ICARDA RESEARCH HIGHLIGHTS

'82

As the reader will see inside, dedicated international scientists made progress during 1982 toward finding solutions to serious socio-economic, agricultural, and food problems of the Middle East and North Africa region.

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Foreword

This edition of Research Highlights *reports on some, but by no means all, of ICARDA's research during 1982. Each year we select 20 to 25 topics to "highlight," and they give a partial insight into the continuing work of our scientists.*

Special emphasis this time has been given to the use of the Center's research results by national programs—our partners in a concerted effort to contribute toward increased agricultural productivity in the region. That, of course, is where new technology is adopted (or ignored) by farmers.

We are aware that in the diverse environment in this region several years of research are needed to produce results and therefore resist any temptation to claim successful findings prematurely. Many of the findings written about here will continue to be tested by ICARDA and national program scientists and by farmers themselves.

Progress has been made in several directions, including the development of dual-purpose barley, food legumes and pasture and forage crops as alternatives to fallow, improved farming systems, new high-yielding and disease-resistant lines of lentils, chickpeas, and barley, and pure lines of faba beans. It is interesting to note that we have been exchanging faba bean germplasm with China—the most important producer of the crop in the world—and we expect other mutually advantageous exchanges as a result of an ICARDA mission to China in May at the invitation of that country's Academy of Agricultural Sciences.

Another type of progress during 1982 should also be mentioned. Toward the end of the year, the construction program for ICARDA's permanent buildings at Tel Hadya got underway—a complex of scientific laboratories and a building to house the training, communications, and administration departments and the computer center.

If the reader would like more information about the research which is very briefly described in this publication or about other ICARDA activities, our 1982 Annual Report is available upon request.

Mohamed A. Nour
Director General

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Correct Citation: International Center for Agricultural Research in the Dry Areas, 1983. Research Highlights for 1982. Aleppo, Syria.

Profile of ICARDA

Established in 1977, the International Center for Agricultural Research in the Dry Areas (ICARDA) is one of the newest links in a world-wide network to improve and increase food production. The Center's principal geographic area of concern involves 22 countries of the Middle East and North Africa with a population of more than 300 million people. It extends from Morocco in the west to Pakistan in the east and from Turkey in the north to Sudan in the south (Figure 1).

ICARDA serves as a regional research and training center, in cooperation with other international centers and national programs, for the improvement of bread wheat, durum wheat, triticale, chickpeas, pasture and forage crops, and farming systems. Also, it has been designated as a world center for barley, lentils, and faba beans.

The Center is governed by an international Board of Trustees and organized into five main operational programs: Farming Systems, Cereal Crops Improvement, Food Legumes Improvement, Forage and Pasture Crop Improvement, and Communications.

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 1982 was provided by the Arab Fund, Australia, Belgium, Canada, Denmark, Ford Foundation, France, Germany, IDRC, IFAD, Italy, Mexico, Netherlands, Norway, OPEC Fund, Spain, Sweden, UNDP, United Kingdom, United States (USAID), and World Bank. Saudi Arabia has joined and will make an annual contribution starting in 1983.

Headquarters for the Center, which includes its principle research station, is at Tel Hadya, Syria, about 30 km south of Aleppo on the Damascus-Aleppo highway. Land for the site—948 hectares—was granted to ICARDA by the Government of the Syrian Arab Republic. Another main station is located in Lebanon, and the Center has sub-stations in several other countries.

Figure 1. The ICARDA Region.

Trade-Off between Grazing Barley at the Green Stage and Grain Production

Barley makes up a large proportion of the diet of sheep in dry areas of the Middle East and North Africa. Often it is grazed as green feed at the tillering stage and then allowed to grow to maturity for consumption as grain and straw. Usually, a field with poor grain yields is grazed rather than harvested.

The amount of grazing of barley at the green stage varies from place to place, but it is practiced, for example, in about two-thirds of the fields in parts of northeastern Syria. Its value derives from its availability during early winter when alternative feeds are scarce and requirements of sheep with newborn lambs are relatively high. In addition, farmers throughout the region prize barley straw as feed for sheep, and its value can approach that of the grain itself. A survey during 1981/82 provides evidence of how grazing barley green or mature varies in importance within Syria (Table 1).

Research to improve barley as a dual-purpose crop (green grazing and grain) has been underway at ICARDA for five seasons. Factors such as variety, seed and nitrogen rate, sowing date, and the timing and number of grazings have been investigated. Yield improvement from selected varieties was reported in the 1981 edition of *Research Highlights*. Improved management can also increase yields.

A clear trade-off exists between grazing and grain production. If too much dry matter is removed by grazing at the green stage, less grain is produced. However, research has shown that re-

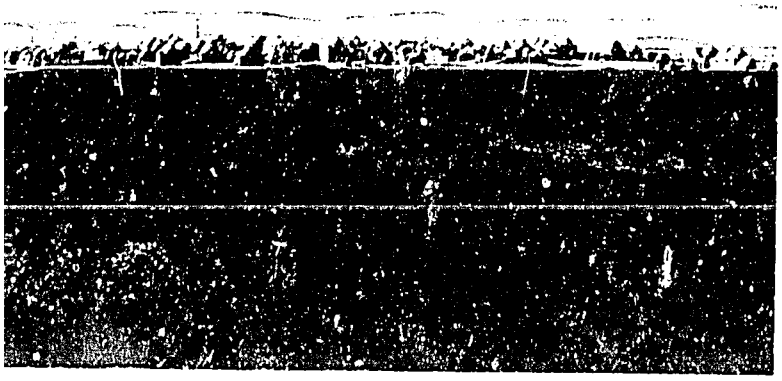
	Northwest[a]		Northeast[a]
Total number of farmers	69		84
		(% of farmers)	
Practicing green barley grazing	25.3		64.2
Frequency of green barley grazing			
Rarely or sometimes	6.5		2.3
In good or exceptionally good years	14.5		21.4
Every year[b]	4.3		40.5
Straw collected for later feeding	72.4	(n = 64)	83.4
Crop residues grazed after harvest	98.4	(n = 64)	100.0
Grazing (some or all) barley instead of harvesting (80 81)	50.4	(n = 64)	15.5
Average barley area (ha) grazed instead of harvested[c]	10.5		6.1

(a) Northwest Syria included the following provinces for the purpose of the survey: Aleppo, Hama, Homs, and Idleb; for the Northeast, Deir-ez-Zor, Hassakeh, and Raqqa.

(b) In the Northwest, two farmers allocate a fixed area for grazing every year.

(c) Among those actually practicing grazing.

Table 1. Farm survey results related to grazing barley in northern Syria.



Left, a Syrian farmer's field of barley. His decision whether to allow green stage grazing by sheep is influenced by a mix of socio-economic and agronomic factors; right, under favorable rainfall conditions, light grazing of green barley can actually improve the value of the mature crop.

moval of a small amount of green material by grazing early in the season can result in larger grain yields. See Figure 2 which shows an example of this for an improved dual-purpose variety (C-63).

In some areas of the region (Jordan, for example), the usual practice is to wait for the first rains, then cultivate to control weeds, and finally sow the crop. But barley producers in Syria usually plant the crop before the first rains (Table 2). This is quite rational for farmers who want early feed for sheep, and such early sowing can result in significantly higher dry matter for early grazing.

In 1982, barley sown before the first rain on October 31 yielded 2.2 t/ha of dry matter in early March compared with only 0.8 t/ha from a field that was planted on November 30 after the first

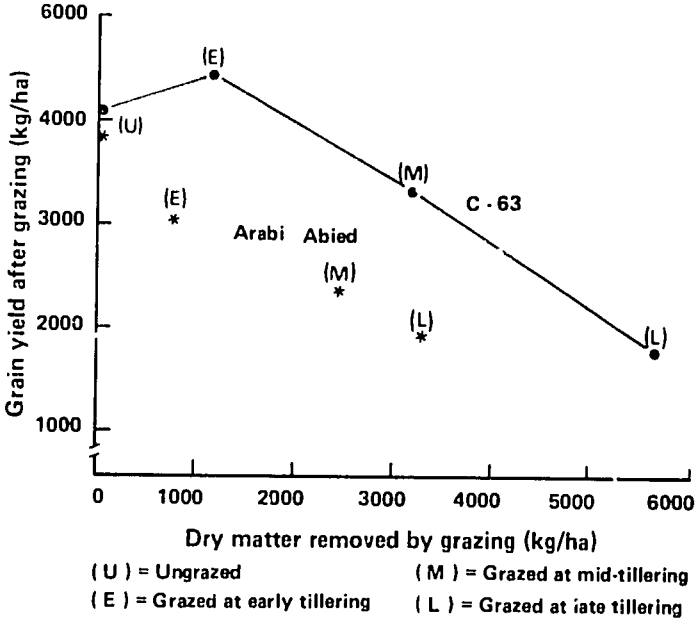


Figure 2. Effect of dry matter removed by grazing on grain yield of two barley selections (C-63 and Arabi Abied) at Tel Hadya, Syria (1980/81).

rains. The early sowing produced green material for grazing about 50 days earlier than the later sowing.

Nitrogen fertilizer (N) is seldom used in the region on barley grown for both grazing and grain, but its application can result in significant gains in both dry matter for grazing and grain yields. One experiment (Table 3) showed that twice as much nitrogen is required to achieve maximum grain yield in grazed plots. The improved dual-purpose barley required more nitrogen to reach its maximum yield compared with the local variety but produced more grain per unit of added nitrogen fertilizer.

Table 2. Sowing periods of barley producers in northern Syria.

	Northwest	Northeast
	(% of farmers)	
After first rains	18.1	0.0
Before first rains	**58.0**	**89.3**
Regardless of rains	10.1	2.4
Different each year	13.8	8.3
Total number of farmers	69	84

Northwest Syria included the following provinces for the purpose of the survey: Aleppo, Hama, Homs, and Idleb; Northeastern Syria, Deir-ez-Zor, Hassakeh, and Raqqa.

Table 3. Estimated nitrogen fertilizer rates required for maximum barley yields at Tel Hadya, Syria (1981/82).

	N rate (kg/ha) for maximum grain yield	
Variety	Ungrazed	Grazed
Arabic Abied (local)	50 (11)*	100 (9)
C-63 (improved)	100 (14)	200 (12)

**Figures in parentheses are kg of grain per kg of N applied.*

Seed rate also affects dry matter available for grazing and subsequently grain yield. In 1981/82, seed rates of 240 kg/ha significantly increased dry matter at grazing but reduced grain yield after grazing compared with lower seed rates (Figure 3). Thus, the best seed rate—like the best stage of growth for grazing—depends upon the relative value to the farmer of green grazing compared with grain.

These results show promise that dry matter of barley at the tillering stage can be increased two fold with little or no reduction in grain yield if barley is given special management as a dual-purpose crop. Future research calls for testing these results under a wider range of

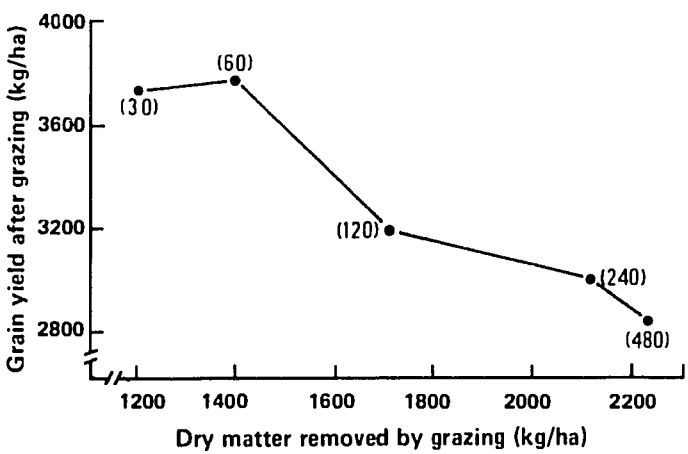


Figure 3. Effect of seed rate (kg/ha in parentheses) on the yield of dry matter at tillering and grain after grazing of barley at Tel Hadya, Syria. (Mean of two varieties 1981/82).

conditions in barley producing areas and then introducing the most economic treatments in trials on farmers' fields.

Farmers' decisions to allow green stage grazing are influenced by a mix of socio-economic and agronomic factors such as farm tenure arrangements, availability and prices of alternative feeds, and crop and sheep response to various barley grazing intensities. Farmers make few crop decisions without considering the demands of their livestock for feed, and few livestock decisions are made without considering the availability of feeds and prices.

An example of the complexity of the trade-off decisions faced by farmers is illustrated in Figure 4. This model, developed by economists at ICARDA, shows that under high rainfall conditions light grazing of green barley (as at point A in the figure) could actually improve the value of the mature crop by reducing lodging and increasing the number of tillers. But under the same rainfall conditions, heavy and repeated grazing (at point H) could cause the loss of what otherwise would have been an excellent grain crop.

In a very dry year, even light grazing (at point B) could reduce the mature harvest value of the barley crop. However, a farmer who owns both the crop and the sheep may decide to allow some grazing even though the crop will suffer. He may figure that gains to his sheep could exceed the expected losses to the barley crop which, in turn, would be

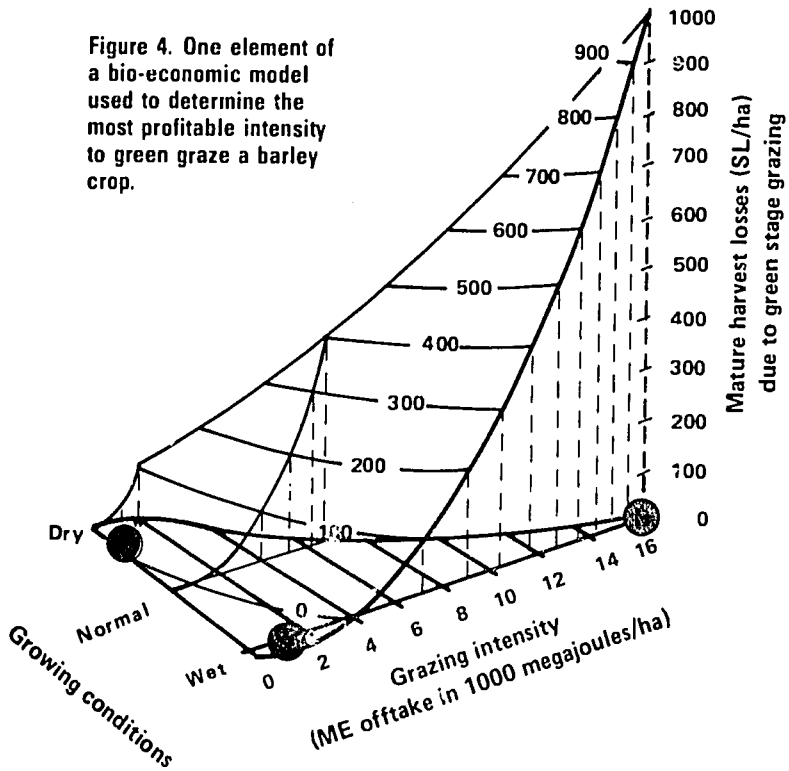
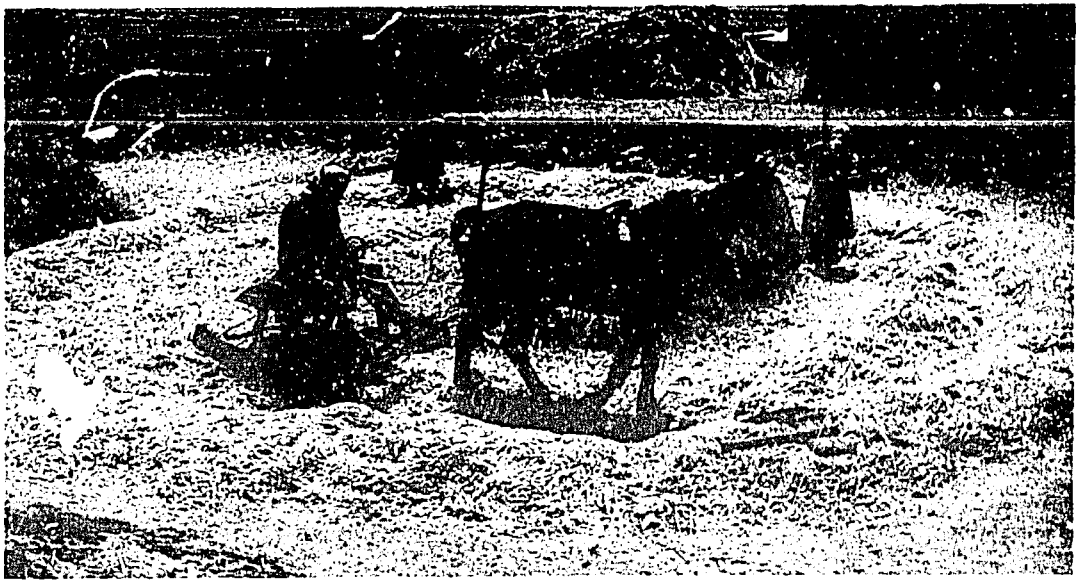


Figure 4. One element of a bio-economic model used to determine the most profitable intensity to green graze a barley crop.



After a farmer threshes his barley, he feeds the straw to sheep; its value for feed can approach that of the grain itself.

less than the cost of alternative feedstuffs.

Dual-purpose barley is a focal point for cooperative research efforts of ICARDA's plant breeders and physiologists, agronomists, animal scientists, and economists.

Barley Production Systems and Yield Trends from Rotation Trials

Detailed agronomy trials on Beecher barley (grown after fallow) during the 1980/81 and 1981/82 seasons at Breda and Khanasser, Syria—two typical barley producing areas—continued to demonstrate dramatic responses to phosphorous (Table 4). But application of nitrogen resulted in little crop response in these dry areas when the barley was grown after a fallow year during which available nitrogen accumulates in the soil profile. However, there is increasing evidence that if farmers grow continuous barley nitrogen fertilizer may also be required to produce optimum responses.

A survey of 153 barley growers in northern Syria showed that a majority of them practice either a barley/fallow or a barley/barley rotation. In the northwest area, 60% practiced a barley/fallow rotation but in the neighboring northeast only 18% did so; continuous barley is common among farmers in that area (56%) but less common (20%) in the northwest.

In addition to providing a large yield response, improved phosphorous nutrition speeds up barley development which results in earlier maturity (Table 4). As the crop continues to mature into early summer, drought stress increases. In these circumstances, earlier maturity constitutes an important drought escape mechanism. Largely because of a shortened growing season, phosphorous application often causes slightly reduced water use and this, combined with the increased yields, results in substantial increases in water use efficiency (Table 4).

During the past year, ICARDA scientists developed a field measurement/computer analyses technique which enables them to apportion measured crop water use into its two components—transpiration through the crop leaf surface and evaporation from the soil surface. Studies the previous year on water use by barley at Breda (Table 4) have been evaluated using this technique. The unfertilized crop actively used only

Table 4. Effect of fertilizer on yields of Beecher barley at two locations in Syria.

	Breda				Khanasser			
	80/81		81/82		80/81		81/82	
	−Fert.	+Fert.*	−Fert.	+Fert.*	−Fert.	+Fert.*	−Fert.	+Fert.*
Straw yield (kg/ha)	2220	4960	3220	3910	1750	2780	954	1473
Grain yield (kg/ha)	1620	2580	1320	2220	1350	2200	376	917
Days to maturity	147	141	174	170	142	135	171	171
Water use (mm)	234	225	231	231	229	221	210	210
WUE** (kg/ha/mm)	6.9	11.5	5.7	9.6	5.9	10.0	1.8	4.4
% increase in yield	59		68		63		144	

*Fertilizer applied: (1980/81) 90 kg/ha of N and P_2O_5; (1981/82) 60 kg/ha of N and P_2O_5.
**Water use efficiency.

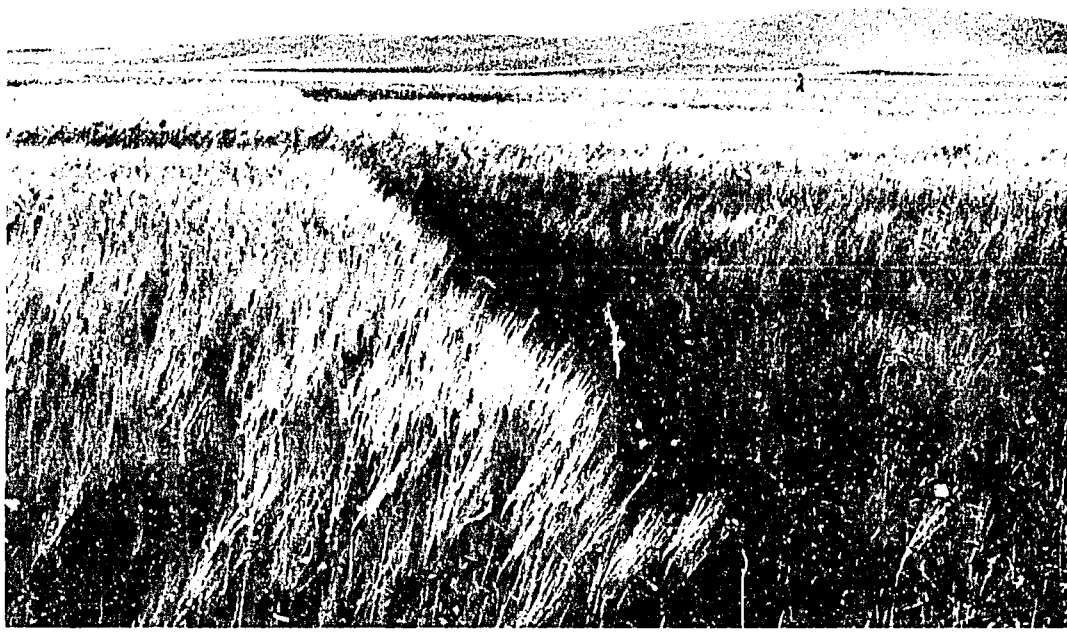
38% of its total moisture as transpiration, the remainder being lost as evaporation from the soil surface. Phosphate application (90 kg/ha P_2O_5) increased transpiration to 55% of the total water use.

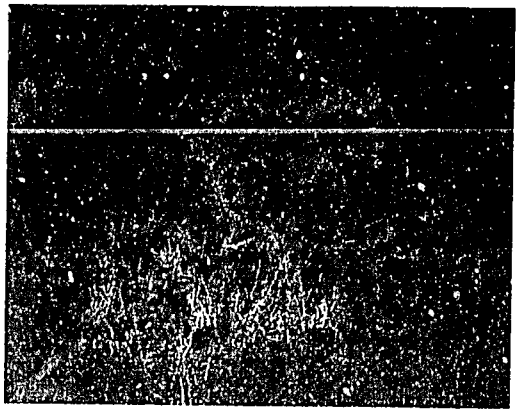
When barley yields in ICARDA trials are compared with those commonly obtained by farmers in the area (600–1000 kg/ha), scientists estimate that the farmers' crop may only use as little as 20% of the available moisture as transpiration, the remainder being ineffectively lost as evaporation from the soil. This demonstrates the huge potential for improved water use efficiency through the introduction of simple, improved management techniques such as phosphorous fertilizer use. These results apply to barley following fallow—the dominant rotation practiced in the northwest area.

Little, if any, moisture conservation occurs through fallowing on heavy textured soils in areas receiving less than 300 mm of rainfall. Therefore, it becomes feasible to use this lost moisture by replacing the fallow year with a forage legume crop which can obtain up to 80% of its nitrogen through biological nitrogen fixation. In this way, a valuable high quality forage crop can be produced without seriously depleting soil nitrogen reserves available to the subsequent barley crop.

Examples of crop yields under various rotations at Breda, Syria are shown in Table 5. At the levels of nitrogen application used in this trial it is clear that

Improved phosphorus nutrition speeded up barley development which resulted in earlier maturity of the crop on the left compared with the one in the right foreground. Under certain conditions, early maturity can be an important drought escape mechanism.





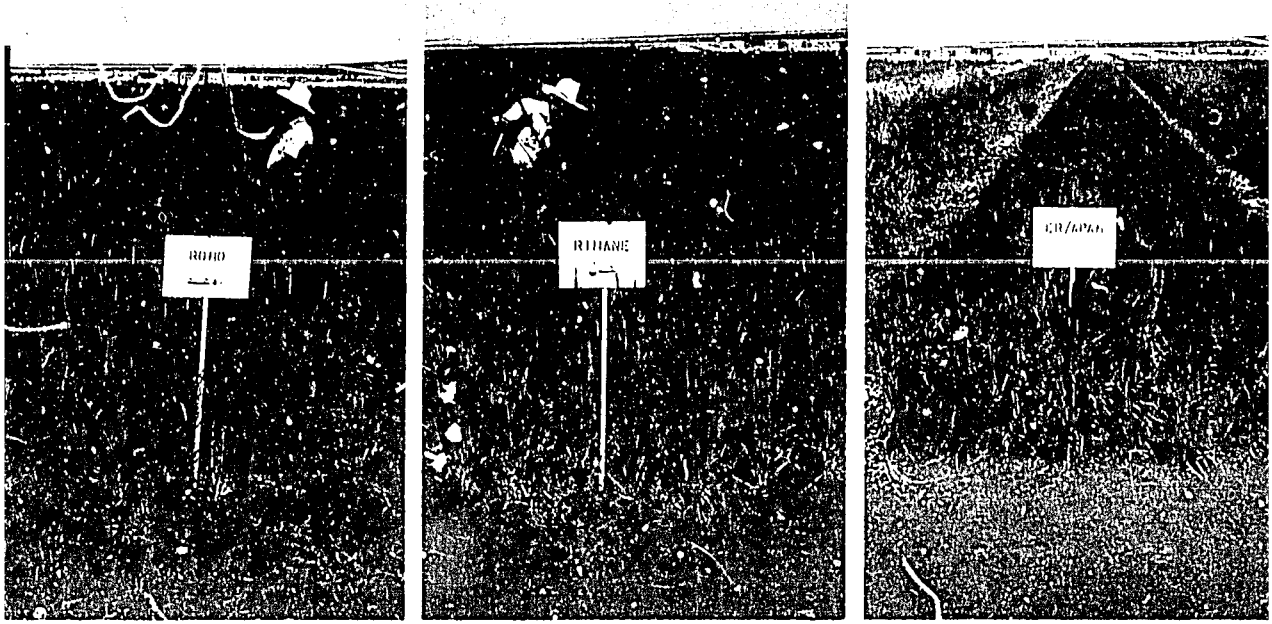
Residual effects in a uniform block of wheat at Tel Hadya, Syria illustrate yield decline in continous cereal. In the previous season, poor growth areas were wheat experimental plots and the luxuriant growth areas were fallow alleyways.

there has been a dramatic yield decline in the continuous barley rotation compared with barley/fallow. Barley yields also declined following a vetch crop but to a lesser extent. Nevertheless, in economic and practical terms, such a yield decline may be more than off-set by the production of up to 1,800 kg/ha of vetch hay which can be stored and used as sheep feed during critical shortage periods.

Crop	Previous crop	Grain yield (kg/ha)	Total biological yield (kg/ha)
Barley + Fert.*	Fallow	1710	5250
Barley – Fert.	Fallow	1470	3700
Barley + Fert.*	Barley + Fert.*	920	2790
Barley – Fert.	Barley – Fert.	490	1300
Barley + Fert.*	Vetch	1120	3380
Barley – Fert.	Vetch	870	2380
Barley + Fert.*	Lentil	1020	2890
Vetch	Barley + Fert.*	—	1830
Vetch	Barley – Fert.	—	1200
Lentil	Barley + Fert.*	860	2580

**Fertilizer addition was 60 kg/ha P_2O_5 and 20 kg/ha N.*

Table 5. Crop yields in alternative two course rotations at Breda, Syria.



Three improved barley varieties which will be multiplied for large scale demonstrations in Tunisia.

New Barley Varieties for Tunisia

Barley—an important cereal crop in Tunisia—is planted on approximately 400,000 hectares, but total production figures are low because of an average yield of only about 585 kg/ha. This is attributed mainly to a lack of high-yielding, well-adapted, stress-tolerant varieties responsive to new production technologies and a large number of major barley diseases in the higher rainfall areas.

Research efforts to overcome these production constraints started under a collaborative project between INRAT (Institut National de la Recherche Agronomique de Tunisie) and ICARDA in the 1979/80 crop season. To find solutions in the shortest possible time, a large number of elite barley lines were tested in Preliminary, Advanced, and Regional Yield Trials during the next three crop cycles in two zones—Northern represented by Beja and Bou Salem and Central represented by Hindi Zetoun. The former zone has an annual rainfall that varies from 350 to more than 600 mm and the latter from 150 to 350 mm.

Trials in the Northern zone helped to identify the genotypes or varieties with high yield potential coupled with resistance to major barley diseases and lodging. The Hindi Zetoun site was well suited to select varieties for moisture stress, and the combined information from various sites was used to assess adaptability of the selected lines. Results are shown in Table 6.

In the Northern zone, ER/Apam consistently out-yielded the check varieties Ceres and Martin. It also showed a remarkable resistance to major diseases compared with the check varieties which were mostly susceptible. This high yield

potential and resistance to diseases provide an incentive for farmers to use more inputs to realize high yields. Although the variety Rihane was also high yielding, its susceptibility to leaf rust and powdery mildew made it unsuitable for this zone.

In the Central zone, varieties Roho and Rihane consistently gave significantly higher yields than the check variety Martin. The performance of ER/Apam in this zone also suggests its wider adaptability.

Tunisian authorities have decided to multiply ER/Apam seed for large scale demonstrations in the Northern zone and Roho and Rihane in the Central zone.

Table 6. Average yield, height, days to heading, and disease reaction of barley varieties in Tunisia.

Variety or cross and pedigree	Av. yield (kg ha)	Plant height (cm)	No. days to heading	Diseases				
				Str.*	NB	Sc	PM	LR
Beja and Bou Salem (Northern zone)								
ER/Apam	4960		120	R	R	R	MR	MS**
Rihane	5055	115	123		—	MR	MS	S
Ceres (check)	3637	105	124	S	VS	MS	MR	S
Martin (check)	3664	131	130	VS	S	VS	MS	S
Hindi Zetoun (Central zone)								
ER/Apam	1322	67	65	R	R	R	MR	—
Roho 03573	1303	70	65	R	R	—	MR	—
Rihane	1020	65						
Martin (check)	803	83	65	VS	S	—	VS	—

*Str.: Stripe disease
NB: Net Blotch
Sc : Scald
PM: Powdery Mildew
LR : Leaf Rust

**MS. Moderately Susceptible
MR: Moderately Resistant
R : Resistent
S : Susceptible
VS : Very Susceptible

"Best Bet" Production Practices for Wheat and Barley in Jordan

Cereal production strategies of Jordanian farmers are strongly influenced by extremely variable climatic conditions, especially rainfall. Most farmers grow cereals for subsistence requirements, with a marketed surplus in good years and deficit purchases in poor ones.

In general, they do not use modern technology such as fertilizers, herbicides, and seed drills, and average wheat yields have been only about 700 kg/ha. However, recent developments indicate a gradual increase in technology adoption and the possibilities of a substantial gain in wheat yields.

One of ICARDA's longest-running collaborative projects started in Jordan in the 1978/79 season. This project, which depends heavily on the support of Jordanian scientists, has two major components—on-farm trials which test production practices in each rainfall zone at as many as 25 sites a year and socioeconomic surveys and studies related to farming practices, agricultural infrastructure, and human nutrition. The importance of wheat and wheat products in the diets of consumers is illustrated by a 1982 nutrition study in Irbid Province which showed that the average consumption per person in rural areas was 457 gm/day and in urban areas 524.

Farm surveys in the same province show that wheat producers have gradually changed some of their production practices over the past two years (Table 7). In 1982, they substantially increased their use of herbicides, Custom drill sowing also increased but at a lower rate. On the other hand, the application of fertilizer and combine harvesting declined because of the dry weather in that year.

The study of the agricultural infrastructure indicated that with adequate

Table 7. Comparison of farmers' wheat production practices in Jordan's Irbid Province in 1980 and 1982.

	% of farmers	
Practice	1980	1982
Deep ploughing	33.0	58.0
Drilling	2.4	8.3
Broadcasting and covering seed	97.6	90.0
Hand weeding	45.0	33.3
Herbicide	12.0	33.4
N application	20.0	10.0
P application	2.4	2.0
Combine harvesting	40.0	19.0

A University of Jordan plant breeder (left) and an ICARDA agronomist inspect durum wheat trials in a farmer's field in Jordan's Irbid Province. On the left is the tall local variety DA 2 and on the right the short improved variety Stork.

planning most of the increase in the demand for inputs can be met. One critical input is the supply of seed drills by custom operators. Currently, almost 90% of the mechanized operations are provided by private contractors or the Jordan Cooperative Organization (JCO). The private contractors are reluctant to invest in drills until the farmer demand for them increases. The leadership of JCO is needed to encourage more farmers to use custom seed drilling.

At the end of the 1981/82 season, ICARDA and Jordanian scientists designed a set of "best bet" recommendations for wheat and barley production based on experimental data, on-farm trials, experience of local scientists, and survey findings (Table 8). Information they obtained covered four diverse seasons typical of the range of climatic conditions found in Jordan. Although the recommendations call for early sowing in November (before the rains begin) to increase yields, farmers will probably adopt the practice only if they can obtain and use herbicides. The traditional method of weed control is to sow crops after the first effective rains. The farmers wait for the weeds to germinate and then turn them under before planting.

The scientists believe that with a coordinated research, farm input supply, and extension effort the current average wheat yield of 700 kg/ha could be increased about 30% to 900–1,000 kg/ha. If this were accomplished, imports could be reduced by approximately 50,000 tons a year which now cost Jordan around US$10 million. This annual figure, even when discounted for imports of the necessary farm production inputs, is significant enough to make an improved wheat production program a proposition that will pay in the long run.

Table 8. Components of "best bet" production practices for rainfed wheat and barley in Jordan.

Rainfall/zones	Zone A (>350 mm)	Zone B (250–350 mm)	Zone C (<250 mm)
Variety[a]	Durum wheat-DA6 and Stork	Durum wheat-Haurani Stork & DA2 Barley-DA106	Barley-Giza 120
Seed rate (kg/ha)[b]	80	80	60
Nitrogen (kg N/ha)[c]	60 (30 at sowing and 30 at tillering if season good)	60 (30 at sowing and 30 at tillering if season good)	30 (preferably at tillering if season good)
Phosphate (kg P_2O_5/ha)[d]	30	30	40
Sowing date[e]	Before rain (November)	Before rain (November)	Before rain (November)
Sowing method[f]	Drill	Drill	Drill
Weed control[g]	2,4-D ester, 800–1000g/ha	2,4-D ester, 800–1000g/ha	2,4-D ester, 800–1000g/ha

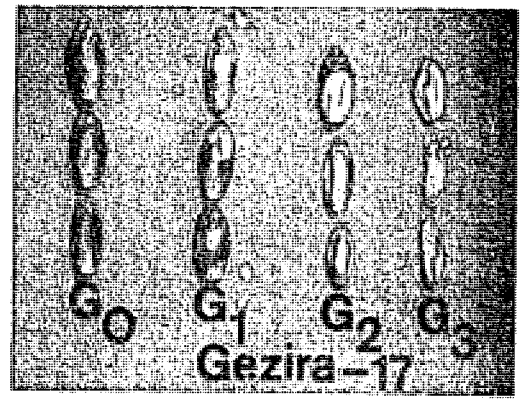
(a) Choice of variety may depend on value placed by the farmer on the straw; seed of some varieties will need to be increased.
(b) Does not greatly affect economics; more research needed on interaction with weed control and sowing method.
(c) A high risk input; thus split application recommended though experimental data are not available.
(d) Individual recommendations should eventually be tied to a soil test.
(e) This practice is only recommended in conjunction with deep sowing (6–8 cm) and herbicide use.
(f) Drill sowing is suggested on the basis that if custom drilling becomes available, it will prove cheaper than hand sowing.
(g) 2,4-D is recommended for broadleaf weed control, especially for early sowings; other chemicals may be economic for grass weeds.

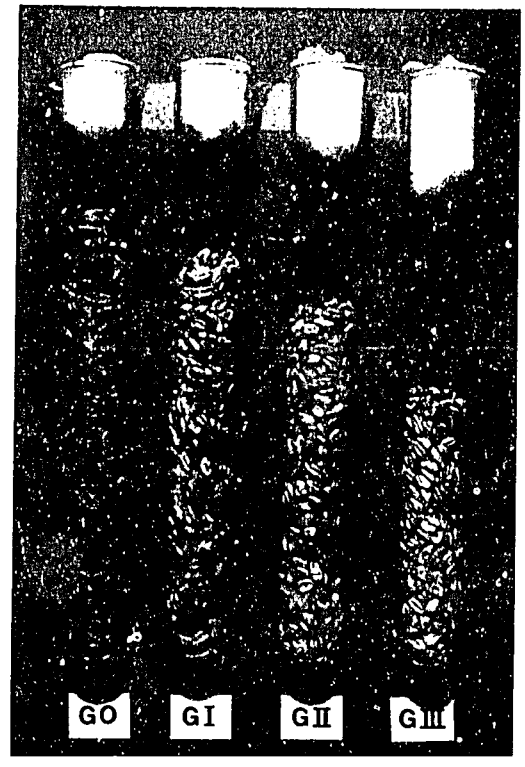
Counteracting Suni Bug Damage to Wheat Flour Baking Quality

The Suni bug (*Eurygaster* spp.) sucks the cell contents of developing wheat kernels and in doing so secretes a saliva containing a powerful enzyme mixture, including a proteolytic enzyme. The enzyme action and the sucking of the insect exhaust the cell contents; the cell walls collapse and will not recover. Flour made from wheat in Syria often has a low protein content (24–25% wet glutten) due to inherently low soil fertility. This, and the effect of the proteolytic enzyme, make the dough collapse and it becomes too weak to make good bread. Large holes and tears appear in the dough and the Arabic bread (khobz) will not rise in the oven.

The consequences of Suni bug damage on the flour milling and baking industries in Syria reached serious proportions during 1982. Some bakers returned flour to the mills because they found it impossible to bake khobz. In ome locations, the insect also reduced the quality of wheat for baking single-layer breads such as saaj and tannour.

The bug's effect on the physical and physiochemical characteristics of wheat and flour was studied in ICARDA's laboratories by separating damaged kernels and adding them to a sound undamaged wheat in different proportions (Table 9). At the request of the Directorate of Milling at Aleppo, several ways to correct the problem faced by the millers were tested. They included: (1) addition of small amounts of chemicals to "strengthen" the dough by oxidation; (2) lowering the pH of the dough to below the optimum for the proteolytic en-





(Upper photo and left to right) A close-up of wheat kernels with no Suni bug damage, one-third of each wheat kernel affected, two-thirds, and three-thirds; (lower photo) 500 kernels in each test tube with the same percentage of affected kernels as above which shows the loss of volume and weight.

zymes; (3) adding powdered wheat gluten to increase the protein content; and (4) blending sound flours with the very weak ones to improve strength and "dilute" the effects of the proteolytic enzymes.

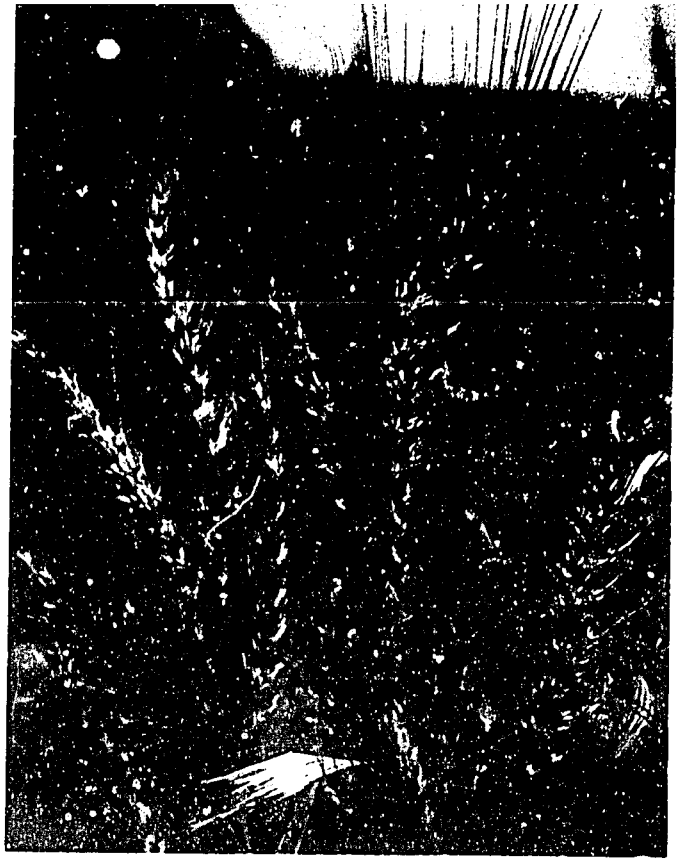
Ascorbic acid at 60 ppm improved baking quality significantly as did the addition of 0.2% lactic acid or citric acid. However, both of the latter left slight "after tastes," and for this reason ascorbic acid was preferred. Also, adding gluten at 2.5% or 25% of a medium strength flour improved baking quality. Both ascorbic acid and dried gluten can be added at relatively low cost by mills that have equipment for blending flour. Sound flours could be blended either at the mills or bakeries.

An example of the drastic effect of the Suni bug on flour quality. The large single layer bread held by the woman was made from sound flour; the smaller one on the saaj was baked with the same amount of dough from Suni bug damaged flour.

Table 9. Influence of adding Suni bug damaged wheat to sound wheat.

Damaged wheat added (%)	Farinograph			Mixograph		Wheatmeal Ferment. time (min)
	Dev. time (min)	Stability (min)	Delta R* (units)	Dev. time (min)	Delta R** (%)	
0	5	9.5	50	3.3	7	200
2	4	9.2	50	3.1	9	176
5	4	6	85	2.8	9	56
10	3	4.5	150	2.6	12	40
20	2.5	2.8	240	2.1	16	41
50	2	1.4	360	1.3	26	37

**Fall in resistance; 50 = very stable; 360 = exceptionally weak.*
***7% = very stable; 26% = extremely weak.*



The best sources of resistance to common bunt disease which has infected these wheat plants are incorporated in germplasm developed by ICARDA for national programs.

Identifying Wheat Genotypes with Broad-Based Resistance to Common Bunt

Common bunt of wheat, also known as stinking or covered smut, affects production in many countries of the ICARDA region but is of major importance in Iran, Afghanistan, parts of Turkey and Pakistan, Syria, Iraq, Jordan, and Lebanon. This disease, incited by *Tilletia foetida*, *T.controversa*, and *T.carries*, is usually more prevalent on winter wheat than on spring wheat, but winter-sown spring types are liable to the attack.

It occurs when soil temperature at sowing time ranges from about 5 to 15° C, especially in areas where certified seeds are not used. Such conditions prevail in a majority of the countries in the region.

Diseased plants become moderately stunted but are most easily distinguished when the heads appear. Bunted heads are usually darker in color and the glumes are spread apart since they surround bunt balls (fungal spores) rather than the normal seeds. The bunt balls are more spherical than the normal seeds and are dull gray-brown in color with a fragile pericarp (cover of the kernel). This cover ruptures during harvest and threshing and releases the

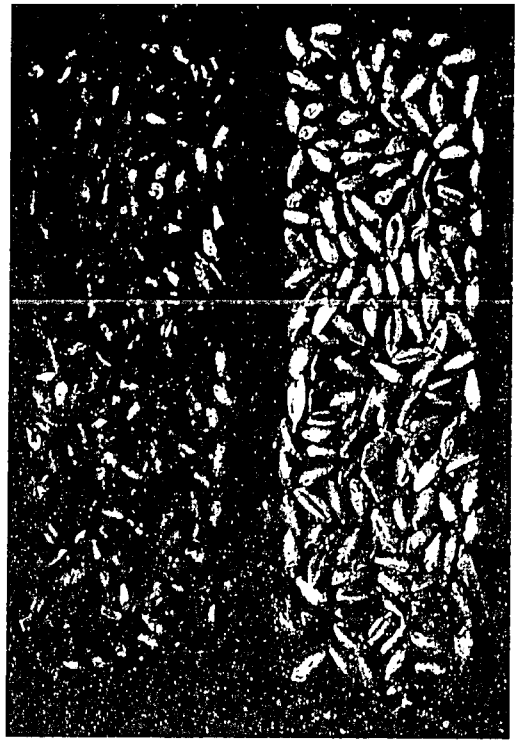
black powdery spores characterized by an odor of rotten fish. This odor is due to the presence of trimethylamine, a volatile malodorous chemical which gives rise to the name stinking smut.

The disease is spread through spores contaminating seeds and soil during harvest and threshing. In the presence of moisture and suitable temperature during crop germination, the spores germinate and infect the emerging seedlings. The infection then progresses to the reproductive tissues, and the disease replaces all kernel tissues as the heads develop. This reduces both yield and grain quality.

Seed treatment with different fungicides helps to control the seed-borne spores of this disease, and more recently some systemic fungicides have also been used to control both seed and soil-borne sources of infection. Although this has been known for a long time, the use of such chemicals is restricted in a majority of the countries in the region for several reasons, including hazards involved in handling treated seeds.

A study aimed at identifying and using sources of resistance to this disease started at ICARDA in the 1979/80 crop season. All genotypes generated in the bread wheat and durum wheat programs (about 15,000 entries to date) were inoculated with a mixture of spores of this disease collected in Syria. The data so far show that, in general, durum wheats are more resistant than bread wheats to this collection.

In 1980/81, six different bunt collections from the region were tested on wheat lines in an attempt to find different sources of resistance. These



Wheat seed infected with common bunt (left) and clean seed (right).

collections came from the following countries: (1) Syria; (2) Turkey (spring wheat); (3) Turkey (winter wheat); (4) Lebanon; (5) Tunisia and (6) Iran. The material inoculated comprised known sources of resistance to this disease used in ICARDA and in other wheat improvement programs.

During the 1981/82 season, four additional races of common bunt were used, bringing the total number of collections to ten as follows: (7) race T-19 virulent to genes for resistance *Bt1,2,3,7*, (8) race T-30 virulent to *Bt1,2,4,6,7,9,10*; (9) a race virulent to *Bt2,5,7,8*; and (10) a race virulent to resistance genes *Bt1,2,3,4*, and *7*.

Each collection and/or isolate was used to inoculate each of 48 wheat genotypes that showed resistance in previous tests. Some of these varieties

carry known genes for resistance while others were selected on the basis of their resistance in previous tests. Examples of the varieties with known genes for resistance are: Nugaines, Hyslop, and Paha which all carry the resistance genes *Bt1*, *Bt3*, and *Bt4* and Luke with genes *Bt9*, *Bt10*, and one more unidentified gene. The aim of this study has been to identify genotypes with broad-based resistance to the common bunt fungus population.

The results show that some varieties confer good resistance to all virulences used (Table 10). They also indicate that certain ones have a differential reaction to these virulences and that the collections and/or isolates used differ in virulence on some of the varieties tested. The best sources of resistance are incorporated in germplasm developed by ICARDA for distribution in the region. (Bread wheat improvement is a joint ICARDA/CIMMYT project.)

Table 10. Bread wheat lines with good resistance to common bunt at Tel Hadya, Syria (1981/82).

Genotypes	Collection and or isolates										Overall average (%)
	1	2	3	4	5	6	7	8	9	10	
	Average infection (%)										
Nugaines (*Bt1,Bt3,Bt4*)**		**0**	**0**	**0**	**0**	**1**	**1**	**0**	**0**	**1**	**0.3**
P 101**	**0**	**2**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**0.4**
Luke (*Bt9,Bt10,Bt?*)**	**0**	**0**	**0**	**3**	**0**	**1**	**0**	**2**	**0**	**0**	**0.6**
Hyslop (*Bt1,Bt3,Bt4*)	0	0	[illegible]	1	1	0	15	0	0	1	1.9
Mc Dermid**	4	1	0	0	5	0	11	2	1	3	2.7
Kirac 66**	6	8	1	1	5	1	2	1	2	1	2.8
Kvz-Gns SWD 71969-12H-OZH-OP	3	2	2	13	0	0	0	6	1	2	2.9
Paha-Cuwon 92-Omar 4** (*Bt1,Bt3,Bt4*)	0	0	0	0	0	1	28	0	0	0	2.9
Super X Cardinal** L 122-3L-2L-OAP		1	1	3	1	10	6	0	4	3	3.2
Kite	8	3	12	1	6	1	3	2	0	4	4.0
Blueboy	7	5	0	9	2	0	21	2	0	2	4.8
Average (%) of susceptible check varieties	63	71	78	59	68	58	73	42	31	43	

**See text for sources of the 10 collections.*
***Resistant also to the first six collections in 1980/81.*

Scope for Improvement in Biological Nitrogen Fixation in Dry Areas

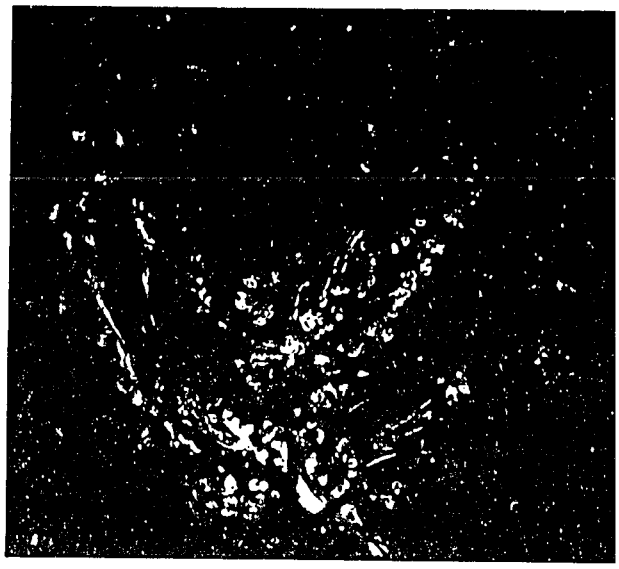
Inorganic nitrogen fertilizer is becoming an increasingly expensive commodity, and rain-fed farming systems in the dry areas of North Africa and the Middle East are at risk of becoming dependent upon it to maintain acceptable levels of soil fertility. ICARDA scientists therefore are searching for ways to reduce this dependence and are examining the ability of food legume crops to biologically fix nitrogen by symbiotic association with bacteria of the genus *Rhizobium*.

Experiments were conducted in the 1981/82 season in which the amount of nitrogen symbiotically fixed by faba beans, chickpeas, and lentils was measured using a technique which measures the dilution of N^{15} supplied in small quantities as fertilizer. In addition, the scientists compared the amount of biological nitrogen fixation (BNF) by crops given traditional and improved management. These comparisons were made when there was little available soil nitrogen following a cereal crop in the previous year.

Results shown in Table 11 for four sites in northern Syria indicate that with good rainfall where soil moisture was less limiting, high rates of BNF were achieved by all three crops. In many instances, more than 80% of their total nitrogen requirement was met by symbiotic fixation. An improved management package was also clearly responsible for increasing the amount of nitrogen fixed by the crop (Table 11). This was particularly true in the case of chickpeas where the effect of winter instead of spring planting is probably a predominant factor.

However, in drier conditions as experienced at Ghrerife, Syria, biological nitrogen fixation and the proportion of total crop nitrogen derived from it were substantially reduced. Bacterial numbers are often very small in these drier areas, and inoculation with suitable rhizobia may become an important means by which BNF can be improved in these more hostile environments.

Research at this early stage indicates that biological nitrogen fixation from food legumes can be considerably improved in the ICARDA region. This suggests that the maintenance of soil fertility on which increased food production depends does not have to be entirely dependent on inputs of inorganic nitrogen fertilizer, even in these drier areas. Furthermore, agronomic improvements to the present farming systems, based on more extensive growth of legume crops, appears to have a good chance of rapid acceptance by farmers because of their low cost nature.



Left, examining rhizobia cultures in an ICARDA laboratory. Right, nitrogen-fixing nodules on faba bean roots. Tests show that more than 80% of the total nitrogen requirement of faba beans at Jindiress, Syria was met by symbiotic fixation.

Site and seasonal rainfall	Crop	Management	Biological nitrogen fixation (kg/ha)	% N from BNF
Jindiress (350 mm)	Faba bean	I*	106	81
	Faba bean	T**	66	84
	Chickpea	I	99	82
	Chickpea	T	12	34
Tal Hadjar (354 mm)	Chickpea	I	120	84
	Chickpea	T	18	27
	Lentil	I	129	87
	Lentil	T	92	84
Tel Hadya (338 mm)	Faba bean***	I	52	78
	Faba bean	T	54	77
	Chickpea	I	28	51
	Chickpea	T	17	45
	Lentil	I	67	87
	Lentil	T	40	61
Ghrerife (261 mm)	Chickpea	I	147	80
	Lentil	I	10	39
	Lentil	T	5	32

**Improved*
***Traditional*
****Herbicide use caused some phytotoxicity.*

Table 11. Biological nitrogen fixation (BNF) trial results for 1981/82 in four locations in Syria.

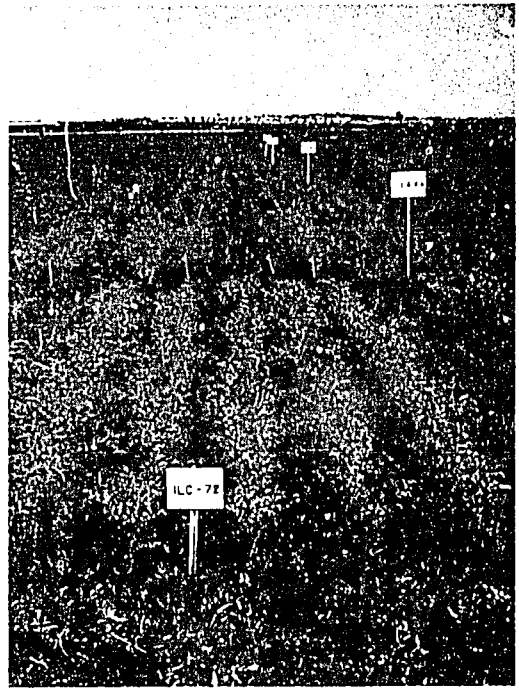
Food Legume Genetic Materials Adapted to North African Conditions

A cooperative project has been initiated to further strengthen national food legume programs and develop a regional program to help ensure that genetic materials more adapted to North African conditions are included in trials and nurseries destined for that area. Two ICARDA scientists have been posted in Tunisia to work with scientists at the Institut Nationale de la Recherche Agronomique de Tunisie (INRAT).

During the first season—1981/82—their research was conducted within Tunisia. Because only a limited amount of genetic material was locally available, the breeding program for faba beans, chickpeas, and lentils depended largely on the introduction of a range of material contained in ICARDA's international trials and nurseries. An agronomy program was started by examining seed yield responses in the three crops to inoculation with rhizobial cultures and to differing plant populations and levels of phosphate and nitrogen. The scientists also compared winter and spring sowing of chickpeas.

Some of the chickpea material introduced in Tunisia and planted in winter-sown trials in 1981/82 showed adequate levels of resistance to Ascochyta blight and good yields (Table 12). These yields, however, were lower than those reported from winter sowing of chickpeas in other countries. Tolerance to wilt disease has also been found in some genotypes introduced from ICARDA.

Although lentil cultivars usually have a narrow adaptation, a number of lines from ICARDA significantly outyielded the local check cultivar (Table 13). The results for both chickpeas and lentils are limited to one or two locations in one season, and further multi-location testing is scheduled to confirm them.



ILC 72—a winter-sown chickpea genotype from ICARDA—showed the best yield performance in trials at El-Kef, Tunisia. It is highly resistant to Ascochyta blight.

Diseases of faba beans during the season highlighted the need to develop disease resistant/tolerant genotypes. A severe attack of chocolate spot (*B.*

fabae) devastated the farmers' faba bean crops in many areas and the experimental trials at one location. Infection by the parasitic weed *Orobanche* is also a perennial and widespread problem, and identification of resistant/tolerant genotypes would help to prevent yield loss.

Table 12. Performance of some winter-sown chickpea genotypes from ICARDA compared with a local cultivar at El-Kef, Tunisia (1981/82).

Entry	Ascochyta blight rating*	Seed yield (kg ha)
ILC 72	1.4	1874
ILC 182	3.0	1427
ILC 191	1.3	1480
ILC 194	1.0	3
ILC 482	2.8	1271
ILC 3279	1.5	1213
Local check	8.3	0

**1 = Highly resistant; 5 = Tolerant; 9 = Highly susceptible.*

Table 13. Yield performance of some lentil genotypes from ICARDA compared with two local cultivars at Beja, Tunisia (1981/82).

Entry	Days to flower	Seed yield (kg ha)
ILL 8	135	1365
ILL 15	139	1452
ILL 28	140	1685
ILL 193	139	1392
ILL 262	139	1683
ILL 983	143	1385
ILL 4400	1[illegible]	1460
Tunisian local 1	1[illegible]5	7[illegible]
Tunisian local 2	153	[illegible]

(Top photo) Tunisian field trials with both wilt resistant and susceptible chickpea lines; (lower photo) A severe attack of chocolate spot disease which destroyed many farmers' faba bean crops in Tunisia in 1982, including the one shown here, highlights the need to develop resistant/tolerant genotypes.

Syria's Directorate of Scientific Agricultural Research has released the chickpea line ILC 482 for winter sowing.

Chickpea Cultivar ILC 482 Released for Winter Sowing in Syria

Trials conducted at ICARDA's main station in Tel Hadya with chickpea cultivars possessing resistance to Ascochyta blight and cold have shown that advancing the farmers' usual sowing date from spring to winter can result in a substantial increase in grain yield. Winter sowing also offers an opportunity to introduce the crop in drier regions.

On-farm trials were conducted jointly from 1979/80 to 1981/82 by Syria's Directorate of Scientific Agricultural Research and ICARDA to compare winter and spring sowing of chickpeas. Originally, three Ascochyta blight and cold tolerant lines—ILC 195, ILC 215, and ILC 482—were sown during the winter, but after the first year only ILC 482 was used because it proved to be superior. The Syrian local cultivar was not sown during the winter of the third year because it lacked resistance to Ascochyta blight. ILC 482 is not only tolerant to this blight but has acceptable seed size and cooking quality.

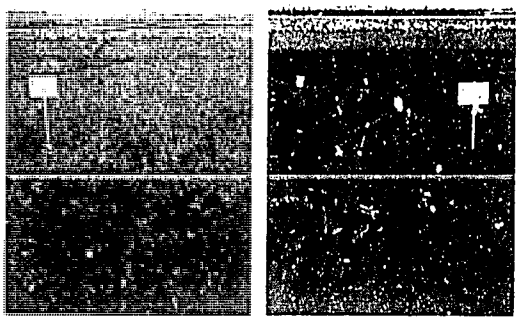
Results of the on-farm trials are summarized in Table 14. Winter-sown ILC 482 produced an average grain yield of 1,593 kg/ha in 62 trials spread over three years compared with 748 kg/ha by the spring-sown Syrian local—a 114% increase. The maximum grain yield produced by ILC 482 was more than 4,300

kg/ha, indicating its high yield potential under favorable conditions.

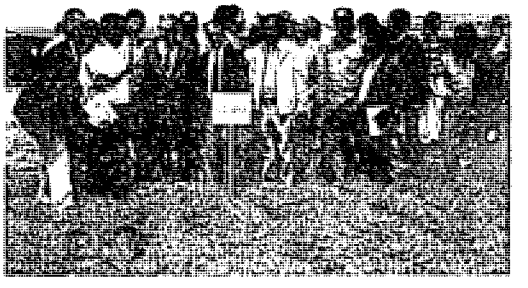
Also, when tested in the Chickpea International Yield Trial during the winters of 1979/80 and 1980/81 in West Asia and North Africa, it produced the highest yield. In addition to its other attributes, it is widely adaptable.

Because of these desirable traits, Syria's Directorate of Scientific and Agricultural Research has officially released ILC 482 for winter sowing in areas receiving 400 mm or less annual rainfall. ICARDA gave 1,500 kilograms of seed to the Directorate of Seed Multiplication at Aleppo during the 1982/83 season and agreed to provide 2,000 to 3,000 kg of nucleus seed to Syria for the next three years to support its seed industry.

ICARDA and ICRISAT scientists who cooperate in this breeding program expect ILC 482 to act as a pace-setter in promoting a gradual shift in the sowing date from spring to winter. Adoption of winter sowing could result in a substantial increase in chickpea production in this region.



Left, the Ascochyta blight and cold-tolerant ILC 482 chickpea line compared with the susceptible Syrian local on the right. Both were winter-sown at the same time.



The Governor of Syria's Aleppo Province (fourth from left), other officials, and ICARDA staff members stop on a field tour at Tel Hadya to see a new chickpea line just released for winter sowing by the Syrian government.

Table 14. Results of three years of chickpea on-farm trials conducted in Syria. (18, 24, and 20 locations in 1979/80, 1980/81, and 1981/82 seasons, respectively.)

Crop year	Chickpea seed yield (kg/ha)				% increase of ILC 482 over Syrian local	
	ILC 482		Syrian local			
	Winter	Spring	Winter	Spring	Winter	Spring
1979/80	1839	—	988	973	89	—
1980/81	1685	962	500	646	161	49
1981/82	1255	875	—	626	100	40
Mean	1593	919	744	748	114	23

Quality Considerations for Kabuli Chickpeas

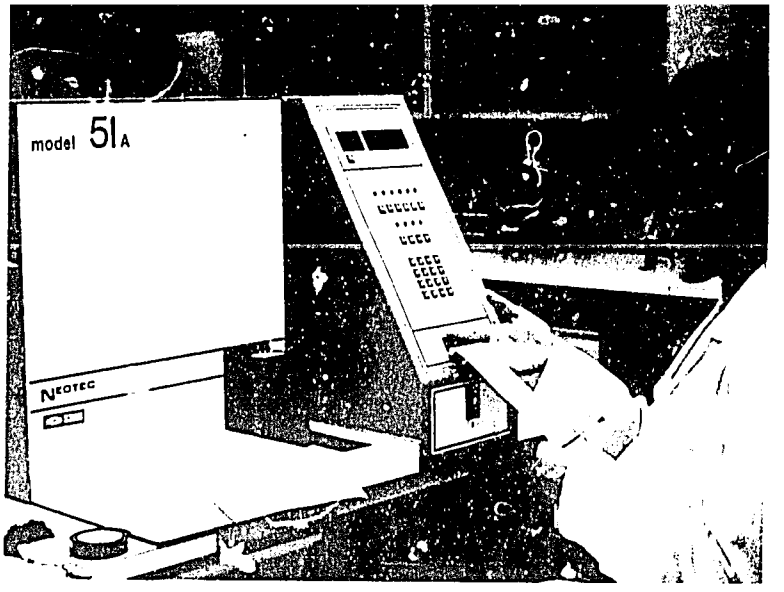
Three important quality factors for kabuli chickpeas—protein content, seed size, and cooking time—have received attention from ICARDA/ICRISAT scientists in the development of improved lines for distribution to national programs.

As a first step, 3,263 germplasm accessions were tested in ICARDA's quality laboratory for protein content using near infrared reflectance. The average protein content in this collection was 20.1% with a range of 16.0 to 24.8%. An interesting sidelight of the analysis was that the mean protein content of samples from various countries did not differ.

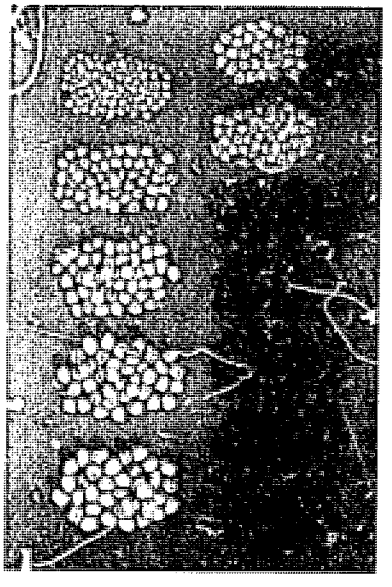
Another step involved the evaluation of hundreds of samples from different cultivars with seed sizes ranging from small to large. The results showed a wide range of cooking time—from 55 to over 200 minutes—if the chickpeas were not soaked before cooking. If they were soaked for 16 hours, the mean cooking time was reduced from 127 to 49 minutes.

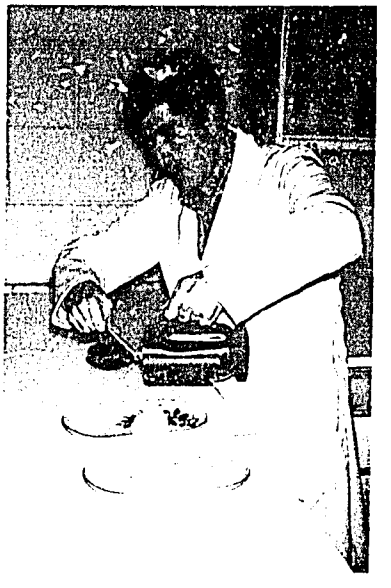
The correlations between cooking times of dried and soaked seeds from different cultivars were low, indicating that after soaking cooking time is largely independent of seed size. Plant breeding selection for larger seeded kabuli chickpeas preferred by consumers therefore does not detract from acceptability by increasing cooking time.

The laboratory also conducted a series of tests to determine quality and consumer acceptance of three types of chickpeas for making hommos-bi-tehineh—a popular food in the Middle East. Kabuli, desi, and intermediate types were evaluated by judges on the basis of color, odor, texture, and taste. (15 judges in experiment 1 and 18 in experiment 2.) Preparations from kabuli and the intermediate type were acceptable, but desi received a poor score in the first experiment mainly because of the color tests which resulted in poor appearance of the hommos. In experiment 2, when prepared from decorticated desi, the product scored highest (Table 15). but the decortication was an extra processing step and resulted in a loss of up to 10% in weight.



Laboratory tests to determine protein content of kabuli chickpeas showed a range of 16 to 24.8%.





Left, different types of chickpeas are tested for various quality factors.

Right, preparing hommos —a popular Middle East food dish made from chickpeas—for color, odor, texture, and taste evaluation by a panel of judges.

Quality	Extreme				
Color	3.7	2	2	3.8	
Odor	3.8	2.6	2	3.5	
Texture	3.6	1.5		3.4	
Taste	3.5	2.3		3.7	

*Scored on 1–5 scale: 1 = unacceptable, 2 = poor, 3 = fair, 4 = good, 5 = excellent.

Table 15. Evaluation of hommos-bi-tehineh prepared from six samples each of three types of chickpeas.

Mass Screening for Resistance to Chickpea Weevil

Weevils (bruchids) not only reduce the amount of food legumes for consumers but also affect the quality of seed for planting and the yield of the following year's crop. Because chemical control of these destructive pests is expensive and addition of a foreign material to a product near consumption is often undesirable, mass screening for plant resistance as an alternative, cheaper method was started in 1982 at ICARDA.

The chickpea weevil *Callosobruchus chinensis* L. rates Number One as the most damaging insect to chickpea seeds in storage. Infestation can be as much as 70 to 80%. To develop reliable techniques to screen plants for resistance, scientists need large numbers of the insect. Their first step is to standardize the mass rearing of the insect at 27° C and 30–40% humidity. Then they study the optimum conditions for obtaining maximum oviposition and homogeneous infestation. The best combination used to detect varietal differences in resistance was to infest 50 seeds with four pairs of adults per replication and per accession.

To facilitate the selection of the cultivars, different parameters such as progeny/female, length of the life cycle, percentage of seeds infested, and average weight of the progeny adults were compared. A resistance index which combines several of these variables was developed. Table 16 illustrates how this is used to select for resistance. For example, lines ICC 1772 and ILC 2442 would be selected for resistance confirmation in further replicated tests, but ILC 2206 and ILC 2361 would be rejected on the basis of susceptibility.

So far, more than 800 lines have been tested. A few have been considered as potential sources of resistance. This system can also be applied to the routine testing of advanced lines and new varieties coming from the breeding program.

Left, chickpea weevil damage to seeds in storage. Infestation can be as much as 70 to 80%.

Procedures followed in mass rearing of chickpea weevils used in resistance screening: Top, infesting each accession with newly emerged adult weevils taken from the mass rearing; the infested accessions are then put in an incubator for oviposition counts and recording of adult emergence (lower photo).

Table 16. Five chickpea accessions compared by indicated factors on susceptibility to attack by chickpea weevil.

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Investigating Variability of the Chickpea Blight Fungus

Over the past four seasons, more than 13,000 chickpea germplasm accessions made up of both "kabuli" and "desi" types mainly from ICRISAT—the largest collection in the world—have been screened for resistance to Ascochyta blight at ICARDA. One result is that researchers have a better understanding of the variability present in chickpeas for their work on blight resistance.

Similar knowledge of the variability present in the blight pathogen *Ascochyta rabiei* in regions of the world where it is endemic is essential for planning an appropriate resistance breeding strategy for the effective control of this serious disease.

During the 1981/82 season, pathologists collected isolates of the fungus from different cultivars and locations in Syria and Lebanon. The variability of this fungus on a wider geographic area is being investigated in an ICARDA-University of Reading (U.K.) collaborative project.

Fifty samples of blight-affected chickpeas were collected from spring-sown local land races in farmers' fields, winter and spring-sown experimental varieties in the experiment stations of the Syrian and Lebanese governments, and from ICARDA's off-station and on-farm trial sites. The isolates showed considerable variation in the growth rate, sporulation capacity, and pycnidial size.

Based on the reaction of a set of 18 different chickpea varieties of both types and including the resistant commercial cultivars released for cultivation in the Indo-Pakistan region but which later became susceptible (C-235,F-8), the 50 isolates were classified into four distinct races (Table 17). The information on the sporulation capacity and necrotic effects further supported the recognition of the races based on the disease severity induced by them.

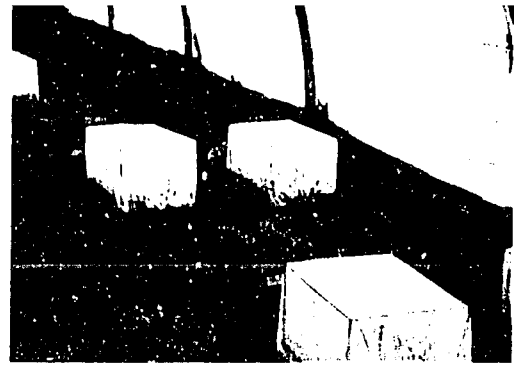
Of the four races, races "2" and "3" were isolated from the pathogen population used for screening at ICARDA. In addition, a biotype of race "3", against which all the differential varieties showed susceptibility, was also isolated. Isolation of the more virulent races from the experimental sites indicates the possible selection pressure of the resistant and tolerant genotypes grown there on the pathogen population for selection toward more virulent races.

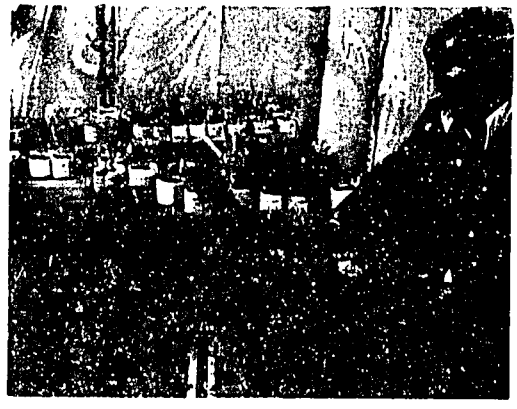
Results indicate that the loss of resistance in F8 in the Indo-Pakistan region may be due to the appearance of

race "1" and that of C-235 because of race "3". A mixture of all four races is being used for screening during the 1982/83 season.

Many resistant genotypes when infected by the matching virulent isolates showed considerable residual effect of the "defeated" genes. The isolates while accumulating the virulent genes lost their aggressiveness as indicated by their reduced sporulation ability on the susceptible genotypes.

(Chickpea research is a cooperative endeavor between ICARDA and the International Crops Research Institute for the Semi-Arid Tropics—ICRISAT.)





(Top photo) A simple, inexpensive screening technique to indentify physiological races of *Ascochyta rabiei*. In each of the plastic covered frames, genotypes of chickpeas are innoculated with different biotypes of fungus and evaluated after a period of incubation; (lower photo, left) 30 genotypes susceptible to biotypes of race "3"; right, genotypes resistant to races "1" and "2".

Differential variety set	Blight reaction*			
	Race "1"	Race "2"	Race "3"	Race "4"
[illegible]	T	[illegible]	R	R
182	S	T	T	R
191	S	S	S	T
[illegible]	R	[illegible]	T	T
200	T	T	T	T
[illegible]	R	R	S	S
[illegible]	R	R	S	S
482	R	R	T	S
[illegible]	T	S	S	T
[illegible]	R	R	S	S
3279	R	R	R	T
[illegible]	T	[illegible]	[illegible]	[illegible]
[illegible]	R	[illegible]	S	S
[illegible]	R	[illegible]	S	[illegible]
3996	R	R	R	R
[illegible]	R	R	T	T
C 235	T	R	S	S
F 8	S	S	S	S

*R = Resistant; S = Susceptible; T = Tolerant.

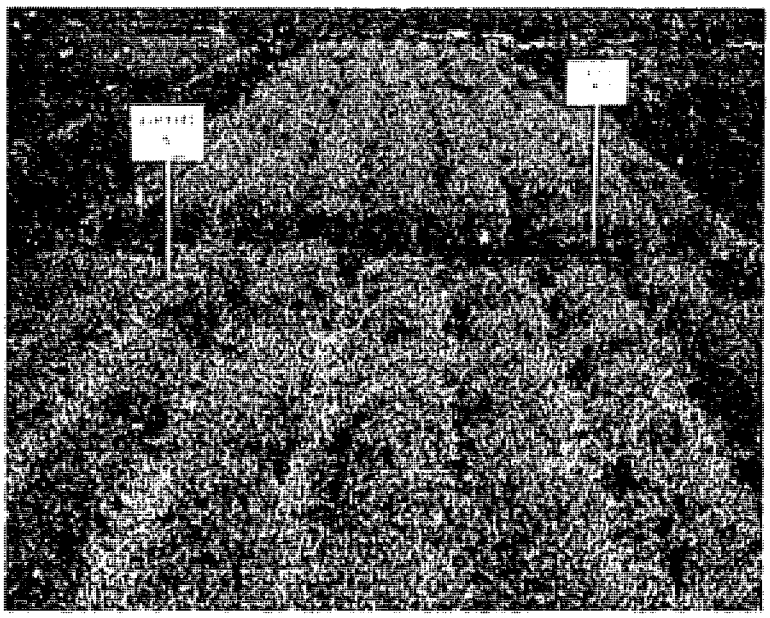
Table 17. Reaction of 18 differential varieties of chickpeas to four races of *Ascochyta rabiei*.

Benefits of Early Planting of Lentils

Many farmers in the Mediterranean region do not sow lentils until January, thereby losing the possibilities of larger yields at harvest time. Their reasons for not planting earlier include the risk of frost damage and weed infestation. However, these disadvantages may be outweighed by larger yields from early sowing.

Trials conducted by ICARDA at its principal experiment station at Tel Hadya and its substations in Syria over the past three years have consistently shown that lentil yields are significantly reduced when planting is delayed beyond December. A shorter period of growth results in smaller plants and probably to less efficient water use. Because one of the major constraints to seed yield in the ICARDA region is limited rainfall, efforts to increase water-use efficiency assume paramount importance.

During the 1981/82 growing season a



An example of the biological response of early planting of lentils (background) compared with conventional late winter planting (foreground). The former leads to improved water use efficiency.

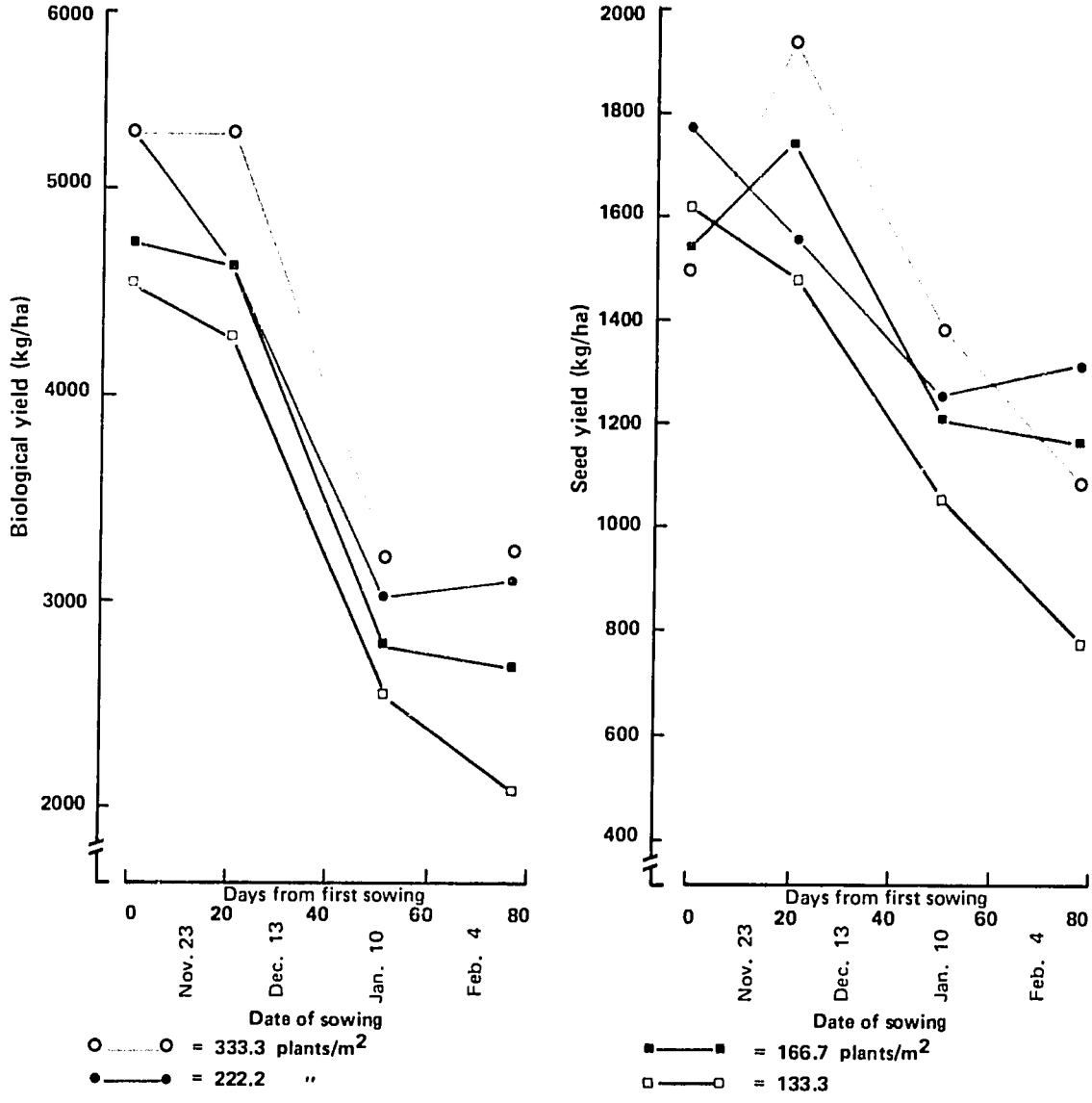


Figure 5. Total biological yield and seed yield (kg/ha) of lentil variety ILL 4400 as affected by the date of sowing and plant population levels.

date of planting x plant population trial was conducted at Tel Hadya, and the results of that season confirmed those of earlier years that the largest total biological and seed yields of lentils are obtained by early sowing at a high plant population (Figure 5).

Advancing the date of sowing from early January to early November also improved the water use efficiency (Table 18). Soil moisture extraction data in Figure 6 show that the crop is able to extract more moisture with the earlier sowing date probably due to better root development. Early sowing could prove a dependable way to improve water use efficiency for the lentil crop in low rainfall areas of North Syria.

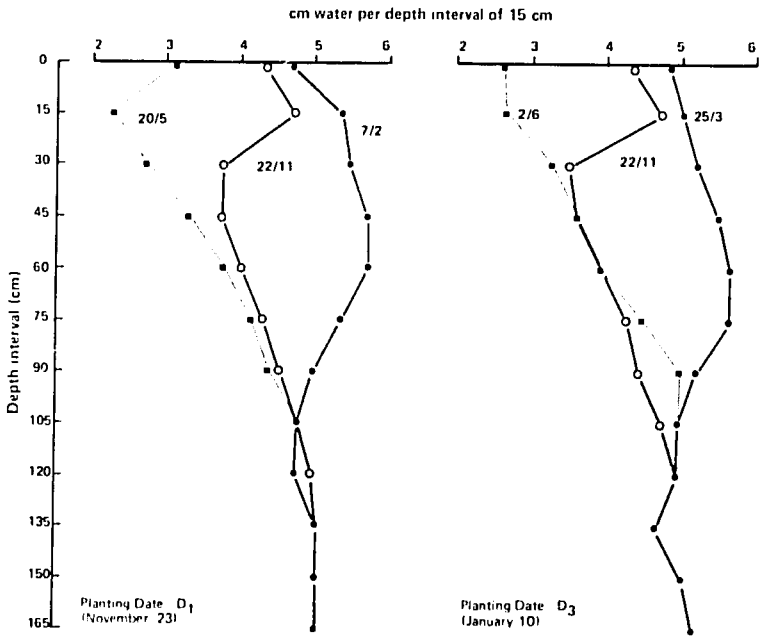


Figure 6. Recharge/ discharge curves for soil moisture in different layers under two dates of lentil planting (ILL 4400) at Tel Hadya, Syria (1981/82).

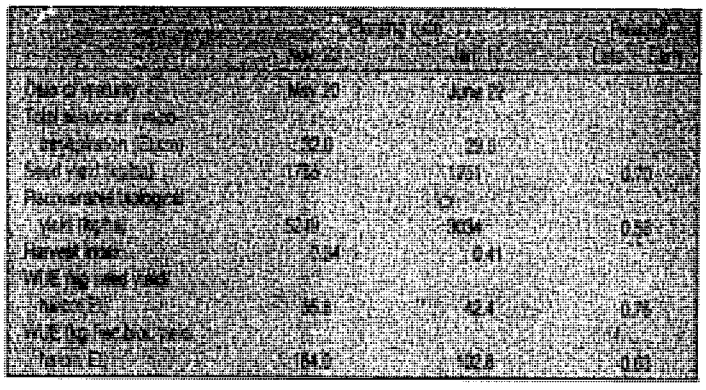


Table 18. Effect of date of sowing on the productivity and water use efficiency (WUE) of lentil variety ILL 4400 with a population density of 222.2 plants/m^2.

ICARDA Lentils Used by National Programs in Multi-Location and On-Farm Trials

Providing superior cultivars to farmers through national programs is the principal aim of the lentil breeding program. Cooperative tests on lentils with Syria's Ministry of Agriculture have shown ICARDA selections to be consistently superior to local cultivars in yield.

Harvesting superior lentil cultivars for seed which will be sent by ICARDA to national programs for on-farm trials.

For example, 78S 26004 yielded an average of 32% more than the best local check in six trials (Figure 7). In addition, ILL 4400 has out-produced the local cultivar over the past four years in Lebanon (Figure 8).

Consequently, these selections and others from the Center are being tested in on-farm trials in those two countries. National programs in Egypt, Jordan, and India (Number One in the world in lentil production) are also using material from the Center's breeding program in either on-farm trials or multi-location testing (Table 19).

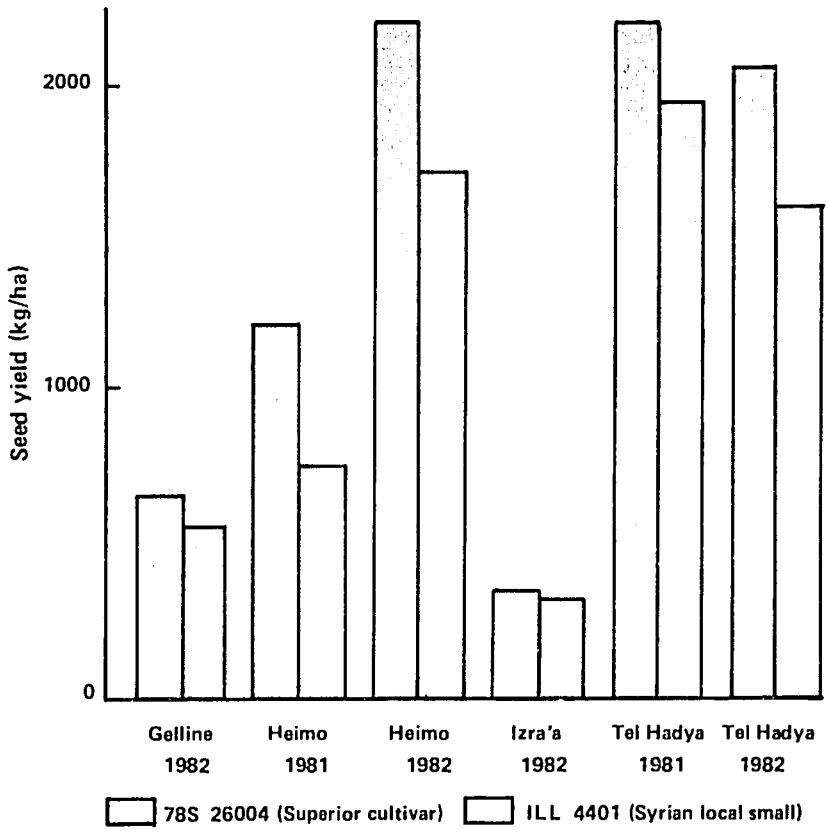


Figure 7. Seed yield of two lentil cultivars in regional trials over 1981 and 1982 seasons at different locations in Syria.

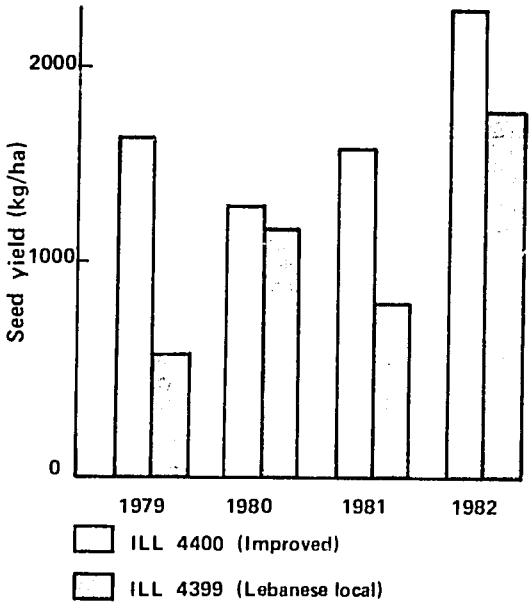
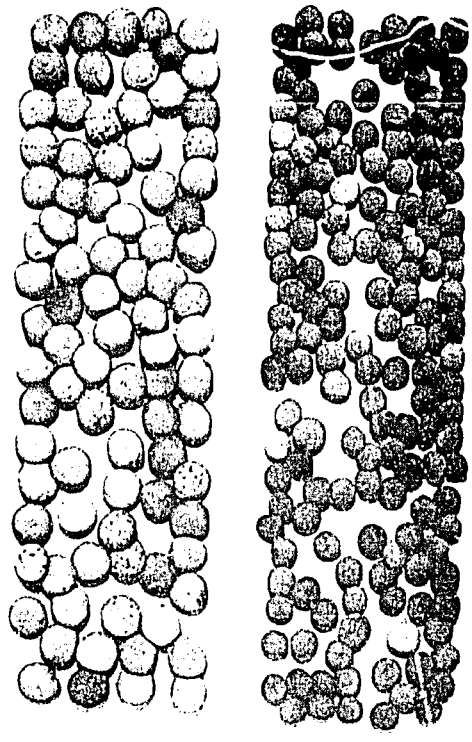
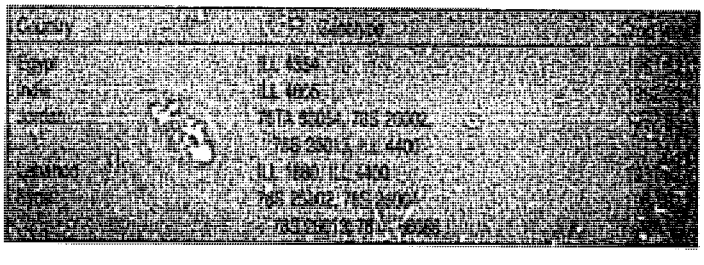


Figure 8. Seed yield of two lentil cultivars in trials from 1979–1982 at Terbol, Lebanon.



Development of large, high quality lentil seeds is one of the objectives of plant breeders. Shown here is a close-up of small and large seeds.

Table 19. Use of lentils supplied by ICARDA to national programs in either multi-location testing or on-farm trials.



Developing and Evaluating Pure Lines of Faba Beans

Scientists at ICARDA have developed a system to produce pure lines of faba beans (*Vicia faba*) which are designated as BPL lines (Broadbean Pure Lines). This became necessary because the International Legume Broadbean lines (ILBs) are open-pollinated heterogeneous, heterozygous collections and therefore difficult to maintain and evaluate for useful traits.

Each ILB line is selfed under insect-free screenhouses with single plants advanced for the next cycle of selfing. This process is carried out from three to five cycles, and in this way several pure BPL lines are developed for each ILB line. Then they are evaluated for useful traits and the best lines multiplied for distribution (Figure 9). BPL lines resistant to major diseases of faba beans are being used in ICARDA's breeding program and distributed to breeders in national programs.

During the past two years, the protein percentage for 780 of these BPL was analyzed. They averaged 28.3% with a minimum of 18.5% and a maximum of 36.3%. Several lines (BPL 331, 1587,

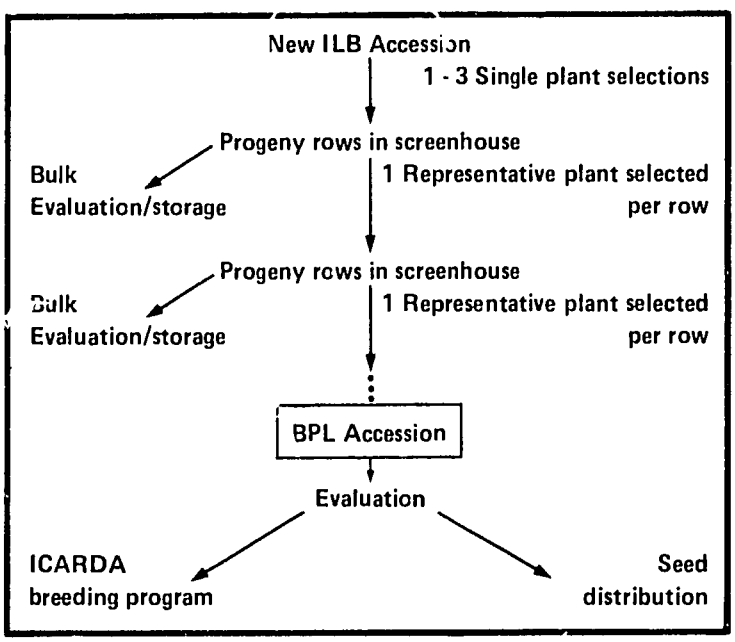
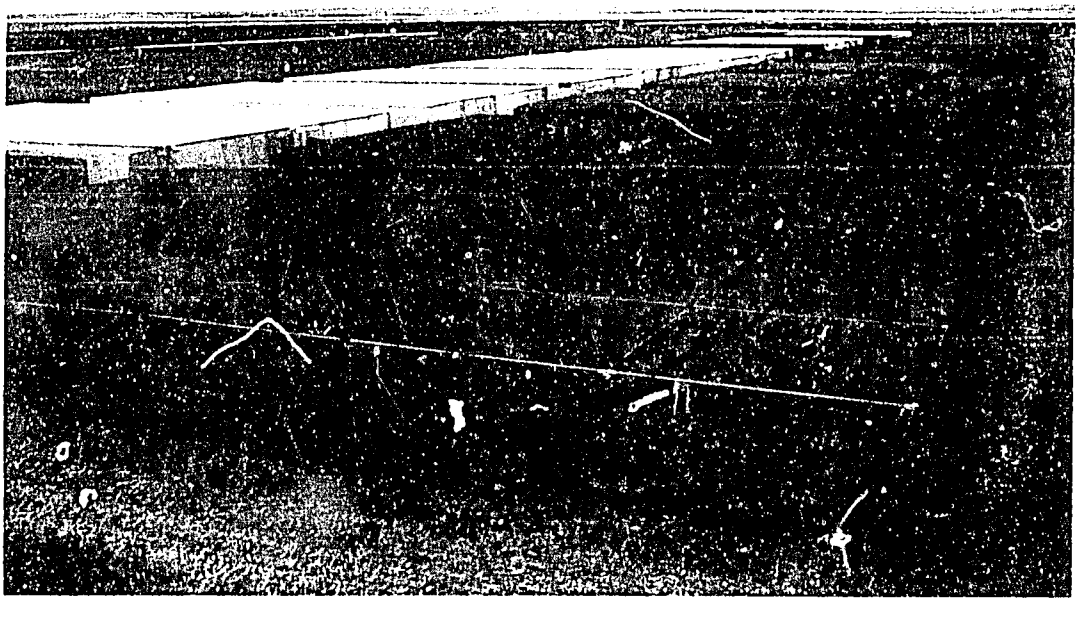


Figure 9. Flow chart showing BPL accession production, evaluation, and use of faba bean germplasm.

717, 521, and 1521) were identified as sources of high protein. Because there does not appear to be a strong negative relationship between yield and protein percentage in faba beans, the chance exists to select for both simultaneously.

Each faba bean pure line (BPL) in ICARDA's screenhouses is evaluated for useful traits and the best lines multiplied for distribution. Cold weather killed the faba beans sown in the front center row; the others are frost-tolerant plants.

A panoramic view of 32 screenhouses at ICARDA with 200 pure lines of faba beans in each one.



Sources of Resistance to Chocolate Spot Disease of Faba Beans

Diseases can inflict large losses in faba bean production (Figure 10), and chocolate spot, caused by *Botrytis fabae*, is the most devastating disease in this crop throughout the Middle East, North Africa, and Europe. A complete crop failure may occur when there is an extended period of wet, cool weather.

Although chemical control measures are available, farmers are reluctant to employ them because they are expensive and difficult. Major emphasis, therefore has been placed by ICARDA's scientists on the development of cultivars resistant to chocolate spot. They realize that monogenic resistance might not provide a lasting solution to the problem, particularly when a variable pathogen such as *B.fabae* is involved. Knowledge concerning pathogenic variability in *B.fabae* is essential to plan a sound breeding strategy.

In a cooperative study with the national program of Egypt and the American University of Beirut (Lebanon), five genotypes previously identified as resistant to chocolate spot were separately cross-inoculated in moist chambers with eight isolates of *B.fabae* collected from different geographical regions in Egypt, Lebanon, and Syria. This study indicated that isolates N (Nubaria-Egypt) and T (Tel Kalakh-Syria) were more virulent than isolates originating from other geographical regions.

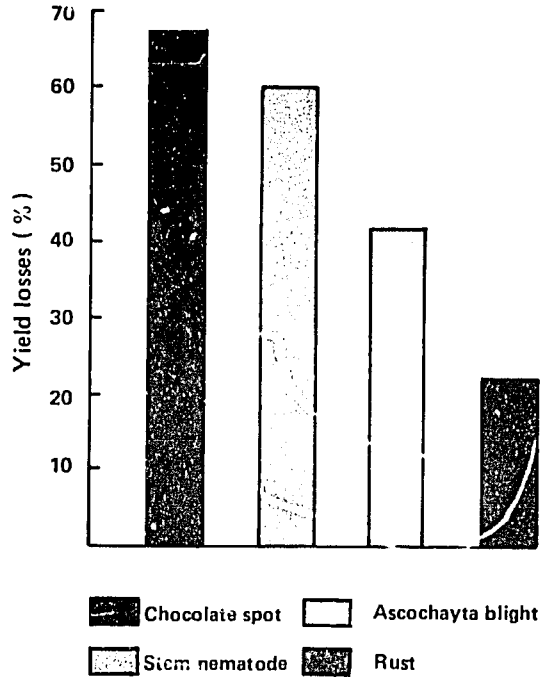


Figure 10. Potential faba bean losses if crop is attacked by major diseases.

Considerable progress has been made recently to identify reliable sources of resistance (Figure 11) by the development of a two-cycle screening technique coupled with multi-location testing. (In the first cycle, scientists use a mix population of inoculant and in the second cycle a more virulent isolate.) Of the 1,730 lines tested by the two-cycle technique at ICARDA's subsite in Lattakia, Syria, 11 were rated 1 (highly resistant) and 104 rate 3 (resistant) on a 1 to 9 disease rating scale. This compared with an average score of 7 for a local check (Figure 11).

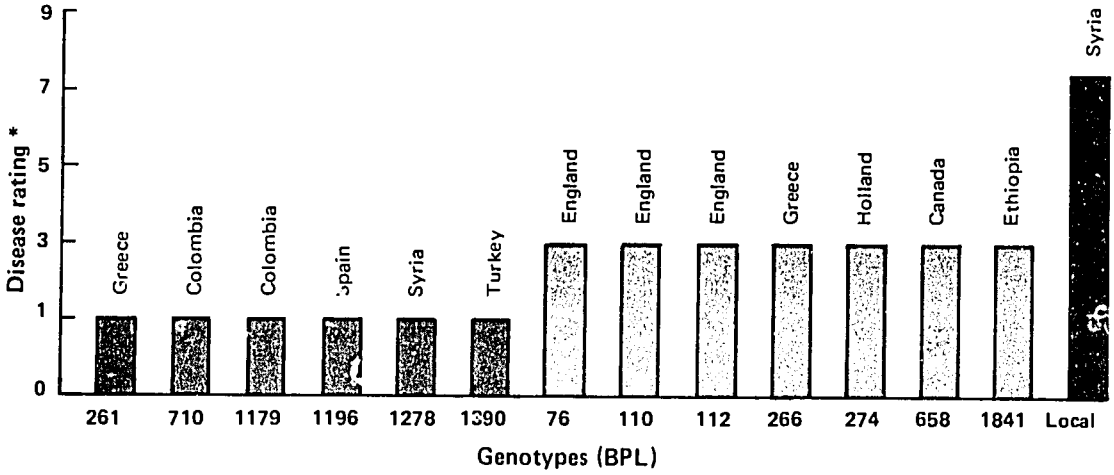
The most resistant selections made from such screening (i.e. BPL 710, 1179, 110) were rated very resistant in both Egypt and the United Kingdom.

A faba bean plant infected with chocolate spot disease.

The two selections—BPL 261 and 266 made from the two cycle technique—seemed more resistant than any other genotype, even to the most virulent Nubaria isolate of *B.fabae* in Egypt. This screening technique contributed significantly to the detection of such sources of multi-location resistance that were lacking in the past. More multi-location testing is underway.

Seeds of all new lines resistant to chocolate spot have been increased at the off-season site near Lattakia, Syria.

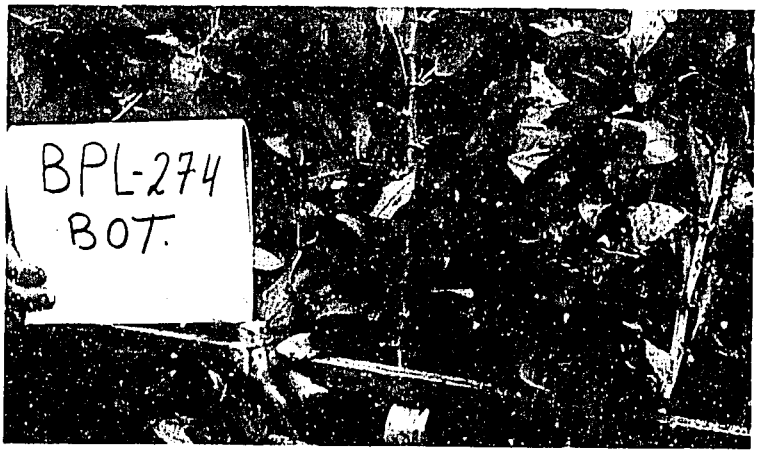
Figure 11. Representative chocolate spot-resistant faba bean genotypes from various countries and selected at ICARDA's sub-site at Lattakia, Syria.



* 1 = Highly resistant; 3 = Resistant; 9 = Highly susceptible.

Seed from this increase has been distributed to Egypt, Tunisia, Algeria, and U.K. to evaluate the resistance to different populations of *B.fabae*. This multi-location testing should help identify specific genes for resistance to *B.fabae* in particular production areas and genes for resistance across different production areas.

Diallel crosses among most promising lines and local well-adapted cultivars will be made in 1983 at ICARDA and in Egypt to create genetic stocks and cultivars with broad spectrum and stable resistance for *B.fabae*. In 1982, about 60 crosses were made with F_1 seeds planted during the same year at the off-season site near Lattakia, and F_2 progenies are being tested there in 1983. At present, ICARDA is close to the stage when such resistant sources will be used in some faba bean production regions.



One of the pure lines rated as resistant to the chocolate spot disease.

Actual and Potential Levels of Ewe Fertility in Awassi Sheep Flocks

Farmers in Syria with well managed Awassi sheep flocks are obtaining as many as 107 lambs born per 100 ewes mated—comparable to results with the best experimental flocks at ICARDA's main station at Tel Hadya. However, farmers with poorly managed flocks get only about half that lambing percentage.

The fertility of Awassi ewes in farm flocks was assessed in 1981/82 by closely monitoring 175 ewes in 13 flocks in Syria's Aleppo Province and compared with data collected in earlier surveys (Table 20). In addition, the results of these surveys were compared with the fertility levels of ICARDA's experimental flocks at Tel Hadya subjected to different grazing/feeding regimes.

Both the village and steppe surveys included one very dry year when lambing percentages were poor. This reduced the overall mean lambing percentage compared with the survey in 1981/82—a year of average rainfall. The much better fertility of the experimental flocks at Tel Hadya that year was due to the good condition of the ewes at mating.

The reason for the below average fertility in these flocks the following year

Weighing one of the ewes from a village flock as part of an ICARDA study of ewe fertility.

	Source	Lambing percentage[a]		
		Mean	Poor flock	Best flock
Steppe survey	1978 81: Farm flocks	84	69	102
Sheep survey	1981 82: Farm flocks	90	57	107
Tel Hadya	1981 82: Experimental flocks	97	90	100
Tel Hadya	1982 83: Experimental flocks	88	68	106

(a) Lambing percentage is defined as the number of lambs born per 100 ewes mated.

Table 20. Lambing percentages in farm and experimental flocks.

Well managed farm sheep flocks such as this one compared favorably with the lambing percentage of ICARDA's best experimental flocks.

was the poor grazing/feeding regimes which influenced the liveweight of the three flocks during the mating period (Table 21). These differences had a marked effect on lambing percentages. Liveweight was chosen as a measure of body condition—an important factor affecting ewe fertility.

Implications of this research include: (1) greater productivity is possible by improving the fertility of poorly managed flocks; and (2) the body condition of the ewe at mating, which depends on the nutritional regime before and during the mating period, has a marked influence on fertility levels.

ICARDA livestock and forage specialists are continuing their efforts to identify the reasons for low fertility levels in many farm flocks and to design and test economic grazing and feeding practices which ensure maximum fertility levels.

	Level of flock management		
	Low	Medium	High
No. ewes in flock	28	28	33
Liveweight at mating (kg)	40	44	49
Lambing percentage[a]	68	86	106

(a) Lambing percentage is defined as the number of lambs born per 100 ewes mated.

Table 21. Effect of liveweight of ewe at mating on lambing percentage of Tel Hadya experimental flocks (1982/83).

Sheep Performance, Husbandry Systems, and Constraints in a Steppe Area

Results of a three-year survey conducted in the low rainfall area of Aleppo and Raqqa Provinces in Syria have identified economic and husbandry constraints that limit sheep production and point the way to needed research and extension activities to overcome them. Flock structure, reproductive rate, and mortality levels are shown in Table 22.

The 17 village flocks in the survey ranged in size from 30 to more than 1,000 head. Additions to the ewe flocks averaged 31%, of which 2% were purchased. Attrition amounted to about 30%. After deducting transfers such as ewes given to other members of the family, the culling rate was 23%. This suggests that the average ewe bears four or five lambs and is culled at an age of six to seven years. Increasing the culling rate would have little impact on ewe productivity because farmers are already removing those found to be barren.

An average lambing percentage of 84% for the 17 flocks was well below the 97% achieved in 1981/82 across the three ICARDA flocks at Tel Hadya, Syria. (Lambing percentage is defined as the number of lambs born per 100 ewes mated.) However, wide variations —from 69 to 102%—existed in the village flocks. The causes of the low percentages in some of them warrant further study. If lambing performance were increased from 84 to 100%, which is a possibility, and mortality held at a constant 10%, lamb sales could be increased by 30%.

Mortality levels for ewes, yearlings, and lambs in the survey were less than expected, but again wide variations existed. There were cases where lamb losses exceeded 30% in localized epidemics.

	Ewes (per 100 ewes in opening inventory)	Yearlings (per 100 yearlings in opening inventory)	Lambs (per 100 lambs born)
Transfers (in)	29	101	—
Purchases	2	1	—
Sales	15	5	40
Deaths	7	2	11
Consumption	1	2	6
Transfers (out)	7	90(b)	43(c)

(a) Average flock size was 176 ewes and 58 yearlings. Over three years these numbers expanded to an annual rate of 3 and 4%, respectively.
(b) Transfers to ewes.
(c) Transfer of female lambs to yearlings.

Table 22. Three-year inventory balance sheet of 17 village sheep flocks.[a]

A three-year survey of village flocks identified economic and husbandry constraints that limit sheep production in low rainfall areas of northern Syria.

The pathogens responsible for these epidemics need to be identified. They often attack healthy lambs that have passed through the critical neo-natal period. Good husbandry practices, particularly nutrition of ewes in late pregnancy, can reduce neo-natal deaths. But good nutritional practices can do little to reduce mortality of older lambs when virulent pathogens are involved. Instead, routine vaccination may be the only effective control.

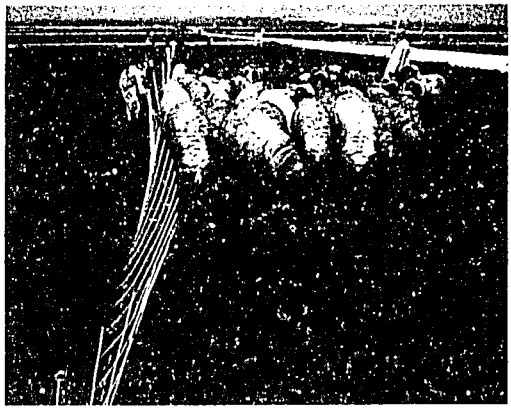
Selections in Forage Cereals for Grazing and Hay Production

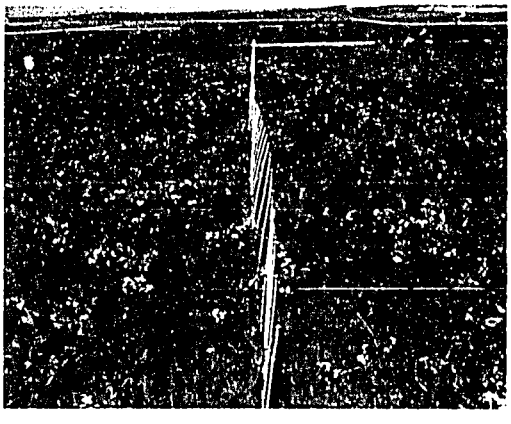
Shortage of feed during late summer and early winter continues to be a major constraint for livestock production and improvement in the ICARDA region. Forage cereals, such as barley and triticale, offer good chances for early winter grazing because of their relatively fast rate of growth compared with other types of forages.

However, many lines of forage cereals are very slow to recover following defoliation and toward the end of the season provide only a limited amount of dry matter (DM) which can be harvested and stored as hay for later use.

During the past three years, ICARDA scientist have been screening hundreds of forage barley and triticale lines to identify suitable lines that can be grazed early in the season and still remain productive for hay. Out of 600 lines screened, five accessions of barley (IFB 250, 249, 264, 251, and 248) and one accession of triticale (IFT 314) were identified as promising.

These lines proved to be high yielding for both grazing and hay and were able to withstand early defoliation because of their ability for later rapid growth.





Top right, early grazing of a mixture of forage peas (*Pisum* spp.) and barley; the same grazed area on the right in the lower photo shows the recovery potential for hay production and compares favorably with the ungrazed area on the left.

Three out of the five accessions of barley (IFB 250, 264 and 248) were still productive even when cut twice early in the season (Table 23). The amount of forage from these lines for grazing late in January–early February ranged from 1.8 to 2.6 t/ha green (0.4–0.5 t/ha DM); the total DM harvested from the same accession toward the end of the season was 5 to 7 t/ha.

Early defoliation also improved the yield of total digestible dry matter in the accessions, especially when the crop received one early cut before a final harvest for hay (Table 24).

Mixtures of the selected lines and forage legumes (*Vicia* and *Pisum*) are now being evaluated for early (winter) grazing by sheep and then will be assessed for yield and quality of hay produced toward the end of the season.

Accession nos.	Control final harvest	One early-cut + final harvest	Two early-cuts + final harvest	Mean
Barley				
250	4743	7824	5846	6137
249	4786	5364	3851	4667
264	3671	6819	4733	5074
251	5438	5578	4241	5086
248	3924	5460	4735	4706
Triticale				
314	5015	5772	3687	4825

Table 23. Total dry matter production (kg/ha) of selected lines of forage barley and triticale in relation to frequency of defoliation.

Accession nos.	Control final harvest	One early-cut + harvest	Two early-cuts harvest
Barley			
250	2.5	5.2	4.0
249	2.5	3.7	2.5
264	2.0	4.5	3.3
251	2.9	3.8	3.3
248	2.0	3.7	3.1
Triticale			
314	2.7	3.8	2.5

Table 24. Total digestible dry matter yield (t/ha) of selected forage barley and triticale under different cutting regimes.

Cutting a barley-vetch (*Vicia* spp.) mixture for hay.

Productive and High Quality Forages for Hay

During the past decade, livestock numbers (particularly sheep) have increased substantially in many countries of the ICARDA region, but this development has not been matched by an increase in feed production. As a result, more than one-fourth of the required animal feed in the region comes from imported grain.

Meanwhile, millions of hectares of land are left fallow every year within the existing cropping system, especially in the medium and low rainfall areas (200–400 mm) that account for about 60% of the arable land in the region. Growing of forage mixtures (legume and cereals) on such available land offers an opportunity to produce locally a less expensive and good quality animal feed.

Adapted lines of forage legumes (*Vicia* spp., *Pisum* spp., *Lathyrus* spp.) and forage cereals (barley, triticale, oats) have been identified by ICARDA scientists. These lines provided the desirable characteristics required for suitable forage mixtures that can be grown and harvested for hay. During 1981/82, studies were carried out at Tel Hadya, Syria to evaluate different forage mixtures and to define proper agronomic

and management practices required for maximum dry matter yield and forage quality.

Out of the several mixtures studied (*Vicia*-oats, *Vicia*-barley, *Vicia*-triticale, *Lathyrus*-triticale and *Pisum*-triticale), the *Vicia*-oats mixture appeared as the most productive (Figure 12). The use of high seed rates (140–180 kg/ha) and moderate phosphate application (40–80 kg P_2O_5/ha) were necessary to maximize dry matter yield in all forage mixtures (Table 25). The study shows that the presence of 20 to 40% of a legume component in the mixtures will significantly improve forage quality without an appreciable reduction in dry matter yields.

Forage mixtures were also evaluated to define the proper time of harvest. Guided by the morphological development of the legume component in the mixture, forage crops were harvested at one of three stages—10% flowering, 100% flowering, or full pod formation.

Dry matter (DM) yield was significantly increased with delayed harvesting in all

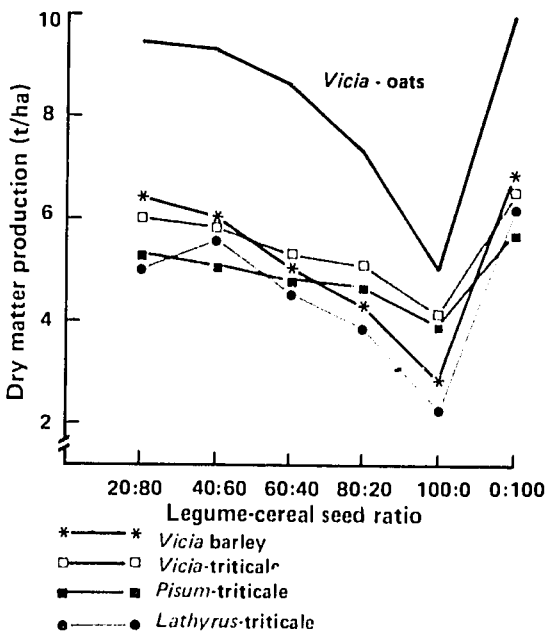


Figure 12. Total dry matter production of forage mixtures as affected by legume-cereal ratios.

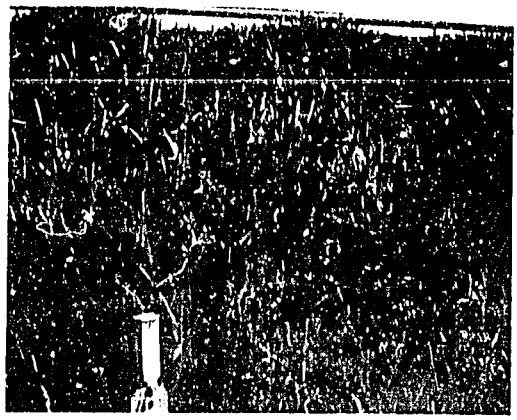
Forage mixture [a]	Seed rate (kg/ha) 80	140	160	180
Vicia-triticale	4595	55[illegible]	5809	6033
Pisum-triticale	4559	4896	5471	5596
Lathyrus-triticale	4161	4830	4923	5573
Vicia-oats	**7446**	**8300**	**8451**	**8737**
Vicia-barley	4317	5647	5807	5600

Forage mixture [b]	Phosphate rate (kg P_2O_5/ha) 0	40	80
Vicia-triticale	4591	5577	6280
Pisum-triticale	4329	5495	5090
Lathyrus-triticale	4213	4912	4775
Vicia-oats	**7641**	**8225**	**8853**
Vicia-barley	4479	5545	5693

(a) Each value is an average of 3 phosphate rates x 6 seed ratios.
(b) Each value is an average of 6 seed rates x 6 seed ratios.

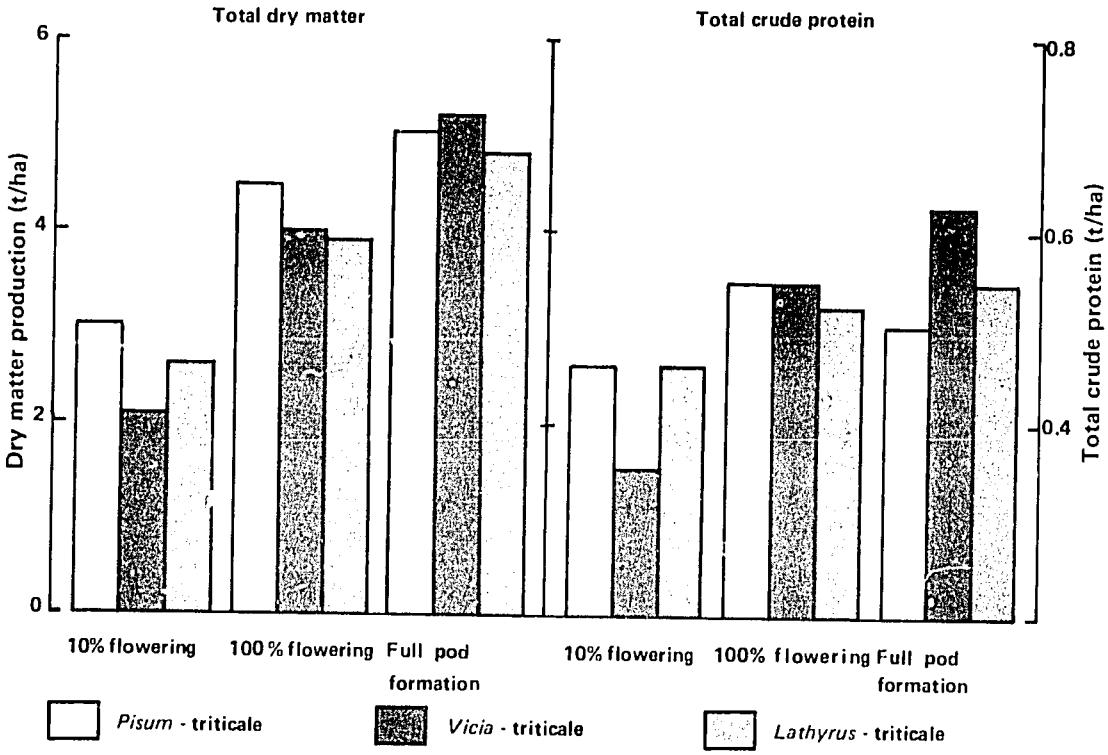
Table 25. Effect of seed rate and phosphate fertilizer application on dry matter yield (kg/ha) in different forage legume/cereal mixtures.

legume-cereal mixtures (Figure 13). Increases in DM of 46% and 66% were obtained for *Pisum*-triticale harvested at 100% flowering and at full pod formation, respectively, as compared with 10% flowering. Similarly, yield of *Vicia*-triticale mixtures harvested at 100% flowering and at full pod formation increased, respectively, by 88% and 145%. Corresponding values for *Lathyrus*-triticale were 46% and 80%.



Out of several mixtures of forage legumes and forage cereals harvested for hay, a vetch-oats mixture produced the highest yields.

Figure 13. Total dry matter and total crude protein as affected by harvesting stage of the legume component in three forage legume-cereal mixtures.



Promising Medic Cultivars for Crop Rotation

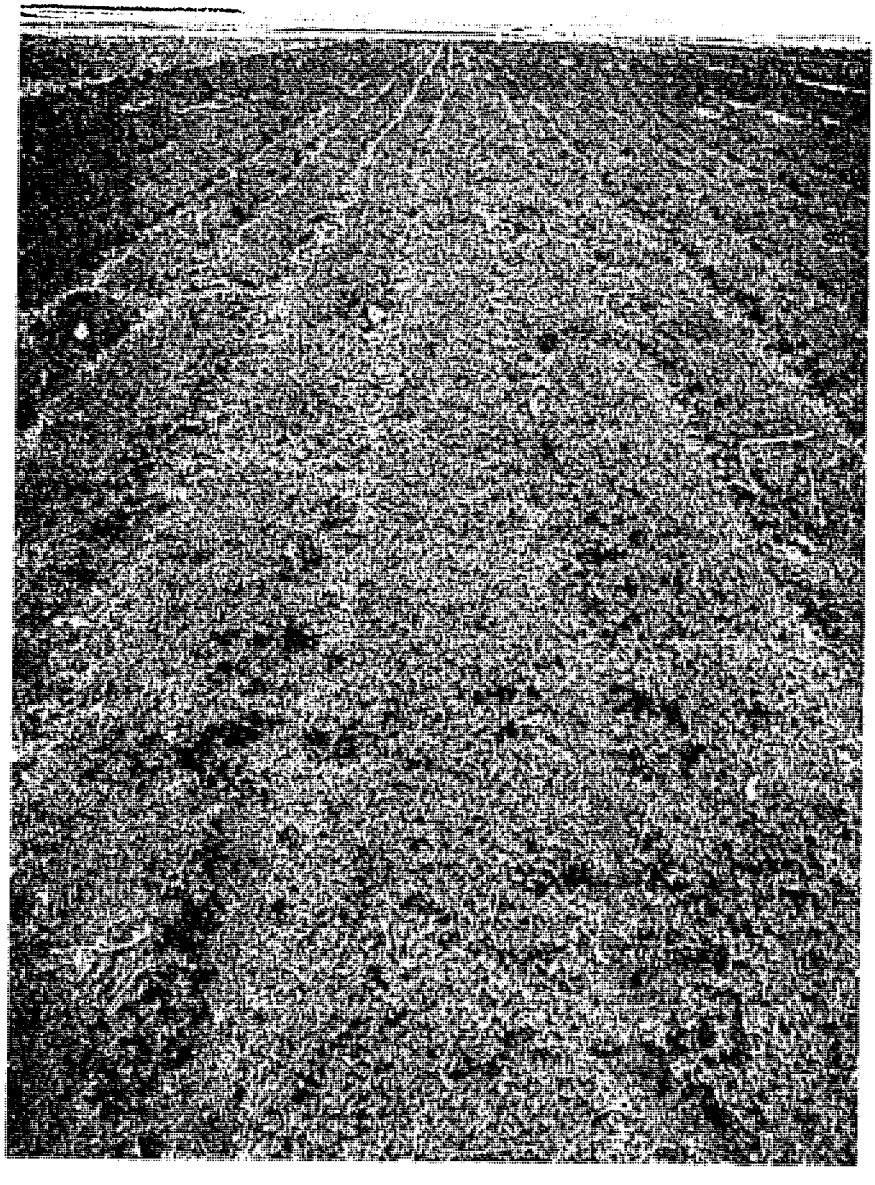
Although there is an urgent need to increase feed supplies for livestock in the Middle East and North Africa, approximately 40 million hectares of agricultural land lie idle in fallow. But the possibility exists to turn these idle hectares into productive pastures to provide additional feed and also improve soil fertility.

Current research focuses on the evaluation of both indigenous species and commercial cultivars. Trials are also underway to determine the most appropriate pasture establishment and grazing management practices and to develop technology to integrate medic pastures in the cropping system in a cereal pasture sequence that will ensure the regeneration of the annual pastures in alternate years.

Results of 1981/82 microplot trials indicated that some accessions of three species—*m.rigidula, m.aculeata,* and *m.noeana*—are outstanding in their herbage and seed yield performance (Table 26). Three other species—*m.rotata, m.constricta*, and *m.blanchiana*—rank lower than the control both in dry matter and seed yield. Although the species might not be impressive at Tel Hadya, Syria, they could be well adapted in other countries of the region. *Medicago truncatula* and *m.scutellata* have continued to be relatively poor performers at Tel Hadya.

Species	No. acc.	DM yield (kg/ha) range of mean	Seed yield (kg/ha) range of mean
M.rigidula	79	9715-3102	1914-549
M.aculeata	7	5307-1826	757-322
M.noeana	3	8182-4681	1496-963
M.rotata	18	6110-2138	2402-594
M.constricta	2	4573-4180	751-254
M.blanchiana	2	3562-3203	949-333
M.turbinata	6	3443-1637	714-184
M.truncatula	6	2760-803	290-159
M.scutellata	1	1271	173
Control (rigidula)		6665	1123

Table 26. Dry matter (DM) and seed yield of medic selections in microplot trials at Tel Hady Syria (1981/82).



Medicago rigidula—an outstanding cultivar in herbage and seed yield performance at ICARDA—is being increased here for on-farm trials.

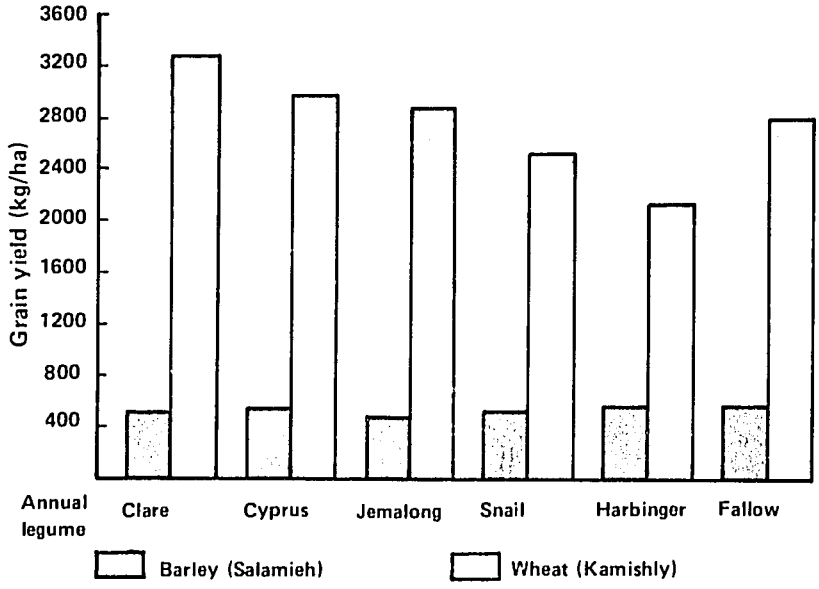


Figure 14. Grain yield of wheat and barley grown after annual legume or fallow (1981/82).

Four Australian medic cultivars—Snail, Jemalong, Cyprus, and Harbinger—were evaluated for establishment and production (dry matter and seed yield) at five locations in Syria (Kamishly, Hama, Lattakia, Idleb, and Homs-Arjoon). Snail and Jemalong were more productive than Cyprus and Harbinger at four out of five locations; at Kamishly and Hama their yields were more than double those of Cyprus and Harbinger and comparable with the promising lines of *m.rigidula* at Tel Hadya.

Grain yield of wheat and barley grown after the annual legume pasture was equal or higher than that of the same cereal crops grown after fallow (Figure 14). A follow-up on these trials is underway to get more information on medic regeneration after the cereal crop during 1982/83.

Marginal Land Improvement with Permanent Pastures

Expansion of cereals as "opportunity crops" on marginal lands is a serious threat to the stability and future productivity of these important areas. A better development would be to establish productive pasture species on these lands. They would include annual grasses, annual self-regenerating legumes, and perennials, either in pure stands or mixtures.

So far, research has been limited to evaluation of cultivars and ecotypes of annual and perennial grasses in terms of their adaption and dry matter distribution under rainfed conditions. Annual self-regenerating legumes were not included in the early stages of this research because no seed of cultivars and ecotypes with suitable seed permeability was available.

An important feature of the evaluation was depended on intense defoliation to simulate continuous grazing. Plants were clipped whenever herbage reached a height of 10–15 cm, except early in winter and late in spring when they were clipped even if the herbage height was only 5–10 cm. ICARDA scientists established three trials with both annual and perennial grasses in 1979, 1980, and 1981.

The Australian cultivars of *Phalaris aquatica* and the ecotypes of *Dactylis glomerate* collected in Syria and Jordan were still actively growing in 1982—three years after their establishment. Furthermore, the accessions of these two species showed good regrowth in the winter of 1982, although this was delayed by the cold temperatures during Novernber and December.

The 1980 adaptation trial, which was a replicated trial, permitted a more precise analysis. Although all species in the trial had a peak production in the spring, differences were found in their ability to grow early in winter and in summer. Total dry matter yield in 1981 and 1982 indicated that *P.aquatica* is the most productive perennial grass in the first few years after establishment. (This is in agreement with results of the 1979 adaptation trial.)

Four years of trials show that the cultivar *Phalaris aquatica* is the most promising perennial grass.

Although only one year data are available for the adaptation trial established with 81 accessions in November 1981 (Table 27), they show that *P.aquatica* is again ranking very high and that local germplasm of this species could be more productive than existing cultivars. As in previous trials, *Lolium perenne* was very productive in the establishment year, but the persistence of this species has proven to be unsatisfactory. A grazing trial established in November 1980 and grazed five times both in 1981 and in 1982 has largely validated the results of the adaptation trials, indicating *P. aquatica* as the most promising perennial grass.

The evaluation of annual grasses established in 1981 (Table 28) shows the overall good adaptation of *Lolium multiflorum* with minor differences between accessions. *Phalaris canariensis* has been identified as a very promising annual grass. An accession of this species, which is both highly palatable and productive, is being multiplied for large-scale testing. An interesting feature of this species is its complete seed retention at maturity which facilitates seed production.

Table 27. Dry matter yield (g/plant) in the best perennial grasses established at Tel Hadya, Syria in November 1981.

Species	Cultivar or country of origin	Total dry matter yield (g/plant)
Lolium perenne	Syria	10.5
Phalaris aquatica	Syria	8.6
Lolium perenne	Tasdal	8.3
Lolium perenne	Iran	8.0
Lolium perenne	Maprima	7.2
Lolium perenne	Victoria	6.9
Stipa tortilis	Turkey	5.8
Lolium perenne	Tasmanian	5.5
Phalaris aquatica	Sirosa	5.1
Lolium perenne	Iran	4.8
Lolium perenne	Iran	4.3
Phalaris aquatica	S. Africa	4.3
Phalaris aquatica	Australian	4.2
SE		±0.7

Table 28. Dry matter yield (g/plant) of three annual grasses evaluated in 1982 at Tel Hadya, Syria under rainfed conditions.

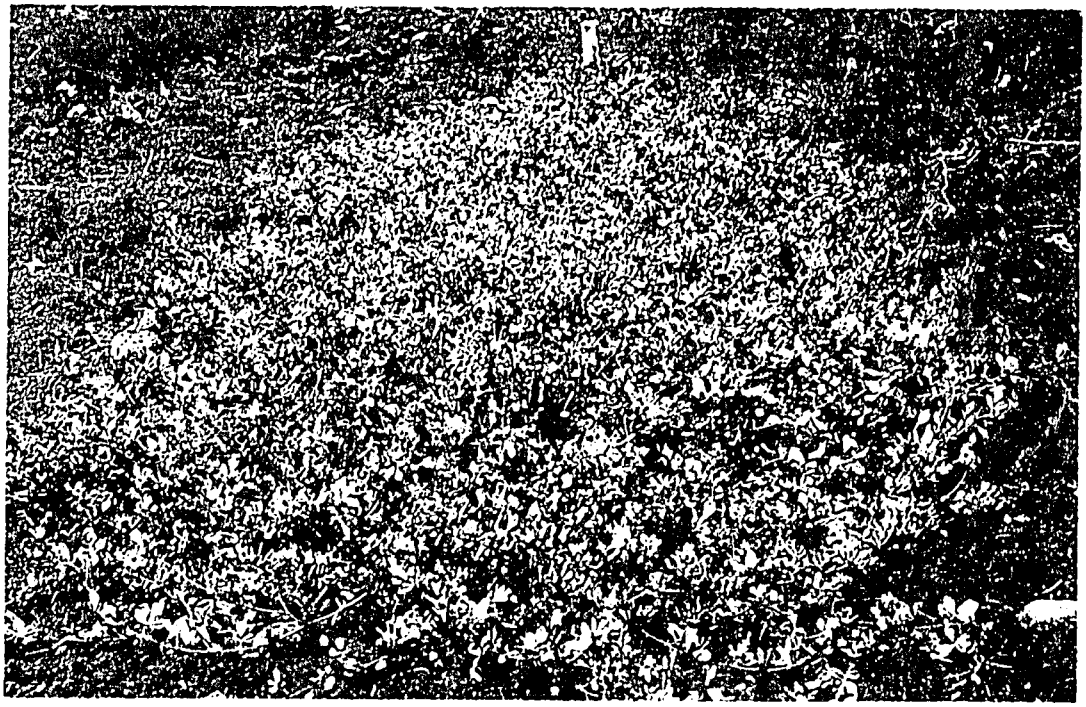
Species	No. acc.	Dry matter yield (g/plant) Average	Range
Lolium rigidum	5	8.4	6.4–10.8
Lolium multiflorum	4	13.6	12.6–14.8
Phalaris canariensis	3	9.3	2.7–13.1

Monitoring the Prevalence of Diseases and Insects of Pasture and Forage Crops

Prior to 1980/81, little information was available on insects and diseases that attack pasture and forage crops in the Middle East and North Africa. For this reason, ICARDA conducted extensive field surveys during 1981 and 1982 in different parts of Syria and Lebanon to identify the economically important pests and then rate their incidence and severity. Also, disease damage on different pasture and forage species was evaluated and the information is being used in screening for disease resistance.

Several diseases were found on *Pisum* spp., but the most important ones included *Ascochyta* caused by *Ascochyta pisi* and *Phoma medicaginis* var. *pinodella*, bacterial blight caused by *Pseudomonas pisi*, and powdery mildew caused by *Erysiphe pisi*. The major diseases attacking *Vicia* spp. were *Ascochyta*, downy mildew (caused by *Peronospora viciae*), and powdery

Based on surveys in 1981 and 1982, powdery mildew is one of the two major diseases of annual medics in Syria and Lebanon.



mildew (Table 29). The latter and spring black stem caused by *Phoma medicaginis* var. *medicaginis* are considered the two major diseases of medics in both countries (Table 30).

Results of the insect survey (Table 31) showed that aphids are the most important pest with three species predominant: *Acyrthosiphum pisum, Aphis craccivora*, and *Therioaphis trifolii*. They are the principal vectors of virus diseases. The crop with the least insect attack was sainfoin. *Pisum* was heavily attacked by thrips, and, in addition to the pests mentioned in the table, it had some infestation of *Laspeyresia* pod borer. However, this was confined to the drier locations.

Crop	Location	Ascochyta	Bact. Blight	Powdery Mildew
Peas	*Syria*			
(*Pisum*	Jableh	3	4	4
spp.)	Himo	3	4	0
	T. El Imam	1	3	0
	Tel Hadya	4	4	3
	El Tah	1	0	0
	Selemieh	3	3	0
	Abou Hakfa	3	0	0
	Ajroun	3	1	0
	Izra	0	3	4
	Lebanon			
	Terbol	3	3	4
		Ascochyta	Downy Mildew	Powdery Mildew
Vetch				
(*Vicia*	*Syria*			
spp.)	Jableh	3	3	4
	Himo	4	2	1
	T. El Imam	1	1	3
	Tel Hadya	4	4	4
	El Tah	0	0	0
	Selemieh	1	3	3
	Abou Hakfa	0	0	0
	Ajroun	0	1	0
	Izra	0	0	4
	Lebanon			
	Terbol	0	1	3

Index: 0 = no obvious disease attack; 4 = disease very severe.

Table 29. Index* of the prevalence of major diseases of annual forage crops at different locations in Syria and Lebanon.

Location	Powdery Mildew	Spring Black Stem
Syria		
Fidio	0	4
Jableh	4	1
Himo	4	4
Tel Hadya	4	4
Al Shoumarieh	1	2
Izra	2	0
Lebanon		
Terbol	2	0
Kafardan	2	0

*0 = no obvious disease attack;
4 = disease very severe.*

Table 30. Index* of the prevalence of major diseases of annual medics (*Medicago* spp.) at different locations in Syria and Lebanon.

Aphids—the principal vectors of virus diseases—are the most important pests of forage crops, including vetch (*Vicia sativa*) shown here.

Table 31. Index* of major insect pests of forage crops in Syria and Lebanon.

Crop	Aphids	Thrips	Leaf-miner	*Hypera* weevil	*Sitona* weevil
Peas					
Pisum spp.	2	4	2	0	0
Vetch					
Vicia spp.	3	2	2	0	2
Sainfoin					
Onobrychis spp.	1	1	0	1	1
Medics					
Medicago spp.	1	0	3	2	0
Alfalfa					
Medicago sativa	4	1	2	3	1

Index: %plants attacked: 0 = 0; 1 = <5; 2 = 5 to 25; 3 = 25 to 50; 4 = >50.

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*Left ICARDA during 1982.