the People's Democratic Republic of Yemen. In extensive trials there, this new variety outyielded the currently grown cultivars (Kalyansona and Sonalika) by about 40% and showed better rust resistance. Ahgaf was grown on about 500 hectares in 1983/84 and is expected to replace Kalyansona and Sonalika throughout the country.

Varieties released so far are only the first to be produced under the collaborative efforts of national and international scientists. It is expected that more new varieties will be released by countries in the region, not only from elite lines supplied by ICARDA but also from crosses made by national scientists using ICARDA and CIMMYT germplasm.

Table 18. Durum wheat varieties released in the region and Portugal.

Country	Variety
Egypt	Sohag = Stork's'
Cyprus	Mesoaria = Anshinga 'S' × Volunteer
	Karpacia = Sham 1
Morocco	Marzak = E12-BD11
Syria	Sham 1 = Plc'S'/Ruff'S'//Gta'S'/ Rtte = Waha
Libya	Marjawi = Eider
	Baraka = AA 'S' (CP^3-GZ × TC_3)
	Zorda = GDo vz 469-AA
	Fazan = D-25
	Qara = Fg/Bo
Portugal	Celta = Sham 1

Table 19. Bread wheat varieties released in the region.

Country	Variety
Iran	Azadi
Morocco	Jouda = Kal × Bb Merchouche
Pakistan	Zargon = Cc-Inia/Tob-Cfn × Bb/72
Sudan	Debeira = HD 2172
Syria	Sham 2 = 7C × Tob/Cno/Kal
People's Dem. Rep. of Yemen	Ahgaf = S311 × Norteno
Libya	Zellaf = Sakha 8
	Sebha = FRCB-74/73
	Germa = Cc/Imia/3/ Tob/Cfn//Bb/4/7C

Left, new wheat varieties from international nurseries are being selected by a national scientist in Pakistan for local adaptation; below, national program and ICARDA/CIMMYT personnel inspect wheat varieties in Morocco.

Tests in ICARDA's Cereal Quality Laboratory have made it possible to identify various quality factors relevant to the principal uses of cereals in the region, and they also help plant breeders to maintain established quality standards in new germplasm.

Stability and Heritability of Cereal Quality Characteristics

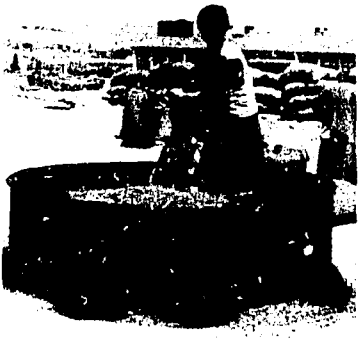
Although research designed to increase the production of cereals receives a high priority, ICARDA does not neglect efforts to improve the quality of cereal-based processed foods for consumers. The principal cereal-based foods in the region and quality factors associated with the grains from which the foods are made can be seen in Table 20.

To complement its grain testing laboratories, the Center has established a Cereal Quality Nursery. Among its objectives are to study the stability of quality characteristics within a series of cereal genotypes as compared with the influence of the crop growing environment and assist national programs to standardize and develop tests to determine quality requirements for local use.

Results of fundamental studies of the nursery material help scientists select the

most suitable cereal lines for advancement. Also, they make possible quality verification of these lines when subsequent generations are grown under widely different conditions in various locations and enable the breeders of barley, bread wheat, durum wheat, and triticale to subject advanced lines of each cereal crop to intense quality pressure.

Protein content in bread wheat and durum wheat—largely affected by soil fertility, management, and moisture availability during the growing season—influences many aspects of quality, including flour strength and water absorption. «Protein strength» or «flour strength» is the capacity of flour, when mixed into dough, to retain gas produced during fermentation, as well as to bind flour particles into an elastic dough that gives good biting texture in the baked product. Flour strength is best measured by a farinograph which gives a graphic record of flour and dough behavior during mixing under standardized conditions. Farinograph development time and stability are stable



Left, judging the quality of two-layer bread (khobz) in the laboratory; right, a step in the preparation of burghul—one of the oldest cereal-based foods in the world. This nutritious food, widely used in the Middle East, is made from durum wheat.

Food	Grain	Quality Factors
Two-layer flat breads (khobz, baladi)	Bread wheat and durum wheat	Medium protein strength and protein content; gassing power; large flour yield.
Single-layer flat breads (tannour, saaj)	Bread wheat and durum wheat	As for two-layer; also light colored grain.
Burghul, couscous, frekeh	Durum wheat	Large percentage of vitreous kernels, amber color; hard kernels essential in wheat.
Pasta	Durum wheat	As for burghul; also high gluten strength, protein, and semolina yield.

Table 20. Grain quality factors for cereal-based foods in the ICARDA region.

characteristics of individual genotypes and closely related to dough handling during baking.

Gluten quality and water absorption of a flour are both affected by mechanically-damaged starch during flour milling. Millions of bubbles of carbon dioxide gas, formed during fermentation, cause the familiar spongy appearance of raised breads. Size of the bubbles and strength of their walls are responsible for bread texture. Mechanically-damaged starch is directly affected by the hardness of the kernel so wheats of medium hardness are best.

Durum wheat is milled into semolina and hard vitreous (translucent) kernels give the highest semolina yields. Therefore, the vitreous kernel count of durum wheat is very important. Durum with many non-vitreous ("yellow berry") kernels produces more flour during semolina milling—an undesirable result. The gluten proteins of durum wheats are usually weaker than those of bread wheats, and the actual protein content of durum should be as high as possible for pasta making, as well as for export. (Most exported durum is used for this purpose.)

Kernel weight is important for durum and barley because larger grains are preferred. Uniform kernel size is a significant characteristic for all cereals, especially barley. This cereal's diastatic potential (converting starch to sugar) indicates its value for energy production in the feed industry. Beta glucan affects digestibility in chickens and other animals and its content should be low. It also affects filtration and clarification of beer during brewing.

Results of field trials indicated a wide variability in the quality of the cereal grains

(Top photo) A high yielding, rainfed durum wheat subjected to intense quality pressure. (Lower photo) Hard vitreous (translucent) durum wheat kernels on the right give the highest semolina yields. The non-vitreous ("yellow berry") ones on the left are much less desirable for milling into semolina for pasta.

from individual lines grown in more than one location or season. Unless the genotype shows stability for grain quality characters at several locations, it is not recommended for planting throughout the region (if it shows, for example, large changes in dough strength). ICARDA and national scientists found kernel weight and diastatic power of barley and kernel hardness of bread wheat and triticale to be highly heritable (Table 21). This means that tests for these characters can be conducted in earlier generations of the three crops.

Factor	Barley	Bread Wheat	Durum Wheat	Triticale
Protein	-	-	-	-
Kernel weight	+ +	+	-	+ ?
Plump kernel count	+	NA	NA	NA
Diastatic power	+ +	NA	NA	NA
Kernel hardness	NA	+ +	-	+ +
Wheat fermentation time	NA	-	-	+ ?
Vitreous kernel count	NA	NA	-	NA
Farinograph absorption	NA	+ +	+	+
Farinograph development time	NA	-	+ ?	-
Farinograph stability	NA	+	+	+
Farinograph mixing tolerance	NA	+	+	+
Mixograph mixing tolerance	NA	+	NA	+
Mixograph development time	NA	+ +	NA	+

+ + Highly heritable; + Heritable; + ? Possibly heritable;
- Not heritable; NA = Not applicable.

Table 21. Stability/heritability of quality factors in cereals.

Identification and Development of Bread Wheat with Stress Tolerance

Cereal consumption in West Asia and North Africa is the highest in the world— more than 150 kg per person per year. Wheat and barley are the two chief cereals in the diets of the people, providing about two-fifths of the daily intake of calories. Most of the bread wheat area in West Asia and North Africa is rainfed, and more than 50% of the bread wheat crop is grown in areas with less than 400 mm annual rainfall; average yields are below 1000 kg/ha. Low rainfall (both amount and distribution), diseases, insect pests, cold, and poor agronomic practices are responsible for these low yields.

The breeding strategy of the joint ICARDA/CIMMYT bread wheat project involves growing and testing genetic material simultaneously under both stressed and favorable conditions. Scientists evaluate the progeny of carefully selected crosses exhibiting variations in different traits (called segregating populations) as well as advanced lines. The stressed condition includes low rainfall (200 to 300 mm) and low fertility (40 kg of N and 40 kg of P_2O_5). Favorable conditions include early planting (middle of October), 100 kg of N and 60 kg of P_2O_5, and two supplemental irrigations to simulate approximately 400 mm of rainfall.

Four locations in Syria representing these stress environments are used to evaluate and select breeding material: Khanasser—214 mm long-term average rainfall, low soil fertility; Breda—278 mm long-term average rainfall, low soil fertility; Tel Hadya—342 mm long-term average rainfall, moderate soil fertility; Tel Hadya—early planting, supplementary irrigation, good soil fertility.

Individual plants in segregating populations of crosses involving spring x spring and spring x winter parents are selected on the

Testing stress tolerance of wheat to drought conditions. The four lines on the right appear much better than the four lines on the left.

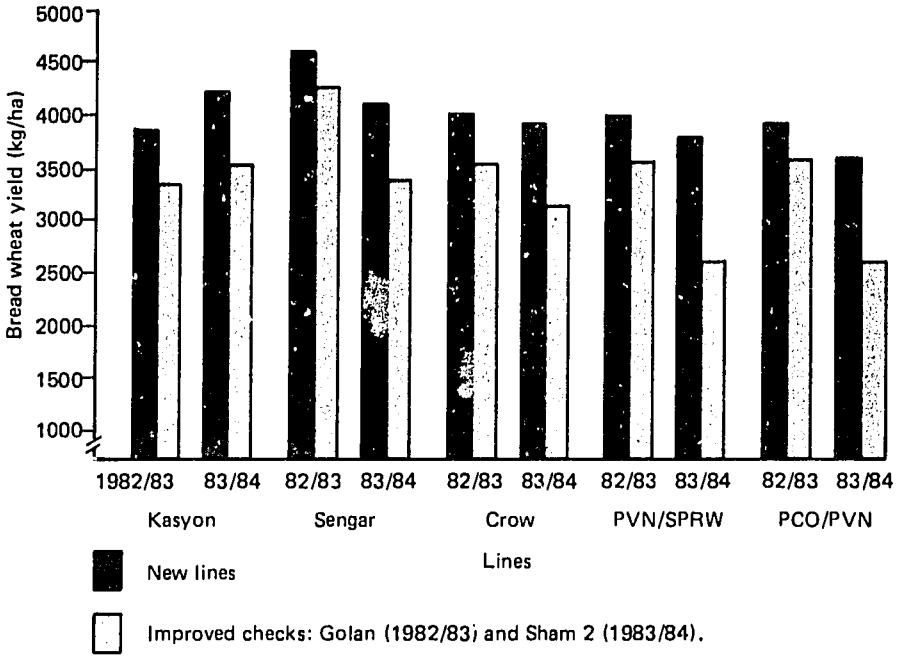


Figure 6. Highest yielding bread wheat lines under low rainfall conditions compared with improved checks Golan and Sham 2 in yield trials in Syria (1982/83 and 1983/84).

basis of disease resistance, tillering ability, spike length, and fertility. Shrivelled grains from selected plants are discarded. Lines from advanced generations (F_5 to F_8) with outstanding agronomic performance are further evaluated in replicated yield trials at these locations. Yield is used as the basis for water stress tolerance.

A large number of advanced lines have been tested in this fashion, and results are encouraging (Figure 6). From preliminary and advanced wheat yield trials grown at these environments, several lines performing better than the improved checks for yield, disease resistance, and quality have been identified. These lines are distributed to countries in West Asia and North Africa through the ICARDA/CIMMYT international nursery system.

Training participants from three countries (left) listen to an explanation of the reasons for the excellent performance of a new bread wheat line, FLK's'/Hork's' now named Kasyon. (See Figure 7.)

During 1983/84, International Nurseries assembled lines developed in this manner and then distributed them to 45 locations in the region. The test locations represent a wide range of environments and stresses in terms of rainfall (both amount and distribution), as well as soil types, diseases, and insect pests.

Bread wheat lines shown in Figure 7 have a large yield potential and adaptation under these variable environments. They were selected by national programs in the region based on their superior performance over the local check varieties which are usually well adapted and widely grown in the country.

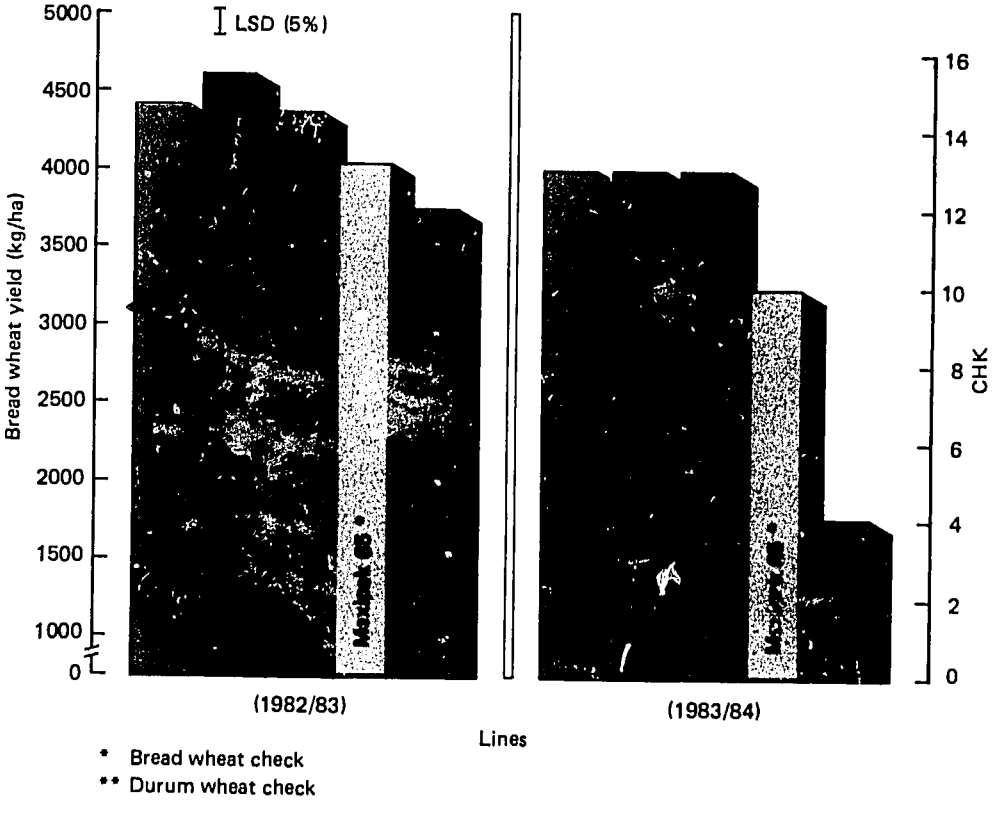


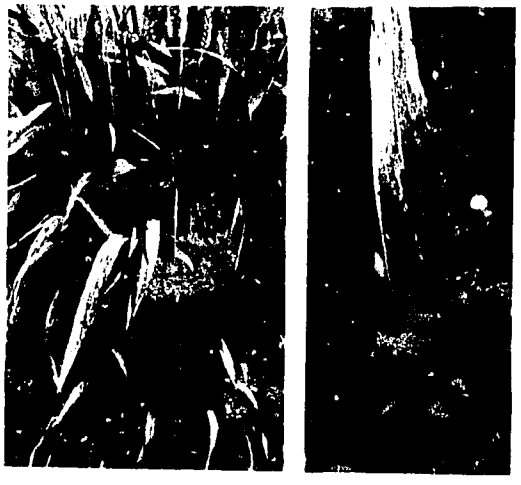
Figure 7. Performance of the highest yielding bread wheat lines during 1982/83 and 1983/84 in the Regional Wheat Yield Trials planted at 2' locations in 12 countries. (CHK = number of locations where the line was superior to the national check.)

Screening Wheat for Resistance to Septoria Leaf Blotch

Septoria leaf blotch caused by the fungus *Septoria tritici*—one of the major diseases of wheat in the ICARDA region—is endemic in relatively high rainfed areas of North African countries and widespread in most of the irrigated areas of the Middle East. Planting resistant cultivars is the best means to control the disease.

Breeding material of both durum and bread wheat is planted in «hot spot» locations under artificially created epidemics or under natural field infection to be screened for resistance to this disease. In addition, a new Septoria nursery started in the 1983/84 cropping season includes 150 and 50 lines of durum and bread wheat, respectively. These lines received a preliminary screening the season before in Afrin, Syria. The nursery was planted in fields at Tel Hadya and Lattakia in Syria, Beja in Tunisia, and Elvas in Portugal where the environmental conditions favor the development of the disease. Artificial inoculation was applied in all sites with a mixture of isolates of the pathogen prevailing in the country. Also, three sets of the nursery were planted in plastic houses at Tel Hadya and each inoculated with one isolate from Syria, one from Turkey, and one from Tunisia, respectively.

Twelve lines of durum showed resistance to the disease at all sites used for screening. (Average scores ranged from 2.2 to 5.4 on a 0 to 9 scale where 0 = highly resistant and 9 = highly susceptible; Table 22.) These lines possess high yield potential under different environments and especially under rainfed conditions. The height of these lines ranges from 75 to 115 cm; crosses with other species of *dicoccoides* or with *haynaldia* are demonstrating resistance to Septoria. However, most of these lines are late maturing (entries 1,4,5,6,7,12 in Table 22) and one is winter type (9). Scientists are working on combining resistance to Septoria with early maturity.



Left, wheat plant showing severe symptoms of Septoria leaf blotch; right, close-up of lesion of Septoria leaf blotch with fruiting bodies (pycnidia) of the pathogen.

Development of the disease on bread wheat was negligible at Tel Hadya and Lattakia. Therefore, only data from Beja and Elvas were considered in the selection and resulted in 12 lines showing resistance to the disease. (Average scores ranged from 0 to 4.5 on the 0 to 9 scale; Table 23.) Resistance in these lines came from two main sources—Russian winter wheats and southern Brazil and Argentina wheats. Most of these lines were already selected at

Patzcuaro/Michoacan where heavy epidemics of Septoria occur. All have been included in the durum and bread wheat Septoria nurseries for the 1984/85 season to reconfirm their resistance.

Observations at the screening sites for Septoria indicate a kind of «host-preference» or specialization of the pathogen. The disease hit bread wheat hard at Elvas, Portugal and also durum at Tel Hadya and Lattakia, Syria. It developed well on both wheats at Beja, Tunisia. These differences can be due to different virulences of the pathogen, origin of the inoculum used, or the environment at each screening site. To check further on those observations, a cross-inoculation test with isolates originating from bread wheat and durum was conducted in a greenhouse at Tunis. The bread wheat isolate attacked 4 out of the 19 wheat cultivars tested but none of the durum lines; the durum isolates did not attack any of the wheat lines. Also, the lesion size and production of fruiting bodies (pycnidia) of the isolates on the corresponding host indicate the preference of the pathogen isolates to attack and develop well on the same host from where they originated. The results obtained should be considered in any screening work in the field or in seedling tests.

ICARDA plans to help a national program in the region develop facilities and expertise for Septoria disease. The first phase of the work for such a center would involve the collection of isolates from the region and the identification of races and their virulences. In the second phase,

Table 22. Durum wheat lines showing resistance to Septoria leaf blotch *(Septoria tritici)* from Durum Septoria Nursery (1984).

Entry	Name or Cross/Pedigree	Av. score in all test sites*
1	Shwa'S'/Bit 'S' CD 20626-4M-4Y-2Y-0Y	4.7
2	Pg'S'/3/G11'S'// T. D. Vern/G11'S' L 0532-1L-2AP-1AP-0AP	4.4
3	Gs'S'/AA'S'//Plc'S'/3/Cit71 L 0576-2L-1AP-2AP-0AP	3.7
[illegible]	[illegible]	[illegible]
5	ZF/Lds//Kohak 2916/3/61-130/4/Stk'S'/Fg'S' ICD 77-0233-2AP-2AP-0AP	3.1
6	Jo'S'/Cr'S'/5/G11'S'/4/Br 180/LK//GZ220/3/21563/AA'S' ICD 77-0045-4AP-0SH	5.3
7	Algerian 83/Mexi75 CD 32954-2TR1AP-0AP-0SH	5.4
8	Gdo VZ385/GS'S'/4/D.dwarf S15//T.D.Vernum/G11'S'/3/Plc'S' ICD 77-0134-4AP-1AP-4AP-0AP-0SH	3.8
9	Riccya (Winter) - 1149 YE 023-26-1-1-4-0E	3.6
10	PI 298547	3.0
11	Ente'S'/Stk'S' CD 08153-12M-3Y-3M-1Y-0M	4.7
[illegible]	[illegible]	[illegible]

*On the 0-9 scale where 0 = highly resistant and 9 = highly susceptible.

material furnished by ICARDA and by the national programs would be screened (seedling test) with the predominant virulences in the region.

Entry	Name or Cross/Pedigree	Av. score in all test sites*
1	Vee'S' CM 33027-F-1M-9Y-0M-1Ptz-0Y	3.0
2	Vee'S' CM 33027-F-15M-4Y-4M-2Y-1M-1Y-0M-1ptz	4.0
6	Barpet/Manantial 4-1-2-2-1-3-0Ptz-0Y	5.0
7	MY54/3/B10/Y50//K.Line/4/Cez/5/Cj71 'S'/6/Pat49 B 13981	4.0
8	Tadorna/Inia 66 F9 060/30152	3.5
9	Cleo/Inia 66 F9 060/30234	4.5
10	Kvz/Cj SWM 1430-4Y-3Y-1M-1Y-100B-500Y-0M	3.5
11	Kal/Bb/Mon'S' CM 40226-5S-3AP-0AP	3.5
12	P 106.19//Soty/JT*3 L 489-2L-2AP-0AP-8AP-0AP	4.0

*On the 0-9 scale where 0 = highly resistant and 9 = highly susceptible.

Table 23. Bread wheat lines showing resistance to Septoria leaf blotch *(Septoria tritici)* from Wheat Septoria Nursery (1984).

Breeding Barley for Low Rainfall Areas

Barley is the most important crop next to wheat in the Near East and North Africa where it is grown for both animal feed and human food. Almost 40% of the 11 million hectares of barley grown in these two large regions receives less than 300 mm annual rainfall as a longterm average (Figure 8). Low rainfall areas are characterized by a wide year-to-year variability. Therefore, almost half of the barley growing area is a «high risk» area where crop failures are frequent. They hit farmers who often have no other options.

To improve the efficiency of barley breeding for unfavorable environments, ICARDA scientists started as early as 1978 designing specific crosses to meet the requirements of specific environments. This strategy is proving its usefulness. During 1983/84, three sets of F_2 segregating populations (for dry, moderate rainfall, and high elevation areas) were cultivated at both Tel Hadya (230 mm rainfall) and Breda (207 mm rainfall). The material was visually screened for plant type, head type, tillering, earliness, and culm length. Selection was done independently at the two Syrian sites. Frequency of populations selected within each group (Figure 9) shows that a higher proportion of F_2s specifically designed for dry areas was selected because of the dry conditions. This indicates that when parents are carefully evaluated and selected, scientists can predict with reasonable accuracy which crosses are more likely to perform well in a given environment.

In these dry areas, barley with sheep is the only farming activity, and, in addition to grain, straw is a valuable commodity. Results of research indicate that the nutritive value of the straw is higher in dry years than in wet ones. This offers an explanation for the high value of the straw in dry areas. Therefore, barley breeding for

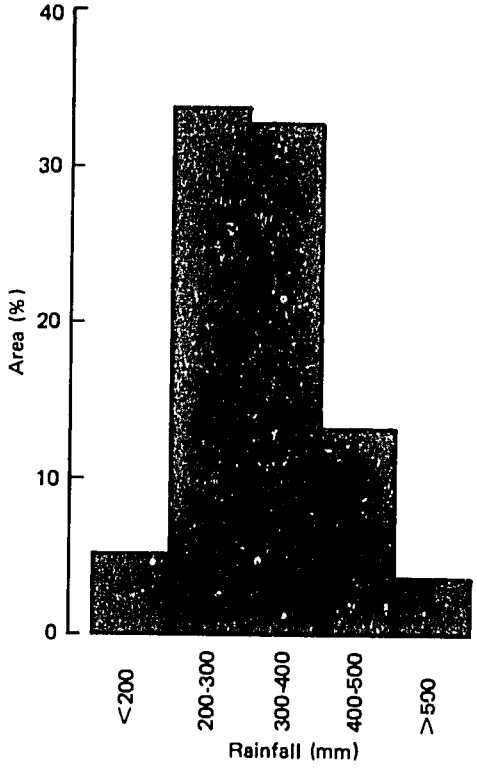
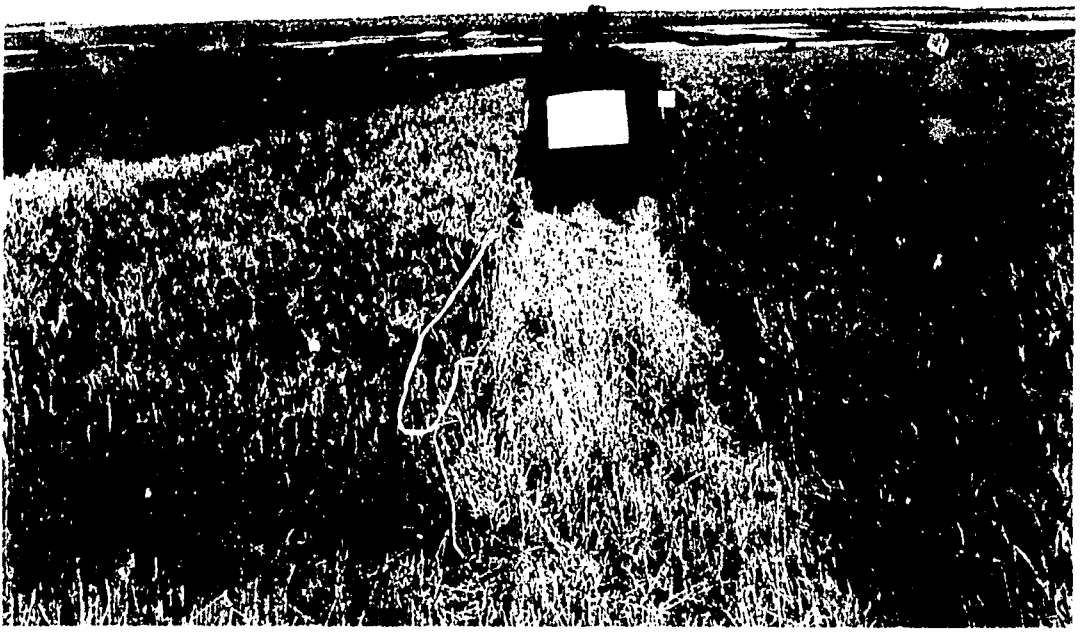


Figure 8. Percent of rainfed barley area in different rainfall zones of Syria.



Harvesting barley in Syria. One of the major objectives of ICARDA scientists is to breed barley with high total biological yield (grain + straw) and improve the nutritive quality of straw for feeding livestock.

low rainfall areas must regard the increase of total biological yield (grain + straw) and the improvement of straw nutritive quality as major objectives. ICARDA research shows that increasing total biological yield is not an incompatible objective with straw quality (Figure 10).

Appropriate selection practices have been adopted to account for micro-environmental variability and to increase the efficiency of breeding work for low rainfall areas.

A better understanding of the morpho-physiological and genetic basis of the adaptation of local cultivars (land races) to dry environments is another way to help the production of genetic material tailored for unfavorable environments. Eventually, the wild progenitor of cultivated barley, *Hordeum spontaneum*, could represent a useful source of genes for adaptation to high levels of environmental stress

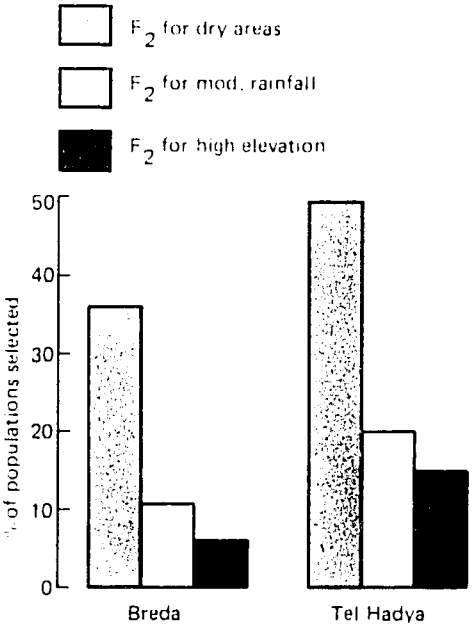


Figure 9. Frequency of populations selected from three types of targeted F_2 barley at Breda, Tel Hadya, and both locations in Syria.

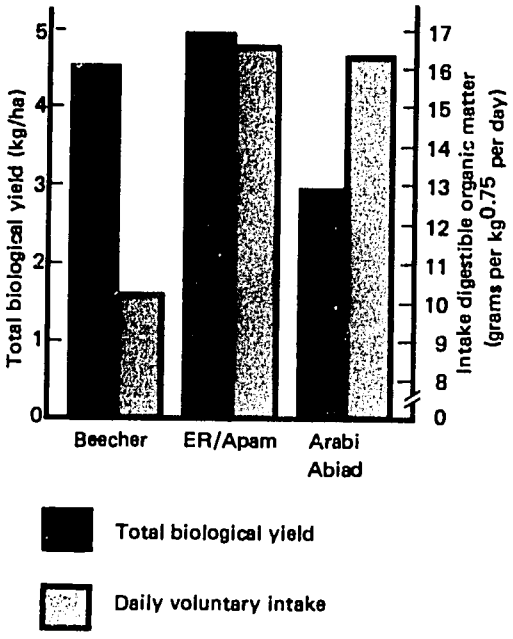


Figure 10. Total biological yield and daily voluntary intake by sheep of two improved barley varieties (Beecher and ER/Apam) and one local cultivar (Arabi Abiad).

Better Triticale Yields and Improved Quality

The genetic makeup of triticale—a 100-year-old, man-made, self-pollinated cereal species created by crossing wheat *(Triticum)* and rye *(Secale)*—is being changed and the genetic variability significantly increased by the continuous efforts of plant breeders around the world. A triticale component exists in the breeding programs of most of the developed and many of the developing countries, including those in the ICARDA region.

During the past 10 years, scientists in many countries have made substantial improvements in grain yields and in maturity and fertility characteristics of triticale, but its grain plumpness and color need to be further improved. Under certain conditions, it has these important advantages over wheat: more disease resistance in most cereal growing areas; tolerance of acidic soil, [illegible]inum toxicity, and cold; and good [illegible]th at high elevations. In addition, triticale appears to be better adapted to low rainfall areas. Consequently, commercial production is now increasing in many countries, including Cyprus, Tunisia, Portugal, France, Italy, Mexico, and Australia. Morocco has selected three triticale lines—Drira outcross-7, Juanillo 95, and Beagle—as potential candidates for release in 1985.

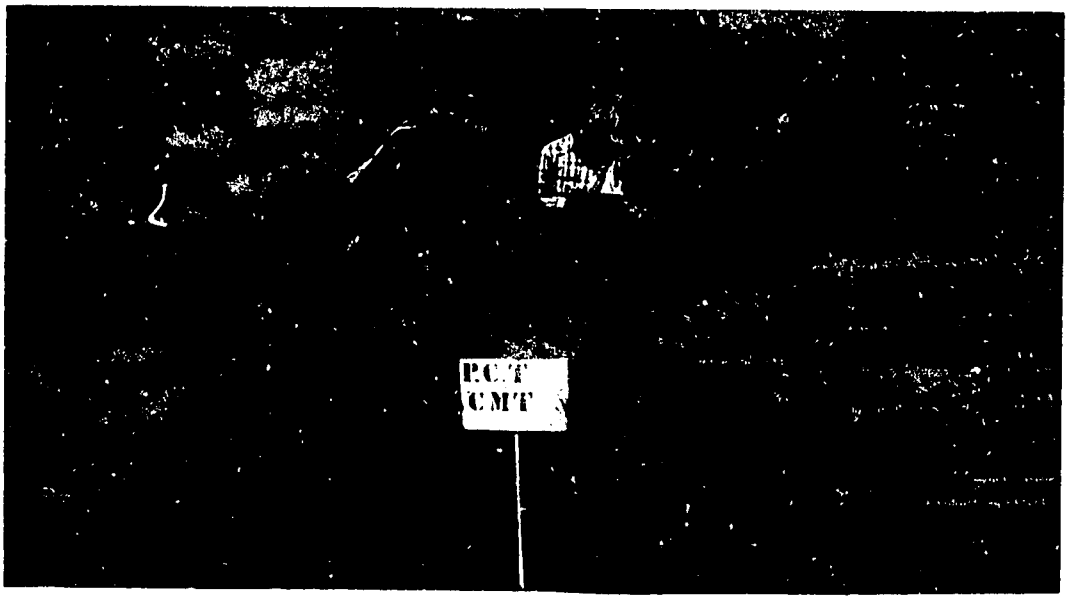
In a limited research program, ICARDA has concentrated on developing lines for rainfed areas. New germplasm has been introduced from different sources, and

genotypes have been evaluated through multi-location testing. New germplasm better adapted to the dry environment in the region is now available to national programs. ICARDA research on triticale has focused on improving the total biological yield and grain yield potential, as well as producing good seed type and better quality for bread making.

Drira outcross-7, an ICARDA selection, gave better yields than the high-yielding durum wheat varieties in the ICARDA regional yield trials of 1981/82 and 1983/84. Similarly, other triticale lines, H 507-71/Bgle, Jlo 89, and Drira outcross-9, ranked first in the regional wheat yield trials of 1982/83. Lines with full rye complement are better adapted to a dry environment than substitution triticale lines in which one or two pairs of rye chromosomes are substituted with «D» chromosomes of bread wheat. One of the newly developed triticale germplasms developed by ICARDA showed better performance than wheat checks in 1983/84—a dry year with only 230 mm of rainfall at Tel Hadya.

Quality analysis at ICARDA shows that flat bread can be made from pure flour of high-yielding triticale (Drira outcross-7 and Drira/M2A), as well as from wheat flour. Triticale usually has a dark-colored grain which is not as desirable as the amber-colored grain of durum and the white-colored grain of bread wheat. However, a line with amber color has been found in an intermediate generation triticale developed at ICARDA.

Triticale observation nurseries at Tel Hadya, Syria. New germplasm has been introduced from several sources and genotypes evaluated through multi-location testing, particularly in rainfed areas.



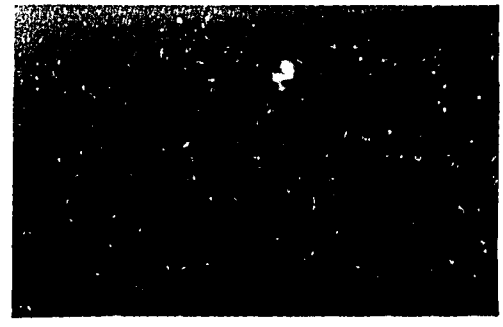
Extending Cereal Research to Farmers' Fields in Syria

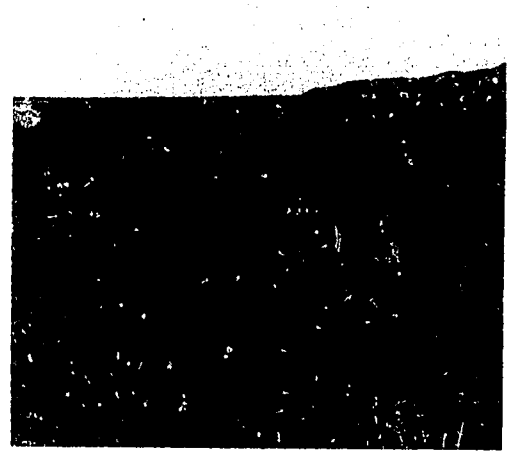
During 1983/84, the Syrian Ministry of Agriculture and Agrarian Reform and ICARDA conducted a series of 33 cereal variety verification trials on farmers' fields throughout Syria— a continuing program of the two organizations. Their objective was to determine under farm conditions the performance of various varieties and breeding lines of durum wheat, bread wheat, and barley that had proved promising at experiment stations. Results of the on-farm tests in one of the three major agricultural zones covered in the trials are shown in Table 24.

The varieties and lines tested originated at ICARDA, the Syrian National Program, CIMMYT, and the Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD). Two varieties released in 1983 —Sham 1 (durum) and Sham 2 (bread wheat)—performed well. Newly tested durum lines such as Korifla and Sebou showed superiority in certain of the lower rainfall areas. This was true also of the bread wheat line Pato-Cal/7CxBb. At other sites, bread wheat lines Flk 's' -Hork and Syri 82 gave higher yields and exhibited better disease resistance than the presently grown variety Mexipak. Rihane 's' combined its high barley yield with disease resistance.

Although these results are encouraging, the 1983/84 season was generally too dry. However, it provided a good opportunity for testing under drought stress. Once the performance of a line is confirmed over several seasons, it is then advanced to the demonstration stage and proposed for release to farmers.

Field verification trials are also used for training purposes whereby trainees from Syria and other countries can learn the methodology, implications, and importance of such trials in the process of variety development in their own areas.





(Top photo) A farmer, an ICARDA staff member, and a Chinese visiting scientist discuss the farmer's on-farm barley trial at Hassake, Syria. These trials are jointly conducted by national program scientists and ICARDA. (Lower photo) Checking the grain field on a Syrian farm in a low rainfall area where different environmental stresses compete to reduce yields.

Weighing grain from one of many on-farm variety verification trials in Syria conducted jointly by the national program and ICARDA.

Cultivar	Sites			
	Akhtarin (233 mm)*	Izraa (300 mm)*	Sarakeb (221 mm)*	Suran (299 mm)*
Durum wheat				
Korifla	1783	1978	2009	1591
Sebou	1599	1884	2044	1302
Sham 1	1786	1829	1888	1609
Haurani	1478	1763	1826	1709
LSD (5%)	248	293	189	466
CV (%)	9	6	5	17
Bread wheat				
Pato-Cal/7CxBb	1995	2389	2326	1625
Sham 2	1787	2405	2211	1556
Mexipak	1893	2049	2170	1667
LSD (5%)	285	302	139	360
CV (%)	8	7	3	11
Barley				
Rihane 's'	2819	3107	3941	2347
Arabi Abiad	3097	2543	3804	2218
LSD (5%)	339	490	452	647
CV (%)	8	11	8	15

*Rainfall in 1983/84—a very dry year.

Table 24. Grain yield (kg/ha) of selected cereal cultivars in verification trials on farmers' fields at four sites in Syria (1983/84). Trials conducted in cooperation with the Syrian Ministry of Agriculture and Agrarian Reform.

Measuring Biological and Environmental Constraints to Increasing Productivity of Marginal Grazing Lands

If the present low productivity of marginal grazing lands could be increased, sheep numbers would rise, thereby improving the stability and income of village farming systems as a whole. Marginal lands now make up approximately 30% of the total surface of western Syria and as much as 60% of some villages. These lands are often steep and usually stony with shallow, infertile soil and severe erosion.

The most effective way to increase livestock production from marginal lands is to have a greater supply of pasture. Other measures such as better location of watering points, selection of better livestock, and control of animal diseases will have little impact unless there is more pasture. To help accomplish this, a necessary first step is to measure the biological and environmental constraints.

Therefore, ICARDA scientists in 1983/84 measured plant numbers, herbage available to grazing animals, and total plant growth near the villages of Bueda and Noumania in western Syria. (They also included an extensive soil analysis.) The total growth of herbage in protected cages was measured against matched sites on the nearby open range.

Total pasture production in the cages was 480 kg/ha and the available pasture at the time of harvesting the total herbage was 460 kg/ha. Seventy out of the 108 cages failed to produce 500 kg/ha—an amount normally accepted as the minimum necessary for sheep to maintain weight. This slight difference in total and available pasture indicated that the sheep ate a very small amount of pasture, even though they grazed for a long period. Also, the inadequate pasture growth was reflected in the amount of supplementary feed provided. Sheep grazing marginal lands required more feeding than sheep kept in pens—an indication of the energy they used in their attempt to harvest the pasture.

Pasture growth was related to plant numbers, although the relationship weakened as the season progressed. The pasture was dominated by grasses, but in some quadrats annual legumes accounted for up to 50% of the population. Total seed present in the early summer was 200-350 kg/ha at both Bueda and Noumania. As with plants, there were more grass seeds than legumes (Table 25). Protecting the range increased seed yield at Bueda by more than 30%, but at Noumania it had little effect.

The vegetation was extremely complex. A preliminary botanical analysis revealed that many grasses were present—both perennial and annual (as well as several legumes, other herbs, and a few shrubs). Foremost among the grasses were *Heteranthelium piliferum*, *Stipa capensis*, and several *Bromus* spp. Of the legumes, *Trigonella stellata*, *Trifolium stellatum*, *T.*

campestre, *Medicago coronata*, and *M. rigidula* were most numerous, but at least seven other species were present. This diversity is one of the more interesting characteristics of marginal lands throughout Syria and Lebanon.

The results were obtained in a year of very low rainfall. In wetter years, pasture growth should exceed the amounts mentioned here, but it is clear that productivity is far below its potential.

Above, the total growth of herbage in protected cages on marginal grazing lands in western Syria is measured against matched sites on nearby open range. This is one of several steps in the research process to find ways to provide more and better pasture for livestock that graze these steep and stony lands (below).

Table 25. Seed yields and seed numbers of grass and legumes in protected cages on open range at Bueda and Noumania, Syria (1983/84).

Area	Grass		Legumes		Others		Total	
	yield (kg/ha)	seed no.	yield (kg/ha)	seed no.	yield (kg/ha)	seed no.	yield (kg/ha)	seed no.
Bueda								
Protected	285	5650	17	790	24	1060	326	7500
Unprotected	208	4080	9	550	26	900	243	5530
Noumania								
Protected	188	5890	16	1850	38	1650	242	9390
Unprotected	145	5100	39	2430	36	1960	220	9490

Winter Growth of Annual Pastures: Species vs. Density

Winter production of annual pastures depends heavily on plant population, and growth rates at populations similar to those achieved in naturally regenerating pastures suggest that a stocking rate of 8 to 10 sheep per hectare may be possible in North Syria. In tests there, pasture species had much less effect than density on winter growth.

In tests with three species of medics at Tel Hadya, Syria, researchers found that rapid winter growth depended much more on planting density than on the species used.

The concept of using pastures to replace fallows is based on farming systems in southern Australia. In that environment, fallows have been replaced by self-regenerating pastures whose roles are to provide livestock with nutritious year-round grazing, replenish soil fertility, and provide a disease controlling break between cereal crops. They have been so successful in southern Australia that livestock numbers have been increased four-fold and cereal yields have doubled since they were first introduced.

Success of the system depends on several factors, one of the most important of which is sufficient winter growth to maintain livestock without extra feeding. For several years, ICARDA has screened annual species of *Medicago* (medics) for adaptability to its region and to a medic-based farming system. Species screened include those developed in Australia such as *M. truncatula*, *M. scutellata*, *M. rugosa* and *M. littoralis* and those common in non-cultivated land of West Asia, especially *M. rigidula*, *M. polymorpha*, *M. noeana*, *M. aculeata*, and *M. rotat*.

Two of the most promising new species were compared in 1983/84 with the best Australian cultivar for ability to grow in winter and spring. The species chosen were *M. rigidula* originally collected in Lebanon, *M. noeana* from Turkey, and *M. truncatula* cv. Jemalong—a widely used strain originally found in the Australian wheat belt. Jemalong was chosen as representative of Australian medics and *M. noeana* and *M. rigidula* for their high herbage and seed yields, respectively.

The three medics were sown at 12 seeding rates (0.5 to 512 kg/ha) and pasture growth was measured nine times from December 27 to April 29. The plot size allowed for nine harvests with sufficient area remaining to prevent border effects. At each harvest herbage was sampled at ground level and dried for 24 hours at 90°C.

Near average temperatures were recorded at Tel Hadya in 1983/84, but rainfall was much below average. Therefore, the experiment was irrigated in February to

maintain growth. Even with an extra 50 mm of irrigation, rainfall plus irrigation remained below the average rainfall.

Growth in early winter was estimated on December 27 and January 19 when the relationship between yield and density remained linear. Thereafter the relationships became curvilinear. Yields increased with density at first, but as density increased further, yields remained constant. Figure 11 shows that at high density all three species had produced more than 1 t/ha by January 19. This clearly demonstrates that rapid winter growth depends heavily on density and is barely affected by the species used.

From January 19 growth rates remained at or above 40 kg/ha/day for the whole winter and reached more than 160 kg/ha/day in the spring (Figure 12). Growth rates fell away in late spring, probably due to the lower than average rainfall.

These data substantiate the value of these medics as grazed pastures. The simplest form of grazing management is continuous grazing at a rate set by winter growth. In

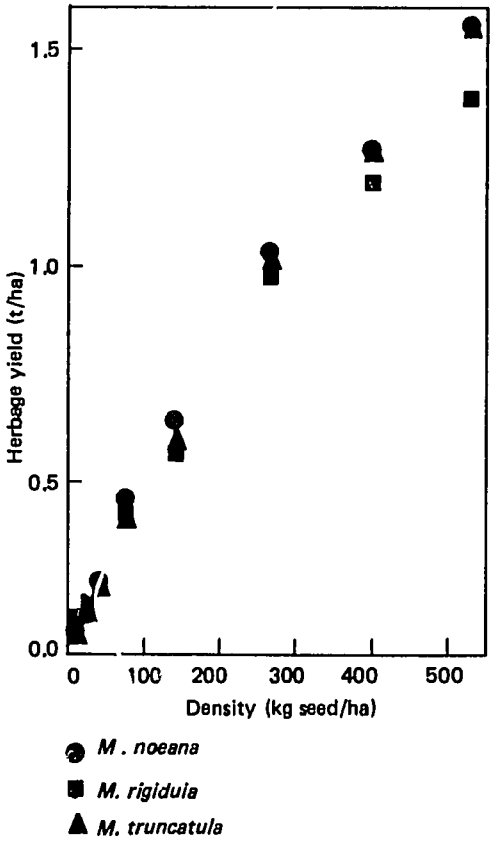


Figure 11. Relationship between herbage yield and sowing density of three medic species on January 19.

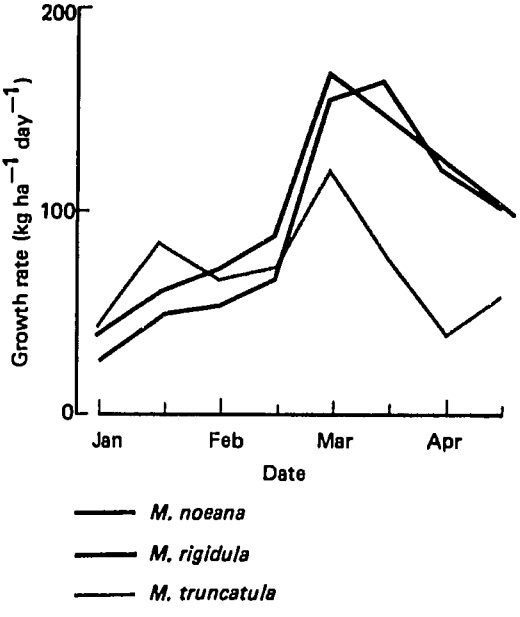


Figure 12. Seasonal growth rate of three medic species from winter until late spring at Tel Hadya, Syria.

this model, sufficient excess growth must be produced in the spring to maintain livestock in the summer and autumn. A good indication of stocking rate under these conditions can be determined using growth rates obtained in the experiment.

Assuming a winter growth rate of 50 kg/ha/day and livestock eating about half of that, 25 kg/ha/day would be available for grazing. Approximately 12 sheep eating 2 kg per sheep per day could be maintained on the pasture. If the pasture growth rate increases to 100 kg/ha/ day for the 10 weeks of spring, excess growth over the sheep's requirements would be 75 kg/ha/day —enough to provide about 100 days of grazing after pasture growth stops. Along with cereal stubble, such a system could support 8 to 10 sheep per hectare for most of the year.

Winter growth at Tel Hadya compares favorably with that measured in southern Australia. Therefore, the results of this experiment suggest that it is feasible to introduce a medic-based farming system to the region, especially in view of the similarity of winter temperatures between Tel Hadya and a wide range of «cold winter» sites in West Asia.

Flower and Pod Loss in Annual Medics

Very high flower losses, resulting in seed yields of only 25% of potential, have been observed in three species of annual medics—species expected to be important in self-regenerating pastures. The medics depend heavily on a large seed set if they are to survive grazing in summer and the growing of a cereal crop in the following winter before regeneration. Improving seed yield is a very important objective of research aimed at introducing self-regenerating pastures.

In a seed yield/plant population study at Tel Hadya, Syria, the numbers of flowers and pods were carefully monitored from the day on which flowers first appeared. Scientists recorded total seed yield and measured the components of seed yield (pod numbers, seeds per pod, and seed size).

Medicago rigidula easily produced the most seed. At a sowing rate of 32 kg/ha its seed yield was nearly 1 t/ha compared with 0.25 t/ha of *M. noeana* seed, and less than 0.2 t/ha of *M. truncatula* seed (Figure 13). Density significantly affected seed yield of *M. rigidula* but had little or no effect on *M. noeana* and *M. truncatula*.

Apart from individual seed weight of *M. rigidula*, neither it nor seed numbers per pod were related to density in any species. However, numbers of pods/m^2 were significantly related to yield of seed of all three species, accounting for 90% of variation in yield of *M. noeana* and *M. rigidula*. Between species, *M. rigidula* had bigger seeds and produced more and bigger pods than the other species. *M. noeana* produced

more pods than *M. truncatula* but fewer seeds per pod resulting in a similar yield.

Because the number of pods/m² easily rates as the most important component of seed yield, the number and fate of flowers (each of which produces a pod) is of great interest. *M. rigidula* flowered first (in early March), followed a few days later by *M. truncatula*, and almost three weeks later by *M. noeana* (Figure 14). Flower production of *M. rigidula* was highest about two weeks after flowering commenced; thereafter the combination of flower and pod number decreased steadily until maturity. Most importantly, only 21% of flowers present

An example of flowers aborted by the medic species, *M. rigidula*. Poor survival of flowers reduces seed yields.

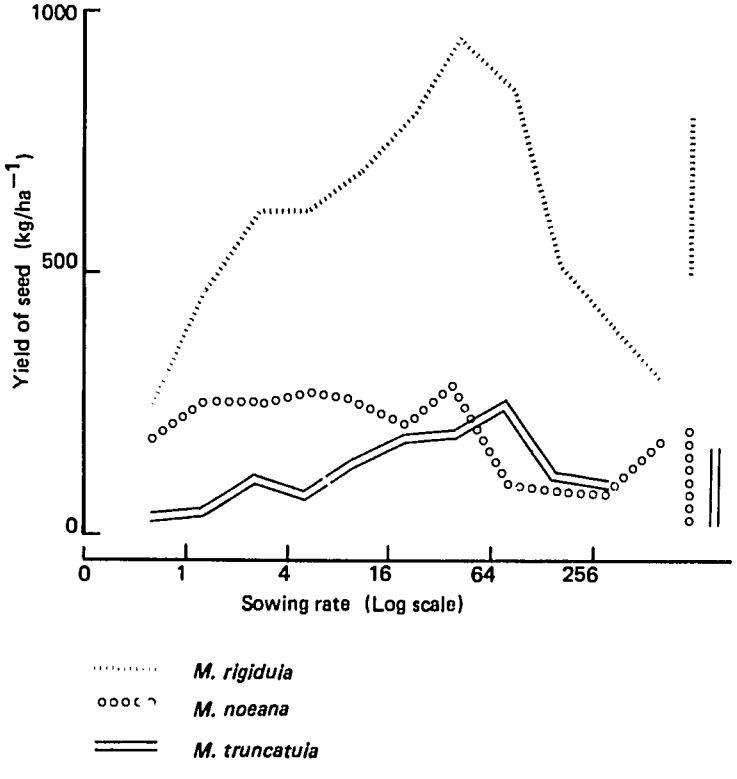


Figure 13. Relationship between seed yield and rate of sowing (log scale) for three medic species. (Bars represent least significant differences, p = 0.05).

on March 18 reached maturity, indicating that nearly 80% of the flowers failed to produce seeds.

The earlier a flower was produced the more likely it was to mature and produce seeds. In the case of *M. noeana*, almost all of the early flowers produced seeds, but of those produced after April 20, only 10% matured. Similar results were obtained in the other species.

Results of the experiment show that seed yields were far below the potential because of the poor survival of flowers. A closer examination of the factors affecting flower survival are clearly necessary if medics are to fulfill their role in self-regenerating pastures.

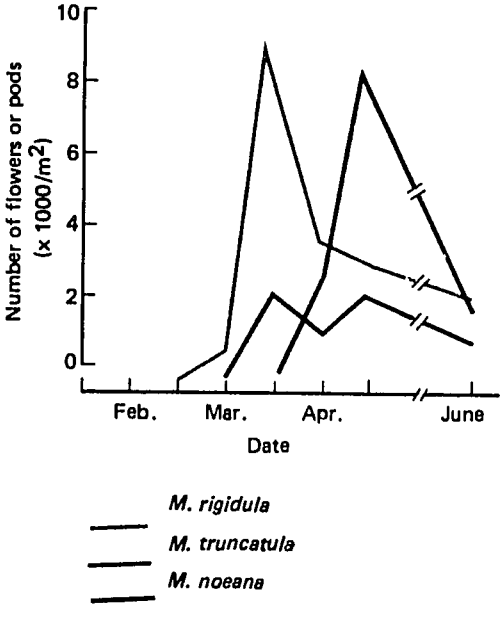


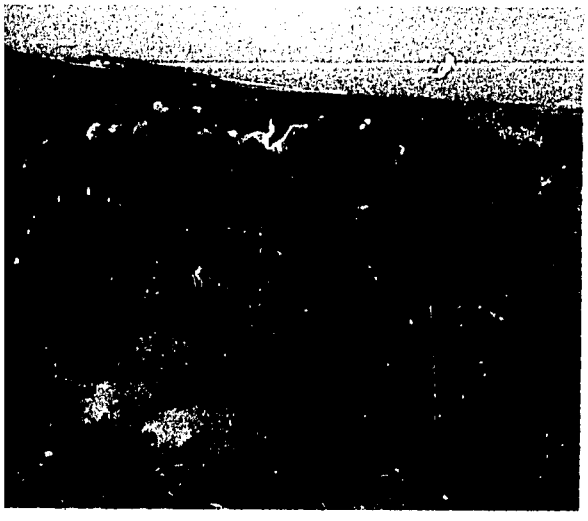
Figure 14. Number of flowers or pods present in three medic species from the beginning of flowering until seed maturity.

Value of Crop Residues as Summer Grazing for Breeding Ewes

Sheep flocks in many North African and West Asian countries graze cereal stubble for three to four months during the hot dry summer. Breeding ewes are mated during this period, and maximum fertility can be achieved if flocks are maintained in good body condition. This does not always happen since the nutritive value and intake of cereal stubble is inadequate to cover their needs. As a result, ewes tend to lose weight as stubble becomes progressively overgrazed, and this can have a negative impact on fertility.

Research has shown that ewes grazing medic residues alone gain weight, and that sheep grazing cereal stubble gain weight when fed modest amounts of cottonseed cake—a protein-rich by-product of cotton plants abundant in Syria. This gain in weight is associated with an increase in straw intake.

Two experiments were conducted in 1984 to investigate the liveweight changes of ewes grazing cereal stubble and medic residues. Groups of ewes grazing the cereal stubble at a stocking rate of five ewes per hectare received daily either 100 grams of cottonseed cake or none, but ewes grazing medic residues followed by cereal stubble at a stocking rate of four ewes per hectare received no supplement. A third experiment investigated the effect of cottonseed cake supplementation on straw intake of penned sheep over a 120-day period. In this case, castrated males were used, but the principles apply to ewes.



Sheep grazing crop residues. Do they lose or gain weight on this feed?

Although drought severely affected herbage and seed production of the medic crop, ewes grazing the residues gained 55 grams per day over an eight week period (Figure 15). During the following seven weeks, they grazed cereal stubble without supplementation and lost 22 grams per day. Over a 91-day period, ewes grazing stubble alone lost 35 grams per day, but those receiving the supplement gained 33 per day. In the penned experiment, the intake of straw was markedly increased by the addition of the cottonseed cake supplement (Table 26). This helps explain the improved liveweight of supplemented ewes grazing cereal stubble.

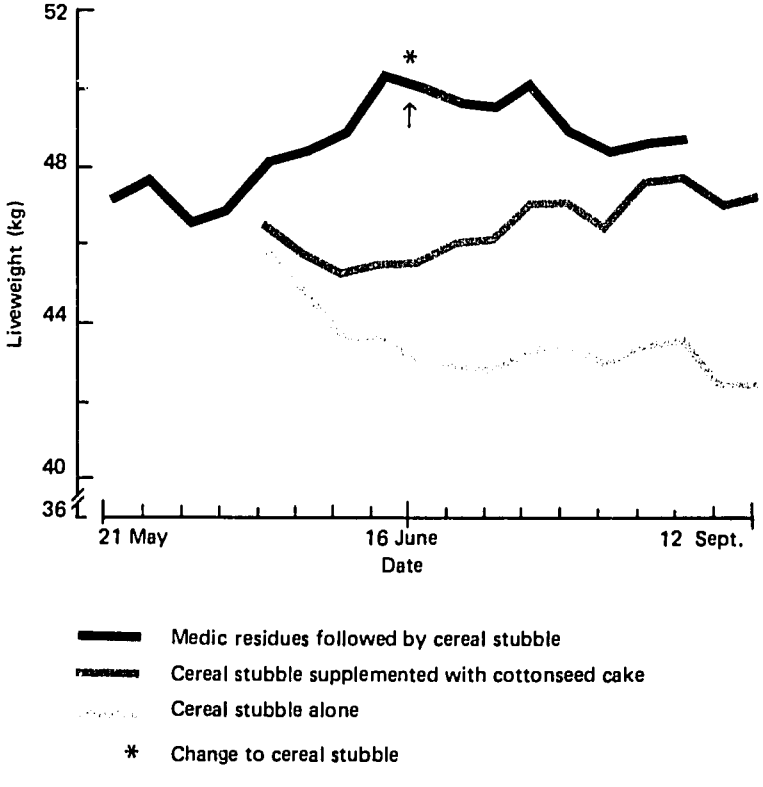


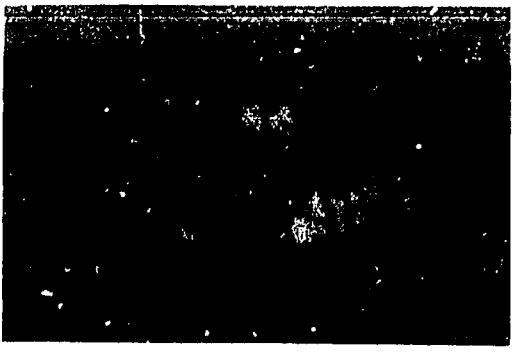
Figure 15. Liveweights of ewes grazing medic residues followed by cereal stubble alone or cereal stubble with and without cottonseed supplementation in summer.

These studies show that medic residues or cereal stubble supplemented with modest amounts of cottonseed cake cover the major nutrient requirements of breeding ewes during a critical phase in the reproductive cycle. The fertility of these ewes will be high enough to reach the genetically determined lambing percentage of the breed. Such supplementation practices are readily transferable to the real farm environment.

Table 26. Daily voluntary intakes and daily liveweight changes of penned sheep offered chopped Arabi Abiad straw alone or with cottonseed cake supplement.

	Straw	Standard error of difference
Number of sheep	4	—
Dry matter intake:		
-Straw alone (g)	626	103.6
-Straw + CSC (g)	626	113.4
Liveweight change (g)	-82	22.8

1: $p < 0.001$; 2: $p < 0.01$.



Different heights of barley and times to maturity. Tall varieties with less leaf and lower stem digestibility produce straw of poor feeding value, while late maturing varieties produce better straw than early varieties

Sheep feeding experiments showed that Beecher— a tall barley variety— produced poorer quality straw than ER/Apam or Arabi Abiad. ER/Apam combines the grain yield of Beecher and the good straw quality of Arabi Abiad.

Predicting Feeding Value of Barley Straw for Sheep

Animal scientists usually consider cereal straws inferior feedstuffs which may make their importance in sheep diets in North Africa and West Asia seem surprising. This importance generates a considerable demand, and straw prices do not reflect nutritive value. Both straw quality and grain yield should therefore be considered in breeding strategies. Releasing improved cereal varieties screened for straw quality offers farmers an opportunity to increase the nutrient supply to livestock without additional costs.

ICARDA scientists are collaborating with the Tropical Development and Research Institute of the British Overseas Development Administration in research aimed to ensure that barley and wheat varieties are released which have superior straw quality and grain yield.

Initial research identified an association between the nutritive value of barley straw and the proportion of leaf in the mature plant, plant height, and days to maturity. Thus, Beecher, a tall variety, had a poor quality straw compared with two short varieties: Arabi Abiad, a Syrian landrace, and ER/Apam, a promising ICARDA variety (Table 27). Due to cutting 15-20 cm above ground level, straw from the machine harvested crop contained less leaf than straw from the hand pulled crop. However, in spite of the higher leaf proportion in the hand pulled crop, soil contamination reduced nutritive value below that of the machine harvested crop. This preliminary study provided evidence that a new selection such as ER/Apam could combine the grain potential of Beecher

Table 27. Effect of barley genotype and method of harvesting on the voluntary intake and digestibility of straw by sheep.

	Beecher		[redacted]			
	Machine harvest	Hand pulled	Machine harvest	Hand pulled	Machine harvest	Hand pulled
Plant height (cm)	74.0	74.0	47.4	47.4	36.2	36.2
Leaf proportion	0.35	0.42	0.43	0.56	0.44	0.57
Grain yield (kg/ha)	2720		3057		1830	
Voluntary intake						
($g/kg^{0.75}/day$*)						
Dry matter	29.4	25.9	36.3	32.3	39.6	39.5
Organic matter	25.8	22.2	32.9	27.0	34.4	34.7
Digestibility (%)						
Dry matter	35.0	32.9	41.8	36.7	42.9	36.7
Organic matter	39.5	38.6	50.6	41.6	47.5	44.0
Intake digestible organic matter ($g/kg^{0.75}/day$)	10.2	8.6	16.6	11.2	16.3	15.2

*Grams consumed per kg sheep metabolic liveweight per day.

with the straw quality of Arabi Abiad.

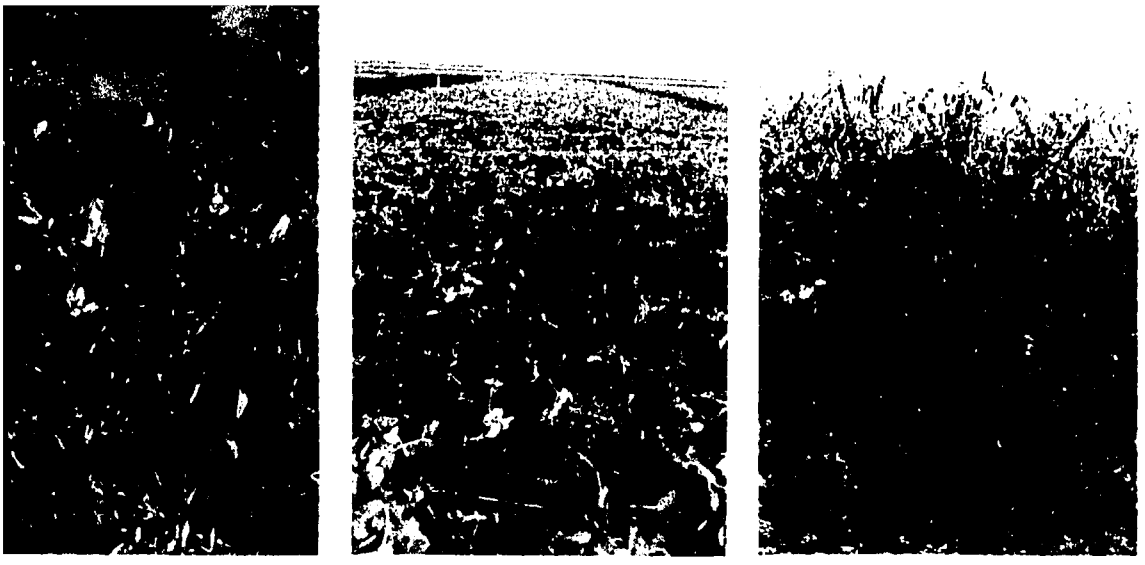
These initial findings lead to studies aiming to identify relationships between straw nutritive value and easily measurable morphological attributes of the mature plant which could be used to screen new selections for straw quality.

A study of eight barley varieties showed how leaf proportion relative to stem falls as plants get taller. Because leaf is more digestible than stems (Table 28), short varieties which have a higher leaf proportion are more nutritious than tall varieties. They have a high proportion of stem. The higher leaf proportion in this second study was due to the plants being shorter in the drought year of 1983/84 compared with the year before. Also, it was found that late maturing varieties had a higher leaf proportion than early maturing varieties.

This research has shown that shorter barley varieties which resist lodging better than tall ones are likely to have higher nutritive value. Furthermore, ICARDA's objective of improving grain yields appears to be compatible with improving straw quality.

Table 28. In-vitro cellulase digestibility (%) of fractions of barley straw from genotypes with contrasting leaf proportion and stem length.

Genotype	In-vitro cellulase digestibility (%)				
	Hand pulled			Machine harvested (above 15-20 cm)	
	Leaf blade	Leaf sheath	Stem	Leaf	Stem
Arabi Abiad	46.5	36.2	21.2	46.4	26.1
ER/Apam	48.3	35.3	21.0	48.8	29.4
Antares	48.7	38.9	22.8	52.8	28.7
Arar	51.5	33.5	21.8	46.9	30.6
Rihane 'S'	52.4	33.7	18.7	48.7	26.4
C 63	49.7	35.5	18.0	49.2	24.7
Badia	49.5	34.9	18.8	48.5	24.0
Beecher	45.8	34.0	18.2	49.4	25.0



Left, pea-barley mixture before being grazed by sheep; center, after being grazed the barley has been eaten, but most of the peas are left in the field; right, researchers have compared yields and palatability of woolly pod vetch (shown here) with several other vetch genotypes at three stages of growth.

Sheep Feeding and Grazing Trials: Palatability of 20 Pea and Vetch Genotypes

Research results from previous seasons indicate that sheep have a definite preference for vetch over peas at the green stage. But is this true for other vetches (narbon vetch, woolly pod vetch), and does this preference also exist for hay made out of these legumes? To find the answers, ICARDA scientists conducted two experiments in 1983-84.

In experiment I, eight genotypes of common vetch (*Vicia sativa*), one narbon vetch (*V. narbonensis*), one woolly pod vetch (*V. dasycarpa*), and 10 peas (*Pisum sativum*) were compared for palatability at three stages. Three adjacent experiments each consisting of the 20 legumes were established in plots, fertilized with 40 kg P_2O_5 ha^{-1}, and replicated three times. Palatability was assessed at three stages: before flowering, at 10% flowering, and at full pod formation. Using one experiment at a time, 100 sheep were allowed to graze the available herbage for one day during the first two stages and for two days at full podding. Herbage consumption was measured by the difference in herbage before and after grazing.

In experiment II, hay harvested from two forage mixtures (vetch-barley and pea-barley) was compared in a feeding trial involving sheep in digestibility crates. The two legumes were sown in November in mixtures with barley (33:66) in a replicated

trial with a randomized complete block design on an area of 1.3 hectares. The two crops were sown at 160 kg seed ha^{-1} and fertilized with 40 kg P_2O_5 ha^{-1} in the form of triple superphosphate. The hay harvested on three dates related to legume maturity: 10% flowering, 100% flowering, and full pod formation. During the second harvest (at 100% flowering), the hay from pea/barley was spoiled by 18.5 mm of rain.

Legumes at the green stage differed in their palatability in experiment I. Total available herbage from all legumes at grazing was 22, 146, and 223 kg, before flowering, at 10% flowering, and at full podding, respectively. The total herbage consumed at the three stages was 19, 77, and 171 kg. Of the 20 legumes, woolly pod vetch yielded most before flowering and at 10% flowering, and narbon vetch the most at full podding. Considering the amounts eaten by grazing animals, common vetch was generally the most palatable. There were only small differences within species so the results are presented as an average of all genotypes for each species in Figure 16.

Experiment II showed that at the early stages of crop harvest (10% and 100% flowering), intakes of dry matter, digestible organic matter, digestible crude protein, and metabolizable energy by sheep from vetch/barley are all significantly higher than from pea/barley. However, at 100% flowering this difference was partly due to rain damage to the pea/barley mixture. At the full podding stage there was no significant difference in sheep intake between vetch or pea mixtures. This was true for all intakes of dry matter, digestible organic matter, digestible crude protein, and metabolizable energy (Table 29).

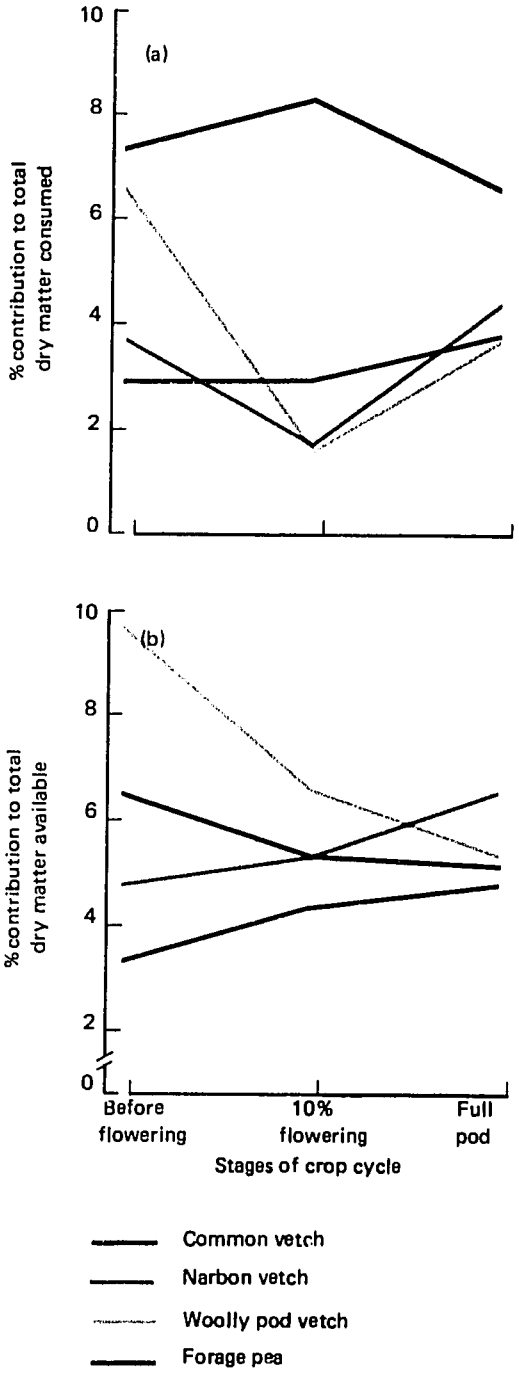


Figure 16. Percentage contribution of four legumes to herbage consumed by sheep (a) and available herbage at three times of grazing (b).

These results confirm that common vetch is more palatable than narbon vetch, woolly pod vetch, and forage pea at the green stage. A comparison of hay quality of common vetch and forage pea showed that common vetch was still better when forage was harvested at early stages of the crop growth cycle, but the differences disappeared when the crops were harvested at the late stage (full podding).

Table 29. Amount of herbage, digestible organic matter, digestible crude protein, and metabolizable energy eaten by sheep in relation to maturity stage of vetch/barley and pea/barley harvested for hay in Tel Hadya, Syria (1984).

Stage of harvesting*	Vetch/Barley			Pea/Barley		
	a	b	c	a	b**	c
Herbage intake (kg per 45 sheep per day)	1.56a	1.70a	1.58a	1.04b	0.62c	1.40ab
Digestible organic matter intake (kg per 45 kg sheep per day)	0.99a	0.97a	0.96a	0.67b	0.39c	0.84ab
Estimated digestible crude protein intake (kg per day)	0.16b	0.19a	0.09d	0.11c	0.04c	0.07d
Estimated metabolizable energy intake (MJ per day)	14.58ab	16.14a	11.08bc	9.78c	5.90d	12.28bc

*a,b, and c are the harvesting stages of the forage crop. Values followed by same letter (s) in the same line are not statistically significant.
** Rain damaged.

Enhancement of Biological Nitrogen Fixation in Legume Crops

The basic thrust of ICARDA's microbiological investigations to identify and overcome constraints to biological nitrogen fixation requires a multi-disciplinary approach involving not only microbiologists but scientists in several other disciplines such as entomology, agronomy, and computer sciences. Research during 1984 on the *Sitona* weevil and phosphate fertilizer and their effects on biological nitrogen fixation and the search for superior *Rhizobium* strains illustrates the value of this approach.

In lentils, the larva of the *Sitona* weevil attacks and destroys the crop's root nodules which are the sites of nitrogen fixation. However, the effect of this damage on the crop's potential for nitrogen fixation and therefore its ability to be partially or wholly dependent on fixed nitrogen (as opposed to soil nitrogen) has not been studied previously.

Working together, a microbiologist and entomologist found that those lentil plants whose root systems were not protected against *Sitona* weevil larva infestation displayed acetylene reduction values which were shorter in duration and never reached values as high as the protected ones (Figure 17). Protection is obtained with soil applied insecticides. (Acetylene reduction value is a comparative and indirect measure of nitrogen-fixing enzyme activity.)

However, the seasonal mean plant dry weight and reported harvest protein values for protected and unprotected plants were similar which indicated that the unprotected plants became dependent on soil nitrogen at an early stage in the growth cycle--an undesirable consequence (Figure 18). One of the attributes of an effective legume is its capacity to improve soil fertility by using atmospheric nitrogen, thereby minimizing the uptake of soil

The *Sitona* weevil has destroyed a lentil root nodule—the site of nitrogen fixation. (Note the empty and dead nodule in the upper part of the photo.) *Sitona* larvae move up and down the roots attacking one nodule after another.

nitrogen. This lack of nitrogen demand from the soil therefore allows regeneration of the nutrient through normal bacteriological processes with this net result: increased nitrogen availability to crops following the legume in rotation.

The research team with agronomists as members determined the effect of phosphate fertilizer on the nitrogen-fixing potential of vetch in rotation with barley. Although the value of phosphate on crop production is well known, its effect on acetylene reduction activity was unknown. Researchers found that the availability of phosphate significantly affected nitrogen fixation. Acetylene reduction values in the trials treated with 60 kg/ha P_2O_5 were more than double those of the untreated

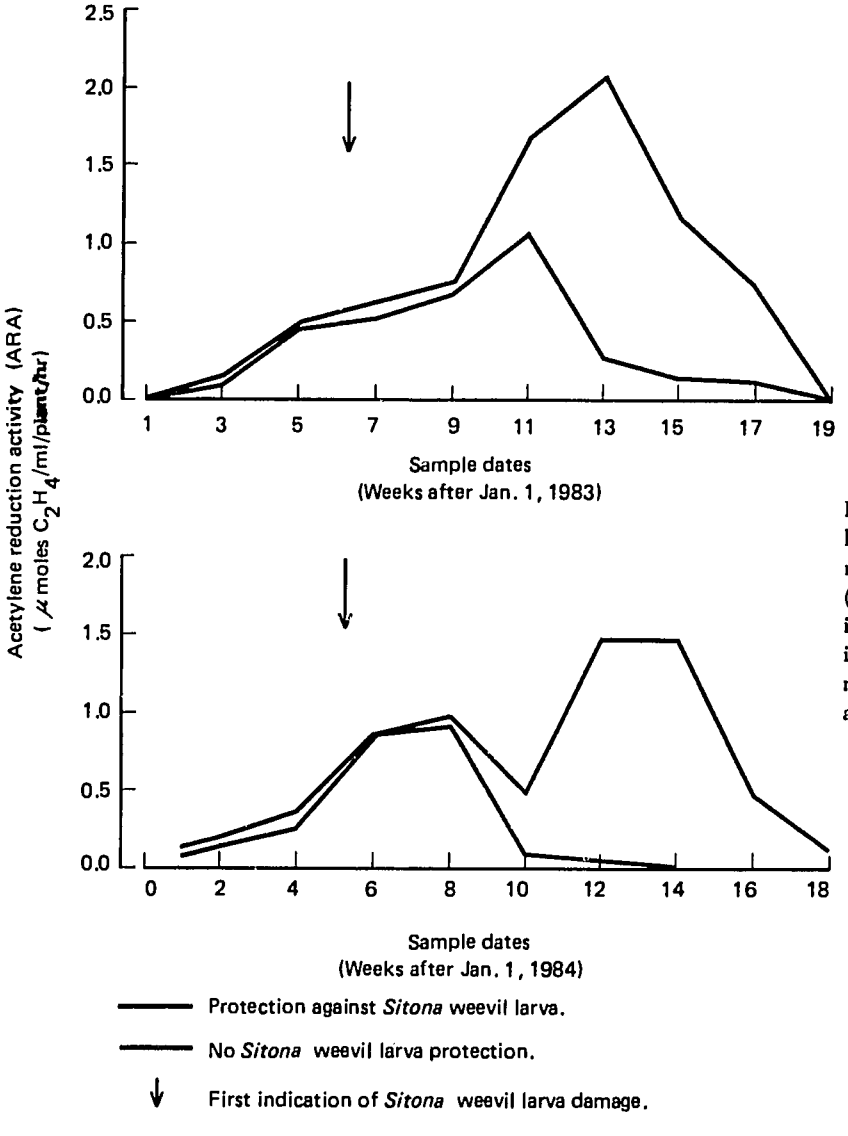


Figure 17. *Sitona* weevil larva effect on acetylene reduction values in lentils. (Acetylene reduction value is a comparative and indirect measure of nitrogen-fixing enzyme activity.)

(Figure 19). This enhancement of nitrogen fixation should be beneficial to succeeding cereal crops. Like lentils, the demand for soil nitrate nitrogen by vetch is minimized so a buildup of this required nutrient will take place.

One of the principal undertakings of any study related to the enhancement of biological nitrogen fixation in legumes is to search for that *Rhizobium* strain not only able to fix greater amounts of nitrogen when in symbiosis with its host but also able to compete with the natural soil *Rhizobium* population for sites of entry into the host's root system and subsequently form nitrogen-fixing nodules. A requirement for effective searching for this organism is an ability to recognize the test strain against the background of natural populations. One method of recognition is to determine the antibiotic resistance patterns of strains selected for testing and to monitor nitrogen-fixing nodule occupants' resistance patterns and compare these with the known patterns of original strains.

However, scientists face difficulties with this comparison because of possible genetic exchange between organisms in the soil. Therefore, the possibility of change in the test strain is real. To accurately compare these patterns, and by so doing determine whether or not the nodule occupant is the introduced test or a differing strain of

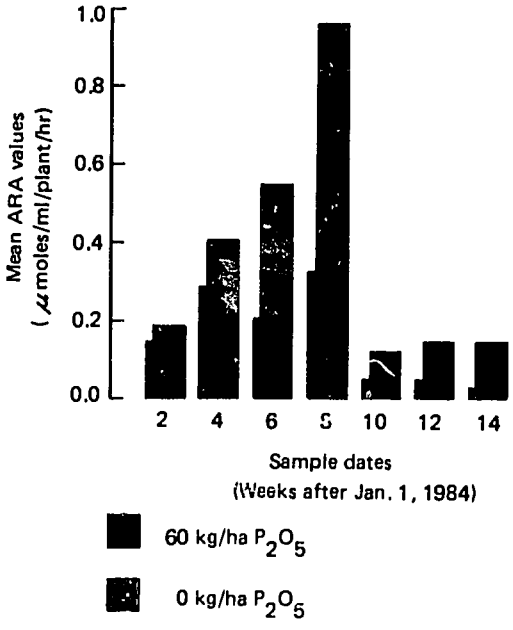


Figure 19. Acetylene reduction profile of vetch grown with and without phosphate fertilization. The sharp drop in ARA values between the fourth and fifth sampling dates coincides with initial indications of *Sitona* weevil larva infestation.

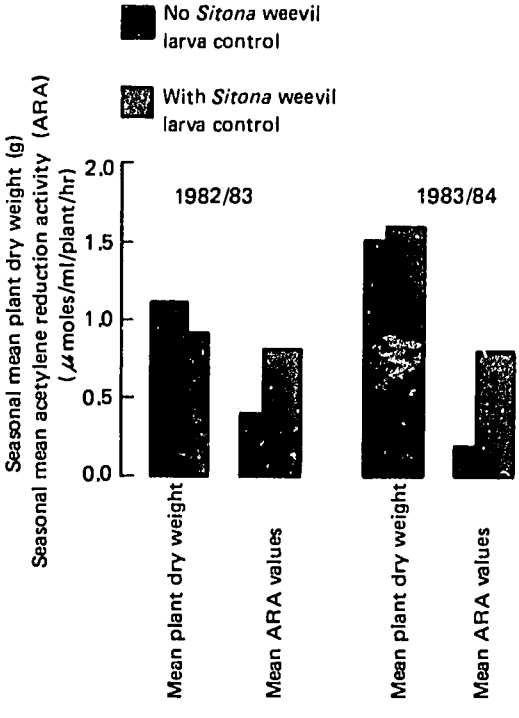
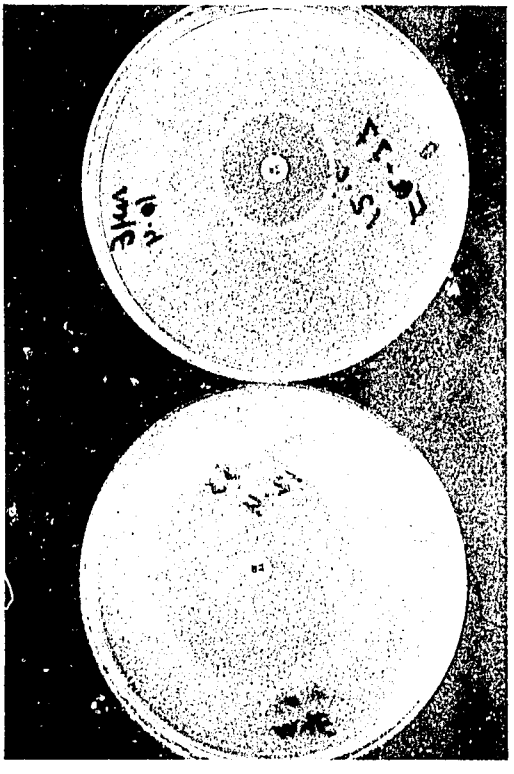


Figure 18. Seasonal mean plant dry weights and acetylene reduction activity (ARA) values for lentils with and without *Sitona* weevil larva control.

Rhizobium, computer scientists prepared a computer program which made possible the comparison of strain resistance patterns. With this analysis of similarities and differences of resistance patterns between the known test and nodule occupant strains, scientists can estimate how alike or unlike the two are. Also, it provides a method to determine whether or not the test strain is competitive with the natural population for entry into symbiosis with the host plant.

Analyzing field acetylene reduction activity (ARA) samples using gas chromatography. The concentration of ethylene, the product of acetylene reduction, in each sample is determined which provides an indication of the activity of the nitrogen-fixing enzyme.



Right, laboratory cultures of *Rhizobium* bacteria growing on artificial medium and displaying differing resistance to two antibiotics. Each *Rhizobium* strain has its own antibiotic resistance pattern much like a finger print. The "halos" in the center of the two plates indicate the degree of resistance to tetracycline (TE) and vancomycin (VA).

Effect of Crop Rotation on Fertilizer Response in Barley Growing Areas of Syria

During the past five seasons, scientists in ICARDA's Farming Systems Program have been looking in some detail at the potential for fertilizer use in dryland farming systems in Syria where barley is grown as the dominant crop and used entirely as a source of feed for sheep. Farmers' yields are very low, averaging between 600-700 kg/ha, and soil nutrient deficiencies are widespread. Dramatic increases of barley yields and water use efficiency resulting from fertilizer application have been consistently demonstrated and reported.

As a result of a joint Syrian Soils Directorate/ICARDA workshop held in March 1984 which reviewed pertinent data, a cooperative program of research between the two organizations has been initiated to examine throughout Syria the economic potential for fertilizer use in dry barley growing areas. It is hoped that this research, conducted entirely in farmers' fields, will enable the Syrian Government to review its fertilizer policy which currently does not recommend fertilizer use in these areas.

Almost all research to date on this topic has focused on barley grown in a fallow/barley two year rotation—the most common practice of farmers in northwest Syria. In this rotation the dominant response has been due to phosphate fertilizer with responses to nitrogen only occurring in certain locations and in wetter than average years. (Survey results indicate that more than 70% of farmers' barley fields are deficient in phosphate.)

However, more farmers are beginning to abandon the practice of fallowing and in northwest Syria continuous barley cultivation is common. There is evidence that crop responses to fertilizer are modified by crop rotation, and therefore scientists have initiated a detailed investigation to examine this in greater detail. It was a very dry year at Breda—the trial location—with only 207 mm of rainfall (70 mm less than the long-term average). Unfertilized barley crops in surrounding farmers' fields were severely stressed, and crop failure was widespread. Nevertheless, substantial yields and interesting results were obtained from this trial.

Five levels of nitrogen and five levels of phosphate, in varying combinations, were tested during 1983/84. The fields were sown with Arabi Aswad barley, an unimproved local landrace. This work is being repeated in the 1984/85 season, and residual effects of fertilizer application in 1983/84 will be recorded.

Results so far show that the available nitrogen (ammonia plus nitrate) and the moisture in the soil at the start of the season are substantially greater on land that had been fallowed (Table 30). This finding agrees with results obtained from previous studies in ICARDA's long-term rotation trials.

Difference in growth rate due to the effects of fertilizer and rotation become apparent at an early stage of growth (Figure 20). Beneficial effect of rotation was evident even at high levels of fertilizer application (N_{90}, P_{180}) and started to show

Available nitrogen (ppm)			Soil moisture (cm/depth interval)		
Depth (cm)		Barley/ Barley	Depth (cm)		Barley/ Barley
0-20		5.2	0-15		1.23
20-40		3.6	15-30		2.11
40-60		3.2	30-45		2.73
60-90		5.7	45-60		3.21
			60-75		3.52
			75-90		3.60

Table 30. Initial available nitrogen and moisture distribution under fallow/barley and barley/barley rotations at Breda, Syria.

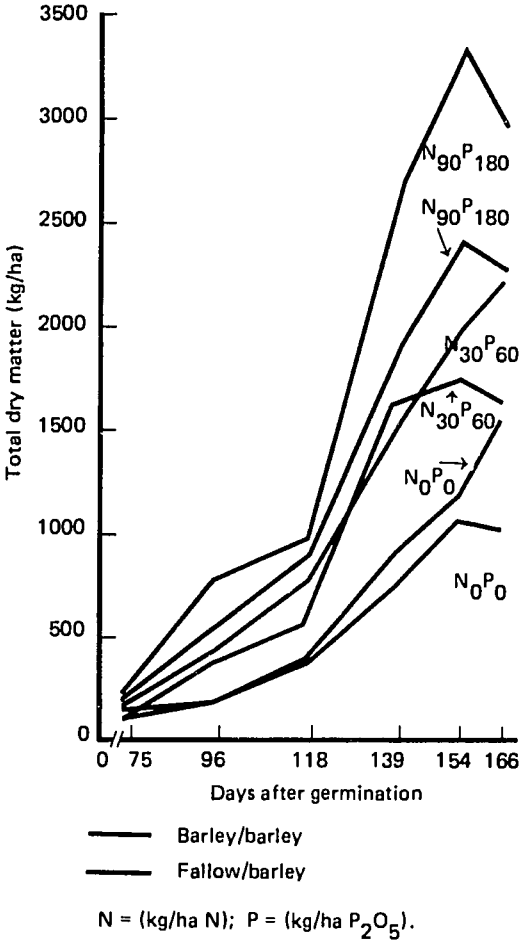


Figure 20. (Right) Total dry matter production (kg/ha) in three selected treatments in two barley rotations at Breda, Syria (1983/84).

during the winter months when the soil was being replenished with water and no stress occurred. The implication is that improved fertility and moisture conditions of land after fallow do not alone account for the observed differences in growth and subsequent yields.

In both rotations the application of fertilizer resulted in large increases in grain and straw yields (Table 31). However, yields for a given fertilizer treatment were consistently larger for the fallow/barley rotation.

Evapotranspiration between germination and maturity was only marginally affected by fertilizer application, largely because of the very dry season affecting all treatments. Nevertheless, the initial wetter soil profile following fallow provided additional available moisture (Table 30). This is evident in the greater seasonal evapotranspiration totals of crops following fallow. The extra moisture was stored at depths of between 30 and 75 cm and was used by the crop during the grain filling period (Figure 21). This additional moisture, which reduced stress, resulted in larger 1000 grain weights of barley after fallow (Table 31). As in previous seasons, the fertilizer application resulted in a dramatic increase in water use efficiency in

Farmers in Syria practice both continuous barley (foreground) and a fallow/barley rotation (background), but more farmers are beginning to abandon fallowing. Research shows that crop responses to fertilizer are modified by crop rotation.

Table 31. Components of barley yield (Arabi Aswad) in selected treatments in NP trial in two rotations at Breda, Syria (1983/84).

		Grain yield (kg/ha)	1000 Grain weight (g)	Straw yield (kg/ha)	T.D.M. (kg/ha)	E_T (G-M) (mm)	WUE* (kg/ha/mm)	
Fallow/Barley	N_0P_0	740	38.6	600	1340	171	7.84	(—)
	$N_{30}P_{60}$	1160	40.7	930	2090	174	12.00	(53%)
	$N_{90}P_{180}$	1540	38.3	1340	2880	176	16.36	(109%)
Barley/Barley	N_0P_0	470	34.4	390	860	160	5.4	(—)
	$N_{30}P_{60}$	770	34.7	810	1580	161	9.81	(82%)
	$N_{90}P_{180}$	1100	32.8	1130	2250	162	13.89	(157%)

*Water Use Efficiency; WUE of T.D.M. figures in parentheses indicate % increase over N_0P_0 treatment for each rotation.

both rotations. However, it was consistently better in the barley/fallow rotation for a given fertilizer treatment.

Current research has clearly shown that improved nutrition of a barley crop results in a more prolific rooting system and that the amount of extractable moisture within a given soil depth interval is closely related to the root length density within that interval (Figure 22).

The main effects of nitrogen and phosphorus fertilizer on total dry matter (grain plus straw) are presented in Figure 23. There are substantial and highly significant differences between the responses to fertilizer in the two rotations. There was no significant response to nitrogen fertilizer in the fallow/barley rotation. However, in the continuous barley rotation there was a substantial

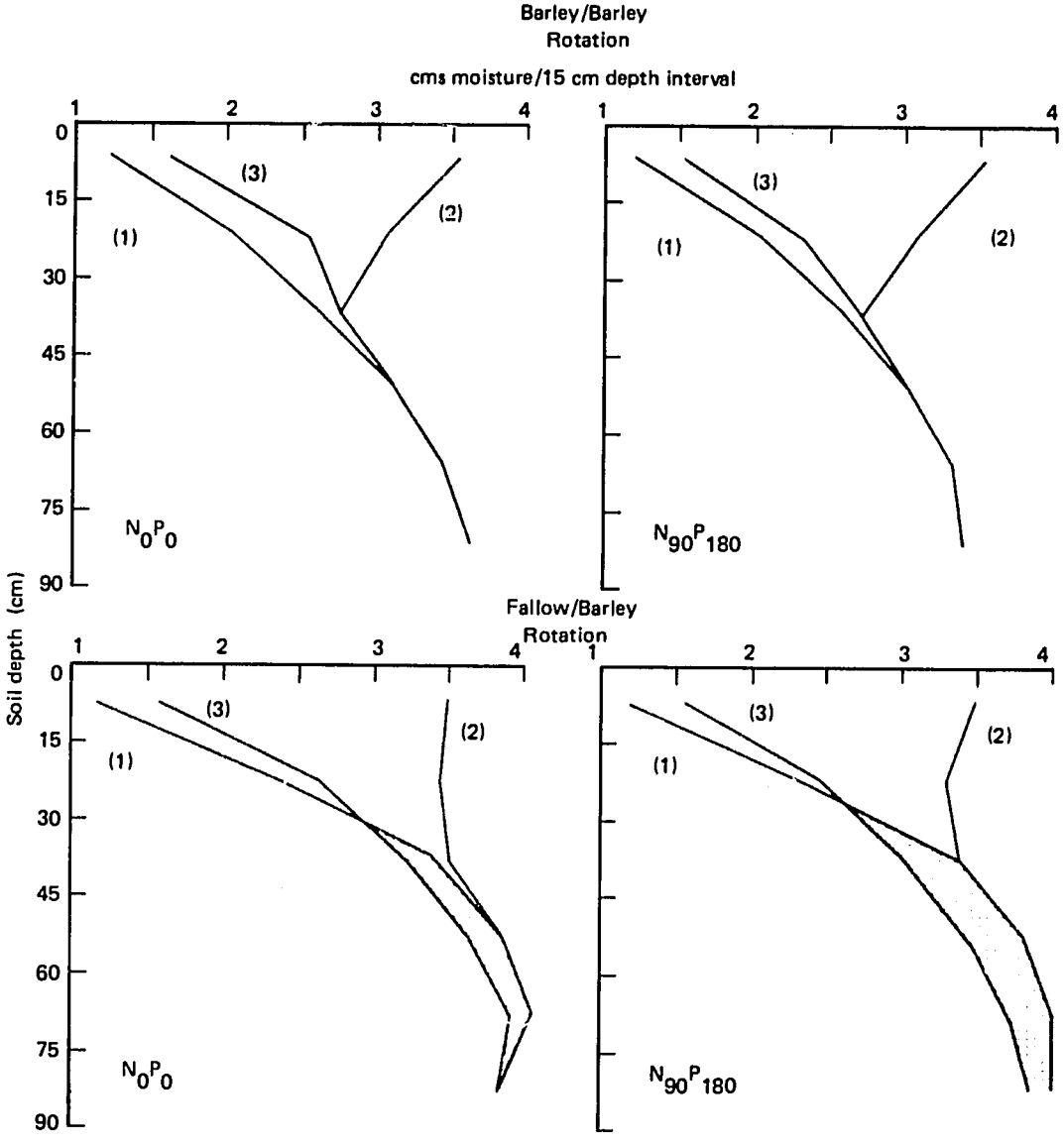
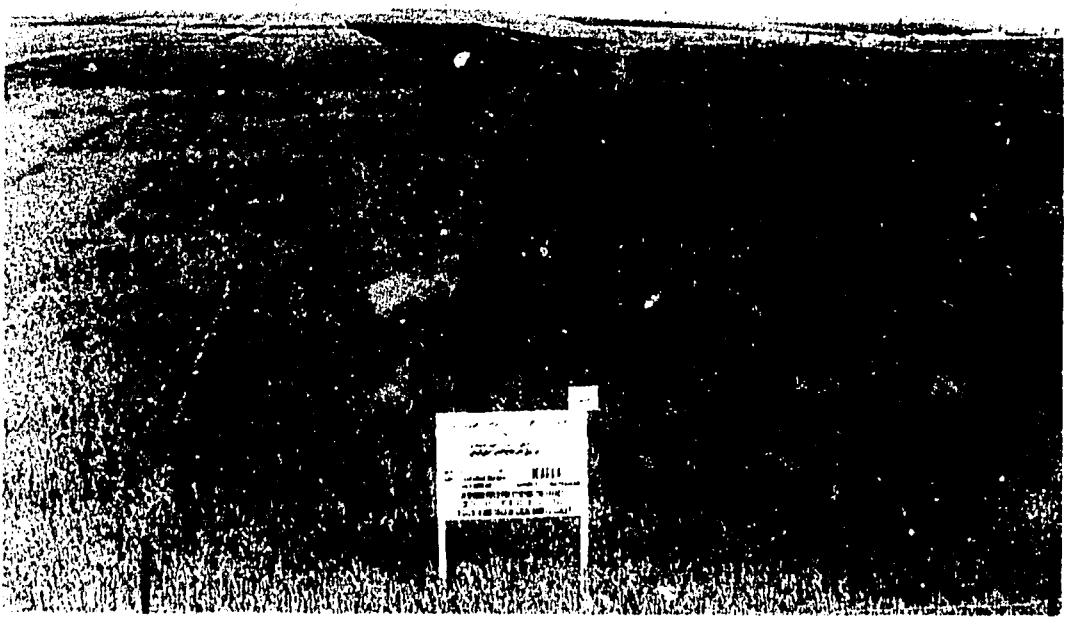


Figure 21. Moisture distributions under two contrasting crop rotations on the selected days (1) initial profile, (2) maximum recharge, and (3) crop maturity. (Color area represents use of moisture stored from the previous season.)

response to nitrogen over the range of 0-30 kg but thereafter the responses to nitrogen were very similar and insignificant for both rotations.

Even after one year of this research, it is clear that the crop rotation practiced by farmers will need to be considered in evaluating fertilizer recommendations for these dry areas. To further evaluate this, research is continuing in collaboration with the Syrian Soils Directorate.



The Syrian Soils Directorate and ICARDA are jointly conducting tests to examine the economic potential for fertilizer use in dry barley growing areas. More than 70% of farmers' barley fields are deficient in phosphate.

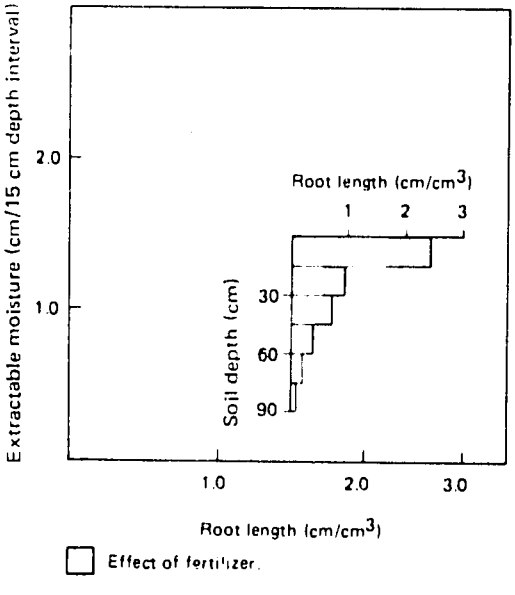


Figure 22. Relationship between root length density of barley and extractable moisture with insert showing effect of fertilizer (color area) on barley root distribution with depth at Breda, Syria (1982-83).

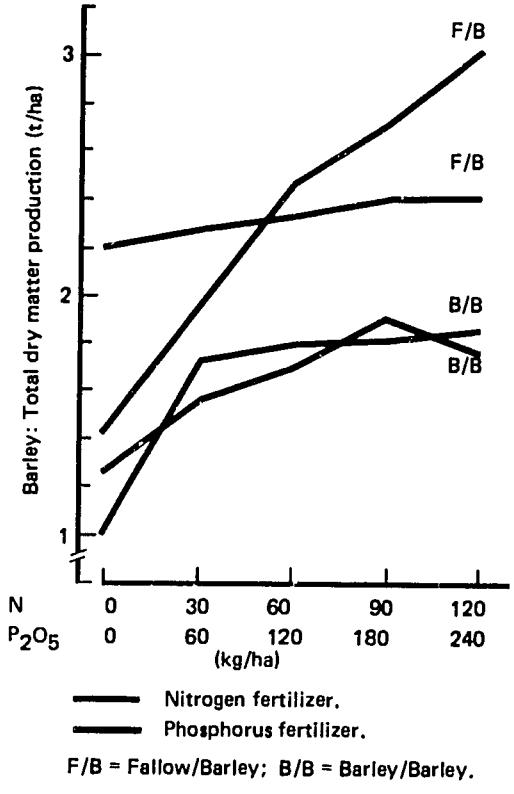


Figure 23. Main effects of nitrogen and phosphorus fertilizer on total dry matter production of barley in two contrasting rotations at Breda, Syria (1983/84).

Feasibility of Annual Sown Forage Legumes in Barley/Livestock Systems

Both experimental station and on-farm tests with annual sown forage legumes in rotation with cereals have shown beneficial results. However, this practice plays a very limited role in the dry areas of Syria. Why? Farmers list three reasons: labor problems, high costs, and risks involved in growing forage legumes in dry areas.

Principles behind substituting annual forages for fallow are simple: A legume crop uses land which would otherwise lie idle or breaks continuous barley cultivation; enhances the yield of the subsequent cereal crop; makes use of residual phosphate fertilizer applied to the cereal crop which otherwise might be lost in the fallow year; fixes a portion of its nitrogen needs from the atmosphere, thereby helping to maintain soil fertility; and provides a nutritious livestock feed.

To obtain additional facts and assess the feasibility of more farmers adopting the practice, ICARDA selected the Al-Bab Mantika of Aleppo Province as a survey site in 1983/84. It has a large area of fallow in the 200-350 mm rainfall range where the area of annual sown legume forages might be expanded. In a random sample of 24 villages, members of the farming systems staff found that the practice is limited primarily because of low yields and slim profits. Farmers did not plant forage legumes in the drier areas or on the

shallower soils because yields there were expected to be poor. Also, costs of planting and harvesting were high. An analysis of estimated costs and returns showed that legumes had higher initial costs and lower profits than cereals grown on comparable soils (Figure 24).

Cereals are usually hand harvested in Al-Bab, and the same labor (including family labor) could be available for the legume harvesting season. Even in wetter areas with considerable legume cultivation, currently available labor is more than sufficient; however, the price is high. Harvest costs were considered by farmers to be prohibitive because of the low economic value of the yields. But with increased yields or better prices, higher labor costs might be tolerated.

The feeding cycle of sheep flocks is another major factor in determining the feasibility and best possible use of forage legume crops. In general, they will be less useful at times when alternate feeds are available at low cost and most valuable as substitutes for expensive feed. The greatest feed shortage occurs in winter. Communal grazing and stubble are freely available in the spring and summer, and farmers rarely purchase feed. Therefore, harvesting mature legume crops for winter feed appears to be the favored option for the near future. Spring grazing of barley is practiced to a limited extent, and it is possible that a grazed legume crop could make a contribution to spring feeding as well. However, due to the high cost of seed, the resulting increase in livestock productivity would have to be substantial to make this practice worthwhile.

Further studies will be conducted next season to assess the availability and mobilization of hired labor, the economics of grazing forage legume crops, and whether improved crop management in farmers' fields can raise legume yields to levels more attractive economically.

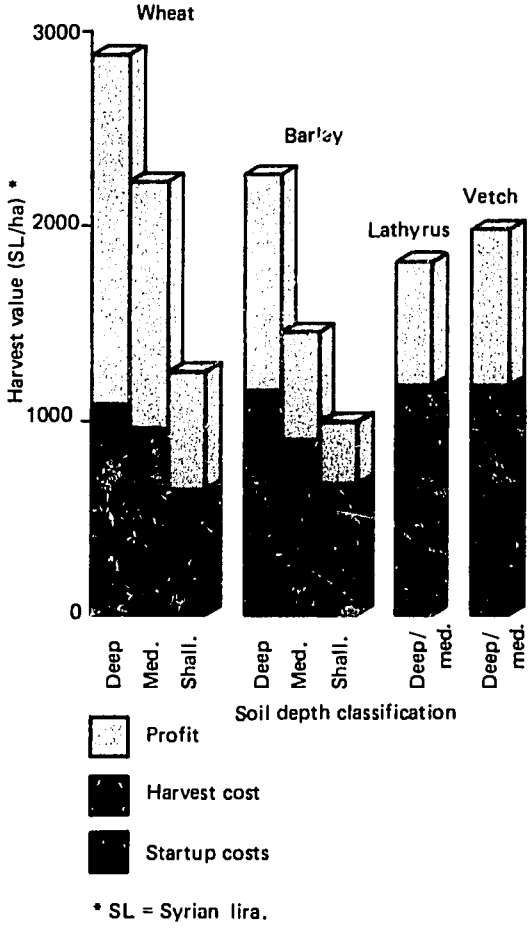


Figure 24. A comparison of estimated costs and returns of cereal and legume crops grown by farmers in Al-Bab Mantika of Aleppo Province in Syria (based on average yields and 1984 market prices).

Discussing the pros and cons of expanding annual sown legume forages in rotation with cereals with a farmer at the Al-Bab Mantika, Syria. This mantika has a large area of fallow in the 200-350 mm rainfall range.

Evaluating Existing and Alternative Fallow/Crop Rotations

Farmers usually grow barley continuously or with alternating fallow years in the dry areas of northern Syria, and generally they do not apply nitrogen or phosphate fertilizer. However, these crop rotations do not make very efficient use of available land resources. ICARDA experiments have been underway since 1980 to compare traditional crop rotations with potentially more productive ones incorporating annual sown forage legumes as either a break crop in continuous cereal production or in substitution of the fallow years.

Because existing and alternative rotations can be assessed realistically only through trials conducted over a number of years, two sets are underway to compare fallow/barley, barley/barley, and forage legume/barley rotations. The first, established in 1980/81 in two typical barley growing areas in Syria (Breda and Khanasser), compares three rotations: fallow/barley, barley/barley, and vetch/barley under different fertilizer applications (Table 32).

Barley yield and water use data from this trial for two years are presented in Table 33. Application of phosphate and nitrogen in both the barley/fallow and barley/barley rotation produced substantial increases in barley yields. With fertilizer, fallow/barley rotations outyielded continuous barley. The results mirror those found in the fertilizer response trial at Breda.

Phase I*	Phase II*	Treatment notation**
Barley (0,0)	Fallow (0,0)	Bo/F
Barley (20,60)	Fallow (0,0)	Bnp/F
Barley (0,0)	Barley (0,0)	Bo/Bo
Barley (20,60)	Barley (20,60)	Bnp/Bnp
Barley (0,0)	Vetch (0,0)	Bo/Vo
Barley (20,60)	Vetch (0,0)	Bnp/Vo
Barley (0,0)	Vetch (0,60)	Bo/Vp
Barley (20,60)	Vetch (0,60)	Bnp/Vp

*Figures in parentheses indicate levels of N and P_2O_5 applied (kg/ha).

**B = Barley; F = Fallow; V = Vetch; o = no fertilizer; n = 20 kg/ha nitrogen; p = 60 kg/ha phosphate.

Table 32. Rotations and treatments of rotation trials at Breda and Khanasser in northwest Syria.

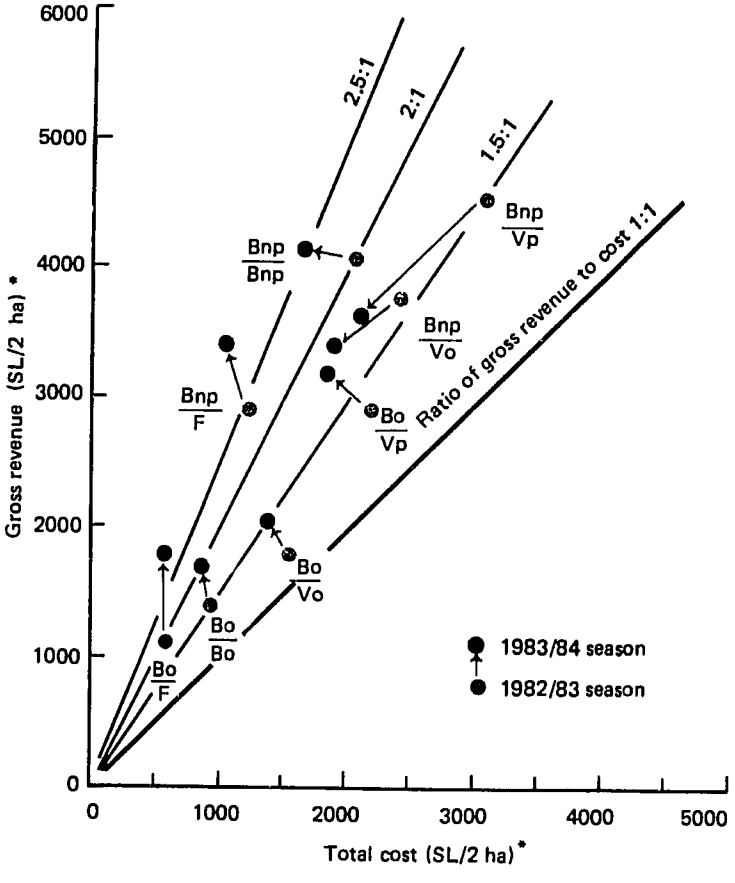
Table 33. Yield and water use data for treatments (see Table 32) in rotation trials at Breda, Syria (1982/83 and 1983/84).

Treatment	Grain yield (kg/ha)		Straw yield (kg/ha)		Water use (mm)		WUE* (kg/ha/mm)	
	82/83	83/84	82/83	83/84	82/83	83/84	82/83	83/84
Barley yields								
Bo/F	810	660	1220	1190	218	191	9.2	9.7
Bnp/F	2080	1290	2980	2140	229	201	22.3	17.1
Bo/Bo	450	260	920	620	201	185	7.0	4.8
Bnp/Bnp	1440	720	2240	1440	207	186	17.9	11.6
Bo/Vo	700	510	1120	970	211	188	8.5	7.9
Bo/Vp	1300	910	1540	1440	—	187	—	12.6
Bnp/Vo	1880	800	2470	1670	208	189	21.2	13.1
Bnp/Vp	2060	920	3010	1720	—	191	—	13.8
LSD (5%)	—	230	00	322	—	—	—	—
Vetch hay yields								
Vo/Bo	—	—	1460	580	—	—	—	—
Vp/Bo	—	—	2170	1050	—	—	—	—
Vo/Bnp	—	—	2270	850	—	—	—	—
Vp/Bnp	—	—	3000	1010	—	—	—	—
LSD (5%)	—	—	—	106	—	—	—	—

*WUE of total dry matter; WUE = Water Use Efficiency.

In general, yields of barley following vetch were greater than those following barley but less than yields of barley following fallow. There was no difference in yield between the various phosphate strategies in the barley/vetch rotations, but all these rotations receiving phosphate gave significantly higher barley yields than barley/vetch rotations without fertilizer.

Because of the overall moisture stress conditions, crop water use was largely unaffected by rotation. However, the fertilized barley/fallow rotation clearly used more moisture. This reflected some storage of moisture under fallow from the previous year and an increased ability to extract this moisture compared with the situation under the non-fertilized fallow rotation. Both rotation and fertilizers had dramatic effects in improving water use efficiency. The trials covered both a wetter than normal season (287 mm of rainfall in 1982/83) and a drier than usual season (204 mm in 1983/84) for the location.



* SL = Syrian lira.

Figure 25. Gross revenue and costs for eight rotations in two seasons at Breda, Syria. (See Table 32 for explanation of symbols for the different rotations.)

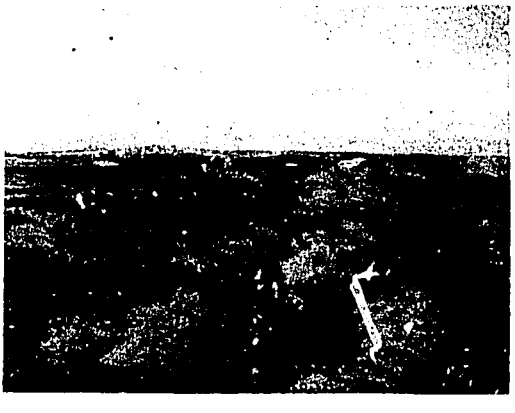
Crop yields in the 1982/83 season were greater than those in the drier 1983/84 season for all of the tested rotations. This was also generally true for much of the non-irrigated farm and grazing land in Syria, causing sheep feed prices to rise sharply by harvest time in 1984. The effect was an increase in net revenues of all but two of the eight rotations in 1984 in spite of lower yields.

All rotations in both years covered their costs, some by small and others by large margins. Rotations can be divided into two groups: low yielding ones with no fertilizer and higher yielding with fertilizer. In terms of revenue/cost ratios, the most profitable rotations were the unfertilized barley/fallow, fertilized barley/fallow, and the annually fertilized barley/barley rotation. Gross revenues were more than double the costs for each of these three. Thus, fallow and/or fertilizer is an inexpensive way to boost crop yields and revenues (Figure 25).

Rotations including vetch hay production involve relatively high seed, harvest, and handling costs. Although direct grazing of vetch avoids the harvest cost, it is questionable whether this saving is sufficient to encourage the adoption of the practice.

Farmers are interviewed in the Goubellat, Tunisia area to assess farming conditions and obtain cooperators for on-farm trials.

Fertilizer use on farms in the area was relatively high compared with herbicide application.



Sheep play an important role in the farming systems of Goubellat.

Farming Systems Research Project Initiates On-Farm Trials in Tunisia

Before starting farming systems research in any area, data are collected on farmers' practices and the problems they face in improving production, and this was the procedure followed during 1984 in the Goubellat area of Tunisia about 60 kilometers southwest of Tunis. It is a major cereal producing region located in a fertile plain surrounded by low hills with a total cultivated area of about 32,000 hectares.

The Farming Systems Project there involves the Institut National de la Recherche Agronomique de Tunisie (INRAT), Institut National Agronomique de Tunisie (INAT), Office des Cereales, Office de Production Vegetal, and ICARDA. Researchers from each of these institutions assist in planning and executing all phases of the project. Its major objectives are to test and demonstrate improvements in farm practices and make it possible for Tunisian researchers to gain experience with farming systems methods.

During 1984, the researchers conducted a survey of 240 farms in the Goubellat region (20% sample) to identify target groups of farmers and to ask questions about their production practices and problems, labor requirements, and other matters. Because it was not possible to include all farmers in the area in on-farm trials, the researchers decided to classify the present farming systems. Based on the survey data, they put the farms into a total of nine different groupings according to farm size, tractor and livestock ownership, rotation practices, and off-farm employment. The project scientists then selected four from these target groups which were considered to have the most potential for improving management of the season's work (Table 34).

On-farm trials, started in late 1984, did not have a goal of developing complex and rigid technology packages because ample evidence exists that farmers do not adopt complete packages. The trials will build on present farm practices and aim at developing technology components or practices which can be adopted in a piecemeal fashion by farmers. Most of the farms in the Goubellat are small and farmers and their families live on the farms instead of in villages. Because of this, on-farm trials are a desirable way to conduct research that will reach small farmers and also be appropriate to their conditions.

Table 34. Farm characteristics in Goubellat region, Tunisia (1984).

Farm size group (ha)	Percent of farmers (n = 240)	Average farm size (ha)	Percent with tractors	Percent with off-farm activity
0-10	[illegible]	[illegible]	[illegible]	[illegible]
10-20	16.3	14.7	8	21
20-50	7.5	34.5	50	23
50+	3.8	260.1	100	11

Project cooperators believe that farmers' reactions to these trials will be as important as the trial results. The first simple trials on farmers' fields will verify and demonstrate the efficiency of fertilizer and herbicide applications and will be evaluated after the harvest in June, 1985. (The survey showed that in 1984 farmers used fertilizer but very little herbicide; see Table 35.)

During 1985, the on-farm trials will continue. Also, farmers' practices will be monitored and a more detailed survey made in the Goubellat region.

Table 35. Farmers' input of fertilizers and herbicides on three crops in Goubellat region, Tunisia (1984).

	Percent of Farmers Using:	
Crop	Nitrogen	Phosphates
Durum wheat	84	82
Bread wheat	89	92
Barley	79	76

Predicting How Wheat Yields Respond to Climatic Factors: A New Computer Program Named SIMTAG

Using a computer model and historical climatic records, ICARDA's scientists can predict how wheat yields are affected by climatic factors. The computer program, named SIMTAG (Simulation of *Triticum aestivum* Genotypes), was developed through a cooperative project with the University of New England in Australia, and 20 years of daily rainfall and temperature records for several locations in Syria were supplied by the Syrian Meteorological Service.

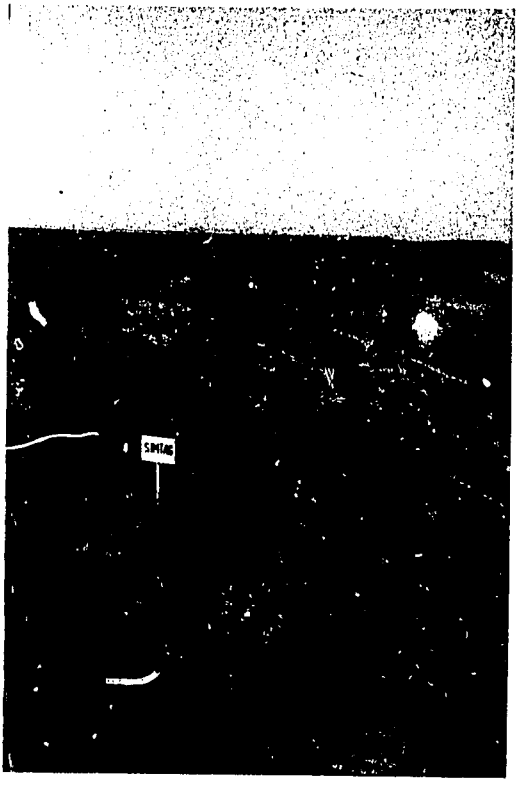
SIMTAG first was used to look at what would be the best wheat type for different places in Aleppo Province. The results indicated that at two drier sites, Breda and Aleppo, an early cultivar would be most productive and reliable. At Jindiress, a wetter site, mid-season and late cultivars outyielded the early one and gave similar yields. Where low winter temperatures slowed growth at another wet site, Kafr Antoon, an early cultivar was the only one that flowered early enough in most years to fill grain before the end of the rainfall season caused severe water stress. According to SIMTAG, the early wheat would be best at Kafr Antoon 6 years in 10.

The scientists also used SIMTAG to examine the depth of soil moisture during the rainfall season, its variability, and the probable importance of fallowing to pro-

vide additional water for crop growth. The depth of wetting of the soil depends on total seasonal rainfall and the time at which rain falls during the season. SIMTAG shows that for a deep soil at Aleppo, in the years of lowest rainfall (one in five years), less than the top 40 cm of fallowed soil will be wet. In one year in two, the depth will be less than 100 cm, but one year in five it will be more than 180 cm.

Water that is stored deeper than 100 cm will be retained over the summer, so that one year in two, fallowing can lead to storage of water from one season to the next. However, whether or not this water can be used by a crop will depend on the rainfall in the next season. Plant roots can only grow in wet soil, so for roots to reach the stored water there must be enough rain to rewet the soil to the storage zone (Figure 26). If this happens, the stored water can increase crop yields. But if rainfall is low in the second season the water stored by fallowing will not be used. On average, a farmer can expect some additional yield as a result of water stored in half of his fallows.

The effect of soil depth on crop yield has also been predicted using SIMTAG. This has shown that when rainfall occurs regularly through the season, shallow soils (about 40 cm) will give as much yield as deep soils (200 cm). In general, however, yields on shallow soils will be lower than on deep soils, and the year-to-year variability will be much greater.



Testing the SIMTAG model in the field at Breda, Syria. If scientists are to simulate the performance of individual wheat cultivars, they need to measure the differences in maturity time. Ten different cultivars are being used in this trial.

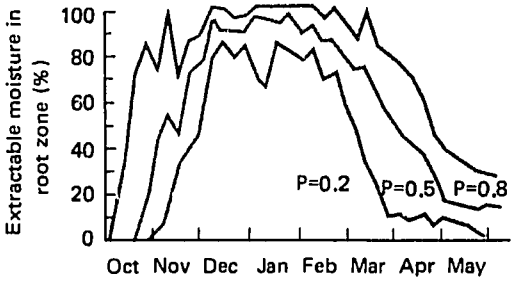


Figure 26. The simulated pattern of plant extractable soil water during the growth of wheat crops over 20 years. The figure shows the level of soil water which will not be exceeded at Aleppo, Syria—2 years in 10 (0.2), 5 years in 10 (0.5), and 8 years in 10 (0.8).

Surface sterilized seed is plated on selective media in the Seed Health Laboratory to detect seed-borne pathogens.

ICARDA's Seed Health Laboratory: Limiting the Risk of Spreading Pests and Pathogens

An extensive seed exchange all over the world presents a challenge to ICARDA, other international centers, national programs, and local quarantine authorities to limit the risk of spreading pests and pathogens to areas where they did not exist before. According to recent estimates, about half of the yield losses due to diseases of many important crops can be attributed to seed-borne pathogens. The number of reports on seed-transmitted viruses, bacteria, fungi, and nematodes is increasing every year.

Although many well-known pathogens have already been spread throughout the world, there are other hazardous organisms that have not, and their introduction into Syria and other countries must be prevented. Unfortunately, information on seed-borne diseases in a specific country is not always available. This results in uncertainty about the risk of importing seeds.

In cooperation with local quarantine authorities, ICARDA's Seed Health Laboratory inspects all seeds imported to the Center and makes laboratory tests and seed treatments if necessary. In many cases, seed is planted for the first season in an isolated corner of the farm, regularly inspected, and pesticide treatments applied if necessary.

A number of pathogens are endemic in the Middle East—the center of origin of many food crops. Some of them, such as *Ascochyta rabiei*, *Ditylenchus dipsaci*, and *Pseudomonas pisi*, are considered statutory quarantine organisms in countries to which ICARDA sends seeds. Therefore, every effort is made to dispatch only disease-free seeds. The seeds are harvested from plants that have been found free from seed-borne diseases during field inspections. Samples are tested in the laboratory, and appropriate treatments are applied before dispatch. It is ICARDA's policy to send only treated material.

During the past year, ICARDA distributed seeds to more than 70 countries (Figure 27) and received samples of germplasm from 33 countries. With the rigorous application of specific seed health measures, ICARDA intends to minimize the risk of distributing harmful organisms along with valuable germplasm that is so important for improving food production in the region.

In many cases, seed imported from elsewhere is planted for the first season in an isolated area of the ICARDA farm and regularly inspected to prevent the spread of pests and pathogens.

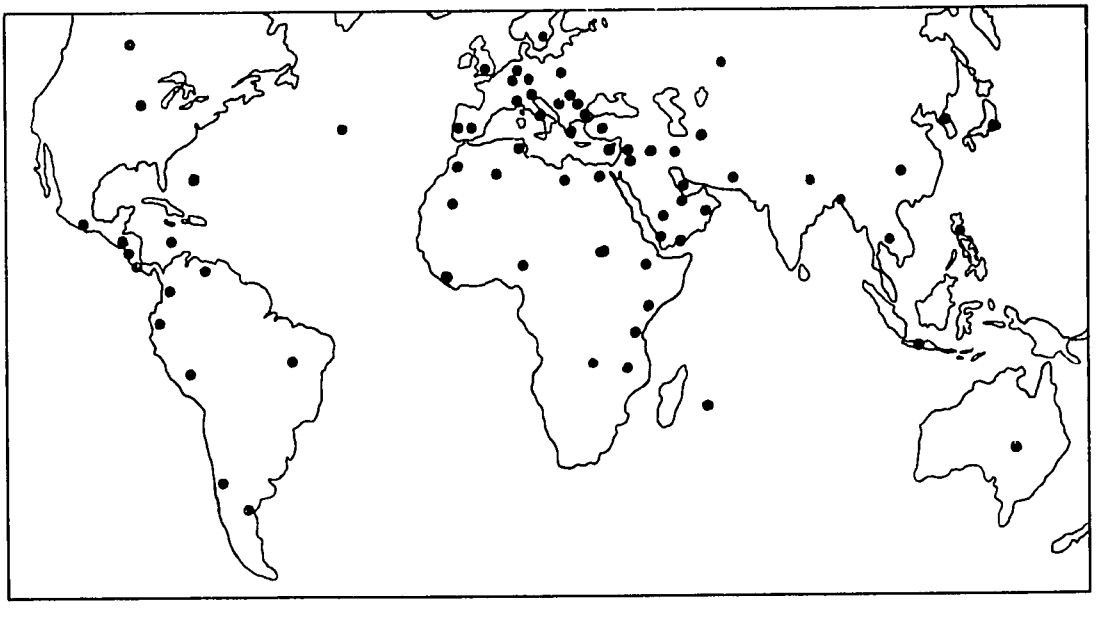


Figure 27. More than 70 countries received germplasm from ICARDA during 1984. All material is inspected and treated to minimize the risk of spreading harmful organisms.

Update on ICARDA's New Buildings

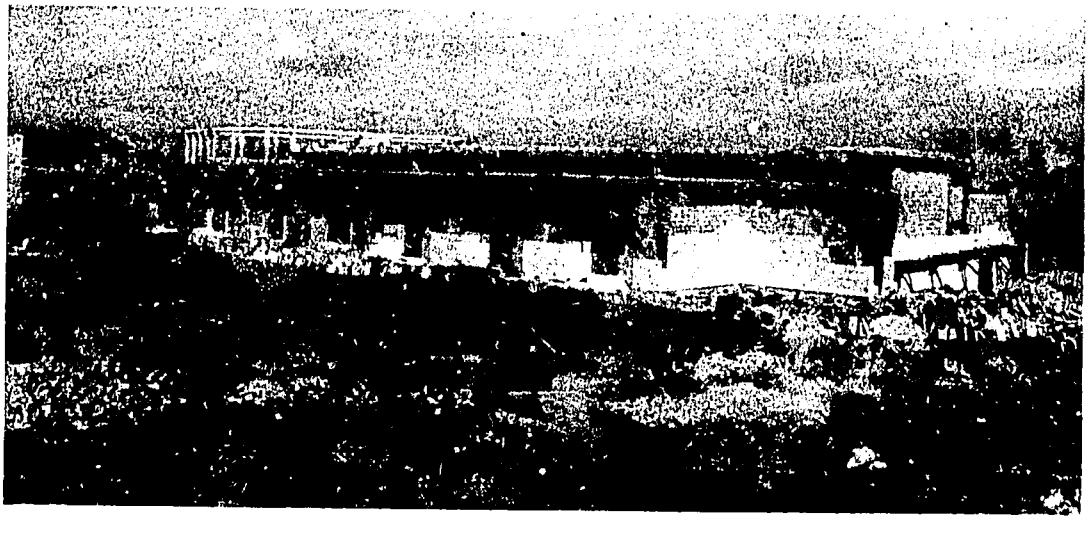
Since the 1983 edition of *Research Highlights* was published, substantial progress has been made on the three new buildings at ICARDA's central headquarters on a 948-hectare research station at Tel Hadya, Syria. By the end of 1984, Laboratory I (started in November 1982) was about 80% completed and Laboratory II begun in September 1983 almost 60%. The Training and Communication Center with conference facilities, computer services, library, and administrative offices is about 60% completed.

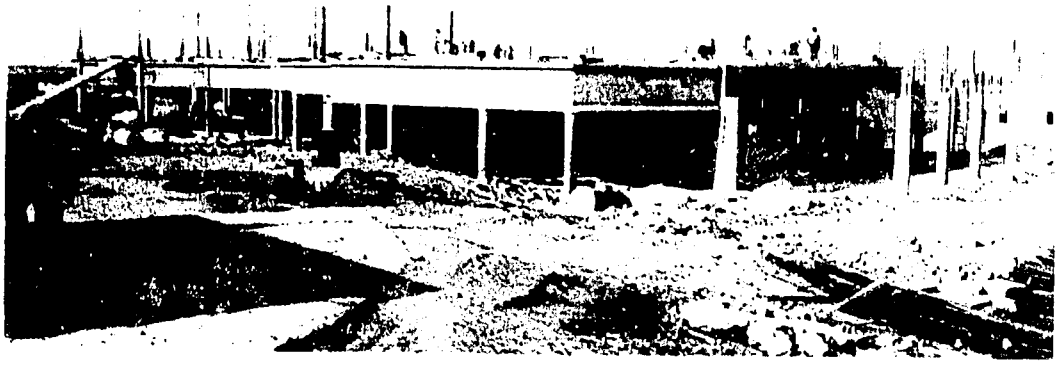
The construction status at the end of 1983 looked like this: Laboratory I 68% completed, Laboratory II 15%, and the Training and Communication Center 30%. (The photos show the difference between the construction progress at the end of 1983 and 1984.)

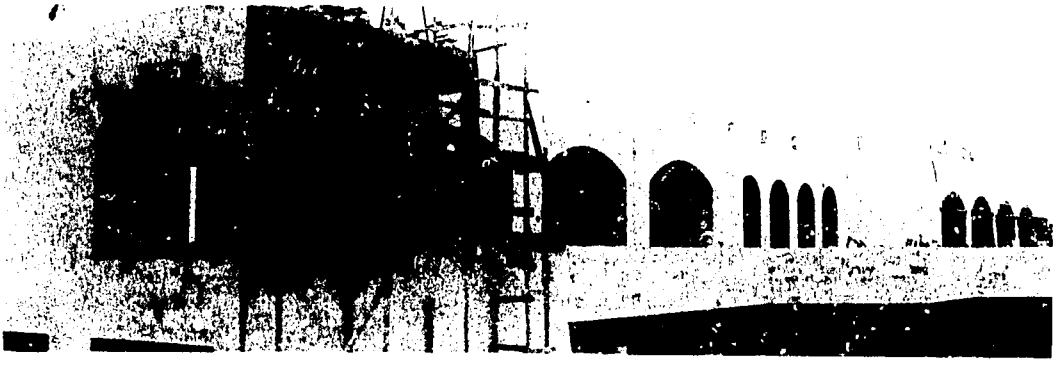
All three structures, with external finishes of local Aleppo stone, are expected to be occupied during 1986. At that time, ICARDA personnel now in two rented office buildings in Aleppo (30 km away) will move to Tel Hadya. Then all principal headquarter operations will be in one location.

The new buildings are being generally financed in the initial stage by generous grants of $3,765,000 from the OPEC Fund for International Development and $3,500,000 from the International Fund for Agricultural Development (IFAD). The core budget of the Center has also supported the construction program.

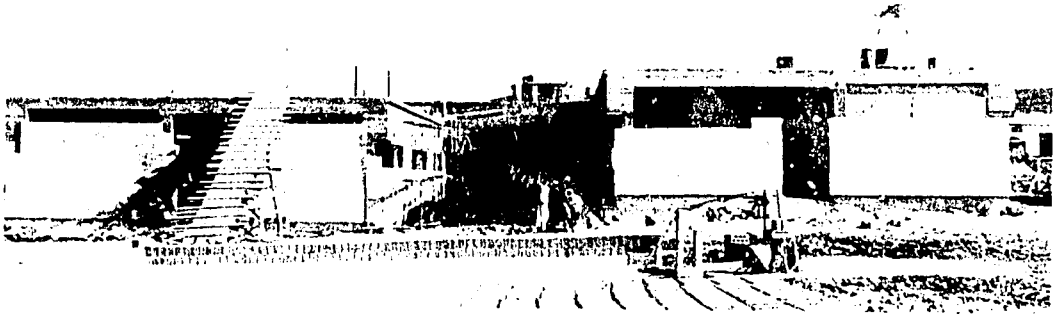
Construction of Laboratory II, started in September 1983, was only 15% finished at the end of that year but almost 60% completed by the end of 1984.

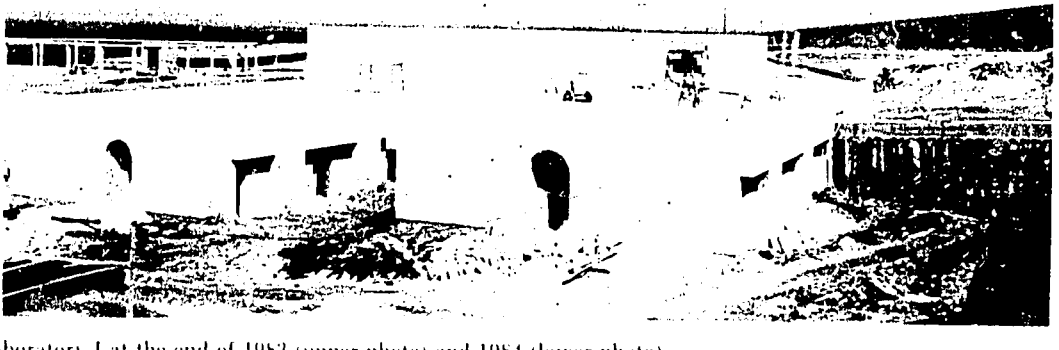






Above, the status of construction at the end of 1983 on the Training and Communication Center which will also have administrative offices, computer services, library, and conference facilities; below, the building as it looked at the end of 1984.





Laboratory I at the end of 1983 (upper photo) and 1984 (lower pheto).

ICARDA Donors

Currency: US $(x 000)

Core Operations (1984)

Unrestricted Funds

Australia	446
Canada	579
China	50
Denmark	129
Ford Foundation	175
Germany	709
IBRD	5,370
Italy	368
Netherlands	306
Norway	224
Saudi Arabia	600
Spain	50
Sweden	368
United Kingdom	500
USAID	5,300

Restricted and Capital

Arab Fund	230
France	38
IDRC	
-Farming Systems	111
-FABIS	115
-LENS	13
IFAD	
-Cereals/North Africa and West Asia	270
-Buildings	1,700
Italy	
-Building (GRU)	840
-Forage	250
OPEC	
-Barley and SWAN	233
-Buildings	1,570
UNDP-SWAN	400

Special Projects (1984)

Ford Foundation-Farming Systems 83/85	75
IBPGR-Barley	15
IDRC-Arabic Dimension	21
IFAD-Nile Valley Special Project	1,250
Netherlands	
-Virologist	63
-Training	48

Board of Trustees

Dr. Andreas Papasolomontos *(Chairman)*
Minister of Agriculture, Ministry of Agriculture and Natural Resources, Nicosia, Cyprus
Dr. Lowell Hardin *(Vice-Chairman)*
Department of Agricultural Economics, Purdue University, West Lafayette, Indiana, USA
Miss Naima Al-Shayji
Director, External Relations Division, International Fund for Agricultural Development (IFAD), Rome, Italy
Mr. Kenneth Anthony
Consultant in Tropical Agricultural Research, Oxted, Surrey, UK
Dr. Ekkehard Clemens
German Agency for Technical Cooperation (GTZ), Eschborn, West Germany
Dr. Alfred P. Conesa
Director, Laboratoire d'Etudes Comparees des Systemes Agraire, Montpellier, France
Dr. Jose I. Cubero
Prof. of Genetics & Plant Breeding, Department de Genetica Escuela Tecnica Superior de Ingenieros Agronomos, Cordoba, Spain
Dr. Sten Ebbersten
Department of Plant Husbandry, Swedish University of Agricultural Science, Uppsala, Sweden
Dr. R.A. Fischer
Principal Research Scientist, Division of Plant Industry, CSIRO, Canberra City, Australia
Dr. Joseph Haraoui
Director General, Agricultural Research Institute, Fanar, Lebanon
Dr. Mustapha Lasram
Director, Institut National de la Récherché Agronomique de Tunisie (INRAT), Ariana, Tunisia
Dr. Amir Muhammed
Chairman, Pakistan Agricultural Research Council, Islamabad, Pakistan
Mr. Hasan Su'ud Nabulsi
Director General, Jordan Cooperative Organization, Amman, Jordan
Mr. Hassan Saoud
Deputy Minister, Ministry of Agriculture & Agrarian Reform, Damascus, Syria
Dr. Mohamed A. Nour *(Ex-Officio)*
Director General, ICARDA, Aleppo, Syria

Senior Staff

Director General's Office

Dr. Mohamed A. Nour, Director General
Dr. Peter Goldsworthy, Deputy Director General (Research)
Dr. Geoffrey Hawtin, Deputy Director General (International Cooperation)*
Dr. Samir El-Sebae Ahmed, National Research Coordinator
Miss Dalal Farah, Executive Secretary*
Mrs. Nada Khattar, Executive Secretary*

Government Liaison & Public Relations

Dr. Adnan Shuman, Assistant Director General (Government Liaison)
Mr. Ahmed Mousa El-Ali, Officer in Charge (Public Relations)

Damascus Office

Mr. Abdul Karim El-Ali, Administrative Officer

Beirut Office

Ms. Afaf Rashed, Executive Secretary/ Office Manager
Mr. Anwar Agha, Senior Accountant

Cairo Office

Dr. Bhup Bhardwaj, Director of Administration & Operations, ICARDA/IFAD Nile Valley Project

Tunis Office

Dr. Ahmed Kamel, ICARDA Representative/ Cereal Pathologist

Finance

Mr. Edward Sayegh, Financial Controller & Treasurer
Mr. Pradeep Mehra, Finance Officer
Mr. Suresh Sitaraman, Finance Officer
Ms. Rima Musalli, Budget Officer
Mr. Salah Deif, Accountant, Nile Valley Project
Mr. Suleiman Iss-hak, Senior Accountant
Mr. Fadel Kandis, Pre-Audit & Control

Computer Services

Mr. Khaled El-Bizri, Director
Mr. Bijan Chakraborty, Senior Programmer
Mr. Bashir Bshara, Senior Programmer
Mr. Bijan Kamrava, Analyst/Programmer

Personnel

Ms. Leila Rashed, Personnel Officer

Farming Systems

Dr. Peter Cooper, Program Leader/ Soils Physicist
Dr. Karl Harmsen, Soils Chemist*
Dr. Abdallah Mattar, Soils Chemist
Dr. John D. Keatinge, Crop Physiologist
Dr. Seweryn Kukula, Weed Scientist
Dr. Kutlu Somel, Agricultural Economist

Dr. Joseph Stephens, Microbiologist
Dr. Hazel Harris, Soil Water Conservation Scientist
Dr. Eugene Perrier, Water Management Agronomist
Dr. Thomas Nordblom, Agricultural Economist
Dr. Thomas Stillwill, Agronomist (Tunisia)
Dr. Denis Tully, Anthropologist
Dr. Ronald Jaubert, Post Doc. Fellow-Agricultural Economist
Mr. Wolfgang Goebel, Post Doc. Fellow-Agroclimatologist
Dr. Awad el Karim el Hamid Ahmed, Post Doc. Fellow- Agricultural Economist
Dr. Habib Amamou, Post Doc. Fellow-Agricultural Economist*
Dr. Fares Asfary, Post Doc. Fellow-Analytical Agronomist*
Ms. Aida Kaouk, Visiting Scientist*
Mr. Abdul Bari Salkini, Research Associate
Mr. Ahmed Mazid, Research Associate
Mr. Mahmoud Oglah, Research Associate
Mr. Sobhi Dozom, Research Associate

Cereal Crops Improvement

Dr. Jitendra P. Srivastava, Program Leader
Dr. Salvatore Cecearelli, Barley Breeder
Dr. Mohamed S. Mekni, Barley Breeder
Dr. Omar Mamluk, Plant Pathologist
Dr. Guillermo O. Ferrara, Bread Wheat Breeder (CIMMYT)
Dr. Miloudi Nachit, Plant Breeder (CIMMYT)
Dr. Mohamed Tahir, Cereal Breeder
Dr. Ahmed El-Ahmed, Plant Breeder (Tunisia)
Dr. Hugo Vivar, Barley Breeder (Mexico)
Dr. Mark Winslow, Cereal Stress Physiologist*
Dr. Habib Ketata, Training Officer
Dr. Dieter Mulitze, Post Doc. Fellow-Agricultural Scientist
Dr. Sui K. Yau, Post Doc. Fellow- Barley Breeder
Mr. Joop Van Leur, Associate Expert-Pathology (Netherlands Government)
Mr. Mumtaz Malik, Research Associate
Mr. Issam Naji, Research Associate

Food Legume Crops Improvement

Dr. Mohan Saxena, Program Leader/Agronomist
Dr. Cesar Cardona, Senior Entomologist
Dr. William Erskine, Lentil Breeder
Dr. Howard Gridley, Legume Breeder (Tunisia)
Dr. Salim Hanounik, Plant Pathologist
Dr. M. Habib Ibrahim, Training Officer
Dr. M.V. Reddy, Chickpea Pathologist (ICRISAT)
Dr. K.B. Singh, Chickpea Breeder (ICRISAT)
Dr. Larry D. Robertson, Faba Bean Breeder
Dr. R.S. Malhotra, Post Doc. Fellow-International Trials Officer
Dr. Said Nahdi Silim, Post Doc. Fellow-Agronomy/Physiology
Dr. Mbaghus Murinda, Post Doc. Fellow-Agronomy*
Dr. Mohamed el-Sherbeeny, Post Doc. Fellow-Faba Bean Breeder
Dr. Abdallah Sayegh, Research Associate*
Mr. Ahmed Hamdi Ismail, Research Associate*
Mr. Patrick Houdiard, Research Associate (Tunisia)*

Pasture, Forage, and Livestock

Dr. Philip S. Cocks, Program Leader/ Pasture Ecologist
Dr. Ahmed El-Tayeb Osman, Agronomist
Dr. Euan Thomson, Livestock Scientist
Mr. Faik Bahhady, Assistant Livestock Scientist
Dr. Ali Abdel Moneim, Training Officer
Dr. Luis Materon, Microbiologist
Mr. Nerses Nersoyan, Research Associate
Mr. Sfouh Rihawi, Research Associate
Mr. Hanna Sawmi Edo, Research Associate
Mrs. Monica Zaklouta, Research Associate
Mr. Munir Turk, Research Associate
Mr. Luigi Russi, Research Associate
Mr. Marco Piccirilli, Research Associate

High Altitude Research

Dr. Edward Matheson, Director

Genetic Resources Unit

Dr. Bhal Somaroo, Program Leader
Dr. Marlene Diekmann, Plant Protection Officer (DAAD, W. Germany)
Dr. Yawooz Adham, Documentation Specialist
Mr. Thomas Ehrman, Research Associate (IBPGR)
Mr. Bilal Humeid, Research Associate

Communications & Documentation

Mr. Larry Chambers, Head
Mr. Philip Kemp, Senior Information Scientist*
Dr. S. Varma, Science Editor
Ms. Lynn Simarski, Science Writer

Training

Dr. Lawrence R. Przekop, Head of Training
Mr. M. Radwan Tchalabi, Assistant Training Officer

Visitors' Services

Mr. Mohamed Hamouieh, Administrative Officer

Travel Services

Mr. Bassam Hinnawi, Travel & Visa Officer

Farm Operations

Dr. Juergen Diekmann, Farm Manager (Tel Hadya)
Dr. P. Jegatheeswaran, Agricultural Machinery Engineer
Mr. Marwan Mallah, Administrative Officer
Mr. Munir Sughayar, Engineer, Farm Operations (Terbol)

Physical Plant

Mr. Salah Rihan, Manager*
Mr. Haitham Midani, Officer, General Services
Mr. Farouk Jabri, Officer, Food & General Services
Mr. Ohanes Kalou, Building Maintenance Engineer

Station Development

Mr. Brian Tierney, Construction Manager
Mr. Khaldoun Wafaii, Civil Engineer
Mr. Isaac Homsy, Civil Engineer

Purchasing & Supplies

Mr. Ramaswamy Seshadri, Manager
Ms. Dalal Haffar, Purchasing Officer
Mr. Bader Khattab, Stores Officer*

International School of Aleppo

Mr. Denis Sanderson, Principal/Teacher

Consultants

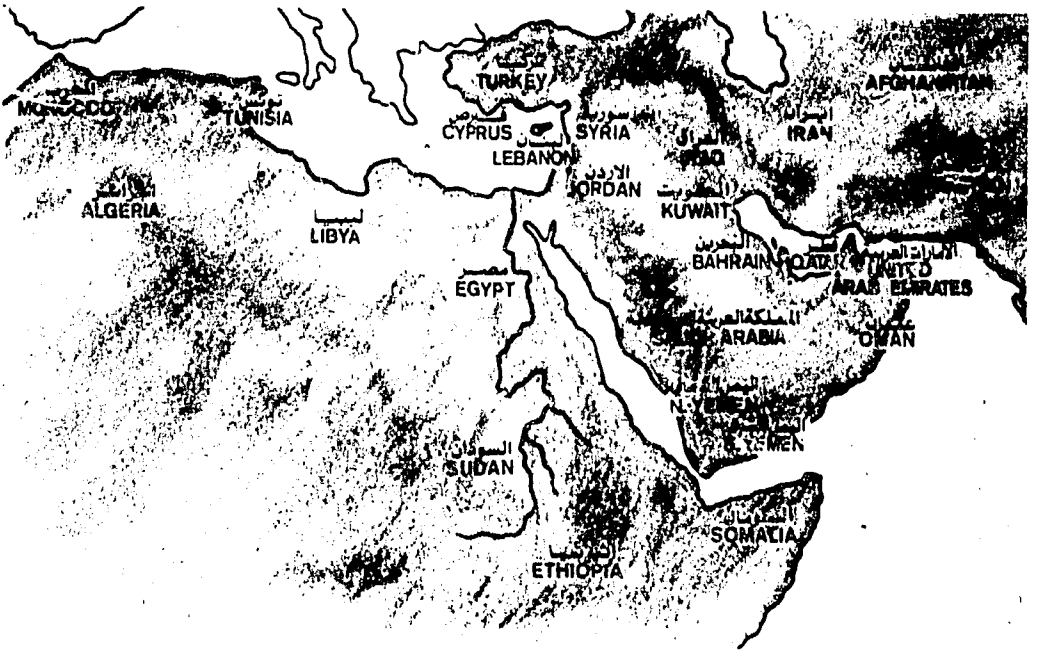
Mr. Tarif Kayali, Legal Advisor (Syria)
Dr. Hisham Talas, Medical Consultant (Syria)
Dr. Edward Hanna, Legal Advisor (Lebanon)
Mrs. Gem Somaroo, Nursing (Canada)
Dr. Philip Williams, Analytical Services (Canada)
Mr. Subrata Dutta, Library & Documentation (India)
Dr. Giro Orita, Veterinary Specialist (Japan)
Dr. Brian Capper, Livestock Scientist (UK)
Dr. Roger Peterson, Senior Biometrician (USA)
Prof. W. B. Ward, Communications (USA)

---

*Left ICARDA during 1984.

ICARDA Addresses

Country	Location	Postal Address	Telex	Telephone
Syria				
Damascus Office	Hamed Sultan Bldg. Abdul Kader Ghazali St. Hourieh Square, Abu Roumaneh	P.O. Box 5908 Damascus	412924SY	331455
Aleppo Head Office/ Main Research Station, Tel Hadya	30 km south of Aleppo on Aleppo/Damascus Highway	P.O. Box 5466 Aleppo	331208SY	213433
Director General's Office			331263SY	235221
Office No.1	Ahmed Khalil Mudaress Bldg., Next to Gov. Guesthouse, Aleppo/Damascus Highway		331206SY	550456
Office No.2	Sebai Bldg., Mouhafaza Area			216722
Lebanon				
Beirut Office	Dahlia Bldg., Rue Bashir Kassar, Verdun	P.O. Box 114/5055 Beirut	22509LE	804071
Research Station	Terbol, Beka'a Valley		21211LE	
Jordan				
Amman	c/o Faculty of Agric., University of Jordan	c/o Faculty of Agr., P.O. Box 5008	21629 UNJV JO	843555
Egypt				
Cairo Office	15 G. Radwan Ibn El-Tabib St 11th Floor Giza	P.O.Box 2416 Cairo	21741 ICARDA UN	723564
Tunisia				
Tunis Office	Immeuble Saadi, Route de L'Ariana, El-Menzah, Tour C-D 7th floor, Apartment No. 25, Tunis	P.O.Box 84 Ariana 2049 Tunis	14066 ICARDA TN	230225



ICARDA's principal geographic area of concern involves countries of West Asia and North Africa with a population of more than 300 million people.

WBW
5M

Published in August 1985

Printed at AL SALHANI Establishment - Damascus