1983

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 supply, 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 bean, 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 1983 was provided by the Arab Fund, AOAD, Australia, Canada, Denmark, Ford Foundation, France, Germany, IBPGR, IDA/IBRD, IFAD, Italy, Mexico, Netherlands, Norway, OPEC Fund, Saudi Arabia, Spain, Sweden, UNDP, United Kingdom, and United States (USAID).

Headquarters for the Center, including the 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.

Correct Citation: ICARDA (International Center for Agricultural Research in the Dry Areas). 1984. Research Highlights for 1983. Aleppo, Syria.

Foreword

One of the most important accomplishments of ICARDA in 1983 was the progress made in cooperative research and on-farm testing with our colleagues in national programs, and we report on part of the work in this publication. There are many specific examples of that progress which we consider to be the lifeblood of this international center, but I will mention only a few.

Our efforts in North Africa were strengthened with the establishment of an office in Tunisia and the assignment of another senior scientist there. Past work has paid off to the extent that the Tunisian national program has reached the stage where it has the capacity to conduct research on barley with only limited support from ICARDA. It has asked us to shift our research efforts to disease control in cereals. Also, our collaborative project with Jordan has reached a similar stage. One of our longest-running projects, starting five years ago and ending in 1983, it demonstrated how cereal yields could be increased substantially.

In the unique Nile Valley Project, research has shown the way to increased faba bean production in Egypt and Sudan, and information on improved practices is ready for widespread dissemination to farmers. Cooperative on-farm cereal trials with Syria's Ministry for Agriculture and Agrarian Reform were expanded to 30 sites throughout the country in the 1982/83 season. During the year, the Ministry released two new wheat varieties, one durum (Sham-1) and one bread wheat (Sham-2), for multiplication and distribution to farmers. These varieties were developed jointly by the Syrian National Program, ICARDA, and a sister international center in Mexico (CIMMYT).

ICARDA's research has shown clearly how phosphate fertilizer can increase the effectiveness with which limited rainfall is used, and so increase grain yields in the barley-livestock farming systems which are typical of the drier environments in large parts of northern Syria. The implications of these findings were the subject of discussions at a seminar organized by the Soils Bureau of Syria and ICARDA.

In 1983 ICARDA had 32 collaborative research projects with universities and other advanced institutions in Australia, Austria, Belgium, Canada, Italy, West Germany, United Kingdom, and the United States. Another expanding activity revolves around our germplasm "bank" which now has the world's largest collection of genes for some of the most important West Asian and North African crops, and more countries than ever before are requesting improved seeds from this collection.

ICARDA's ties with China have continued with visits by our scientists in 1983 to see the research work of the Academy of Science and visits by Chinese scientists to our Center. These visits have fostered a useful exchange of information and faba bean and barley genetic materials.

For the first time in "Research Highlights," an article on our training program will give readers an inside look at a high priority activity that may be one of the most long-lasting accomplishment of ICARDA. Another "first" is a report on the status of the building program and our new computer system which we use as a research and management tool to improve efficiency. In the near future, we hope to be able to extend our computer services to assist national programs.

During the year, ICARDA experienced an external review of its mandate and research and training programs by a team of eleven eminent scientists selected by the Consultative Group on International Agricultural Research (CGIAR). Each center in this network undergoes such a review every five years, and it was our turn in April 1983. Points of strengths and weaknesses were intensively examined, and most of the recommendations involved strengthening, intensifying, or expanding research and training activities. In no case did ICARDA receive a signal to diminish any segment of its work.

Highlights described in this publication, representing only a portion of those that could have been included, show that ICARDA is responding to the challenge of helping to increase food production in a harsh and uncertain environment. A much more complete "accounting" is available in our 1983 Annual Report.

Mohamed A. Nour
Director General

Contents

Farming Systems

5 *Barley Survey Results: Constraints and Production Potential in Northern Syria*

9 *Responses to Weed Control in Wheat Fields*

11 *Tools for Predicting Performance of Agricultural Practices under Different Climatic Conditions*

14 *Influence of Variable Rainfall on Crop Establishment in Barley Growing Areas*

15 *Economic Contribution of Forage and Fodder from Barley Crops in Western Syria*

18 *Effects of Green-Stage Grazing of Barley*

20 *Supplementary Feeding Strategies for Awassi Ewes*

22 *Value of Comparative Profiles of Enzyme Activity as a Measure of Nitrogen-Fixing Abilities of the Legume/Rhizobium Complex*

Cereals

26 *New Wheat Varieties Released for Syrian Farmers*

29 *Evaluating New Wheat Lines for Two-Layer Bread Making Quality*

31 *Cereal Lines Resistant to Wheat Stem Sawfly*

33 *Developing Barley Lines for Broad-based Resistance to Diseases*

35 *Advanced Barley Lines for National Programs*

37 *Wheat Lines and Production Practices for Pakistan's Mountainous Areas*

41 *Untangling Cereal Production Constraints in Jordan: Five Years of Collaborative Research*

Food Legumes

43 *Development of Wilt-Resistant Chickpeas in Tunisia*

44 *Field Screening for Cold Tolerance in Chickpeas*

46 *Screening Chickpeas for Resistance to Leaf Miner*

48 *Role of Fungicides to Control Ascochyta Blight in Chickpeas*

49 *Cataloging Kabuli Chickpea and Lentil Germplasm*

53 *Crop Borders to Prevent Out-crossing in Faba Beans*

55 *Host-Plant Resistance to Ascochyta Blight in Faba Beans*

57 *Proper Water Management: A Key to Increased Production of Faba Beans in the Nile Valley*

60 *Lentil Seed Size, Straw Yields, and Genetic Variation in Straw Quality*

Pastures and Forages

62 *Legume and Cereal Mixtures for Hay Production*

64 *Managing Forage Crops for Grazing and Hay*

65 *A New Pasture Species for Northern Syria*

Germplasm "Bank"

68 *Safeguarding Plant Resources for the Future*

Lebanon Research Station

71 *ICARDA's Terbol Station in Lebanon's Beka'a Valley Provides Research Advantages*

Training

74 *Update on Training: A Direct Linkage with Research Programs*

Computer Services Development

77 *Managing Research Data More Accurately, Quickly, and Easily with Computers*

New Building Complex

79 *Progress Report on ICARDA's Building Program*

81 **Board of Trustees**

82 **List of Senior Staff**

Barley Survey Results: Constraints and Production Potential in Northern Syria

The first stage in farming systems research emphasizes formal and informal surveys to gather information about current farmer practices and identify constraints that limit production. This is followed by research on improved practices and techniques appropriate to farmer conditions. An extensive survey of 153 farmers in 51 villages during the 1981/82 cropping season in northern Syria, which covers about 95% of the barley producing areas in the country, has provided a wealth of information useful in influencing research activities.

The survey followed the farmers' operations in three visits: prior to planting, during the spring, and after harvest.

One of several analyses of the survey results completed in 1983 shows that the drier areas in both the northeast and northwest have been going through a process of exploitation that is producing serious resource degradation. Soils are poor in available phosphorus. Fertilizer use is confined to the higher rainfall Zone 2 in the northwest (Table 1). Continuous barley,

ICARDA staff members interview farmers in northern Syria to find out about their current practices and the constraints that limit barley production.

necessitated by the feed demands of the livestock-dominated farming systems, is equivalent to "mining" the soils because there is hardly any replenishment of soil nutrients.

This process has taken its toll and the farmers are aware of it. Their long-run grain yield expectations are low, between 0.5-1.0 ton/ha (Table 2), and their problems are compounded by climatic instability. Out of every three to five years, they expect to have one "poor" year. Because of such poor environmental conditions, farmers have been unwilling to commit more than a minimum of resources to barley production. Even then, net returns are small when a poor season like 1981/82 occurs.

However, the future is not bleak because farmers recognize that improvements are possible. They rank rainfall and soils as the main physical factors limiting yields and list management and lack of inputs as the main economic factors. The management problem arises mainly because some of the family labor resources are allocated to non-farm and/or non-agricultural activities. This is observed in the low male to female ratios in the productive ages (Figure 1) and in the fact that 23% of the labor resources of the average family in the 20-60 age group are employed full or part time outside the farm. On the average, farm households in the northwest receive 27% of their income from activities outside the farm, primarily from non-agricultural ac-

Table 1 Barley production practices in 1981/82 in three regions of Syria (% of farmers).

Regions:	Northwest				Northeast				Northern Syria
Zones:	2	3	4	Total	2	3	4	Total	Total
Number of observations	30	24	15	69	21	27	36	84	153
Fallowed the previous year	70	46	20	62	29	11	11	15	36
Land preparation									
Plowing before fall	70	58	67	65	43	19	14	23	42
Plowing in the fall	67	42	17	47	81	78	89	83	67
Plowing both before and in the fall	43	21	3	27	33	7	11	16	21
No tillage	7	21	20	15	10	11	8	10	12
Planting									
Drilling	43	21	3	27	52	48	36	44	37
Mechanical broadcasting	7	0	3	4	48	48	50	49	29
Hand broadcasting	50	79	93	70	0	4	14	7	35
Fertilizer Use									
Phosphate in the fall	50	0	0	22	5	0	0	1	11
Nitrogen in the fall	50	0	0	22	0	0	0	0	10
Nitrogen in the spring	37	0	0	16	0	0	0	0	7
Harvesting									
No harvest	20	67	40	41	24	41	28	31	35
Combine harvested	43	0	7	20	76	59	61	64	44
Hand harvested	37	33	53	39	0	0	11	5	20

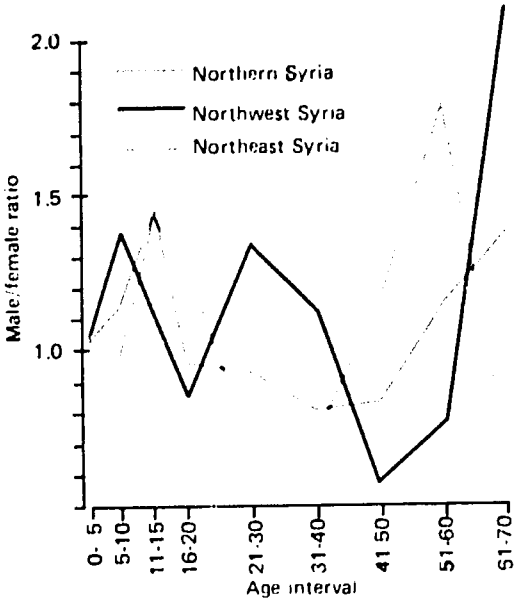


Figure 1. Male/female ratio by age groups in an average barley producer household.

tivities. For the northeast, the situation is almost similar with 23% of the household income originating from activities outside the farm.

ICARDA research has shown that rainfall and soils need not impose binding constraints. In particular, phosphate fertilizer use, which necessitates the removal of the input constraints through government policy measures, can improve the productivity, stability, and profitability of barley yields. This may also induce managerial capacity to remain on the farm. Because of the relative scarcity of labor in the region, mechanization is expected to gradually become more prominent in farming operations.

Table 2. Yield, returns, and costs in 1981/82 in barley production in three regions of Syria.

Regions and zones	Expected long run yields (kg/ha)	Grain yields 1981/82 (kg/ha)	Gross income (SL/ha)	**Net income (SL/ha)**	Total costs (SL/ha)	Machinery costs (SL/ha)	Labor costs (SL/ha)	Material costs (SL/ha)	Probability of poor years (%)
Northwest									
Zone 2	861	698	1113	**454**	659	210	210	238	26
Zone 3	957	494	785	**346**	439	118	212	110	28
Zone 4	573	376	518	**55**	462	101	275	87	32
NW Total	826	556	869	**330**	538	154	224	160	28
Significance level*	n.s.**	7%	8%	**15%**	8%	0.4%	n.s.**	0.1%	n.s.**
Northeast									
Zone 2	997	586	578	**320**	258	141	2	117	22
Zone 3	782	283	316	**119**	197	105	3	89	22
Zone 4	567	322	360	**124**	236	110	34	93	34
NE Total	741	381	405	**176**	229	117	15	98	28
Significance level*	0.1%	1%	2%	**2%**	10%	15%	5%	0.2%	0.1%
Northern Syria	776	463	622	**248**	373	134	113	127	28
Significance level*	n.s.**	1%	0.1%	**6%**	0.1%	0.3%	0.1%	0.1%	n.s.**

* Test is for differences between zone means in each region and between regional means for northern Syria.
** No significant difference between means.
SL = Syrian lira.

The demand for barley is based on consumer demand for livestock products which is increasing rapidly in Syria and throughout West Asia. Even though barley, the dominant feed crop, is grown in resource poor "problem" areas, there are promising research results which indicate that the neglected status of barley should change for the better. The opportunity cost of not allocating research priority and other resources to barley is measured in the scarce foreign exchange resources allocated to importing feeds and livestock products.

A comprehensive report on the barley survey which was conducted by interdisciplinary teams of ICARDA scientists including agronomists, soil scientists, economists, plant breeders, pathologists, and entomologists will be published in 1984.

The farm survey in northern Syria showed the importance of the interaction between barley and livestock. Growing continuous barley to help meet the feed demands of livestock-dominated farming systems has "mined" the soils in many areas.

Responses to Weed Control in Wheat Fields

Weeds, a major problem in wheat fields in the high rainfall areas (>350 mm) of West Asia and North Africa, cause severe yield losses because of weed competition for soil nutrients, solar radiation, and, most important, for available soil moisture. However, herbicides are available which will control a broad spectrum of the weed flora, and results from trials conducted in northwest Syria demonstrate dramatic and highly economical responses to weed control.

The results in Table 3 are taken from a factorial trial conducted at several locations which examined the effects on wheat yields of nitrogen and phosphate fertilizer, seeding rate, weed control, and improved variety. Weed control was achieved by a single spraying of Brominal Plus at stem elongation. At all three locations, weed control was shown to be the most important factor leading to increased yields, and only when weeds were controlled were economical responses to nitrogen and phosphate fertilizer achieved. This fact is due to the substantial response of weeds to fertilizer (Table 4), a response which not only tends to smother the wheat crop and

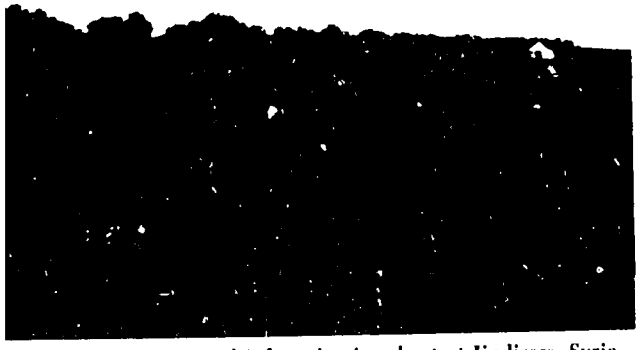
	Jindiress	Kafr Antoon	Tel Hadya
Seasonal rainfall (mm)	417	341	323
No weed control	(t/ha)		
Grain yield	1.39	1.68	1.09
Straw yield	2.46	2.59	2.19
With weed control			
Grain yield	2.27	2.09	1.70
Straw yield	3.27	3.12	2.93

Table 3. Main effects of weed control on grain and straw yields of wheat at three locations in northwest Syria (1982/83).

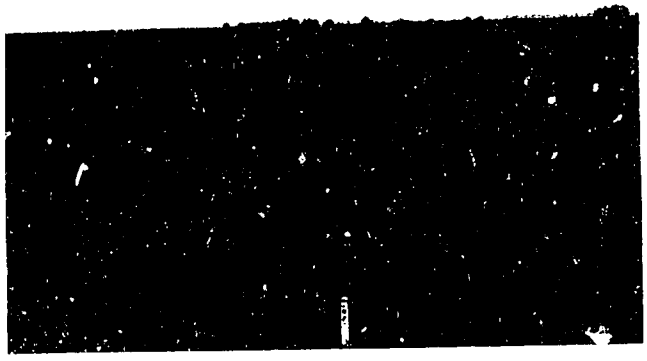
	Jindiress	Kafr Antoon	Tel Hadya
Principal weed species	*Sinapis arvensis*	*Avena sterilis*	*Sinapis arvensis*
	(t/ha)		
No nitrogen	1.12	0.40	1.22
Plus nitrogen(1)	2.39	0.67	2.02
No phosphate	1.20	0.45	1.32
Plus phosphate	2.31	0.62	1.92

(1) 100 kg/ha N and 60 kg/ha P_2O_5 applied at Jindiress and Kafr Antoon.
60 kg/ha N and 45 kg/ha P_2O_5 applied at Tel Hadya.

Table 4. Main effects of nitrogen and phosphorus on dry weight of weeds at the time of anthesis of the wheat crop at three locations in northwest Syria (1982/83).



Severe weed infestation in wheat at Jindiress, Syria was controlled by a single application of a herbicide at the start of stem elongation.



Application of nitrogen and phosphorus fertilizer to the plot on the right trebled weed dry matter production which resulted in a negative response of wheat yields to fertilizer.

thus reduce its response to fertilizer, but in some cases actually results in a decrease of wheat yields if fertilizer is applied without weed control.

Economic returns from weed control are very attractive. The cost of herbicide application in this trial was about 110 SL/ha (Syrian lira), but the increase in value of grain yield (based on a value of 1.20 SL/kg of bread wheat and durum wheat) was 1,060 SL/ha at Jindiress, 730 SL/ha at Tel Hadya, and 500 SL/ha at Kafr Antoon. This simple comparison excludes the increased harvesting costs but also the increased value of the wheat straw achieved through weed control and the additional benefit of reduced weed problems in succeeding crops.

Wheat is a poor competitor with weeds compared with barley, and farmers can go a long way toward suppressing their weed problems by ensuring good crop establishment and rapid early growth of the wheat crop. Results from Tel Hadya (Table 5) show a marked response to weed control at low seeding rates but a much smaller response at higher rates. This was associated with a two-fold decrease in weed dry matter production when seeding rates were increased from 30 to 150 kg/ha.

Weed control technology in wheat through herbicide use is well understood, and the results from these experiments and many others in the region clearly indicate that if herbicides and the means to apply them are both demonstrated and made available to farmers, substantial increases in wheat yields will be obtained. It is also certain that successful control of weeds under wheat crops will lead to reduced weed problems in successive crops.

Seeding rate (kg/ha)	Wheat yields (t/ha)		Increase in yield (%)
	Without herbicide	With herbicide	
30	0.98	1.36	39
90	1.78	1.97	11
150	1.98	2.12	7

Table 5. Effect of seeding rate on response of wheat yields to herbicide application at Tel Hadya, Syria (1982/83).

Tools for Predicting Performance of Agricultural Practices under Different Climatic Conditions

Climatic variability is the most significant single influence on agricultural systems in West Asia and North Africa and differing environments and amounts of rainfall between locations cause agricultural research to be location-specific and therefore expensive. Even at one location, differences in rainfall from one year to the next can be large and impart a high level of uncertainty to both agricultural production and research.

Several years of trials in many locations would be required to assess the effects of all or most of the environmental factors that influence agricultural production. But one way of using scarce research resources efficiently is to clearly delineate target areas which exhibit substantial homogeneity in agricultural characteristics. A tool developed at ICARDA to analyze the effects of climatic variability in given target areas is the "Multiple Season-Multiple Site" (MS-MS) trials. These series of trials are held in a fairly homogeneous area within which a few critical climatic parameters vary between locations. Careful choice of homogeneous target areas allows close focus on the effects of the climatic factors in agricultural production by enabling research to be carried out in a fewer number of sites.

ICARDA's scientists have developed techniques, using data from comprehensive studies, to predict performance of a given package of recommended practices under different conditions. Only trials at a number of sites over several seasons can assess how climatic variation, particularly fluctuating annual rainfall, affects crop yields. A survey of barley production in Syria therefore spanned five sites, including ICARDA's research farm at Tel Hadya and four other sites within a 100 km radius (Figure 2). These sites comprise a transect across variation in rainfall (from more than 500 mm in the northwest to less than 250 mm in the southeast) and represent a spectrum of rainfall variation in the entire

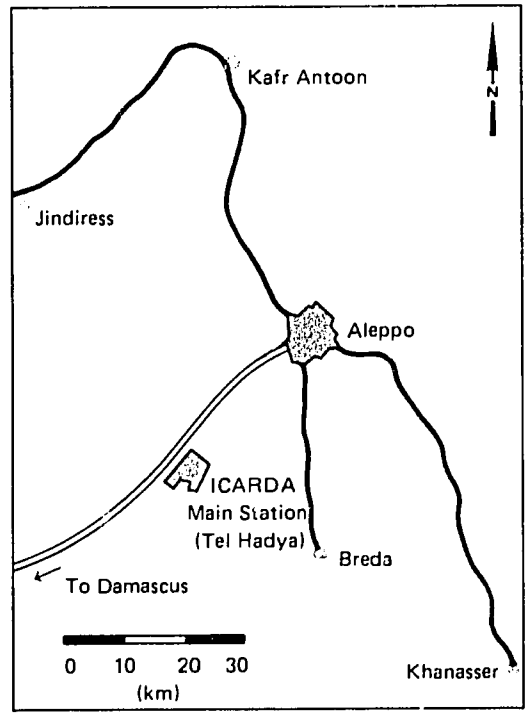


Figure 2. Trials at the five sites shown on the map and subsequent statistical analysis enabled scientists to take a comprehensive look at the interaction between biological and climatic factors.

region. Trials at each site assessed how management factors (nitrogen and phosphate fertilizer and seed rate) affect yield and how the responses to these factors are influenced by environment, particularly rainfall.

Such trials, and subsequent statistical analysis, enable a comprehensive look at the interaction between biological and climatic factors. Furthermore, each site within the trials represents a particular type of site in the region under certain environmental conditions. (Site selection, then, is an extremely critical part of research design for such studies).

The massive amount of data gathered from comprehensive surveys can be analyzed with statistical regression techniques. Regressions like those done on the barley survey data produce statistically more reliable results than regressions that address one site or season in isolation.

Agronomic recommendations are usually made for average climatic conditions, but better statistical techniques help to assess how a given set of recommendations work under different conditions. Data from Breda, a typical dry barley growing area in Syria, illustrates how statistics can help to make more finely-tuned recommendations that encompass climatic variability.

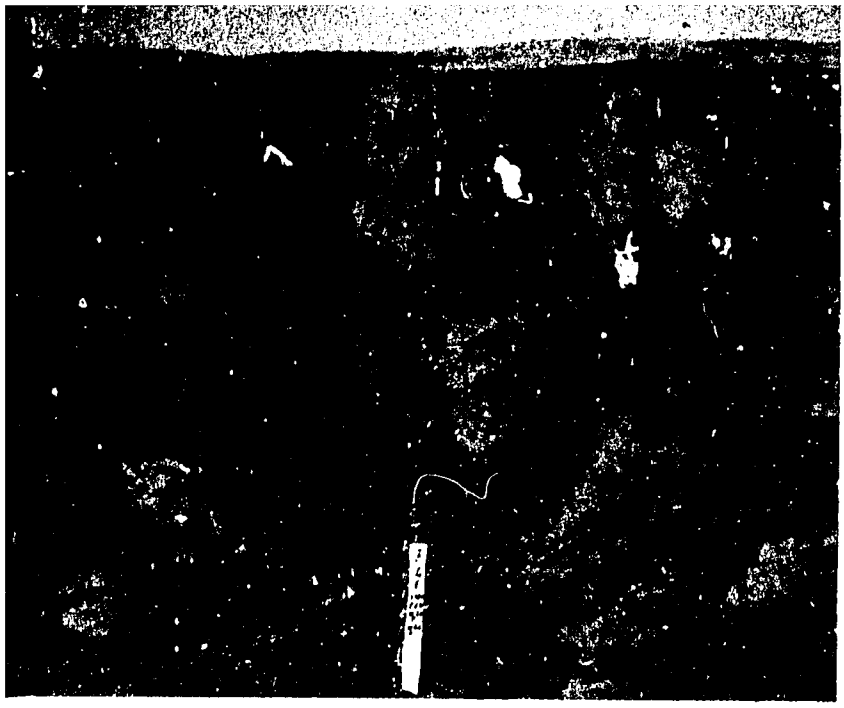
Breda's average rainfall for the past 19 years was 283.6 mm, and economically optimum fertilizer levels are 35 kg of nitrogen/ha and 59 kg/ha of phosphate. By substituting values in regressions for rainfall, for seed rate, and for optimum amounts of fertilizer, the researcher can derive a frequency distribution of expected barley yields with and without fertilizer (Table 6).

The emphasis of the analysis, of course, is on practical results for the farmer. Thus, a certain level called "grazing threshold" has

Frequency(1) (%)	Rainfall(2) (mm)	Predicted yields (kg/ha)(3)			
		N + P +	NoP +	N + Po	NoPo
5	112.5	200(4)	200	200	200
5	137.5	200	200	200	200
5	162.5	200	200	200	200
5	187.5	200	200	200	200
21	262.5	1934	1719	1176	1029
26	287.5	2224	1966	1553	1352
5	312.5	2621	2320	2038	1783
5	337.5	3063	2719	2566	2258
5	362.5	3484	3096	3074	2712
11	412.5	4006	3532	3769	3301
5	462.5	3673	3113	3611	3035
Averages	283.6	2131	1885	1689	1477

(1) Does not add up to 100 due to rounding.
(2) Mid-points of rainfall ranges.
(3) N + = 35 kg/ha; P + = 59 kg/ha; No, Po = 0 kg/ha.
(4) Assumes that 200 kg/ha is the grain equivalent of grazable dry matter when crop failure occurs.

Table 6. Frequency distribution of rainfall and predicted yields of Beecher barley with and without fertilizer at Breda, Syria.



Striking evidence of correct fertilizer use at the early growing stage of barley at Breda, a dry area in northern Syria. With techniques using data from recent comprehensive studies, ICARDA scientists are able to predict performance of recommended practices under diverse conditions.

been identified. This threshold is the yield level below which barley harvest would be unprofitable; that is, the level at which sheep should graze the mature crop instead. The grazing threshold was estimated at about 235 kg/ha in a barley survey in northern Syria.

Although the use of fertilizer cannot eliminate crop failures caused by low rainfall, an analysis of the data from Breda showed that expenditures on fertilizers will be recovered 80% of the time if recommendations are followed. In addition, if recommendations call for adoption of different fertilizer components step by step, farmers should begin using phosphate first and nitrogen later. Specifically, if farmers adopt economically optimum fertilizer levels, they will reap an average 215% rate of return. If they adopt phosphate first, they will achieve a 227% rate of return, and if they then adopt nitrogen, they will reap an additional 198% rate of return. To sum up, the study shows that for a variable environment like Breda, fertilizer use will pay off in the long run.

More broadly, then, regression techniques which pool data from different sites and seasons facilitate better recommendations for agriculture in variable environments. Environmental factors other than rainfall, such as soils and available nutrients, can be incorporated into the analysis. This implies that these environmental factors need to be monitored as part of the trials.

Such techniques applied to the barley trial data show that it is possible to predict how different management practices affect yield under different climatic conditions. In addition, optimum levels of inputs, such as seed rate, nitrogen, and phosphorus, can also be identified for average or other climatic conditions. Finally, if frequency distributions of environmental conditions are available, the probability distributions of yields for given recommendations of inputs can be determined.

Influence of Variable Rainfall on Crop Establishment in Barley Growing Areas

Better prediction of the onset of northern Syria's rainy season aids the design of improved crop management strategies. In this area, barley is grown almost exclusively in a zone with 150-300 mm annual rainfall. Rain comes mostly in the cool winter season, and the onset of the rainy season varies considerably from year to year and from place to place. Cropping strategies must balance potentially higher yields against increased risk of crop failure.

Rainfall patterns were examined for three northern Syrian sites that represent the wet (Tel Hadya), intermediate (Breda), and dry (Khanasser) parts of the barley growing area. Scientists quantified the variation, in time and space, of the first rainfall sufficient to cause seed germination. In addition, they assessed the subsequent risk that seedlings may be exposed to drought periods of varying duration and the implications of this risk for successful crop establishment.

Table 7 shows results that have been calculated on the assumption that the first rains to cause seed germination must total a minimum of 10 mm over three days or less. As shown for three different seeding dates, the likeliest germination date varies considerably between sites. Also, results show that the seeding date profoundly affects the probable date of crop germination at all sites.

Recording temperature and rainfall data which will be used to help determine crop management practices that could diminish risks of financial loss to farmers.

Figure 3 displays the likelihood of crop germination being followed by a 30-day drought, severe enough to prevent successful crop establishment. Clearly, for example, a germination date in mid-

Table 7. Median dates for rain events causing germination after selected sowing dates. (Conditional on receiving >10 mm of rain in three days.)

Sowing date	Median germination date		
	Tel Hadya	Breda	Khanasser
1/10	29/10	4/11	15/11
1/11	15/11	20/11	27/11
1/12	9/12	13/12	18/12

November at Khanasser would be associated with a risk of a severe seedling stage drought at least one and a half years in every 10. This risk is lower at Breda and Tel Hadya but increases as the germination date advances to the beginning of November.

The sowing dates in Table 7 when related to Figure 3 can provide quantified guidance to the farmers in the three areas to help them decide when to sow to balance high potential crop yields with risk of crop loss in the seedling stage. This is one example of an application of the analysis of long-term climate data to determine management practices that will diminish risks of financial loss.

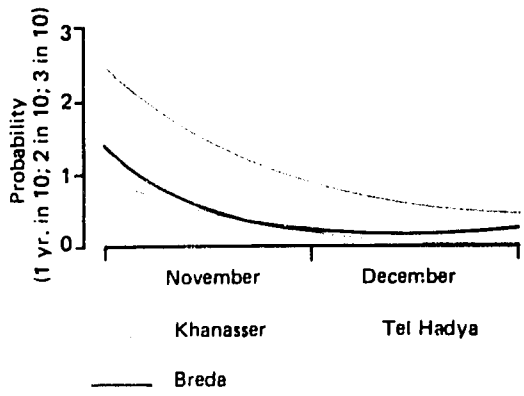


Figure 3. The risk of receiving less than 5 mm of precipitation in the 30 days following crop germination at three sites in northern Syria.

Economic Contribution of Forage and Fodder from Barley Crops in Western Syria

Few cropping decisions in dryland farming are made without considering the demand for feed by livestock and few livestock decisions without considering the availability and prices of feeds. An economic model prepared from data obtained in a survey of barley farmers demonstrates the importance of barley forage and fodder in relation to the value of grain in western Syria. Forage and fodder as defined in the model include straw and stubble gathered and fed or grazed directly, the grazing of immature barley plants which are later allowed to mature, and the grazing of mature crops as an alternative to harvest.

An economic model of the value of the forage component of mature crops was used with the survey data to estimate empirically cost and benefit relationships. Net harvest benefits (grain plus straw value, minus harvest costs) and direct grazing values of mature barley crops were estimated as linear functions of grain yield per hectare. The parameter estimates are given in Table 8 for the grain, straw, and direct grazing value functions. Also given are estimates of grain yields in poor, normal, and good crop years and the frequencies at which such years occur.

The anticipated grain yield at which the direct grazing value of a crop is just equal to the net harvest benefit is called the "grazing threshold." Below the threshold, direct grazing of the mature crop is more profitable to the farmer than harvesting. Above the threshold, harvesting the crop is more profitable. Thresholds will vary with the prices and costs facing a farmer.

For western Syria, the average 1981/82 grazing threshold was 321 kg/ha, estimated by regression analyses. A separate survey of sheep husbandry systems in Aleppo province provided a similar estimate of 352 kg/ha (SD ± 67.2 kg/ha) for barley grazing thresholds.

Grain yields in the poor seasons averaged only 208 kg/ha (Table 8) which is below the calculated grazing threshold of 321 kg/ha, indicating that the crop would be more profitably grazed than harvested. The direct grazing value is given to the forage and fodder component and grain value set at zero since there is no harvest. In normal and good seasons, grain is harvested and the forage and fodder component includes mainly the straw and stubble.

The crop component values in each class of years were multiplied by their respective frequencies of occurrence. The products were summed to yield the long-run

Table 8. Barley yield frequencies and the contributions of forage and fodder to total crop value in western Syria.

	Class of crop year			
	Poor	Normal	Good	Long-run
Frequency (percent of years)	24	53	23	100
Average grain yield "Y" (kg/ha) if harvested	208	803	1563	862
Value of crop components(1)				
Forage and fodder (SL/ha)	**242(2)**	**532(3)**	**996(3)**	**569**
Grain (SL/ha)	**0(4)**	**956**	**1860**	**934**
Forage and fodder value, as percent of total crop value	100	36	35	38

(1) These values are computed from the following regression equations using the average grain yield figures above (SL = Syrian lira).

		n	$\bar{R}^2$
Direct grazing value	= 0.14 Y + 212.4	49	0.12
Straw and stubble value	= 0.61 Y + 42.1	45	0.46
Grain value	= 1.19 Y	56	0.99

Where "Y" is grain yield (if harvested) in kg/ha, and values are in Syrian lira per hectare.

(2) Value of the mature crop for direct grazing.

(3) Value of straw and stubble after harvest.

(4) Assumes no grain is harvested since direct grazing value exceeds net harvest benefit (grain + straw — harvest costs).

Because of the importance of barley stubble and straw for feed in sheep husbandry systems, scientists consider their palatability and digestibility in breeding new barley cultivars.

weighted average value of forage and fodder and that of grain. The long-run contribution of the forage and fodder component is about 38% of the total crop value (Table 8), with the harvested grain contributing 62%. These estimates do not include the economic value of green-stage barley grazing because sufficient data were not available. The survey showed that only about 10% of the barley farmers in western Syria followed this practice in all seasons, while others practiced it only occasionally.

Theoretical models developed at ICARDA give an economic rationale for green-stage grazing, even when it reduces grain yields. Agronomic research is presently under way at the Center to define the parameters of gains and costs involved. Although green-stage grazing is a relatively small factor in western Syria, it could slightly increase the forage and fodder component of crop value.

There are both quantitative and qualitative dimensions to the forage and fodder component. Thus, straw quality (digestibility and palatability) now enter the list of selection criteria in breeding new barley cultivars for western Syria.

Grazing of barley crops ma be a better alternative to harvesting in a dry year.

Effects of Green-Stage Grazing of Barley

Trials in past years at Tel Hadya have shown little or no loss in barley grain yields after limited green-stage grazing. But in clipping trials in 1983 at Breda and Khanasser, low rainfall sites more representative of the barley growing areas of Syria, even a single early clipping of barley was damaging to final crop yields. Moreover, an additional two clippings to simulate grazing on subsequent dates caused increasing losses in grain and straw production.

Clipped green herbage offtake came at a high cost even when this forage was priced optimistically, with dry weight having double the price of grain at the first clipping and exactly the price of grain at the third clipping. On the average, each Syrian lira of clipped herbage value caused reductions in net harvest values (grain plus straw values minus harvest costs) of 2.3 lira at Breda and 2.6 lira at Khanasser. (See Figure 4 for results at Breda.) This evidence indicates that green-stage grazing in the dry areas is not a profitable practice.

These results are consistent with earlier

flocks. Attention will also be paid to economical feeding strategies which improve flock fertility.

In a comprehensive supplementary feeding trial, the maximum margin-over-feed-cost was obtained by low levels of supplementary feeding during pregnancy of Awassi ewes but high levels during lactation.

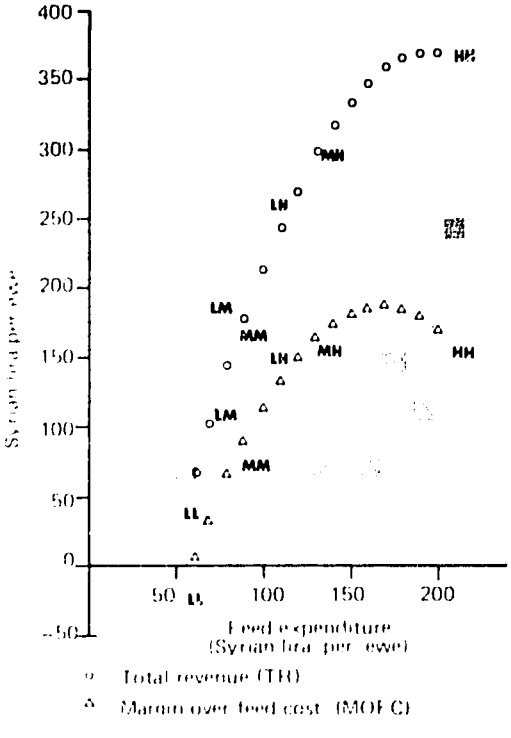


Figure 5. Estimated total revenue and margin-over-feed-cost per ewe under six nutritional regimes at Tel Hadya, Syria (1982-83).

Value of Comparative Profiles of Enzyme Activity as a Measure of Nitrogen-Fixing Abilities of the Legume/ *Rhizobium* Complex

Comparative profiles of enzyme activity in legume crops can be determined by measuring the ability of the nitrogen-fixing enzyme associated with the legume/ *Rhizobium* complex to reduce acetylene to ethylene. Such profiles, when constructed for legume crops over a range of environmental areas, are of value to agronomists when they design and evaluate rotation systems.

Acetylene reduction profiles are of value also to the legume breeder because knowledge of the apparent enzyme activity, combined with other desirable characteristics, can then be used for the selection of parental breeding material. This selection, in turn, minimizes the possibility of inadvertently reducing the effectiveness of progeny nitrogen-fixing potential.

A technician injects acetylene into the root system of a legume in one of several steps to prepare a profile of nitrogen-fixing enzyme activity which will be useful to agronomists when they design and evaluate rotation systems.

models of green-stage grazing decisions which were based on information provided by farmers in a comprehensive survey of Syrian barley production. In high rainfall and irrigated areas where other crops are dominant and little barley is grown, barley yields may be unharmed or even improved by properly managed green-stage grazing. However, in the drier areas with barley as the dominant crop, green-stage grazing is not frequently practiced except where sharecropping tenure arrangements reduce the graziers' interest in the final crop yields.

At Breda there was a large increase in total barley crop values in response to an application of only 45 kg P_2O_5 per hectare. Total crop (grain + straw + clipping) value was boosted by about 900 lira per hectare in the case of no clipping and by about 600 lira in the case of three clippings. Total crop values were roughly the same (about 1,100 lira) when three clippings were taken from a barley crop with phosphate as from a crop without phosphate which was unclipped. At the Khanasser site the responses to phosphate, while significant ($P<0.05$), were much smaller than those at Breda. The fact remains, however, that green-stage grazing would not have been justified on economic grounds in either case or at either site.

ICARDA's barley breeding efforts toward the development of "dual purpose" cultivars are now being reviewed in terms of survey results which show green-stage grazing to be a practice in limited use and in terms of the economic analyses which help to show why this is so. As breeding of "dual purpose" cultivars progresses, selections will be made in drier environments more representative of the barley producing areas in Syria.

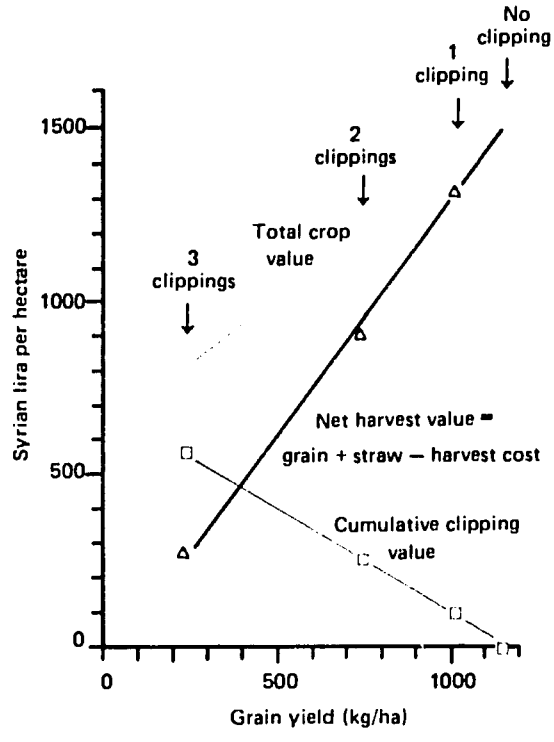


Figure 4. Effects of clipping barley on the components of total crop value at Breda, Syria (1983).

Supplementary Feeding Strategies for Awassi Ewes

According to surveys by ICARDA over the past five years in Aleppo province (Syria), natural rangelands may supply only about 20% of the annual nutrient needs of sheep breeding flocks, the remainder by stubble and feed supplements. The surveys also indicated that farmers were over-feeding their flocks in winter at a time when breeding ewes are pregnant or lactating.

Recognizing the importance of supplements in sheep husbandry systems, an extensive supplementary feeding trial was conducted at Tel Hadya in 1982/83 to define economically optimal supplementary feeding strategies for pregnant and lactating Awassi ewes. This trial involved 180 Awassi ewes divided into six groups.

Three levels of supplementation, low (L), medium (M), and high (H), were chosen to give six different combinations during pregnancy and lactation: LL, LM, LH, MM, MH, and HH. (The combination LL indicates low levels during pregnancy and during lactation; LH low levels during pregnancy and high during lactation, etc.) The inputs, outputs, revenues, and expenditures for all treatments were recorded throughout the breeding cycle. Since supplementary feed costs are the major source of expenditure, subtracting them from total revenue is a good indicator of flock profitability. This indicator is called the margin-over-feed-costs (MOFC).

Dramatic differences between the supplementary feed costs and total revenue of flocks were apparent (Table 9). For example, a four-fold increase in supplementary feed costs between flocks LL and HH was outweighed by a 10-fold increase in total revenue.

Total revenue and MOFC for each of the six flocks are plotted against feed expenditure in Figure 5, together with regression curves fitted to the results. The MOFC curve reaches a maximum which is about SL 30 (Syrian lira) more than the MOFC of the MH and HH flocks. The maximum could be achieved by lower levels of supplementary feeding during pregnancy but higher levels during lactation. This is a feeding strategy similar to flock LH which had the best economic performance.

The trial showed that the pattern of feeding is just as important as the total amount provided. Future research will study supplementary feeding systems which increase economic returns from breeding

Nutritional regime	LL	LM	MM	LH	MH	HH
Total revenue(1)	38	187	167	260	293	367
Feed cost	62	77	94	110	136	215
Margin-over-feed-cost	**-24**	**109**	**73**	**150**	**156**	**153**

(1) Includes lamb, milk, cull ewe, and wool sales.

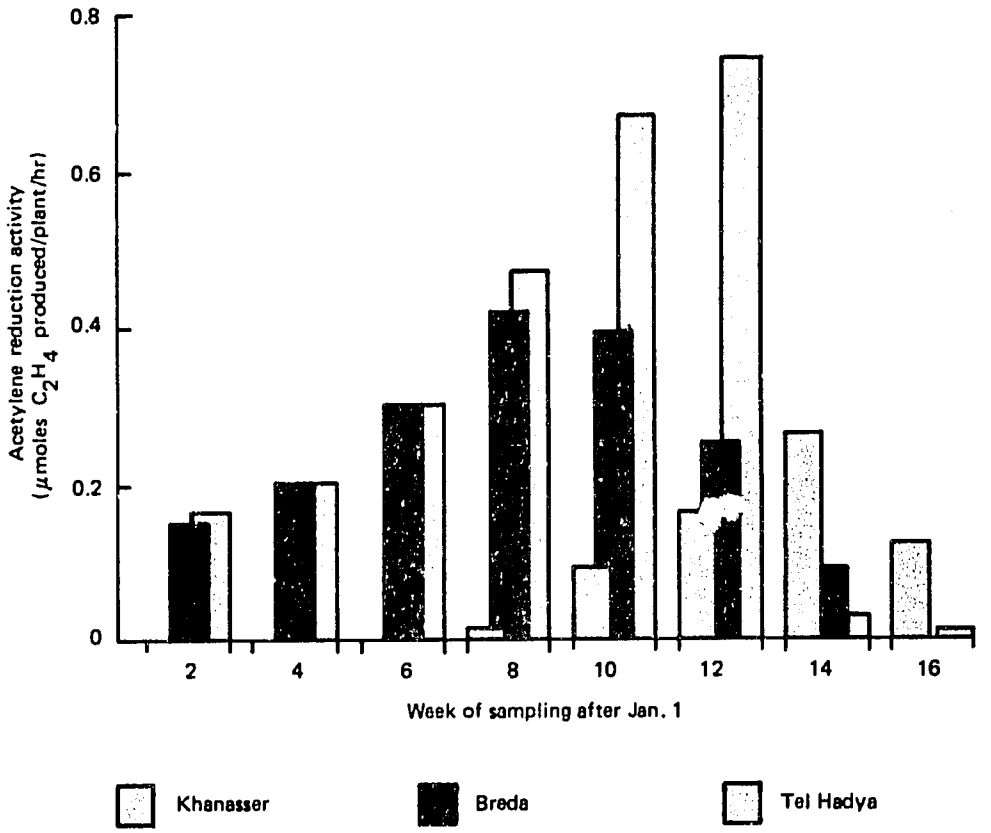
Table 9. Total supplementary feed cost, total revenue, and margin-over-feed-cost of sheep flocks. (Syrian lira per ewe.)

Vetch (*Vicia sativa*) as a forage crop is one of the legumes selected for legume/cereal rotations at Tel Hadya, Breda, and Khanasser, Syria. (These sites have long-term average rainfalls of 350, 250, and 200 mm, respectively.) If the constructed acetylene reduction profiles at these sites are compared, it becomes evident that not only does enzyme activity decrease with decreasing rainfall but that the beginning of observable enzyme activity at the driest site, Khanasser, was seven weeks later than at Breda and Tel Hadya. This delayed activity appears to be directly related to initial seedling vigor since average plant dry weights at Khanasser were appreciably less than those of Breda and Tel Hadya over this period. In fact, initial enzyme activity was only apparent at the driest site when mean plant dry weights approached those seen at the other sites in the second week of January.

The effect of differing moisture regimes on plant vigor, and hence enzyme activity, is also evident in Tel Hadya and Breda profiles. In this instance, the effect of the apparent stress is not only a peak activity at Breda four weeks in advance of Tel Hadya but also a maximum value of about half that evident at the heavier rainfall site.

Because water availability has a direct effect on plant vigor and hence nitrogen-

Figure 6. Acetylene reduction activity of vetch grown at Khanasser, Breda, and Tel Hadya, Syria.

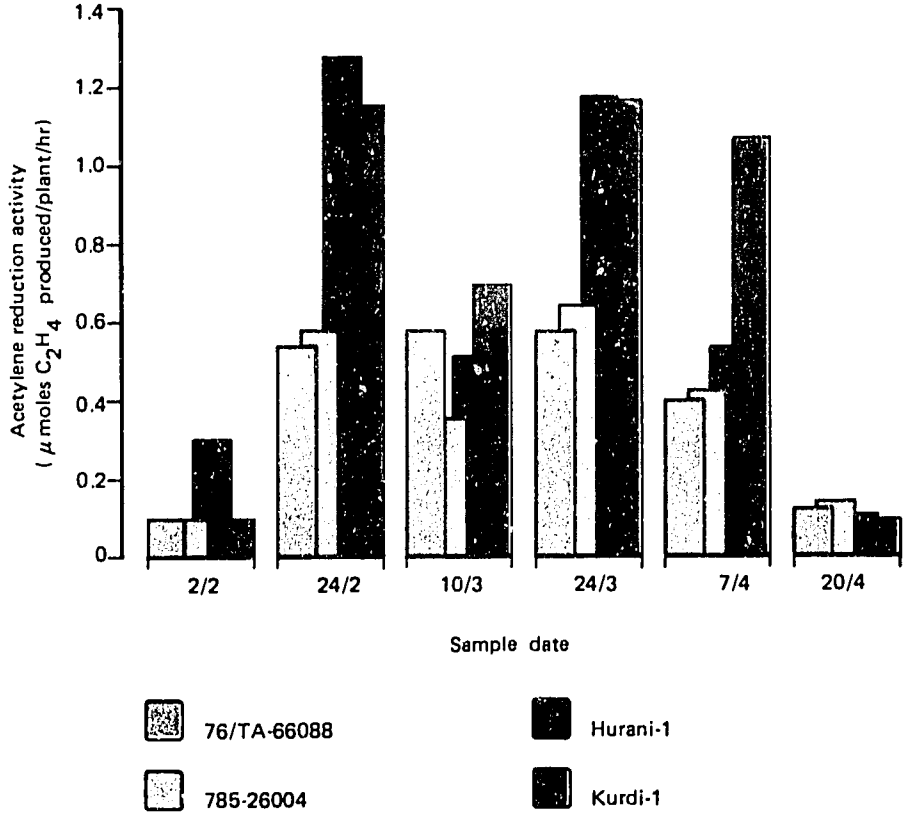


fixing potentials, the nitrogen-fixing attributes of vetch cannot be adequately exploited in the 200 mm rainfall area, marginally in the 250 mm area, and adequately only in the 350 mm zone (Figure 6). However, at Breda and Tel Hadya, where environmental pressures appear to be within acceptable limits, the possibility of increasing this crop's apparent nitrogen-fixing potential might be realized by the selection of a competitive strain of *Rhizobium* displaying greater apparent enzyme activity than the indigenous strains. This selection process, involving numerous crops, is an ongoing endeavor by ICARDA.

When comparing the acetylene reduction profiles of a number of lentil lines, of which four are shown in Figure 7, large discrepancies in their apparent enzyme activities became evident. Kurdi 1 and 78s 26004 lines produced much higher values than did the 76TA 66088 and Hurani 1 lines, but 76TA 66088, which displayed the lowest values, had the longest sustained maximums.

Although lentil seed and cotyledon size and color would not seem to be linked with a genotype's ability to fix nitrogen, there was some interaction between these characteristics in the lines monitored. Kurdi 1 and 78s 26004, which displayed the

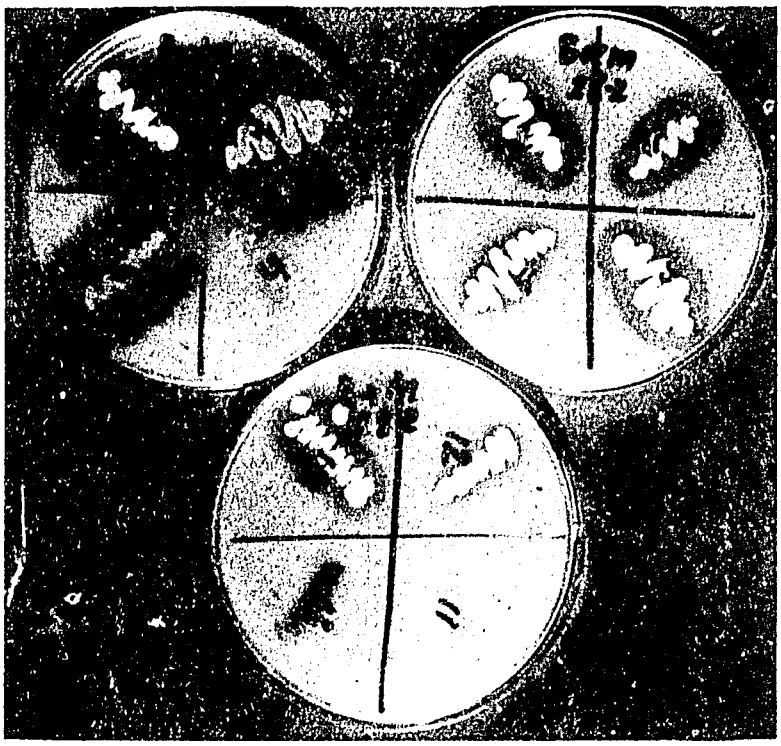
Figure 7. Acetylene reduction activity of four lentil cultivars grown at Tel Hadya, Syria.



highest rates of acetylene reduction, are both large-seeded with intermediate to large yellow cotyledons. Those with the smaller acetylene reduction values are small-seeded with small red cotyledons. Whether these relationships are real or due to fortuitous selection of test lines is not clear, but further investigations are expected to provide the answer.

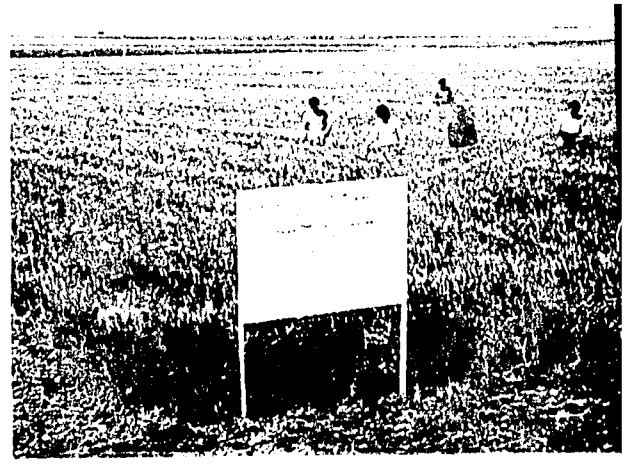
The acetylene reduction representation also indicates that 76TA 66088 is less susceptible to cold temperature shock than the other monitored lentil lines. Except for 76TA 66088, there was a noticeable decrease in the enzyme activities in all lines between February 24 and March 10 sampling dates. These decreases appear to be related to the low temperature (-5.6 °C) registered on March 7.

With continued measurement of apparent enzyme activities in a range of environments and crops, it is expected that nitrogen-fixing abilities of the legume/*Rhizobium* complex, when used in a cereal/legume rotation system, can be exploited fully through the selection of crops for different environmental areas. Also, in an attempt to maintain or increase the apparent nitrogen-fixing capacity of a range of food legumes, monitoring of parental and progeny material will continue.



In the laboratory, microbiologists test soil bacteria on these plates to degrade milk protein which gives an indication of the bacteria's ability to break down crop residues.

Before new wheat varieties are released to farmers they are tested and evaluated in farmers' fields for several seasons.



One of the multiplication fields for the two new wheat varieties, Sham-1 (durum) and Sham-2 (bread wheat), released in 1983 by the Syrian government.

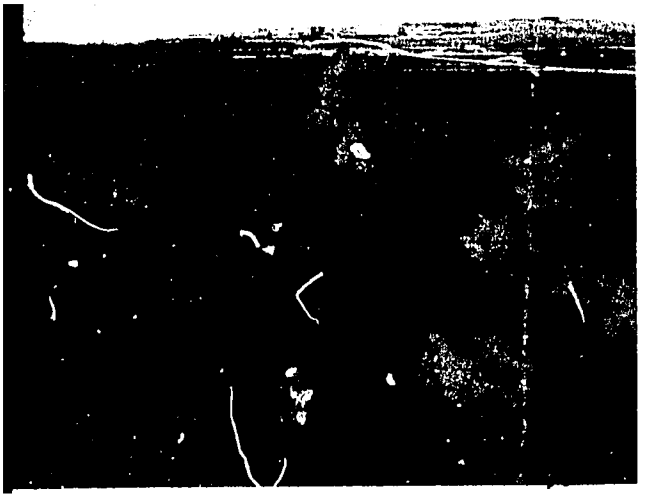
New Wheat Varieties Released for Syrian Farmers

Two wheat lines, one durum and the other a bread wheat, have been approved by Syria for release to farmers as new varieties. The Syrians released the durum wheat line, Waha, under the name of Sham-1. It is a derivative of a cross received from CIMMYT, the international wheat and maize center in Mexico.

After being identified as a promising line through yield testing in Lebanon and Egypt, it was extensively evaluated in the region under ICARDA's International Nurseries Network and found to be consistently high yielding. Approval for release came after four years of testing and evaluation in farmers' fields throughout Syria in a collaborative effort between the Syrian Ministry of Agriculture and Agrarian Reform and ICARDA.

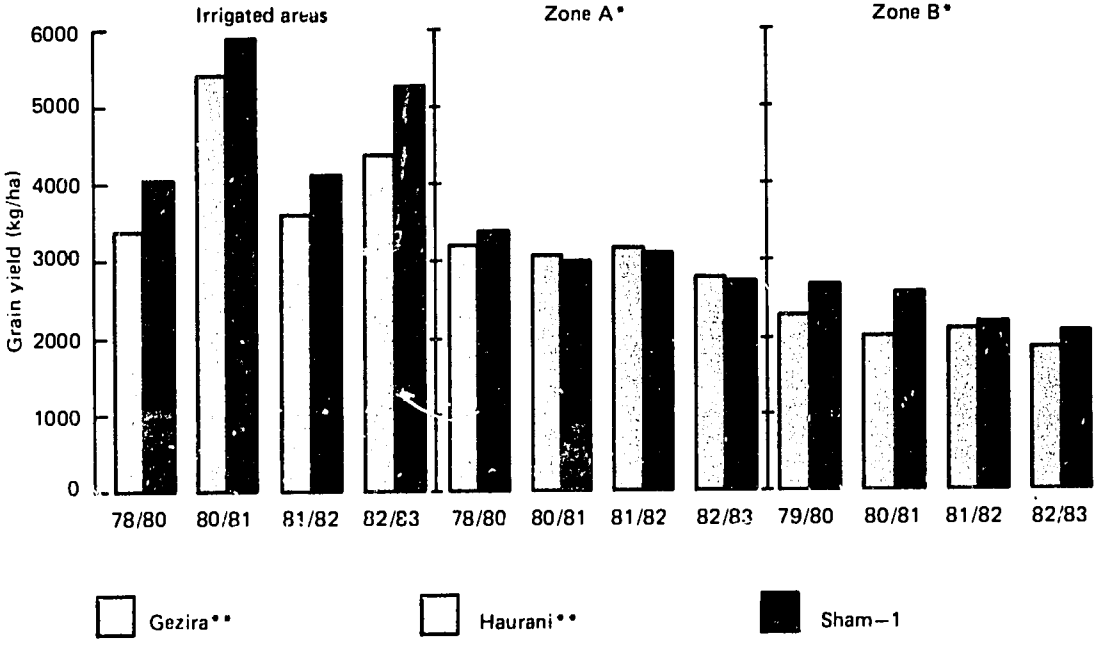
Sham-1 which exhibits good plant characteristics and attractive kernels also possesses good yielding ability and wide adaptability. A summary of its performance in farmers' fields is presented in Figure 8. This variety is resistant to stripe rust disease caused by the fungus *Puccinia striformis* but susceptible to bunt caused by *Tilletia* spp., a disease that can be controlled by seed treatment.

The bread wheat line was released under the name of Sham-2. It also comes from a cross made in CIMMYT. After being identified as a promising line in Lebanon, it was tested in the region through ICARDA's International Nurseries Network. In four years of tests in farmers' fields in the ir-



The new bread wheat Sham-2. The flour of this variety has superior quality for baking and a high protein percentage.

Figure 8. Performance of the durum wheat variety Sham-1 in field verification trials in different climatic zones of Syria.



Zone A*: annual rainfall greater than 350 mm.

Zone B*: annual rainfall between 250 and 350 mm.

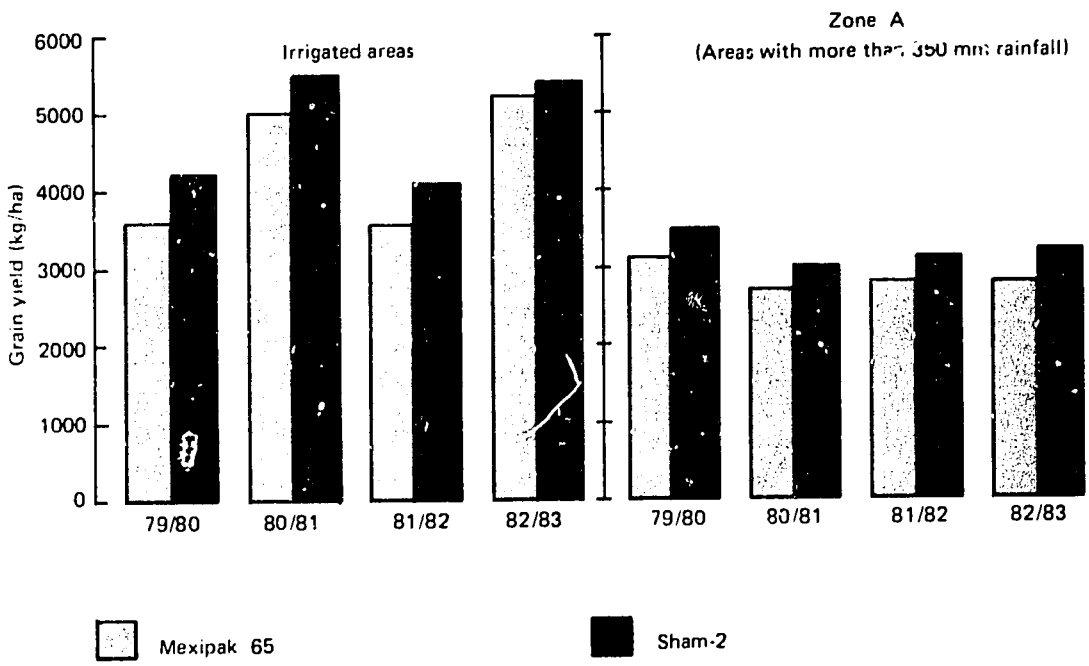
**: widely grown local cultivars.

rigated and high rainfall areas of Syria, it proved itself to be consistently higher yielding than the local cultivar, Mexipak 65 (Figure 9). Plant height and time to maturity of Sham-2 and Mexipak 65 are the same, but the new variety has better disease resistance.

Flour of Sham-2 has superior quality for baking and a high protein percentage. Thus, its flour can be blended with "weak flour" to improve baking properties.

Seeds of both the new varieties are being multiplied by the National Seed Organization for distribution to Syrian farmers. Sham-1 is recommended for growing under rainfed conditions in the higher rainfall areas and Sham-2 for the irrigated and high rainfall areas of the country. Also, Sham-1 has been identified as a promising durum variety in several other countries in the region.

Figure 9. Yield comparison of the new variety of bread wheat Sham-2 with the local cultivar Mexipak 65 in field verification trials in Syria.



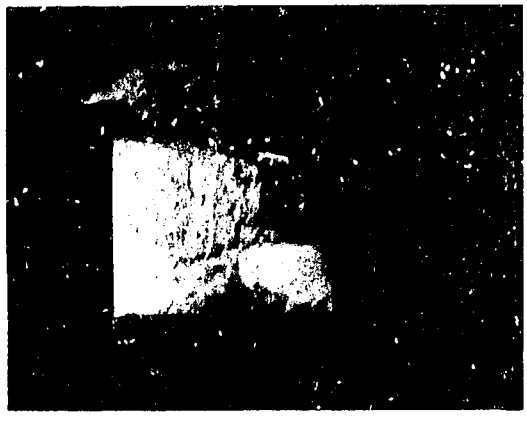
Evaluating New Wheat Lines for Two-layer Bread Making Quality

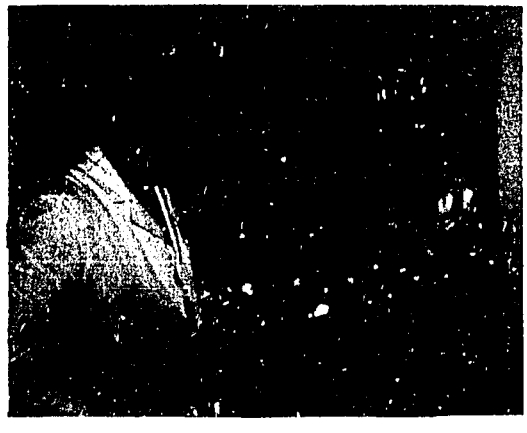
Because a large number of wheat cultivars are developed at ICARDA each year, a standardized and easy-to-follow system for testing their two-layer bread making quality has been designed by the Center's cereal quality laboratory. This popular bread, commonly called "khobz" or "shami," is made from a blend of bread and durum wheat flours or from bread wheat flour alone.

In the process of developing the evaluation system, the laboratory staff surveyed the baking methods used in small and large commercial bakeries in Syria, Lebanon, Jordan, and Egypt and then installed a traditional stone oven to carry out the evaluation on a practical basis. Commercial-type sheeting rolls and a small-scale mixer completed the baking laboratory equipment. The laboratory identified 10 characteristics that should be used in judging the bread (Table 10). Each is scored 1 to 5 and given equal importance, and breads with the highest total score are rated the best quality. Medium strength flours have proved to be the most suitable for making two-layered breads.

Flour "strength" enables dough to retain gas produced during fermentation and is responsible for the volume and texture ("bitability") of bread of all types. It is chiefly a function of the protein and reflects the elasticity, state of oxidation, and hydration capacity of the proteins. A recent study of flours made from wheat lines in

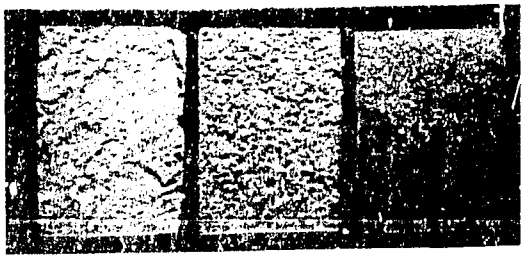
Flour dough is rolled out in thin sheets for two-layer bread with this equipment.



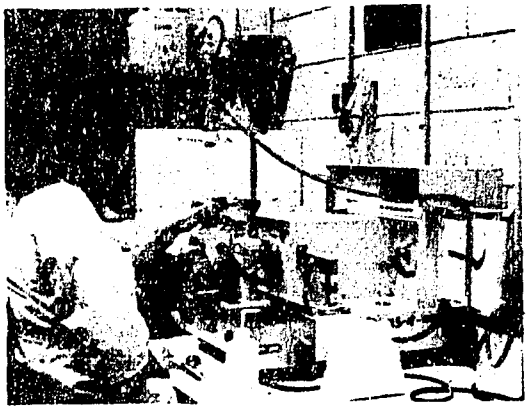


Two-layer bread being cooked in the stone oven in the laboratory and then removed for quality testing.

ICARDA nurseries revealed that the elasticity of the gluten washed from flours with a wide range of strength (as measured by farinograph stability) was virtually constant. Therefore, it was concluded that the state of oxidation and hydration capacity of the protein had the most influence on strength. These are both affected by the temperature, humidity, and moisture availability during grain maturation, as well as by the genetic makeup of the cultivars. The relative baking scores of seven wheat cultivars tested at ICARDA are shown in Table 11.



Different crumb textures of two-layer bread. Left to right: dense waxy texture, very coarse open texture, and uniform cells. The latter is the most acceptable.



A laboratory technician tests "strength" of different flour from various wheat lines.

Table 10. Characteristics used for the evaluation of two-layered bread (khobz).

Dough	
(1)	Handling at dividing
(2)	Handling at sheeting
Bread	
(1)	Color
(2)	Diameter and shape
(3)	Crumb texture
(4)	Separation
(5)	Odor
(6)	Taste
(7)	Biting texture
(8)	Keeping quality

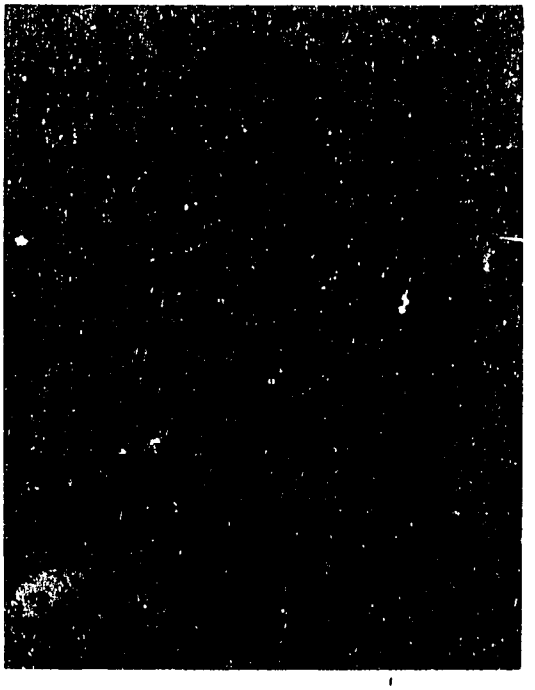
Table 11. Ranking of seven wheat cultivars for "khobz" bread making quality.

Cultivar	Baking score	Rank
Blodan	31.5	5
S311 x Norteno	31.0	7
Mexipak	34.5	3
Florance/Aurore	36.0	2
Flk 'S'/Hork	38.0	1
7 C/Tobar 166	33.0	4
Pato cal	31.5	5

Cereal Lines Resistant to Wheat Stem Sawfly

Larvae of the wheat stem sawfly (*Cephus pygmaeus*), a widely distributed and important insect pest of cereals in West Asia and North Africa, tunnel up and down the stems of the plants and feed on the soft inner tissue. Sawfly-infested plants have reduced yields due to lodging and shrunken kernels. Because chemical control is practically impossible and cultural practices have limited effects on sawfly populations, the best method of control is host-plant resistance.

Mass screening of durum and bread wheat lines for sawfly resistance started in 1979, and barley and triticale were included in 1982 and 1983. The evaluations are conducted under artificial infestation at ICARDA's Tel Hadya farm and under natural infestation in a "hot spot" in Syria. High levels of resistance have been detected in all four cereal crops and some of the lines have proved to be highly resistant throughout the years (Table 12).



Lodging caused by the wheat stem sawfly.

Resistance was confirmed when several genotypes were submitted to varying levels of infestation. The bread wheat resistant line MT-777 CI 9294/Fortuna had significantly less damage at all levels of in-

Table 12. Barley, durum, bread wheat, and triticale lines with high levels of resistance to wheat stem sawfly. (Averages of five to six seasons for durum and bread wheat, two seasons for barley, and one for triticale.)

Line or variety	% infestation
Barley	
Kataja	3.9
Europa	1.7
MP-112 (BW) (check)	20.4
Durum	
D-Dwarf 'S' 15 x Cr'S'	2.1
Gerardo VZ 469-Cr'S' CM 459-2S-2S-1S-0S	1.0
Cr 'S' -21564 CM 194-8M-1Y-3M-0Y	2.0
Hammari (check)	23.4
Bread Wheat	
MT-777 CI 9294/Fortuna	1.6
MT-773 CI 9294/Fortuna	3.3
Fortuna	3.4
Sawtana	4.3
MP-112 (check)	25.0
Triticale	
Sel Fert/Cineum/Bgl B52-OAP2	4.4
Golan (BW) (check)	10.8

festation than MP-112 and Golan, the susceptible and local checks, respectively (Figure 10). Yield losses in the resistant line were also smaller than in the checks (Table 13), thus confirming the importance of resistance to this trait. Cereal breeders are now using this information to incorporate wheat stem sawfly resistance genes into commercial varieties.

Figure 10. Regression of four levels of infestation with wheat stem sawfly on the percent infestation in three bread wheat varieties at Tel Hadya, Syria (1983).

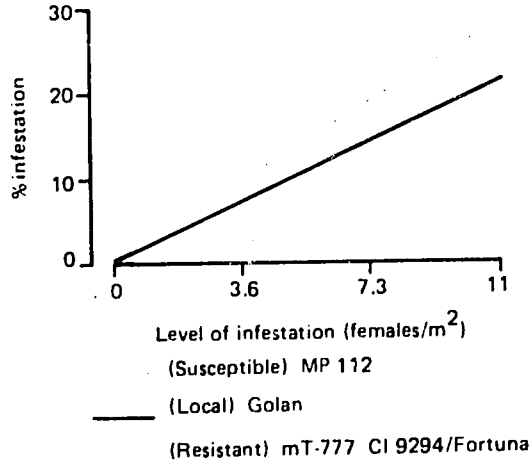


Table 13. Percentage yield losses due to different levels of infestation with wheat stem sawfly in three bread wheat varieties at Tel Hadya, Syria (1983).

Level of infestation (females/m²)	MT-777 CI 9294/ Fortuna (resistant)	% yield loss Golan (local)	MP-112 (susceptible)
0	0	0	0
4	1.3	6.5	12.8
7	1.4	6.9	11.9
11	3.4	15.1	23.2

An adult wheat stem sawfly lays eggs on a wheat stem, and the larva feeds on the soft inner tissue.

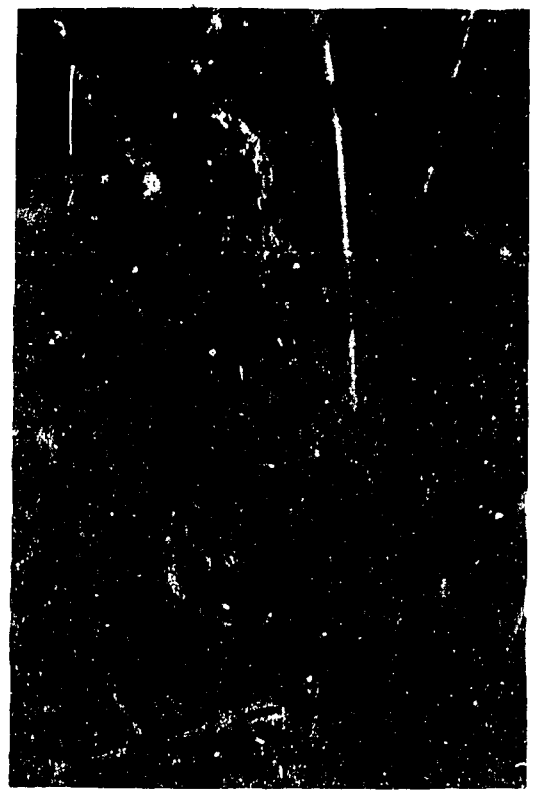
Developing Barley Lines for Broad-based Resistance to Diseases

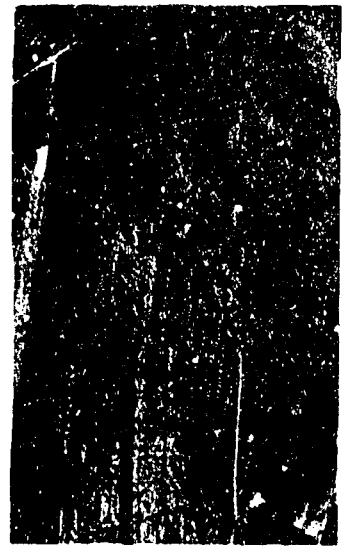
Because barley is a low input crop and most farmers in North Africa and West Asia grow their own seed and seldom treat it with fungicides, making available barley lines with disease resistance is the best solution to the control of diseases. Losses caused by disease are less in dry areas where most barley is grown, but seed-borne diseases such as *Helminthosporium* spp. are important regardless of the amount of rainfall.

Furthermore, the region experiences wide year-to-year variations in rainfall, and in wetter years when farmers might expect good harvests, disease epidemics are more likely to occur.

Developing barley varieties with resistance to diseases involves selection in segregating populations and subsequent screening of the pure lines under conditions that favor development of diseases. Through early planting and irrigation at ICARDA's main experimental farm at Tel Hadya, an environment favorable to disease development can be created and epidemics initiated by artificial inoculations. Barley at Tel Hadya is subjected to powdery mildew, yellow rust, leaf rust, scald, net blotch, and barley stripe.

However, before lines are used as parents for crosses, information on resistance is obtained from Barley Observation Nurseries in more than 40 other locations. In addition, all lines in yield trials in the Key Location Disease Nurseries are tested in 10





Some barley lines resistant to diseases such as leaf rust (top) and yellow rust (below) have been developed, but few show the desirable type of resistance in different parts of the region.

"hot spots" where heavy natural epidemics of one or more diseases are usually severe.

A fair amount of resistant material is available now, especially in the most advanced yield trials, but few lines show the desirable type of resistance active in more than one environment (Table 14). To facilitate the screening for broad-based resistance, special nurseries for different diseases are being assembled. These nurseries will consist of lines performing well in screening tests in Syria and lines submitted by national programs.

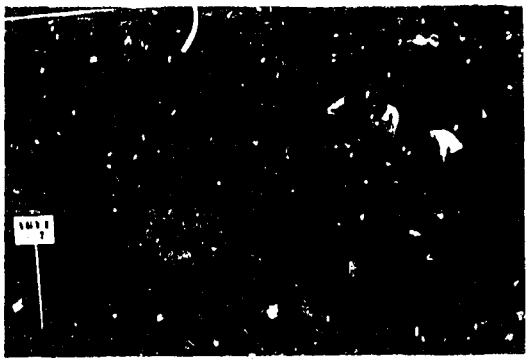
For the 1984/85 season, nurseries for yellow rust, leaf rust, scald, net blotch, and barley yellow dwarf virus will be dispatched and tested in a limited number of locations. Lines showing a broad-based resistance will be included the next year in the Key Location Disease Nurseries to be tested against other diseases. By following this method, ICARDA plans to create germplasm pools in which a wide variety of resistance genes for a disease is placed in different agronomic backgrounds. These pools can be of use to national programs that want to improve the resistance of their material.

Table 14. Percentage of barley plants with low disease severity in the yield trials represented in the Key Location Disease Nurseries (1982/83).

	Elite yield trial	Advanced yield trial	Prelim. yield trial
No. of entries	42	294	549
Yellow rust			
(<10% severity)			
Syria (Tel Hadya)	33	8	4
Pakistan (Islamabad)	26	17	15
Both locations above	10	6	4
Leaf rust			
(<10% severity)			
Yemen (Taiz)	24	6	7
Egypt (Gemeiza)	83	56	68
Egypt (Sakha)	48	27	15
Tunisia (Beja)	90	76	85
Four locations above	12	1	2

Advanced Barley Lines for National Programs

Barley is the second most widely grown cereal crop in West Asia and North Africa and in the drier areas the dominant crop. To assist with the improvement of barley production, a large number of advanced lines which possess good agronomic traits, disease resistance, and high yield potential, have been developed at ICARDA and sent to different countries for testing and selection by national programs under their local conditions.



The advanced barley yield trial in 1983 at ICARDA's main experimental farm included 2,416 lines.

The total number of lines selected from the improved barley germplasm in the last six seasons by 12 representative countries of the region is shown in Figure 11. Countries which maintain close cooperation with ICARDA's barley program, such as Tunisia, Syria, Lebanon, and Jordan, have made the best use of the materials (Figure 12). The most promising ICARDA-developed barley lines identified by each of these four countries included ER/Apam, Rihane, and Rihane 'S'-2.

Results of the regional barley yield trials of the last six seasons showed that the performance of the barley lines developed at ICARDA has improved (Table 15). Every year, starting from 1979/80, eight to 13 newly developed lines yielded better than Beecher, the long-term check variety in these trials. Beecher was the third highest yielding variety in 1977/78 and the top yielder in 1978/79, but its rank dropped to 14th, 9th, 14th, and 10th in the following four seasons, respectively.

Other high yielding lines were also continuously being replaced by newer lines

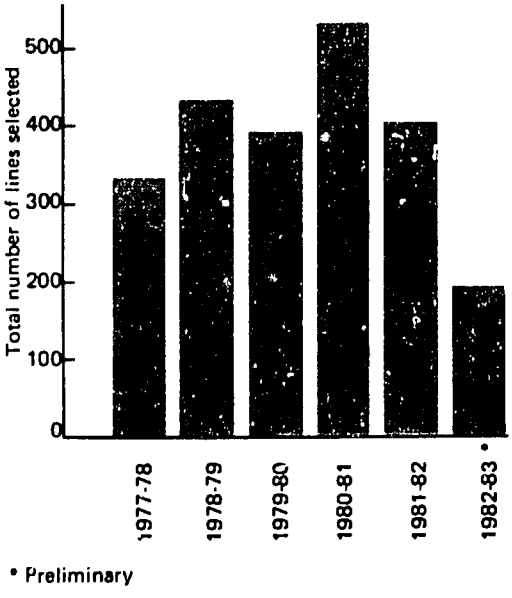


Figure 11. Number of promising barley lines selected by 12 countries from ICARDA's improved germplasm over the period 1978-83.

with even greater yielding ability. For example, in the seasons 1979/80 and 1980/81, the barley line ER/Apam had the highest mean yield, but its ranking dropped to second and fifth place in 1981/82 and 1982/83, respectively. In the past two seasons, the newly developed lines, Rihane and its sib, are the top yielders. Incidentally, despite the seasonal fluctuations, an improvement in the yield of the long-term check cultivar is discernible over the six seasons. Such a trend probably reflects an improvement in management practices by the national programs.

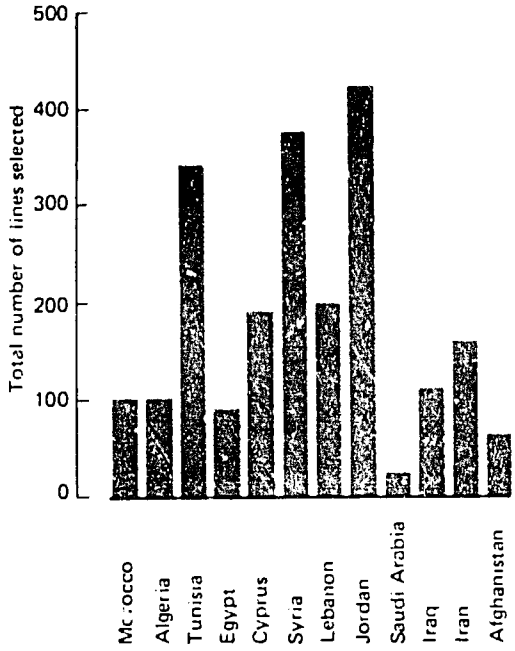


Figure 12. Total number of promising barley lines selected by each of 12 countries from ICARDA's improved germplasm from 1978-83.

Table 15. Ranking of selected barley entries in the regional yield trials over the past six seasons.

Year	Rank and name of entry				
	1st	2nd	2rd	4th	5th
77/78	Cr. 366-13-2	**Comp. Cr.89**	**Beecher***	Cr. 366-16-2	H251 3Y-1B-0Y
78/79	**Beecher***	Cr. 368-4-1	WI 2291	**Comp. Cr.89**	Cr. 366-13-2
79/80		WI 2198	CM67/SV.Mari	Minn126/CM67	**Comp. Cr.89**
80/81		Ky 63-1294**	Carina	Minn126/CM67	Emir/Nordgard
81/82			Khouzama 'S'**	Rihane 'S'**	As54/Tra/*
82/83	Rihane 'S'-2**		Mari/CM67	Khouzama 'S'**	

* Long-term check variety. ** ICARDA-developed germplasm.

Wheat Lines and Production Practices for Pakistan's Mountainous Areas

Cereal production in Pakistan could be increased substantially with better varieties and production practices and the expansion of the cultivated area in its vast Baluchistan province which makes up almost 40% of the country. It has more than 5.4 million hectares of still uncultivated land. Average wheat yields there are poor (1.1 t/ha) because of unimproved varieties, extreme temperatures, moisture stress, and diseases. (Better wheat varieties and growing practices could also benefit large areas of Afghanistan and Iran with similar agroclimatic conditions.)

To improve cereals in Baluchistan, ICARDA began collaborating in 1980 with Pakistan's Agricultural Research Council (PARC) and the Provincial Department of Agriculture. Scientists concentrated their work on two activities: on-site screening of varieties improved with new germplasm and developing a package of production practices. From 1980-83, approximately 7,000 lines/varieties of bread wheat, durum wheat, and barley were screened in many locations to see how they yielded in the presence of major diseases.

Table 16 compares the average yield at Quetta of top yielding bread wheat lines with two varieties: Zargoon, the local improved check variety, and Bezostaya, identified earlier as a high yielding, winter cold-tolerant variety. Top entries yielded 36 to 76% more than Zargoon, the best check. All four lines also showed resistance to stripe rust. Parents of two top yielding lines, entries 56 and 91, have Turkish germplasm. The other two lines, entries 75 and 21, originated from winter-spring crosses.

Table 16. Top yielding bread wheat lines in the initial yield trial at Quetta, Pakistan (1983).

Entry no.	Varieties/lines	Yield (kg/ha)	% increase over checks A	% increase over checks B
75	**Inia 66 (R)//Hhgn/DRC SWO 71218**	**9700**	**87**	**76**
56	Eys/Balal//P101/3/1150-18 Stacat = YA 6203-18A-0A	8300	59	51
21	Kvz/3/HD/On//Bb/4/Ypopr/3/Rbs/ 55-1744//Su/Gns = SWO 73097	7500	44	36
91	Kanred/Funo//119933-3B-1Y-1B-1T YA 4302-3A-1A-1A-0A	7500	44	36
A	Bezostaya (check)	5200	—	—
B	Zargoon (check)	5500	—	—

Scientists inspect a promising wheat cultivar in a mountainous area of Baluchistan province in Pakistan.

Three high yielding durum wheat lines which are resistant to stripe rust and cold (Table 17) have also been selected for further extensive tests. They showed an average increase of 10 to 15% above Zargoon, the best check variety. (It is a bread wheat but was used as a check because there is no commercial durum variety.) Also, four high yielding bread wheat varieties/lines are being extensively tested. One line, Lovrin 6/Samson, has shown an increase of up to 24% over the check variety. The next step is to test the newly identified, high yielding lines of bread and durum wheat in many locations of Baluchistan.

A gradual shift is taking place in the production of cereals from the irrigated low altitude flat areas in the province to its rainfed high plateau areas. The principal reasons for this development include an increasing demand for food and the economic

Entry no.	Variety/line	Plant height (cm)	Yield (kg/ha)	% of improved check
Durum wheat				
90	Mugan	130	4800	100
271	Mag'S'/Jor'S'/3/G11'S'// 61 – 130/Lds	90	5300	110
321	Bit'S'/Cdo VZ 394	115	5500	115
399	Zargoon (improved check)*	95	4800	100
400	Local White (check)*	140	2900	60
Bread wheat				
40	Bezostaya	100	4000	118
44	Alba/Gn'S'/Sn	110	3500	103
110	NS 984 – 1/NE 791136	110	3400	100
118	Lovrin 6/Samson	95	4200	124
124	63T113	95	3400	100
150	Zargoon (check)	95	3400	100

* These bread wheats were used as checks because there is no commercial durum wheat.

Table 17. Average plant height and yield of selected wheat lines in observation nurseries at Quetta, Pakistan (1983).

advantage for farmers to grow cash crops in the flat lands.

However, little research has been done in the past to develop a package of production practices for wheat in the semi-arid to arid environments in the high plateau zone, and farmers' yields have been extremely poor, averaging only about one-half ton per hectare. Farmers in this harsh environment face a host of production problems, but one of the priorities was to find out the response of wheat yields to fertilizer application so farmers could realize a reasonable economic return from growing the crop.

Fertilizer experiments were conducted during the past two crop seasons (1981/83) at two sites: one at Pishin almost in the middle of Quetta valley with an elevation of 1,750 meters, the other at Kan Mehterzai on a high plateau with an elevation of 2,500 meters. Annual rainfall at Pishin ranges from 250 to 300 mm and minimum temperature from November through late February stays below zero. (The average temperature for the coldest month of January is -3.9°C.) At Kan Mehterzai the temperature from the beginning of October until the end of March is also below freezing. Snowfall in the area is heavy and covers the ground during the coldest months of December through February. Moisture holding capacity of the soil is poor, and strong, cold winds blow during winter and hot winds in early summer which increase the evapotranspiration from the soil and crops. Soils at both of the sites are calcic yermosols, formed in alluvial material with sandy loam to sandy clay loam texture and low organic matter content (0.3-0.5%).

Because the soils at both sites are nitrogen deficient, application of N at the rate of 30 and 60 kg/ha resulted in significant yield response in the Local White and Zargoon wheat varieties (Figures 13 and 14). Test results showed that Pishin is a better site for growing both varieties. Without nitrogen fertilizer, the yield of Local White was only 640 kg/ha at Kan Mehterzai and 1,760 at Pishin; comparable figures for the Zargoon variety were 1,040 kg/ha and 2,800. With 30 kg/ha of N applied, the yields at Kan

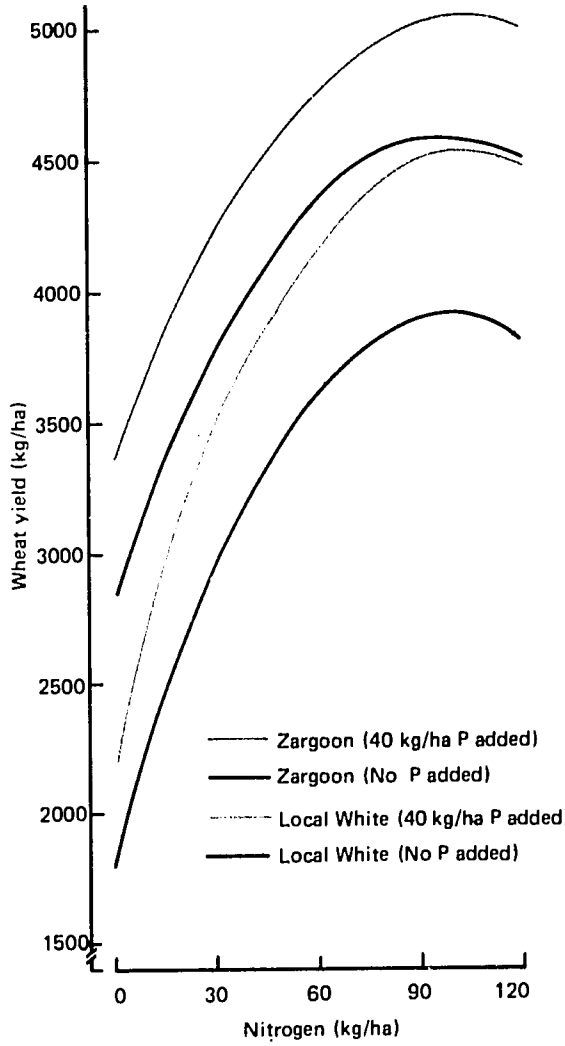


Figure 13. Wheat yield response to nitrogen (N) and phosphate (P_2O_5) at Pishin, Pakistan (1983).

Mehterzai for Local White doubled (from 640 to 1,360 kg/ha) and increased from 1,760 to 2,960 at Pishin. Also, yields of Zargoon were substantially larger.

A nitrogen application of 60 kg/ha increased yields even more, but higher rates were not economic, probably because evaporation rates were high and there was insufficient water during the growing season. In fact, the yield increase per kg of N applied fell rapidly at rates above 60 kg/ha.

Yields of both wheat varieties were also larger (14%) when phosphate fertilizer was applied, but did not respond to the same degree as when nitrogen was added.

An economic analysis of the Pishin data showed that the application of fertilizer resulted in an average cost/benefit ratio for both the Zargoon and Local White wheat varieties of 1/9.2 with 60 kg/N/ha and 1/8.1 with the same amount of N but with P_2O_5/ha added at the rate of 40 kg/ha. At Kan Mehterzai, the corresponding cost/benefit ratios were 1/7.2 and 1/6.5.

The research findings reported here will be tested on farmers' fields in Baluchistan during 1984 under a collaborative ICARDA/FAO/PARC project.

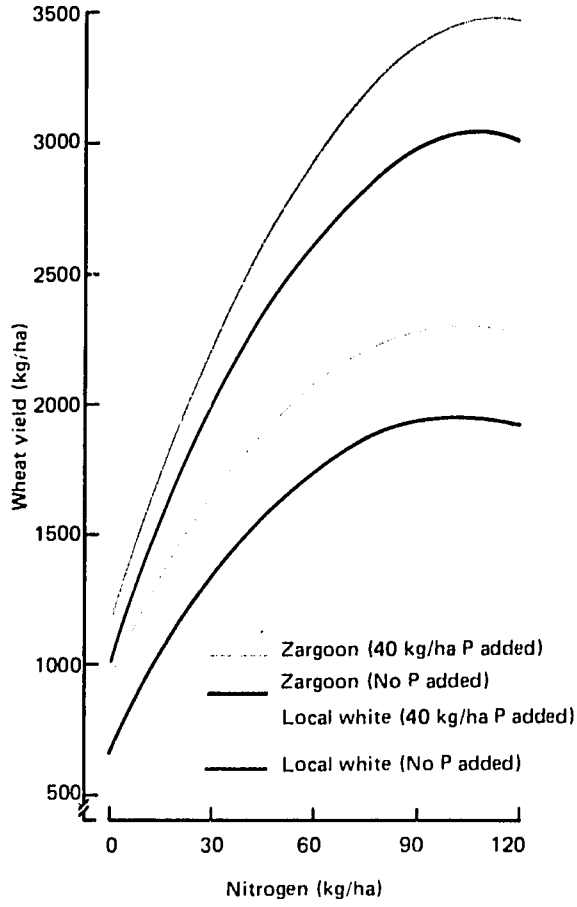


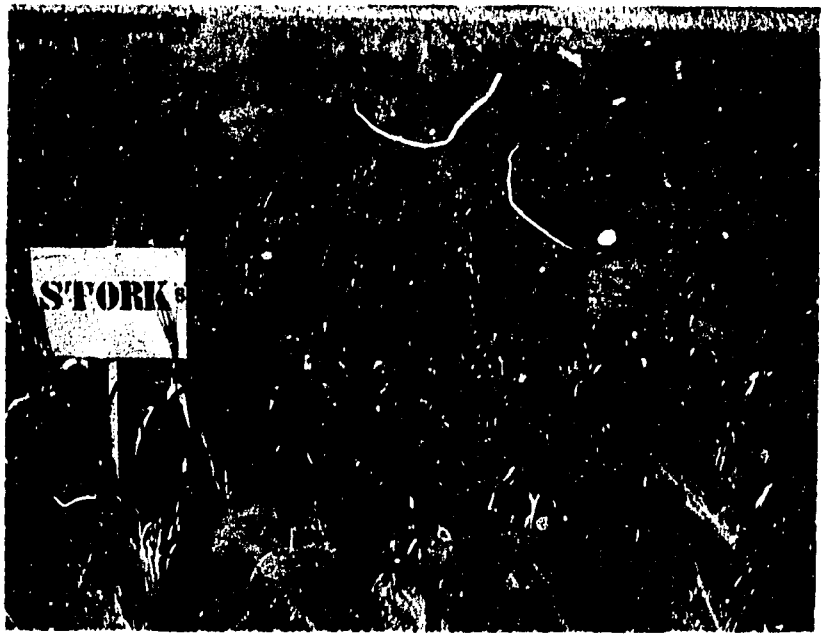
Figure 14. Wheat yield response to nitrogen (N) and phosphate (P_2O_5) at Kan Mehterzai, Pakistan (1983).

Untangling Cereal Production Constraints in Jordan: Five Years of Collaborative Research

One of ICARDA's longest-running collaborative projects, which started in the 1978/79 season in Jordan and ended in 1983, demonstrated that with a proper choice of improved technologies cereal grain yields could be substantially increased, particularly in areas with an average annual rainfall of 250-400 mm. This small agricultural country depends on large wheat imports for food and locally grown barley is used mainly as a livestock feed.

Based on five years of experiment station research and on-farm trials, both Jordanian and ICARDA scientists believe that the current average wheat yield of about 700 kg/ha could be increased approximately 30% to 900-1,000 kg/ha. If farmers accomplish this, Jordan could reduce imports by about 50,000 tons a year. Recent developments indicate a gradual adoption of new technology by farmers and the possibilities of gains in wheat yields.

Over the five year period, many trials were carried out in three different climatic zones: Zone A with over 350 mm of average annual rainfall, Zone B with 250-350 mm, and Zone C with less than 250 mm. In general, the results showed that among the durum wheats the variety Stork was the most adaptable to Zone A and Variety DA 2 to Zone B. (Durum wheat is the major cereal crop in Jordan.) The most promising barley varieties were DA 106 and Giza 120.



In five years of trials in Jordan, the Stork variety was the most adaptable of the durum wheats in areas with more than 350 mm of annual rainfall.

Early planting had a consistent advantage over late planting in all climatic zones.

The beneficial effect of nitrogen fertilization was demonstrated in all three zones, even in relatively dry environments (Figure 15). The most noticeable effect occurred at 30 or 60 kg/N/ha, depending on the environment, and the best responses were recorded when nitrogen fertilization was associated with other improved practices such as the use of improved varieties, phosphorus fertilizer, and herbicides for weed control. ICARDA and Jordanian scientists have designed a set of "best bet" recommendations for wheat and barley production based on these and other experimental data, on-farm trials, experience of local scientists, and survey findings. (See 1982 *Research Highlights*.)

Throughout its five years, this collaborative project involving the University of Jordan, Ministry of Agriculture, and ICARDA depended heavily on the support of Jordanian scientists. It had two major components: on-farm trials which tested production practices in each rainfall zone at as many as 25 sites a year and socio-economic surveys and studies related to farming practices, agricultural infrastructure, and human nutrition. A training component at the Master of Science degree level was also included.

Funding for the agronomic parts of the project came primarily from the Ford Foundation and for the socio-economic aspects from the Netherlands government.

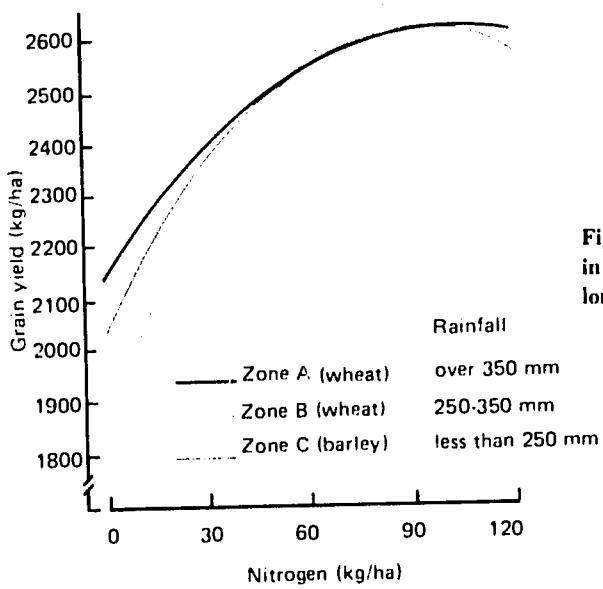


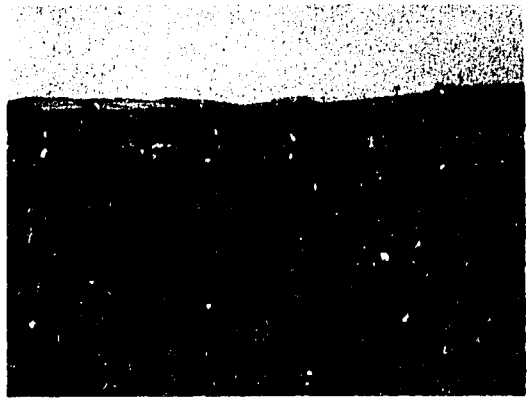
Figure 15. Response of wheat and barley to nitrogen in Jordan in 1980/81, a year that approximated the long-term average rainfall.

Development of Wilt-Resistant Chickpeas in Tunisia

Any new chickpea cultivar released to Tunisian farmers should possess resistance to a wilt caused by *Fusarium oxysporum* and to Ascochyta blight. Chickpea cultivars from ICARDA-derived material resistant to the latter disease are available, and trials at the Beja research station in northwest Tunisia show progress in the development of wilt resistant material.

In cooperative research between the Institut National de la Recherche Agronomique de Tunisie (INRAT) and ICARDA during the first season (1981/82), scientists made selections of single wilt-resistant plants from the local landrace Amdoun. The progenies stemming from these were screened for *Fusarium* wilt resistance and seed yield in the 1982/83 season and were found to outperform the local Amdoun check. For example, one of the superior chickpea entries with a low wilt rating (1.3) produced a seed yield of 1,620 kg/ha. The corresponding yield of the local check with a high wilt rating of 8.7 was only 16 kg/ha. (The *Fusarium* wilt rating was based on a visual scale: 1 = no symptoms and 9 = all plants killed.)

In a 1982/83 international yield trial from ICARDA, several of the 23 entries were also significantly superior to the local Amdoun check for both seed yield and *Fusarium* wilt resistance (Table 18).

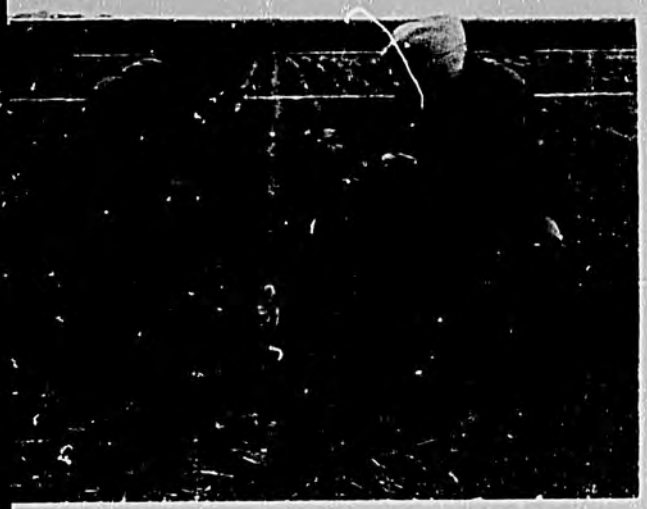


Fusarium wilt-resistant and susceptible chickpea lines in field trials in Tunisia. Cooperative ICARDA and INRAT research in that country has shown considerable progress in the development of wilt-resistant lines.

Table 18. Seed yield and *Fusarium* wilt ratings of superior chickpea entries in an international yield trial at Beja, Tunisia (1982/83).

Entry designation	*Fusarium* rating*	Yield (kg/ha)	Yield % local check
ILC 237	1.5	1450	346
493	3.8	1138	272
FLIP 81-52	4.0	1194	285
-54	3.5	1656	395
-65	3.3	1619	386
ILC 4	4.8	1006	240
35	5.5	738	176
295	5.3	731	174
1929	5.3	881	210
FLIP 81-31	4.3	988	236
-40	4.8	931	222
Tunisian local check	5.0	419	100

* 1 = no symptoms; 9 = all plants killed.



Left, scientists check for cold tolerance of winter-sown chickpeas at an early stage of growth; right, close-up of a tolerant plant and one killed by the cold.

Field Screening for Cold Tolerance in Chickpeas

Earlier sowing of chickpeas in the Mediterranean region, in winter instead of spring, results in a substantial increase in seed yield. However, winter sowing is possible only with cultivars possessing cold tolerance and resistance to Ascochyta blight disease.

In screening tests in Turkey three years ago, only six lines out of 3,158 were found cold tolerant, and 2,846 or 90% were highly susceptible. Then in 1981/82 at ICARDA's main experimental farm at Tel Hadya, many lines were killed and others affected to varying degrees by cold; 31 nights had subzero temperatures. Out of 10,800 lines made up of germplasm accessions, advanced breeding lines, and entries from yield trials, 1,808 lines were found highly cold tolerant, 325 lines died, and the remaining were affected at varying degrees of susceptibility.

The following season (1982/83) was the coldest winter in the recent past with 53 nights of subzero temperatures. Many lines identified tolerant earlier succumbed and only a few proved tolerant. It is expected that these cold tolerant lines may maintain their tolerance in the Mediterranean region at low to medium elevations. They included ILC 666, ILC 668, ILC 1071, ILC 2487, ILC 2505, ILC 3081, ILC 3287, ILC 3470, ILC 3598, and ILC 3789.

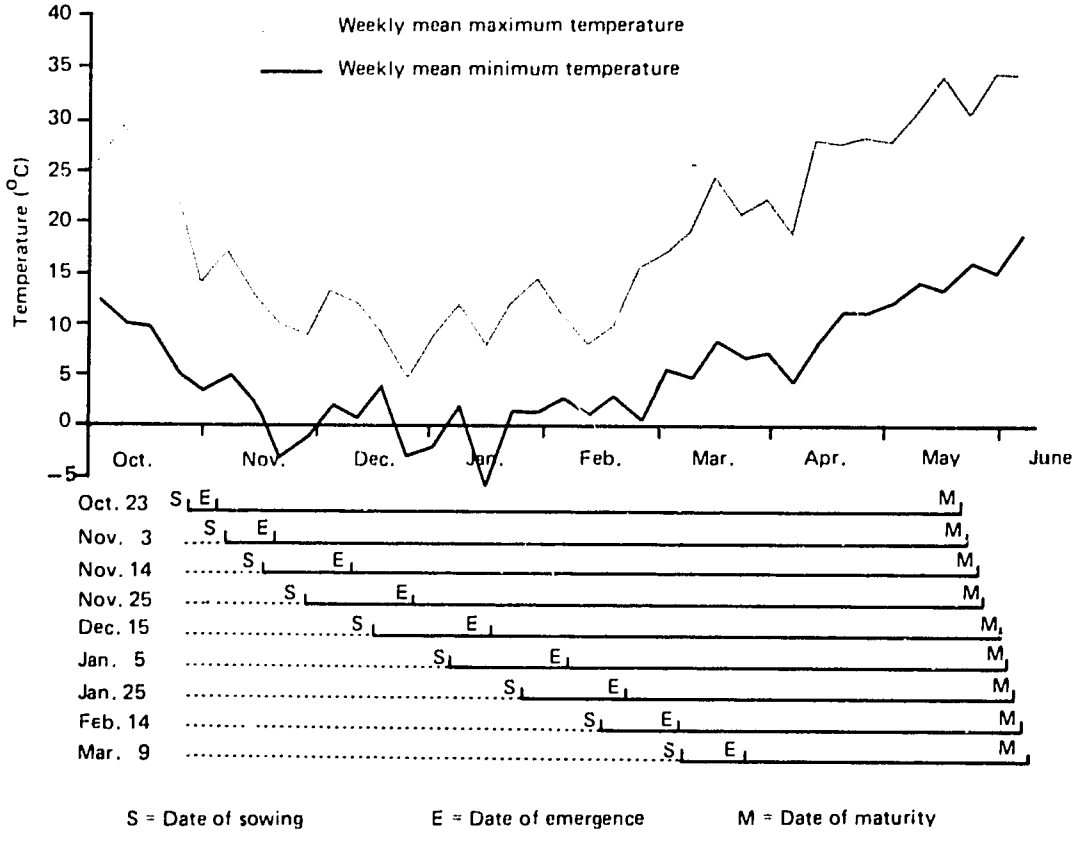
In an attempt to develop a suitable field screening technique for cold tolerance, a set of genotypes ranging from highly tolerant

to highly susceptible were sown on nine dates starting on October 23, 1982 and ending on March 9, 1983 (Figure 16). Cold injury was observed in the first four dates of sowing but the most reliable results were obtained from the first date of sowing.

Early-sown plants are larger and exposed to cold longer which makes them a more reliable indicator of tolerance to cold than late-sown plants.

Based on these findings, ICARDA and ICRISAT scientists believe that the development of a field screening technique and identification of tolerant lines will be useful in breeding for cold tolerant chickpeas for winter sowing in the Mediterranean region.

Figure 16. Exposure of chickpea materials (sown at different dates) to different temperatures at Tel Hadya, Syria during the 1982/83 season.



Screening Chickpeas for Resistance to Leaf Miner

Most important and widespread insect pest of chickpeas in North Africa and West Asia is the leaf miner, *Liriomyza cicerina*, which can cause between 18 and 20% yield loss. Effective but costly insecticides have been identified, but the joint ICARDA/ICRISAT program has intensified the search for a cheaper and longer lasting alternative control measure: host-plant resistance.

A simple visual damage score scale ranging from 1 (no visual damage, highly resistant) to 9 (very heavy damage, highly susceptible) has been developed. A few very susceptible lines which have been identified are now being used as spreader rows. The scheme of mass screening of chickpea lines involves the sowing of spreader rows at frequent intervals, the monitoring of adult populations, and, in the future, the artificial infestation of the fields with large numbers of newly emerged adults. Lines found promising are sown in the following season for reconfirmation.

To measure levels of resistance detected so far, the yields of 18 lines of known reaction to leaf miner were measured with and without protection. Table 19 shows the performance of nine of these lines. Yield losses due to leaf miner ranged from 3.9 to 23.1%, and in most cases resistance levels were confirmed.

A total of 1,504 germplasm accessions were evaluated during 1981/82 and 13 lines found resistant (Table 20). An additional 3,367 lines were then evaluated during 1982/83 and 13 new lines were found promising. When the 13 lines identified as resistant during 1981/82 were evaluated for a second season, some variation in the pattern of resistance was noted. This emphasizes the need for at least two seasons of

Line	Rating	Yield (kg/ha)		% yield loss
		Protected	Unprotected	
ILC 726	**R**	**1803**	**1733**	**3.9**
2319	**R**	**1670**	**1579**	**5.5**
3350	**R**	**1673**	**1555**	**7.0**
2618	I	2051	1827	10.9
2512	S	1967	1512	23.1
2993	S	1599	1264	21.0
482	S	2036	1612	20.8
562	S	2136	1709	20.0
Local	S	2122	1923	9.4
LSD 5% for yields		161	212	

R = Resistant; I = Intermediate; S = Susceptible.

Table 19. Performance of nine chickpea lines selected for varying degrees of response to leaf miner at Tel Hadya, Syria (1982/83).

Left, larva of the leaf miner damaging a chickpea leaf and a close-up of the adult; below, leaf miner insect damage to chickpeas (left) and a resistant plant (right) in the same field.

testing for resistance and for further improvement of the field screening technique. However, some lines showed consistent resistant reaction in both seasons. Three such lines, ILC 726, ILC 1776, and ILC 3350, merit special mention and are now being used in the resistance breeding program.

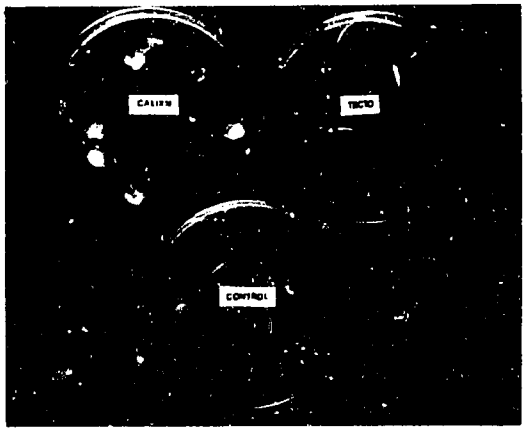
Table 20. Results of screening kabuli chickpea germplasm accessions for leaf miner damage at Tel Hadya, Syria (1981/82 and 1982/83).

Visual damage score	1981/82		1982/83	
	No.	%	No.	%
1	0	0.0	0	0.0
3	13	0.9	13	0.4
5	80	5.3	76	2.2
7	381	25.3	691	20.6
9	1030	68.5	2587	76.8
Total	1504	100.0	3367	100.0

Scale: 1 = highly resistant; 3 = resistant; 5 = intermediate; 7 = susceptible; 9 = highly susceptible.

Role of Fungicides to Control Ascochyta Blight in Chickpeas

Although host-plant resistance is the best answer for controlling Ascochyta blight in chickpeas, fungicides applied as seed dressing or foliar sprays can also play a significant role in managing the disease. If host-plant resistance breaks down because of new races of blight fungus, *Ascochyta rabiei*, the use of fungicides can fill the gap until a new resistant variety is developed. They are also useful and economic in controlling blight in tolerant cultivars and are large-seeded chickpea types that bring premium export prices.



The top two plates show chickpea seeds infected with *A. rabiei* and treated with fungicides Calixin M and tecto. No fungus is growing in either of these plates, but that is not the case in the lower plate where the infected seeds have not been treated.

Seed-borne inoculum of *A. rabiei*, a major source of blight development in the field, can be eradicated with a suitable

Cultivar	Time of application	Blight severity* Vegetative stage	Blight severity* Podding stage	Seed yield (kg/ha)
ILC 195	Flowering	3.0	3.3	909
	Early podding	**3.0**	**2.8**	**1658**
	Late podding	3.5	4.0	1124
	Control	3.0	3.3	1371
ILC 482	Flowering	5.0	8.0	717
	Early podding	**5.0**	**5.5**	**1604**
	Late podding	5.8	7.8	504
	Control	5.8	8.0	287
ILC 1929	Flowering	9.0	– (1)	0
	Early podding	9.0	–	0
	Late podding	9.0	–	0
	Control	9.0	–	0
SE ±				160.2
CV%				51.7

* Rating scale: 1-9; 1 = no disease, 9 = complete killing of plants.
(1) Plants killed before podding.

Table 21. Effect of foliar application of chlorothalonil (bravo 500) on blight severity and yield of chickpea cultivars of different degrees of susceptibility.

fungicidal dressing, and foliar application of fungicides can help produce Ascochyta blight-free seed for sowing.

Several systemic and contact fungicides have been screened during the past five years to determine their efficacy for eradicating the seed-borne inoculum of *A. rabiei*. Calixin M (11% tridemorph + 36% maneb) and thiabendazole (tecto 60) gave almost complete eradication of the fungus from seed with deep infection lesions. While Calixin M showed slight phytotoxic effects at higher doses (6g/kg), thiabendazole was found to be very safe.

Eleven foliar sprays of chlorothalonil (bravo 500) at 10-day intervals gave complete protection to a susceptible cultivar against blight under severe disease pressure. Although this much protection is not economical, results show the potential of chlorothalonil in controlling Ascochyta blight. More important is the fact that when only one spray of the fungicide was given in the early podding stage to a tolerant cultivar (ILC 482), the yield was five times that of the control (Table 21). The fungicide spray mainly reduced pod infection.

Cataloging Kabuli Chickpea and Lentil Germplasm

Since its beginning in 1977, ICARDA has given high priority to assembling and evaluating kabuli chickpea and lentil germplasm to serve as the genetic base for the future improvement of these crops. In collaboration with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), the Center maintains a world collection of kabuli chickpea seeds and currently holds 5,356 germplasm accessions assembled from 34 countries in different parts of the world (Figure 17). In addition, the world lentil collection at ICARDA now includes 5,673 germplasm accessions from 54 countries.

More than 3,300 accessions of chickpeas have been evaluated for 27 descriptors. Sufficient genetic diversity has been observed for most characters (Table 22). Sources of resistance to many stress conditions have been identified from the germplasm. Lines for these sources and for some other desirable characters are listed below:

Resistance to Ascochyta blight disease: ILC 72, 196, 201, 202, 2506, 2956, 3274, 3279, 3346, 3856, 4421.

Resistance to *Orobanche* sp. parasite: ILC 229, 280, 348, 351, 613.

Tall type: ILC 72, 196, 201, 202, 779, 2951 to 2957, 3272 to 3274, 3279, 3346.

Large seeds: ILC 95, 96, 97, 99, 100, 101, 148, 149, 445, 470, 1250, 1253, 1254, 2398, 2593.

The passport information and evaluation details have been stored in computer files and a "Kabuli Chickpea Germplasm Catalog" has been produced. In this catalog

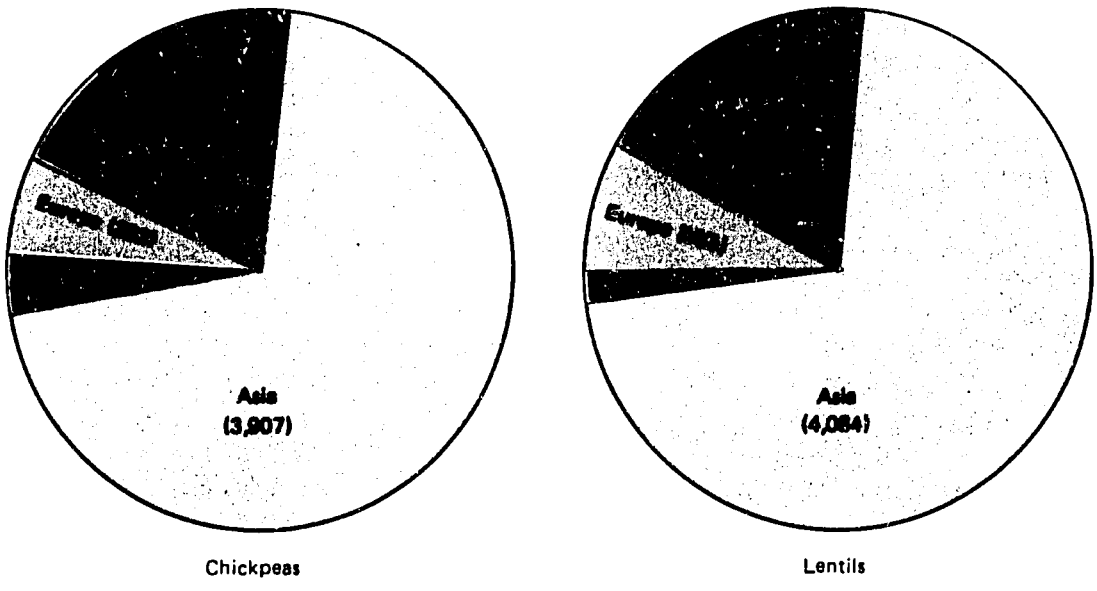
there is for each character a summary of statistics, a listing of elite accessions, and graphical presentation of the frequency distribution for easy access to the data. The most important finding from correlation studies was that seed yield was strongly correlated with both biological yield and seed weight.

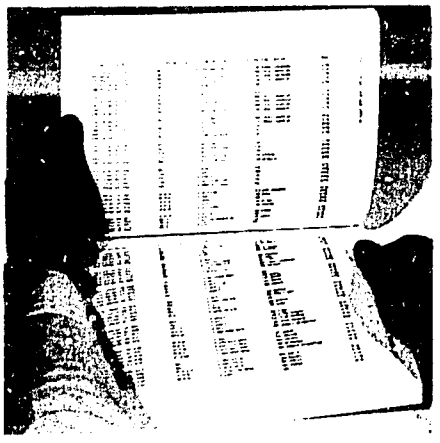
An analysis of variance by country of origin has provided guidelines for future collection. Additional collections from the USSR could be useful for Ascochyta blight and frost resistance and height; from Spain for large seed size and high biological yield; from Chile for a high number of primary and secondary branches, high harvest in-

Character	Range	Character	Range
Days to flower	70-94	No. seed/pod	0.1-3.1
Flowering duration (days)	11-36	Biological yield (g/m²)	35-533
Days to maturity	114-124	Grain yield (g/m²)	7-292
Plant height (cm)	15-50	Harvest index (%)	7-76
No. primary branches/plant	2.3-16.0	100-seed weight (g)	8.7-59.1
No. sec. branches/plant	0.3-22.7	Protein content (%)	16.0-24.8
No. pods/plant	4-100		

Table 22. Genetic diversity among kabuli chickpea accessions in the ICARDA collection.

Figure 17. Number of kabuli chickpea and lentil accessions in ICARDA's collection obtained from different parts of the world.





Passport information and evaluation details on the kabuli chickpea collection have been stored in computer files and this catalog produced for the use of plant breeders in national programs.

dex, and protein content; and from India for cold tolerance.

A major advantage of cataloging germplasm is the facility to query. For example:

QUESTION: List all chickpea accessions with a plant height greater than 33 cm.

ANSWER: 323 accessions qualify, and a list follows.

The computer will also respond to questions for any combinations of characters.

In addition to the value of the catalog in pinpointing desirable accessions, analyses of the data bases have revealed fundamental patterns of variation which relate to the crops' evolutionary history.

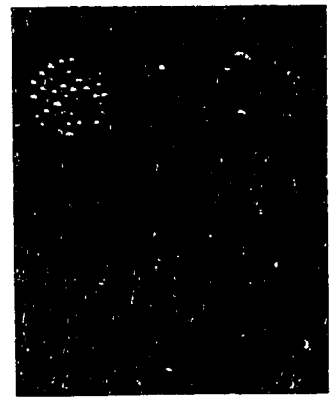
Lentils (*Lens culinaris*) are divided into two sub-species on the basis of seed size. Separate analyses were done for the large-seeded (*macrosperma*) and small-seeded (*microsperma*) accessions with the division set at 4.5 g/100 seeds. The small-seeded group was much more diverse than the large-seeded material with a greater range for all the quantitative characters measured, as expected from the more diverse origins of the small-seeded group.

On the average, the small-seeded accessions are earlier to flower and mature than the large-seeded accessions. With this briefer period of growth, they are correspondingly shorter in stature (Figure 18). The small-seeded accessions have a lower yield of seed, straw, and total dry matter but a larger harvest index than the large-seeded material. There are more cold tolerant accessions (29%) among the large-seeded accessions than among the small-seeded group (3%) because the large-seeded material originates predominantly from the northern, colder latitudes. There are also marked differences between the two groups in the qualitative characters of the seed. For example, the large-seeded accessions generally have a yellow cotyledon, the small-seeded accessions a red cotyledon.

An analysis of the lentil data on the basis of country of origin revealed striking differences between the accessions from each country, illustrating their unique adaptation. For example, lentil germplasm from Egypt is particularly distinctive since it combines an early flowering habit with a tall plant height. The information is also useful in tracing the history of cultivation in the "New World" where lentil cultivation is post-Columban. Chilean material has very

large seeds and late maturity, whereas Mexican germplasm is much earlier to mature and has small seeds. This strongly suggests two separate introductions of lentils to the Americas from different sources.

One of ICARDA's major objectives in genetic resource work has been to supply germplasm to national programs, and 6,238 chickpea germplasm lines were distributed globally from 1978-83.



These different types and colors of lentil seeds are among the wide range of accessions to be found in ICARDA's world collection from 54 countries.

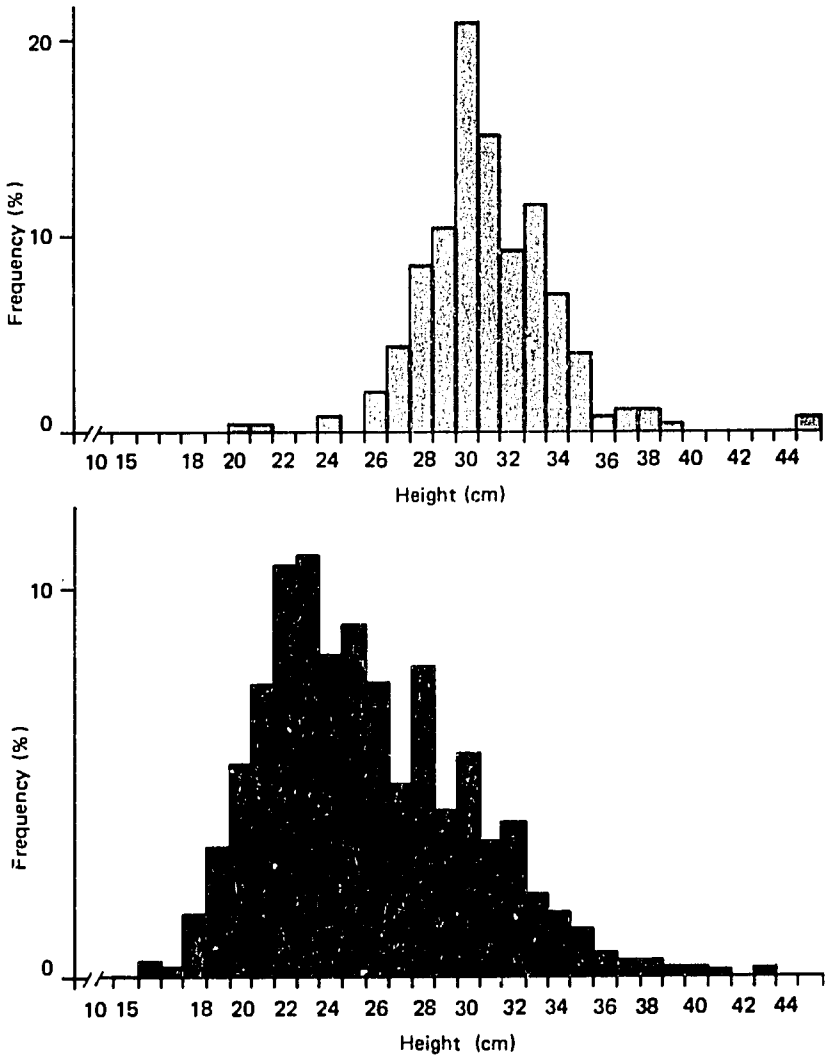


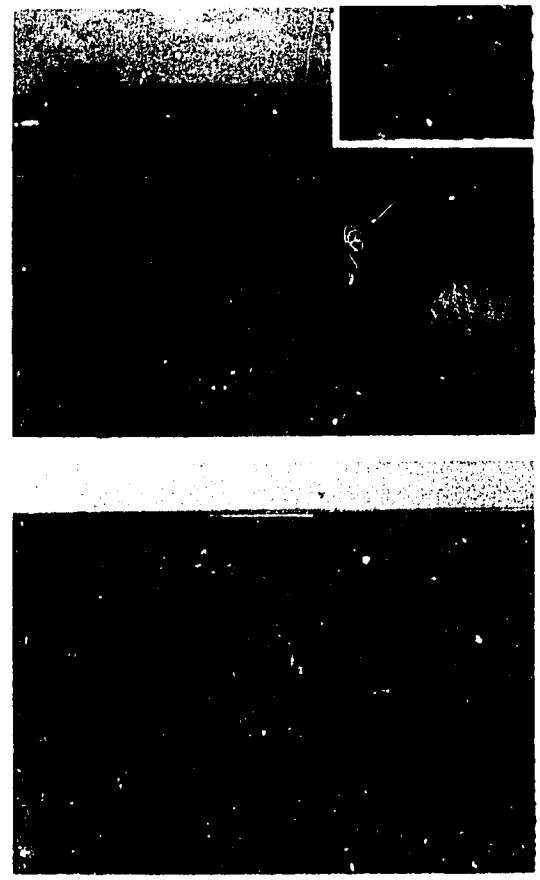
Figure 18. Top, distribution of plant height (cm) in the lentil germplasm collection for large-seeded accessions (>4.5g/100 seeds) and below, small-seeded accessions (<4.5g/100 seeds).

Crop Borders to Prevent Out-crossing in Faba Beans

Insect pollination in faba beans is essential for the best production in commercial fields, but in large-scale breeding programs out-crossing due to insect pollinations is undesirable because of the difficulty to maintain the genetic purity of different lines. To prevent out-crossing, cumbersome and costly methods of isolation have had to be used, including long distances between plots, insect-proof cages, or individual bagging of plants with nylon nets. But a simpler and cheaper technique to increase and evaluate a large number of genotypes at low out-crossing rates shows promise in preliminary tests: the use of borders of triticale and *Brassica*.

The main purpose of isolating faba bean genotypes is to prevent pollinators from transferring pollen from one genotype to another. To achieve this, faba bean plots can be surrounded by triticale which grows taller than the faba beans and acts as physical barrier, thus making it difficult for the insects to reach the faba bean flowers. Another possibility is to surround the faba bean plots with a crop attractive to the insects and competitive with the faba beans for bee visits to the flowers. *Brassica* was chosen for this purpose. The flowering periods should coincide, and this can be secured by planting the *Brassica* two or three weeks in advance of the faba beans.

In the 1982/83 season, different faba bean genotypes were planted in 9 x 12 m plots. These plots were completely surrounded by 6 m wide strips of *Brassica* or triticale. In a different field, faba bean plots of identical size were planted, but in this case they were separated by 6 m strips



The use of *Brassica* (top photo) and triticale (lower photo) as borders around faba beans to prevent out-crossing due to insect pollination shows promise in preliminary tests. *Brassica* borders were more efficient than triticale in reducing bee activity in faba bean research plots. The border technique is cheaper and simpler than individual bagging of plants.

of bare soil to serve as a check. During the flowering period regular counts of honey bees and solitary bees visiting faba bean flowers were made in each of four replications of each treatment. Judging by the number of insects foraging the flowers, *Brassica* was very efficient in reducing honey bee and solitary bee activity in faba beans (Figure 19). Triticale was less efficient. Attractants and repellents were also tried, but they did not improve the efficiency of the *Brassica*.

Reduced bee activity should result in lower out-crossing rates. To measure this, check plots were grown with the Reina Blanca variety which has a white hilum marker. Seeds from these plots will be grown and scored for out-crossing in 1984. Preliminary results from previous years showed low out-crossing rates for both *Brassica* and triticale isolation plots (7 and 9%, respectively). These low out-crossing values are very acceptable for pragmatic breeding programs when compared to a natural out-crossing rate of around 36%.

A further possibility suggested from the results of bee counts within *Brassica* isolation plots would be the growing of F_2 populations and later generation progeny rows in blocks surrounded by *Brassica*. This hypothesis is being tested by growing marker rows within faba bean plots surrounded by *Brassica* to confirm expectations that out-crossing rates are low within a plot because few insects visit them. Another improvement might be the reduction of the area planted with *Brassica* around each plot. This would reduce land requirements for the technique. Two-meter and one-meter strips are being tested.

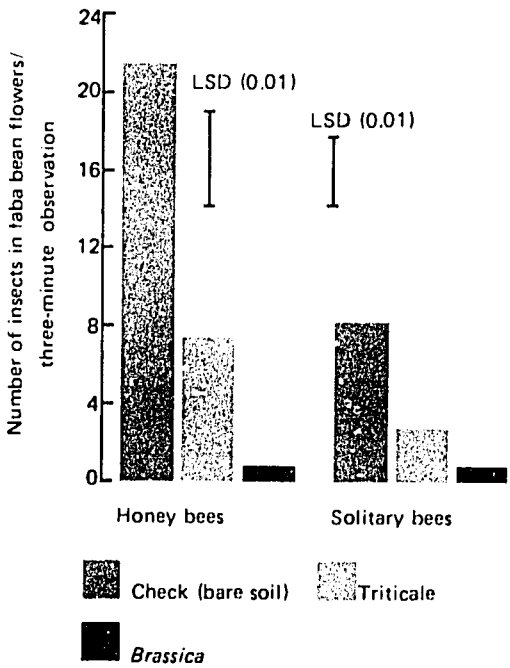


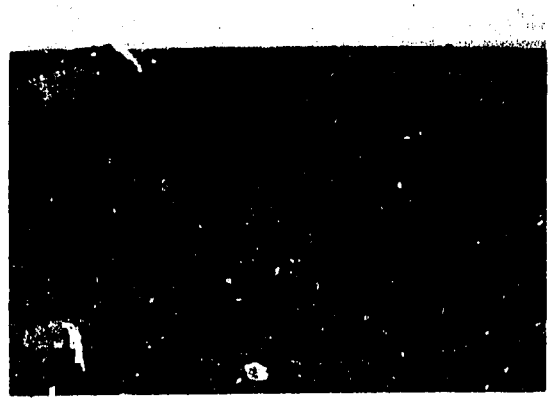
Figure 19. Effect of isolation mechanisms on the number of honey bees and solitary bees visiting faba bean flowers in 9x12 m plots (means of six scoring dates).

Host-Plant Resistance to Ascochyta Blight in Faba Beans

Ascochyta blight (*Ascochyta fabae*), a destructive seed and air-borne disease of faba beans (*Vicia faba*) throughout Asia, North Africa, Europe, Canada, and the USSR, can cause yield losses of up to 50% with moderate disease levels and 90% with a severe disease epidemic (Figure 20). So far, the only means to help control it have been modified cultivation practices, sanitary measures, and expensive fungicides which are out of reach of poor farmers.

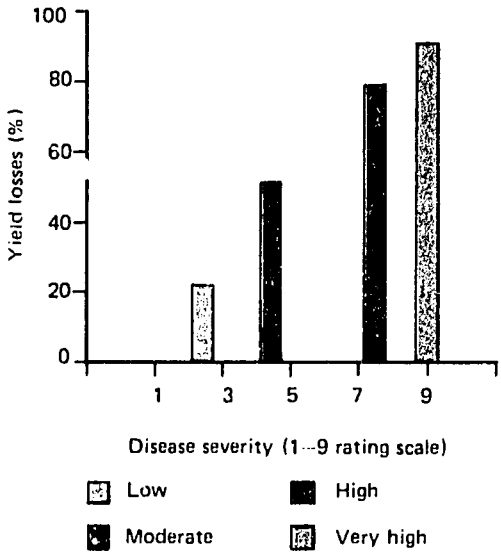
Because effective disease management cannot be attained without host-plant resistance, large numbers of faba bean germplasm accessions have been screened for resistance to Ascochyta blight at ICARDA's sub-site in Lattakia, Syria on the Mediterranean coast where disease-inductive conditions prevail during the growing season. Of the 2,200 accessions tested over the past five years, only five were rated 1 (highly resistant), and eight rated 3 (resistant), on a 1-9 scoring scale. All local checks were susceptible with ratings of 7 or 9 (Figure 21).

Seeds of the resistant sources have been increased and distributed for evaluation and use in different geographical regions. In this multi-location testing, resistant sources identified by ICARDA in Syria were also rated resistant to highly resistant



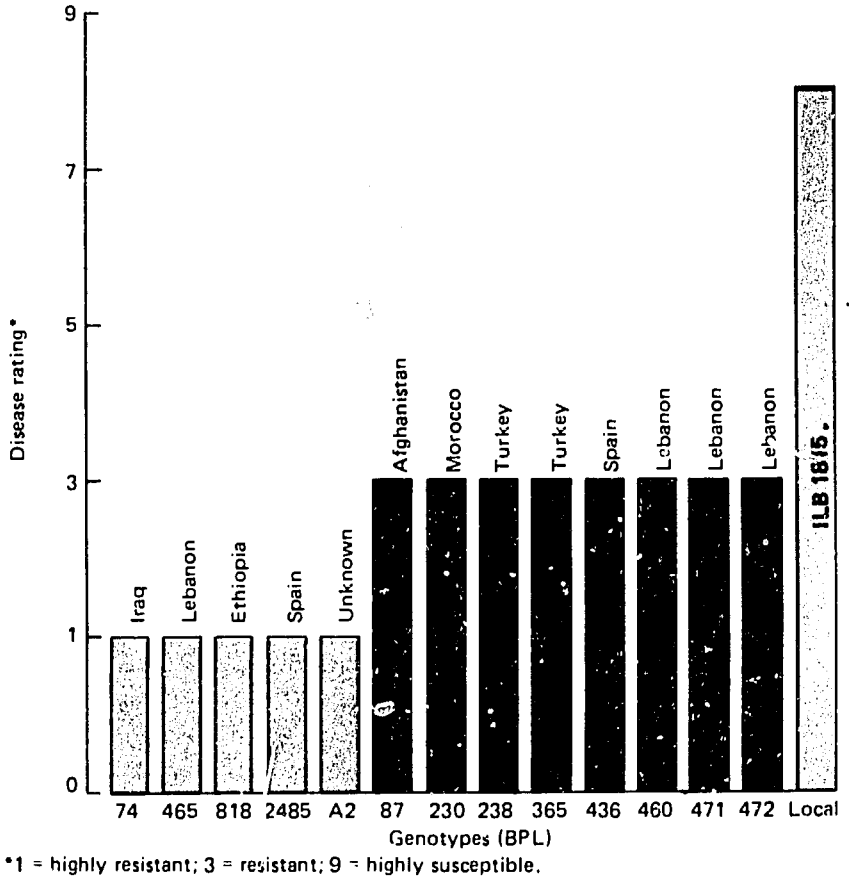
Faba bean field (above) hit with a severe epidemic of Ascochyta blight. A faba bean line resistant to Ascochyta blight (left) and a susceptible local check (right).

Figure 20. Potential faba bean losses due to Ascochyta blight at different levels of disease severity.



in Canada, Sweden, and the UK. One of the best sources of resistance (BPL 2485) provided by the Center was also rated resistant to the three known races of *A. fabae* in Canada. These sources of resistance are being used by ICARDA scientists to develop other blight resistant and high yielding lines.

In addition, crosses have been made to combine genes from lines having different mechanisms for resistance (such as tolerance and hypersensitivity) to create genetic stocks and cultivars with durable resistance to *A. fabae*. Other crosses have also been made to combine genes for resistance to Ascochyta blight with those for resistance to rust and chocolate spot. Multiple disease resistant lines are important for areas where complex disease situations are encountered. At present, F_2 and F_4 progenies from these crosses are being evaluated.



*1 = highly resistant; 3 = resistant; 9 = highly susceptible.

Figure 21. Ascochyta blight resistant faba bean genotypes with country of origin. (Selected at ICARDA's sub-site at Lattakia, Syria.)

Irrigating faba beans at seven-day intervals in Sudan gave better yields and larger economic returns than conventional 14-day intervals.

Proper Water Management: A Key to Increased Production of Faba Beans in the Nile Valley

Millions of people in Egypt and Sudan depend on faba beans (*Vicia faba*) as a main staple food for both breakfast and supper. In recent years, demand has been outstripping local production and to bridge the gap these countries have had to import faba beans at high prices. Research by Egyptian and Sudanese scientists, in cooperation with ICARDA, has highlighted the importance of proper water management as one of the key factors to increase faba bean production.

A common practice of farmers in Egypt is to delay the first post-planting irrigation by more than a month which subjects the crop to soil moisture stress. Also, the crop generally receives only one irrigation before the canal is closed for annual cleaning in January. Results of field studies in southern Egypt at three research stations (Sids, Mallawi, and Matana) showed that faba bean yields were severely reduced if the first post-planting irrigation was delayed by more than four weeks (Figure 22). The

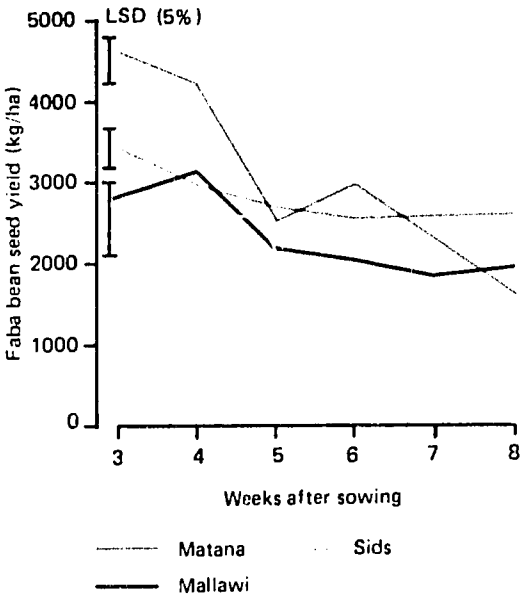


Figure 22. Effect of the timing of the first post-planting irrigation on the yield of faba beans at three research stations in southern Egypt.

recommended practice, which results in better plant growth and podding, calls for two post-planting irrigations before the annual closure of the canal, with the first one not later than four weeks after sowing.

In Sudan, where the growing season is short and the winter mild, the beneficial effect of more frequent irrigation than normally practiced by farmers was particularly noticeable. In an experiment conducted at Hudeiba, Shendi, and Shambat research stations in northern Sudan, irrigating faba beans at an interval of seven days gave significantly better yields and larger net economic returns than the conventional practice of irrigating at two week intervals (Table 23). The practice of more frequent irrigation (at 7 to 10-day intervals) was further evaluated in a series of farmer-managed trials in Aliab, Zeidab, and Selaim irrigation schemes in northern Sudan, and the results (Table 24) reinforced those obtained at the three experiment stations.

Table 23. Effect of recommended irrigation frequency on the seed yield and net economic returns from faba beans in North Sudan.

Location	Irrigation frequency: Recommended (7-day interval)	Irrigation frequency: Conventional (14-day interval)	LSD (5%)
	Seed yield (kg/ha)		
Hudeiba	2157	1450	219
Shendi	2086	1265	237
Shambat	2954	1639	167
Mean	2399	1451	
	Net benefit (Sudanese pounds/ha)		
Mean	1235	819	

The research reported here is part of the Nile Valley Project supported financially by the International Fund for Agricultural Development (IFAD). This project is unique because it places the responsibility for leadership, coordination, and actual execution of the work with the national scientists, and it involves the farmer himself in the research process. ICARDA plays a catalytic and research backup role.

Irrigation systems in Sudan contribute to research projects. A farmer being interviewed about his experience with a farmer-managed faba bean trial in northern Sudan.

Locations (sites)	Production practices*	Seed yield (kg/ha)	Net economic returns/ha**
Aliab	**Recommended**	**2831**	**1229**
	Farmer's	2316	1054
	SE ±	116	
Zeidab	**Recommended**	**3583**	**1846**
	Farmer's	2464	1314
	SE ±	143	
Selaim	**Recommended**	**3439**	**1942**
	Farmer's	2875	1692
	SE ±	142	

* Recommended practices included more frequent irrigation and weed and pest control, but, because the weed and pest infestations were negligible, the main factor in the improved practices was more frequent irrigation.

** Sudanese pounds per hectare.

Table 24. Effect of recommended practices on the seed yield and economic returns of faba beans in the farmer-managed trials in North Sudan.

Lentil Seed Size, Straw Yields, and Genetic Variation

Lentils are cultivated in West Asia both for seed and straw, and an economic analysis of survey data shows that the revenue to the farmer from the sale of lentil straw as a livestock feed is sometimes as large as that from the seed. When grain yields are poor, the relative contribution of straw to the total value of the crop is greatest, providing a buffering mechanism to the farmer against total crop loss.

The straw enters into both local and international trade and comprises the pod walls, leaflets, and branches obtained by the traditional threshing process. Research on lentils addresses both the seed and straw components of the crop. A study was undertaken to determine the relationship between these components as one means of assisting the advancement of the breeding program. In a world germplasm collection of 3,586 accessions grown at one location, the mean yields of seed and straw were 1,287 and 2,932 kg/ha, respectively. Correlations showed that large seed yields tend to be associated with large straw yields.

In the second part of the study, the mean yields of seed and straw of 24 cultivars grown in three rainfed locations were 1,222 and 3,166 kg/ha, respectively. Again there was a strong and positive correlation between seed and straw yields, indicating that

After the lentil harvest (left) a farm family starts the process of separating the lentil seed from the straw (center); then

in Straw Quality

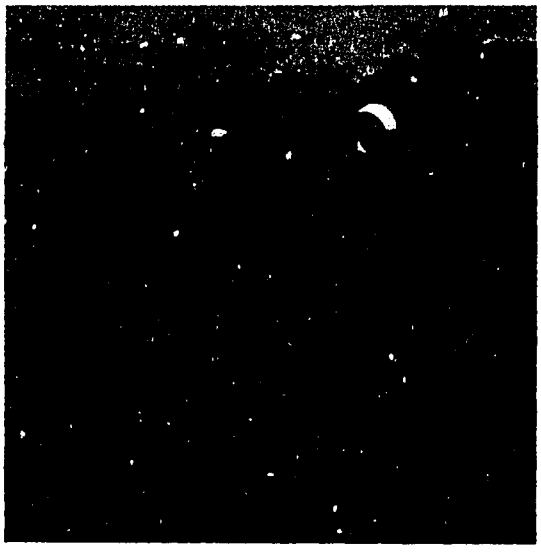
continued selection for seed yield will not reduce straw yield but will likely increase it.

Because the quality of straw for livestock feed must also be taken into account in lentil improvement, a study of the genetic variation in straw quality was conducted at Tel Hadya. The neutral and acid detergent fiber contents of the straw varied from 55-64% and 38-45%, respectively. There were also highly significant differences among the genotypes in dry matter digestibility which varied from 48 to 58%. The dry matter digestibility of the local check was 54% on the average. The overall productivity of the trial was 1,414 kg/ha of seed and 2,464 kg/ha of straw.

The plants were well nodulated, and there were significant genetic differences in the protein content of both straw and seed. The range in straw protein content was from 5.9 to 8.6% with the local checks showing a level of 6.5% protein on the average. The corresponding range for seed protein content was from 24.3 to 25.7%. The average seed protein yield and straw protein yields were 353 kg/ha and 171 kg/ha, respectively.

Results of this research clearly establish the presence of considerable genetic variation in the quality of lentil straw. As a result, the quality of straw of lentil selections will be monitored in the future.

seed is screened (right). Studies show a strong and positive correlation between seed and straw yields.



Legume and Cereal Mixtures for Hay Production

Results of research from earlier years showed that cereals yield more hay than either vetches or peas but that the quality of cereal hay was poor. However, if some legume were added, hay quality improved without greatly affecting yield. Because the exact proportion of legume was still uncertain and the effect of different seasons needed further study, a more detailed analysis of the problem has been made.

Six forage mixtures, vetches and peas in combination with barley, oats, and triticale, were sown at three seeding rates (120, 160, and 200 kg/ha) and five ratios of legume to cereal (0:100, 33:66, 50:50, 66:33, and 100:0). The mixtures were harvested when the legumes were all flowering, and the components were separated by hand. The quality of the hays was determined using Kjeldahl nitrogen analysis and *in vitro* digestibility assays.

The effect of rate of sowing was slight and differences were not statistically significant. This may be explained by the good season and long growing period which always reduces differences due to plant population. However, the effect of seed ratio was far more important. In no case was there a reduction of yield due to inclusion of legumes. In fact, legume/cereal mixtures yielded more than either component when grown alone (Figure 23). Again hay quality was far better by including legumes. The yield of digestible dry matter of the best mixtures was almost double and protein almost four times that of cereals alone (Figure 24).

At least half and as much as two-thirds of the seed sown should be legume. The question of which species to use is still not resolved. In field tests, the yield of both pea and vetch mixtures consistently exceeded 5

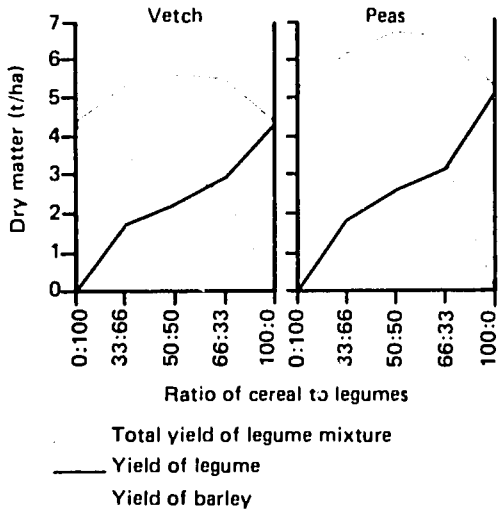
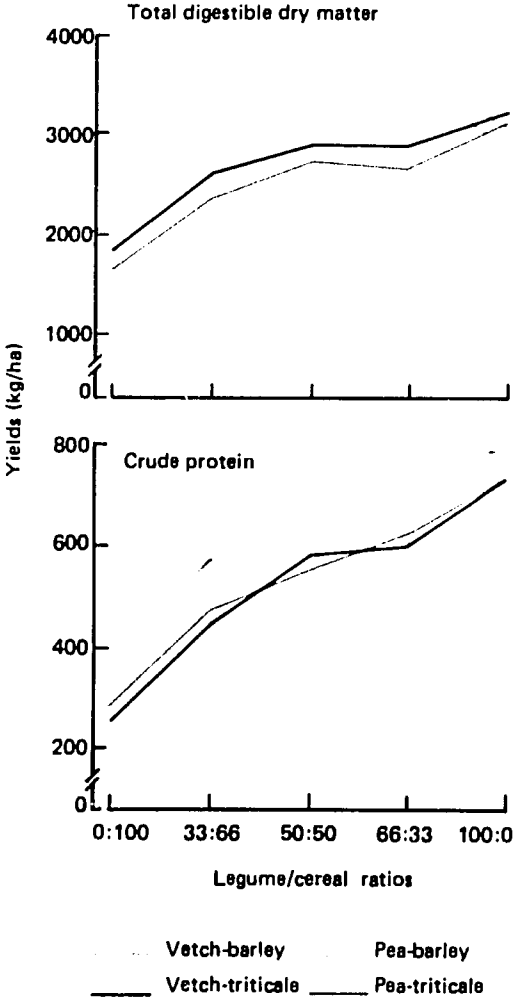


Figure 23. Dry matter yield effects of different proportions of vetch and peas in mixtures with barley for hay production.

t/ha, approaching 6 t/ha when vetches were sown with oats, and exceeding 6 t/ha for peas with barley.

It is likely that better varieties will eventually be selected and that the best species will vary between both sites and seasons. For example, in Syria during the 1982/83 season vetches were best at the southern site of Izraa and peas at the northern site of Hama; vetches were best at the dry Salamieh site and peas at the far northeast site of Kamishly.

Collecting rumen fluid from a sheep for laboratory tests to determine digestibility of forage mixtures.



Based on laboratory assays, the yield of digestible dry matter of the best legume/cereal mixtures for hay production was almost double and protein almost four times that of cereals alone.

Figure 24. Total digestible dry matter and crude protein yields of four forage mixtures at different ratios of legume to cereal.

Managing Forage Crops for Grazing and Hay

One of the options open to farmers is to use their forage crops for grazing in winter and then cut the regrowth for hay in the spring. How does this practice affect hay production and quality? During 1983, ICARDA scientists designed experiments to find some answers to this question.

They sowed four mixtures: barley with peas, barley with vetches, triticale with peas, and triticale with vetches. The mixtures consisted of 60% cereal and 40% legume, and the rate of sowing was 150 kg/ha. Half the area was grazed in February to ground level by sheep and half ungrazed. Yield was measured before and after grazing (when the plants were 15-20 cm high) and at full flowering. At each harvest the components (cereal and legume) were separated by hand and total dried forage, crude protein percentage, and digestible dry matter calculated.

In grazing trials, sheep showed a definite preference for a vetch/cereal mixture (background) compared with a cereal/pea mixture (foreground). The peas were the last item in the mixture to be eaten.

Results showed that the animals had a definite preference for vetches compared with peas at the green stage. At grazing time, 24% of the mixtures eaten by the sheep consisted of vetch, only 14% of peas. However, at haymaking time, the vetch accounted for approximately half of the

Table 25. Effects of winter grazing on total dry matter (DM), total crude protein (CP), and total digestible dry matter (TDDM) yields of forage mixtures (1983).

	Barley/pea			Barley/vetch			Triticale/legume(1)		
Treatment	DM	CP	TDDM	DM	CP	TDDM	DM	CP	TDDM
Grazed(2)	3850	476	2284	2960	415	1775	3794	476	2665
Ungrazed	4459	408	2562	4085	473	2156	4435	495	2954
LSD (5%)	n.s.(3)	n.s.	n.s.	1145	n.s.	173	591	n.s.	n.s.

(1) Values are means for triticale/vetch and triticale/pea in the same trials.
(2) Values include amounts consumed by grazing animals.
(3) n.s. = not significant.

mixture. Grazing actually increased the proportion of legumes in the barley mixtures while there was little effect of grazing on the composition of the triticale mixtures. However, total yield and total digestible dry matter of barley/vetch mixtures were significantly reduced by grazing. This was not the case with either the triticale/legume or the barley/pea mixtures (Table 25).

Observations in this preliminary study are being verified, and, together with the new results, they will form the basis of ICARDA's recommendations on using forage crops for both grazing and hay.

A New Pasture Species for Northern Syria

Introducing legume-based pastures to replace the fallow in cereal/fallow rotations is one of ICARDA's objectives. A farmer who follows a system in which livestock graze the pasture in the first year of the rotation and cereal is sown in the second not only improves his ability to feed his livestock but also increases cereal yields as a result of improved soil fertility.

The most important group of plants used in the system are annual species of *Trifolium* (clovers) and *Medicago* (medics), the former on acid soils and the latter on alkaline soils. Because most of the soils in the region are alkaline, the greatest interest has centered on a search for the best adapted medic species. *M. rigidula*, native of the Mediterranean basin, Iraq, Iran, and parts of the Soviet Union, is one of them. Its wide distribution has resulted in extreme variability, and botanists have identified four varieties: *rigidula*, the most common variety and abundant in the west; *cinerascens*, a rare variety throughout its habitat; *submitis*, restricted to the east; and *agrestis*, more common in the east. The varieties are not distinct and tend to merge into each other.

Medic selection by ICARDA began in 1977 when more than 1,600 genotypes of 28 species were examined in nursery rows. By 1983, these had been reduced to five genotypes of *M. rigidula* growing at four sites in Syria. Time to maturity, seed coat impermeability, seed yield, herbage yield, and a large number of other attributes were used to narrow down the original variability. The herbage and seed yields at the four sites and also of the Australian cultivar Jemalong (*M. truncatula*) are shown in Table 26.

The ICARDA selections come from three of the varieties. The most promising genotype, 811/716, belongs to the relatively rare variety *cinerascens* and was collected at Jisr El Shaghour in the high rainfall zone southwest of Aleppo, Syria. It is a vigorous

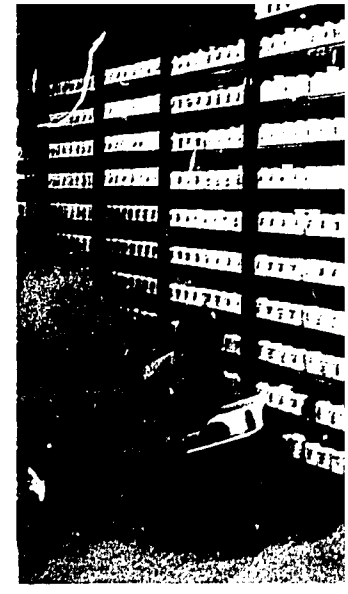
Seed of *Medicago rigidula* (right) is being sown in relatively large areas of northern Syria to study grazing management of annual pastures and the integration of livestock and pastures in farming systems. A Syrian farmer (below) is using a medic in his farming system instead of leaving his land fallow for a season without a crop. His sheep graze the medic pasture one season and he plants cereal the next. If lightly grazed, the medic will set seed and regenerate itself.

grower in winter, flowers a little before Jemalong, and produces copious amounts of seed of an acceptable level of seed coat impermeability. Pods are spiny but not excessively so.

The selection process is not yet finished. The genotypes still need to be tested under grazing conditions and in rotation with cereals. More work is also needed to determine exactly where *M. rigidula* will grow compared with other promising species. But it is clear that the selections show great promise and in the near future a new plant species will be brought into cultivation.

Table 26. Evaluation of five selections of the medic species, *M. rigidula*, at four sites in Syria (1982/83).

		Dried herbage (kg/ha)			
Acc.no./Sel.no.		Kamishly	Hama	Salamieh	Izraa
M. rigidula	835/1295	4671	6646	1686	2780
«	1783/ 734	4450	6531	1705	2058
«	1075/1304	4343	6621	1071	1586
«	281/1310	3957	5242	1533	1718
«	811/ 716	3268	6282	1717	4184
M. truncatula cv.	Jemalong	318	4465	780	2728
LSD (5%)		1547	1124	984	1556
		Seed production (kg/ha)			
Acc.no./Sel.no.		Kamishly	Hama	Salamieh	Izraa
M. rigidula	835/1295	463	821	210	724
«	1783/ 734	415	674	277	495
«	1075/1304	591	940	277	878
«	281/1310	412	684	383	489
«	811/ 716	495	1083	330	775
M. truncatula cv.	Jemalong	68	501	133	681
LSD (5%)		188	358	140	326



Part of ICARDA's germplasm "bank" of about 70,000 holdings in seed form. Much of the "bank's" stock of the most important West Asian and North African crops is active and sent to many countries for study or use in plant breeding programs.

Safeguarding Plant Resources for the Future

Spearheading an effort to stem the loss of genetic variability, ICARDA now has the world's major collection of genes for some of the most important West Asian and North African crops. Its germplasm "bank", a treasury of approximately 70,000 holdings in seed form, is vital for future plant breeding research.

Germplasm collections are the source of genetic diversity from which to modify and improve crop plants through breeding to produce new high yielding varieties. These new varieties have proved to be an indispensable part of agricultural development.

The gene spectrum in the "bank" reflects the Center's responsibility for particular crops. Holdings from many sources in the world number in the tens of thousands for durum wheat and barley, and in the thousands for chickpeas, lentils, and faba beans. Pasture and forage crops are another important part of the collection. All new seed sent to the "bank" is carefully evaluated for health because it is important to insure that no exotic diseases or insects are distributed to or imported from any country.

Data on morphological and agronomic characteristics and other factors are being documented for each accession in the germplasm collection. Although con-

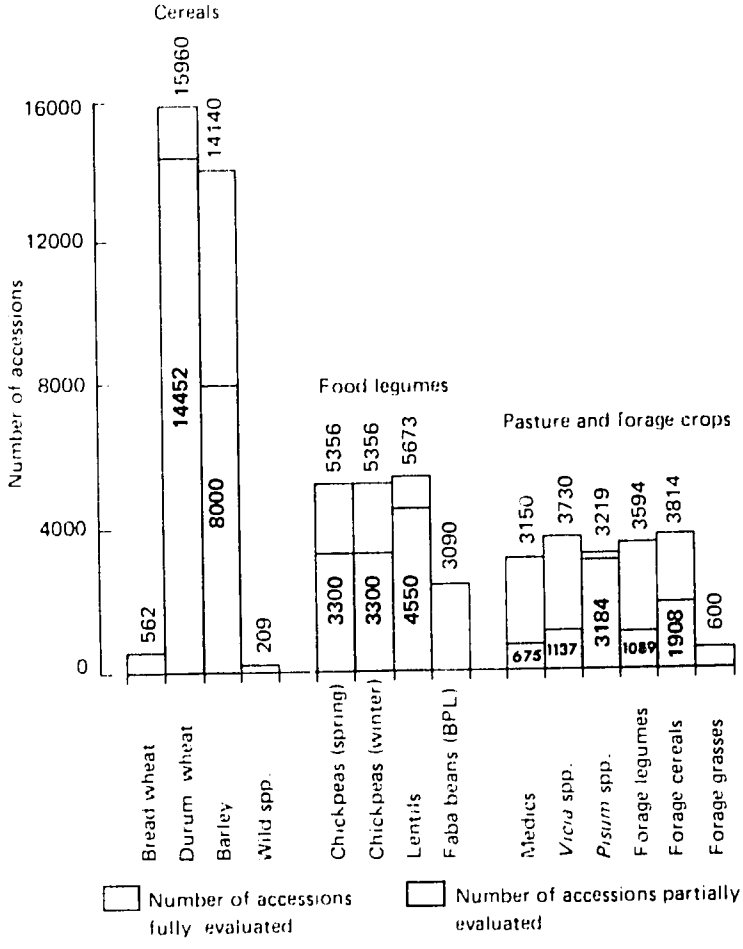


Figure 25. Status of evaluation of ICARDA's germplasm collection at the end of 1983.

siderable progress had been made by the end of 1983, the work is only partially completed (Figure 25).

Much of the "bank's" stock is sent to countries for study or use in breeding programs. A separate base collection is left sealed for as long as 25 years. The gene "bank" is continually augmented to fill geographic and genetic gaps. Expeditions have sought germplasm from Syria, Jordan, Iraq, Turkey, Lebanon, and Morocco.

During 1983, ICARDA scientists explored Morocco for wild species of medic, a legume from the Mediterranean area with potential as pasture in the region. During 1984, they expect to join a group sponsored by the International Board of Plant Genetic Resources (IBPGR) in collecting all land races of wheat in Morocco. It is part of a cooperative effort between ICARDA, IBPGR, and national programs to insure that the region's genetic treasures will not be lost forever. ICARDA leaves a portion of each collection with the host country and trains local scientists in genetic conservation techniques.

The Center's location enhances its ability to safeguard key crop resources. Many cultivated plants evolved in the Mediterranean and Near East area. The greatest variety of a plant's genes exists near where it originated, as does the greatest number of pests that attack the crop. Therefore, plants with genes that provide resistance to such pests are apt to be found where the plants first emerged.

To preserve crop diversity for the future, ICARDA collecting expeditions seek out the germplasm incorporated in landraces and in wild relatives of the cultivated species. Landraces, grown for a long time by farmers, have not been improved by scientists. A landrace has a specific genetic makeup and is therefore adapted to a particular ecological environment.

New scientifically-bred varieties are quickly replacing landraces in most of the world. In West Asia and North Africa, for example, a new blight-resistant chickpea will probably supplant the area's indigenous chickpeas, but in the future the new chickpea could fall prey to an unknown insect. If so, breeders will be able to draw genes from the germplasm "bank" that might provide resistance to the pest. These useful genes for resistance are very likely to be obtained from wild relatives of the cultivated species.

ICARDA's Terbol Station in Lebanon's Beka'a Valley Provides Research Advantages

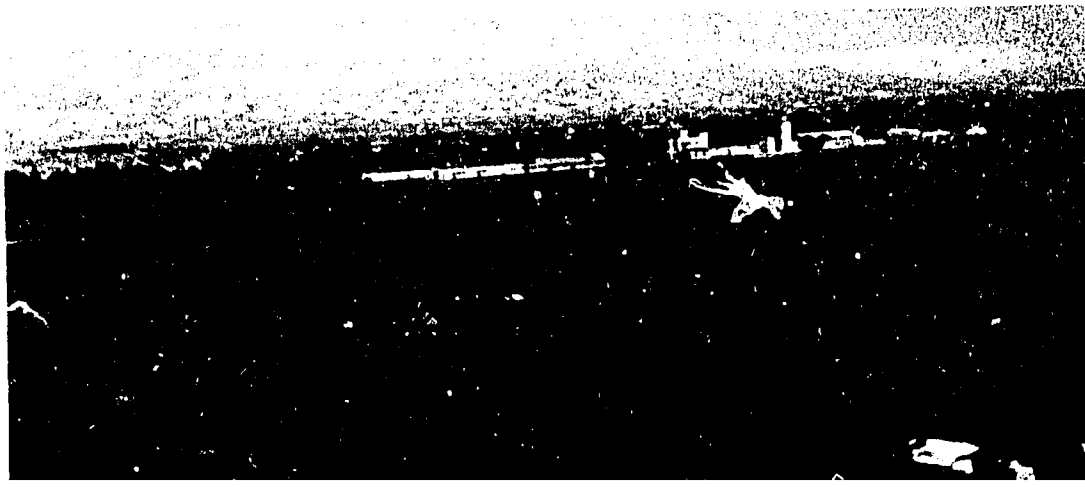
Despite the difficult and uncertain conditions in Lebanon's Beka'a valley, ICARDA's 50-hectare research station at Terbol kept going and completed its assigned work in 1983. Its cooler and wetter environment than that at Tel Hadya, Syria makes it a valuable asset for various research purposes.

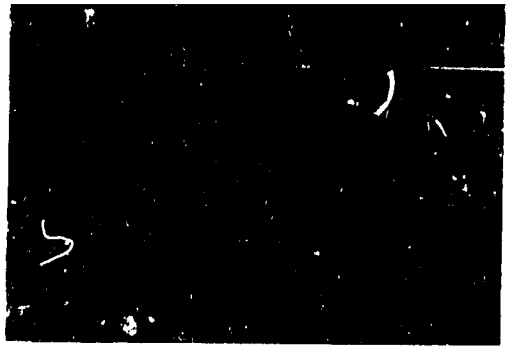
Because of its temperatures at 890 meters above sea level, ICARDA scientists use the station to test selected crops for cold tolerance under winter temperatures that drop as low as -15°C. A wetter (570 mm average annual rainfall) and more humid environment has advantages for studying diseases and developing resistant cultivars. Cereals are screened for resistance to rusts and winter chickpeas for resistance to Ascochyta blight.

Terbol's weather also permits a longer season for crossing and cooler summers allow for off-season cropping. For example, the mild summer season makes it possible to grow a successful crop of chickpeas which cannot be done at Tel Hadya. However, decreasing day length in late summer and autumn prevents the late-maturing chickpea types to mature before the onset of frost. Preliminary studies have shown that artificial light at night to extend day length hastened reproductive development of most genotypes and ensured early and uniform maturity.

A photoperiod experiment was conducted during one summer using 16 contrasting chickpea genotypes grown in different photoperiods (Figure 26). One treatment was natural day length which ranged from 14 hours at the beginning of crop growth to about 11 hours toward the end. Results (Table 27) show that genotypes ILC 1919 (ex-India) and ILC 1933 (ex-

General view of a portion of the 50-hectare Terbol research station in Lebanon.

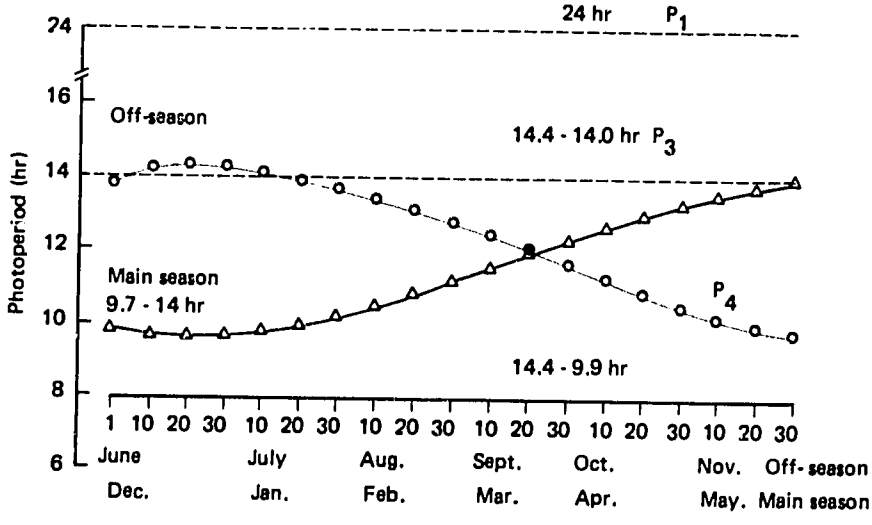




Cereal crossing blocks at Terbol. The environment there permits a longer season for crossing; cooler summers than those at ICARDA's principal experimental farm at Tel Hadya, Syria allow for off-season cropping.

Artificial lights (right) turned on at night to extend day length hastened reproductive development of most chickpea genotypes and ensured early and uniform maturity compared with those on the left without continuous light.

Figure 26. Changes in photoperiod during the off-season and main season cropping period of chickpeas at Terbol, Lebanon. (P_1, P_3, and P_4 are the periodic treatments.)



Sudan) responded less than genotypes ILC 72 (ex-Spain) and ILC 3279 (ex-USSR). Continuous light greatly hastened flowering in the latter genotypes. Night break (P_2) shortened the time to flowering of the latest genotypes only. A 14-hour photoperiod was adequate to shorten the time to maturity of most genotypes, but not for the late-maturing types from the USSR.

The findings have two important implications: It is possible to advance a generation of chickpeas during summer with the help of supplementary daylight, and the summer season can be used to screen genotypes for less photoperiod sensitivity. The chickpea breeding program has taken full advantage of both. The F_1 generation is grown with supplementary light to ensure maturity of all the material. F_3 generation material onward is grown under natural daylight which helps to eliminate highly photosensitive genotypes. This has practical significance. Lines which do not mature under natural daylight in the summer adapt poorly to spring sowing in the Mediterranean region and to winter sowing in the sub-tropical region.

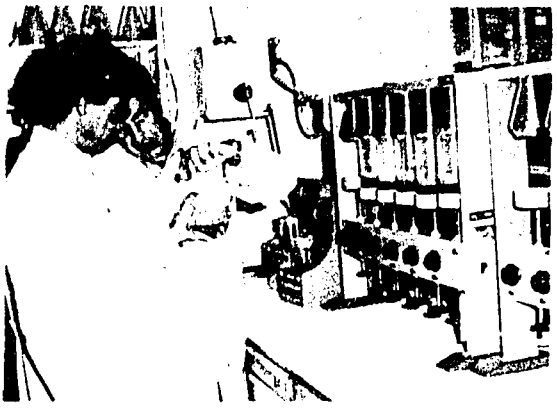
By making full use of the off-season facilities at Terbol, several cultivars have been bred and furnished to national programs. Some have already reached on-farm trials or multilocational trials.

Table 27. Effect of photoperiodic treatments on flowering and maturity of some diverse chickpea genotypes during the off-season planting at Terbol, Lebanon.

	Days to first open flower				Days to physiological maturity			
	Photoperiodic treatments				Photoperiodic treatments			
Genotypes	(P_1)	(P_2)	(P_3)	(P_4)	(P_1)	(P_2)	(P_3)	(P_4)
July 2 planting:								
ILC 482 (Turkey)	44	51	49	49	72	74	73	81
ILC 1919 (India)	34	39	42	39	55	62	64	62
ILC 1929 (Syria)	36	40	40	41	62	66	67	62
ILC 1933 (Sudan)	31	34	34	35	56	62	62	62
ILC 72 (Spain)	49	65	73	79	68	86	104	104
ILC 3279 (USSR)	49	58	74	77	72	82	104	NM
July 16 planting:								
ILC 482	30	46	53	59	59	72	85	83
ILC 1919	29	44	44	43	60	69	69	69
ILC 1929	30	41	43	48	58	66	68	76
ILC 1933	29	33	39	38	58	65	62	65
ILC 72	31	69	63	NF	58	94	86	NM
ILC 3279	32	63	64	NF	59	89	90	NM

P_1 = continuous light; P_2 = night break, 00-1 a.m.; P_3 = 14 hr. of light, 4 a.m. -6 p.m.; P_4 = natural daylight.
NF = not flowered; NM = not matured.

A training participant from Saudi Arabia (center) gets "hands on" experience with mechanical planting equipment.



In this laboratory, a trainee learns how to determine the protein content of forage crops.

Update on Training: A Direct Linkage with Research Programs

One year after ICARDA started operations in 1977, it began a training program to help develop the human resources needed for national research programs in West Asia and North Africa. Since then, 444 national scientists and technicians from 32 countries have been introduced to the work being done at the Center, to the research methodologies employed, and to new forms of technology. But this training has not been a "one-way street." ICARDA also benefits because its own research capacity is enhanced, and the Center's scientists are able to keep in close touch with the practical needs of national programs.

At first, all of the training took place at the Center's headquarters in Syria, but gradually in-country courses, in cooperation with national scientists, were offered

Two training participants from China visit a research station in Egypt with an ICARDA faba bean breeder.

in Morocco, Egypt, Sudan, and various locations in Syria. Others are scheduled for 1984 in Pakistan, Morocco, and Syria.

The largest number of training participants have come from Syria, Morocco, Sudan, Egypt, Tunisia, and Jordan, followed by Pakistan, S. Yemen, Afghanistan, Turkey, and Algeria. Most of the participants trained at ICARDA's headquarters have been involved in either short-term courses of two to three weeks or long-term courses. The latter generally are scheduled for six months with field and classroom/laboratory instruction. The practical field instruction accounts for about two-thirds of the training time. Each participant is assigned a research problem relevant to his or her work in the home country.

Several junior and senior scientists from national programs also come to ICARDA for a predetermined period to work individually with the Center's scientists. For example, one young scientist from Ethiopia spent nine months in 1981 doing plant breeding research in collaboration with an ICARDA senior scientist at Tel Hadya. He is now pulse coordinator for the highlands in his country. Another from Pakistan worked on cereal breeding projects for six months during 1981 and today is principal wheat breeder at the Quetta research station.

A visiting senior scientist from Sudan came for one month in 1983 to become familiar with gas liquid chromatography equipment in the Center's microbiology laboratory. When he left, he took similar equipment with him to use in his research in Sudan. Two other visiting scientists during 1978-79 are now senior scientists on the ICARDA staff.

A few graduate students from various universities do their thesis research for ad-

Trainees from Syria, Afghanistan, and Iran are briefed on a barley experiment by a senior scientist (center). Field instruction accounts for about two-thirds of the training time in long-term group courses.

vanced degrees under the direction of ICARDA senior scientists. Recent theses include such titles as *Response of Faba Bean Lines to Bruchus dentipes*, *Effect of Grazing of Barley on Available Soil Nutrients and Moisture under Rainfed Conditions*, and *Inheritance of Morphological and Physiological Characters of the Local Cultivar Arabi Abiad*.

In 1983, the first quinquennial review of ICARDA by a panel of internationally recognized authorities called for the formulation of appropriate strategies to improve the quality and quantity of training, as well as enhancing the Center's ability to efficiently deliver this training both at its headquarters and directly to national programs at selected in-country sites. One of the first actions taken by the Center after the review was to appoint a head of training to be responsible for administration and coordination of training operations. He works closely with the training officer in each of the major research programs who plans, develops, and implements the courses in his specialized area in cooperation with the program leader and scientists.

Better classroom and library facilities at ICARDA's headquarters will improve the quality of teaching when the new permanent training and communications building now under construction is completed in 1986. Most of the resident classroom instruction at the Center has had to be in inadequate temporary buildings.

ICARDA is seeking a broader base of training resources through increasing the scope of collaborative activities with other international centers and national agricultural research institutes and organizations. Also, progress is being made to establish additional formal linkages with regional universities to help meet the agricultural research manpower needs of national programs through jointly developed training programs.

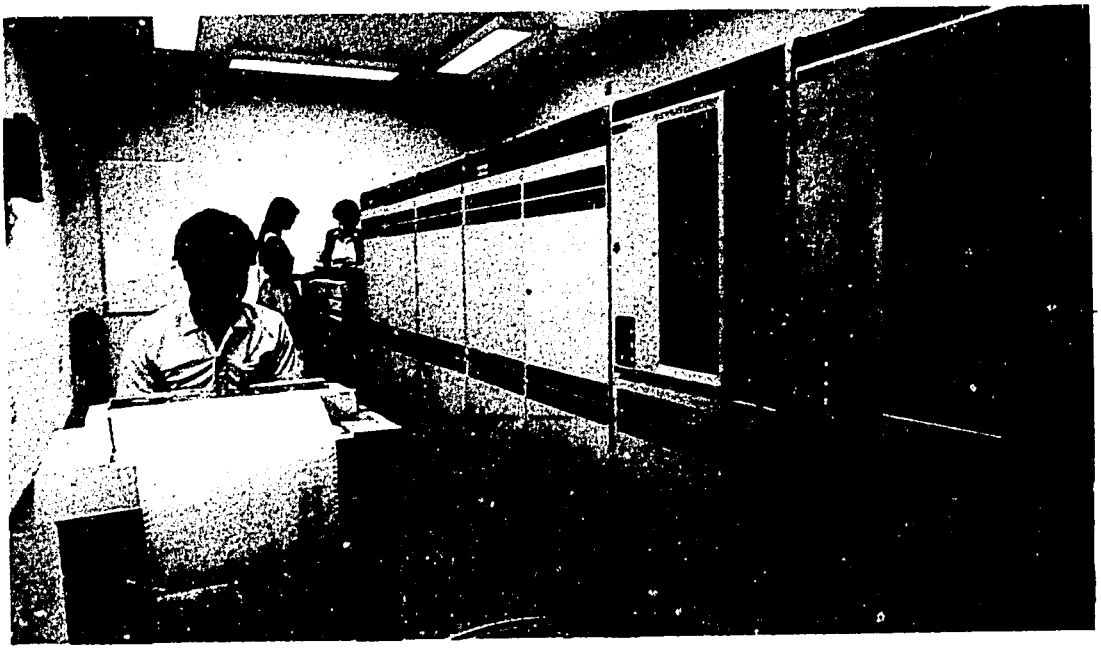
A graduate student from Syria, registered at Reading University in England, is doing her Ph.D. thesis research under the direction of an ICARDA senior scientist.

Managing Research Data More Accurately, Quickly, and Easily with Computers

By the end of 1983, the first stage of ICARDA's computer services development was completed, including meeting the basic analytical needs of scientists. They can now use the computer for tasks ranging from designing experiments to handling huge amounts of data from hundreds of trials to producing final performance tables to interpreting farm survey results. The computer also helps to meet administrative needs, from payrolls to investments, more quickly and accurately.

Efforts of the Center's computer specialists have focused on three areas. The first has been the development of basic software, including proper packages (or suites of computer programs) for needs as diverse as genetic resources, meteorological data, cereal nurseries, and mailing lists.

ICARDA's computer is used by scientists for analyzing results of experiments and for many other purposes.



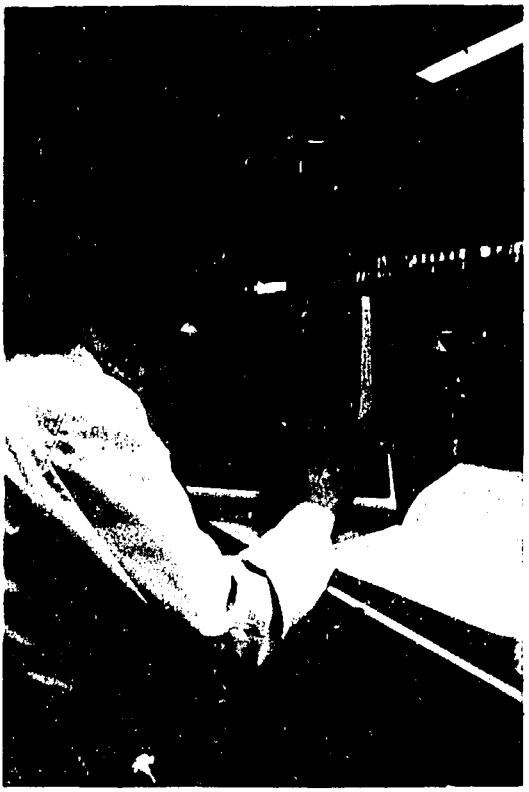
The computer staff has also produced a unique data base management system to coordinate the use of special purpose computer programs.

A second priority, statistical analysis and experiment aids, has been addressed by a statistical package developed primarily for plant breeders. However, it is used by scientists in all ICARDA research programs to analyze results from international nurseries, produce variety performance tables, and select the best cultivars. Software foundations for more sophisticated statistical analyses are also in place.

Vital details on basic characteristics of parental crop lines, previously lost or inaccessible, can now be saved. For example, before the computer services became available in September 1982, the Center might have selected 50 lines of durum wheat from 10,000, but the selection process went unrecorded. Now, data behind the selection can be sent worldwide. Also, in ICARDA's program to provide superior germplasm to national programs, the computer system makes it possible to report more quickly and accurately how a given genotype performs in many different locations and environments.

Harnessing the computer for documentation has also begun with the production of ICARDA's first computerized catalog containing data on 3,300 kabuli chickpea lines. Germplasm catalogs for other crops are now being prepared.

Another advantage of the system will appeal especially to scientists for future field work. Plans call for portable microcomputers which they can take to the field, enter data on yields and other characteristics, weigh seeds on a computer balance, then link the small computer to one back at headquarters. The process of logging harvest data should then become less laborious and time-consuming.



Data from laboratories can be recorded directly on the computer for analysis and later recall.

The third goal met by computer services has been streamlining administrative data processing. Original management programs created for the Center's needs allow efficient tracing of financial transactions, and status reports now reach scientists and donors more rapidly.

ICARDA's Computer Unit consists of two separate facilities: one at the Tel Hadya headquarters with a VAX-11/780, one of the most advanced minicomputers available, and a second in Aleppo with a PDP-11/34A system.

Progress Report on ICARDA's Building Program

After several years of fund raising activities and preparing architectural designs and plans, three of ICARDA's permanent headquarters buildings are now taking shape on its 948-hectare research station at Tel Hadya, Syria. The three new structures, started in November 1982, include two laboratories which will provide both research and office facilities for scientific staff and a training and communications center with conference facilities, computer services, library, and administrative offices.

Construction of these permanent buildings at headquarters, financed 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), is well underway. At the end of

The new building program is well underway. When these photos were taken in late 1983, one laboratory was more than two-thirds complete, another one about 15%, and the training and communications building about one-third. Plans call for all three to be ready for use in 1986.

1983, one laboratory was more than two-thirds complete, the second laboratory about 15%, and the training and communications building about one-third finished. All three buildings, constructed in reinforced concrete with external finishes of local Aleppo stone, are expected to be ready for use in 1986. Then the remaining ICARDA offices now located in two rented buildings in Aleppo 30 km north will be moved to Tel Hadya.

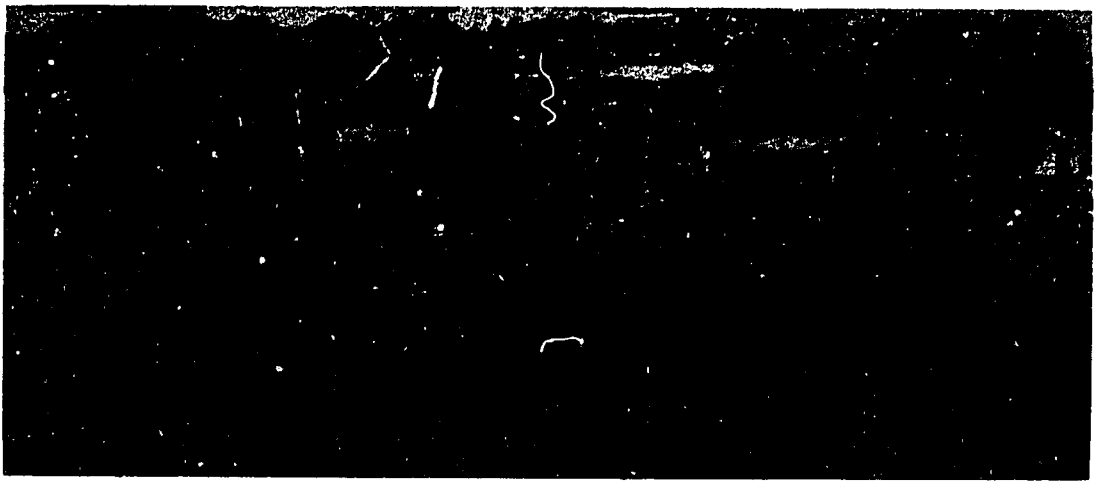
The farm complex at Tel Hadya was completed first with facilities primarily for maintenance, farm machinery, motor pool, health clinic, warehouse, sheep shed and corrals, and short-term seed storage. Built by ICARDA soon after the Center was established in 1977, the farm complex also temporarily houses some research programs and administrative offices.

Services are now in place for both the farm complex and the new headquarters buildings, including water, sewers, and electricity.

Local materials and construction firms have been used wherever appropriate. The low bidder and principal contractor for the new construction work is the Milihousing Establishment of Syria.

ICARDA recently received a grant for a Genetic Resources Center from the Italian Government and construction will begin in 1984. Funds are still being sought for a permanent greenhouse complex, short-term housing and recreational facilities, as well as senior staff housing. At the present time, there are none of these facilities at the principal experiment station site.

Architect's sketch of the complex of new buildings located on a hillside above the experimental fields of Tel Hadya.



Board of Trustees

Dr. Andreas Papasolomontos *(Chairman)*
Director General, Ministry of Agricultural & Natural Resources, Nicosia, Cyprus

Dr. Lowell Hardin *(Vice-Chairman)*
Department of Agricultural Economics, Purdue University, West Lafayette, Indiana, U.S.A.

Dr. Kenneth Anthony
Principal Agricultural Advisor, Overseas Development Administration, London, U.K.

Dr. Ekkehard Clemens
German Agency for Technical Cooperation (GTZ), Eschborn, West Germany

Dr. Jose I. Cubero
Prof. of Genetics and 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 Recherche Agronomique (INRAT), Tunis, Tunisia

Dr. G.T. Scarascia-Mugnozza
Faculty of Agriculture, Universita Della Tuscia, Viterbo, Italy

Dr. Amir Muhammed
Chairman, Pakistan Agricultural Research Council, Islamabad, Pakistan

Mr. Hassan Saoud
Deputy Minister, Ministry of Agriculture and Agrarian Reform, Damascus, Syria

Miss Naima Al Shayji
Director, External Relations Division, International Fund for Agricultural Development (IFAD), Rome, Italy

Dr. Fahrettin Tosun
Dean, Faculty of Agriculture, Ondokuzmayis Universitesi, Samsun, Turkey

Dr. Mohamed A. Nour
Director General, ICARDA, Aleppo, Syria

List of Senior Staff

DIRECTOR GENERAL'S OFFICE

Dr. Mohamed A. Nour, Director General

Dr. Peter R. Goldsworthy, Deputy Director General (Research)

Dr. Geoffrey C. Hawtin, Deputy Director General (International Cooperation)

Mrs. Joan Joshi, Director of Administration and Training*

Ms. Dalal Farah, Executive Secretary

Mrs. Nada Khattar, Executive Secretary

FINANCE

Mr. Edward Sayegh, Financial Controller and Treasurer

Mr. P. Mehra, Finance Officer

Ms. Rima Musalli, Budget Officer

Mr. S. Siteraman, Finance Officer

Mr. Anwar Agha, Senior Accountant (Beirut Office)

Mr. Salah Deif, Accountant, Nile Valley Project

Mr. Suleiman Ishaak, Senior Accountant

Mr. Fadel Kandis, Pre-Audit and Control

GOVERNMENT LIAISON AND PUBLIC RELATIONS

Dr. Adnan Shuman, Assistant Director General (Liaison)

Mr. Ahmad Mousa El-Ali (Public Relations)

FARMING SYSTEMS

Dr. David Nygaard, Program Leader and Agricultural Economist*

Dr. Peter Cooper, Soils Physicist and Acting Program Leader

Dr. Karl Harmsen, Soils Chemist

Dr. John D. Keatinge, Crop Physiologist

Dr. Seweryn Kukula, Weed Scientist

Dr. Kutlu Somel, Economist

Dr. J.C. Stevens, Microbiologist

Dr. Euan Thomson, Livestock Scientist

Dr. Fares Asfary, Analytical Agronomist

Dr. Ronald Jaubert, Agricultural Economist

Dr. Thomas Nordblom, Agricultural Economist

Dr. Habib Amamou, Post-Doctoral Fellow

Mr. Faik Bahhady, Asst. Livestock Scientist

Mr. Abdul Bari Salkini, Research Associate

Mr. Sobhi Dozom, Research Associate

Mr. Ahmad Mazid, Research Associate

Mr. Mahmoud Oglah, Research Associate (Jordan)

CEREAL CROPS IMPROVEMENT

Dr. Jitendra P. Srivastava, Program Leader

Dr. Mohamed S. Mekni, Barley Breeder

Dr. Omar Mamluk, Cereal Pathologist

Dr. Walter K. Anderson, Agronomist*

Dr. Walter Nelson, Bread Wheat Breeder (CIMMYT)*

Dr. G. Ortiz-Ferrara, Wheat Breeder (CIMMYT)

Dr. Mohamed Tahir, Cereal Breeder

Dr. Ahmed El-Ahmed, Barley Breeder/Pathologist (Tunisia)

Dr. M. Miloudi Nachit, Durum/Triticale Breeder

Dr. Rients Niks, Durum Breeder

Dr. Mark Winslow, Physiologist

Dr. Habib Ketata, Training Officer

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 C. Saxena, Program Leader and Agronomist

Dr. Cesar Cardona, Senior Entomologist

Dr. William Erskine, Lentil Breeder

Dr. Howard Gridley, Legume Breeder (Tunisia)

Dr. Salim Hanounik, Plant Pathologist

Dr. M. El 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, Plant Breeder*

Dr. M.V. Murinda, Agronomist

Dr. Mohamed El-Sherbeeny, Plant Breeder, Nile Valley Project

Mr. Patrick Houdiard, Research Associate (Tunisia)

Mr. Ahmed Hamdi Ismail, Research Associate

Mr. Abdullah Sayegh, Research Associate

Mr. Munir A. Turk, Research Associate

PASTURE AND FORAGE CROPS IMPROVEMENT

Dr. Philip Cocks, Program Leader and Pasture Ecologist

Dr. Ahmed El-Tayeb Osman, Agronomist

Dr. Jiroo Orita, Veterinary Specialist (JICA, Japan)

Dr. Ali Abdel Moneim, Training Officer

Mr. Nerses Nersoyan, Research Associate

Mr. Sfouh Rihawi, Research Associate

Mr. Hanna Sawmi Edo, Research Associate

Mrs. Monika Zalklouta, Research Associate

HIGH ALTITUDE RESEARCH

Dr. Edward M. Matheson, Director

COOPERATIVE PROGRAMS

Dr. Bhup Bhardwaj, Director of Administration, Nile Valley Project (Cairo)

Dr. Samir El-Sebae Ahmed, National Research Coordinator (Syria)

Dr. Ahmed Kamel, ICARDA Representative (Tunisia)

COMMUNICATIONS AND DOCUMENTATION

Mr. Larry Chambers, Head

Mr. Philip Kemp, Documentation Specialist

Dr. S. Varma, Science Editor

COMPUTER SERVICES

Mr. Khaled El-Bizri, Director

Mr. Bizhan Kamrava, Analyst/Programmer

GENETIC RESOURCES UNIT

Dr. Bhal Somaroo, Program Leader

Dr. Marlene Diekmann, Plant Protection Officer (DAAD West Germany)

Dr. Yawooz Adham, Documentation Specialist

Dr. Bilal Humeid, Research Associate

TRAINING COORDINATION

Mr. Mohamed Tchalabi, Assistant Training Officer

FARM OPERATIONS

Dr. Juergen Diekmann, Farm Manager (Tel Hadya)

Mr. Marwan Mallah, Admin. Officer

Mr. Munir Sughayyar, Station Operations Engineer (Terbol, Lebanon)

SUPPORT SERVICES

Ms. Leila Rashed, Personnel Officer

Mr. R. Seshadri, Manager, Purchasing and Supplies

Ms. Dalal Haffar, Purchasing Officer

Mr. Badar Khattab, Stores Officer

Mr. Mohamed A. Hamwieh, Admin. Officer Vistors' Section

Mr. Bassam Hinnawi, Travel and Visa Officer

Mr. Haitham Midani, Housing Officer

Mr. Salah Rihan, Manager, Physical Plant

Mr. Farouk El-Jabri, Officer, Food and General Services

Mr. Ohanes Kalou, Building Maintenance Engineer

Mr. Brian Tierney, Construction Manager

Mr. Khaldoun Wafaii, Civil Engineer

Mr. Isaac Homsy, Civil Engineer

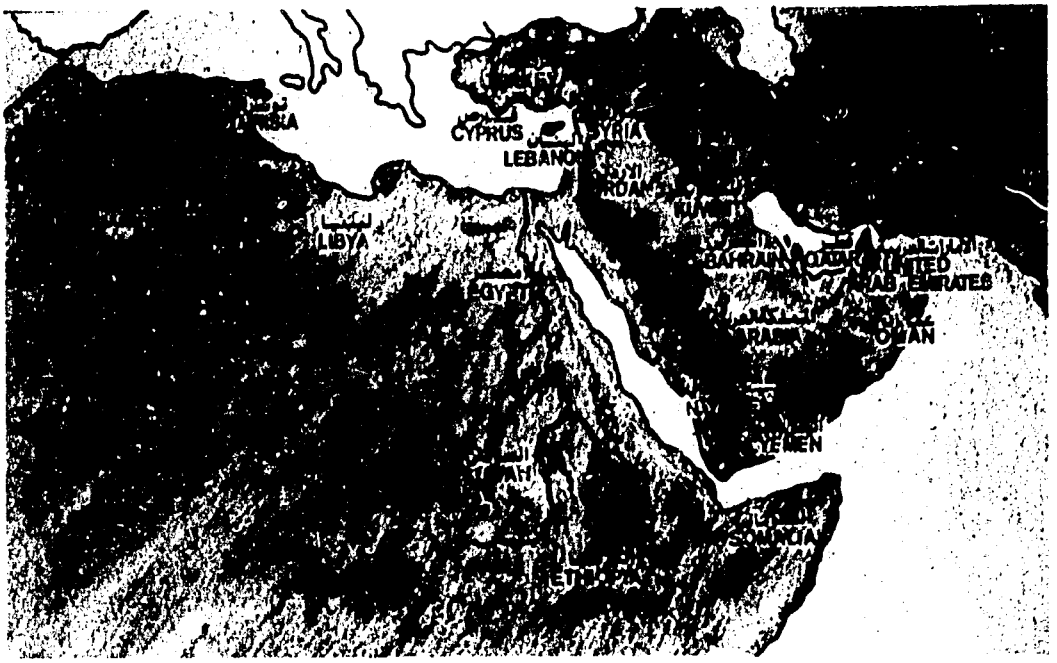
Ms. Afaf Rashed, Executive Secretary/Office Manager, Beirut Office

Mr. Abdul Karim El-Ali, Admin. Officer, Damascus Office

---

*Left ICARDA during 1983.

Entrance to ICARDA's main experimental farm and headquarters at Tel Hadya, Syria. Land for the 948-hectare site continues beyond the hill in the distance.



The Center's principal geographic area of concern is the countries of West Asia and North Africa.

Published in July 1984
WBW

SALHANI ESTABLISHMENT PRINTING P.O. BOX 6089 DAMASCUS