ICARDA Annual Report 1983

ICARDA
Annual Report
1983

International Center for Agricultural Research in the Dry Areas

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Contents

Statement of Objectives

The International Center for Agricultural Research in the Dry Areas (ICARDA) was established in 1977 to undertake research relevant to the needs of developing countries and specifically for the agricultural systems in West Asia and North Africa. The overall objective of the Center is to contribute towards increased agricultural productivity, thereby increasing the availability of food in both rural and urban areas, and thus improve the economic and social well-being of people.

ICARDA's primary involvement is with rainfed agricultural systems in areas that experience limited, winter rainfall. Investigational work may be extended into irrigated areas where it is logical and cost effective to do so, but Center policy remains to give first priority to problems of the rainfed sector, an area which has always been at or near the bottom of any research priority list. In these environments barley, lentils, and faba beans (*Vicia faba*) are among the most important crops. For this reason, ICARDA has been assigned the principal responsibility for their improvement. The Center has five principal objectives:

a. To serve as an international center for research into and for the improvement of barley, lentils, and faba beans (*Vicia faba*) and such other crops as may be designated by the Board of Trustees in consultation with the Consultative Group on International Agricultural Research.

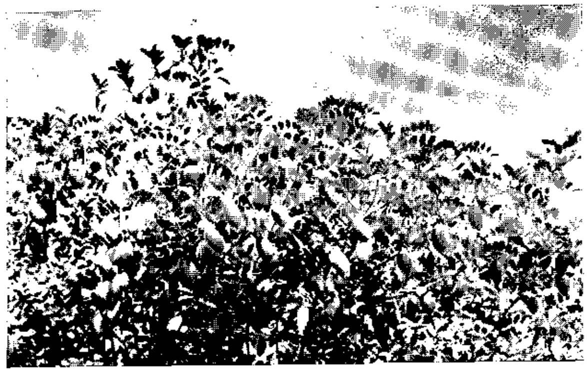
b. To serve as a regional center, in cooperation with other appropriate international agricultural research centers, for research into other crops of major importance to the region, such as wheat and chickpeas.

c. To conduct research into and develop, promote and demonstrate improved systems of cropping, farming, and livestock husbandry.

d. To collaborate with and encourage cooperation and communication among other national, regional, and international institutions in the adaptation, testing, and demonstration of improved crops, farming, and livestock systems.

e. To foster and support training in research and other activities carried out in the furtherance of its objectives.

ICARDA's Principal Research Areas



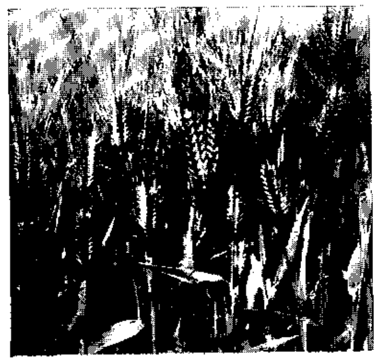
Latin
English
Arabic

Lens culinaris
Lentil
Adas عدس

Cicer arietinum
Chickpea
Hummus حمص

Vicia faba
Faba bean
Ful فول

Farming Systems
الأنظمة الزراعية



Hordeum (spp.)
Barley
Shai'r شعير

Triticum (spp.)
Wheat
Qamh قمح

Pasture and Forage Crops and Livestock
برنامج الأعلاف والمراعي والمواشي

ICARDA Donors

Currency: US $ (x 000)

Core Operations

Unrestricted Funds

Australia	485
Canada	625
Denmark	76
Ford Foundation	200
Germany	807
IDA/IBRD	4,995
Italy	439
Mexico	50
Netherlands	375
Norway	279
Saudi Arabia	600
Spain	75
Sweden	355
United Kingdom	531
USAID	5,000

Restricted Funds

Arab Fund	230
IDRC	366
IFAD	610
IFAD (Bldg)	1,300
OPEC	187
OPEC (Bldg)	1,000
UNDP	200
France	65

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IDRC-Arabic Dimension	5
IFAD	1,400
IBPGR Barley	15

Board of Trustees*

* Dr. J. I. Cubero (Spain) and Miss Naima Al Shayji (Italy) joined the Board during 1983. Drs. A. Hardan (Iraq), N. Boukli (Algeria), and G. J. Koopman (Netherlands) completed their tenure during 1983.

Introduction

Each of the International Agricultural Research Centers of the Consultative Group on International Agricultural Research (CGIAR) is subjected every five years to an independent review of its program—or, as was commonly called—*The Quinquennial Review*. The Review Panel is appointed by the CGIAR, to which body it submits its final report. In April 1983 it was our turn, and for the first time, to undergo an external program review—as it is now called. A team of eleven eminent scientists chaired by Dr. Guy Baird of IADS conducted this exercise at ICARDA, Aleppo, having made prior visits to our core-supported program in Morocco and Tunisia and earlier to the Nile Valley Project in Egypt. A short visit was also made by two members of the Panel to the Terbol Station in the Beqa'a, Lebanon. The names and addresses of the Panel members are given in Appendix 1 in this report.

Our mandate, strategies, research and training accomplishments as well as our points of strength and weakness were intensively examined. This historic event gave us a singular opportunity to look into the past six years (ICARDA was officially created in January 1977), and in the light of contemporary financial realities, to reflect onto possible future plans and potentials of ICARDA. It would be presumptuous, indeed fool-hardy, on my part to attempt summarizing the review report and the recommendations of the CGIAR on it. Nevertheless, I owe it to readers of this Annual Report to put on record a few salient points on the outcome of this important exercise.

1. The Quinquennial Review Report, and the CGIAR response, were supportive of ICARDA programs in almost every aspect. Where changes were proposed, such as the transfer of the Livestock Unit from the Farming Systems Program to the Pasture and Forage Improvement Program, they addressed shifts in emphasis within and between programs.

2. In no case did we receive a signal to diminish any activity. On the contrary, almost all the recommendations pointed towards strengthening, expansion, or intensification of our research and training programs.

3. One major recommendation, also approved by the CGIAR, is that ICARDA should embark on supplementary irrigation research but without slowing its thrust on dryland agricultural research. A specialist will be appointed in 1984 through the core budget to start this vitally important aspect of research.

4. We are told that despite the stunting effects of financial constraints on the growth and development of ICARDA and despite the political realities in this region, ICARDA has made significant strides; and its staff at all levels are highly motivated.

Thus, the review outcome gave a remarkable boost to an already healthy climate of confidence at ICARDA and an overall sense of commitment in what we are endeavouring to do towards the fulfillment of our mandate and the achievement of those objectives for which ICARDA has been created.

In my Foreword to last year's Annual Report (1982) I stated that: "At ICARDA we realize the importance of climate to agricultural research and are resisting the temptation to claim successful findings prematurely. A look at the climatic variation during our short tenure in Aleppo, Syria, reinforces this perspective. First, consider annual rainfall: at Tel Hadya, our main experiment station, 338 mm of precipitation was received in the 1981/82 cropping season. This is close to the long-term seasonal average, but it must be considered in the light of a wide range of seasonal precipitation experienced in the previous 25 years from 153 to 465 mm. We now have had five seasons with average for Tel Hadya being 350 mm. Our results have not yet been tested in a real dry year".

The 1982/83 season had its own climatic variations to make it different from the past seasons. The rainfall was slightly lower than average (324 mm instead of 341 mm), with an almost normal distribution. The temperatures during the November to April period were considerably lower than average, 8.4°C instead of 10.2°C. Also, a new absolute minimum of -9.8°C was recorded at the station during January 1983. In addition, the number of frost days was 52, compared to 30 as a five seasons'average. The main frost period occurred from December 1982 to February 1983. This delayed the plant development considerably and the crops suffered frost damage.

The year marked the completion of the first stage of development of our computer services. Basic software, including specialized packages, were developed at ICARDA and are now in use. They address diverse areas in research and administration.

A database management system called ICADET was developed as the basis for many packages which deal with such areas as international nurseries, crop agronomy, genetic resources, and meteorology.

An expanded version of CRISP (Crop Research Integrated Statistical Package) is used as the basic statistical tool. Overall estimates of varietal performance and a more rapid selection of cultivars is carried out on specially designed modules.

As a management tool, the computer was put to use for accounting, control, and information. MAS (Management, Accounting, and Information System), designed and developed at ICARDA, produces daily and periodic comparative reports reflecting the financial status of ICARDA. MAS spans a range of ICARDA's financial activities. It includes, for example, the budgeting process, made easier through special program modules. Payroll and Personal Service Processors provide more effective monitoring of overheads. The forthcoming release of the Inventory Control and Order Entry Program Sub-Systems will minimize unnecessary investments in stocks, and increase the efficiency and rapidity of procurement. These additions will complete the basic components of the financial and administrative information system and lay the foundation for the next stage of development for a further refinement of the management and control of expenditure.

In addition the foundation for the second stage of development, which aims at addressing specific problems, was laid. It included, for example:

1. The development of the management system for the active cereal collections to permit an analysis of the performance of parents and provide a more rapid technique for planning of experiments, taking full account of the history of the cultivars.

2. Rapid identification of microbe strains in legume crops, using a derivative of ICADET. Analysis of such data will provide a greater understanding of the microbiological and pathological factors in crop improvement.

3. ICADET supports an on-line search facility of crop abstracts. This is also used in the production of diverse catalogs.

The progress by computer services has been indeed exciting; all the more so because it could be achieved in a relatively short time. We hope that in the near future the services of our computer will extend to assist national programs in this region.

Two new wheat varieties, identified by the joint project between ICARDA and the Agricultural Research Center (ARC) of the Syrian Ministry of Agriculture and Agrarian Reform, were approved by the Syrian Variety Release Committee for multiplication and release to farmers. Sham 1, the new durum wheat variety, is suitable for Zone A (350 mm and above) and Zone B (250-350 mm). The new bread wheat variety, Sham 2, is to be released for Zone A in Syria.

A separate Genetic Resources Unit has been established at ICARDA, Aleppo, to serve as a center for the collection, characterization, documentation, maintenance, conservation, and distribution of germplasm of ICARDA's mandate crops. Previously each of the crop improvement programs had independent genetic resources activities. The Unit has developed plans to fill geographic and genetic gaps in ICARDA's germplasm holdings. Thanks to a generous contribution by the Italian Government of $ 840,000—the Genetic Resources Unit building will be constructed at the Tel Hadya site.

Training activities were broadened to include more collaborative in-country courses, and individual training responsive to specific agricultural research needs of national programs. The newly-appointed Head of Training began establishing an organizational framework for training support operations and job descriptions for Training Section for short and long-term agricultural research training needs; as well as strengthening the collaborative network of national, regional and international training institutions involved in countries of the ICARDA mandate region. We have plans to make significant progress in this field over the next five years.

Tangible progress in our collaboration with many national programs in the region, and elsewhere, was made in 1983. For example, collaborative research with the national program in Syria expanded to include, in addition to the Agricultural Research Center (ARC), the Steppe and Range Directorate and the Extension Department and the Soils Bureau. A greatly increased level of collaboration with the Arab Center for Studies of Arid Zones and Dry Lands (ACSAD) has also brought a new dimension to the on-farm cereal trials in Syria as well as to many other aspects of ICARDA's research and training endeavours.

ICARDA's efforts in North Africa were also considerably strengthened during the year with the establishment of an office in Tunisia. The past work of ICARDA in helping to strengthen the Tunisian barley improvement program has paid-off to the extent that the national program now has the capacity to conduct research on barley with only limited support from ICARDA. As a result the Government has requested us to transfer the major part of our own research efforts in support of cereals in Tunisia to pathology.

In the Nile Valley Project, supported by IFAD, the research has reached a stage where several improved practices for faba bean production are ready for widespread dissemination to farmers. It is planned, for example, to conduct a pilot project to demonstrate improved cultural practices on a total of over 300 acres in northern Sudan in the coming season in cooperation with the extension service. Similar efforts to transfer the research results to farmers are also being planned as part of the future project activities in Egypt.

Cooperation with our colleagues in national programs is the life blood of ICARDA. Suffice it to say here that we are proud of our achievements in 1983 in further strengthening our links with national scientists in almost every country of the region.

Considerable progress was made in our buildings complex at Tel Hadya. Laboratories 1 and 2 and Training and Communication blocks reached an advanced stage of construction, and site preparation progressed.

Beginning with this Annual Report, ICARDA will produce Arabic versions of its annual reports for its Arab readers. The Arabic version of this report will follow shortly.

The progress of work reported in this document has been possible due to the generous support of our donors, dedicated efforts of ICARDA's staff, enthusiastic cooperation from national programs and research institutions in most countries of the region as well as many institutions in the developed countries of the world, and our sister international research centers. The work, I hope, amply reflects that ICARDA has continued to respond positively to the challenge of improving food production in a harsh and uncertain environment.

I welcome this opportunity to express my deep sense of appreciation and thanks to all those on whose support ICARDA is so gratefully dependent.

Mohamed A. Nour
Director General

Meteorological Data 1982/83

The 1982/83 season was typified by abnormally cold air temperatures in the vegetative growth phase of most crops (December-February). Dec 1982 was the third coldest December in the period 1960-82: similarly January was the third coldest January, and February the fifth coldest (based on number of frost days in Aleppo). This resulted in a seasonal total of frost days exceeded by only one season, 1971/72, in the period 1960-82. Furthermore the absolute minimum temperature for the year -9.8°C (late January) was the third coldest event recorded in the previous 22 years and approached closely the period's absolute minimum of -11.3°C (1972/73).

Precipitation was in general favorable for crop growth. The first rains capable of causing germination occurred in mid-November, which is close to average for Tel Hadya. Distribution in time was good up to 1 Jan with totals slightly below average. However, in January only 17.1 mm were received, which is a total exceeded in 9.5 years out of 10. This very dry month was compensated for by a slightly wetter than average February and March and a wet April in which 49.5 mm were recorded. The precipitation season was therefore well distributed in time and prolonged by the last effective event, a fall of 14.8 mm in mid-May. This resulted in a seasonal total of 323.3 mm which is only very slightly drier than the site's long-run average of 342.0 ± 99 mm.

Other meteorological events capable of causing severe reductions in crop productivity such as abnormally high temperatures in early summer, hail, or excessive winds were not important factors in 1982/83. A full summary of weekly average data is presented in Table 1.

Table 1. Weekly meteorological data for Tel Hadya from 5 Sept 1982 to 31 Aug 1983.

Week No.[1]		Mean max. air temp.[2] (°C)	Mean min air temp.[3] (°C)	Pan evap.[4] mm/d	Inc. rad.[5] $MJ/m^2/d$	Wind run[6] km/d	Total rain[7] mm/wk
5 Sept 1982	1	35.7	18.5	13.3	17.80	374.9	0.0
	2	34.6	17.3	10.9	16.79	324.1	0.0
	3	32.5	15.6	9.8	16.73	345.7	1.2
	4	31.8	15.8	9.3	15.12	299.4	0.2
	5	27.3	13.1	6.4	13.46	235.0	4.2
	6	29.7	13.8	6.8	11.66	204.7	0.6
	7	26.2	10.5	7.1	12.48	233.1	0.0
	8	25.3	10.1	5.3	11.44	190.5	0.8
	9	23.4	2.9	5.1	12.15	155.0	13.0
	10	13.4	5.1	2.5	6.44	214.3	10.2
	11	17.8	4.4	2.6	9.58	227.9	8.6
	12	13.1	3.1	2.1	7.45	203.3	5.8
	13	10.4	-2.9	1.2	7.22	123.1	10.8
	14	8.4	-0.8	1.0	6.18	176.2	20.5
	15	12.4	2.1	1.3	6.78	229.5	0.0
	16	12.3	0.0	1.1	7.28	155.5	2.8

Contd.

Table 1. *Contd.*

Week No.[1]		Mean max. air temp.[2] (°C)	Mean min air temp.[3] (°C)	Pan evap.[4] mm/d	Inc. rad.[5] MJ/m²/d	Wind run[6] km/d	Total rain[7] mm/wk
	17	10.3	4.8	0.9	4.28	185.4	29.0
	18	4.3	-2.0	1.0	6.48	210.8	1.6
	19	9.4	-2.6	0.8	7.81	193.7	2.6
	20	12.1	2.8	1.2	3.64	274.2	12.5
	21	8.3	-4.5	2.0	10.17	197.4	0.4
	22	11.6	1.0	2.0	7.86	229.9	15.3
	23	13.2	2.8	1.7	10.95	123.1	4.6
	24	11.4	2.9	1.7	7.51	224.4	37.2
	25	7.5	1.1	1.6	9.85	244.4	9.4
	26	10.7	4.6	1.3	7.43	241.9	32.6
	27	15.0	-0.7	3.7	14.59	206.0	0.0
	28	17.3	4.5	4.5	12.10	331.1	0.8
	29	17.3	5.0	3.4	12.61	228.1	28.4
	30	23.4	8.4	6.2	16.10	232.6	2.2
	31	21.1	7.5	3.6	13.09	189.5	28.6
	32	22.1	7.1	5.2	16.80	191.1	2.8
	33	17.8	5.5	4.5	15.88	217.8	15.4
	34	26.7	7.1	6.7	19.77	148.3	0.5
	35	28.0	11.6	8.8	18.88	267.0	0.0
	36	28.4	10.8	9.0	19.25	212.7	14.8
	37	26.9	12.7	5.6	15.84	188.1	3.9
	38	29.8	13.6	10.6	21.10	303.4	0.8
	39	33.6	14.4	11.6	20.30	225.4	0.4
	40	30.6	16.3	12.0	20.22	400.2	1.6
	41	33.4	14.5	13.6	22.22	368.5	0.0
	42	33.2	18.3	14.0	21.87	474.7	0.0
	43	35.0	17.9	14.2	21.65	413.4	0.0
	44	33.6	19.6	14.0	21.50	517.9	0.0
	45	36.4	18.3	13.8	20.87	469.7	0.0
	46	35.6	21.5	15.0	20.66	537.2	0.0
	47	35.0	19.2	13.7	19.82	379.5	0.0
	48	37.3	21.3	16.1	19.67	503.6	0.0
	49	34.9	20.2	14.0	19.79	570.4	0.0
	50	34.8	20.4	13.7	19.32	543.5	0.0
	51	34.3	19.4	13.9	18.83	516.4	0.0
31 Aug 1983	52	33.3	16.0	11.7	17.34	317.4	0.2

1. 7-day intervals starting with Sunday 5 Sept 1982.
2. Weekly mean maximum screened air temperature °C.
3. *Weekly mean minimum screened air temperature* °C.
4. Class A pan evaporation mm/d.
5. Weekly mean incoming radiant energy MJ/m²/d.
6. Weekly mean wind run km/day.
7. Weekly accumulation of precipitation.

Table 2. Seasonal rainfall at ICARDA research sites in Syria, 1982/83.

Site	Latitude	Longitude	Altitude (m)	Long-term average rainfall (mm)	1982/83 seasonal rainfall (mm)
Breda	35°55'N	37°10'E	350	278	285
Hama	35°08'N	36°45'E	316	325	383
Hassake	36°30'N	40°45'E	300	279	269
Homs	34°45'N	36°43'E	487	480	533
Idleb	35°56'N	36°39'E	446	479	575
Jindiress	36°23'N	36°41'E	231	479	417
Kafr Antoon	36°32'N	37°02'E	555	438	340
Khanasser	35°47'N	37°30'E	350	214	296
Lattakia	35°30'N	35°47'E	7	784	871
Qamishly	37°03'N	41°13'E	467	480	315
Raqqa	35°57'N	39°00'E	251	207	217
Salamieh	35°00'N	37°02'E	480	309	292
Sweida	32°42'N	36°35'E	997	364	389
Tel Hadya	35°55'N	36°55'E	362	342	323

Table 3. Agroecological zonation of Syria.

Zone 1a	Average rainfall over 600 mm. A wide range of crops can be grown. Fallowing is not necessary.
Zone 1b	Average rainfall between 350 and 600 mm and not less than 300 mm in two-thirds of the years surveyed. At least two crops can be grown every 3 years. The main crops are wheat, pulses, and summer crops.
Zone 2	Average rainfall between 250 and 350 mm and not less than 250 mm in two-thirds of the years surveyed. Two crops are normally planted every 3 years. Barley, wheat, pulses, and summer crops are grown.
Zone 3	Average rainfall over 250 mm and not less than this in half the years surveyed. One or two crops will yield in every 3 years. Barley is the principal crop but some pulses can be grown.
Zone 4	Average rainfall between 200 and 250 mm and not less than 200 mm during half the years surveyed. Barley is grown. The area is also used as grazing land.

In general terms, zones 1a and 1b can be referred to as zone A, zone 2 as zone B, and zones 3 and 4 as zone C.

FARMING SYSTEMS

Contents

Cover: Handweeding the parasitic weed Orobanche *sp. by a farmer in a faba bean field in Egypt. Weed control research was added to the Farming Systems Program in 1982 and the results achieved are described in detail in this report for the first time.*

Farming Systems

Introduction

ICARDA's research is conducted keeping in view the prevalent farming systems in the region. The Farming Systems Program (FSP) helps the Center's other research programs in determining their research priorities and approaches to suit these systems. During the past 3 years, FSP has developed a research approach that seeks solutions to the agronomic and economic constraints to increasing agricultural productivity in the region. The approach is briefly described below and the problems under study are enumerated. Then, the research results for the 1982/83 season are presented.

FSP researchers continually interact with farmers for whom the research is intended.

Farming Systems Research (FSR) at ICARDA is a process that first identifies problems limiting agricultural productivity and then searches for their solutions. FSR also attempts to evaluate new technologies in the light of all the components of the system including the complex interdependencies of these components. This process recognizes the resources and constraints of the farming families (who are both producers and consumers), and seeks solutions that are relevant, useful, and acceptable. The FSP scientists therefore *continually interact with farmers for whom* the research in intended.

The FSP research passes through four stages: (1) diagnostic, (2) design or experimental, (3) testing, and (4) extension. This process is dynamic and iterative, since we frequently return to previous stages to clarify points as we gain knowledge, confront problems, and consider research alternatives. In addition, the distribution between stages is not sharply defined as there is much overlap, and we work at several stages simultaneously.

Program Goal and Long-Range Objectives

The program seeks to find strategies that will add stability and improve the farming systems in the region by increasing the technical and economic efficiency of utilization of limited resources. Particular emphasis is placed on soil and water resources, combined with improvements in crop and livestock husbandry. To achieve this goal, the program has the following two overriding objectives.

The first objective is to develop methods and tools necessary to conduct FSR. An agricultural system is determined by its natural and human resources, historical development, and the prevailing social and economic environment. Because the ICARDA region is large and diverse, these factors are found in many combinations; consequently, the systems in our region are numerous. Therefore, we do not aim to develop a new system or technology that has wide applicability or adaptability, but rather a process that can be used to improve a particular system and then be repeated elsewhere.

The second objective is to promote the use of FSR in areas of ICARDA's concern. Thus, exposing scientists in the region to this approach, and training them to use it, is a high-priority activity of the program. A first step is to test the efficacy of the approach outside of Syria (we have chosen Tunisia for this test) and then adopt a training strategy to broaden the geographical base to include other countries.

The research in the Program is divided into six Projects:

Project I: Productivity of Cereal Crops in Rainfed Mediterranean Environments.

Project II: Nitrogen Fixation, Productivity, and Water Use of Grain and Forage Legumes in Rainfed Mediterranean Environments.

Project III: Crop Rotations and Cropping Systems.

Project IV: Livestock in the Farming Systems.

Project V: Environmental Zoning.

Project VI: Farming Systems Research in Tunisia: A Test for FSR Methodology.

Microbiology and weed control were added to the FSP in 1982 and this is the first time their results are being reported in detail. In 1983/84, the livestock research will transfer to the Pasture and Forage Improvement Program (PFIP) to better balance the activities and size of the two programs. While the objectives of Project IV will not change and the relationship between the FSP scientists and the livestock scientists will continue, livestock research will be reported by PFIP in the future.

Project VI received funds in 1983; the research results will be reported in 1984.

Project I: Productivity of Cereal Crops in Rainfed Mediterranean Environments

In the Mediterranean basin where the winter rainfall is both limited and erratic, barley and wheat are the principal cereal crops. Both yield and stability of yield of cereal production are affected by a broad-spectrum of environmental, management, and socioeconomic factors. Consequently, the FSP has conducted research, now in its fifth year, on traditional and new management practices within the framework of established crop rotations to determine their effects on: (1) the underlying processes and rates of crop growth as they are regulated by the physical and nutritional environment and (2) productivity within the limits of economic profitability and social acceptability.

The research in this Project in 1982/83 was somewhat different from that conducted in 1981/82. After 3 years of detailed agronomic study of seeding rate and nitrogen and phosphorus fertilizers (SNP) on barley production, the original design was replaced by a simpler, 2^5 factorial trial. Weed control was a new factor added because of its importance in limiting yields, particularly in the higher-rainfall zones.

In this report we concentrate on the agronomic and weed control research conducted in 1982/83. However, during that period other aspects of cereal research were also undertaken and these are indicated below. Full reports on this work will become available during 1984.

1. Socioeconomic research

The barley survey in Syria was completed this year and progress was made in analyzing these data by computer. The results will be reported in full in early 1984. In addition, three research projects were completed in the collaborative project (Ministry of Agriculture, University of Jordan and ICARDA) in Jordan.

2. Agronomic research

During the three seasons, 1979/80-1981/82, a rich data set was obtained from trials which examined the effect of seed rate, nitrogen, and phosphorus on barley yields across five locations in northern Syria with rainfall ranging from 475 to 220 mm/annum. Until now, these results have only been analyzed by site and year. During 1982/83, considerable efforts have been made by FSP staff to analyze these data across site and year and we hope to report this work next year.

In addition, work was initiated to examine the performance of improved barley varieties under low-fertility conditions in dry areas (<300 mm). This work produced sufficiently interesting results to warrant an expanded effort in 1984. These will be reported after the second year of investigation.

Component 1: Agronomic Research

Grain Yield Trials in Northern Syria

Agronomic reseach on barley and wheat production conducted by the Cereal Improvement Program and the FSP during the previous 3 years has made it possible to draw up recommendations for farmers at each of six locations in northern Syria. However, in the SNP (seed rate, nitrogen, and phosphorus) trials conducted by the FSP during the past three seasons, the effect and interaction of weed control with other factors was not assessed. In the 1982/83 season a series of 2^5 factorial trials across the same six locations (Jindiress, Kafr Antoon, Tel Hadya, Breda, Ghrerife, and Khanasser) was conducted to assess the relative importance of major agronomic variables, including weed control. The factors studied were: nitrogen fertilizer (N), phosphorus fertilizer (P), weed control (W), variety (V), and seed rate (S). Each factor was studied at two levels of application (Table 1).

Table 1. Site characteristics and management practices in cereal agronomy trial at six locations in northern Syria, 1982/83.

Trial details	Zone 1		Zone 2	Zone 3/4		
	Jindiress	Kafr Antoon	Tel Hadya	Breda	Ghrerife	Khanasser
Seasonal rainfall (mm)	417	341	323	285	232	295
Soil type	Chromic Vertisol		Vertic (calcic) Luvisol	Calcic Xerosol		
Soil depth (m)	> 1.5		> 1.5	> 1.5		
Aspect	Flat		Flat	Flat		
Sowing date	10 Nov	13 Nov	27 Nov	15 Nov	19 Nov	22 Nov
Preceding crops	Chickpeas, Sesame		Lentils, Melons	Barley, Fallow		
Management:						
Nitrogen (kg N/ha) (N)						
High	100		60	20		
Low	0		0	0		
Phosphorus (kg P_2O_5/ha) (P)						
High	60		45	45		
Low	0		0	0		
Weed control (W)						
High	Brominal		Brominal	Brominal		
Low	None		None	None		
Variety (V)	Bread Wheat		Durum Wheat	Barley		
High	Nortino		Sahl	Beecher		
Low	Mexipak		Hourani	Arabi Aswad		
Seed rate (kg/ha) (S)						
High	100		100	100		
Low	60		60	60		

The seed was drilled in plots 6.3 × 12.5 m, with phosphate fertilizer and 20 kg N/ha where applicable, at a between-row spacing of 17.5 cm. Where required, remaining nitrogen was top-dressed at the start of stem elongation. Weed control was achieved with a single spray of Brominal Plus (bromoxynil plus MCPA) at stem elongation.

At anthesis, weed numbers, weed species, and weed dry-matter production were assessed in two 1-m^2 microplots within all plots not receiving weed control. At maturity, crops were harvested by Hege Combine with a single pass per plot (1.25 × 12.5 m) and Harvest Index was estimated separately from 4-m sample rows taken adjacent to the harvested strip. Total dry-matter production, 1000-grain weight, straw yield, and grain number were recorded.

To highlight important factors, discussion will be centered on grain yields, but where important, reference will be made to the other components of yield.

Effect of nitrogen fertilizer. The main effects and interactions of nitrogen across the six locations are summarized in Table 2. Only significant first-order interactions are included.

At the two wettest locations in Zone 1, Jindiress and Kafr Antoon, significant responses to nitrogen were obtained. At Jindiress, weeds were a serious problem and there was a strong interaction between nitrogen application and weed control. Weeds responded so vigorously to nitrogen that, without weed control, wheat yields were depressed by nitrogen application. However, with weed control, large responses in

Table 2. Main effect and interactions of nitrogen application on cereal grain yield (tonne/ha) at six locations in northern Syria, 1982/83.

		Jindiress	Kafr Antoon	Tel Hadya	Breda	Ghrerife	Khanasser
Main Effect	+ N	1.94	2.11***	1.33	0.77	1.10***	0.95
	− N	1.72	1.66	1.46	0.74	0.95	0.95
SE ±		0.08	0.06	0.07	0.03	0.03	0.02
Interactions							
	N − N +						
N × P	P −		1.47 1.71*			0.84 0.86*	
	P +		1.85 2.51			1.06 1.34	
	N − N +						
N × W	W −	1.47 1.32***					
	W +	1.98 2.56					
	N − N +						
N × S	S_H		1.64 2.30*				
	S_L		1.67 1.92				

*** *Effect or interaction significant ($P<0.001$)*. * *Effect or interaction significant ($P<0.05$)*.
1 tonne = 1000 kg.

grain yields were obtained. At Kafr Antoon, weeds were not such a serious problem, and a significant main-effect response to nitrogen application was obtained. But, as might be expected on soils deficient in both N and P, an N × P interaction was found. This interaction was also observed in total dry-matter and straw yields at Jindiress.

At the four driest locations, nitrogen responses were either small or insignificant (Table 2). Only at Ghrerife was a significant response obtained, and again, an N x P interaction was found.

Although not shown in Table 2, nitrogen application reduced the 1000-grain weight at all locations, and was highly significant at Kafr Antoon, Breda, Ghrerife, and Khanasser. This agrees with our results from crop growth/water-use studies in previous years, indicating that enhanced vegetative growth caused by N application results in greater depletion of soil-moisture reserves at the start of grain filling and hence in reduced grain size. This effect is made even more serious by the tendency for nitrogen application to delay maturity.

These yield responses to nitrogen support those of previous years in indicating a greater response in the wetter zones than in the drier zones, but they emphasize the fact that in nitrogen-deficient soils, where P deficiency and weeds are also a problem, reduced and even negative responses to nitrogen can be expected unless these two problems are overcome.

Effect of phosphorus fertilizer. A highly significant response of grain yield to phosphorus application was obtained at all sites except Tel Hadya (Table 3), confirming the importance of improved phosphorus nutrition on these calcareous soils. As in previous years, no response to phosphate was recorded at Tel Hadya. In addition, a P x S interaction was observed at Khanasser, similar in nature to the N x S interaction at Kafr Antoon. This indicates that fertilizer response can be reduced at suboptimal seeding rates.

Table 3. Mean effect and interactions of phosphorus application on cereal grain yield (tonne/ha) at six locations in northern Syria, 1982/83.

		Jindiress	Kafr Antoon	Tel Hadya	Breda	Ghrerife	Khanasser
Main Effect	+P	2.05***	2.11***	1.43	0.99***	1.22***	1.02***
	−P	1.61	1.66	1.36	0.52	0.85	0.89
SE ±		0.08	0.06	0.07	0.03	0.03	0.02
Interactions							
	P− P+						
P x N	N−		1.47 1.85*			0.84 1.06*	
	N+		1.71 2.51			0.86 1.34	
	P− P+						
P x S	S_H						0.94 1.13***
	S_L						0.84 0.92

1 tonne = 1000 kg.
*** Effect or interaction significant ($P < 0.001$).
* Effect or interaction significant ($P < 0.05$).

Phosphorus application, like nitrogen application, enhances vegetative growth and thus results in increased rates of moisture use. However, in contrast to nitrogen application, improved phosphorus nutrition speeds up cereal physiological development resulting in considerably earlier dates of anthesis and maturity. Our previous studies have clearly demonstrated that this enhanced rate of growth compensates for the greater rate of water use and results in little or no difference in moisture use and profile depletion at the onset of grain filling. At the two wettest locations, Jindiress and Kafr Antoon, the advanced date of onset of grain filling caused by phosphorus application, coupled with the more favorable moisture conditions at those sites, resulted in a significant increase in 1000-grain weight. At the two intermediate sites (Tel Hadya and Breda), the effect was not clear. But at the two driest sites, Ghrerife and Khanasser, in spite of earlier anthesis and onset of grain filling, the less favorable moistrue status coupled with the greater crop canopy resulting from P fertilizer increased moisture stress during grain filling and thus reduced 1000-grain weight.

In barley-growing areas, straw is very important as feed for sheep during summer, often equal in value to the grain. Phosphorus application produced large and significant increases in straw yield at Breda, Ghrerife, and Khanasser.

Effect of weed control. Dry-matter production data of weeds at anthesis are presented in Table 4. At Jindiress and Tel Hadya, *Sinapis arvensis* was a severe problem. Weed growth responded strongly to N and P applications resulting in highly significant main effects and N x P interactions. In the presence of N or P alone, only small increases in weed dry-matter production were found, but where N and P were applied together, the response was very large. It is not clear why, in the light of such a pronounced response of weed growth to fertilizer at Tel Hadya, that last year's and this year's results show no response of cereal crops to fertilizer when weeds are controlled at this location.

Increased seed rate significantly suppressed weed growth at Tel Hadya and Khanasser. Similar (but not significant) trends were

Table 4. Main effects and interactions of N, P, V, and S on weed dry matter (tonne/ha) at anthesis at six locations in northern Syria, 1982/83.

	Jindiress	Kafr Antoon	Tel Hadya	Breda	Ghrerife	Khanasser
Principal weed species	*Sinapis arvensis*	*Avena sterilis*	*Sinapis arvensis*	*Vaccaria pyramidata*	*Neslia apiculata*	
Main Effects +N	2.39***	0.45	2.02***	0.32	0.24*	0.37
−N	1.12	0.62	1.22	0.25	0.17	0.35
+P	2.31***	0.62	1.92***	0.32	0.14***	0.38
−P	1.20	0.45	1.32	0.25	0.28	0.34
Imp. Var.	1.63	0.57	2.04***	0.27	0.20	0.39
Loc. Var.	1.89	0.50	1.20	0.31	0.22	0.34
Seed rate						
high	1.55	0.50	1.40*	0.23	0.18	0.28***
low	1.96	0.56	1.84	0.34	0.23	0.44
Interactions						
N x S (N− N+)						
S_L		0.31 0.81*				
S_H		0.59 0.42				
N x P (N− N+)						
P−	1.01 1.39***		1.34 1.30***		0.20 0.35***	
P+	1.22 3.39		1.10 2.75		0.14 0.13	

1 tonne = 1000 kg.
*** Effect or interaction significant ($P < 0.001$).
* Effect or interaction significant ($P < 0.05$).

Table 5. Main effects and interactions of weed control on cereal grain yield (tonne/ha) at six locations in northern Syria, 1982/83.

	Jindiress	Kafr Antoon	Tel Hadya	Breda	Ghrerife	Khanasser
Main Effect + W	2.27***	2.09***	1.70***	0.83***	1.09**	0.98*
− W	1.39	1.68	1.09	0.68	0.96	0.93
SE ±	0.08	0.06	0.07	0.03	0.03	0.02
Interactions						
W x N (W− W+)						
N−	1.47 1.98***					
N+	1.32 2.56					
W x S (W− W+)						
S_L						0.83 0.93*
S_H						1.04 1.03

1 tonne = 1000 kg.
*** Effect or interaction significant ($P<0.001$).
* Effect or interaction significant ($P<0.05$).

observed at other locations. It was also reflected in the significant N x S interaction at Kafr Antoon.

The results also suggest some interactions which should be studied further. Where *Sinapis arvensis* was the dominant weed, P application resulted in increased weed growth which suppressed crop growth. However, at Ghrerife, where *Neslia apiculata* was the dominant species, P application resulted in large responses of barley growth which significantly depressed weed growth. In addition, at Tel Hadya there was a significant effect of cereal variety on weed growth. The local durum wheat, Hourani, competed more successfully with weeds than the improved variety, Sahl. This was reflected (although not significantly) in a W x V interaction on grain yield which indicated that with weed control, both varieties gave a similar performance; but, without weed control, the local variety was superior. This observation has important implications on selecting improved varieties under optimum management conditions.

The main effects and significant interactions of weed control on grain yield are presented in Table 5. There were significant responses to weed control at all six locations, the magnitude of the response decreasing from the wettest to the driest location. Comparison of data in Tables 4 and 5 indicates a positive relationship between the weed dry-matter production at anthesis, and the decline in grain yields in the absence of weed control.

These results suggest that, particularly in wheat-growing areas, chemical weed control would be an economic and easy practice for farmers to adopt. However, it must be borne in mind that farmers who do not practice chemical weed control often harvest certain weed species for both human and animal consumption. This practice not only provides an economic return from weeds, but also constitutes a form of weed control. The economics and effectiveness of this practice should be evaluated relative to that of chemical weed control.

Effect of improved variety. The main effects of improved variety on grain yield are summarized in Table 6. There were no significant interactions between variety and other factors with regard to grain yield.

At Ghrerife only did the improved variety give a significant increase in yield. At other locations, the improved variety yielded the same as the local or was even significantly poorer.

Effect of seeding rate. The main effects and interactions of seed rate on grain yields are presented in Table 7. At four of the six locations, higher seed rates gave significantly improved yields, and similar (although not significant) trends were observed at the other two locations. In previous years, conflicting results have been obtained with regard to seed rate. Because of season-to-season variation, and the possible interactions between seed rate, fertilizer, and weed control (Table 7), it would not

Table 6. Main effects of improved variety on cereal grain yield (tonne/ha) at six locations in northern Syria, 1982/83.

	Jindiress	Kafr Antoon	Tel Hadya	Breda	Ghrerife	Khanasser
Main Effect						
Imp. Var.	1.81	1.86	1.27***	0.68***	1.08*	0.97
Loc. Var.	1.86	1.91	1.52	0.83	0.97	0.94
SE ±	0.08	0.06	0.07	0.03	0.03	0.02

1 tonne = 1000 kg.
*** Significant (P<0.001).
* Significant (P<0.05).

Table 7. Main effects and interactions of seed rate on grain yield (tonne/ha) at six locations in northern Syria, 1982/83.

	Jindiress	Kafr Antoon	Tel Hadya	Breda	Ghrerife	Khanasser
Main effect S_H	2.00***	1.97	1.41	0.80***	1.08*	1.03***
S_L	1.66	1.80	1.38	0.70	1.97	0.87
SE ±	0.08	0.06	0.07	0.03	0.03	0.02
Interactions						
S_L S_H						
S x N N –		1.67 1.64*				
N +		1.92 2.30				
S_L S_H						
S x P P –						0.84 0.94**
P +						0.92 1.13
S_L S_H						
S x W W –						0.83 1.04*
W +						0.93 1.03

1 tonne = 1000 kg.
* Effect or interaction significant (P<0.05).
** Effect or interaction significant (P<0.01).
*** Effect or interaction significant (P<0.001).

seem advisable to recommend to farmers to change from the commonly used 100 kg/ha to a lower seed rate. This is supported by the knowledge that germination percentages of farmers'seed are often appreciably lower than that of our experimental seed, implying viable seed rates of about 70-80 kg/ha, or possibly less.

Conclusions

Weed infestation was severe at the three wetter locations, Jindiress, Kafr Antoon, and Tel Hadya, and wheat was poorer than barley in competing with weeds.

Based on these and previous observations, the following recommendations, subject to economic verification, could be made to farmers practicing rotations similar to those outlined in Table 1.

Jindiress, Kafr Antoon (bread wheat). Weed control measures should be adopted. Nitrogen (100 kg/ha) and phosphorus fertilizer (60 kg/ha) should be applied in conjunction with weed control for larger yield responses. We would not recommend lower seed rates than those commonly used.

Tel Hadya (durum wheat). Fertilizer responses at Tel Hadya have always contrasted with those obtained at other locations and, without further extensive testing, it is difficult to assess how representative the site really is in this respect. Nevertheless, we would recommend to farmers to adopt weed control measures, but would not recommend adoption of a lower seed rate or application of fertilizer.

Breda, Ghrerife, Khanasser (barley). We would recommend the application of phosphate fertilizer (45 kg P_2O_5/ha) at all three locations, and at Breda and Ghrerife would recommend top-dressing with 20 kg N/ha. Weed control could provide economic returns. We would not recommend to farmers to adopt a lower seed rate.

From the plot data, it is possible to present grain and straw yields representing those obtained by farmers growing the local variety at a standard seed rate and applying no fertilizer or weed control measures. These can be compared with the yields obtained with the recommended practice. Yield and economic data are presented in Tables 8 and 9.

Table 8. *Prices related to barley and wheat production in* Aleppo Province, 1982/83 season.

Price of durum wheat	1.25	SL/kg
Price of bread wheat	1.20	SL/kg
Price of barley	0.92	SL/kg
Price of cereal straw	0.33	SL/kg
Transport (Rajad) cost	9.00	SL/bag
Wheat threshing cost	17.50	SL/bag
Barley threshing cost	14.00	SL/bag
Price of superphosphate, 46 % P_2O_5	1250.00	SL/t
Price of ammonium nitrate, 33 % N	870.00	SL/t
Nitrogen application cost	5.00	SL/sack
Bag cost	5.75	SL
Barley bag weight	100 kg	
Wheat bag weight	120 kg	

Source: Market and farmer surveys by the FSP.

For the risk-averse farmers, one way of assessing the acceptability of the recommended practices is to look at the marginal rate of return (increased revenue/additional costs). The returns on investments were high (between 2.2 and 4.2) at Jindiress, Kafr Antoon, and Tel Hadya. In such areas, where the effect of season-to-season variation in climate is not likely to be as severe as that found in drier barley-growing areas, the recommended practices have a high likelihood of acceptance, and this is reflected by the fact that many farmers already use fertilizer and weed control measures.

Table 9. Partial budget estimates of local and recommended practices at six locations in northern Syria, 1982/83.

	Jindiress	Kafr Antoon	Tel Hadya	Breda	Gherife	Khanasser
	----Bread Wheat	----	Durum Wheat	----------	--Barley--	----------
Local Practice						
Grain (t/ha)	1.44	1.41	1.14	0.62	0.70	0.91
Straw (t/ha)	2.35	2.16	2.44	0.52	0.85	0.79
Recommended Practice						
Grain (t/ha)	3.55	2.81	2.03	1.20	1.44	1.26
Straw (t/ha)	5.33	3.55	3.68	1.03	1.49	1.14
Increased Yields						
Grain (t/ha)	2.11	1.40	0.89	0.58	0.74	0.35
Straw (t/ha)	2.98	1.39	1.24	0.51	0.64	0.35
Increased Revenue (SL/ha)						
Grain	2532.0	1680.0	1112.5	533.6	680.8	322.0
Straw	983.4	458.7	409.2	168.3	211.2	115.5
Total	3515.4	2138.7	1521.7	701.9	892.0	437.5
Additional Costs (SL/ha)						
P_2O_5	163.0	163.0		122.3	122.3	122.3
N	261.0	261.0		52.2	52.2	
Nitrogen application	30.0	30.0		6.0	6.0	
Herbicide	75.0	75.0	75.0	75.0	75.0	75.0
Herbicide application	34.0	34.0	34.0	34.0	34.0	34.0
Transport (Rajad)	189.9	126.0	80.1	52.2	66.6	31.5
Bagging	101.1	67.1	42.6	33.4	42.6	20.1
Threshing	307.7	204.2	129.8	81.2	103.6	49.0
Total	1161.7	960.3	361.5	456.3	502.3	331.9
Net Increase in Revenue (SL/ha)	2353.7	1178.4	1160.2	245.6	389.7	105.6
Rate of return = increased revenue/ additional costs	3.03	2.23	4.21	1.54	1.78	1.32

1 tonne = 1000 kg.

The rates of return in the drier areas were smaller (1.8 to 1.3). In such areas, where drought years are more common, farmers may not accept the complete package. Responses to weed control were small, and the economic returns from harvesting weeds for animal and human consumption need to be evaluated. If weed control measures were not included in the recommendations, rate of return values of 2.0, 1.6, and 1.9 would be obtained for Breda, Ghrerife, and Khanasser, respectively.

Lastly, in evaluating the likelihood of acceptance of the recommended practices, it should be borne in mind that some of the costs included in the partial budget may not be as high as indicated. Second-hand bags are often used and transport costs from fields close to the homestead could well be much less. In addition, if family labor undertakes some of the extra work, a higher proportion of the net benefit will remain within the family group. If a farmer and his family could expect such savings, they would be more inclined to accept the improved management techniques.

Weed Control Research

The basic objective of the weed control research on cereal crops is to study the effect of agronomic factors on weed infestation and productivity. Two pairs of trials were conducted in 1982/83 at Tel Hadya. The first pair of trials, one on barley (ER/Apam) and the other on wheat (Sahl), compared the effect of methods of weed control, seed rate, and row spacing on grain production and weed infestation. The major weed species in the barley trial were *Sinapis arvensis*, *Phalaris brachystachys*, and *Vaccaria pyramidata*. In the wheat trial, the major weeds, in addition to those in the barley trial, were *Ceranium tuberosum* and *Euphorbia* spp. The second pair of experiments compared the effect of time of sowing and weed control on barley and wheat production and weed infestation. One was on wheat at Tel Hadya, and the other on barley in farmers' fields at Sfireh and Humaymeh in nothern Syria.

Both trials in the first pair were conducted in a split-plot design in three replications. In each trial there were three weed control treatments (no weed control, handweeding, and chemical weed control), three seed rates (30, 90, and 150 kg/ha), and three row spacings (10, 17.5, and 25 cm). The results of these trials are summarized in Tables 10-12. In the barley trial the numbers of weeds (plants/m^2) were counted, whereas in the wheat trial the total dry weight (kg/ha) of weeds was determined in each plot. Handweeded wheat plots contained some weeds, whereas handweeded barley plots were practically free of weeds, reflecting the higher competitive ability of barley as compared to wheat. The herbicide for chemical weed control was bromoxynil plus MCPA (Brominal Plus), a broadleaf weed killer.

Weed control: use of appropriate safety procedures is imperative.

Table 10. Effect of row spacing and weed control on grain yields (kg/ha) of cereal crops and weed infestation at Tel Hadya, 1982/83.

Crop	Row spacing (cm)	No control		Handweeding		Herbicide	
		Yield	No. of weeds/m²	Yield	No. of weeds/m²	Yield	No. of weeds/m²
Barley	10	3845	191	4312	0[a]	4617	66
	17.5	3476	122	3928	0	3887	76
	25	3035	118	3605	0	3477	60
			Yield	No. of weeds			
LSD (5%) for weed control:			595	29			
row spacing:			551	38			
		Yield	TDW	Yield	TDW	Yield	TDW
Wheat	10	1810	1595	2181	95	2172	383
	17.5	1537	922	1831	83	1731	439
	25	1394	1106	1642	122	1547	267
			Yield	TDW			
LSD (5%) weed control:			334	451			
row spacing:			96	391			

a. Not counted; taken as zero.

Grain yields in both trials tended to increase with increasing seed rate and decreasing row spacing. The largest yields in both trials were recorded at a row spacing of 10 cm and a seed rate of 150 kg/ha in plots where weeds were controlled.

Weed infestation in both trials tended to increase with decreasing row spacing and decreasing seed rate, being highest in plots with a row spacing of 10 cm and a seed rate of 30 kg/ha.

Weed control significantly decreased the levels of weed infestation. In the barley trial, handweeding was significantly better than chemical weed control. In the wheat trial, the same trend was observed, but the difference was significant only at the lowest seed rate (Table 11).

Weed control tended to increase grain yields of wheat and barley at all seed rates and row spacings (Tables 10 and 11); the effect was most pronounced at lower seed rates and narrower row spacings, where weed infestation levels were highest (Table 12). There were no significant differences between handweeding and chemical weed control in their effect on grain yield.

The effect of seed rate on yield was highest in unweeded plots. This was because higher seed rates also tended to suppress weed growth more than lower seed rates, a result which is also highlighted in the previous section (see Tables 1-4).

In the second pair of trials, early sowing (before the rains) increased the yields, but it also required more weed control. Late sowing (after the rains start) allowed weeds to be controlled by preplanting tillage operations, but yields were often substantially smaller than with early sowing.

Table 11. Effect of seed rate and weed control on grain yields (kg/ha) and weed infestation of cereal crops at Tel Hadya, 1982/83.

Crop	Seed rate (kg/ha)	No control		Handweeding		Herbicide	
		Yield	No. of weeds/m²	Yield	No. of weeds/m²	Yield	No. of weeds/m²
Barley	30	2603	180	3498	0[a]	3408	89
	90	3616	127	3949	0	4215	61
	150	4138	124	4395	0	4358	52
			Yield	No. of weeds			
LSD (5%) weed control:			437	29			
seed rate:			241	32			
		Yield	TDW	Yield	TDW	Yield	TDW
Wheat	30	982	1978	1533	122	1355	578
	90	1783	1028	1961	99	1974	322
	150	1968	617	2159	89	2122	189
			Yield	TDW			
LSD (5%) weed control:			339	381			
seed rate:			126	258			

a. Not counted; taken as zero.

Table 12. Effect of row spacing and seed rate on grain yields (kg/ha) and weed infestation of cereal crops at Tel Hadya, 1982/83.

Crop	Seed rate (kg/ha)	Row spacing (cm) 10: Yield	10: No. of weeds/m²	17.5: Yield	17.5: No. of weeds/m²	25: Yield	25: No. of weeds/m²
Barley	30	3493	172	3147	120	2866	112
	90	4372	130	3952	89	3454	64
	150	4907	83	4188	89	3796	92
			Yield	No. of weeds			
LSD (5%) row spacing:			374	50			
seed rate:			241	46			
		Yield	TDW	Yield	TDW	Yield	TDW
Wheat	30	1462	1033	1250	883	1157	761
	90	2213	711	1828	361	1677	367
	150	2478	328	2022	200	1748	367
			Yield	TDW			
LSD (5%) row spacing:			117	309			
seed rate:			126	258			

The trial with durum wheat (Sahl) was conducted in a split-plot design in three replications, with two sowing dates (main plots) and five weed control treatments (subplots). The major weed species in the trial were *Sinapis arvensis*, *Phalaris brachystachys*, *Vaccaria pyramidata*, and volunteer lentils.

Time of sowing had no significant effect on yield, but weed control increased the yields of late-sown crops significantly. There were no significant differences between handweeding and any of the herbicides used.

The trial with barley (ER/Apam) was conducted in farmers' fields at two comparatively dry locations (about 250 mm/annum): Sfireh and Humaymeh. The design of the trials was a split-plot with two sowing dates (main plots) and three weed control treatments (subplots), in four replications at each location.

Yields were poor and variable at both locations and the results inconclusive (Table 13). The effect of time of sowing on barley yields and weed infestation at low-rainfall locations needs further study.

Table 13. Effect of time of sowing and weed control on yield (kg/ha) of barley in farmers' fields in northern Syria, 1982/83.

Location	Treatment	Time of Sowing: Early	Late
Sfireh	No control	524	752
	Handweeded	1000	986
	Printazol	829	372
LSD (5%)	weed control :	128	
	time of sowing :	65	
		Early	Late
Humaymeh	No control	506	516
	Handweeded	785	1055
	Printazol	766	754
LSD (5%)	weed control :	230	
	time of sowing :	43	

Component 2: Joint-Managed (Scientist and Farmer) Barley Trials at Breda and Khanasser

The trials reported in this section were conducted on farmers' fields, and constitute the third stage in the FSR philosophy, namely, the stage at which improved technologies are tested under farmers' own management conditions.

Our previous research under controlled conditions at Breda and Khanasser indicated significant responses to phosphorus application.[1] These responses were demonstrated over three growing seasons and were particularly impressive in the drier areas. ICARDA's Cereal Improvement Program was also recommending Beecher barley as an improved alternative to local varieties. Based on these factors, tests on farmers' fields in Breda (Zone 3) and Khanasser (Zone 4) were first conducted during the 1981/82 growing season. The experimental design was a 2^2 factorial (two varieties and two levels of phosphorus) with replications over different sites.

During the 1982/83 crop year, trials were repeated in the same areas to evaluate the effect of variety (Beecher vs local Arabi Aswad) and phosphorus application. In addition, a fifth trial was included in which nitrogen fertilizer was also added. The trials were conducted on eight farmers' holdings, four at Breda and four at Khanasser.

The specific objectives of the trials are to (1) measure and compare the yield of local Arabi Aswad and Beecher varieties, (2) evaluate, and compare the effect of phosphorus application on the yields of both varieties, (3) evaluate the effect of nitrogen and phosphorus on the yield of Beecher barley and compare it with yields obtained with farmers' practices, and (4) determine any constraints that would prevent the farmer from adopting the recommended practices.

The non-test factors were held at the farmers' levels. As last year, we provided the farmers with Beecher and phosphorus and nitrogen fertilizers, while they provided land (0.5 ha) and other inputs. In each village four sites of 0.5 ha each were selected to be representative of the different soil types of each zone.

The plots were divided into five treatments of 0.1 ha each:

1. Arabi Aswad barley with farmers' normal practices (without fertilizer).
2. Beecher barley with farmers' normal practices (without fertilizer),
3. Arabi Aswad barley with farmers' practices plus 60 kg P_2O_5/ha applied at planting,
4. Beecher barley with farmers' practices plus 60 kg P_2O_5/ha applied at planting, and
5. Beecher barley with farmers' practices plus 60 kg P_2O_5/ha and 30 kg N/ha (ammonium nitrate, 10 kg at planting and 20 kg topdressed in spring).

The plots were fallow in 1981/82 and managed by farmers according to their normal practices during the 1982/83 cropping season. All plots were cultivated in the spring of 1982 either by disc plow or duck-foot cultivator (except one farmer, No. 4, in Khanasser, who plowed his field in the summer). In early November, the trial plots received one cultivation before sowing. The seeds were broadcast by hand at a rate of 100 kg/ha. In Breda, covering was done by a duck-foot cultivator, while in Khanasser a *tabban* was used.

1. FSP Reseach Report 1982. Project I: the productivity of cereals. ICARDA.

Samples of Arabi Aswad seeds used by each of the eight farmers were tested in the laboratory to determine the germination rate by sowing 100 seeds of each sample in dishes (in three replicates) and counting the emerged plants. The germination rates of the local barley sampled in Khanasser were similar to those of Beecher (94%); seed samples from Breda were slightly superior (96%) to Beecher.

The grain and straw yields of the trial plots are reported in Table 14. With respect to variety, both grain and straw yields for Arabi Aswad were on average higher than for Beecher on all unfertilized plots except one, but the difference was not statistically significant. At Breda, with phosphorus application, Beecher did better than Arabi Aswad but the converse was true at Khanasser. Again there was no statistical difference between the varieties due to the large degree of variability between sites.

The phosphorus response was much more dramatic. Beecher grain yields increased by 81% at Breda with phosphorus application and 28% at Khanasser. Arabi Aswad yields increased 30% with phosphorus application at Breda and 58% at Khanasser. Straw yields exhibited similar large responses to phosphorus application. Besides its effect on yield, phosphorus was observed to advance the maturity of both varieties at both sites by 4-11 days.

Finally, the results seemed to indicate that nitrogen application (in the N/P treatment) had a negative effect on grain yields and no effect on straw yields at both sites, when compared to the treatments with phosphorus alone.

Through informal interviews, information was gathered from farmers about their reactions to the trials and the production constraints that might limit the adoption of the proposed technologies. The main issues raised by farmers in these interviews were:

Table 14. Grain and straw yields (kg/ha) of barley in on-farm trials at Breda and Khanasser, 1982/83.

Location	Trial	Beecher		Arabi Aswad		Beecher		Arabi Aswad		Beecher	
		− P		− P		+ P		+ P		+ N/P	
	No.	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Breda	1	1010	1352	533	637	1647	2137	1065	1532	1475	1981
Zone 3	2	690	1085	851	1113	1361	1569	953	1202	1251	1783
	3	518	829	878	1170	1031	1292	1174	1790	1032	1605
	4	615	812	882	1114	1107	1778	913	1337	864	1392
	X	708	1020	786	1009	1287	1694	1026	1465	1156	1690
	SD	213	254	169	249	279	356	118	255	265	251
	CV(%)	30.1	24.9	21.5	24.7	21.7	21.0	11.5	17.4	22.9	14.9
Khanasser	5	693	1165	951	1454	1055	1243	1593	2418	946	1687
Zone 4	6	1099	1351	1315	1348	1451	1986	1750	2148	971	1628
	7	980	1306	1005	1375	1002	1481	1316	1620	945	1814
	8	368	529	459	554	521	1168	1237	1588	397	838
	X	785	1088	933	1183	1007	1470	1474	1944	815	1492
	SD	326	381	354	422	381	369	239	407	279	443
	CV(%)	41.5	35.0	37.9	35.7	37.8	25.1	16.2	20.9	34.2	29.7

1. Confusion among farmers in Khanasser between Beecher and a Canadian variety (Sobargolan) that was grown in the area some years ago but discarded due to its poor feed quality.

2. Complaints of poor feed quality of Beecher. Farmers claimed that the straw is tough even if it is chopped, and grain needs to be crushed before feeding it to animals.

3. Expectation that Arabi Aswad would perform at least as well as Beecher in terms of grain and straw yields. Farmers in Khanasser were unanimous in their expectations to obtain higher yields from Arabi Aswad.

4. Higher prices for Arabi Aswad compared to Beecher for grain (15%) and straw (20-25%).

5. Availability of phosphorus fertilizer through agricultural banks. (Fertilizer is not recommended by the Ministry of Agriculture and Agrarian Reform for Zones 3 and 4; therefore, they would have to buy it in the open market at prices 20-25% higher). Farmers in Khanasser also indicated that because of the high probability of a poor cropping year they cannot afford to run the risk of higher financial losses by applying fertilizer.

6. With respect to weeds and pests, farmers in Khanasser explained that by planting early in the season, weeds are crowded out by barley plants which germinate very quickly after the first rain. The land is seldom fallowed in that area and the soil is relatively clean and can easily be weeded by hand if necessary. They worried however about a red round scale insect (*Porphyrophora tritici* Bod) which attacked the roots of the plant and may cause up to 60% losses in barley yields. They explained that this pest is more of a problem in bad years when the plants are weak. It is likely that monocropping with barley is the major cause of the problem since it was observed that the insect was more widespread on such fields.

7. Finally, with respect to growing continuous barley, which is more widespread in Khanasser, farmers indicated that this rotation is imposed on them by the small size of their land holding.

Project II: Nitrogen Fixation, Productivity and Water Use of Grain and Forage Legumes in Rainfed Mediterranean Environments

Nitrogen deficiency is a widespread factor limiting crop productivity in North Africa and West Asia. Nitrogen fixed biologically by grain and forage legume crops is one important way in which nitrogen available for crop growth can be increased. Previous research at ICARDA has shown that there is considerable scope for the improvement of legume crop productivity, so there is a strong emphasis in the FSP on increasing symbiotic nitrogen fixation by better agronomic management of the crop and utilization of improved *Rhizobium* spp. inoculants.

Our work on examining the interactions between crop management, crop productivity, and biological nitrogen fixation continued during 1982/83 and again demonstrated large potential increases in nitrogen fixation from improved management. This work will be expanded in 1983/84 to examine the main effects and interactions of the various components of the improved management. A full report of the first 2 years' research (1981/82, 1982/83) will be produced in 1984.

Considerable research on weed control in legumes was undertaken, with special reference to *Orobanche* sp., with promising results. In addition, our economists cooperated with the Food Legume Improvement Program in on-farm trials with chickpea and lentil in Syria, and in research in the Nile Valley Project in Egypt and Sudan. This cooperative work is reported by the Food Legume Crop Improvement Program.

Component 1: Microbial Studies

Testing of *Rhizobium* spp. Culture Collections

A priority of the microbiology section in 1982/83 was to resuscitate the entire *Rhizobium* spp. collection which consisted of 432 individual cultures, the majority of which had been stored on agar slopes for over 18 months. Each culture was tested for viability, purity, and its ability to form effective nodules in association with its specific host symbiont. Although time-consuming, this exercise was necessary to maintain an adequate *Rhizobium* spp. culture collection as a resource base for ICARDA and other research establishments in the region.

Any culture collection is of limited value unless each strain within the collection can be identified. Two methods are being used to identify strains with respect to field competition and effective nodulation: intrinsic antibiotic resistance (IAR) and Elisa serological typing (Enzyme-linked immunosorbent assay). Facilities for Elisa methodologies are not yet available at the Center. However, arrangements have been made with the Max Planck Institute, Cologne, West Germany to have a limited number of isolates typed by the Elisa technique at no cost to ICARDA.

Rhizobium spp. Inoculant Carrier

Previously, ICARDA purchased peat for inoculant production from Australian sources. In 1982/83, an acceptable source of peat was found in Turkey.

Although peat is a universally accepted carrier, not all forms of peat are able to sustain growth and/or viability of rhizobia. The peat from Turkey maintains numbers of rhizobia under proper storage conditions for an acceptable period (Table 15). Although the pH values were high, the carrier material was deemed suitable for use as the values corresponded well with those of the soils under investigation.

General Soil Microbiology

The microbiology of rhizobia cannot be separated from general soil microbiology since the rhizobia not only interact with other bacteria in the soils but are also exposed to the same selection pressures. Therefore, knowledge of the numbers and metabolic diversity of the general soil bacterial population is useful.

Counts were made from Janury to June at three sites: Tel Hadya, Breda, and Khanasser. The numbers of aerobic heterotrophic organisms were reasonably uniform in fallow fields (Fig. 1). These values were one to two orders of magnitude lower than the norm known for fertile soils. In addition, preliminary

Table 15. *Rhizobium* spp. inoculum viability in a peat acquired from Turkey.

Sample time (Weeks)	*Rhizobium leguminosarum* number/g of peat. All counts are x 10^7			
	Coarse[1]	pH	Fine[1]	pH
0	29.2	8.20	22.2	7.90
1	25.3	8.25	24.6	7.94
2	20.4	8.31	25.0	8.05
3	29.2	8.21	22.2	7.92
4	28.8	8.03	20.6	8.07
5	23.2	7.98	22.7	8.03
6	25.0	7.98	27.6	7.96
7	28.4	8.20	25.7	8.09
8	26.0	8.06	28.0	8.15
9	24.8	8.03	26.1	8.03
10	29.4	8.14	29.8	8.19

1. Peat was ground using two sieves.
Coarse = 2 mm diameter, Fine = 0.5 mm diameter.

testing of the metabolic diversity of these mesophylic, heterotrophic populations indicated a narrow range of activity (Fig. 2); the greater percentage of the isolates utilized only the six most readily available carbon sources. The lack of organisms able to produce H_2S was expected, given the state of the soils in those area locations. (This activity is usually associated with low redox potentials and bacteria associated with the anaerobic decomposition of organic matter).

Further testing is necessary to confirm this narrow range of metabolic activity. Lack of diversity may be a partial explanation of the decreasing yields observed on monoculture barley fields, since it can give rise to a condition referred to as soil sickness, which is brought about by the continual selection of metabolically similar organisms. Thus, lack of diversity can lead to incomplete degradation of root exudates and/or dead root systems which results in a build-up of products detrimental to general crop vigor.

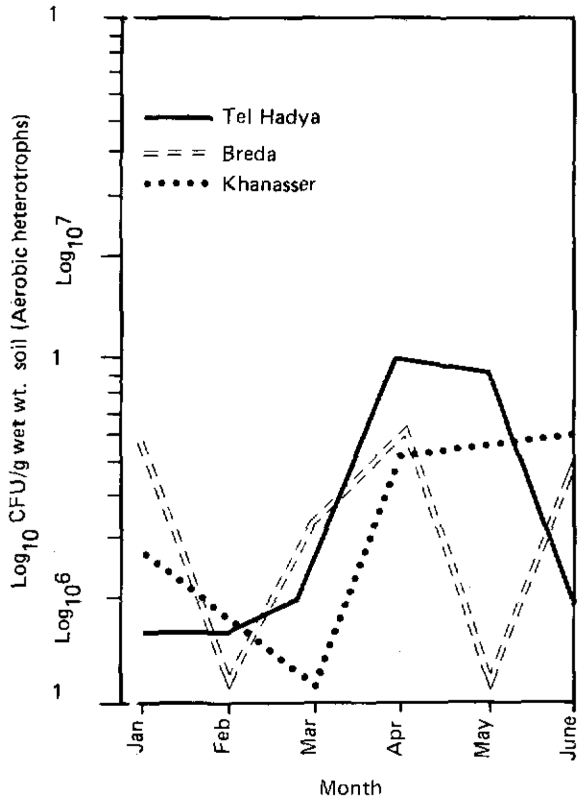
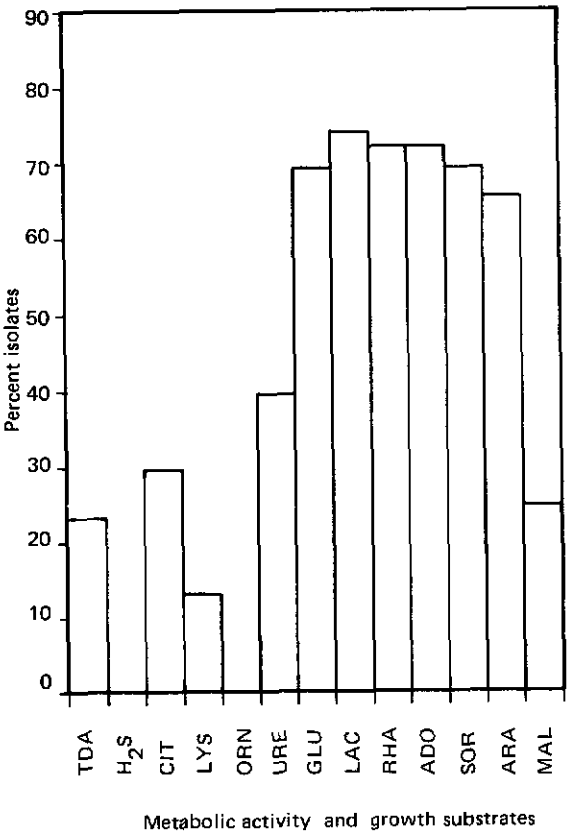


Fig. 1. A comparison of colony-forming units (CFU) of aerobic heterotroph populations in fallow fields at Tel Hadya, Breda, and Khanasser, 1982/83.



TDA = Tryptophan deaminase; H_2S = Production of H_2S; CIT = Citrate; LYS = Lysine (decarboxylase); ORN = Ornathine (decarboxylase) URE = Urease production; GLU = Glucose; LAC = Lactose; RHA = Rhamnose; ADO = Adonitol; SOR = Sorbitol; ARA = Arabinose; MAL = Malonate.

Fig. 2. Distribution of metabolic diversity of 40 aerobic heterotrophic bacteria randomly isolated from Breda, Khanasser, and Tel Hadya soils, 1982/83.

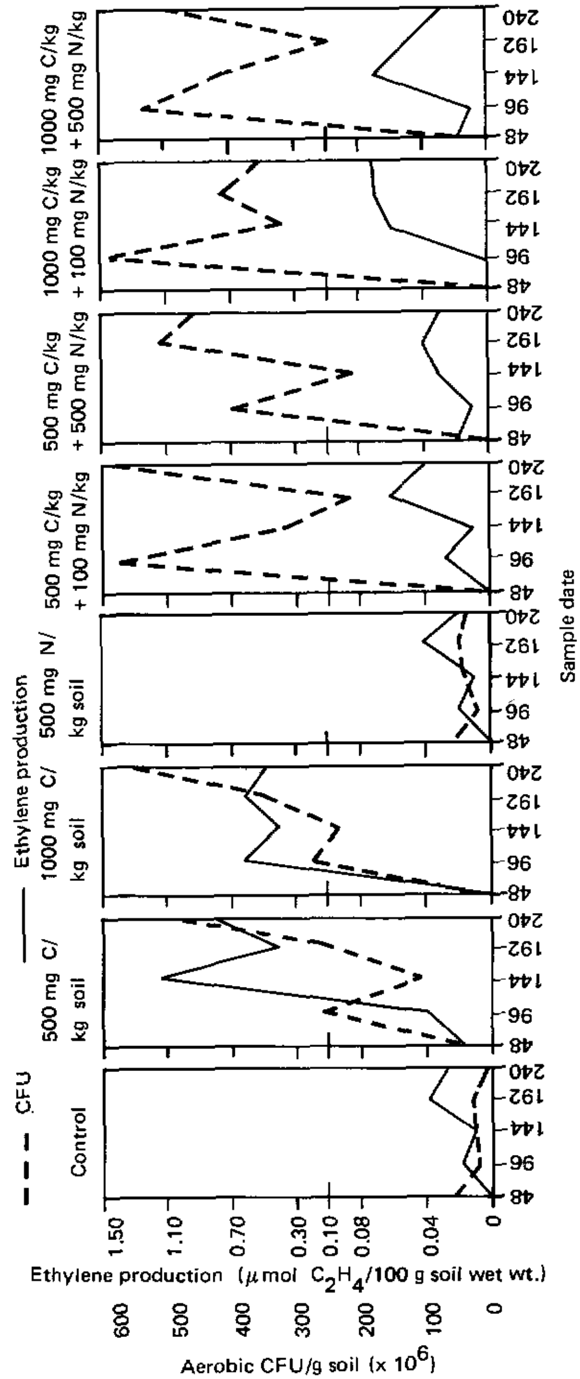


Fig. 8. Effect of various soil amendments on colony-forming units (CFU) and ethylene production activity with time in soils from Khanasser, 1982/83.

Many natural biological systems are limited by a lack of nitrogen. But the soils in Khanasser were carbon limited (Fig. 3). Laboratory studies showed an immediate response of microbial numbers, including free-living nitrogen fixers, to a readily available carbon source. The free-living nitrogen fixers responded less in those soils to which both carbon and nitrogen were added than in those with carbon alone, probably due to the inhibition of the nitrogenase enzyme system in the presence of available nitrogen.

So far, we have found carbon to be limiting in soils only at Khanasser. Nevertheless, we believe that it may be so at other locations too, since soil organic-matter content is reasonably uniform (approximately 0.5%) at all sites.

Naturalized *Rhizobium* spp. Populations

A survey to monitor the populations of naturalized *Rhizobium* spp. will be a continuing activity of the microbiology unit to determine temporal and *spatial fluctuations in* populations.

Most Probable Number (MPN) estimates were made using two methods to assess nodulation (a visual rating and measurement of ethylene production of those plants appearing to be nodulated). Different host plant species (e.g., faba beans, vetch, lentils, and peas) were used to enumerate *Rhizobium leguminosarum* (Figs. 4, 5, 6).

The numbers of *R. leguminosarum* which nodulated vetch were constant with time at the three locations sampled and were generally between 100 and 400/g wet weight of soil (Fig. 4). For lentils, the numbers were initially about the same at each location (25 - 50/g), but over time they increased sharply (up to 600 at Breda and Khanasser and 1500 at Tel Hadya). Fig. 5 shows the pattern for the same organism when peas were the host plant. Similar to lentils, the numbers at Tel Hadya increased to approximately 2000/g; whereas those at Breda remained constant at about 300/g. Uninoculated and inoculated soils were used to determine specific organisms for faba beans. Results (Fig. 5) show that *R. leguminosarum* numbers were initially low in the uninoculated plots but increased over time to as many as in the inoculated soils.

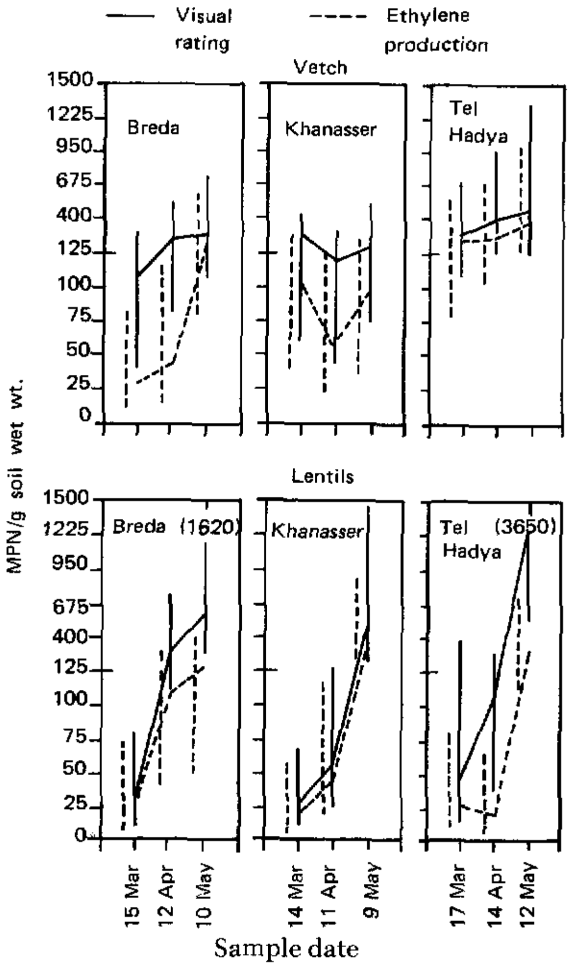


Fig. 4. Most probable number (MPN) estimates of *Rhizobium leguminosarum* using vetch and lentils as host symbionts and two methods to assess nodulation: 1. visual rating, 2. ethylene production. Vertical bars represent 95% confidence limits.

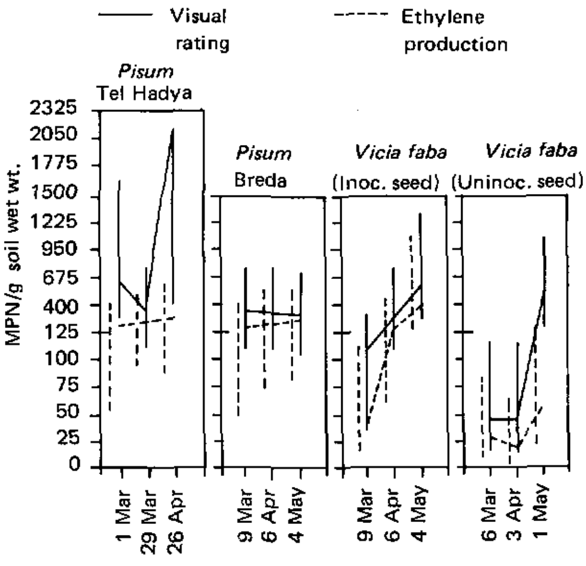


Fig. 5. Most probable number (MPN) estimates of *Rhizobium leguminosarum* specific for *Pisum* sp. at Tel Hadya and Breda and for *Vicia faba* at Tel Hadya, 1982/83. Vertical bars represent 95% confidence limits.

The results of the survey indicate some specificity in *R. leguminosarum* strains indigenous to Breda, Khanasser, and Tel Hadya soils. This is evident by fewer being initially specific for lentil and faba bean than for pea and vetch. In addition, the strains displayed different growth characteristics across locations. Vetch numbers appeared uniform over time at all locations, lentil increased over time at all locations, and pea increased over time at Tel Hadya. Although the lentil-specific strain increased at all locations, at Khanasser the increase became evident approximately one month later than those at Breda and Tel Hadya.

Soil samples from *Rhizobium* spp.-inoculated plots showed that Tel Hadya soils could support a population of *R. cicer* after introduction but soils of Breda and Khanasser could not (Fig. 6). *R. meliloti*, the organism associated with medics, appeared not to be adapted to local environmental conditions.

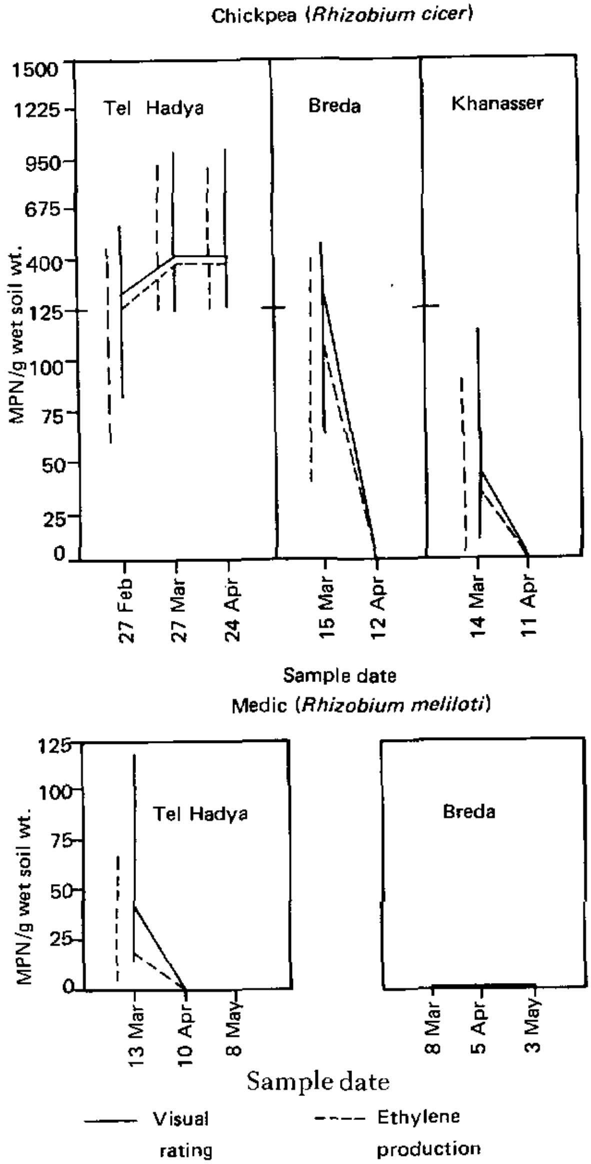


Fig. 6. Most probable number (MPN) estimates of *Rhizobium cicer* and *R. meliloti* at different locations, 1982/83. Two methods of observation of nodules were used: 1. visual rating, and 2. ethylene production. Vertical bars represent 95% confidence limits.

Although the 95% confidence limits in Figs. 4-6 indicate that our two methods measured the same population, the possibility of two populations with different genotypic makeup cannot be ruled out. Visual assessment of nodulation will be influenced by the entire nodulating population, whether or not these are nitrogen fixers, whereas the ethylene production assay measures only the nitrogen fixing portion of the population.

Our major selection parameter is temperature. Reports are available in the literature on the effect of temperature on *Rhizobium* spp. In the laboratory, *Rhizobium* spp. do not survive temperatures exceeding 45°C, and survivors over 35°C regularly display different phenotypic expression apparently due to the spontaneous loss or alteration of plasmids associated with nodulation and fixation.

Soil temperatures at Tel Hadya (measured daily at 1300 hr on bare soil previously planted to chickpea) are at times higher in the top 5 cm (Table 16) than those quoted in the literature as lethal to *Rhizobium* spp. Also, temperatures in the 5-10 and 10-15 cm levels reach values that could suppress the nitrogen-fixing capacity of rhizobia. Indeed, these temperatures select for survivors only, which may not necessarily have the highest potential to fix nitrogen.

Field Measures of Nitrogenase Activity

Estimates of nitrogenase enzyme activity, using the ethylene production technique were undertaken on a number of agronomy trials. Ethylene production values were measured in vetch and pea and in barley/vetch and barley/pea mixtures at two locations (Tel Hadya and Breda). As expected, the monitored enzyme activities of the legumes were different (Fig. 7). Pea showed much greater ethylene production activity in pure and mixed stands at Tel Hadya and Breda.

Quantifying symbiotic nitrogen fixation by ethylene production method.

Table 16. Mean soil temperatures (°C) at three depths[1] at Tel Hadya, summer 1983.

Working Week	5 cm			10 cm			15 cm		
	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.
17-21 July	49.2	47	51	42.0	37	44	37.0	33	39
24-28 July	49.2	47	50	40.8	39	44	35.2	34	38
31 July - 4 Aug	47.2	46	48	39.4	38	40	34.2	32	36
7-11 Aug	42.8	41	44	38.2	36	40	33.0	31	35
14-18 Aug	41.8	40	46	36.2	35	38	32.6	30	35
21-25 Aug	42.2	40	44	35.8	34	38	33.2	31	36
28 Aug - 1 Sept	42.8	40	46	36.8	32	39	32.4	29	34
4-8 Sept	45.2	41	47	35.6	33	38	31.0	30	32
11-15 Sept	42.6	39	46	32.6	31	35	30.8	27	33

1. Temperatures were taken at three depths, 5 cm, 10 cm, and 15 cm at 1300 hr, 5 days a week (Sunday to Thursday) on bare soil which was previously planted to chickpeas.

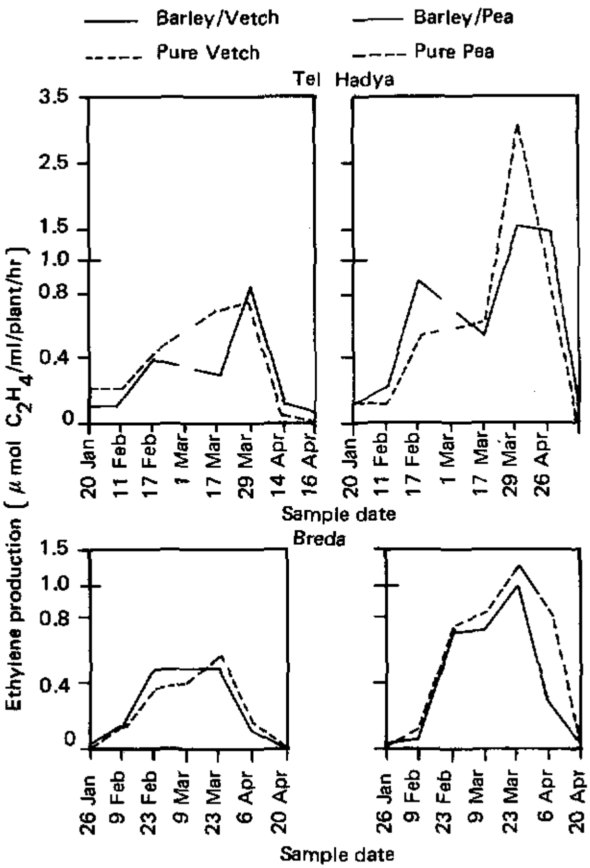
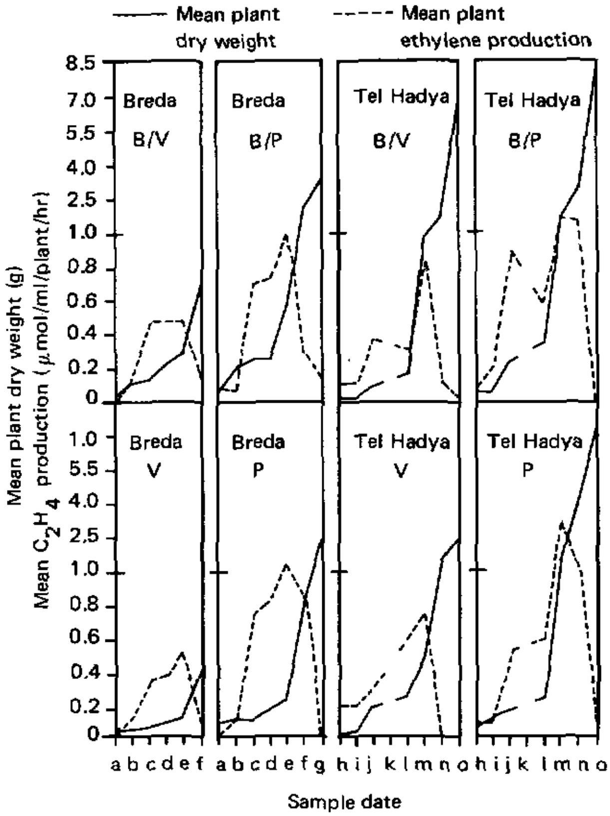


Fig. 7. A comparison of ethylene production values in mixed cereal/legume and pure legume stands at Tel Hadya and Breda, 1982/83.



a. 26 Jan, b. 9 Feb, c. 23 Feb, d. 9 Mar, e. 23 Mar, f. 6 Apr, g. 20 Apr, h. 20 Jan, i. 1 Feb, j. 17 Feb, k. 1 Mar, l. 17 Mar, m. 20 Mar, n. 4 Apr, o. 26 Apr.

Fig. 8. A comparison of mean plant dry weights and ethylene production values with time for vetch and peas planted in a barley mixture and pure stand at two locations, Breda and Tel Hadya, 1982/83 (B/V = barley/vetch, B/P = barley/pea, V = pure vetch, P = pure barley).

Location differences were also largest with pea in pure and mixed stands. The maximum ethylene production values were 3.1 and 1.5 μmol/ml/plant/hr for pure and mixed stands, respectively, at Tel Hadya and 1.3 and 1.0 μmol/ml/plant/hr at Breda. A similar pattern of production was found for vetch, with maximum values at Tel Hadya reaching 0.81 and 0.72 μmol/ml/plant/hr for pure and mixed stands, respectively, and 0.56 and 0.48 μmol/ml/plant/hr for pure and mixed stands at Breda.

The maximum enzyme activity was 2 weeks earlier at Breda than at Tel Hadya (Fig. 7), for inexplicable reasons. There were no observable plant differences at the two sites and, indeed, early flowering occurred during 29 March to 4 April at both sites. We expected a decrease in activity during early to mid-flowering, but this was apparent only at Tel Hadya.

If the areas under the ethylene production curves in Fig. 7 are compared and those for Tel Hadya are set at 100%, the values at Breda were only 79% of those at Tel Hadya for a pure stand of peas, 59% for a barley/pea mixture, 64% for pure vetch, and 88% for a barley/vetch mixture. The 20% difference between mixed barley/pea and pure pea stands at Breda was unexpected since the values for the two systems at Tel Hadya were within 1% of each other. In contrast, the ethylene production from vetch in a barley/vetch mixture was 24% greater than in pure stand. An explanation of these differences is not readily apparent.

Fig. 8 compares legume dry weight and ethylene production over time at the two sites. The greater portion of plant dry weight accumulated after the date of maximum monitored values of ethylene production (see also Table 17). The final dry-matter production in these legumes appears to be dependent to a large extent on soil nitrogen. Thus, it seems possible that with the selection of more efficient *Rhizobium* spp. strains and better adapted cultivars monitored enzyme activity can be maintained longer.

Conclusions

1. Selecting *Rhizobium* spp. strains for specific crops and specific locations is a priority. The two methods of identifying strains (IAR and Elisa) will be utilized in this selection process.

2. Reliance upon naturalized *Rhizobium* spp. populations for nodulation and fixation is unsatisfactory since they have been naturally selected for survivors and not necessarily for good or even adequate nitrogen-fixing ability.

3. Efforts should be made to increase soil organic matter and hence available carbon sources for microbial growth.

Table 17. Percent of total plant dry weight added after the onset of decline of ethylene production capability at Breda and Tel Hadya, 1983.

Site	Crop	Seeding practice	Date[1]	Percent plant dry wt[2].
Breda	Vetch	Pure stand	23 Mar	63
	Vetch	Barley/Vetch mixture	23 Mar	57
Breda	Peas	Pure stand	23 Mar	89[a](67)
	Peas	Barley/Pea mixture	23 Mar	83
Tel Hadya	Vetch	Pure stand	29 Mar	80
	Vetch	Barley/Vetch mixture	24 Apr	86
Tel Hadya	Peas	Pure stand	4 Apr	57[a](44)
	Peas	Barley/Pea mixture	29 Mar	81[a] (65)

1. Date of maximum C_2H_4 production.
2. Percent plant dry weight accumulated after the start of decline of C_2H_4 production.
a. C_2H_4 production values did not decrease drastically until after the following sample date. Figures in parentheses indicate dry weight accumulation evident after the rapid decline of enzyme activity.

4. Through changes in cultivar genotypes and inoculum quality, it is necessary to extend the duration of monitored nitrogenase enzyme activity in order to decrease the apparent dependence of the crops on soil nitrogen for dry-matter production.

5. Environmental studies will be undertaken to identify those parameters which have the greatest positive or negative impacts on the microbe/plant nitrogen-fixing system.

6. Ethylene production values need to be calibrated against ^{15}N values. Further reports on nitrogen fixation studies can be found in the chapters on the Food Legume Improvement Program and the Pasture and Forage Improvement Program.

Project III: Crop Productivity and Profitability within Rotation Systems

In Project III we are focusing on the components of existing systems, improving these components, or even changing the rotations themselves.

In 1982/83, we were involved in the five components of research indicated below:

Component 1. Rotation trials at two dryland barley-growing locations in northern Syria, Khanasser (220 mm), and Breda (275 mm): These trials examine the long-term effect of crop performance and soil conditions in commonly employed crop rotations (barley-barley, barley-fallow), and contrast these with possible alternative rotations in which either a forage or food legume is introduced to the system. Special emphasis is laid on the management of phosphate fertilizer in these rotations. They were established in 1980/81, and initial results have been reported in previous annual reports. During the 1981/82 and 1982/83 seasons, detailed crop, soil-moisture, and soil-nutrient studies have been made in these trials and the results will be reported in full as part of a Ph.D. study. Interim and detailed reports on this work are available from FSP.

Component 2. In 1982/83 we established two additional rotation trials, one at Tel Hadya and one at Breda on two-course barley rotations, with special emphasis on the inclusion of forage legumes, vetch, and peas. Fertilizer management is again an integral part of these trials, but additional attention is paid to the effect of including the forage legume either as a pure stand, or as a legume/cereal mixture. Method of harvesting (hand pulling vs cutting) is also investigated. Interesting results were obtained in the first year of this trial and will be reported later as rotational effects become established.

In this annual report, we focus our attention on the three components listed below which are either new fields of research (components 3 and 5) or are reported for the first time in FSP (i.e., component 4). Component 4 is a well established rotation trial at Tel Hadya (1978/79), but is of special interest for two reasons: first, it examines the effect of weeds, weed control measures, and contrasting tillage techniques within a two-course wheat-lentil rotation, and second, the impact of these contrasting treatments on soil moisture dynamics was investigated for the first time in 1982/83.

Component 3: Resource Management in Low-Rainfall Areas: The Problem

The dry cultivated areas of Syria receiving less than 350 mm of average annual rainfall are undergoing rapid deterioration[1]. Although they are an important component of Syria's agricultural sector[2], these areas are currently ignored by agricultural development policies which concentrate primarily on the higher rainfall and irrigated areas. For example, modern inputs which are government controlled are only distributed in the wetter areas. While the agricultural production is not fully exploited in these wetter areas, and this justifies the present orientation of development efforts, the degradation process in the drier areas, if it continues, will clearly jeopardize agriculture's future. This in turn could substantially reduce the beneficial effect of efforts undertaken in the more productive wetter area. Considering Syria's rapid population growth, the dry cultivated areas represent a potential which ought to be preserved.

The rapid degradation of the resource base is an essential component of the problem faced in the dry areas. Mismanagement of the available natural resources has led, in particular, to a loss of soil fertility, decline in production of grazing areas and, in some cases, exhaustion of underground water supplies. The resulting drop in agricultural productivity of these areas has implications in terms of methods and techniques for agricultural development. Approaches aimed at increasing the productivity of a given commodity or component of the system and the transfer of techniques developed in more favorable environments need to be considered with caution since they could increase the present disequilibrium. In order to restore the agroecological equilibrium there is a need to consider and study the resource base as a whole, analyze the present management, and determine the potential of the available resources. This is a precondition to defining technical changes adapted to the area.

1. Jaubert, R. 1983. *Sedentary Agriculture in the Dry Areas of Syria. Development Problems and Implications for ICARDA*. Preliminary Report, FSP, ICARDA. Final report in preparation.
2. The dry cultivated areas represent about 25% of Syria's total area, 50% of the cultivated area, and 25% of the rural population.

Present Management and Potential of the Available Resources

Agriculture in dry areas is a «mining» activity generally, as no efforts are made to maintain the agricultural potential. In most cases, no inputs (fertilizer or manure) are added to cultivated lands, while most of the biomass produced is removed (straw and grain). Similarly, uncultivated areas are subjected to heavy and uncontrolled grazing. Consequently the on-going degradation of environmental resources is not surprising.

Intensive cultivation has expanded over the past 30 years only,to the detriment of the steppe. In many respects farmers are still using extensive management practices which are not suited to the type of farming that has recently been developed. This is particularly true with respect to livestock production. In most mixed farming systems, animals play an important role in terms of resource management. However, in the study area, flock management clearly conflicts with the management of both cultivated and uncultivated areas. The large gap between present and desired practices of animal management indicates a wide scope for improvements. Better management of the available resources would not only contribute to stabilizing the farming systems but would also increase productivity. For example, areas which cannot be cultivated are used for grazing flocks (in the western part of the study area these marginal areas represent about 30% of the total area). These grazing lands are degraded and are facing erosion, but they could be improved by appropriate management.

The low input of organic matter is a central component in the loss of soil fertility. A few farmers apply manure in rainfed crops and this illustrates the potential for livestock to contribute to the maintenance of soil fertility. In 1982/83, a three-fold increase in yields of barley was observed in farmers' fields resulting from several years of application of sheep manure by the farmer. Information collected in Aleppo Province indicates that sheep could make a significant contribution to maintaining soil fertility if flock management techniques were modified.

Many villages have irrigated lands. Although limited in area, they are an important component of farming systems. It is likely that the available underground water could be more efficiently used than it is at present. In addition, on sloping land runoff water represents a potential water supply which is usually lost to the system.

Forage research in the Pasture and Forage Improvement Program is important. Annual and perennial forage crops are likely to be important components in stabilizing the farming systems. Forage crops have a positive effect on soil fertility; they are also important for grazing lands by providing an alternative source of feed which would help prevent the overgrazing which is currently practiced.

These examples show that several components of the farming systems could probably be improved by appropriate management. They also emphasize that stabilizing the farming systems will require a set of complementary changes affecting several linked components of the systems. In this respect livestock is a key component, and animals are studied with respect to their direct and indirect role in resource management rather than only in relationship to crop utilization.

The diagnostic research in 1982/83 has given us a better understanding of the magnitude of the problem and pointed to areas in which the system could be improved. Research in 1983/84 will aim toward developing techniques for preventing further degradation of the resource base.

Component 4: Effect of Tillage, Fertilizer, and Weed Control in a Two-Course Rotation at Tel Hadya

A two-course lentil-wheat rotation was begun at Tel Hadya in the 1978/79 season with the objective of studying the effect of different tillage systems, weed control methods, and levels of fertilization on crop yields and weed flora. A split-split-plot design was selected; the main factors (tillage systems) included:

1. Conventional tillage early: plowing, harrowing, fertilizing, and sowing before rain,
2. Conventional tillage middle: plowing before rain, harrowing, fertilizing, and sowing after rain,
3. Conventional tillage late: all cultural practices were done after rain,

4. Zero tillage early: direct drilling before rain, and

5. Zero tillage middle: direct drilling after rain.

Five different weed control methods were superimposed on each tillage system:

1. No control (no weeding)
2. One handweeding
3. Two handweedings
4. Broadleaf herbicide
5. Broad-spectrum herbicide

Two fertilizer treatments were superimposed on each weed control method:

1. Fertilized
2. Unfertilized

In the 1982/83 season, soil moisture measurements were made on selected treatments. Conventional tillage early and zero tillage with early planting were selected as main treatments; weedy and weed-free as subtreatments; fertilizer vs no fertilizer as a sub-subtreatment.

The soil of the experimental plot has been classified as a Vertic (calcic) Luvisol with a pH of 8-8.5, organic matter 0.9-1%, and EC (electrical conductivity) 0.62-1.48 mmhos. The soil depth was greater than 2 m except in small spots where it was around 80 cm. Lentils were seeded with an Amazone planter on 25 Oct 1982 at a seed rate of 100 kg/ha. Fertilizers were broadcasted before sowing at the rate of 60 kg P_2O_5/ha plus 20 kg N/ha. Harvesting was by hand from 12 to 16 May.

Throughout the season, moisture status in the soil profile was monitored using the neutron-probe technique. Other data collected included grain yield, dry weight of lentil plants (at the time of weeding), and dry weight of broadleaf and grass weeds. Meteorological variables, including air temperatures, Class A pan evaporation (E_0), and precipitation (P) were recorded weekly. Evapotranspiration (E_T) for a given time period was determined according to the equation: $E_T = \Delta m + P - R - D$

where Δ m is the change in total moisture stored in 0-180 cm. R (runoff) and D (drainage below 180-cm depth) did not occur in this trial and thus were ignored in computing E_T.

Climatic Variables

Fig. 9 shows weekly precipitation, evaporation, and mean air temperature in the 1982/83 season and indicates trends typical of the low-altitude Mediterranean climate. The rainy season started in early November. Emergence of lentil plants occurred in the last 10 days of November. The distribution of rain was favorable during the growth season. Atypically low air temperatures were experienced during the growth period (December to mid-March), with 33 frost days. The minimum temperature was -9.8°C in January. From the second half of March onward, air temperatures and E_0 values rose rapidly, and rainfall frequencies and amounts decreased. These typical patterns of climatic variation are also reflected in the changes observed in the soil-moisture status (Table 21); this will be discussed in more detail later.

Agronomic Studies

Effect of tillage, weed control, and fertilizer on weed number. Soil preparation in conventional tillage systems reduced the number of weeds (broadleaf plus grass weeds) by more than 50% compared with zero-tillage treatments (Table 18). Among conventional tillage systems, the

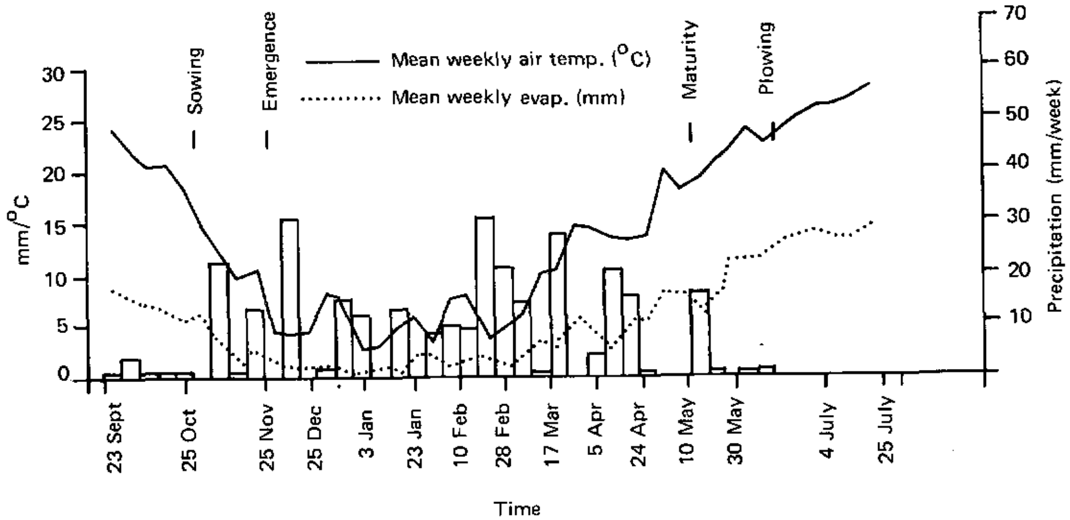


Fig. 9. Seasonal variation in precipitation, air temperature, and evaporation at Tel Hadya, 1982/83.

Table 18. Effect of different tillage systems, broadleaf and grass weed control methods, and levels of fertilization on the number of weeds (plants/m²) at Tel Hadya, 1982/83.

		Control	One weeding	Two weedings	Broad-leaf herbicide	Broad-spectrum herbicide
Conventional	Fert.	736	171	66	143	124
T. early	Unfert.	539	180	144	193	128
Conventional	Fert.	434	146	61	60	40
T. middle	Unfert.	275	141	52	49	32
Conventional	Fert.	831	104	45	28	35
T. late	Unfert.	233	75	69	22	24
Zero tillage	Fert.	1306	311	108	774	942
early	Unfert.	2278	419	165	442	390
Zero tillage	Fert.	2666	590	190	433	841
middle	Unfert.	1472	498	157	319	464

LSD (5%):	Tillage systems	476
	Fert. levels	170
	Fert. levels at the same level of tillage system	380
	Tillage systems at the same level of fert. level	718
	Weed control (WC) (Methods)	194
	Weed control (WC) at the same level of tillage system	434
	Tillage systems at the same level of WC method	612
	Weed control method at the same level of fert. late	274
	Fert. late at the same level of WC method	298

differences in the number o weeds were not significant. The number of wild mustard plants (the common broadleaf weed in the area) was significantly smaller in the zero tillage (early and middle planting) compared with the conventional (early and middle planting). The distribution of the numbers of the two most common grasses, wild oat and canary grass, showed the strong effect of date of sowing regardless of the kind of tillage systems. The number of wild oat plants was highest in the early date of sowing, but declined sharply in the middle and late dates of sowing. The number of canary grass plants was highest in the conventional tillage (late planting) and in the zero tillage (middle date).

Handweeding or applying herbicides significantly reduced the number of weeds including wild mustard, wild oat, and canary grass plants compared with the weedy control. Applying the broadleaf herbicide Brometryne significantly reduced the number of wild mustard plants and the grass killer Bronamid had a similar effect on wild oat and canary grass plants.

Adding fertilizers did not result in any significant increase in the number of weeds (wild mustard, wild oat, or canary grass).

Effect of tillage, weed control, and fertilizer on weed dry weight. Delayed soil operations in the conventional tillage system did not result in a significant reduction in the total dry weight of weeds (Table 19).

Early soil preparation, conventional tillage early, encouraged the growth of grass weeds but reduced the numbers of broadleaf weeds. In contrast, in the conventional tillage middle treatment the growth of grasses was reduced more than the growth of broadleaf weeds.

Nevertheless, the soil operations in the conventional tillage treatments reduced the total weight of weeds to half that of the zero tillage. The growth of broadleaf weeds in the zero tillage late was more vigorous than of grasses, whereas the growth of broadleaf and grass weeds was equal in the zero tillage early planting.

Controlling weeds by hand or by applying herbicides significantly reduced the total dry weight of weeds (Table 19). Handweeding twice was most effective for controlling weeds. Applying the broadleaf herbicide Brometryne alone or in combination with the grass killer Bronamid was more effective than one handweeding. Adding nitrogen and phosphorus fertilizers resulted in a significant increase in total dry weight of weeds (Table 19).

The dry weight of broadleaf weeds in the fertilized treatments was about 20% more than that in the unfertilized treatments.

Effect of tillage, weed control, and fertilizer on lentil yield. Among the conventional tillage systems, early plowing and seedbed preparation resulted in a slight increase in the grain yield (Table 20) and dry matter of lentils. Zero tillage with early planting gave as large yields as conventional tillage practices. Severe reduction in lentil yields was observed with zero tillage and late planting. This was due to shallow seed placement during sowing in relatively wet soil which exposed the seeds to the direct effect of frost and bird attack during the early stages of plant growth. The conventional tillage and zero tillage with early planting gave almost the same grain yield, dry matter, and number of lentil plants.

Table 19. Effect of different tillage systems, weed control methods, and levels of fertilization on the total dry weight of weeds (g/m^2) at Tel Hadya, 1982/83.

		Control	One weeding	Two weedings	Broad-leaf herbicide	Broad-spectrum herbicide
Conventional	Fert.	108	54	4	37	29
T. early	Unfert.	68	24	7	16	10
Conventional	Fert.	161	77	9	29	20
T. middle	Unfert.	26	12	4	6	4
Conventional	Fert.	168	49	4	6	13
T. late	Unfert.	20	6	1	1	1
Zero tillage	Fert.	172	66	14	86	94
early	Unfert.	158	28	9	39	35
Zero tillage	Fert.	205	85	31	76	76
middle	Unfert.	52	28	10	33	34

LSD (5%):	Tillage systems	35
	Fert. levels	15
	Fert. levels at the same level of tillage system	33
	Tillage systems at the same level of fert. level	58
	Weed control (WC) (Methods)	14
	Weed control (WC) at the same level of tillage system	31
	Tillage systems at the same level of WC method	45
	Weed control method at the same level of fert. level	19
	Fert. L. at the same level of WC method	23

Competition with weeds caused severe reductions in grain yield of lentils (Table 20). Handweeding once and twice increased the grain yield significantly. Handweeding twice resulted in a significant increase in the grain yield over handweeding once. Applying the broadleaf herbicide (Brometryne) individally or in combination with the grass killer (Bronamid) controlled weeds effectively and increased the grain yield significantly. The comparison between applying broadleaf herbicide alone or in combination with the grass killer did not show a significant difference in the grain yield, but applying the combination of the two herbicides controlled grass weeds.

Adding nitrogen and phosphorus fertilizers resulted in a significant increase in the grain yield of lentils (Table 20).

Moisture Studies

Seasonal changes in soil-moisture profile. Changes in total moisture in the profile (0-180 cm) are shown for all treatments in Table 21. During the cool wet winter, when rainfall exceeded crop evapotranspiration, profile recharge occurred in all treatments, maximum profile recharge being recorded on 17 Mar. During the recharge period, treatment effects became apparent. Weed growth caused greater

Table 20. Effect of different tillage systems, weed control methods, and levels of fertilization on the lentil grain yield (kg/ha) at Tel Hadya, 1982/83.

		Control	One weeding	Two weedings	Broad-leaf herbicide	Broad-spectrum herbicide
Conventional T. early	Fert.	342	935	1039	751	671
	Unfert.	275	478	529	369	425
Conventional T. middle	Fert.	273	662	945	737	838
	Unfert.	325	452	419	352	347
Conventional T. late	Fert.	92	845	888	860	654
	Unfert.	321	512	454	474	414
Zero tillage early	Fert.	222	905	1249	507	689
	Unfert.	101	580	566	266	448
Zero tillage middle	Fert.	37	437	662	118	130
	Unfert.	77	311	435	166	135

LSD (5%):	Tillage systems	257
	Fert. levels	86
	Fert. levels at the same level of tillage system	192
	Tillage systems at the same level of fert. level	374
	Weed control (WC) (Methods)	65
	Weed control (WC) at the same level of tillage system	145
	Tillage systems at the same level of WC method	288
	Weed control method at the same level of fert. level	92
	Fert. L. at the same level of WC method	118

water use which resulted in less total profile recharge (6.16 cm mean value for all weedy treatments compared to 7.67 cm for unweedy treatments). A similar main effect of fertilizer was observed resulting from enhanced crop and weed growth (6.52 cm for fertilized treatments compared to 7.30 cm for unfertilized treatments). Tillage treatments did not appear to have any consistent main effect other than that associated with weed population, mean values of 7.0 and 6.8 cm being recorded with conventional and zero tillage, respectively. These differences in profile recharge are reflected in both depth of profile recharge and accumulated water use which are discussed in more detail later.

Between 17 Mar and 24 Apr, crop and weed moisture use in both the weedy and fertilized treatments exceeded rainfall, and profile discharge commenced. However, in the weeded unfertilized treatments where crop and weed cover was least, only slight profile discharge or recharge occurred. Following this period, rapid profile discharge occurred in all treatments until harvest on 10 May 1983. Treatment effects were again apparent and were reflected in the extent and rate of profile discharge. In the weeded treatments, fertilizer greatly increased the rate of profile depletion (1.21 vs 0.77 mm/d) in this period, but in the unweeded treatments, where profile recharge was severely reduced by fertilizer application, a reverse picture was

Table 21. Moisture (cm) changes in the soil profile at Tel Hadya.

	No. of Days	Accum. precipi-tation	Conventional tillage				Zero tillage			
			Weedy		Weeded		Weedy		Weeded	
			Fert	Un-fert	Fert	Un-fert	Fert	Un-fert	Fert	Un-fert
1982										
25 Nov	0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12 Dec	17	31.3	2.01	1.96	1.85	1.89	1.42	1.42	1.65	1.60
1983										
3 Jan	39	63.1	3.07	3.23	2.98	2.99	2.34	2.75	2.98	2.98
23 Jan	59	79.8	3.28	3.55	3.40	3.41	3.14	3.04	3.37	3.44
10 Feb	77	100.0	3.30	4.11	4.09	4.07	3.02	3.34	4.05	4.09
28 Feb	95	146.7	5.47	6.12	5.48	6.25	4.91	5.53	6.47	6.53
17 Mar	112	180.1	5.60	7.32	7.40	7.66	5.46	6.25	7.62	7.98
5 Apr	131	241.1	3.13	5.64	5.50	6.23	2.44	4.95	5.62	7.39
24 Apr	150	257.6	2.18	5.12	5.72	7.96	1.89	3.92	5.02	7.53
10 May	166	258.1	-1.15	0.28	2.09	4.02	-1.70	-1.38	-0.16	3.34
30 May	186	277.6	-1.03	-0.08	1.91	3.57	-1.27	-1.19	-0.65	3.02
4 July	221	279.6	-1.85	-1.00	0.76	2.31	-2.67	-2.51	-2.03	-0.51
3 Aug	251	279.6	-2.42	-1.72	0.17	1.39	-3.08	-3.63	-3.90	-2.26
5 Sept	284		-2.43	-2.09	-0.13	0.90	-3.37	-3.73	-4.01	-3.01
12 Oct	321		-2.66	-2.60	-0.14	0.85	-3.80	4.06	-4.42	-3.32

observed due to the greater available moisture at the onset of discharge period in the unfertilized plots. Rates of profile depletion were also higher (with the exception of zero tillage + fertilizer) in the weedy plots than the weeded plots (1.3 vs 0.84 mm/d).

Resulting from these treatment effects, there were clear differences in the moisture status of the plots at harvest and these are illustrated in Table 22.

Table 22. Profile moisture status (cm) at harvest (10 May) relative to date of first reading (25 Nov) at Tel Hadya, 1982/83.

	No fertilizer	Plus fertilizer	Mean
Weeded	3.68	1.93	2.81
Unweeded	-0.55	-1.43	-0.99
Mean	1.57	0.25	

Extractable moisture. Extractable moisture is defined as the difference between the maximum value observed in any discrete soil horizon and that at harvest. The values calculated for all soil-depth intervals are shown in Fig. 10. Moisture extraction below 75 cm was minimal, either because the available moisture did not penetrate to that depth (i.e., in weedy treatments) or because lentil roots were not active below 75 cm (weeded treatments).

Weeds and fertilizer again had predictable effects on the ability of the crop (or crop + weeds) to extract moisture. The addition of fertilizer and the presence of weeds both gave higher extractable moisture levels. In addition, in the weeded plots, tillage affected the extractable moisture; higher levels were observed in the zero tillage plots. However, this effect was not consistent in the weedy plots.

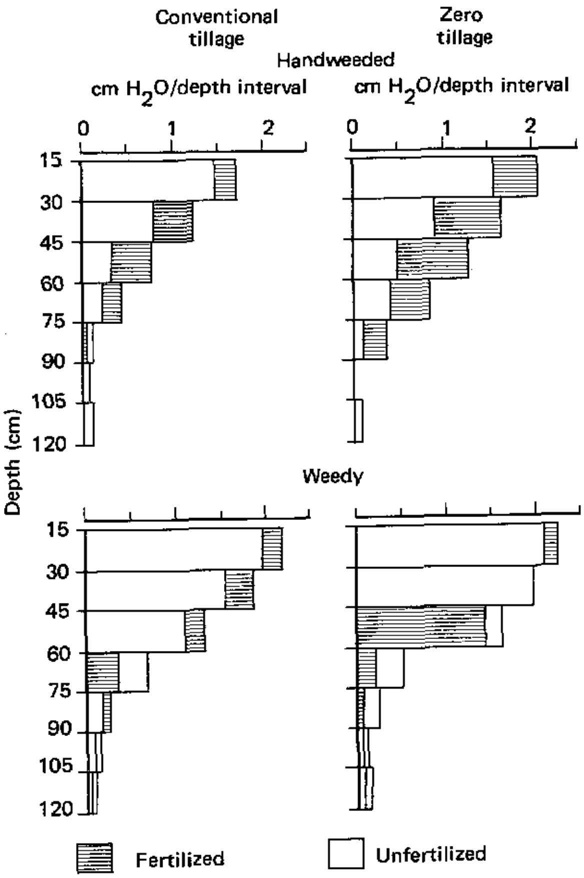


Fig. 10. Effect of tillage systems on extractable moisture within discrete depth intervals at Tel Hadya, 1982/83.

Table 23. Accumulated water use (E_T, mm, germination to maturity) by different tillage systems, weed control methods, and levels of fertilization at Tel Hadya, 1982/83.

		25 Nov	12 Dec	3 Jan	23 Jan	10 Feb	28 Feb	17 Mar	5 Apr	24 Apr	10 May
Conventional											
Control	Fert. +	0.0	11.2	32.4	47.0	67.1	92.0	124.1	182.8	235.8	269.6
Control	Fert. –	0.0	11.7	30.8	44.3	59.0	85.5	106.9	157.7	206.4	255.3
Conventional											
Handweeded	Fert. +	0.0	12.8	33.3	45.8	59.2	88.3	106.1	159.1	200.4	237.2
Handweeded	Fert. –	0.0	12.4	33.2	45.7	59.4	84.2	103.5	151.8	178.0	217.9
Zero Tillage											
Control	Fert. +	0.0	17.1	39.7	48.4	69.9	97.6	125.5	189.7	238.7	275.1
Control	Fert. –	0.0	17.1	35.6	49.4	66.7	91.4	117.6	164.6	218.4	271.9
Zero Tillage											
Handweeded	Fert. +	0.0	14.8	33.3	46.1	59.6	82.0	103.9	157.9	207.4	259.7
Handweeded	Fert. –	0.0	15.3	33.3	45.4	59.2	81.4	100.3	140.2	182.3	224.7
Evaporation (E_0)		0.0	13.8	35.6	50.9	77.4	108.2	153.6	247.6	332.1	457.0
Rain[1]		43.4	74.7	106.5	123.2	143.5	190.1	223.5	257.5	301.0	301.5

1. Rain accumulated from the onset of the season.

Crop – water use. Accumulated crop evapotranspiration (E_T) between germination and maturity are presented in Table 23 together with accumulated E_0 and rainfall. Between germination and 23 Jan 1983, there were no differences between treatments in evapotranspiration. During this period, there was little crop ground cover and almost all of the E_T occurred as evaporation from the soil surface under the crop (E_{sc}) as opposed to crop transpiration (T). Rates of E_{sc} are largely determined by frequency of wetting of the soil surface when ground cover is small, thus differences would not be expected until the T component becomes more important. Until 23 Jan 1983 E_T values were close to accumulated E_0 values (Table 23).

By 28 Feb the presence of weeds had caused greater evapotranspiration, and the effect of fertilizer was becoming apparent. By 17 Mar, these differences were clear, and persisted until harvest on 10 May 1983. A comparison of total evapotranspiration shows that, as would be expected, both the presence of weeds and addition of fertilizer caused substantial increases in crop evapotranspiration.

Water-use efficiency (WUE) data are presented in Table 24. As observed, in all treatments, application of fertilizer increased water use, but the increase in lentil and weed dry-matter production was proportionally much greater, resulting in increased WUE for both lentil yields and total biomass in the fertilized plots. Weeds increased water use, but depressed lentil yields, and thus dramatic increases in WUE were observed as a result of handweeding.

Maximum WUE of lentil total dry matter (8.6 kg/ha/mm) recorded in the trial was low compared to maximum values obtained for lentils grown at Tel Hadya (16.4 kg/ha/mm) in 1982, and we have observed that lentil itself is less efficient in water use than wheat or barley, where values of over 30 kg/ha/mm are often recorded. This reflects the fact that the lentil crop is much slower to achieve full ground cover than cereals and thus a higher proportion of E_T is lost as soil evaporation, rather than any basic differences in the transpiration efficiency of the species themselves.

It was interesting to observe that the maximum WUE of total biomass production (crop + weeds) achieved in this trial (9.8 kg/ha/mm) was not markedly greater than that achieved by a pure, weeded lentil stand. Weeds are strong competitors for water, nutrients, and light and at the density experienced in some treatments of this trial would contribute greatly to the rapid establishment of complete ground cover. It would thus be expected that, in very weedy plots receiving fertilizer, the WUE achieved

Table 24. Harvest data and water-use efficiency of lentils and weeds under different tillage practices, weed control methods, and fertilization at Tel Hadya, 1982/83.

		Lentils		Biomass		Water-use efficiency (kg/ha/mm)		
						Lentils		Biomass
		Grain yield (kg/ha)	Dry matter (kg/ha)	Dry weight (kg/ha)	Water use (mm)	Grain yield	Dry matter	Dry weight
Conventional								
Weedy	Fert.	342	1128	2212	270	1.3	4.2	8.2
Weedy	Unfert.	275	667	1352	255	1.1	2.6	5.3
Weeded	Fert.	1039	2038	2075	237	4.4	8.6	8.8
Weeded	Unfert.	529	751	823	218	2.4	3.4	3.8
Zero tillage								
Weedy	Fert.	222	970	2693	275	0.8	3.5	9.8
Weedy	Unfert.	101	336	1918	272	0.4	1.2	7.0
Weeded	Fert.	1249	2161	2304	260	4.8	8.3	8.9
Weeded	Unfert.	566	767	854	225	2.5	3.4	3.8

would represent a near maximum for that location in that year. If this was true, it could be concluded that the maximum WUE achieved by pure lentil stands represents near-maximum expected values for that season.

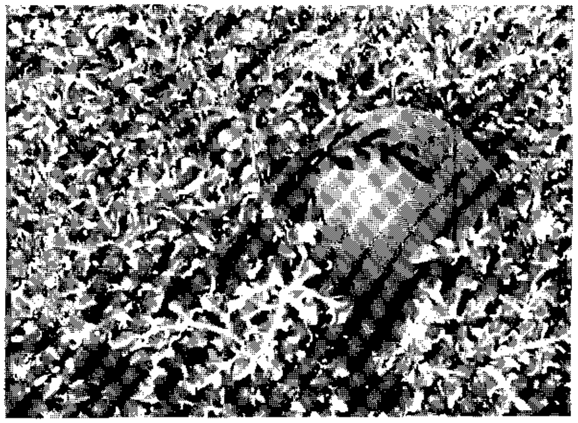
Component 5: Watermelon Production Versus Fallowing in Rainfed Agriculture

The three-course rotation of cereals-legumes-fallow or summer crop is a common practice in rainfed agriculture in those parts of the ICARDA region where annual rainfall is more than 300 mm. Watermelon is the main summer crop in the region, particularly in Syria. Yet, no work has been done to assess its effect on soil N, P, and soil-moisture residues for succeeding crops (wheat or lentils).

Therefore, a field experiment was designed to (1) compare residual values of N and P under bare fallow and the summer crop watermelon, (2) contrast soil-moisture residues under bare fallow and the summer crop watermelon, (3) determine the response of watermelon to N and P fertilization, and (4) measure the root depth and distribution for a watermelon crop.

A factorial experiment of five treatments and four replicates was laid out on the FSP site at Jindiress. The treatments were 0, N+, P+, N+P+, and F, where 0 is cropped with no fertilizer, N+ is 30 kg N/ha as ammonium nitrate, P+ is 13.5 kg P/ha as triple superphosphate, and F is bare fallow. Each treatment was applied to a plot of 12 × 14 m in a randomized block design.

The land is under a three-course rotation of cereals-legumes-summer crop, and was under the summer crop sesame in the preceding year. Crop and land management was similar to the farmers' practices. After land preparation, local seeds of watermelon (Chilean Black) were hand-sown at a rate of 1.25 kg seed/ha (6 seeds/hill) at 15 cm depth on squares (3 × 3 m). This plant spacing gave 20 hills in each plot with only six central plants to sample harvest. Nitrogen and phosphate fertilizers were applied to the six central plant hills only. The N and P applications was split into two depths. At 40 cm depth, 20 kg N/ha and 9 kg P/ha, and at 20 cm depth 10 kg N/ha and 4.5 kg P/ha were applied.



Summer crops are an integral part of three-course rotations in northern Syria. Can an improved agronomic practice be developed?

Soil moisture was measured by the neutron-probe technique to 180 cm depth in three replicates for the F and 0 treatments. On the 0 plots the measurements were taken at three distances from the plant center (10, 75, and 150 cm). The measurements were taken on four occasions: Plant emergence (80% of hills), flowering, maturity, and final harvest. The soil moisture for the 0-15 cm depth was measured gravimetrically.

Soil samples for mineral N and P analysis were taken at emergence and at final harvest from F and 0 treatments, in successive increments (0-15, 15-30, 30-45, 45-75, 75-105, 105-135 cm) to 135 cm depth. At harvest, soil samples from the 0 treatment were taken at three distances from the center of the plants (10, 75, and 150 cm). The bulk sample of the soil was weighed, mixed, and subsampled for N and P analysis and soil-moisture content measurement.

At harvest, the rest of the soil sample was used for root measurements. The soil was washed by a jet of water on a sieve of 1 mm^2 aperture placed on a sieve of 0.5 mm^2 aperture. The roots and organic matter were kept in preserving solution. Living roots (white and light brown) were separated from organic matter and dead roots, and their fresh weight (FW), length, diameter, and dry weight (DW) were measured.

Central plant tops and easily recovered roots were sampled at final harvest from all cropped plots. The samples were separated into leaves, stems, and easily recovered roots, dried at 80°C, weighed, ground, and kept for total N and P analysis.

Fruits were thinned to 1-3 fruits/plant depending on plant and fruit sizes. Edible fruits were harvested depending on their maturity; the harvest season therefore extended over a long period (2 Aug to 5 Sept 1983). Individual edible fruits were weighed (FW), subsampled, dried, ground, and kept for total N and P analysis. Thinned fruits were also dried, ground, and kept for total N and P analysis.

The development of crop cover (%) was measured by a grid of 3 × 1.5 m frame and 10 × 10 cm divisions. The measurements were taken weekly from emergence until maturity.

Yields

The data presented here will include crop production, root measurements, and soil-moisture measurements. Table 25 presents the DW production of the different plant parts and the FW of edible fruits at harvest. Larger DW yields of the different plant parts were obtained with P application. The yield of edible fruits (FW) in the P+ treatment was significantly more (41.5%) than the control.

Table 25. Total DW (kg/ha) of different plant parts and FW (kg/ha) of edible fruits of watermelon at harvest at Jindiress, 1983.

Treatments	Plant parts			Fruits		
	Leaves	Stems	Roots[1]	Thinned DW	Edible DW	Edible FW
0	200.3	101.0	3.1	33.1	787.3	9512.4
N+	210.0	98.7	3.6	35.0	595.2	6895.3
P+	311.1	152.9	4.6	79.0	1163.2	13459.6
N+P+	191.2	94.7	4.1	36.9	713.3	8731.4

LSD (5%) for edible fruits (DW) = 289.81 and at 1% = 416.39.

1. This value represents the DW of easily recovered roots.

The good response to fertilizer P under such dry conditions can be attributed to two main factors: (a) deep placement of fertilizer P (at 20 and 40 cm soil depth) provided more moisture for the fertilizer to dissolve and become more available to plants, and (b) increases in P concentration enhance local root proliferation. A larger root system increases water and nutrient uptake.

Nitrogen application had a negligible effect on the DW production of different plant parts, except the edible fruits. The yields of edible fruits were less with N than without, but the effect was not statistically significant. The effect was small on N + P + plots (Table 25). It seems that when N and P were both applied, the positive effect of P may have counterbalanced the negative effect of N.

Root Distribution

Root length densities (cm/cm^3) slightly decreased with distance from the center of the plants, but the decrease was not statistically significant (Fig. 11). However, this spatial variation of root densities is expected under such a wide spacing (3 × 3 m). The root length density decreased with depth and was highest (0.09 cm/cm^3) in the 0-15 cm soil depth.

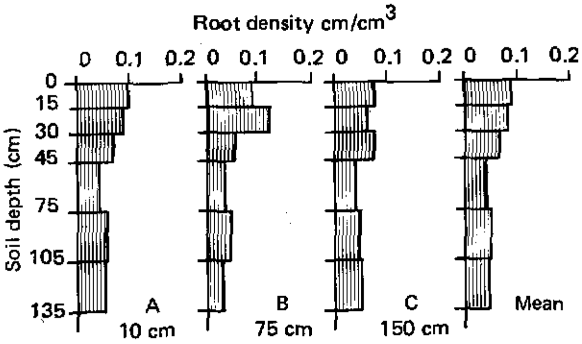


Fig. 11. Root-length densities (cm/cm^3) at final harvest for the different distances from the center of plants (A, B, C) and the mean value of A, B, and C at Jindiress, 1982/83.

The pattern of root distribution in the profile, and the high proportion (17.8%) of the measured root system in the 105-135 cm depth interval suggest that the roots of the watermelon crop may have penetrated below the maximum depth which was sampled. This is supported by the profile depletion patterns (Fig. 12).

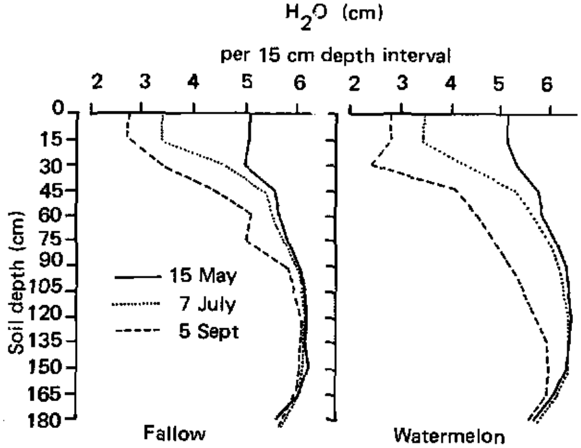


Fig. 12. Soil moisture contents (H_2O cm^3) on 15 May, 7 July, and 5 Sept under bare fallow and unfertilized watermelon at Jindiress 1983.

Table 26 presents the root length (m/m^2) at final harvest averaged for all distances from the center of the plants. The total root lengths to 135 cm soil depth were 756 m/m^2, with 48% of the measured root system in the 0-45 cm depth interval. The root lengths at soil depth 0-45 cm were 363.7 m/m^2 corresponding to an L_A value of 3.64 cm root/cm^2 soil surface, and about 0.08 cm of root/cm^3 of soil.

Measurements of root diameter showed a wide range (0.05-5 mm) of variation. Most of the roots (68%) were within 0.1-0.5 mm diameter, and 7, 21, and 4% were within the diameter ranges of < 0.05, 0.6-1.5, and 1.6-5 mm, respectively.

Table 26. Root length at final harvest for unfertilized watermelon at Jindiress, 1983.

	Soil-depth interval (cm)						
	0-15	15-30	30-45	45-75	75-105	105-135	Total
Length (m/m^2)	134.21	127.78	101.68	109.16	149.08	134.48	756.38

Table 27. Total depleted moisture from the soil ($\Delta 0$), E_T (mm H_2O) and the rates of E_T and $\Delta 0$ (mm/d) under bare fallow (F), and unfertilized watermelon (0) at Jindiress, 1983.

	Fallow				Unfertilized watermelon			
Dates:	15 May to 7 July	7 July to 21 Aug	21 Aug to 5 Sept	Whole period 15 May-5 Sept	15 May to 7 July	7 July to 21 Aug	21 Aug to 5 Sept	Whole Period 15 May-5 Sept
$\Delta 0$	27.1	34.3	13.4	74.8	36.3	88.7	7.4	132.1
$\Delta 0$/d	0.51	0.76	0.89	0.66	0.68	1.97	0.49	1.17
E_T	40.2	34.3	13.4	87.9	49.4	88.7	7.4	145.5
E_T/d	0.76	0.76	0.89	0.78	0.93	1.97	0.49	1.29
E_0/d					10.91	14.56	12.14	12.60
E_T/E_0	0.07	0.05	0.07		0.09	0.14	0.04	

Soil-Moisture Dynamics

The soil-moisture content slightly increased with distance from the center of the plants, but the differences were not statistically significant at all dates and for all depths. Therefore, the data were averaged for all distances.

By harvest the soil-moisture content was more depleted at all depths under watermelon than under bare fallow (Fig. 12). The total amount of extracted water to the 180-cm soil depth was 74.8 mm H_2O under fallow and 132.4 mm H_2O under watermelon. About 52% (68.7 mm H_2O) of the extracted water under watermelon was from the 0-45 cm soil depth. Therefore, a high proportion (48%) of the extracted water under watermelon was from layers below 45 cm, which corresponds to the high proportion (52%) of the root system growing below that depth.

Also, at flowering (7 July) there were small increases in soil-moisture content under watermelon in layers below 135 cm (Fig. 12). Under bare fallow small increases were also observed at 165-180 cm soil depth during the season. These observations may suggest that there was a slow drainage of water below 120-cm and 135-cm soil depths under watermelon and bare fallow, respectively.

The data in Table 27 indicate that until maturity (21 Aug) the rates of soil-moisture depletion ($\Delta 0$/d) were higher under watermelon (0.68 and 1.97 mm/d) than under bare fallow (0.51 and 0.76 mm/d). Later in the season the rate of moisture depletion was higher under bare fallow (0.89 mm/d) than under watermelon (0.49 mm/d). This depletion pattern of soil moisture indicates that after the end of the crop cycle, the soil under bare fallow tends to lose more moisture than that under watermelon. Thus the excess amount (57.6 mm H_2O) of moisture conserved under bare fallow compared to that under watermelon at harvest will decrease during the postharvest period. If the differences between the rates of moisture depletion under both treatments were similar to that measured between 21 Aug and 5 Sept (0.4 mm H_2O/d) then a decrease of 18 mm H_2O can be expected by the beginning of the next cropping season (2 months).

Estimates of moisture depletion for different soil layers were calculated from the decrease of soil-moisture content in successive 15 cm increments between T_2 and T_1, assuming that there was no transfer between soil layers. Table 28 shows an example of the calculation for the period 7 July to 21 Aug 1983 for both treatments. During this period there was no rain. The rates were variable across the profile and depletion rates under watermelon were higher from the 15-75 cm depth than from 0-15 cm. These rates were calculated to indicate that the depletion rate of soil moisture averaged for the whole profile conceals a wide range of values.

Table 28. Rates (mm/d) of soil moisture depletion from successive soil layers under watermelon (N_0P_0) and fallow (F) at Jindiress, 1983.

Depth interval (cm)	Watermelon (N_0P_0)	Fallow
	7 July to 21 Aug 1983	
0-15	0.20	0.20
15-30	0.42	0.22
30-45	0.25	0.12
45-60	0.23	0.04
60-75	0.22	0.05
75-90	0.19	0.03
90-105	0.15	0.02
105-120	0.11	0.01
120-135	0.07	0.01
135-150	0.06	0.02
150-165	0.04	0.01
165-180	0.02	

Crop-Water Use and Water-Use Efficiency (WUE)

The total crop-water use by the end of the season was 145.5 mm H_2O (Table 27). About 91% of the cumulative E_T was from the soil-moisture reserves.

The rates of E_T varied throughout the growing season and were in the range of 0.49-1.97 mm/d (Table 27). This variation in E_T rates can be attributed to the changes in atmospheric evaporative demand, soil-moisture deficits, and crop cover.

The WUE for total dry-matter production (using the measured root weight of 250 kg/ha to 135 cm soil depth) and DW of edible fruits were 8.88 and 5.41 kg/ha/mm, respectively. However, *the wide plant spacing used for this* crop and the slow development and small size of its plant cover (crop cover was 0.4, 11.6 and 20.7% at 3 weeks after emergence, flowering, and maturity, respectively) suggest that most of the crop-water use was lost by soil evaporation and only a small proportion was actually transpired by the crop. Assuming that the amount of water transpired by the crop was equal to the difference between E_T under watermelon (145.5 mm) and E_T under bare fallow (87.9 mm), the transpiration efficiency (TE) for total dry matter and edible fruits was 22.31 and 13.67 kg/ha/mm, respectively. These values of WUE and TE for total dry matter will be slightly higher due to leaf litter losses and the unmeasured part of the root system below the 135-cm soil depth.

However, when using the equation, $TE = 102 - 13\ E_0 + 0.53\ E^2_0$, developed by Fischer (1981)[a] for estimating the transpiration efficiency of barley, a C_3 crop, the estimated TE for watermelon (also a C_3 crop) was 22.34 kg DM/ha/mm, which is very close to the *measured* TE.

Project IV: Livestock in the Farming Systems

Livestock systems research has been conducted in the Farming Systems Program since 1978 using a four-stage approach: (1) systems description and problem diagnosis, (2) component testing and system design, (3) on-farm testing of components, and (4) diffusion. The field surveys of stage I consisted of the Steppe Survey 1978-81 and Study of Sheep Performance 1981/82. In 1980, a program of on-station research was initiated at Tel Hadya which addresses questions relating to stage 2 of the FSR process. In 1981, stage 3 research started and was expanded in 1982/83. These stages are integrated through socioeconomic studies which focus on crop-livestock interations.

During the year under review the major research activity of Project IV was conducted at Tel Hadya. However, the on-farm research also became a more important effort. At Tel Hadya the research is conducted within the framework of two unit farms, three flocks, and the associated fenced areas of natural grazing. The objective of this reasearch is to investigate improved nutritional strategies based on pastures, hays, and straws, and to assess the economic benefit of these changes on sheep and crop productivity at the farm level. The on-farm testing aims to test and refine management practices designed on station, which are relevant to the farming system and therefore acceptable to farmers.

a. Fischer, R.A. 1981 Optimizing the use of water and nitrogen through breeding of crops. Plant and Soil 58: 249-278.

Component 1: Crop-Livestock Integration

Livestock-Cropping Systems

The analysis of results from the 1978-81 Steppe Survey at three locations, Bir Amaleh, Hazm Alsurr, and Mouhaseneh in northwest Syria, where the cultivated zone receiving about 200 mm annual rainfall merges into the steppe, was completed in 1982/83. This survey aimed to describe a farming system in which sheep are the dominant enterprise and to identify factors which are likely to limit system productivity.

The importance of barley grain in the annual feeding cycle of sheep can be seen in Table 29. Barley grain supplied 33% of the metabolizable energy in the supplements fed to the study sheep flocks in winter. The start stock represents that part of the opening inventory of barley actually fed to the sheep. The remainder of the opening inventory is seed from the farmers' own barley crop. The end stock represents that part of the farmers' own barley production, after deducting the next year's seed requirements, which is consumed by sheep during the winter of the following cropping year. The sum of the purchases and start stock of barley represents the total consumption by sheep.

There were significant between-year differences ($P < 0.01$) in the case of the start and end stocks, but not in the case of purchases ($P < 0.05$). In the «dry» year, stocks were diminished because the barley yields were poor.

Table 29. Physical flow of barley grain (kg per flock).

	1978/79 «dry»	1979/80 «wet»	1980/81 «norm»	Mean	SD[1]	Significance Year	Location
Start stock[2]	1767	1053[a]	7453	3726	8169	**	NS
Purchases[2]	9862	4420	3779	5306	7808	NS	***
End stock[2]	989[a]	7435	12818	8214	9118	**	NS
Change in stocks[3]	-856	12068	979	4979	10511	**	NS
Change in flows[3]	-11128	9644	4444	3241	14433	**	NS
Change in systems[3]	-11983	21712	5424	8220	17260	***	*

1. $\sqrt{\text{Residual mean square}}$.
2. Feed sector only. See text for explanation of concepts.
3. Includes seed used in own production.
a. *End stock in 1978/79 differs from start stock in 1979/80 because additional farmers were included in the 1979/80 sample.*

* = $P<0.05$
** = $P<0.01$
*** = $P<0.001$

Hence, barley purchases were 9862 kg per flock and the overall system balance[1] was 11,983 kg in deficit. However, in the «wet» year the system generated a considerable surplus of 21,712 kg per flock, on average.

The importance of presenting these system flows is related to the desire of farmers to produce their own barley and the government legislation which prohibits cultivation of land below the 200 mm rainfall isohyet. Such a policy aims to conserve the resource base in areas that are particularly prone to erosion, where every effort should be made to maintain the cover of natural vegetation. The government is increasingly enforcing this legislation. Therefore, the definition of systems flows is useful in showing the degree of dependency of sheep flocks on farm-produced barley and for indicating what the consequences of a total cessation of barley cultivation would be. On average, the systems were generating a surplus of 8220 kg barley per flock.

1. Here the systems' balance represents the sum of the change in stocks and the change in flows. This latter term is the difference between the flows out of the system (sales of grain, transfers to combine operators, relatives, and partners) *minus* flows into the system (grain purchases).

In view of this conflict of objectives, and because ICARDA and regional scientists are seeking alternative management practices which will restore the equilibrium in this particularly delicate agroecological belt between the cropped and grazing zones, further research is needed which provides farmers with feed sources other than their own barley grain. ICARDA scientists are well aware of this need and have already initiated research on pasture species which are suited to the driest of rainfed agricultural areas.

Unit Farms

Most of ICARDA's on-station sheep husbandry research is conducted within a «whole farm» environment provided by unit farms established at Tel Hadya in 1979. Medium(M)- and high(H)-input unit farms cover 14.1 and 10.9 ha, respectively. Each unit farm has an area of shallow, stony soil and of deep soil, on which 2-year and 3-year rotations, respectively, are practiced.

In addition to providing most of the feed for the experimental flocks, the unit farms have yielded detailed input and output data. When local costs and prices are applied to these data, they provide a basis for budget estimates to compare the economic performance of the various experimental sheep husbandry practices. Comparisons for the 1982/83 season are summarized here.

Low (L), medium (M), and high (H) levels of ewe nutrition during pregnancy were defined in the following six combinations with post-lambing nutrition levels: LL, LM, LH, MM, MH, and HH. LL means low nutrition levels in both pre- and postlambing phases; LH means low nutrition in pregnancy, followed by high nutrition after lambing, etc.

The LL flock was offered only limited supplements while the HH flock was heavily fed. The other flocks were managed at nutritional levels between these two extremes. The output, inputs, revenues, expenditures, and margins over feed costs for the six experimental flocks were recorded. Dramatic differences between flocks became apparent. For example, a four-fold increase in supplementary feed costs between the LL and HH flocks was outweighed by a ten-fold increase in total revenue.

Subtracting the costs of feed from total revenue gives the margin-over-feed-costs (MOFC). The MOFC is an expression of economic productivity which is useful in budget comparisons since the difference between flocks in the other overall costs (e.g., replacement ewes and veterinary costs) were small.

The total revenue and MOFC for each of the six flocks are plotted against feed expenditure in Fig. 13, along with quadratic regression curves fitted to these results. The MOFC curve reaches

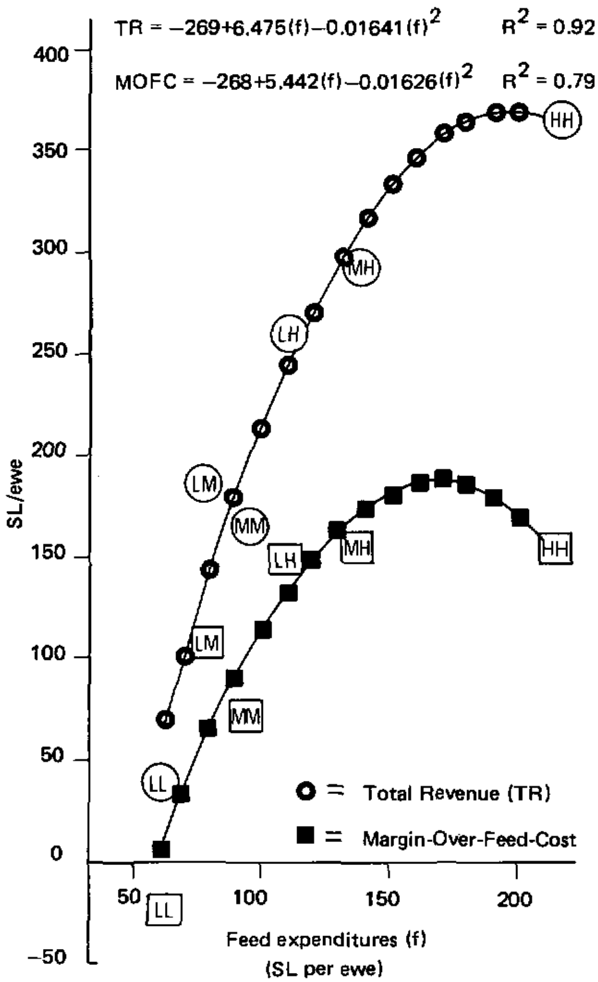


Fig. 13. Estimated total revenue and margin-over-feed-cost per ewe under six nutritional regimes at Tel Hadya, 1982/83.

its maximum at a level of feed expenditure between the MH and HH flocks. However, no observations were available at that level. The regression curve suggests that an increase in MOFC of about SL 30/ewe could have been obtained by feeding slightly more than the MH flock received, but in a different pattern. This could be achieved by low levels of feeding during pregnancy followed by a rather higher H level of feeding during lactation, using greater levels of concentrate.

Among the six flocks, those subjected to the LH feeding regime showed the best economic performance: relatively low feed expenditures, yet having profits (MOFC) comparable to the more heavily fed flocks. It is, therefore, not surprising that LH feeding regimes are commonly practiced already by Syrian flock owners[1]. The pattern of feeding is as important as total amounts of feed provided.

During 1983/84 research will continue to substantiate the results from the 1982/83 feeding trial but the treatments LL and HH will be excluded as being economically unpromising. Greater feed inputs will be made during the lactation period to boost milk production and put ewes in good condition for mating. Further efforts will also be made to design pasture-based feeding strategies which will, together with these lactation inputs, ensure that ewes enter the summer period in good condition. This will obviate the need to provide ewes with barley supplements in summer. It was those supplements which reduced the MOFC of the HH flock. However, some protein supplementation may be necessary to improve the utilization of the cereal stubbles.

Simulated Green-Stage Grazing of Barley

In parts of Syria immature barley stands are commonly grazed by sheep in the winter months, then left to mature as a grain and straw crop. Because of this, considerable interest has been generated at ICARDA, where research is being conducted on two main aspects:

1. At Tel Hadya, barley breeders are selecting and testing varieties which have dual-purpose characteristics in terms of their ability to withstand grazing and still produce satisfactory grain yields. Several promising varieties have been identified and preliminary information is available on frequency and timing of grazing and its effect on subsequent grain and straw yields. However, this information is being generated at a location which is far wetter and more fertile than the typical barley-growing areas.

2. Social scientists are involved in studying the economic implications of green-stage grazing and its interactions with land-tenure systems and alternative feed supplies. In order to quantify these relationships they require detailed information on the actual amounts of forage available and the effects of grazing on subsequent grain and straw yields.

The results of an experiment conducted at a low-rainfall site, Breda, are reported here. They provide information to supplement that which is available from the Tel Hadya trials. The results are consistent with previous experience which indicated that barley growth and yields at Tel Hadya are not typical of the drier areas where most of Syria's barley is produced.

As already described under Project I, 2^5 factorial trials were conducted in 1982/83 at six locations in northwest Syria to assess the relative importance of five crop management factors known to affect cereal yields. Those factors are: nitrogen, phosphorus, seed rate, variety, and weed control. Of the six locations sited along the 200 to 600 mm rainfall transect, two of the drier locations (Breda and Khanasser) were selected for the simulated green-stage grazing trials. These two locations are more representative of

1. Thomson, E.F. and Bahhady, F. 1983. Aspects of sheep husbandry systems in Aleppo Province of northwest Syria. Farming Systems Program, Research Report. ICARDA. p. 25.

the main barley-growing areas than the Tel Hadya site. However, only the results from Breda are highlighted here[1].

Within each of the 32 plots of the 2^5 trial, eight microplots (1 m^2) were marked out and four simulated grazing regimes were imposed: no clipping, clipping once (8 Feb), twice (8 Feb and 16 Mar), and three times (8 Feb, 16 Mar, and 6 Apr). Each «grazing» regime was repeated on two microplots per plot in the parent 2^5 experiment. On the specified dates, the «grazed» microplots were hand-clipped to a height of approximately 1 cm. The clipped material was weighed to assess dry matter removal. After completion of the clipping regimes, the crop was allowed to mature and was then hand-harvested. The grain and straw yields were recorded.

Economic evaluation of the results required several cost and price assumptions. Grain and straw were priced at SL 1.15 and SL 0.55/kg , respectively. Regression estimates derived from recent survey results[2] were used to link harvest costs (SL/ha) to the grain yield (kg/ha):

$$\text{Harvest Cost} = 120 + 0.32 \times \text{grain yield}.$$

Thus, estimates of net harvest value (grain + straw values − harvest cost) could be calculated for the mature crop associated with each level of «grazing» intensity.

To estimate the economic grazing value of green herbage at each stage of clipping, further assumptions were made. For the material clipped on 8 Feb, a price double that for grain (per kg of dry weight) was assumed. For the final clipping (6 Apr), the material was given the same price as grain per unit of dry weight. The price given to material clipped at the second grazing date was estimated according to the number of days from the first date.

There are sound reasons for giving a higher value per unit of dry weight to the early grazing. First, early-season grazing replaces concentrate feeds at a time when other grazing opportunities are scarce. The later stage of grazing comes at a time when other sources of forage are more freely available. In addition to the decline in costs of substitute feeds from 8 Feb to 6 Apr, there is a drop in the nutritional value of green-grazed barley. Prices assigned to the clipped materials are considered to show green-stage grazing in a favorable light, that is, the material is certainly not underpriced relative to grain.

It is worthwhile examining in some detail the economic trade-offs implicit in the clipping results across all treatments in the parent 2^5 trial at Breda. In 78% of the trial plots, final yields were reduced by a single early clipping. Even larger yield reductions occurred in 97 and 100% of the plots subjected to two and three clippings, respectively.

Net harvest benefits and cumulative grazing (clipping) values are shown in Fig. 14. These are plotted according to the average grain yield associated with each level of clipping. In the case of no clipping, the average net harvest value was greatest. One clipping yielded about SL 90/ha in grazing value but resulted in a larger loss in harvest benefits. As a result, total crop value (grazing + harvest values) was reduced due to a single clipping. Subsequent clippings caused increasing losses of total crop value. These results can be summarized by noting that each SL of green-stage grazing value is estimated to cost, in terms of reduced net

1. Detailed analyses for both locations are being done.

2. Mazid, A. and Hallajian, M. 1983. Crop-Livestock interactions: information from a barley survey in Syria. Farming Systems Program, ICARDA. (in Press).

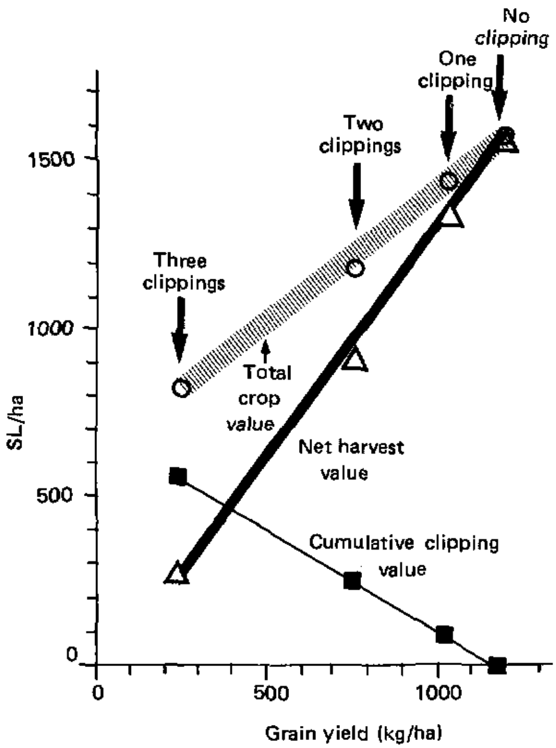


Fig. 14. Effects of clipping on the components of total barley crop value: averages over all treatments in a 2^5 trial at Breda, 1983.

harvest value, about SL 2.3. Thus, green-stage grazing appears to be very unprofitable according to our pricing assumptions and to the overall responses to clipping in the parent 2^5 trial.

The trial showed that yields of green herbage, grain, and straw were significantly increased by an application of 45 kg P_2O_5/ha. However, both with and without phosphate, total crop values were substantially reduced by clipping. The phosphate boosted total crop value by about SL 900/ha in the case of no clipping and by about SL 600/ha in the case of three clippings. Total crop values were almost the same (about SL 1100/ha) when three clippings were taken from a crop with phosphate as from a crop without phosphate which was unclipped. The fact remains, however, that green-stage grazing would not have been justified on economic grounds in either case.

The above analyses indicate that the farmers who face trade-offs between mature harvest value of the whole crop and the value of green-stage grazing, would allow no grazing. However, under particular ownership conditions there may be strong economic incentives to allow green-stage grazing even though it is known to cause damage to the mature crop. Such are the cases in northeastern Syria where small landholders rent their land to larger operators in return for one-third of the crop plus the privilege of green-stage grazing early in the season. This grazing is effectively limited to the early growth period up to February when flocks are required by law to leave the cultivated areas.

The reason for a strict and early calendar date limit on grazing is clear. Since the small landholder only gets one-third of the grain crop, each Syrian lira of green-stage grazing value will cost him less than a Syrian lira in terms of reduced rent from the land. If there were no limit to his grazing activities, he would prefer to extract the maximum amount of grazing, even to the point where there would be no grain harvest[1]. The indication that green-stage grazing is very unprofitable on drier sites is consistent with earlier survey results showing that it is a rare practice except when tenure arrangements reduce the grazier's interest in the final crop yield.

ICARDA's barley breeding efforts towards dual-purpose cultivars may need to be reviewed

1. Nordblom, T. 1983. *Livestock-crop interactions, the case of green-stage barley grazing.* Discussion Paper No.9, ICARDA, pp. 20-24.

Is green-grazing a profitable practice? Research is under way to find the answer.

both in terms of the survey results, which show green-stage grazing to be a limited practice associated with share-cropping, and in terms of the above economic analysis which helps explain why this is so. As breeding for dual-purpose cultivars continues, the selections should, if possible, be made in a drier environment more typical of the barley-producing areas in Syria.

Component 2: Pasture Crops and Animal Nutrition

On-Farm Forage and Grazing Trials

The third stage of the FSR process involves testing the components of improved husbandry practices which were designed and tested in scientist-managed trials. These may be either on-station or on farmers' fields. Joint-managed trials are those conducted on farmers' fields where both farmers and scientists collaborate in the research. Farmer-managed trials are the third type in the research sequence from scientist- to farmer-managed trials. Involvement of the farmer in the research process is essential since he is the ultimate user of a recommended husbandry practice; he will largely determine whether or not a new practice is adopted.

First attempts at joint scientist/farmer-managed on-farm trials involving barley and forage crops were made in 1981/82. Many lessons were learned from those initial attempts. Acknowledging the essential role of on-farm trials in the FSR process, the trials were considerably expanded in 1982/83 to include first attempts at on-farm livestock trials.

The villages in contrasting rainfall areas (200, 250, and 350 mm average annual rainfall) were visited in October 1982. Using a questionnaire, nine farmers were selected from within those villages depending on willingness to collaborate, suitability of land, and ownership of sheep. Agronomy trials were laid out on six farmers' fields using a standardized experimental design. Three species were tested: vetch (*Vicia sativa*), peas (*Pisum sativum*), and the annual *Medicago rigidula*. These were planted in 500 m^2 main plots, with 50 kg P_2O_5/ha applied to half of each plot.

One of these agronomy trials was modified to serve as a grazing trial by increasing the area of vetch and peas to 1500 m^2 per species. It was still possible to collect yield data for the two species since three 2 × 2 m areas within each subplot were protected from grazing, using wire netting. Since the farmer did not own sufficient lambs for the grazing trial, 20 Awassi lambs about 4 months old and weighing initially about 15-18 kg, were transported from ICARDA's research station to the site and divided between the two main plots. They were penned at night.

In June 1983, follow-up interviews were held with collaborating farmers in order to elicit their views regarding the trials.

The dry-matter yields (DM) from the sites are shown in Table 30. DM yields of the medic were not taken because of poor growth. The mean DM yields at Breda (250 mm annual rainfall) were about 28% higher than at the wetter site, Deir Qaaq (350 mm). Peas generally yielded 25% more ($P<0.05$) than vetch in the unfertilized and 38% more ($P<0.05$) in the fertilized plots. While the response to phosphate application was variable, on average peas responded better (21%) than vetch (10%).

The higher DM yield of peas than vetch in these joint-managed trials confirms the results from the scientist-managed rotation trials being conducted by the FSP. However, the overall DM yields in the joint-managed trials were well below the yields of scientist-managed trials in nearby plots. Such a finding is common when yield comparisons between experimental plots and farmers' fields are made.

The mean DM yields of vetch and peas were 280 and 210% higher, respectively, in 1982/1983 than those found in 1981/82 at

Table 30. Dry-matter yields (kg/ha) of vetch and peas with and without phosphate fertilizer, 1982/83.

		Peas		Vetch	
Location	Farmer	Fo[1]	F+[1]	Fo	F+
Deir Qaaq	1	1019	1285	780	731
	2	1069	1408	905	878
	Mean	1044	1347	843	804
Breda	3	1422	2113	932	1313
	4	806	1099	611	1072
	5	1612	1595	1341	1167
	6	1501	1453	1325	1326
	Mean	1335	1565	1052	1220
	Overall Mean	1238	1492	982	1081

1. Fo = No P_2O_5 applied; F+ = 50 kg P_2O_5/ha applied.

Breda. Part of this difference was certainly due to site and seasonal variations. But it is suggested that much of the increase in yield found in 1982/83 was due to the increase in the seed rate (140 vs 70 kg/ha) and P_2O_5 level used (50 vs 25 kg/ha).

It has already been noted that the mean DM yield was higher at the drier than the wetter site. Furthermore, with the exception of vetch at Deir Qaaq, there was a mean response of 21% to phosphate application (Table 30). There is insufficient knowledge of the soil and meteorological conditions at the various sites to explain the inconsistency of these results. A variable response of barley to phosphate fertilizer was reported in the 1981/82 barley on-farm trials. This was corrected in the next season and the responses in the trials in 1982/83 were more consistent largely due to greater care when selecting sites. Certainly, cropping history of the plots appears to be very important.

Some inconsistencies in the results are a feature of both joint- and farmer-managed trials where data on climatic, soil, and microbial environments are sparse or missing. However, the DM yields and the fertilizer responses in these trials are close to those that would be obtained by farmers operating on their own.

The grazing trial was the first attempt at a joint-managed trial involving livestock and, even though modest, it was very instructive. When conducting on-farm trials involving livestock, often a compromise has to be found between the need to measure the production (such as milk, weight gain, wool, dung, and traction) relevant to the farming systems, and the difficulties in doing so. Thus, lambs were chosen for grazing because measuring liveweight gain poses fewer problems than measuring milk production, even though it is envisaged that pastures would most likely be utilized by lactating ewes. In retrospect, we now think that a farmer would be more impressed by a new farming practice if he could see a change in performance of his flock over a short period of time. Thus, a change in milk yield would have been a better variable to determine than the growth rate of lambs since changes in milk yield could be measured by farmers themselves. It is therefore proposed in 1983/84 to monitor the milk production of ewes in two flocks before, during, and after they graze vetch or peas.

Table 31. Liveweights and liveweight changes of lambs grazing peas and vetch pasture at Breda, 1983.

	Vetch	Peas
Dry-matter yield[1] (kg/ha)	1122	1768
Dry-matter availability[2] (kg/lamb/day)	0.94	0.98
No. of lambs[3]	10	10
Start of grazing	4 Apr	4 Apr
End of grazing	22 Apr	1 May
Grazing days	18	27
Initial liveweight (kg)	17.1	15.6
Final liveweight (kg)	18.1	15.8
Av. daily liveweight gain (g)	55	10

1. Mean of fertilized and unfertilized plots -- see Table 30 farmer 3 (Breda).
2. (Dry-matter yield/ha x 0.15) ÷ (10 x grazing days).
3. Each group of lambs had five males and five females, about 4 months old at start of experiment.

The results of the grazing trial are shown in Table 31. The lambs appeared to prefer the vetch to the peas. Lambs on vetch were observed to rest after grazing in the morning but lambs on peas appeared to be continuously in search of feed. It was also observed that lambs found unfertilized vetch more palatable than fertilized vetch. There were differences in animal gains between the two groups; animals grazing the vetch gained, on average, 55 g/day while those grazing peas gained only 10 g.

The different lengths of grazing periods were partly due to the difference in the amount of dry matter available. However, on a daily basis, dry-matter availability per head was similar in both vetch and peas. But the intakes of the two species differed since after 18 days of grazing the vetch, lambs had removed all the crop. But, even after 27 days of grazing, considerable quantities of pea plant material remained.

Although the average daily liveweight gains per lamb were quite small on the vetch plots, expressing them as total liveweight gain/day/ha gives a value of 3.7 kg. This is similar to the value of 3.8 kg found at Tel Hadya in 1980/81 and 3.7 kg in 1981/82. The small average daily gain of the lambs was probably due to the high stocking rate chosen, 67 lambs/ha, and low DM availability. Converting to 45-kg ewe equivalents, this would have represented a stocking rate of about 25 ewes/ha.

Applying the same basis of measurement to lamb gains on the pea plots a value of 0.67 kg liveweight gain/day/ha is obtained, even though there was nearly 1 kg DM available/lamb/day (Table 31). The lambs' low voluntary intake of pea forage was responsible for their poor growth performance. Grazing studies by the Pasture and Forage Improvement Program (PFIP) have shown similar results. This is an important finding which has led to many discussions between scientists in the FSP and PFIP, particularly as peas have the advantage that they yield more. This point illustrates the value of conducting animal evaluation studies as early as possible when designing new elements for a farming system.

Several questions need to be asked regarding peas as a forage crop. Is green pea herbage really unpalatable? Do ewes as well as lambs find it unpalatable? What is the palatability of pea hay and pea straw? What is the nutritive value of these feeds? The PFIP grazing studies showed that adult sheep find mature pea plants more palatable than the early growth. Hay from pea and vetch will be fed to sheep in 1983/84 to assess voluntary feed intake and digestibility. Furthermore, grazing studies are planned for 1983/84 to evaluate the palatability of green peas for ewes and, in view of farmers' preference to harvest forage crops for grain and straw, the nutritive value of pea straw will be assessed.

One particularly important aspect of these trials was the opinion of farmers as expressed in the follow-up interviews. Although the yield of vetch was lower than peas, farmers preferred vetch to peas. This may be because they are more familiar with vetch as a forage crop. Also, some farmers could sell their pea seed only at a very low price because of insect damage.

As is often the case when seeking to introduce new technology into a farming system, a shortage of cash was felt by 80% of the farmers to be a constraint to introducing a forage crop into the crop rotation even though yields were sufficient to cover the variable costs. The desire of 80% of the farmers to use the forage crop for straw and grain production is understandable. First, they like to grow a crop which provides them with seed for planting in the next season. This solves the problem of a shortage of cash to buy the seed. Hay production, however, does not have this advantage. Second, the high economic value of straw, which constitutes an important component of sheep diets in winter, makes it an attractive product. Farmers showed no interest in hay production, perhaps because it is an unknown practice in the area.

One particular concern of the farmers was the effect of a forage crop which replaces a fallow on the yield of the subsequent barley crop. One farmer at Breda complained that the 1982/83 barley crop on the 1981/82 forage trial was poor. Unfortunately, the grain yield of this barley crop was not measured. However, the site of the previous year's forage trial could clearly be seen. Apparently, the application of phosphate fertilizer in the forage trial had stimulated the growth of the indigenous *Lolium* species. Some of the *Lolium* planted in 1981/82 had self-sown and regrown. Even though the 1982/83 barley crop may have suffered, the grazing value of the area after harvest was well above what it would otherwise have been. The farmer agreed with this point and was quite happy to provide all his fallow area (2.2 ha) for the 1983/84 forage trial.

Two particularly important lessons were learned during the 1982/83 season's on-farm forage trials: the first was in regard to plot size. Plot size was increased from 100 m^2 (1981/82) to 500 m^2 (1982/83). This had the desired effect of providing more realistic farming conditions in which the farmers were better able to evaluate new techniques. Furthermore, some farmers felt the area was sufficiently large to make it worthwhile harvesting the crop for straw and seed. This is an important step towards ensuring that farmers continue to grow the crop after the scientist has withdrawn his input.

The second lesson concerned the adoption of a «best bet» approach in joint-managed trials rather than rigid adherence to agronomic recommendations arising from small-plot trials. Such an intuitive and pragmatic approach uses a knowledge of local farming practices gained during initial survey work. For example, a seed rate of 140 kg/ha was chosen in 1982/83, based on the quantity of barley seed broadcasted by farmers in the area. The 70 kg/ha seed rate used in 1981/82 was found to be optimal in scientist-managed trials where seed was drilled into well prepared seed beds under higher fertility conditions than are usually found in areas with less than 300 mm annual rainfall. In the forage trials, a sowing method typical of the area was used, i.e., cultivation, hand broadcasting, and a final covering cultivation.

The first year of joint-managed on-farm forage and grazing trials have highlighted many socioeconomic and agronomic problems which need further research at the second stage of the FSR process. Scientists were already aware of many of these problems but are now better able to define research priorities as a result. The information feedback from the trials has pointed to the need for further research at the design and testing stages. Sharpened perspectives on these socioeconomic and agronomic problems provide ICARDA scientists with a more concrete framework for conducting on-farm testing of improved livestock husbandry practices. In 1983/84, efforts at ICARDA to develop and refine the on-farm pasture, forage, and livestock trial methods will continue. A regional workshop focused at on-farm trial methodology is planned for early 1985 at ICARDA.

Nutritive Value of Barley Straws[1]

Barley straw contributes a significant proportion to the diets of sheep in North Africa and West Asia. In poor rainfall years in the drier areas grain yields are lower and the quality of straw is a primary factor determining the value of the barley crop. Long-term estimates, which include poor and good years, indicate that at least 39% of the total economic value of barley crops in western Syria can be attributed to the straw and direct grazing provided in addition to the grain[2]. Although investigations are proceeding to introduce annual forages into the fallow in barley-fallow and to replace one year's barley in continuous barley rotations, it is very probable that straw will continue to remain a valuable feed material for many years to come. Straw quality is an important consideration amongst farmers. Farmers pointed out two years ago that Arabi Abied straw is much preferred by sheep compared with straw from the Beecher variety. Table 32 presents results of voluntary intake and digestibility trials which confirm these farmers' observations. Intake of digestible organic matter from Arabi Abied straw provided sufficient energy to nearly maintain animal liveweight, while Beecher straw resulted in a severe energy shortage: 2.9 MJ of metabolizable energy less than that required for maintenance of liveweight. This led to a weight loss of 145 g/day.

This preliminary research prompted investigations into possible reasons for differences in nutritive value between varieties. Data are now available on the morphological characteristics (Table 33) and on the chemical composition (Table 34) of three barley varieties harvested at Tel Hadya during 1983. At Tel Hadya, Beecher, a six-rowed barley, is comparatively high grain yielding, with tall, thick stems, and a low leaf-to-stem ratio. Arabi Abied, in contrast, is a relatively low grain yielding, two-rowed plant with thin stems, and a higher leaf-to-stem ratio. Possessing good characteristics of both, ER/Apam is a high-yielding, two-rowed barley with a leaf-to-stem ratio comparable with that of Arabi Abied. Beecher straw is more highly lignified than either Arabi Abied or ER/Apam straw which explains its lower digestibility. It is also lower in crude protein, but this factor alone is insufficient to explain differences in feed intake and digestibility.

ER/Apam demonstrates that high grain yield and acceptable straw value are not incompatible objectives in a plant selection program. Of course, these must be considered in combination with other factors, e.g., drought tolerance, when predicting the suitability of varieties for different rainfall zones[3].

As an aid to selection of varieties with adequate straw quality, straw from a number of barley variety trials harvested in 1983 is currently undergoing chemical analysis and determination of leaf-to-stem ratios. Facilities are now available at ICARDA for intake and digestibility tests of advanced varieties prior to release to farmers. This research will be extended in 1983/84 in order to investigate a greater range of barley genotypes and phenotypes. Research is also planned to examine the nutritive value of straw from different varieties under different types and levels of energy and protein supplementation. Such research is already helping plant breeders make decisions regarding future research objectives.

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1. In collaboration with the Tropical Development and Research Institute, England.
2. Mazid, A., Hallajian, M., Somel, K., and Nordblom, T. 1984. The economic contribution of forage and fodder from barley crops in western Syria. RACHIS No.3: 17-19.
3. Nordblom, T. 1983. Livestock-crop interactions: the decision to harvest or to graze mature grain crops. Discussion Paper No. 10, ICARDA, 21 pp.

Table 32. Daily voluntary feed intake and digestibility of Beecher and Arabi Abied straw (per 45 kg sheep).

	Barley variety	
	Beecher	**Arabi Abied**
Dry matter intake (g)	623.0	763.1**
Dry matter digestibility (%)	36.6	41.0***
Organic matter digestibility (%)	40.9	50.6***
Intake digestible organic matter (g)	231.3	363.4***
Metabolizable energy intake (MJ)	3.4	5.4***

*** = Significantly different, $P < 0.001$
** = Significantly different, $P < 0.01$

Table 33. Factors affecting nutritive value of three barley straws.

	Barley variety		
	Beecher	**Arabi Abied**	**ER/Apam**
Grain yield (kg/ha)	2720	1830	3057
Straw yield (kg/ha)	1731	1009	1819
Leaf: stem ratio of straw	0.5:1	0.8:1	0.8:1
Plant height (cm)	74.0	36.2	47.4
Stem thickness (cm)	0.33	0.21	0.20

Table 34. Crude protein and lignin composition of the straw of three barley varieties.

	Stems			Leaves		
	Beecher	**AA[1]**	**ER/Apam**	**Beecher**	**AA[1]**	**ER/Apam**
Crude protein (%)	2.0	2.1	2.1	3.3	3.6	4.2
Lignin (%)	11.3	9.0	10.2	7.7	6.9	5.2

1. AA = Arabi Abied

Conclusion

In 1982/83, considerable further understanding of several topics relating to the role of livestock in farming systems was gained. Analysis of the data from the 1978-81 Steppe Survey was completed and on-farm grazing and livestock trials were started. Research on simulated grazing and nutritive value of barley straws should increasingly help the barley breeders define their future research priorities.

In 1983/84, research will focus on the further development of methods to evaluate the performance of livestock given improved husbandry in on-farm trials and in refining elements of husbandry practices being developed on station. On-farm grazing trials, at 10 sites, are planned and the forages will be grazed by sheep flocks of the landowners. Attempts will be made to monitor the milk yield of the ewes. Four of these trials will be part of a new study which aims to relate sheep feeding strategies to sheep performance (see Project III, component 1).

There will be a shift in the focus of the on-station research towards designing and testing of systems which have an increased pasture component. The unit farms and the three flocks provide a research framework which should be very suitable for realizing this goal. In addition, linear programming analyses will be conducted using the 4 years of data so that economic viability of various crop/livestock combinations can be tested.

Project V: Environmental Zoning

Project V was developed to provide scientists at the Center with information on environmental conditions that affect agricultural production in the ICARDA region. Agroclimatic and socioeconomic characteristics are all important, and describing differences in these parameters from one geographical area to another is vital for the successful transfer of our research findings to the farm.

This Project has three objectives: (1) to collect, collate, and analyze agroclimatic data for use in agroecological zoning; (2) to collect information and describe soil conditions in ICARDA region; and (3) to collect data on socioeconomic characteristics within the region and analyze the effect they may have on agricultural production.

In 1982/83 this project received only 3% of the FSP budget. This was a deliberate decision on our part since it was not clear whether this research should take place in FSP. Recommendations in favor of the project came from the report of the Quinquennial Review (QQR) as well as ICARDA scientists. The QQR panel suggested that «ICARDA should clarify its plans for continuing this project both in relation to the physical and the economic environment.» Project V will therefore receive greater attention in future.

The likelihood of experiencing severe drought conditions is being estimated.

Project V in 1982/83 concentrated on the collection and analysis of agroclimatic data.

Although relevant to Project V, research on soils in 1982/83 was restricted to Aleppo Province and this is reported in Project I. Also, research on socioeconomic factors was restricted to barley production in northern Syria, and this is reported in Project I as well.

Component 1: Collection, Collation, Distribution, and Use of Agroclimatic Data

Data Collection for the 1982/83 Cropping Season

The standard range of daily-recorded meteorological variables were monitored for a fourth season at the five principal FSP research sites -Jindiress, Kafr Antoon, Tel Hadya, Breda, and Khanasser. On 1 Sept 1983, recording at Kafr Antoon was terminated because this site is now being redeveloped by the Syrian Ministry of Agriculture and Agrarian Reform. Meteorological data records from these sites are now available to all ICARDA users at the Computer Center by using the «METEOR» data retrieval program.

A summary of these data is presented in the chapter «Meteorological Data» in this report.

Long-Term Data Collection and Collation

In the 1982/83 season data collection from long-term records was guided by two major developments. First, the official agreement between ICARDA and ACSAD (Arab Centre for Studies of the Arid and Dry Lands) enabled both organizations to formally collaborate in compiling a climatic data bank for North Africa and West Asia. ACSAD scientists have agreed to concentrate on collecting monthly data from a wide range of countries, whereas ICARDA will concentrate on collecting daily data for specific long-run stations where ICARDA outreach activities are in progress or are proposed. Therefore, ICARDA collection efforts have been directed towards data from Syria, North Africa, northern Egypt, and Baluchistan (northwest Pakistan).

Syria. Recent data acquisitions from Syria are summarized in Table 35. Long-term daily maximum and minimum temperature and rainfall records are being used in the technical development of zoning schemes in collaboration with the University of Reading, England, and the University of New England, Australia. In addition, new monthly rainfall data for Aleppo 1931-55 has been obtained (Fig. 15).

Table 35. Daily meteorological data holding for Syria.

Site	Precip	Max. and Min. Temp
Aleppo	1946-79	1960-82
Jindiress	1960-83	1965-83
Azaz	1957-80	1959-82
Saraqeb	1960-80	
Breda	1957-83	
Khanasser	1957-80	
Hama	1962-83	1960-82
Tal Abiad	1960-83	1957-82
Qamishly	1962-83	1960-82
Sweida	1960-83	1960-74
Izraa	1959-83	1960-83
Nabek	1974-83	
Salamieh	1974-83	

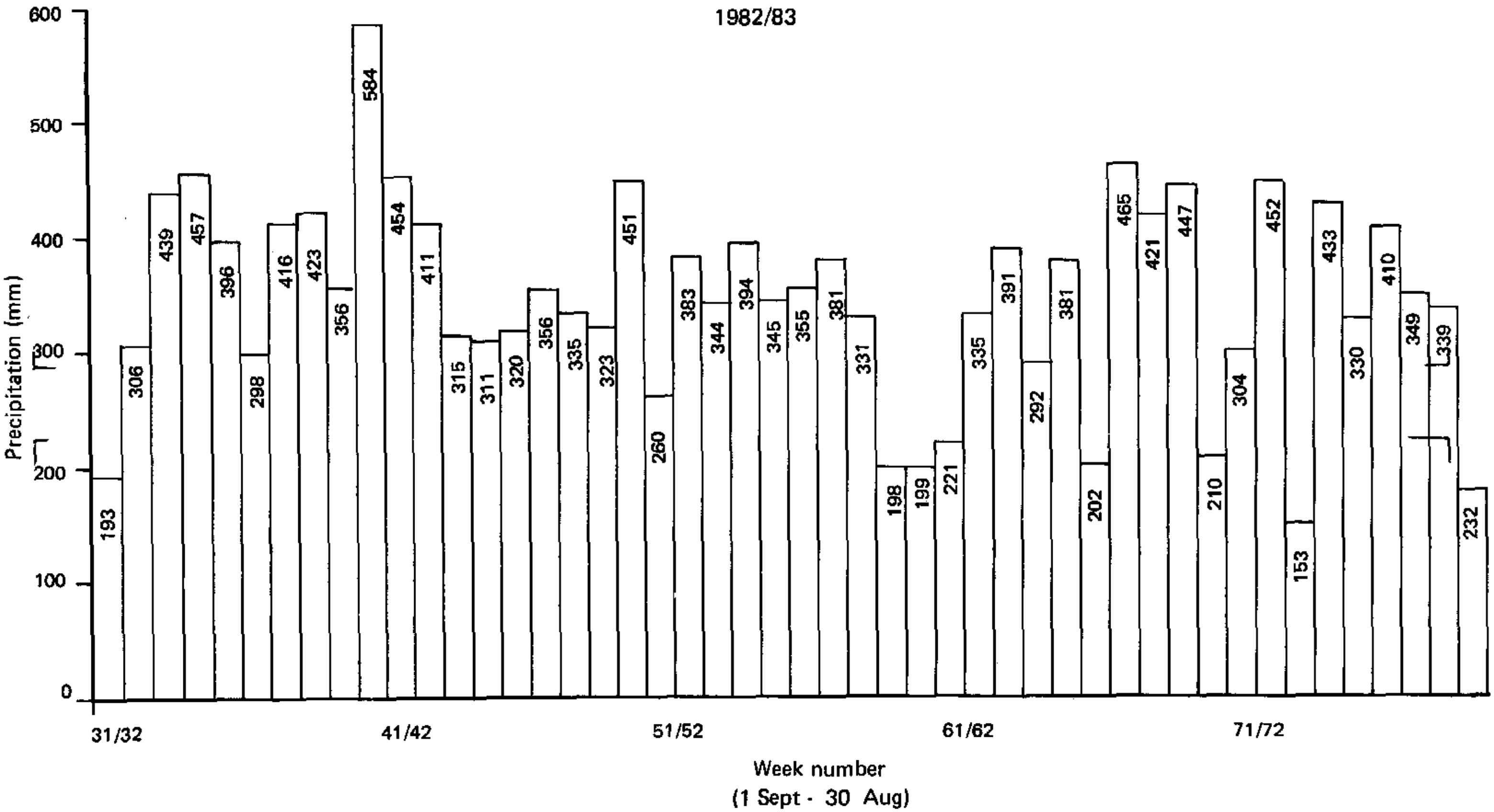


Fig. 15. Seasonal precipitation, Aleppo, Syria.

North Africa. At the start of the 1982/83 season there were no data holdings for North Africa. This large gap in the data bank is now being filled. Monthly air temperature and rainfall data of variable record length have been obtained for principal meteorological stations in the following countries: Algeria, Canary Islands, Egypt, Libya, Morocco, and Tunisia. A considerable volume of daily data has also been acquired. This has largely been of an historical nature and it is planned to obtain more recent data in the 1983/84 season. Present holdings from Algeria, Libya, Mauretania, Morocco, and Tunisia are summarized in Table 36.

Northwestern Egypt. Data, principally monthly maximum and minimum air temperatures and precipitation, were obtained for the complete records of four stations. These were Mersa Matrouh (1907-1979), Sollum (1910-1979), Sidi Barrani (1910-1939 and 1951-1969), and Ras el Dabba (1910-1940). Daily records were obtained for Sollum (1932-1940). The data records indicate the acute variability in seasonal rainfall in the coastal region of northwestern Egypt (Fig. 16). Further daily data, particularly rainfall and possibly rainfall intensity, will be collected in support of ICARDA projects proposed for this area.

Northwestern Pakistan (Baluchistan/Quetta). We have identified 84 precipitation recording stations with long-run data in Baluchistan, 19 of which are in the environs of Quetta which is a proposed ICARDA project site. Station selection will be an important aspect of data collection efforts from Pakistan in the 1983/84 season. We have initially obtained monthly precipitation and temperature data for Quetta Brewery (1878-1970), Fort Sandeman, Kalat (1882-1970), and Dalbandin. Variability in seasonal precipitation at Quetta Brewery can be seen in Fig. 17. Large season-to-season variability is also a feature at this site.

Initial Zoning Development Steps

Cooperation with the University of Reading, England. The daily rainfall data collected for six stations in northern Syria during the 1981/82 season was further analyzed in 1982/83. In cooperation with the University of Reading a rainfall record was simulated for Tel Hadya from two adjacent meteorological recording stations: Aleppo and Saraqeb. This study has been published (Dennett, M.D., Rodgers, J.A., and Keatinge, J.D.H. 1983. Simulation of a rainfall record for the site of a new agricultural

Table 36. Daily meteorological data holdings for North Africa.

Country	No. of stations	Years of record	Variables
Tunisia	92	1949-54, 1964-1982	Daily precip. (+ monthly temp.)
Algeria	31	1951-61 (1957-71) Monthly	Daily precip., max. and min. temp.
Morocco	20	1951-63	Daily precip., max. and min. temp.
Mauretania	25	1900/1920 - 1965	Daily precip.
Libya	All stations in Cyrenacia	1920-1940	Daily precip. (+ monthly temp.)

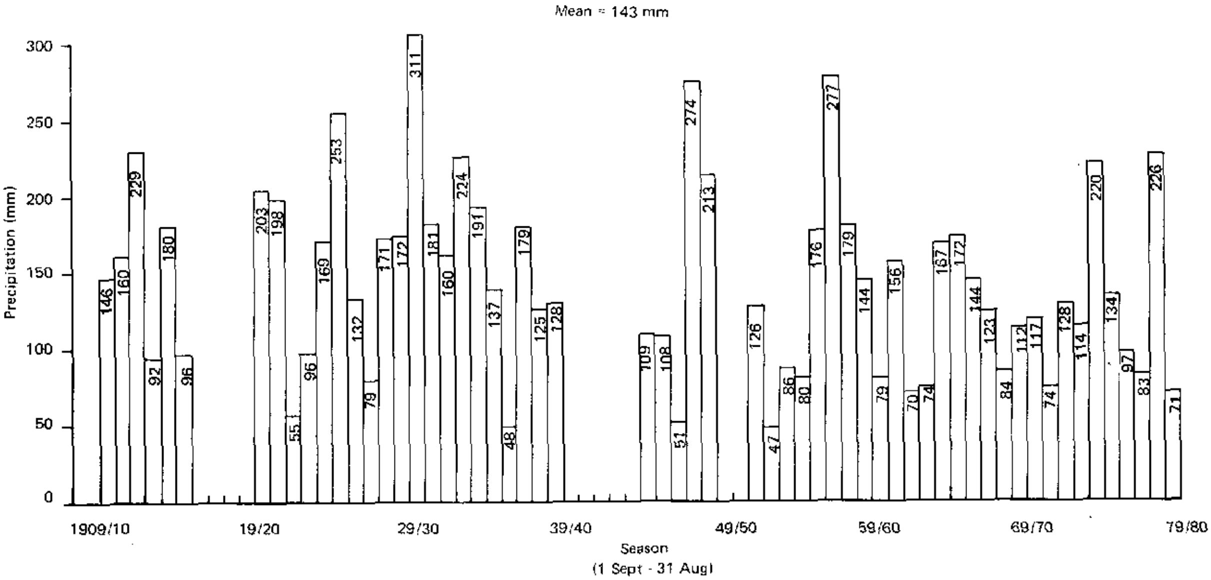


Fig. 16. Seasonal precipitation at Mersa Matrouh, Egypt, 1909-1979.

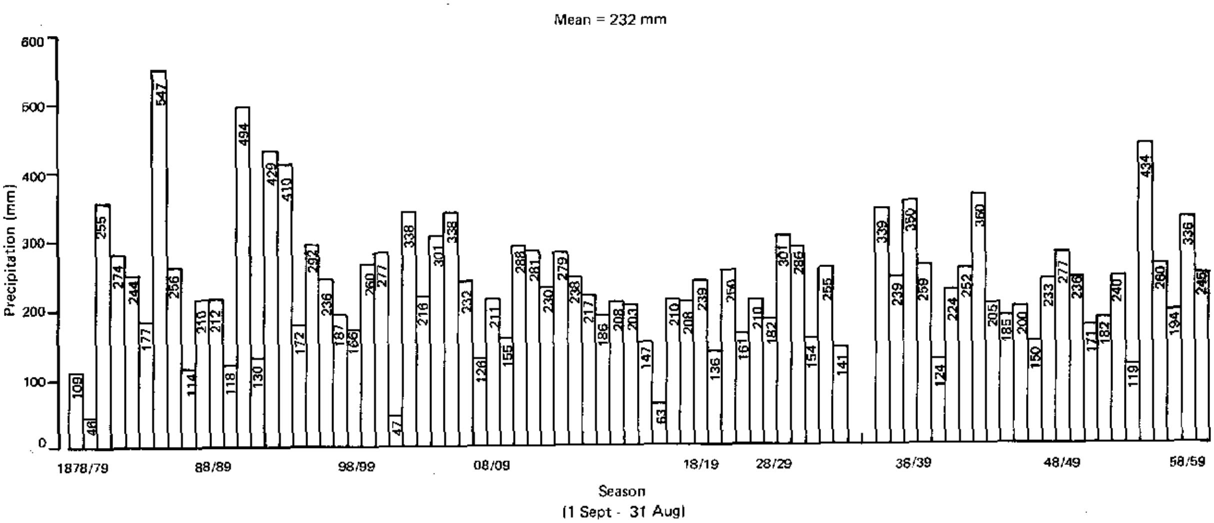
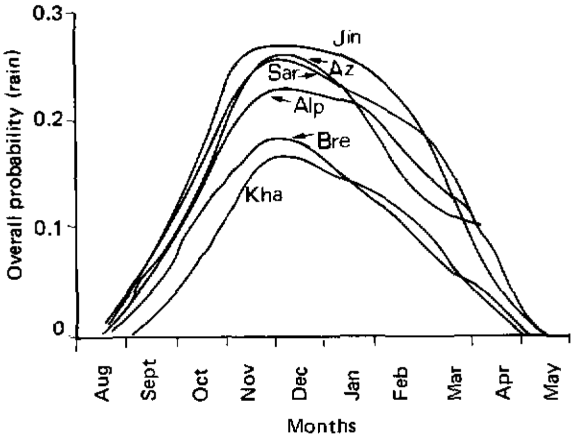


Fig. 17. Seasonal precipitation at Quetta Brewery, Pakistan, 1878-1960.

development: an example from northern Syria. Agricultural Meteorology 29: 247-258).

Rainfall models for six sites, Jindiress, Azaz, Saraqeb, Aleppo, Breda, and Khanasser were produced from approximately 20 years' daily rainfall data. A comparison of the rainfall regimes of these sites shows marked differences which can be summarized as follows:

1. When the overall probability of rain on any one day in the season is considered, the site with *the highest mean seasonal* rainfall (Jindiress) has the highest probability of occurrence of a rain event and the site with the lowest seasonal mean has the lowest probability of the occurrence of rain (Khanasser). Other sites follow the same trend. The probability of rain in January at Jindiress is twice that at Khanasser (Fig. 18).



Jin = Jindiress, Az = Azaz, Sar = Saraqeb, Alp = Aleppo, Bre = Breda, Kha = Khanasser.

Fig. 18. Overall probability of rain at six sites in northern Syria.

2. The cumulative probability distribution of total rainfall and number of rain days (Figs. 19 and 20) shows a clear segregation between sites, with Khanasser and Breda (the two driest sites) being particularly *deficient in rain events.*

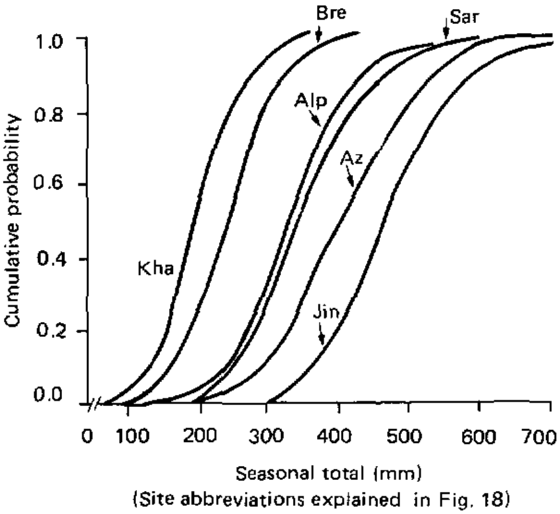


Fig. 19. Cumulative probability distribution of seasonal rainfall totals at six sites in northern Syria.

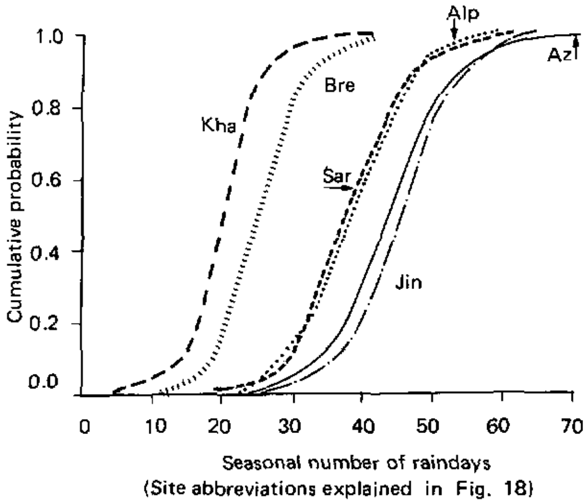


Fig. 20. Cumulative probability distribution of the seasonal number of rain-days at six sites in nothern Syria.

3. The gamma distribution of the rainfall models is a measure of the size of a rain event. These show some variation and indicate that the mean size of an event is largest at Jindiress (10.1 mm) and smallest at Khanasser (7.9 mm) with other stations falling approximately in the order expected from their seasonal totals.

4. The probability of receiving 20 mm of rain over a 3-day period, which is a fair definition of an event sufficiently large to allow germination at the beginning of the season, varies considerably between the sites (Fig. 21). This figure shows that the probability of crops receiving a germinating rain event at the two driest sites is only half as big as the probability of this event occurring at the wetter sites in the period mid-October to early December.

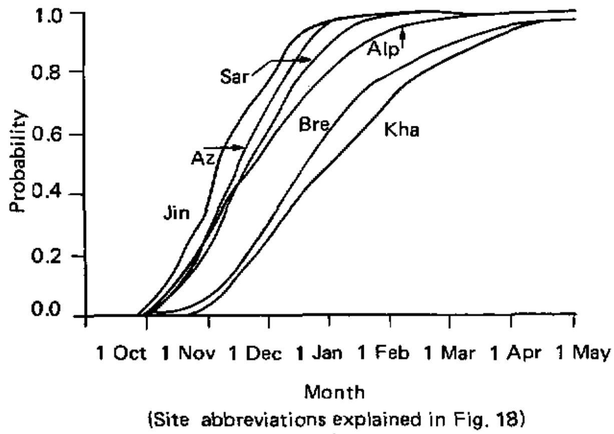


Fig. 21. Probability of receiving germinating rains (20 mm in 3 days) at six sites in northern Syria.

5. The probability of dry spells, for example of 10 days length, following a rain event is again much larger at Khanasser than at the other sites (Fig. 22). This length of dry conditions may be of critical importance at sensitive crop growth stages such as germination. The inverse of this type of example also has considerable agronomic significance as it can be seen in Fig. 23 that the probability of receiving four or more rain days/10-day period at Jindiress is three times as large as the risk of such an event at Khanasser and Breda. This suggests that the risk of crop foliar diseases might follow a similar trend.

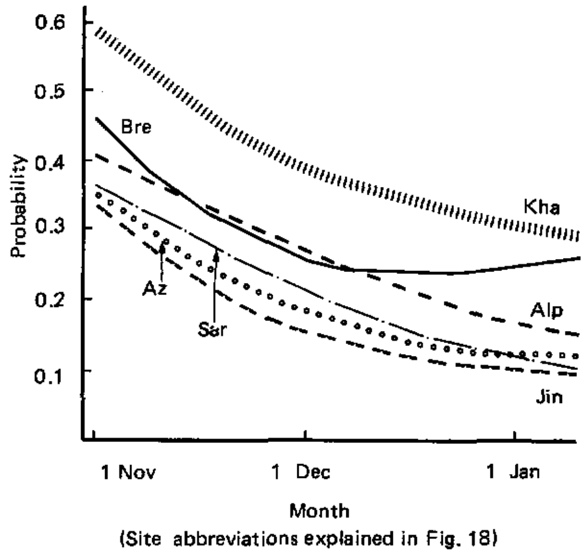


Fig. 22. Probability of less than 5 mm of rain in a 10-day period following a rainy day at six sites in northern Syria.

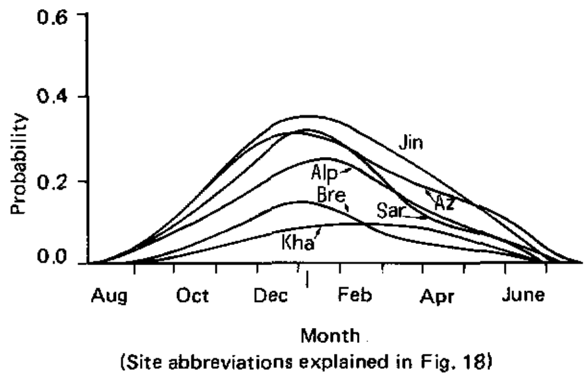


Fig. 23. Probability of having more than 4 rain-days in a 10-day period at six sites in northern Syria.

It is clear from the previous discussion that the rainfall models produced enable an extremely flexible approach to be adopted to the analysis of a rainfall regime. Comparison with other sites both within and outside the region is now feasible, and a wide range of questions can be considered. For example, Kairouan in Tunisia has a mean annual rainfall of approx-

imately 298 mm. Is its rainfall regime more like Aleppo or Breda? Does it have the same start time and duration of rainy season? Are its rain events more numerous and/or regular than sites in northern Syria? Is its probability of within-season drought higher? Are rain events in general heavier or lighter? Is there the same risk of rain days/10-day period in the wet season? Are foliar diseases going to be more or less of a problem?

If this technique proves to be functional, the model constants could be used as discriminatory building blocks for more precise environmental zoning.

Future developments of this technique in the 1983/84 season will include the first application of this type of Markov chain modelling to maximum and minimum air temperature data. By combining these three variables for each site, it will allow consideration of questions such as a comparison of seasonally effective precipitation, risk and intensity of frosts, the probability of hot, dry spells at the beginning and end of the season, etc. If this technique can be successfully transferred from rainfall to temperature, it will at least double the effectiveness of our scheme for environmental zoning.

Cooperation with the University of New England (UNE), Australia. The ICARDA/UNE wheat growth model is now complete and will be transferred to ICARDA in January 1984. Initial results from the model, which predicts crop maturity date and potential productivity from air temperature, solar radiation, and rainfall data are promising (Fig. 24a,b). Comparisons of predictions for two locations in West Asia (Table 37) include the capability of the model to evaluate both the long-term yield potential of differing genotypes, and the stability of cultivar production.

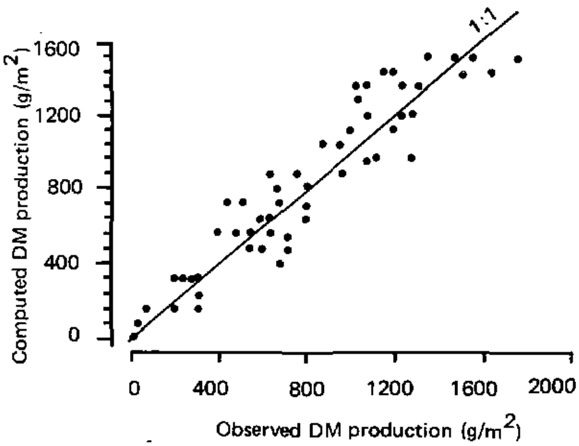


Fig. 24. (a) Observed vs computed dry-matter production (g/m^2) for 40 crop-years at nine locations in Australia, Mexico, South Africa, Syria, and USA.

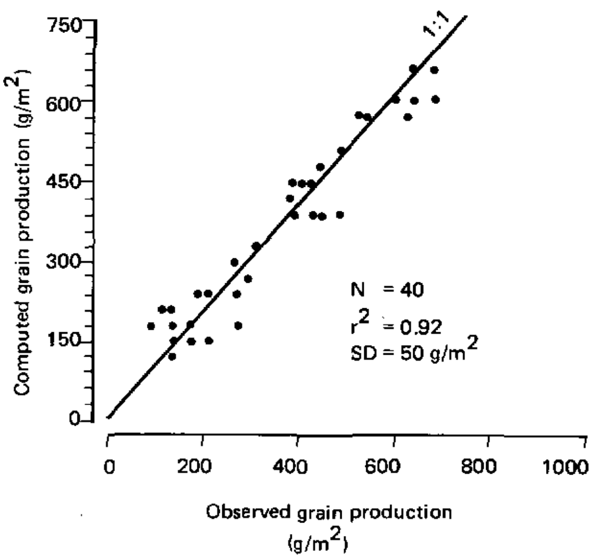


Fig. 24. (b) Grain production for 40 crop-years at nine locations in Australia, Mexico, South Africa, Syria, and USA.

Future Developments in the 1983/84 Season

1. Data collection will continue at Jindiress, Tel Hadya, Breda, and Khanasser. The possibility of establishing a new semipermanent research site to replace Kafr Antoon will be considered.

Table 37. Computed grain yields (kg/ha) for three wheat cultivars over 17 years at Aleppo and Gilat.

Cultivar	Maturity group	Aleppo		Gilat	
		Long-term yield potential (kg/ha)	Stability[1] Index	Long-term yield potential (kg/ha)	Stability Index
Sonalika	Early	3060	0.53	1930	0.23
Maxipak	Medium	3280	0.29	2130	0.23
Novi Sad	Late	3130	0.18	2180	0.53

1. Stability Index = No. of times highest yield/No. of years.

2. Data collection of long-term records will continue for daily data in Syria, North Africa, northwestern Egypt, and northwestern Pakistan. The intensity of operation will be dependent on available funds and the emphasis will be on obtaining daily temperature and rainfall data.

3. Further development of environmental zoning techniques based on rainfall and temperature records will continue. The analysis program «EVENT» is to be transferred from the University of Reading to ICARDA.

4. The UNE/ICARDA growth model will be tested and evaluated as a tool for large-scale environmental zonation. Its further development can only be possible if additional funding is obtained, as the current funding expires at the end of 1983.

5. Research on agricultural policy will aim to estimate and analyze protection rates and develop supply responses for major ICARDA crops. In order to improve the management of data required for this research we have purchased Production, Trade, Fertilizer and Price Yearbook tapes from FAO. We will continue to use data from other sources. We plan to visit several countries in the region and establish contact with authorities and scientists involved in agricultural policy. It is hoped that this will gradually build into a network of scientists interested in agricultural policy.

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1. Can be obtained on request from ICARDA's Farming Systems Program.

CEREAL CROPS IMPROVEMENT

Contents

Cover: Farmers evaluating newly developed wheat and barley lines at ICARDA's research farm at Tel Hadya.

Cereal Crops Improvement

Introduction

Wheat and barley cover approximately 70% of the total area annually devoted to food crops in West Asia and North Africa. ICARDA's target areas for cereal improvement are those with low to moderate (250-500 mm) rainfall, where the bulk of the barley and wheat is grown. In these areas winter rainfall is both limited and erratic and crop yields are limited by biological, environmental, management, and socioeconomic factors. Mountainous areas with elevations of over 1000 meters are found from Pakistan to Turkey and in Algeria and Morocco. Except for the Turkish plateau, farming in these areas has been relatively untouched by agricultural research. These regions require winter or facultative-type wheats with tolerance to severe environmental stresses.

The Cereal Program works both on improving varieties and developing better farming practices. Factors, such as diseases, insects, frost, drought, and nutrition are being tackled jointly by pathologists, entomologists, physiologists, agronomists, and breeders. The activities of the Cereal Program are conducted in close cooperation with national programs and research results are evaluated at the national level.

Wheat breeder (extreme right) explains the objectives of the crossing program to ICARDA's Board of Trustees members, and Dr. Nour (fourth from left) and Dr. Greening, CGIAR (fifth from left).

When comparisons are made between the local varieties currently grown in specific countries and materials provided through ICARDA's international nursery system, selections from the program have usually resulted in increases in yield over the local variety. This demonstrates that by adopting improved genotypes and cultural practices, substantial increases in production are possible in the 250-500 mm rainfall areas. To achieve such yield increases, improved cultural and pest management practices must also be employed. This includes the necessary inputs of credit, fertilizers, pesticides, farming systems, seed availability, marketing, and price incentives for the farmer. To accomplish this requires the development and dissemination of appropriate technology and a cadre of trained scientists and extension workers and, more importantly, the determination of the national governments to improve food production.

Crop improvement projects are multidisciplinary in approach, including research activities in breeding, pathology, entomology, agronomy, physiology, and grain quality. The strategies used in the disciplines are described below.

Breeding

The crop breeders realize that successful varieties must possess tolerance to environmental stresses and resistance to various diseases and insects. Emphasis is placed on thorough study of parental materials for large-yielding ability combined with tolerance to important stresses. Early-generation populations are grown in different stress environments to allow the identification and selection of superior gene combinations. Carefully selected multilocation testing sites for advanced generations are used.

The strategy of the breeding effort for improving performance in unfavorable environments is summarized below.

1. Identify stress-resistant parental lines by screening at key stress sites throughout the region:

Drought—Syria: Khanasser, Breda, Hegla, Tel Hadya (late planting); Jordan: Ramtha; Tunisia: Hindi Zitoun; Cyprus: Athalassa; Morocco: J. Shaim, Sidi Aidi, K. Zemamra.

Heat—Sudan: New Halfa and Wad Medani.

Cold—Syria: Sarghaya, Tel Hadya (early planting); Lebanon: Terbol; Morocco: Annaceur; Pakistan: Khan Mehterzai,Pishin.

Salt—Syria: Hegla.

Diseases—20 Key Location Disease Nurseries (KLDNs).

Insects—Syria: Tel Hadya, Suran; Morocco: Kodia, Sidi Kasem; Egypt: Aphid sites.

2. Cross stress-, disease-, and insect-resistant parents with high-yielding, agronomically desirable lines, and handle the segregating generations as follows:

a. F_1: summer nursery seed increases.
b. F_2: 3-4 locations (from high to low stress levels). Best populations are sent to 50-80 locations.
c. F_3: 3-4 locations (from high to low stress levels).
d. F_4: 5-6 locations (from high to low stress levels).
e. F_5-n: (First stage of bulking: non-bulked lines will be followed in later segregating generations).
   Initial Yield Trial (unreplicated, augmented design) at 5 locations (from high to low stress levels) and Initial Disease Nursery, at 5 locations.
f. Preliminary Yield Trial (3 reps), at 3 locations plus unreplicated testing at 5 locations and 20 KLDNs.
g. Advanced Yield Trials (3 reps), at 6 locations plus unreplicated testing at 6 locations and 20 KLDNs.
h. International Observation Nursery-unreplicated, 50-80 locations.
i. International Yield Trials - 4 replications, 50-80 locations.

Our bread wheat breeding work is a joint endeavor with CIMMYT (Centro Internacional de Mejoramiento de Maiz y Trigo), based in Mexico. CIMMYT has posted a bread wheat breeder and shares the operating expenses. A bread wheat line was released in Syria in 1983 and named «Sham 2».

The triticale project has identified lines with yields better than, or equal to that of the wheats and near-acceptable grain quality. Triticale lines have exhibited disease resistance superior to that of bread or durum wheats.

Durum wheat lines with good grain yield as well as kernel quality have been identified. Syria has released a durum wheat line, named «Sham 1». Several new lines, e.g., Sebou and Korifla are being tested for possible release.

Barley lines with good yield potential have been identified. More emphasis will be placed on developing barley lines for the very low productivity areas with 250-300 mm annual rainfall. The barley project will expand its area of activities beyond the Middle East and North Africa, towards its global mandate.

The high-elevation cereals project has increased its links with national programs in mountainous areas of the region. Wheat and barley germplasm developed for high-elevation areas have been selected at several sites in the Baluchistan province of Pakistan and at Annaceur, a site in the Atlas mountains in Morocco.

Pathology

Cereal pathology work focused on enhancing disease resistance in the germplasm through resistance breeding. The effort was successful in developing good disease pressure at Tel Hadya for several diseases and in obtaining good disease screenings at several key locations within and outside Syria where specific disease pressure was high. The laboratory facilities have been improved resulting in increased effectiveness of inoculation for yellow rust, septoria, bunt, and scald. However, so far little work has been done at the base program on root rots and viral diseases.

Agronomy

The gap between cereal crop yields in farmers' fields and the potential yields in West Asia and North Africa is large. The yield gap is generally smaller in the higher rainfall and irrigated areas. Our results indicate that good yield improvements can be made in the rainfall zones with less than 450 mm precipitation, where a large proportion of durum wheat and barley are grown. Agronomic experiments at several locations in Syria, Jordan, and Pakistan indicated increased grain and straw yields under improved practices.

Grain Quality

The cereal grain quality laboratory made good progress in determining the grain quality parameters required for local consumer uses in the region. It provided valuable service to all the breeding projects. Several technicians from national programs were trained.

Entomology

Identification of lines with resistance to wheat stem sawfly, suni bug, and aphids will remain the main priority of the cereal entomology work. However, effort will be increased to assess economic losses due to each of these pests. The kernel damage by suni bug reduced grain yield, grain quality, and yield of the subsequent crop if the damaged grain was planted as seed. Outside funding is being sought to initiate work on aphid tolerance in Egypt and Sudan.

The Cereal Improvement Program is organized into eight projects, which bring the several disciplines together to work in a problem-oriented approach towards each topic. The Projects are: I. Barley Improvement; II. Durum Wheat Improvement; III. Bread Wheat Improvement; IV. Triticale Improvement; V. High-Elevation Cereal Improvement; VI. International Cooperation; VII. International Nursery System; and VIII. Training.

Project I: Barley Improvement

Barley is the second most widely grown cereal crop in West Asia and North Africa. It is predominant in the drier areas (350 mm rainfall or less). Barley is more dependable than other cereal crops under low soil fertility and drought conditions and is grown in areas where environmental stresses prevail after heading and significantly reduce yields of later maturing crops. The ICARDA barley program is focusing special attention on developing suitable varieties and appropriate production technology for the lower rainfall areas.

An urgent task at the beginning of ICARDA's barley work was to assemble and evaluate a large barley germplasm pool and to widen the genetic base of the crop. Lines from crosses between introductions and adapted germplasm are now being characterized for their agronomic type, disease resistance, and yield potential and are being distributed to national programs to meet the urgent need for finished lines. The strategy is to quickly distribute early-generation segregating populations for selection in environments where they are to be grown. To meet this objective and to achieve large yields, we use the following strategy:

- Continue to work closely with national programs. Results from the international nurseries clearly show that ICARDA's germplasm was better exploited in countries where the cereal program staff have kept close contact.
- Select (mainly in the F_2 generation) and screen at several low-rainfall locations. The objective is to identify parental lines and cultivars for the agroclimatic conditions of barley-growing areas.
- Understand and exploit heritable genotypic differences in response to environmental stresses, in cooperation with ICARDA's agronomists and physiologists.
- Improve the disease resistance level of high-yielding, ICARDA-developed germplasm by selective crossing.
- Screen and advance successive generations using a full-season summer nursery site. Hopefully the site will be in Syria.
- Develop high straw yield cultivars for direct grazing for areas where straw and grazing values are superior to grain harvesting.
- Develop improved agronomic practices for barley-growing areas.

Component I: Breeding

Barley Varieties for Low Rainfall Areas

The main objective of this project is to develop disease-resistant barley genotypes with greater yield potential, yield stability, and adaptation to the lower rainfall areas in the region. Barley is the dominant cereal crop in these areas and, with sheep, constitutes the main farming activity. Information on breeding material tested in this project is presented in Table 1. The table shows an increase in the number of segregating populations in 1980/81 and 1981/82, due to the large number of crosses made earlier to create the germplasm pool. The number of segregating populations is now decreasing. Our emphasis on international nurseries continued, and in 1982/83 we began sending diverse sets of segregating populations to the different barley-growing areas. We decreased our screening activities after the two initial seasons (1978-80). The large collections tested in the earlier years have been replaced by fewer lines being examined more intensively for specific characters, mainly disease resistance.

The scheme of ICARDA's barley breeding and testing procedures is shown in Table 2. The procedure is a modified pedigree system in which selection is based on single plants in the F_2 generation, when the desirable characters from both parents are assembled; in later generations, selection of the best families is emphasized, followed by selection of the best plants within those families. Two generations are grown per year unless space in the summer nursery does not permit growing the later generations. Bulking and yield testing can begin as early as the F_5 generation. Information on disease resistance is collected as soon as lines are bulked for preliminary yield testing and thereafter in the following cycles in the Key Location Disease Nursery (KLDN) before promoting the germplasm to international nurseries. Prior to distribution to national programs, the most promising bulks and cultivars are tested in preliminary yield trials over 2 years and three environments in Syria: Khanasser, Breda, and Tel Hadya, with average annual rainfall values of 242, 275, and 325 mm, respectively. The most promising cultivars are promoted to advanced testing over seven environments. These, in addition to the three environments in Syria, are: Hindi Zitoun (230 mm) and El Kef (450 mm) in Tunisia; Terbol (650 mm) in Lebanon; and Athalassa in Cyprus (250 mm).

Table 1. Number of lines in nurseries, segregating populations, and yield trials in the barley breeding program from 1978/79 to 1983/84.

Type of material	Season					
	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84
Tel Hadya screening nurseries	13412	13496	3310	5361	2490	2325
International nurseries (including selected segregating populations)	448	349	374	473	767[a]	785
Segregating populations (Tel Hadya base program)	13316	14412	22976	20030	18165	15158
Yield trials[1]	1078	1117	1188	1386	987	1239

a. Different sets of segregating populations began to be sent to different environments.

1. Lines under initial yield testing are not represented in the numbers from 1978/79 to 1982/83.

Table 2. Scheme of ICARDA barley breeding and testing procedures.

Year	Season	Selection/testing	Sites	Selection/testing strategy
Year I	Spring	Make the crosses		
	Summer	Grow F_1 generation	Summer nursery site	
Year II	Spring	F_2 generation	*Full set at:* Breda and Tel Hadya in Syria; Hindi Zitoun in Tunisia; *15-20 subsets for:* low-rainfall sites high-altitude sites high-rainfall sites	Single-plant selection based on agronomic and disease characteristics.
	Summer	F_3 generation	Summer nursery site	Selection for photoperiod response and rust resistance.
Year III	Spring	F_4 generation	*Full set:* Tel Hadya in Syria; subset, Tunisia	Selection among the families, then plants within the best families.
	Summer	F_5 generation	Summer nursery site	Similar to F_3; bulking of best families for replicated testing.
Year IV	Spring	Preliminary testing of F_5 bulks not grown in the previous summer nursery and later-generation bulks	Tel Hadya and, whenever possible, Khanasser or Breda in Syria.	Only agronomically desirable, disease-resistant lines that outyielded the long-term check, the local check, and the improved check are promoted to advanced testing.
			Cyprus and Tunisia as an observation nursery	Preliminary testing in the disease nursery (4 sites in Syria.)
Year V	Spring	F_6 generation Continued preliminary testing	Tel Hadya, Syria	Continued bulking of the best families; promotion to international testing of lines and cultivars that outyielded the checks and show resistance to the major diseases in the region.
		Beginning of advanced testing	Tel Hadya, Breda, and Khanasser in Syria; Terbol, Lebanon; El Kef, H. Zitoun in Tunisia	All lines are also included in the Key Location Disease Nursery (KLDN) for disease testing at key locations in the region where natural epiphytotics occur.
Year VI	Spring	International testing in observation nurseries.	50-80 locations mainly in the region	The best lines in the region are promoted to international yield testing.
Year VII	Spring	International testing in yield trial	50-80 locations mainly in the region	Best lines tested in farmers' field variety and agronomic verification trials.

Table 3. Number of promising lines selected by national programs from ICARDA's barley international nurseries.

Country	Season						
	1977/78	*1978/79*	*1979/80*	*1980/81*	*1981/82*	*1982/83*	Total
Afghanistan		1	14	38	12		65
Algeria	4	47		43	9		103
Cyprus	20	37	68	12	23	31	191
Egypt	42	29	7		0	14	92
Iran	71	11		65	49		146
Iraq	16	11	37	50			114
Jordan[1]	70	66	120	35	124	13	428
Lebanon[1]	27	46	29	43	35	25	205
Morocco		39	3	38	5	19	104
Saudi Arabia		9	16	1			26
Syria[1]	61	132	29	69	65	21	377
Tunisia[1]	20		66	136	75	52	349

1. *Countries where* ICARDA *has maintained closest contact.*

From the barley germplasm distributed by ICARDA, a large number of promising lines were selected by national programs from 1978 to 1983 (Table 3). Better use was made of ICARDA germplasm in countries such as Tunisia where ICARDA was able to maintain closer cooperation. This indicates the need to improve contacts where they are at present inadequate.

The main achievement in Syria has been the confirmation of the promising lines ER/Apam and Badia for Zone B (250-350 mm rainfall). WI 2269 and Harmal, both two-rowed, short-season barleys, were promising in Zone C (rainfall 250 mm).[1]

In Tunisia, the lines Roho, WI 2198, and Rihane confirmed their good performance in the drier areas of the country and are candidates for possible release to farmers there. ER/Apam continues to show suitability for northern Tunisia; its multiplication will start during the 1983/84 season following its good performance in on-farm demonstration trials by the national seed distributing agency (Office du Blé).

The improvement in yields among the best performing entries in the advanced yield trials at Tel Hadya since the 1978/79 season can be seen in Table 4. It appears possible to improve yields in the region over the 1000 kg/ha average using the newer varieties and more appropriate production technologies. The Rihane sister lines, in particular, have maintained a consistently high yield over the past three crop seasons. Increased yield potential of most of the germplasm from which lines are selected and distributed to national programs is also evident when the results are considered over years and locations (Table 5). The local check mean yield has shown a 42% increase between 1978 and 1983. The mean of the best 10 lines, however, has increased 73% over the same period indicating that the increase can be attributed in part to genotypic advances. These yield increases are paralleled by those obtained by cooperating national programs. Over five con-

1. Detailed information is provided in the 1982/83 Farmers' Field Verification Trials Report, Cereals Improvement Program, ICARDA.

Table 4. Highest yielding entries in the advanced yield trials in three growing seasons at Tel Hadya, 1980-83.

Year	Cross/pedigree	Yield (kg/ha)	LSD (5%)	% of check[1]
1980/81	Mari/CM67 CMB 72-140-8Y-1B-3Y-1B-1Y-0B	5963	600	142
	Rihane[2]	5670	1006	135
	Harmal'S'[2]	5631	966	134
1981/82	Rihane'S' Sel, 2L-1AP-3AP-0AP	6533	700	155
	As46/Pro AP, Sel.	6366	1096	151
	Rihane'S' Sel, 12L-2AP-0AP	6294	618	149
1982/83	Cerise	7136	838	168
	Pro/Avt CMB 72-A-9-2L-1AP-0AP	6661	664	156
	Rihane'S'[2] Sel, 12L-2AP-0AP	6577	666	155

1. The long-term check Beecher had an average yield of 4206, 4220, and 4254 kg/ha for 1980/81, 1981/82, and 1982/83, respectively.
2. ICARDA-developed germplasm.

Table 5. Evolution in yield levels of advanced lines over 5 years (1978-83) and two locations (Tel Hadya in Syria, and Terbol in Lebanon).

	Mean yield (kg/ha)					% change between
	1978/79	1979/80	1980/81	1981/82	1982/83	1978 and 1983
Highest yielding line	4486	5234	5963	6533	7136	59
Mean of the best 5 lines	3959	4260	5452	6280	6673	69
Mean of the best 10 lines	3757	3960	5556	6075	6490	73
Local check mean yield	3650	3641	3765	5060	5207	42
Number of lines tested[1]	120	240	220	240	240	

1. Results are combined over all advanced yield trials grown at Tel Hadya station. Each trial tested 20 genotypes of barley.

secutive seasons, the average yield of the best five lines increased from 3400 to 4100 kg/ha in the Regional Barley Yield Trial; the yield of the top-ranking line increased from 3500 to 4300 kg/ha; while the long-term check maintained a relatively constant yield of about 3400 kg/ha (Table 6).

The Regional Barley Yield Trial (RBYT) generally consists of 20 barley lines and a national check from each location. Two triticale lines and a durum line are also included for comparison. Data for the 1981/82 RBYT were received from 34 locations. Entry No. 11, As46/Avt//Aths, had the highest mean yield over locations (4165 kg/ha), and ranked among the top 10 lines in 25 of 28 locations. ER/Apam ranked second and was among the 10 highest yielding lines at 25 locations as well, and had ranked first in the RBYT of 1980/81. The triticale entries ranked 13 and 16, the durum entry ranked 24. There was a large genetic

Table 6. Yield (kg/ha) of the most promising genotypes in ICARDA region tested in the Barley Yield Trial during five seasons (1977-1982).

	Seasons[1]				
	1977/78	1978/79	1979/80	1980/81	1981/82
Long-term check	3464	3175	3320	3695	3375
Best 5 lines	3458	3024	3775	4063	3907
Best line	3556	3150	4155	4345	4105
LSD (5%)	262[a]	144	152	195	186

1. Means are over 28, 24, 20, 23, and 18 locations, for the years 1977/78 to 1981/82; 24 genotypes were tested each year. Complete data for 1982/83 were not available at the time of writing the report.
a. LSD calculated on the basis of 21 locations only.

diversity for most of the agronomic characters studied. Moreover, each entry in the RBYT was resistant or moderately resistant to two or more diseases. Detailed discussion of the results obtained over 34 locations is available in the 1981/82 ICARDA Cereal International Nurseries Report.

The 1981/82 Barley Observation Nursery (BON) consisted of 150 entries, with Badia as check every 20th entry. Entry numbers 10, 30, 50, 70, 90, 110, 130, and 150 were triticale lines. Data were received from 25 locations. Eight lines were selected at nine or more locations in the region indicating more outstanding lines being generated for the future. The detailed summary of the agronomic and disease traits of those eight lines is presented in Table 9 of the 1981/82 ICARDA Cereal International Nurseries Report.

To supplement the information obtained at low-rainfall sites in Tunisia, Syria, and Cyprus and to select for drought resistance in advanced lines, a set of the advanced yield trials was sown 3 months late (around mid-February). The purpose of late planting is to expose the lines to heat and drought stress during kernel filling, and to assess their resistance to these stresses. Kernel weight was generally maintained, or even increased, with late sowing in cultivars that yielded the largest in late sowing (Table 7). Lines that produced smaller yields when planted late had smaller kernels. The production of large kernels with late sowing thus seems to indicate stress resistance. These results confirm those obtained in the 1981/82 season under similar management (ICARDA Annual Report 1982), when large-yielding lines under late-planting stress were those which increased their kernel weight.

Dual-Purpose Barleys (Grain and Grazing)

Barley is often grazed in the early stages of growth during the winter months in the North African and West Asian regions. Barley genotypes respond differently to this practice. It is important to assess the effect of grazing intensity on new barleys to identify the plant charcteristics associated with recovery from grazing, and to assess barley genotypes for their forage or dual-purpose (forage plus grain after grazing) potential.

During the 1982/83 season, 110 genotypes were evaluated. C 63, an improved barley

Table 7. Mean yield, protein percentage, and kernel weight of lines in the advanced barley yield trials planted in normal (1 Dec) and late (15 Feb) sowings.

Entry No.	Line, cross, or pedigree	Yield (kg/ha) Normal	Yield (kg/ha) Late	Protein (%) Normal	Protein (%) Late	1000-kernel wt. (g) Normal	1000-kernel wt. (g) Late
Lines yielding largest under late sowing							
803	Athos (A)	4983	4819	10.1	12.3	32.8	32.1
905	Roho/Delisa ICB 77-166-5AP-0AP	5561	4594	11.1	13.0	40.8	45.3
715	Arma (C)	4489	4533	9.4	12.1	32.9	36.5
822	Kervana/Masurka ICB 77-369-2AP-0AP	5175	4502	9.7	12.0	33.8	34.7
1005	WI 2349	5689	4277	10.2	12.9	44.4	45.1
Lines yielding largest under normal sowing							
1011	Cerise	7136	3683	12.2	11.7	33.5	32.3
4111	Rihane'S' Sel, 12L-2AP-0AP	6577	4169	11.0	10.6	43.0	38.4
408	Rihane	6497	4002	10.7	11.5	42.8	37.2
308	Bco. Mr/Mzq CMB 73A-33-3B-1Y-500B-0Y	6397	3827	10.0	11.6	39.8	35.8
317	WI 2197/Arabische ICB 77-42-4AP-0SH-0AP	6317	4119	10.8	11.3	45.4	39.1

Dual-purpose barleys are scored for regrowth vigor after simulated grazing (mowing). Border rows are left uncut.

selection, was used as check. Genotypes were grouped in yield trials. A randomized complete block design with five replications was used. There were three checks and 21 genotypes in each trial. Two replications were grazed and the other three left ungrazed. The parameters measured were dry-matter yield at grazing (grazing simulated by mowing at 5 cm above ground level in mid-February); tiller number/m^2 prior to heading; number of spikes/m^2; tiller mortality (tiller number minus head number); recovery from grazing; and mature-stage total dry-matter and grain yield.

Recovery from grazing was judged visually by height and groundcover before maturity using the following 1-5 scoring scale:

1 = more than 80% of the grain and dry-matter yield of the ungrazed treatments.
2 = 60-80% of the grain and dry-matter yield of the ungrazed checks.
3 = 40-60% of the grain and dry-matter yield of the ungrazed checks.
4 = 20-40% of the grain and dry-matter yield of the ungrazed checks.
5 = less than 20% of the ungrazed grain and dry-matter yield.

Genotypic differences in grain recovery and grazed dry-matter production were used to separate forage, grain, and dual-purpose barleys and to assess dual-purpose genotypes for their grain and forage potential (Fig. 1). Genotypes with larger grain yield but smaller

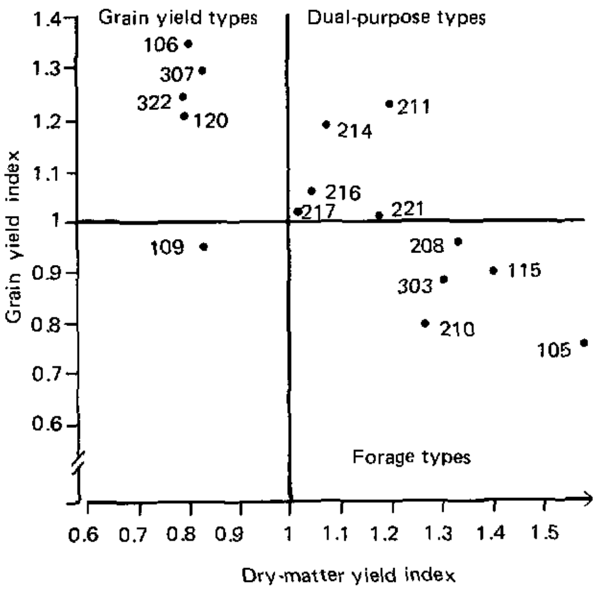


Fig. 1. Identified grain, dual-purpose, and forage-type barleys, 1981/82. In the three-digit numbers, the first digit indicates the trial number, and the second and third digits indicate the entry number.

dry-matter yield than the experiment means are classified as grain types; those with a larger grain-and-dry-matter yield than the mean are classified as dual-purpose types; those with a larger dry-matter yield but a lower grain yield than the mean are classified as forage types. The genotypes below the mean for both characters are discarded. There was a reduction in grain and dry-matter yields following cutting; this was much smaller for dual-purpose genotypes than for forage types (Table 8).

Collaborative Projects

Collaboration with National Programs

In Tunisia, a large collection of barley germplasm was screened in the 1982/83 season. A large number of promising cultivars were selected from ICARDA yield trials for the national yield trials, while from the International Barley Yield Trial, Matnan, Rihane, ER/Apam, and Kervana/Masul were selected. Rihane and its sister lines as well as ER/Apam continued to do well over three widely differing environments: Beja (650 mm rainfall, high soil fertility); El Kef (400 mm annual rainfall, medium soil fertility); and Hindi Zitoun in central Tunisia (230 mm annual rainfall, poor soil fertility).

Cooperation with the Moroccan national program has been strengthened. ICARDA established nurseries at several sites differing in rainfall and altitude. Such research, along with the development of short-season barley in a frost-free environment (Cyprus), has helped the barley program select appropriate material and send different sets of germplasm for low-and high-rainfall and high-altitude sites.

Collaboration with Centers in Developed Countries

Studies on rooting habit and photoperiod/temperature interactions of barley are being conducted in cooperation with the University of Reading with the support of a grant from the UK Overseas Development Administration (ODA). A grant from GTZ (German Association for Technical Cooperation) provides for varieties to be examined at Munich University for salinity tolerance. Screening, selection, and testing of Male-Sterile Facilitated Recurrent Selection Populations (MSFRSP) is being conducted in cooperation with Montana State University, USA.

Component 2: Pathology

In ICARDA region, barley is restricted to the lower-rainfall areas. These are not the highest

Table 8. Classification of barley genotypes into grain, forage, and dual-purpose types at Tel Hadya, 1983.

Entry No.	Line, cross, or pedigree	Grain yield after grazing (kg/ha)	Grain yield ungrazed (kg/ha)	Grain[1] index	Dry-matter[2] index	Tiller[3] No./m^2	Head[3] No./m^2
	Grain types:						
106	Comp. Cr.29	4458	4947	1.34	0.98	437	337
120	Seed source 72-Sel.	3983	4844	1.20	0.80	313	350
307	Gerbel (A)	4387	4627	1.29	0.84	610	460
322	Arma	4183	4277	1.23	0.80	577	437
	Dual-purpose types:						
211	Rihane'S'	5429	6083	1.22	1.21	503	373
214	Matnan	5241	5102	1.18	1.08	547	447
216	Harmal'S'	4670	4572	1.05	1.05	780	617
217	Assala'S'	4537	5408	1.02	1.02	486	420
	Forage types:						
105	Lignee 527 (Montpellier)	2470	3847	0.74	1.58	517	493
208	WI 2197	4241	5038	0.95	1.34	767	520
210	M69.69/Hja C4715//Tra/1038	3533	4688	0.79	1.28	640	483
303	CM67/3/Apro//Sv.02109/Mari	2958	5130	0.87	1.31	483	480

1. Grain index after grazing.
2. Dry-matter index at the time of grazing.
3. Taken in ungrazed plots.

risk areas for most diseases. Nevertheless, the following barley diseases are important in ICARDA region: powdery mildew (*Erysiphe graminis*), scald (*Rhynchosporium secalis*), yellow rust (*Puccinia stiiformis*), barley stripe disease (*Helminthosporium gramineum*), leaf rust (*Puccinia hordei*), and barley yellow dwarf virus (BYDV).

Emphasis was placed on screening for resistance to yellow rust, leaf rust, and scald.

Yellow Rust

During the 1982/83 season a heavy epiphytotic of yellow rust was created at Tel Hadya on the yield trials, nurseries, and germplasm plantings. Table 9 gives the number of lines which showed resistance (severity< 5%). The higher percentages in the advanced and elite trials indicate that selection was effective in the past years. Additionally, approximately 300 lines showing a moderate resistance (severity< 25%) were selected from all nurseries grown at Tel Hadya. These will be retested in the 1983/84 season at Tel Hadya and by CIMMYT in Ecuador and Portugal, where natural epiphytotics of yellow rust occur regularly. In addition, 3000 entries from the USDA barley world collection were grown by ICARDA's germplasm unit at Tel Hadya and 70 of them showed resistance to yellow rust.

Table 9. Number of entries in the different barley yield trials showing yellow rust resistance (severity < 5%) at Tel Hadya, 1982/83[a].

Trial	Number	% of entries tested
Preliminary trial	21	4
Advanced trial	16	6
Elite trial	6	14

a. Average severity at Tel Hadya was 77%.

Useful data on the performance of material in the Barley Observation Nursery 1982/83 (BON-83) exposed to a high level of yellow rust disease pressure were received from Santa Catalina in Ecuador (average severity 18%) and Quetta in Pakistan (average severity 18%). The lines performing well at those two locations and at Tel Hadya (average severity 77%) are listed in Table 10.

Table 10. Best-performing lines for yellow rust resistance at three locations with a high average disease severity (Barley Observation Nursery 1982/83).

Line name, cross, or pedigree	Severity and reaction[1] Tel Hadya Syria	Quetta Pakistan	S. Catalina Ecuador
BKF Magnelone/Iris Tc 73-18-0AP	0	0	20 MS
Cam/B1//Piroline ICB 78-0603-5AP-0AP	0	0	5 MS
BKF Magnelone 1604/3/Apro// SV.02109/Mari CMB 77A-1615-1AP-0SA-4AP-0AP	0	0	5 MS
CM67/U.Sask 1800//Pro/CM67/3/Cl13871 ICB 78-0063-11AP-0AP	0	0	40 S
Athos (B)	5 MS	0	0
Location mean	77%	18%	18%

1. MS = moderately susceptible; S = susceptible.

Scald

A moderate level of scald infection was present at Afrin, a high-rainfall location north of Aleppo, Syria. Around 20% of the tested lines were resistant. Some screening was possible at Tel Hadya, but was hampered in later stages by extensive yellow rust development. Until now data on scald resistance have been received from the BON planted in Santa Catalina, Ecuador, only. Lines showing resistance both in Syria and Ecuador are listed in Table 11.

Table 11. Entries showing resistance to scald both at Afrin in Syria and Santa Catalina in Ecuador (Barley Observation Nursery 1982/83).

Line name, cross, or pedigree
Cq/Comun//Apam/3/12410/Giza 134
TH.U.48
As54/Tra//Cer/Toll4/3/Avt/Ki//Bz/4/Vt/5/Pro/6/Minn 480/Gva
ICB 79-0562-1AP-0AP
M69.69/Hja C4715//WA 2196.68
CMSWB 77A-0045-1AP-1AP-0AP
Roho/Delisa
ICB 77-0165-2AP-2AP-0AP

Leaf Rust

Screening for leaf rust resistance at Tel Hadya is difficult because of the late appearance of this disease and the high incidence of yellow rust. From outside Syria, valuable information on leaf rust resistance of the lines in BON was received from France (average severity 18%), Italy (average severity 20%), Mexico (average severity 49%), and Ecuador (average severity 7%). The lines performing well at these locations are listed in Table 12.

Component 3: Agronomy

Several trials were conducted at Tel Hadya and Breda in Syria to determine the response of a number of new genotypes to seed rate, fertilizer, and grazing.

Response to Seed Rate

The aim of these experiments was to compare the response to seed rate for selected new

Table 12. Best-performing lines for leaf rust resistance at four locations with a high disease severity (Barley Observation Nursery 1982/83).

	Severity and reaction[1]			
Line name, cross, or pedigree	Montpellier *France*	Rome *Italy*	Obregon *Mexico*	S. Catalina *Ecuador*
As46/Avt//Aths	10 MR	0	5 MS	5 MS
ICB 76-0011-12L-2AP-0AP				
Cq/Comun//Apam/3/12410/Giza 134	15 S	0	15 MS	0
N-Acc 4000-301-80	5 MS	0	10 MS	5 MS
Matnan'S'	0	2	5 MS	5 MS
Sel. 1AP-2AP-4AP-0AP				
Roho/Masurka	5 MR	2	10 MS	0
ICB 77-0169-4AP-2AP-0AP				

1. Reaction type: MS = moderately susceptible; MR = moderately resistant; S = susceptible.

varieties of barley, possibly to be released in the region, with checks already grown in Syria. It is intended that these experiments should form the basis for future experiments in farmers' fields prior to the release of new lines. The data indicate that seed rates from 60 to 150 kg/ha gave similar yields, but reducing the rate below 60 kg/ha caused a loss in yield. There was no significant variety x seeding rate interaction.

Response to Grazing

Twenty lines of barley, some previously selected as forage types, were grazed by sheep and tested for dry-matter production at the tillering stage and for subsequent grain production. Based on 2 years data, six barley varieties performed well (Table 13). In good seasons the grain yield after grazing for these varieties occasionally exceeded the ungrazed grain yield. This may have been due to increased tillering, reduced plant height and lodging, and delayed maturity which helped to avoid late frost damage. However, these observations need further validation.

An experiment was also carried out to test the nitrogen fertilizer requirements of Arabi Abied and C 63 when grazed. Nitrogen was applied entirely at sowing or split equally between sowing and the time of grazing. In the cold conditions experienced early in the 1982/83 season, only the local variety Arabi Abied responded positively to applied nitrogen in dry-matter production at grazing time. For grain-yield production after grazing, both varieties responded positively to 50-150 kg N/ha. Where the crop was not grazed, the maximum response was to about 50 kg N/ha for Arabi Abied and 50-100 kg N/ha for C 63. These relative responses confirmed the increased requirement for nitrogen of grazed crops found in previous experiments.

The seed rates for maximum green-grazing and subsequent grain yields at Tel Hadya were also investigated in relation to sowing times (before and after the first rains). At the early sowing date (31 Oct) maximum dry matter was produced with 120 kg seed/ha for Arabi Abied and 240 kg/ha for C 63. With the later sowing date (1 Dec) dry-matter yields were less than half of those for the early date when grazed at the same chronological date. In general, maximum dry-matter yields required about 240 kg seed/ha for both varieties when seeded at the later date. For grain production the seed rate required for maximum yield was 60-120 kg/ha for both varieties and sowing dates. This implies that farmers should choose a seed rate depen-

Table 13. Dry-matter and grain yields of grazed barley varieties at Tel Hadya, 1981/82 and 1982/83.

	Dry-matter at tillering (kg/ha)		Grain yield after grazing (kg/ha)	
Variety	**1981/82**	**1982/83**	**1981/82**	**1982/83**
Antares	1357	899	3693	3303
2762/Beecher-6L	1453	874	3751	3187
Alger Ceres	1662	989	3406	3388
Saida	1442	827	3969	3528
Bco.Mr/Mzq	1453	865	3453	3255
Windsor	1470	928	3646	3319
C 63 (check)	1392	703	3871	3547
LSD (5%)	159	183	785	244

ding on the value of green grazing compared to the cost of extra seed. Grain yields after grazing were about the same at the later sowing as the ungrazed yields.

An additional experiment was conducted in 1982/83 at Breda (about 260 mm average rainfall) to test combinations of variety, seed rate, and nitrogen rate on production of green grazing and grain. In respect to green-stage dry matter, Arabi Abied and C 63 responded significantly ($P < 0.05$) to 60 kg N/ha (Table 14), but only at the higher seed rates tested (80 and 120 kg/ha). At all seeding rates both varieties responded to this N rate with an increase in final grain yield. Both varieties responded with a significant ($P < 0.05$) increase in green-stage dry matter to increasing seed rate, but only if nitrogen was supplied. Grain yield of Arabi Abied did not respond to increasing seed rates, but C 63 gave a significantly higher grain yield at higher seed rates, especially at higher N rates of up to 80 kg/ha. Thus, the initial indication is that 60 kg N/ha and 80-120 kg seed/ha should result in green-stage dry-matter yields of about 700-1700 kg/ha and grain yields of about 600-1000 kg/ha under low-rainfall conditions (Table 14).

Work by the Farming Systems Program in 1983 indicated that green-stage grazing in the very dry areas such as Breda may severely reduce subsequent grain yield, and may be economically unprofitable, because of the high value of grain. These observations point out the need for further study and evaluation of the role of green-stage barley grazing throughout the ICARDA region, especially in light of the economic and livestock-management considerations. The agronomic work has shown that crop management techniques can greatly affect the production of green-stage grazing and subsequent grain yield.

Response to Nitrogen

At Tel Hadya three barley varieties were tested using three nitrogen rates and three ratios of splitting (0/100, 50/50, and 100/0 at sowing and tillering, respectively). The responses of the varieties differed. The site was high in initial soil fertility, and nitrogen did not significantly affect the grain yields of the improved varieties Beecher and ER/Apam. In contrast, the grain yield of Arabi Abied decreased from 4300 to 3900 kg/ha (significant at $P < 0.05$) when more

Table 14. Dry-matter and grain yield (kg/ha) of barley after grazing as affected by variety, seed rate, and nitrogen at Breda, 1982/83.

Seed rate (kg/ha)	Arabi Abied N kg/ha 0	60	120	C 63 N kg/ha 0	60	120
	Dry-matter at grazing					
40	624	688	710	388	457	371
80	814	1434	998	481	653	762
120	952	1701	1183	526	837	820
LSD (5%) 144 kg/ha						
	Grain yield after grazing					
40	516	745	792	490	810	605
80	361	648	805	514	1012	925
120	371	554	712	572	999	1042
LSD (5%) 133 kg/ha						

than 60 kg N/ha was applied, due to extreme lodging. The yield reduction was greatest when all the N was applied at sowing.

At Breda, following a fallow, where only Beecher was tested, the maximum grain yield with nitrogen applied all at sowing or all at tillering was about the same. However, only 20 kg N/ha was required to attain maximum yield if it was applied at tillering, whereas 40-60 kg/ha was requied if it was all applied at sowing (Fig. 2).

These experiments demonstrate the complex interactions that may occur between land history, season, variety, nitrogen rate, and method of split nitrogen application. Further testing is needed to determine the effect of these factors as a basis for better recommendations of the economic amounts of nitrogen to apply at sowing and at tillering.

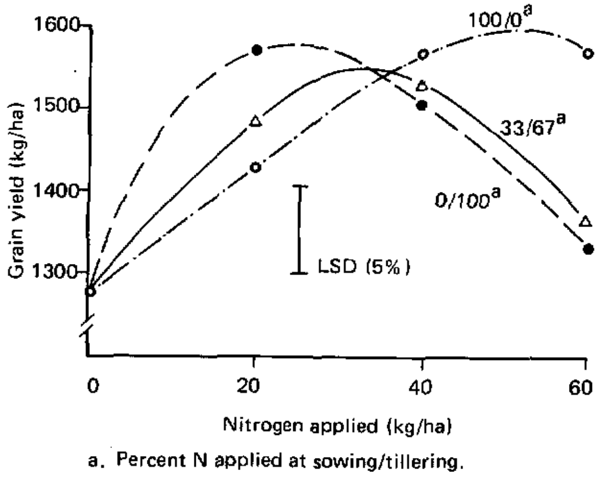


Fig. 2. Grain yield response of Beecher barley to rate and ratio (sowing/tillering) of nitrogen fertilizer at Breda, 1982/83.

Table 15. Tests carried out on barley lines, Sept 1982 - Sept 1983.

Test	No. of lines tested
Protein	1861
1000-kernel weight	1861
Hardness	155
Particle size distribution	456
Diastatic power	148
Total tests	4481

Component 4: Grain Quality

Routine Testing

The number of barley lines tested by the Cereal Quality Laboratory (CQL) during 1982/83 is presented in Table 15. Research was also carried out on the development of test procedures.

Diastatic power determination. Evaluation of advanced material for potential malting quality was continued. The high negative correlation between diastatic potential (DP) and plump kernel count was verified, and coefficients of correlation exceeding -0.9 were observed for some series. As a result of the high coefficient of correlation for DP between locations, it was concluded that heritability of DP is high, and hence barley cultivars of high (or low) DP selected at one location will likely retain this characteristic at other locations.

Cereal Quality Nursery (CQN)

The CQN has been grown for three seasons (1980-1983). It is a vehicle for investigating the intereactions between environmental factors and quality characteristics. Data from the 1983 season across nine locations indicate that several parameters appear to be closely associated with the genetic constitution of the cultivars, and may therefore be regarded as suitable for screening in an evaluation program (Table 16). In barley, kernel weight, plump kernel count, and diastatic potential are highly heritable.

Table 16. Influence of growing location on quality parameters in barley.

Parameter	Correlation coefficient[1]
Protein	0.05
Kernel weight	0.94
Plump kernels[2]	0.72
Small kernels[3]	0.63
Diastatic potential	0.85

1. Average coefficients of correlation between test data of 10 cultivars grown at nine locations.
2. Proportions of kernels retained by 2.8 + 2.5 mm screens.
3. Proportions of kernels passing through 2.2 mm screen.

Component 5: Entomology

As in previous seasons most emphasis in barley entomology in 1982/83 was on the search for sources of resistance to wheat stem sawfly and aphids. Surveys on the incidence of scale insects in Syria were conducted.

Resistance to Wheat Stem Sawfly

Screening for resistance to this insect was conducted at Suran under natural infestation and at Tel Hadya under artificial infestation. The results are summarized in Table 17. In both places the genotypes Deir Alla 106, TH. U. 48, Europa, 80/5116, TH. U. 32, and Choyal/M64-76-CMB 73-225-1Y-1B-3Y-1B-1Y-0B showed very low infestation levels (0-1.7%).

Resistance to Cereal Aphids

Out of 81 lines tested in 1982/83, none was found to be resistant to cereal aphids.

Incidence of Scale Insects in Barley

A survey of scale insects affecting barley in Syria was conducted. Two major species were recorded: *Porphyrophora tritici* Bod. in most barley- and wheat-growing areas and *P. polonica* (L.) restricted to the Raqqa region. *P. tritici* infestation varied widely from less than 25% of the plants infested with less than 0.5 nymphs/plant to more than 75% of the plants infested with more than 3.0 nymphs/plant. The highest infestations were found in the Hama-Homs region. *P. polonica* preferred barley and was a very serious pest of this crop. It is estimated that in the Raqqa area infestations of more than 50 nymphs/leaf affected between 30,000 and 40,000 ha of barley. The observations indicated that the lack of rotation in this part of Syria is the most important factor favoring the build-up of populations of this insect. A report suggesting some control measures was produced and submitted to the Syrian national program.

Table 17. Screening of barley lines for resistance to wheat stem sawfly at Suran and Tel Hadya, 1982/83.

Location	No. of lines tested and range of % infestation	% infestation in the check (Arabi Abied)	No.of promising lines and range of % infestation
Suran	81 (0 - 35.0)	15.7	6 (0 - 1.7)
Tel Hadya	81 (1.1 - 16.7)	10.0	6 (1.1 - 1.7)

Project II: Durum Wheat Improvement

The total durum wheat acreage is approximately 20 million hectares (Srivastava, J.P. 1983. Durum wheat-its world status and potential in the Middle East and North Africa. RACHIS 3: 1-8). Nearly 60% of the durum acreage is found in the developing countries, four-fifths being in North Africa and the Middle East (Fig. 3). In Algeria, Jordan, Morocco, Syria, and Tunisia two out of every three hectares planted to wheat are occupied by durum wheat (Fig. 4). But durum wheat yields in North Africa and the Middle East are low, and production is lagging considerably behind consumption requirements.

In North Africa and the Middle East, durum wheat is grown in the 300-500 mm rainfall zone. The area is characterized by unpredictable and scanty rainfall, and hot, dry summers. Most of this area is still sown to either indigenous local cultivars or selections from them. Successful varieties must possess resistance to environmental stresses and various diseases and insects.

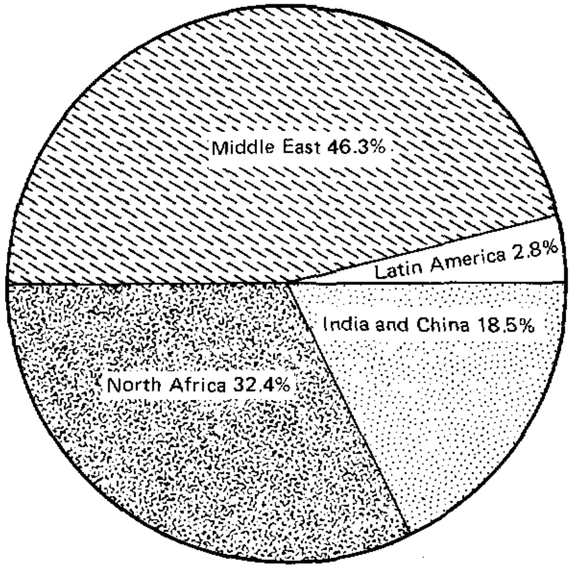


Fig. 3. Regions in the developing world where durum wheat is grown.

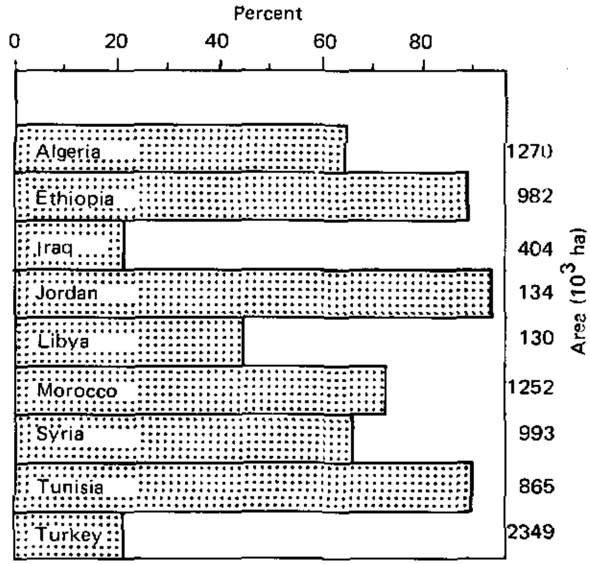


Fig. 4. Estimated area under durum wheat, and the proportion of all wheat which is durum, in the major durum-growing countries in North Africa and the Middle East.

Component 1: Breeding

To meet the needs of moderate- to low-rainfall areas, this project aims to develop germplasm and production technologies that would increase yield dependability in poor years while exploiting the environment during favorable years. The project aims to achieve these objectives by identifying parental material with tolerance to specific stresses prevalent in the region. Superior parental lines are then combined, and the early-generation populations are exposed to stress environments to identify and select superior gene combinations under these conditions. In early-generation screenings, fertility and other management factors are kept at a moderate level to allow adequate gene expression. In the F_4, F_5, and advanced generations, emphasis is placed on carefully selected sites for multilocation testing in the region. Lines selected from these key locations are then distributed to national programs through the internationl nursery system. Data and germplasm from national programs are an intergral and important component of the durum improvement strategy at ICARDA.

Durum Wheat Line Waha Released as «Sham 1» in Syria

After 4 years of testing and evaluation in research plots on farmers' fields throughout Syria under the collaborative research program between the Syrian Ministry of Agriculture and Agrarian Reform and ICARDA, the durum wheat line Waha has been approved by the Syrian variety release committee. The committee gave the line the name Sham 1. The line is a derivative of a cross made in CIMMYT, Mexico, and its full name and pedigree is

Sham 1, the new durum wheat line, has been approved for release by the Syrian Ministry of Agriculture.

Plc'S'/Ruff'S'//Gta'S'/Rtte, CM 17904-B-3M-1Y-1Y-0SK. It was identified by ICARDA as a promising line through yield tests in Lebanon and Egypt, and was extensively evaluated in the region through ICARDA's international nursery system. It was consistently among the highest yielding entries in the region. Waha is resistant to stripe rust (*Puccinia striiformis*) but it has shown some susceptibility to bunt (*Tilletia* spp.). However, this will be controlled by seed treatment. A summary of the yield performance of Sham 1 in farmers' fields is presented in Table 18.

Durum Wheat in Farmers' Field Verification Trials in Syria

In collaboration with the Directorate of the Agricultural Research Centre of the Syrian Arab Republic, a number of durum lines are tested under farmers' field conditions annually. The testing sites cover each of the major agricultural zones in which durum is grown (irrigated; Zone A, over 350 mm rainfall; Zone B, 250-350 mm). The most interesting aspect of the results for 1982/83 was the excellent performance of two newly entered genotypes, Sebou and Korifla. Sebou outyielded the other tested lines at almost all sites under irrigation and in Zone A. Korifla, which was only tested in Zone B, outyielded the other entries there, immediately followed by Sebou. Both entries are being tested again in the 1983/84 trial, to which three more newly developed lines, Belikh, Qattina, and Khabur have been added.

Performance of Durum Wheat Lines in the Region

Promising lines from the breeding programs are distributed in international nurseries to cooperators in national programs, primarily in the region, to provide them with diverse germplasm for their evaluation and use. The national programs provide the information to ICARDA, where the data are summarized. The combined results from all locations are reported back to the cooperators.

Regional yield trials. Yield data for the Regional Durum Yield Trial 1981/82 (RDYT) and the Regional Rainfed Durum Yield Trial 1981/82 (RDYT-Rf) were received from 23 and 17 loca-

Table 18. Yield performance (kg/ha) of Sham 1 compared to Gezira 17 and Haurani in field verification trials under irrigated conditions, Zone A (>350 mm), and Zone B (250-350 mm) in Syria, 1979-83.

Variety	1979/80	1980/81	1981/82	1982/83	Average
			Irrigated		
Sham 1	4080	5904	4116	5296	4849
Gezira 17	3383	5415	3546	4423	4192
LSD (5%)	461	149	191	958	
			Zone A		
Sham 1	3384	3023	3192	2824	3106
Gezira 17	3217	3066	3181	2819	3071
LSD (5%)	332	552	480	275	
			Zone B		
Sham 1	2731	2573	2196	2066	2392
Haurani	2260	1992	2032	1852	2034
LSD (5%)	400	330	691	253	229[a]

a. Based on pooled S^2.

tions, respectively. For both trials the yield performance of the best of the 24 entries are summarized in Tables 19 and 20. In RDYT-Rf the triticale line Drira Outcross was the highest yielding entry. Several new durum entries performed well but their yield was not significantly higher than the improved durum line Sahl in RDYT-Rf. However, in the RDYT, high rainfall, two durum wheat lines significantly outyielded the national checks in 16 of 23 locations; these lines were also significantly higher yielding than the national check in the overall combined analysis.

Observation nurseries. The observation nurseries provide a vehicle for an initial screening of promising advanced lines at the national program testing sites, by national program staff. Data from the Durum Observation Nursery-Irrigated (DON-IRR) and Durum Observation Nursery-Rainfed (DON-Rf) for the 1981/82 season are presented in Tables 21 and 22. The 1982/83 data are currently being collected and processed.

In both nurseries, several of our lines were selected more frequently than the regional checks. Detailed tests from a few of the sites indicate that at least some of these lines have equal or superior grain-quality characteristics. Disease infestations were relatively low, but further testing is needed to verify resistance in these lines.

Table 19. Performance of the largest yielding entries and the improved check Sahl in the Regional Durum Yield Trial Rainfed 1981/82 (Data from 17 locations).

Entry	Average yield (kg/ha)	Rank	F[1]	N[2]
Drira Outcross (triticale)	4179	1	14	14
Sahl (regional check)	3579	11	8	10
National check	3663	7	8	
Nursery mean yield	3562			
LSD (5%)	192			
CV (%)	17			

1. Number of locations where the line was among the 10 highest yielding entries.
2. Number of locations where the line was superior to the national check.

Table 20. Performance of the largest yielding durum wheat entries and the improved check Waha in the Regional Durum Yield Trial 1981/82 (Data from 23 locations).

Entry	Average yield (kg/ha)	Rank	F[1]	N[2]
Waha (regional check)	4772	1	17	14
Jo/Rabi'S'	4697	2	14	16
Mal'S'	4627	3	16	16
National check	4356	9	11	
Nursery mean yield	4377			
LSD (5%)	200			
CV (%)	16			

1. Number of locations where the line was among the 10 highest yielding entries.
2. Number of locations where the line was superior to the national check.

Table 21. Agronomic and disease data of the most frequently selected lines in the Durum Observation Nursery for irrigated sites (DON-IRR), 1981/82.

Entry No.	Line	FR	DH	DM	Ht	Protein (%)	Vitreous (%)	1000-kernel weight (g)	ACI YR	ACI LR	ACI SR	PM	ST
23	Plc'S'//Salti Autma/Hiti/3/ Fg'S'/4/Mexi 75												
	CD 16895-A-3M-2Y-5M-0Y	12	126	178	82	12.2	82	52.5	6	3	3	2	0
58	Gta'S'/TC 60//Mexi'S'												
	CD-4853-E-1Y-1M-0Y	12	130	179	82	14.0	96	51.4	2	5	4	3	0
22	Stk'S'/Gta'S'												
	CD 12935-1L-1AP-0AP	11	128	178	78	14.2	93	42.8	1	3	3	4	0
83	Dack'S'/Kiwi'S'												
	CD 15647-3M-1Y-2M-0Y	11	133	179	87	13.7	91	46.5	0	5	12	3	0
88	Oyca'S'/Magh'S'//Ruff'S'/FG'S'												
	CD 16913-13-2M-2Y-3M-3Y-0M	11	131	180	80	14.1	95	40.3	1	3	0	4	4
	Waha (regional check)	5	130	177	82	15.0	97	40.0	0	9	2	6	0
	Stork (regional check)	3	125	179	85	13.0	93	47.0	3	8	1	3	0

FR = number of locations where the entry was selected as promising, based on visual evaluation of agronomic type and disease resistance; DH = days to heading; DM = days to maturity; Ht = plant height (cm); Protein (%) = kernel percentage protein; Vitreous (%) = percentage of kernels that are completely free of yellow-berry; ACI = average coefficient of infection (lower numbers indicate resistance and low disease severity at the sites used, 0-100 scale); YR = yellow rust; LR = leaf rust; SR = stem rust; PM = powdery mildew; ST = *Septoria tritici*; PM and ST resistances were scored on a 0 (resistant) to 9 (susceptible) scale.

Table 22. Agronomic and disease data of the most frequently selected lines in the Durum Observation Nursery for low-rainfall sites (DON-Rf), 1981/82.

Entry No.	Line	FR	DH	DM	Ht	Protein (%)	Vitreous (%)	1000-kernel weight (g)	ACI YR	ACI LR
45	*Indus*									
	ICD 77.81-3AP-0SH-0AP	11	118	179	77	13.7	86	42.9	4	7
62	Jo'S'/Cr'S'//USA 06179/3/Jo'S'/Gr'S'									
	CD 10579-F-6M-1Y-4M-0Y	11	120	178	76	13.8	93	42.8	1	4
48	SO 179*2/Durum 6/3/21563/AA'S'//Fg'S'									
	CD 20626-1AP-2AP-1AP-0KE-0AP	10	129	188	79	12.2	77	51.8	0	5
53	Frigate'S'									
	CM 17904-B-3M-1Y-1Y	10	117	179	77	14.0	99	43.6	3	9
85	Ful'S' /Fg'S'/3/0yca//Ruff'S'/Fg'S'									
	CD 17305-A-5M-1Y-1M-0Y	10	120	179	76	13.2	98	43.9	1	7
96	Fg'S'/Jo'S'/3/Gu'S'//61-130/Lds									
	L86-6AP-1AP-1AP-0AP	10	120	179	82				2	5
98	Swan'S'									
	CD 16707-E-1M-2Y-5M-0Y	10	120	178	76	12.9	82	44.7	2	5
	Haurani (regional check)	2	125	181	79	13.4	80	47.0	5	7
	Sahl (regional check)	6	119	179	76	12.0	92	44.0	1	8
	No. of locations reporting	19	12	10	15	3	3	3	5	3

FR = number of locations where the entry was selected as promising, based on visual evaluation of agronomic type and disease resistance; DH = days to heading; DM = days to maturity; Ht = plant height (cm); Protein (%) = kernel percentage protein; Vitreous (%) = percentage of kernels that are completely free of yellow-berry; ACI = average coefficient of infection (lower numbers indicate resistance and low disease severity at the sites used, 0-100 scale); YR = yellow rust; LR = leaf rust.

Germplasm Development

Crosses were made to develop high and consistent yielding genotypes for the prevailing durum wheat growing environments in the region. Evaluation of germplasm at Tel Hadya and in the international yield trials and observation nurseries revealed several genotypes with

In the 1981/82 season, 14,452 durum wheat accessions obtained from international germplasm collections were tested for agronomic characters. Of these, 165 entries with the best agronomic traits were grown in an observation nursery in the 1982/83 season. The top 13 of these 165 lines have been included in a preliminary yield trial and in the crossing block for 1983/84.

Advanced Durum Yield Trials

Selected, sufficiently homogeneous lines from advanced generations (F_5 onward) are entered into yield testing trials. The first testing is in a nonreplicated Initial Durum Yield Trial (IDYT) arranged in an augmented design. The best yielding lines with acceptable disease and insect resistance and good grain quality are promoted to the Preliminary Durum Yield Trial (PDYT)

rainfall (about 650 mm) and good fertility. These environments were chosen to enable simultaneous selection for yield potential and disease resistance (SIR, EP, and Terbol) and for the ability to cope with moderate drought stress and low fertility (Rf). Thus, inclusion of an entry in the international nursery is based on its performance over 3 years at several locations. Table 23 presents the yield performance of two ADYT entries in 1982/83 and the performance

Stress Tolerance

Identification of drought tolerance in durum wheat. The 336 lines that constituted the ADYT were evaluated for their relative drought tolerance in the 1982/83 season by (1) visual evaluation at locations with different amounts of rainfall, including Tel Hadya under supplementary irrigation(approx. 450 mm): Tel Hadya-rainfed (approx. 350 mm), Breda (approx. 275 mm), and Khanasser (approx. 240 mm); and (2) planting very late (February) at Tel Hadya under rainfed conditions, to expose the late growth stage of the plants to heat. Forty-seven lines were selected at both Breda and Khanasser. Segregating populations were also grown at Breda. Selected plants were advanced to the next generation, following the bulk method.

Identification of frost tolerance in durum wheat. The 336 lines of the ADYT were also grown as a yield trial under early planting (EP). Early planting advances plant growth and hence the plants are more frost-vulnerable at the time when the frosts normally occur and better selection can be carried out. Haurani was used as a cold-tolerant check and Sahl as a cold-sensitive check. Table 25 shows the frequency distribution for frost tolerance on a 1-9 scale. Eleven lines scored equal to, or better than Haurani for frost tolerance.

Selected segregating populations were also planted early to screen for frost tolerance. The frost-tolerant plants were selected and bulked.

Identification of salt tolerance in durum wheat. Lines that were visually superior when grown in a saline, dry, lakebed nursery at Hegla, Syria, were further evaluated under the same conditions in 1982/83. Screening for salinity resistance will continue with the testing of some 60 local landraces and collection accessions of durum wheat in 1983/84. Derivatives of crosses in which at least one of the parents was supposed to have salt tolerance are also planted at the salt lake, to develop salinity-tolerant populations.

Selection for Grain Characteristics in High-Yielding Lines

In durum wheat the quality of the grain is crucial for farmer acceptance. Large, vitreous kernels are preferred. The local variety Haurani has good grain characteristics in terms of vitreousness (i.e., absence of mottling of the grains) and protein content, but the grain size is medium, and the yield performance under improved crop-growing conditions is poor. Since management practices and crop-growing conditions influence the expression of the quality characters of the grain, it is necessary to select under conditions that discriminate well between high- and low-grain quality lines. Selection for high yield potential should be achieved without sacrificing grain quality.

For the 336 entries in the ADYT, grain samples were taken from the five management practices at Tel Hadya, i.e., early planting

Table 25. Frost tolerance in advanced durum wheat germplasm.

	Frost tolerance scale[1]								
	1	2	3	4	5	6	7	8	9
Number of entries	0	1	10	28	76	82	94	37	8
Positions of checks			Haurani					Sahl	

1. 1-3: good frost tolerance; 4-6: medium frost tolerance; 7-9: low frost tolerance.

(EP), supplementary irrigation (SIR), rainfed (Rf), late planting (LP), and unfertilized but receiving supplementary irrigation (0N). These samples were analyzed for 1000-kernel weight, protein content, and percentage vitreousness. Yield data obtained from Tel Hadya (EP, SIR, Rf) and Terbol (Lebanon) were used to assess the yield potential of the lines.

Fig. 5 illustrates that of the five management practices, 0N was the most effective in selecting against susceptibility to mottling of the grains. It appears that a nursery grown under supplementary irrigation but without nitrogen application is useful to enable selection for lines with constant and high grain quality.

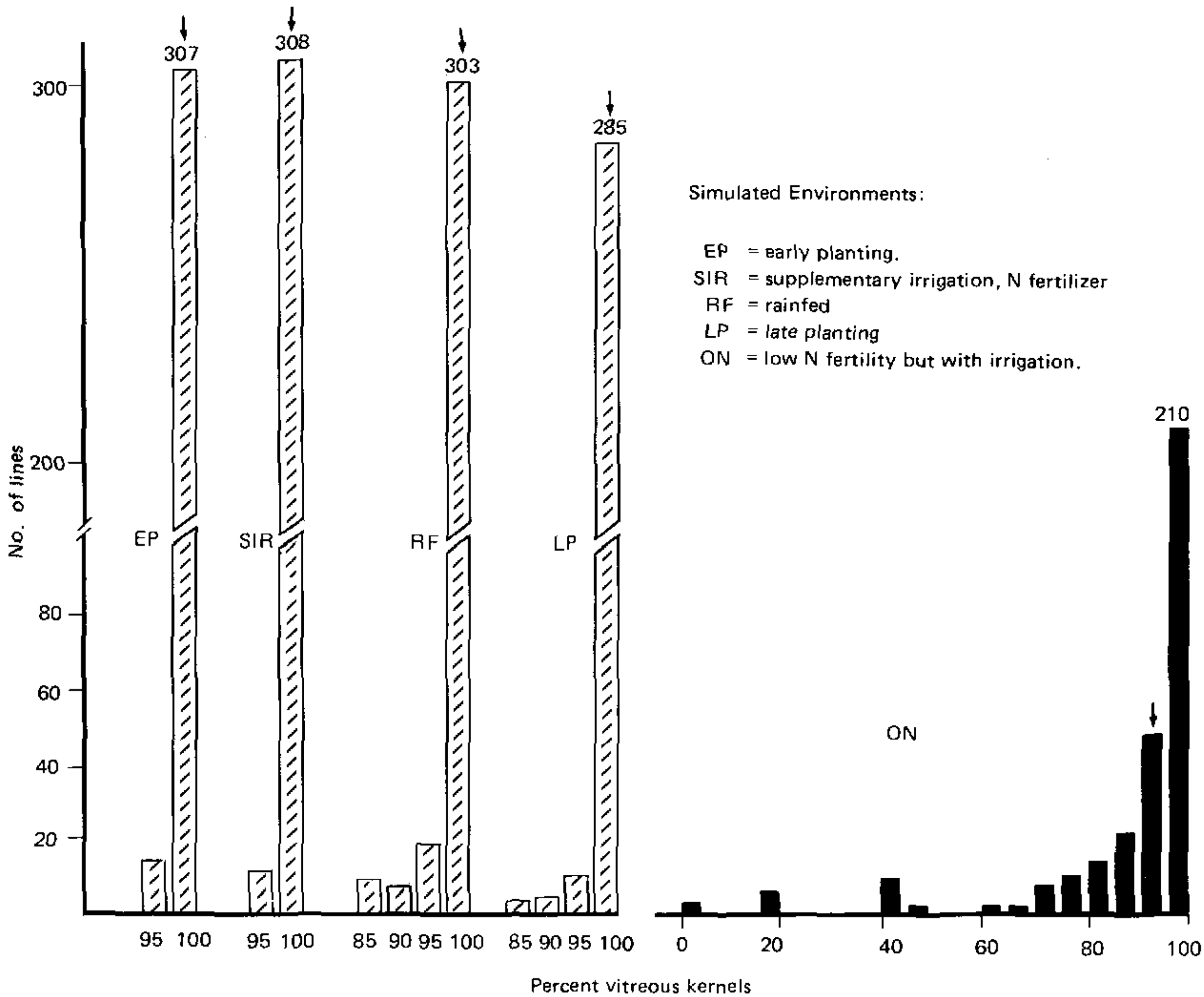


Fig. 5. Frequency distribution of the percentage of vitreous kernels of 336 lines in the ADYT, tested under five simulated environments at Tel Hadya. The average value for the check Haurani is indicated by an arrow.

Table 26. Average yield performance and grain quality characteristics of nine ADYT entries with superior grain quality to Haurani.

ADYT entry No.	Average % protein[1]	Average 1000-kernel weight[2]	Vitreousness[3] (%)	Average yield (kg/ha)[4]
209	14.6	45.7	99	4617
210	14.2	46.0	100	4751
407	15.0	45.7	99	4466
411	15.0	46.2	100	4307
1119	14.2	45.4	98	4559
1307	14.2	46.3	98	4522
1417	14.5	44.6	95	4592
Haurani	14.8	42.5	93	3880
LSD (5%)	0.7	2.1		376

1. Five environments; 2. Five environments; 3. One environment; 4. Four environments.

Average grain yield and quality characteristics of nine entries from the ADYTs were compared with Haurani (Table 26). Seven entries were found that combined significantly higher 1000-kernel weight and yield than Haurani and had the same level of protein content.

Component 2: Pathology

Compared to bread wheat, durum wheat is grown in areas that are less favorable for the development of some diseases. However, yield losses due to diseases in these areas are still quite extensive. In addition, further improvement of the yield potential of durum will extend its growing area into more humid regions in the future. Therefore, breeding for disease resistance receives a high priority in our durum-breeding program.

Priority diseases for resistance breeding in durum wheat are: yellow rust (*Puccinia striiformis*), septoria leaf blotch (*Septoria tritici*), leaf rust (*Puccinia recondita*), stem rust (*Puccinia graminis*), tan spot (*Helminthosporium tritici-repentis*), common bunt (*Tilletia caries*; T. *foetida*), and bacterial leaf streak (*Xanthomonas transluscens*).

Yellow Rust

As in barley, artificial inoculation method was used to create a yellow rust epiphytotic at Tel Hadya for effective selection for resistance. A spontaneous yellow rust epiphytotic occurred in Marae, a location in the high-rainfall region north of Aleppo, where the Key Location Disease Nursery was also planted. In this nursery all entries in the preliminary and advanced yield trials are included. Table 27 shows the number of entries that exhibited resistance both at Marae and Tel Hadya.

Table 27. Number of entries in the different yield trials showing resistance to yellow rust both at Tel Hadya (artificially inoculated) and Marae (natural infection), 1982/83.

Trial	Number	% of entries tested
Durum Preliminary Yield Trial	33	10
Durum Advanced Yield Trial	31	6

From the Durum Observation Nursery, data on yellow rust resistance were received from the following six locations: Tel Hadya, Syria (average severity 6%); Afrin, Syria (average severity 6%); Marae, Syria (average severity 26%); Terbol, Lebanon (average severity 3%); Elvas, Portugal (average severity 9%); and Sevilla, Spain (average severity 6%).

Of 124 entries, 25 showed good resistance to yellow rust at all six locations. Of these 25 lines, six also showed adequate resistance to leaf and stem rust at other locations (Table 28).

Table 28. Entries in Durum Observation Nursery 1982/83 showing resistance to yellow, leaf, and stem rusts.

Entry No.	Line
4	Stk'S'/Cit'S' L 0415-0L-2AP-0AP
7	Pen'S' CD 19858-B-2Y-1M-0Y
13	D.dwarf S15/Cr'S'/3/Plc/Cv/Jord 119 ICD 77-0021-5AP-0SH-0AP
18	Jo'S'/Cr'S'//USA 06179/3/Jo'S'/Gr'S' CD 10579-F-6M-1Y-4M-0Y
66	Gs'S'//S15/Cr'S' CM 18694-22Y-1Y-0Y-0KE-1B
78	Kif'S'//Ruff'S'/Fg'S' CD 12781-5Y-4M-1Y-1M-0Y

Septoria Leaf Blotch

Septoria blotch is a serious disease especially in the North African countries. During the 1982/83 season, screening for resistance was carried out in artificially inoculated nurseries planted in Afrin in the high-rainfall region north of Aleppo. Of 100 entries in the Durum Septoria Nursery 1982/83 selected from the KLDN 1981/82 in Tunisia, only four showed a reasonable resistance against the Syrian isolates used in Afrin (Table 29). Thus, the difference in virulence between the pathogen populations in North Africa and Syria is clear. The Durum Septoria Nursery 1983/84, consisting of 150 entries selected at Afrin from all nurseries planted, will be tested in Syria and Tunisia by ICARDA staff and in Portugal by CIMMYT staff.

During 1982/83, 58 crosses were made for septoria blotch resistance. The F_1s were grown in ICARDA's summer nursery in Shawbak, Jordan. The F_2s are now planted at Tel Hadya. A permanent low-volume irrigation system has been established to create a favorable environment for disease development. Resistant F_3 populations will be sent to Tunisia and Portugal. It is hoped that this methodology will develop lines with broad-based resistance to septoria blotch.

Table 29. Lines resistant to *Septoria tritici* in Tunisia (1981/82) and Syria (1982/83).

Dack'S'/Rabi'S' CD 12498-6Y-7M-1Y-1M-2Y-0M
Plc'S'/Cr'S'//Rabi'S'/Blt ICD 77-0148-5AP-6SH-0AP
Snipe'S'//Amareleja/Haynaldia ICD 77-0216-10AP-2SH-0AP
Gdo 548/Ato'S'/3/Kranich'S'/T.dur.T.carthilicium CD 22564-A-1AP-0AP

Leaf Rust

Data from the KLDN 1982/83 planted in Taiz, Yemen, a location with exceptionally high disease pressure, resulted in identification of only five durum lines (0.2%) with complete resistance (compared to 45% of the entries in the bread wheat KLDN grown at the same location). During the coming season more attention will be given to screening for leaf rust resistance by planting a large set of germplasm at Lattakia and Sarghaya in Syria where favorable conditions for leaf rust development exist.

Bacterial Leaf Streak

In past years there have been restricted outbreaks of this disease in Turkey and northern Syria. In 1981/82, a screening nursery was planted in an area where the disease is thought to be endemic. Inoculation gave some infected plants, but the disease did not spread. This might have been caused by the absence of aphids, a possible vector of this bacteria, during that season.

Component 3: Agronomy

Agronomic experiments were conducted with the objective of determining the characteristics and requirements of selected new durum lines in comparison with local cultivars, particularly with respect to seed rate and fertilizer application.

Seed Rates

Two new durum cultivars, Sahl and Waha (Sham 1), were compared with two local cultivars, Haurani and Gezira 17, at five seed rates (30, 60, 90, 120, and 150 kg/ha) in a replicated experiment at Tel Hadya. The results indicated that 90 kg/ha was the best seed rate for all varieties in 1982/83. More research in this area is needed to control other sources of variation such as differences in seed size, row spacing, and date of planting.

Nitrogen Response Studies

Five rates of nitrogen combined with five methods of splitting total nitrogen were applied in rainfed conditions to the durum variety Sahl in continuation of a similar experiment conducted during the previous season. There was a positive response to nitrogen for grain yield (Table 30) and grain protein content. Kernel weight was slightly but significantly decreased by heavy applications of nitrogen. In the 1981/82 experiment, which followed a green-manure crop, durum wheat Sahl gave about the same grain yield when 30 kg N/ha was applied at tillering as when 90 kg N/ha was applied at sowing. The results of the 1982/83 season did not show any significant differences among ratios or ratio x rate contributions. This lack of response may be due to higher initial nitrogen in the soil of this experiment which was on a land following a fallow, a common practice in the area. However, there is still some indication that low rates at tillering can have the same effect as higher rates at sowing.

Table 30. Effect of rate and ratio (sowing/tillering) of N applications on grain yield of durum wheat Sahl at Tel Hadya, 1982/83.

N ratio (% at sowing-% at tillering)	N rate (kg/ha) 0	30	60	90	120	Mean
0-100	3948	4140	4193	4301	3744	4072
25-75	3948	4077	3896	4496	3977	4064
50-50	3948	4114	3822	4245	3702	3951
75-25	3948	4272	4133	3985	3793	4007
100-0	3948	3910	3790	4234	4041	4028
Mean	3948	4103	3967	4252	3852	

LSD (5%) for N rate means = 243 kg/ha.

On-Farm Agronomy Trials

Trials were conducted in farmers' fields to determine appropriate levels of fertilizer requirements using one durum variety (Sahl) in an unreplicated experiment at six sites in Zone B (250-350 mm) of Syria. Results indicated that in farmers'fields being annually fertilized there is still substantial yield increase due to nitrogen or phosphorus applications with no apparent interaction between the two fertilizers over the range of rates used.

An improved practices trial was also included among on-farm agronomy trials using one local durum cultivar, Haurani, and an improved durum cultivar, Sahl. Treatments included nitrogen and phosphorus fertilizers as well as weed control. Although the results differed with sites, there was clear indication that nitrogen fertilizer was important in determining grain yield in Zone B, where most durum is grown. Phosphorus, weed control, and variety each influenced yield at only one or two sites. These experiments indicated the potential impact of improved production technologies but also the fluctuation in their effects. It is concluded that testing in a representative set of locations should be continued in order to draw broader and more definite conclusions on specific production techniques.

Our agronomist spent considerable time in assisting scientists from national programs to formulate agronomic practices. He was also involved in agronomic research in Jordan and Pakistan collaborative projects, which are reported in a later section of this report.

Component 4: Grain Quality

In the durum wheat improvement project emphasis is given to grain quality characters, to ensure that while breeding for increased yield potential the grain quality is not sacrificed. The tests allowed the identification of a number of advanced lines possessing high yield and superior grain quality. Also, in early generations, grain size, color, and vitreousness were given prominent attention in seed selection.

An important activity was the study of the methods of *burghul* preparation in Aleppo city and Seraqeb town. *Burghul* is a traditional product for which durum varieties with larger grains are preferred. It was found that in the city the preparation of *burghul* involves four stages: boiling, peeling, milling, and purifying. In the rural areas, the processing is confined to two stages, boiling and milling. The purpose of the study is to develop a laboratory procedure for the preparation of *burghul*, to assist in the evaluation of advanced lines of durum wheat.

Component 5: Entomology

Resistance to Wheat Stem Sawfly

The resistance of 83 durum lines was measured at Tel Hadya and Suran. Even though natural infestations at Suran were lower than in the previous season, 16 of the tested lines were rated as promising (Table 31). The lines, Uveyik 126/61-130//Kohak 2916/Lds/3/Albe ICD 77.186-5AP-0SH-0AP and Loon'S' CM-14528 were the best and confirmed their value as reliable sources of resistance to wheat stem sawfly.

Economic Importance of Suni Bug

This insect is found throughout West Asia. In

Table 31. Number of durum lines tested and number of lines found promising for resistance to wheat stem sawfly, 1982/83.

Location	No of lines tested and range of % infestation	% infestation in the check (Hammari)	No. of promising lines and range of % infestation
Suran	83 (0-15.0)	2.2	16 (0-3.3)
Tel Hadya	83 (0-25.8)	14.5	16 (0-3.9)

Syria, it has become a major pest. Our surveys have indicated that suni bug is present in all provinces of Syria, from Hassake in the northeast to Sweida in the south. The infestation levels in durum varied widely from 0.1 to 81.0% seeds damaged. The highest infestations occurred in the Aleppo and Idlib provinces. In some fields, samples were taken to calculate the relationship between suni bug damage and losses in kernel weight. The correlations between percentage of seeds infested and percentage reduction in weight were significant ($P < 0.01$) for both Hammari ($r = 0.977$; $n = 50$) and Gezira 17 ($r = 0.928$; $n = 25$) durum wheat varieties. Mean percentages of kernel weight reduction were 16.1 and 10.4%, respectively.

The suni bug not only affected the yield and quality of the grain for bread making, but also the quality of the seed used for planting. Seeds were classified in damage grades: 0 = sound grain (check); 1 = 1/3 of each grain affected; 2 = 2/3 of each grain affected; 3 = complete grain affected. Increasing proportions of affected seeds of each damage grade were mixed with sound seeds and then sown at Tel Hadya to simulate the situation of a farmer who does not recognize, or disregards suni bug damage when choosing seeds for planting. Under field conditions, a significant effect of both damage grades and percent infested seeds used for planting was observed. The percent establishment of the crop decreased significantly as the proportion of the infested seeds planted increased (Fig. 6).

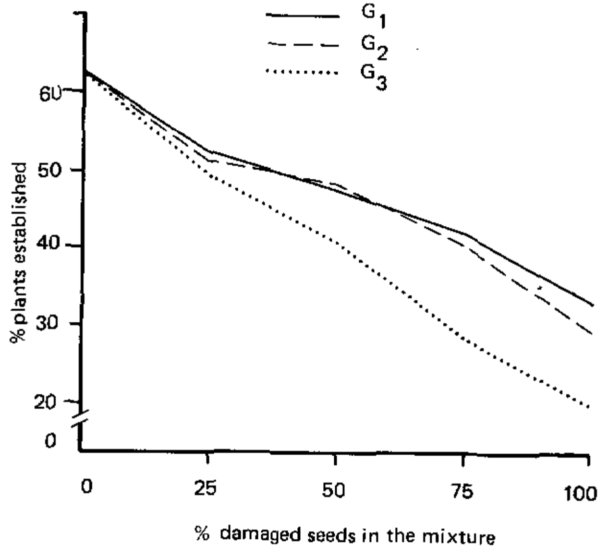


Fig. 6. Percent establishment of Gezira 17 durum wheat plants as affected by the sowing of increasing proportions of damaged seed at three grades of suni bug damage, 1982/83. G_1 (one-third of seed affected), G_2 (two-thirds of seed affected), G_3 (seed completely affected).

In another trial, seeds of different damage grades were planted at different seed rates, the higher seed rates aimed at compensating for poor establishment of the crop due to suni bug damage to the seeds. The results indicated that at all seed rates the planting of suni bug damaged seeds adversely affected the final yield of the crop (Table 32). Reduced yield was a result of reduced vigor at all growth stages and consequently lower tiller numbers and lower numbers of seeds/head. Thus, it seems that suni bug damage also has some detrimental effect on the germination and vigor of infested seed.

Table 32. Effect of planting sound and suni bug damaged seeds at three seed rates on the final yield (g/3 m^2) of Gezira 17 durum wheat at Tel Hadya, 1982/83.

Seed rate (kg/ha)	Suni bug damage grades[1] 0	1	2	3	Mean
100	915.5	753.6	562.8	475.5	676.8
150	760.7	791.7	586.6	384.8	631.0
200	979.8	887.1	648.6	543.7	764.8
Mean	885.3	810.0	599.4	468.0	690.9

F for seed rates: NS
LSD (5%) for suni bug damage grades = 241.1
CV (%) = 28.7

1. Grade 0 = sound seed; grades 1, 2, and 3 = 1/3, 2/3, and complete seed affected, respectively.

Project III: Bread Wheat Improvement

World bread wheat production averaged 450 million metric tonnes in 1980/81.[a] About 10% of this (approximately 44 million metric tonnes) was produced in West Asia and North Africa.

Bread wheat ranks first among the food crops in the Middle East and North African countries. The consumption is in excess of 150 kg wheat/capita/annum. Total wheat imports in these countries have been increasing sharply to meet consumption demands. Food imports averaged 15 million metric tonnes annually during the last 5-year period and most of these were of bread wheat.

Over 90% of the bread wheat grown in the region is rainfed at precipitation levels of 250-650 mm and 50% of the area receives less than 400 mm. There are several constraints limiting wheat production in the lower rainfall areas. Diseases, insect pests, frost, heat, drought, and other environmental factors in combination with the lack of good agronomic practices (poor land preparation, weeds, poor conservation of moisture, sowing problems, poor crop stands) are the main problems to be tackled.

Component 1: Breeding

This project involves a joint CIMMYT/ICARDA breeding effort with collaboration from ICARDA scientists in agronomy, physiology, pathology, entomology, and grain quality. The project has a special responsibility to develop suitable varieties for the lower rainfall zones. Large-yielding varieties combined with improved agronomic practices offer hope for large increases in production in the region.

Our efforts continued on the development of high-yielding lines for the limited-rainfall conditions of the region. In addition to drought resistance, new materials were selected for cold, heat, and salt tolerance. Improved resistance to diseases is an important aim, so particular attention was paid to the three rusts, and septoria blotch, bunt, and bacterial blights. Insects are also a serious problem in many areas. Lines were screened for resistance to stem sawfly, hessian fly, suni bug, and aphids. Screening for grain quality was also performed.

a. FAO Monthly Bulletin of Statistics, March 1982.

We made 320 single and 156 double crosses in 1982/83 for specific traits such as sawfly, drought, cold, and bunt resistance, which are particular problems in ICARDA region. A wide base of germplasm is maintained through the use of CIMMYT nurseries and segregating populations. In 1982/83, 883 F_2s were received. These provided germplasm with potential for rainfed and irrigated areas, aluminum toxicity resistance (a character often associated with resistance to many foliar diseases), *Helminthosporium* spp., and spring x winter crosses for cold tolerance.

A total of 10,769 entries in segregating generations F_2-F_8 were screened in 1982/83. All these lines were grown with two forms of management. The first consisted of a rainfed crop supplied with a small amount of fertilizer; the second with supplementary irrigation and optimal fertilizer conditions. It is believed that by growing segregating populations with these two forms of management, simultaneous selection can be made for large yield and yield stability.

Results from preliminary and advanced yield trials indicate the progress achieved to date on developing higher yielding lines relative to the widely-grown variety Mexipak 65 and the improved check Golan (Table 33). Some lines are superior to the checks, especially in the more favorable irrigated environments.

Yields at Tel Hadya this year were reduced by frost damage. The timing of the frost caused more damage to the early- or medium-maturing lines and less to the later lines such as Mexipak and Golan. To avoid a selection bias toward late lines, the mean yield of each trial was used as a base for selection along with special attention to frost damage and date of heading.

Stability of Performance

Table 34 lists the six lines selected at nine or more of 20 locations as being visually superior to both local and long-term checks in the Wheat Observation Nursery (WON) during 1982/83 which returned the data until the time of writing this repot. These selected lines are from different origins including ICARDA, CIMMYT, Egypt, and Turkey. The locations to which this nursery was sent constitute a wide range of environments and diseases in ICARDA region and beyond. The outstanding lines in this nursery were promoted to the regional yield trial. Several of them will be used as parents in the crossing block next year.

Table 33. Number of lines that gave significantly ($P<0.05$) better yields than the checks Mexipak and Golan in the 1982/83 preliminary and advanced (PWYT and AWYT) yield trials.

Location/trial	Average yield (kg/ha)	Number of lines tested	Lines higher yielding than Mexipak No.	Lines higher yielding than Golan No.
Tel Hadya - Rainfed				
PWYT	3592	858	9	8
AWYT	4137	176	0	7
Tel Hadya - Irrigated				
PWYT	4928	396	9	30
AWYT	5266	176	17	7
Terbol				
AWYT	5495	176	0	15

Table 34. Lines selected nine or more times at 20 locations in the WON, 1982/83.

Entry No.	Selection frequency	Cross and pedigree
34	11	Bb/2*7C//Y50E/3*Kal CM 29014-7S-2AP-1AP-4AP-0AP
125	11	Sakha18//Cno'S'/Cal/4/Sakha/3/Tzpp//Sn64/Napo S 2896-100-1S-3S-0S
71	9	7C/Pvn'S' CM 36569-8Y-1M-1Y-2M-0Y
16	9	Cv/Ald'S' L 882-1AP-0AP-2AP-0AP
65	9	Snb'S' CM 34630-D-3M-3Y-1M-1Y-0M
127	9	Sakha69

Six years of results from the regional wheat yield trial are given in Table 35, comparing the two largest yielding bread wheat lines with Mexipak and the national check. During the last five seasons there was a trend for the top two new lines to perform slightly better than the national check. During the last six years the top line has yielded an average of 266 kg/ha, or 6.6%, more than the national check. This is a modest increase and indicates some improvement in wide adaptation. The national check usually is a recommended large-yielding variety with proven adaptation at that location.

A summary of the largest yielding lines in the Regional Wheat Yield Trial 1982/83 is presented in Table 36. Grain yield and other agronomic data were compiled from 21 different locations, including two simulated environments at Tel Hadya, using rainfed and supplementary irrigation conditions. The overall average yield of the entries, excluding the national checks, was 4057 kg/ha, with individual entry means ranging from 3619 to 4512 kg/ha.

Experimental error in some of the locations was large and resulted in a relatively large overall CV (18%) for the combined analysis. Disease scores were reported by most cooperators but heavy infection was only reported in a small number of locations.

Flk'S'/Hork'S' was the largest yielding line and was among the top 10 entries at 16 out of 21 locations. This line was also superior to national checks at 13 locations. However, it is susceptible to cereal rusts (particularly leaf rust and yellow rust) at several locations. The second largest yielding line, HD 2206/Hork'S' ranked among the top 10 entries at 14 locations and it was also superior to the national check at 13 locations. This line is moderately susceptible to leaf and stem rust.

Entry No.9 (Vee'S'), which is a winter x spring cross, ranked third and combines large yield with a good yield stability, medium maturity, and good disease resistance. Considering all factors, it seems to be the most promising line in the trial.

One of the most important achievements of the CIMMYT/ICARDA bread wheat improvement program during the 1982/83 crop

Table 35. Yield of the two largest yielding bread wheat lines (kg/ha) in the Regional Wheat Yield Trials, compared to check varieties, for six seasons.

Entry	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	Average
Top bread wheat line	3607	3875	4507	4110	4862	4876	4306
Second bread wheat line	3577	3729	4374	4080	4853	4729	4224
Mexipak	3278	3615	4151	3803	4504	4277	3938
National check	3477	3743	4107	3893	4616	4403	4040
LSD (5%)				129	171	292	
Number of locations	24	33	27	37	29	18[a]	

a. Data were available from 18 locations only. A complete summary will be reported in the 1982/83 Cereals Nursery Report.

Table 36. Performance of the highest yielding lines in the Regional Wheat Yield Trial at 21 locations, 1982/83.

Entry No.	Cross and pedigree	Yield (kg/ha)	CHK[1]	SEL[1]	Days to maturity	Protein (%)	1000-kernel wt. (g)
17	Flk'S'/Hork'S' CM 39816-1S-1AP-0AP	4512	13	16	153	11.8	35.1
16	HD 2206/Hork'S' CM 39808-62M-1Y-1M-0Y	4444	13	14	152	11.7	33.3
9	Vee'S' CM 33027-F-9M-1Y-4M-500Y -500M-502Y-0M	4403	13	17	154	12.1	36.4
20	Inia/Napo//3*Cal/3/Cj/4/Kpk NCP 212-A-1K-3AP-0AP	4360	13	14	156	12.0	31.2
1	Mexipak 65 (B.W. check)	4012	10	8	151	11.6	34.1
12	Waha (D.W. check)	3832	4	6	151	12.8	41.0
Overall Mean		4057					
LSD (5%)		292					
CV (%)		18					

1. CHK = Number of locations where the line was superior to the national check.
SEL = Number of locations where the lines were among the 10 highest yielding entries.

season was the decision of the Syrian Ministry of Agriculture and Agrarian Reform to release one bread wheat variety (Sham 2) for Syrian farmers in the irrigated and high-rainfall areas (above 350 mm rainfall). Table 37 summarizes the performance of this new variety when compared to Mexipak 65 during the last 4 years (1979-83) in field verification trials for these two zones.

New bread wheat line Sham 2 has been approved for release by the Syrian Ministry of Agriculture.

Sham 2 (7C//TOB/CNO'S'/3/KAL CM 8865-D-4M-1Y-1M-2Y-0M), has demonstrated better yield performance than Mexipak 65 which is widely grown in these zones. Its average yield in the irrigated areas over the last 4 years was 4812 kg/ha, which is 12% more than Mexipak 65. In Zone A (rainfed, above 350 mm), the average yield for 4 years was 3217 kg/ha or 11% more than the check variety.

Table 37. Summary of the performance of Sham 2 compared to Mexipak 65 in field verification trials in the irrigated zone and Zone A (above 350mm rainfall) in Syria, 1979-1983.

	Irrigated zone yield (kg/ha)						Diseases ACI[a]			
Variety	1979/80	1980/81	1981/82	1982/83	Average	Percent	LR	SR	YR	ST
Sham 2	4257	5517	4082	5390	4812	112	3	5	1	2
Mexipak 65	3585	5026	3545	5073	4307	100	20	8	9	5
			Zone A							
Sham 2	3520	2999	3148	3202	3217	111				
Mexipak 65	3148	2740	2873	2830	2898	100				

a. ACI = Average Coefficient of Infection.

LR = leaf rust; SR = stem rust; YR = yellow rust; ST = *Septoria tritici*.

Disease resistance, protein percentage, and bread-making quality of this variety are also better than Mexipak 65. In general, the maturity and plant height of both varieties are the same. Breeders' seed of this variety was produced and about 6000 kg of basic seed will be available next year.

Component 2: Pathology

During 1982/83, efforts were continued to maintain and improve the disease resistance of bread wheat. Extensive screening of advanced and segregating material was performed for several diseases prevalent in ICARDA region.

The priority diseases for resistance breeding in bread wheat are: yellow rust (*Puccinia striiformis*), septoria leaf blotch (*Septoria tritici*), common bunt (*Tilletia caries*, *T. foetida*), leaf rust (*Puccinia recondita*), stem rust (*Puccinia graminis*), and tan spot (*Helminthosporium tritici-repentis*).

Information on yellow rust, septoria leaf blotch, common bunt, leaf and stem rust, and tan spot was received from ICARDA observation nurseries and processed. A list of the best performing bread wheat lines for leaf and yellow rust in the 1982/83 Wheat Observation Nursery is presented in Table 38. Data were received from Bangladesh, Ecuador, Egypt, Jordan, Mexico, Pakistan, Portugal, Spain, and Yemen. Twenty-three entries out of 127 in this observation nursery showed a good overall resistance to yellow rust, while 31 lines from the same nursery had leaf rust resistance.

Table 38. Entries in the Bread Wheat Observation Nurseries showing resistance to yellow rust and leaf rust, 1982/83.

P106.19//Soty/It*3
L 0489-1AP-0AP-6KE-0AP
Tob'S'/3/Cno67/Jar//Kvz
CM 20707-A-1Y-8M-1Y-0M-0Ptz
Bow'S'
CM 33203-F-4M-4Y-1M-1Y-0M
Bow'S'
CM 33203-K-9M-2Y-1M-1Y-1M-0Y
Gll/YR Resel (B)/3/Au//Kal/Bb
CM 34603-A-1M-GY-4M-1Y-2M-0Y
Snb'S'
CM 34630-D-5M-5Y-3M-1Y-0M
Bch'S'//Y50 E/Kal*3
CM 39761-9K-2AP-0AP-2AP-0AP

Septoria leaf blotch is an important disease of bread wheat in the North African countries. Data from our septoria nursery planted in Afrin, Syria and those from ICARDA's Wheat Observation Nursery planted in Elvas, Portugal have been processed. Table 39 lists the lines which showed good levels of resistance both in Portugal and Syria.

Table 39. Entries in the Bread Wheat Observation Nurseries showing resistance to *Septoria tritici* in Syria and Portugal, 1982/83.

Inia/Napo//Tob/3/Sprw'S'
L 0017-5S-4S-2AP-1AP-1AP-0AP
Tob/Cno'S'//Pi 62/3/Ska
L 0771-4L-2AP-0AP
NR/3/Cno'S'/Pj//Gll
CM 23125-2AP-2AP-0AP-1AP-0AP
Cmn 72. 428/Mrc//Flr'S'
CM 46869-2AP-0AP
Crun/Coc
SWM 6493-2AP-0AP
Sakha 91

Common bunt resistance is an important objective in the bread wheat program. In our screening effort, all material in preliminary and advanced yield testing was grown in special bunt nurseries, and artificially inoculated with a mixture of Syrian isolates. Lines that showed resistance will be retested in the coming season.

If their resistance is confirmed, these lines will be tested against a number of non-Syrian strains in a well-isolated area. Lines having a broad-based resistance will be promoted to the crossing block. Results so far have been encouraging and efforts will continue to screen resistant material in this fashion.

Component 3: Agronomy

Several management factors were examined in multilocation trials on farmers' fields in Syria. In fertilizer trials, nitrogen was found to be the most important fertilizer in moderate- to high-rainfall areas. Studies of genotypic differences in responsiveness to N continued. Previous experiments had shown that while significant genotypic differences exist, they were often not repeatable between seasons or sites. Previous cropping history, climate, and soil type interact in a complex fashion with nitrogen uptake and utilization by the plant.

For the third season, a plant ideotype experiment was conducted to determine if an optimum balance of yield components exists for the local environment. Eight bread wheat varieties with contrasting yield-component characteristics were tested at five plant populations (approx. 50, 100, 200, 400, and 800 plants/m^2). The aim of these experiments was to determine which yield components, if any, were more consistently related to large yields under rainfed conditions at Tel Hadya. This information could help plant breeders to select large-yielding lines for rainfed conditions in the region.

In each season so far the effects of weather had the most readily identified influence on grain yield. The effects of frost during the vegetative stage and continuous cool temperatures were dominant factors in 1982/83. Frost during heading was not a problem, but temperatures in winter were cold for longer than usual and heading was delayed. These circumstances restricted tillering in low seeding-rate treatments, and there was therefore a larger effect of increasing plant density on final grain yield than in the previous years. There was a tendency for lines with many tillers to give the largest yields. Considering the large year-to-year variability in yield components, it was concluded on the basis of 3 years' data that plant breeders would do better to select on the basis of yield, rather than on differences in yield components.

Component 4: Grain Quality

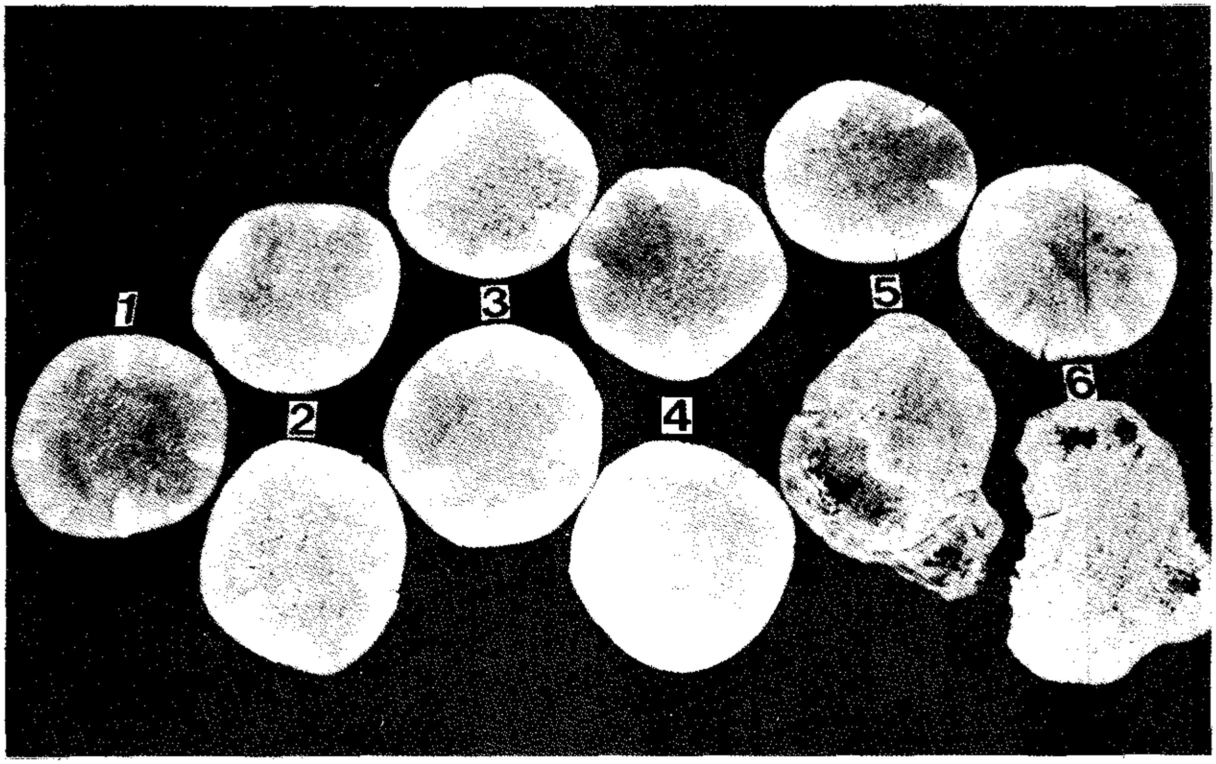
In 1982/83, a large number of lines were tested for grain quality. In addition, studies were made of the effects of environment on quality (Table 40).

Kernel hardness was little affected by environment and was the most highly heritable of the characters. Kernel weight was also under more genetic than environmental control. Protein content and wheatmeal fermentation time (WMFT) were each more affected by the environment than by genotype. The WMFT test appeared to be affected by both season and location and therefore of little value in selection, unless the populations contain distinctly different genotypes, i.e., a very wide range of dough strengths.

Table 40. Influence of growing season and heritability of some quality factors in bread wheat.[1]

Parameter	Between seasons	Between locations
PSI (hardness)	0.98	0.97
Protein	0.64	0.72
WMFT	0.21	0.47
Kernel weight	0.77	0.83

1. Data are average coefficients of correlation between test data of eight cultivars grown at six locations for 2 years.



Effect of suni bug damage on *khobz* quality. Loaves in upper rows, including No. 1, were made from undamaged seed. Proportion of damaged seed in loaves 2, 3, 4, 5, and 6 was 2, 5, 10, 20, and 50%, respectively.

Little is known about the quality characters of the Arabic flatbreads, called *khobz*. Studies were conducted to define these characters and develop a scoring system to evaluate flour samples. Dough handling, dividing, and sheeting properties, *khobz* color and diameter, crumb and biting texture, layer separation, odor, taste, and keeping quality, were scored on a point system for routine and repeatable evaluation of entries.

The effect of suni bug damage on physical dough properties was studied. Physical dough characteristics were affected even when only 5% of the seed was damaged. Flours made from seed with 20% or more infestation were impossible to handle in *khobz*-baking procedures, and would not rise in the oven.

A test was developed to detect suni bug damaged flour samples. A normal wet gluten test is carried out on 10 g of flour. After washing and drying, the gluten is stretched 5 cm against a scale. The degree to which the gluten retains its elasticity gives a measure of the presence and severity of suni bug damage. The presence of as little as 2% damaged wheat can be detected by this test, which is simple and only needs easily available, inexpensive equipment.

Component 5: Entomology

Wheat stem sawfly, suni bug, and cereal aphid received special attention. The search for resistant germplasm is proving more successful with the sawfly than with the other two pests.

Resistance to Wheat Stem Sawfly

Using a light natural infestation which occurred at Suran, Syria and a heavier artificial infestation at Tel Hadya, 79 bread wheat lines were screened for resistance to wheat stem sawfly. As in previous seasons, Fortuna and Fortuna-derived lines were the best sources of resistance to this insect (Table 41). The consistency of this resistance was confirmed when the resistant line mT-777 CI 9294/Fortuna, together with a local check (Golan) and a susceptible check (MP 112) were exposed to increasing levels of infestation. Even with the heaviest infestation of 11 females/m² the proportion of stems infested in the resistant line was significantly less than in the local and susceptible checks (Fig. 7).

Table 41. Bread wheat lines with high levels of resistance to wheat stem sawfly in six consecutive seasons at Suran in Syria.

Genotype	Percent of stems infested
mT-777 CI 9294/Fortuna	1.6
mT-773 CI 9294/Fortuna	3.3
Fortuna	3.4
Sawtana	4.3
mT-778 CI 11490/Fortuna	3.5
Limpopo	4.3
Lew	5.4
MP-112 (check; mean of 5 years)	25.0
Golan (check; 1983)	9.3

Suni Bug Incidence in Syria

As indicated by surveys, the suni bug is present in all bread wheat growing areas of Syria. As with durum wheat the greatest damage was detected in the Aleppo and Idlib provinces where on average 17 and 6% of seed, respectively, was damaged. These levels of suni bug damage seriously affect quality of the flour for bread making purposes. None of the 79 lines screened for suni bug damage was rated as resistant.

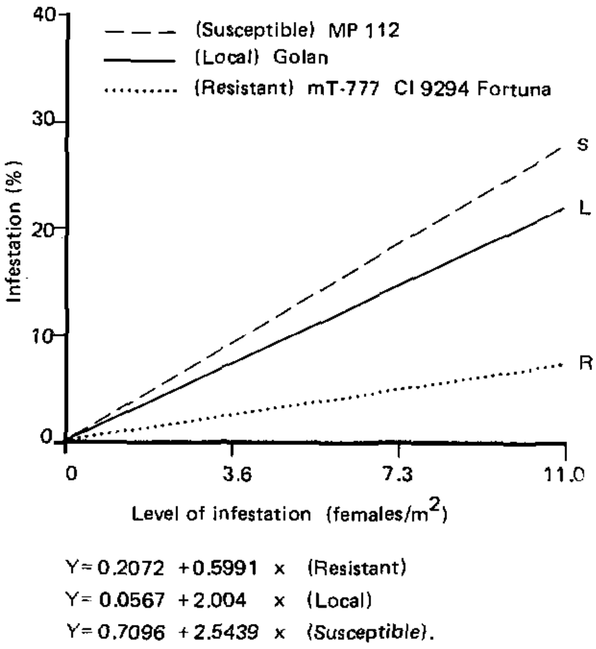


Fig. 7. Regression of four levels of infestation with wheat stem saw fly on the percent infestation in three bread wheat varieties, Tel Hadya, 1983.

Resistance to Cereal Aphids

When 79 bread wheat genotypes were exposed to a natural infestation of aphids, the same lines that showed resistance to wheat stem sawfly (Table 41) also showed moderate resistance to aphids. Other accessions with a moderate resistance to aphids were PH 93 and PH 94.

Project IV: Triticale Improvement

Triticale can produce more grain than bread wheat or durum wheat in more favorable rainfed areas and may also possess a higher level of disease resistance and in some cases stress resistance. Emphasis is placed on improving the grain quality to enhance the consumer acceptability of triticale. We are also evaluating triticale for its total phytomass production and its value as food and feed.

The program is addressing problems associated with drought resistance, leaf rust, and septoria resistance, winter survival, frost tolerance, yield stability, and yield performance.

Triticale types with different ranges of maturity possessing adequate winterhardiness have been identified and they are being used as parents. Lines that maintain their ability to produce acceptable grain yields under drought stress also have been identified and tested over a wide range of climatic conditions.

Identification of the triticale line Tetraprelude//OD 289/Bgl is of special interest for the triticale project of ICARDA. It has plump grains, makes excellent bread, and was selected from a cross known to carry a 1A/1D translocation which resulted in the movement of genes that changed flour quality from 1D to 1A.

The available data show that several triticale lines have better resistance than wheat to many of the more important diseases.

Component 1: Breeding

Strategies to Improve Triticale Production

The triticale project at ICARDA is trying to combine the gene pools of bread wheat, durum wheat, and rye, and is selecting plants with desirable and economically important traits. Combining the large yield of wheat with the tolerance to environmental stresses of rye is the major objective. Improvement of grain quality for several possible consumer uses also receives high priority.

The triticale project has adopted a breeding strategy aimed at developing germplasm which performs relatively well under less favorable environments while allowing good exploitation of the favorable ones. We are trying to achieve these objectives through screening of parental materials for tolerance to specific stresses prevalent in the region. Superior parental lines are then combined and the early-generation populations are exposed to stress environments to allow the identification and selection of superior gene combinations under these conditions.

Emphasis is placed on multilocation testing of the advanced lines in carefully selected sites in North Africa and West Asia. The testing and screening are done in barley, durum, and bread wheat nurseries to compare the performance of triticale with that of the other three cereal crops.

Different sowing dates are used at Tel Hadya to create differences in crop maturity and climatic stresses. Early sowing exposes the plant to frost during the susceptible stages of plant development (tillering and flowering stages), while late sowing exposes the plant to frost at a different stage of development and to heat and drought during grain filling.

The drought stress sites, Breda and Khanasser, with low annual precipitation (275 and 242 mm, respectively) are used for testing and selection of advanced and segregating generations.

Research on grain quality is also being conducted with a view to identify triticale germplasm with desirable and stable quality characteristics.

Development of Germplasm

Parental lines have been identified for large grain yield; resistance to fungal diseases, leaf rust, yellow rust, stem rust, and *Septoria tritici*; resistance to insects (sawfly and hessian fly); tolerance to frost and drought; and for good industrial and nutritional qualities. They are now being used in the crossing program. As many as 394 crosses were made in the 1982/83 season. A large proportion of the crosses was for kernel-quality improvement, especially with the parental lines carrying hard plump kernels and good bread-baking quality. Emphasis was also placed on stress tolerance, especially drought and frost. Triticales were crossed to rye, bread wheat, and durum wheat to incorporate more desirable traits from rye and wheat into triticale.

Segregating populations from F_2 to F_6 were screened and selected at Tel Hadya, under rainfed conditions, late-sowing management, simulated-grazing conditions, and at Breda under moisture stress. Selections were made under each condition for tillering capacity, number and size of spikes, earliness, height, kernel quality, and disease and insect resistance.

Evaluation of Germplasm

Replicated advanced yield trials (ATYT) of 114 lines were conducted under rainfed conditions (60 kg N/ha, 40 kg P_2O_5/ha) at Tel Hadya in the 1982/83 season. The largest yield achieved was 4023 kg/ha. The durum check variety Sahl was significantly outyielded by 10% and the bread wheat check variety Golan by 9% of the lines (Table 42). The tillering capacity of the majority of the lines which outyielded the wheats was medium to high and their heading dates were earlier than those of the wheats. Their heights were between 100 and 115 cm at Tel Hadya and 60 and 75 cm at Breda, whereas Golan measured 80 cm at Tel Hadya and 50 cm at Breda. They had better tolerance to frost and better growth during the seedling stage than wheats.

The average yield of the triticale lines tested in the ATYT was larger than that of bread and durum wheat and the triticale check Beagle. Table 43 shows the average yield of the five best yielding triticale lines in ATYT in comparison to the average of ATYT and the checks. The average of the ATYT lines exceeded the bread wheat check Golan by 3%, and the five best triticale lines exceeded Golan by 34%. This increase again shows the triticale grain-yield potential under rainfed environments.

In the preliminary yield trials (PTYT) 304 triticale lines were tested under rainfed conditions. The results show that 3% of all the lines significantly outyielded Golan, and 6% exceeded the durum wheat check Sahl (Table 42). The average yield of the five best triticale lines

Table 42. Number and percentage of triticale lines significantly out-yielding ($P<0.05$) wheat checks at Tel Hadya, rainfed, 1982/83.

Wheat checks	ATYT		PTYT	
	Number	Percent	Number	Percent
T. *aestivum* (Golan)	10	9	8	3
T. *durum* (Sahl)	11	10	17	6

ATYT (Advanced Triticale Yield Trials): 114 lines.
PTYT (Preliminary Triticale Yield Trials): 304 lines.

exceeded Golan by 38%, while the average of all the lines tested in PTYT was only 2% less than Golan (Table 43).

The capacity of a crop variety to yield under variable conditions and at a range of sites and over several years is as important as its yield potential. Table 44 shows the yield performance of some promising triticale lines over the last 3 years in comparison to durum and bread wheat checks. Genotypes which yield consistently well over many years are of great importance for

Table 43. Yield of Advanced (ATYT) and Preliminary (PTYT) Triticale Yield Trials, in comparison to the five best lines and checks at Tel Hadya, rainfed, 1982/83.

Entry	ATYT (114 entries)		PTYT (304 entries)	
	kg/ha	Percent	kg/ha	Percent
Average yield: All entries	2815	103	2729	98
Average yield: 5 best triticales	3735	134	3829	138
Average yield: Durum (Sahl)	2686	98	2704	98
Average yield: Bread wheat (Golan)	2736	100	2774	100
Average yield: Triticale (Beagle)	2674	98	2658	96

Table 44. Grain yield (kg/ha) of selected triticale lines over 3 years, 1980-83.

Entry	Year		
	1980/81	1981/82	1982/83
Drira Outcross 3	3950	4600	3124
Drira Outcross 12	3500	4800	3167
1A/M2A//Pi62/3/Bgl	3894	5058	3552
Tej/Bgl//NV'S'	3756	3758	3015
Checks			
Durum (Sahl)	2651	2876	2686
Bread wheat (Golan)	2695	3665	2739
LSD (5%)	672	568	383
CV (%)	14	12	11

Table 45. Performance of three triticale lines at 13 locations in North Africa and West Asia, 1982/83.

Entry	Yield kg/ha	Disease Scores[1]				
		Yellow rust	Leaf rust	Stem rust	*Septoria tritici*	Powdery mildew
Drira Outcross	4567	1	1	0	0	0
Bgl/Addax	4500	1	0	0	0	0
IRA/Bgl	4593	0	1	0	0	0
Durum (Waha)	4080	2	3	4	6	5
LSD (5%)	549					
CV (%)	13					

rainfed environments. Table 45 shows the average performance of three triticale lines across 13 locations in North Africa and West Asia. Among these lines is Drira Outcross. This line has shown good yield potential across a wide range of environments for the last 2 years. In addition, these lines demonstrated a high level of resistance to the prevalent diseases in this region.

Yield Potential of Triticale under Different Sowing Dates

Table 46 shows the performance of some triticale lines which produce a relatively large grain yield under different sowing dates, i.e., they are less affected by advancing or delaying the date of sowing. The frost tolerance of these lines during the vegetative stage and their ability to tiller quickly during a short growing period and withstand heat and premature desiccation during the grain filling stage were the main factors determining their ability to perform well across both early and late sowing dates.

Grain Quality

Generally, bread made from triticale flour has poor strength, is heavy, and has a short shelf life. To overcome this problem, at least in part, we are using the 1A/1D translocation lines developed at Winnipeg, Canada, to incorporate genes located on chromosome 1D into the 1A chromosome in triticale. Table 47 shows the quality characteristics of some triticale lines in comparison with the check Golan. The results also indicate the combination of large grain yield with quality in triticale.

The preliminary evaluation of triticale germplasm for quality characteristics illustrates the large variability available in our material. The range for protein varied from 12 to 17%, the 1000-kernel weight 35-55 g, and the hardness index 6-29. This range encompasses the hardness of durum and bread wheats. For the wheatmeal fermentation time the range was from 20 to 260 minutes. This large variability in the quality characteristics demonstrates the possibility of using triticale grain for different cereal products.

Table 46. Yield performance of some triticale lines under different sowing dates at Tel Hadya, 1982/83.

Entry	Grain yield (kg/ha)			Frost tolerance[1]	TKW[2] (g)
	Early sowing	Rainfed	Late sowing		
Jllo 100	5772	3910	2109	7	47
Drira Outcross 13	5500	3732	1572	8	51
Jllo 90	5845	3658	2545	8	48
Jllo 97	5836	3648	2000	7	47
IA/M2A//Pi62/3/Bgl	5800	3552	1545	7	50
Jllo 95	5381	3727	2091	7	49
Checks					
Barley (Badia)	4942	4115	2027	4	51
Durum (Sahl)	5844	2686	1272	3	43
Bread wheat (Golan)	5736	2791	1320	4	30
LSD (5%)	822	389	642		
CV (%)	12	7	15		

1. Scale for frost tolerance: 1, low; 5, medium; 9, high.
2. TKW: 1000-kernel weight, calculated from late sowing management.

Table 47. Grain quality of some triticale lines, in comparison with the wheat check.

Entry	Percentage yield relative to Golan	Protein content (%)	TKW[1]	PSI[2]	TW[3]
Drira Outcross	120	12.3	40	16	75
Selfert/Cineum//Bgl	113	12.0	47	19	75
Gq/3/M2A/Ira//Bgl	109	12.0	43	17	74
Bread wheat (Golan)	100	11.7	28	20	77

1. TKW = 1000-kernel weight.
2. PSI = Particle size index (hardness).
3. TW = Test weight (hectoliter weight).

For enhancing the production level in such areas, ICARDA's high-elevation cereal research project has two major components: (1) germplasm development and (2) development of improved production methods.

Component 1: Germplasm Development

The breeding program seeks to identify germplasm which is better adapted to the stresses of these areas, employing one of the local parents in the crossing program followed by multilocation testing and selection of early generation material at Terbol, Lebanon; Annaceur, Morocco; Quetta, Pakistan; and Sarghaya, Syria.

There was a wide range in growth habit from short-duration spring types to long-duration winter types in the material sown at the testing sites. The majority of the genotypes originated from winter x winter or winter x spring crosses. All the crosses involving winter x winter and winter x spring types were made at Tel Hadya where the temperature during the winter months is cold enough to fulfil the vernalization requirements of winter-habit material.

Project V: High-Elevation Cereal Improvement

Eight of the countries in ICARDA region, Afghanistan, Algeria, Iran, Iraq, Morocco, Pakistan, Turkey, and Yemen, have a significant land area at high elevation (1000 meters and above). The production per unit area in these mountainous areas is low due to several factors: lack of large-yielding, better-adapted varieties; scanty or no information on cultural practices such as seed rate, sowing time, fertilizer requirements; frost, heat, and drought at the reproductive phase; and weeds and diseases (stripe rust, bunt, and tan spot).

High-elevation areas have received relatively little attention in cereal production improvement programs in the past and that was restricted, in the majority of cases, to testing of technologies developed for the lower elevation areas. Due to complex environmental factors the technologies of lower elevation areas do not often prove successful. Our studies during the past 2 years indicate the need for a special plant ideotype which should have a longer vegetative phase and shorter reproductive phase with adequate cold, drought, and disease tolerance to enhance production per unit area.

The majority of the lines/varieties tested in the form of observation nurseries and yield trials originated from national and international winter wheat improvement programs. Two types of yield trials were conducted: Initial Winter Bread Wheat Yield Trials, and Comparative Performance of Winter Cereal Yield Trials. The augmented design was used for yield-testing the large numbers of genotypes entered in the Initial Winter Bread Wheat Yield Trials, whereas the randomized block design was used for the Comparative Performance Trials.

Besides the yield data, selections were also based on cold tolerance, resistance to diseases such as rusts, bunt, and tan spot (*Helminthosporium tritici-repentis*), and agronomic type. The locations in Terbol and Sarghaya provide useful information on frost tolerance and on agronomic type.

Observation Nurseries

The number of lines selected in the Winter Bread Wheat Observation Nursery (WBWON) was 38 (25%), 13 (9%), and 85 (57%) at Annaceur, Morocco; Quetta, Pakistan; and Tel Hadya, Syria, respectively (Table 48). In the Winter Durum Observation Nursery (WDON), out of 400 entries only 10.4, 8.8, and 31.8% of lines were selected at Quetta, Annaceur, and Tel Hadya, respectively. The proportions of lines selected in the Winter Barley Observation Nursery (WBON) were 14% at Quetta, 14.1% at Annaceur, and 26% at Tel Hadya. Selections were based on agronomic score, resistance to diseases, and cold tolerance.

ICARDA and AZRI researchers test new varieties and agronomic practices at the high-altitude site in Quetta, Baluchistan.

In general the genotypes performing best differed at different sites; however, about 4% of the selected lines performed well both at Quetta and Annaceur. Five of the best lines selected in the WDON and WBWON from Quetta and Annaceur are listed in Table 49. Of these, entry numbers 90 (Mugan) and 321 (Bit'S'/Gdo VZ 394) in WDON were among the 4% that performed well at both sites.

Table 48. Number of lines selected out of tested winter cereal germplasm at different sites, 1982/83.

Nursery	No. of entries	No. of selected entries Quetta Pakistan	Annaceur Morocco	Tel Hadya Syria
Winter Barley Observation Nursery	150	21	22	39
Winter Durum Observation Nursery	400	42	35	127
Winter Bread Wheat Observation Nursery	150	38	13	85
Initial Winter Bread Wheat Yield Trial	150	31	13	56
Initial Durum Wheat Trial	178	11	6	99

Table 49. Promising lines/varieties selected out of WDON and WBWON at Quetta, Pakistan, and Annaceur, Morocco, 1982/83.

Quetta		Annaceur	
Entry No.	Line/variety	Entry No.	Line/variety
		Durum wheat	
90	Mugan	90	Mugan
271	Magh'S'/Jor'S'/3/Gll 'S'//61-130/Lds'S'	163	MG 5231
		272	Ureyik 126/61-130//Kohak 2916/Ld'S'/3/Sincape 9
321	Bit'S'/Gdo VS 394		
109	MG 568	321	Bit'S'/Gdo VS 394
335	Gorm'S'/Gdo VS 394	368	TC60/4/62Fn/Gll'S'//Gta 'S'/3/Ibis'S'
		Bread wheat	
40	Bezostaya	3	Paiyu Pao
44	Alba/Gns//Fn/SN	53	Agm/Hys//7C
110	NS 984-1/NE 701136	58	Dj/Bza//WA-II-5204-2P-1H-0P
118	Lovrin 6/Samson	83	Asp/Hys
124	63T 113	141	Quetta 1

The low percentage of better performing lines in WBWON at Quetta and Annaceur may be because those lines were developed and selected under different environments and in the presence of different disease complexes. Most of those lines were selected under continental types of climate where the winters are wet and severe and summers are mild. Lines selected under these conditions have a longer vegetative period, a longer reproductive phase, and a low level of moisture-stress tolerance. On the other hand, Quetta and Annaceur have cold winters but short springs and hot summers characterized by moisture stress. Under such conditions the short-duration, winter-hardy lines performed best. This observation has indicated that for this type of environment the successful varieties should have a longer vegetative phase, short reproductive phase, more tillers/plant, and short heads which will facilitate drought escape. The severe cold at these sites may have been responsible for the low percentage of selection of superior lines in the WDON and WBON.

The second major factor which impedes broad adaptation of genotypes is the difference in the disease complexes at different sites. The most serious diseases at Quetta were stripe rust and common bunt and most of the lines were found to be highly susceptible. On the other hand, at Annaceur the serious diseases were tan spot (*Helminthosporium tritici-repentis*) and stripe rust. Tan spot appears almost every year in an epiphytotic form. The materials screened at Annaceur were not specifically developed for this area, so they could not withstand those two diseases. The differential performance of varieties in the two environments is illustrated by the case of the variety Local White. It was selected as being highly resistant to all diseases at Annaceur, but was highly susceptible at Quetta.

Segregating Populations

Bread wheat, durum wheat, and barley F_2 populations were planted at Quetta, Annaceur, and Tel Hadya.

As compared to barley a higher percentage of progenies was selected in the case of wheats. This can be attributed to the fact that in the majority of the crosses one of the parents was from the high-elevation areas of the region which presumably contributed to adaptability. The lower percentage of selected populations in the case of the barleys may be due to a lower level of cold tolerance and disease resistance, since most of the local germplasm from high-elevation areas is of spring habit (except for a few intermediate types from Iran).

Yield Trials

Initial yield trial of bread wheat. In 1982/83, 150 lines were tested in the initial yield trials at Tel Hadya and Quetta. The data on the four best yielding entries are presented in Table 50. Two of the best yielding lines at Quetta (entries Nos. 56 and 91) were of Turkish parentage; the other two lines originated from winter x spring crosses with multiple parentage from Oregon. However, none of these lines was among the best yielders at Tel Hadya. There were a few genotypes which were selected at both sites but they were not the best yielders.

Comparative performance of winter cereals. The comparative performance of the best genotypes of barley, durum wheat, bread wheat, and triticale was tested at Quetta, Annaceur, and Tel Hadya. The yield and plant height data are presented in Table 51. The varietal mean data for different species indicate that at Quetta, a low (250-300 mm) rainfall environment, barley gave the largest yield, followed by triticale and bread wheat. Durum

Table 50. Best yielding lines in Initial Winter Bread Wheat Yield Trial at Quetta, Pakistan, and Tel Hadya, 1982/83.

Entry No.	Line/variety	Yield (kg/ha)	% increase over checks A	% increase over checks B
Quetta				
75	Inia 66(R)//Hhgn/DRC SWO 71218-04H-0H-2H-3P-0H	6078	85.6	78.4
56	Eys/Bolal//P101/3/1150-18 Stacat YA 6203-18A-0A	5167	57.8	51.7
21	Kvz/3/HD/On/Bb/4/Ypopr/3/Rbs/55-1744/ Su//Gns SWO 73097-90-2P-4H-3H-0P	4667	42.5	37.0
91	Kanred/Funo//119933-3B-1Y-1B-1T YA 4302-3A-2A-1A-1A-0A	4653	42.1	36.6
A	Bezostaya (check)	3275		
B	Zargoon (check)	3407		
Tel Hadya				
28	Spn/Au/Ymh	3250	37.5	52.2
66	DJ/Bza//WA-II-5204-2P-1H-0P	2792	18.1	30.8
64	Lfn/D180//Kol/Len SWO 70469	2708	14.6	26.9
26	Ron-Tast/Bon, F1/3/Dibo//Su92/CI 13645	2667	12.8	24.9
A	Mexipak (check)	2363		
B	Bezostaya (check)	2135		
LSD (5%) for Quetta		1435.9		
for Tel Hadya		316.5		

Table 51. Mean plant height and yield of winter cereals at Quetta (Pakistan), Annaceur (Morocco), and Tel Hadya (Syria), 1982/83.

Line/Variety	Plant height (cm)				Yield (kg/ha)		
	Quetta (1)	Annaceur (2)	Tel Hadya (3)	% reduction 3 and 2	Quetta	Annaceur	Tel Hadya
Barley							
Badia	104.3	65.7	105.0	37.4	2044	2355	1035
Alger/Ceres	91.0	56.3	93.3	39.7	1377	2355	1408
Colonial	120.0	52.3	120.0	56.5	1333	1555	754
Beecher	111.3	62.3	106.7	41.7	1688	2622	693
Reno	114.7	61.6	120.0	48.7	1066	1200	968
ER/Apam	94.7	38.3	76.7	50.1	2355	2044	671
Local check	120.7	68.0	81.7		2577	1466	1262
Durum wheat							
BD 1658	143.7	80.7	131.7	38.7	1111	3333	933
BD 272	124.3	74.7	133.3	44.0	755	386	497
MC 502	106.3	70.0	125.0	44.0	933	4133	600
MG 422	119.3	73.3	116.7	37.2	1066	3555	1524
Waha	94.7	67.7	93.3	27.4	1155	4622	1524
Simaroon/Sari Bursa	85.7	60.0	83.3	28.0	1244	4711	1435
Bread wheat							
NS 18-30	91.0	60.0	91.7	34.6	1200	3688	1631
F 29-76	85.0	53.3	95.0	43.9	1111	4844	1106
Stephens	90.1	48.3	85.0	43.2	844	4754	720
Qt 4081-PWTH/3Cndr.	101.0	70.0	93.3	25.0	2000	4088	1324
Chambord/5133	124.0	63.3	126.7	50.0	1244	3066	760
Bezostaya	100.7	68.0	106.7	36.3	1466	4088	1395
Local check	126.0	65.7	98.3		2311	4532	1417
Triticale							
Juanillo 90	119.3	93.3	123.3	24.3	1466	4177	1706
Selfert/Cineum	124.7	91.7	126.7	27.6	1511	4443	1173
Cin/Pi	128.7	88.3	121.7	27.4	1600	3999	1168
Drira Outcross	129.7	88.3	120.0	26.4	1866	4043	1564
LSD (5%)	0.2	1.9	8.2		185.3	246.4	218.8

wheat gave the smallest yield. At Annaceur (375-475 mm rainfall), the triticales and bread wheat varieties gave the largest yield, followed by durum wheat, with barley yields being the smallest.

Intervarietal differences within the species were statistically significant. Only one barley line (ER/Apam) statistically equalled the check variety at Quetta; others were significantly smaller yielding. However, at Annaceur all the barley entries, except Reno, outyielded the check variety. At Tel Hadya only ER/Apam gave significantly smaller yield than the check. There were significant intervarietal differences in plant height at all locations. However, lines such as Badia and Alger/Ceres showed comparatively more stability in height and gave larger yields at all locations.

In the case of durum wheat, none of the entries was found to be significantly better than the local bread wheat check at Quetta. At Annaceur all entries outyielded the local durum varieties, BD 1658 and BD 272. The variation in plant height was significant at all locations. However, varieties such as Waha and Cimarron/Sari-Bursa, showed minimum fluctuation in their plant height and gave consistently better yield in all three environments.

Only one bread wheat line, Qt 4081-PWTH/3Candor, yielded equal to check varieties and the rest of the entries were significantly smaller yielding at Quetta. However, under Annaceur conditions four entries, F 29-76, Stephens, Qt 4081-PWTH/3Candor, and Bezostaya yielded better than, or equal to the check variety. The performance of entry Nos. 17 and 19 was good at Tel Hadya as well as at other sites.

Significant differences in plant height among different varieties were obseved at all locations. The influence of environment on plant height was very obvious (Table 51) as the reduction in height at Annaceur as compared to Tel Hadya ranged from 25-50%. The entries which had minimum reduction in plant height gave larger yield under all three environments. The line Qt 4081-PWTH/3Candor with the least reduction (25%) was remarkable in its performance at all the locations.

Component 2: Agronomy

To determine the seed rate for different varieties and response to fertilizer application, experiments were carried out at Pishin and Khan Mehterzai in Baluchistan province of Pakistan.

Effect of Seed Rate

Trials were conducted to determine the effect of seed rate on the yield of wheat in the semi-arid environment at Pishin. No single seed rate was found to be significantly better for all varieties (Table 52). Most varieties responded differently to different seed rates; however, the effect of seed rate was not significant for the varieties Local White and S311 x Norteno. The mean yields of varieties were significantly different, however.

Effect of N and P Fertilizers

The effect of N and P fertilizers on the yield of wheat varieties, Local White (unimproved) and Zargoon, was studied at Pishin and Khan Mehterzai. The varieties differed significantly in their yield at both sites. Zargoon gave a larger yield than Local White at both sites under all

Table 52. Effect of seed rate on the yield (kg/ha) of wheat varieties at Pishin, Pakistan, 1982/83.

Variety	Seed rate (kg/ha) 60	120	180	Variety mean
Local White	2800	2880	2640	2773
S 311 x Norteno	3280	3120	2240	2880
Zargoon	2960	4000	4160	3707
Zamindar	3600	2720	3360	3227
Bezostaya	3040	3760	2880	3227
Average	3136	3296	3056	

LSD (5%) for comparison of variety x seed rate combination = 568
LSD (5%) for variety mean = 328

fertility levels. Both varieties responded highly significantly to nitrogen fertilizer (Table 53). The increase in yield with the application of nitrogen fertilizer was much greater in the case of Zargoon than Local White.

In the case of phosphate application a significant increase in yield (14%) was obtained but no phosphate x variety interaction was found. The effect of nitrogen application was much more pronounced than phosphate.

Project VI: International Cooperation

The impact of ICARDA's research on farmers' yields has to come about through the transfer of technology by national programs. Therefore, we place considerable emphasis on exchange of germplasm and scientists' visits with national programs and accord priority to training their staff in research. Workshops, conferences, and publications constitute key elements in the process of establishing and strengthening these linkages.

Component 1: Collaborative Projects

During 1982/83, collaborative efforts between the Cereal Improvement Program and Syria, Pakistan, and Morocco were considerably strengthened. Progress continued in cooperative programs with Tunisia and Cyprus. This was the last year of the Cooperative Winter Cereals Improvement Project in Jordan, funded by the Ford Foundation and the Government of the Netherlands.

Syria

The collaborative research program between the Syrian Ministry of Agriculture and Agrarian Reform, represented by the Agricultural Research Centre (ARC), and the Cereal Improvement Program of ICARDA, conducted several joint research trials during the 1982/83 season (Table 54). They included several nurseries of crossing blocks, segregating populations, and different types of yield trials as well as agronomy, disease, and entomology nurseries. The trials were jointly planted at 14 research stations, extending from Dera'a in the south to Qamishly in the north and from Jableh and Lattakia near the coast to the steppe and the range beyond Aleppo and Hama.

Farmers' field verification trials. In addition to the above mentioned trials, the collaborative research program conducted 57 variety

Table 53. Effect of N and P fertilizers on the yield (kg/ha) of wheat varieties at Pishin and Khan Mehterzai, Pakistan, 1982/83.

Site/variety means N + P	Khan Mehterzai Local White	N x V mean	Zargoon	N x V mean	N mean	Pishin Local White	N x V mean	Zargoon	N x V mean	N mean
0 + 0	640		1040			1760		2800		
		800		1120	960		2000		3080	2540
0 + 40	960		1200			2240		3360		
30 + 0	1360		1840			2960		3760		
		1480		1960	1720		3468		3960	3560
30 + 40	1600		2080			3360		4160		
60 + 0	1760		2880			3680		4400		
		1960		3000	2480		3960		4600	4280
60 + 40	2160		3120			4240		4800		
90 + 0	1840		2960			3760		4480		
		2040		3160	2600		4080		4720	4400
90 + 40	2240		3360			4400		4960		
120 + 0	1920		3040			3840		4560		
		2120		3280	2700		4160		4800	4480
120 + 40	2320		3520			4480		5040		

Khan Mehterzai:
LSD (5%) for variety = 136
LSD (5%) for N x V means = 312
LSD (5%) for N means = 216

Pishin:
LSD (5%) for variety = 96
LSD (5%) for N x V means = 208
LSD (5%) for N means = 152

Table 54. Number of joint cereal research nurseries and trials conducted in Syria, 1982/83.

Crop	Nursery or trial: Crossing block (entries)	Disease nurseries	Segregating populations	Yield trials	Agronomy trials
Barley	460	5	300	9	27
Durum wheat	150	5	265	22	28
Bread wheat	150	5	259	5	22

verification trials on wheat and barley on farmers' fields in different ecological zones in the country, with a view to test a range of cereal varieties and production practices found to be promising under more controlled conditions on research stations. This type of research is very important in providing technologies suitable for increasing cereal productivity at the farm level.

Results of this collaborative research program have been promising. Two new wheat varieties identified by this program were approved by the National Variety Release Committee in Syria in 1983. Detailed descriptions of these two cultivars are given in other sections of this report.

More promising lines for the future are currently being tested. Sebou and *Korifla durum* wheat lines ranked first in the 1982/83 season under irrigation and in Zones A (>350 mm rainfall) and B (250-350 mm rainfall) in comparison with the national checks Gezira 17 and Haurani which ranked the last at those locations. Sebou exceeded the national check (Gezira 17) by 38, 20, and 13% under irrigation and in Zones A and B, respectively, while Korifla exceeded the national check (Haurani) by 17% in Zone B where this line was tested.

Two high-yielding bread wheat *lines* were also identified in the 1982/83 season, which topped all others at all locations: Pato-Cal/7CxTob which exceeded the national check (Mexipak) by 21, 13, and 1% under irrigation and in Zones A and B, respectively; and Flk'S'-Hork which exceeded the national check by 19 and 23% under irrigation and in Zone A, respectively. Grain quality and disease resistance of these lines are also acceptable, and they will be further evaluated in 1983/84. The national program has identified many superior yielding and disease-resistant lines for further use.

Agronomy. Thirty-five agronomy trials were conducted on farmers' fields to determine important agronomic factors in wheat and barley production in different areas of the country. Results, more thoroughly discussed in other sections of this report, indicated that substantial yield increases can be obtained with adequate nitrogen fertilizer in Zones A and B. Phosphorus fertilizer, while not as important in these two zones, is more effective in increasing barley yield in Zone C.

Diseases and insects. Disease development was observed in farmers' fields in wet conditions particularly in El Ghab area and in irrigated fields at Lattamneh, Homs, and Sahm Golan. Bacterial leaf streak caused by *Xanthomonas transluscens* was observed on wheat cultivars *Gezira 17, Bouhouth 1, and Bouhouth 3.* Development of yellow rust (*Puccinia striiformis*) was severe on several cultivars, particularly Mexipak. Leaf rust (*P. recondita*) was also observed in several fields at Sahm Golan and Homs. Barley stripe disease (*Pyrenophora graminea*) was observed on ER/Apam.

Infestation by stem sawfly was more severe this season than in previous ones, particularly in Suran and Saraqeb. Damage by this insect was observed on the barley variety Arar, the bread wheat Sannine/Alondra, and the durum wheat Sahl.

Pakistan

A pilot collaborative cereal research program between the Government of Pakistan and ICARDA has been in operation for the past two seasons in Baluchistan. It functions from the Arid Zone Research Institute in Quetta and the Provincial Agricultural Research Institute at Sariab, and is concerned with evaluation of cereal germplasm and production technology in the environments of highland Baluchistan. The collaborative program is supported by only a small budget. ICARDA supplies germplasm and some items of a capital nature (e.g., a vehicle and threshers), expertise from base program to assist with design and management of research, a small element of training, and a contribution towards operating expenses. The National Institute provides scientific and technical staff for the conduct of the trials, land, laboratory and field facilities, and operating expenses.

The results to date have revealed some of the factors that severely limit cereal yields in the region. Two diseases, stripe rust and common bunt, are responsible for major losses. Control of the former is practical only by genetic resistance. The Provincial Breeding Program has identified and named two well-adapted stripe rust resistant varieties, Zargoon and Zamindar. The yield trials show that yields up to 7000 and 3000 kg/ha can be achieved with well-managed irrigated and rainfed crops, respectively, against the current yield levels of 4000 and 300 kg/ha. However, farmers are unable to make full use of the new varieties or practices due to the lack of an effective seed increase and distribution scheme and on-farm demonstration program. Some control of common bunt could be achieved with seed dressings, such as Vitavax and Benylate. Seed treatment increased yield of the Local White variety from 323 to 866 kg/ha without irrigation.

Production trials show a widespread response to nitrogen fertilizer in Baluchistan. Yields of 600 and 2800 kg/ha of local and improved varieties were obtained with an application of 100 kg N/ha and 30 P_2O_5/ha. This compares with corresponding yields without fertilizers of 300 and 500 kg/ha, respectively. Plant population experiments demonstrated that 100 kg/ha was the optimal seed rate.

Beginning in the 1983/84 season, FAO is contributing funds of U.S.$ 18,000 over a 2-year period for large-scale demonstrations of improved varieties and production technologies on farmers' fields in Baluchistan.

Morocco

Cereals are grown on 80% of the cultivated area in Morocco and contribute approximately 50% of the cash value derived from plant production. Sixty percent of the cereal acreage is planted to barley, 31% to durum wheat, and 9% to bread wheat. The production areas include a variety of agroclimatic conditions, ranging from semi-arid to high rainfall, from low-elevation to mountainous areas, with each environment presenting its own challenge to growers and scientists.

Yields per unit area are relatively low. Low-yielding varieties, disease and insect pests, a combination of low fertility and limited use of fertilizers, moisture stress, and weed competition are some of the main factors responsible for the current low level of productivity.

Besides the international nurseries, special germplasm was planted in 1982/83 at Annaceur and several other research stations. Material planted at Annaceur was primarily intended for use in high-elevation areas, whereas other locations enabled screening for septoria, tan spot, and hessian fly. Some of the barley and durum lines have been identified as promising and are being extensively tested by the national program. We hope to further extend and strengthen cooperation with the Morocco national program.

Tunisia

The 1982/83 season was the third year of the collaborative cereal program between Tunisia and ICARDA. This season was characterized by continuous rains from October to January which accounted for 70-90% of total rainfall received during the season and caused delays in nursery planting. On the other hand, the period from February to April was very dry and resulted in a 24% reduction of national production, as compared to the 1981/82 season.

Barley yield trials were conducted in semi-humid locations at Beja, Koudiat, El Kef, and Moghrane and at low-rainfall sites, Hindi Zitoun and Tejerouine. Observation nurseries and segregating populations were planted in most of the locations, while disease nurseries were planted at Mateur and Beja.

Results obtained have been encouraging and three barley lines (ER/Apam, Roho, and WI 2198) have been submitted to the 'Office des Cereales' for further testing and demonstration to farmers at several locations. Seed from these three lines has been multiplied by INRAT to provide seed for further increase by national seed multiplication agencies during 1983/84. Possible release of one or more of these lines awaits performance results in 1983/84 season.

In the breeding work, artificial inoculation of disease nurseries permitted good screening against scald and leaf rust in barley as well as tan spot and leaf rust in durum wheat.

In Oct 1983, the collaborative program was jointly reviewed at Tunis by ICARDA and Tunisian scientists. The Tunisian counterpart appreciated the work done by ICARDA in establishing a functional barley breeding program. A Tunisian researcher was appointed as head of the barley program, and a request was made that ICARDA cereal scientists in Tunisia pay more attention to cereal diseases.

In the field of cereal technology there has been considerable exchange of information and visits between Tunisia and ICARDA in an effort to strengthen the cereal technology laboratory at INRAT. Visits to ICARDA's research farm at Tel Hadya were arranged for other Tunisian staff including the head of the Beja research station.

Cyprus

Our collaborative program with the Cyprus national program emphasizes selection of barley and wheat for conditions of mild winter and short growing season. The collaboration is in the form of selection and testing of the germplasm at two or three locations in Cyprus as well as in the development of germplasm with early maturity. A number of barley and wheat lines selected in Cyprus are early maturing and are performing well in countries where short duration is a desirable attribute. One of the durum lines (Sebou) which has given high grain yields in several countries was selected in Cyprus. This collaborative program has provided valuable testing sites and it is hoped that cooperation will continue beyond 1984.

Jordan

Our Jordan Cooperative Winter Cereals Improvement Project, conducted jointly by the University of Jordan and the Jordanian Ministry of Agriculture and funded by the Ford Foundation and the Government of the Netherlands, completed its fifth and final year of work. The project examined the economic and agronomic constraints which keep cereal production low in

Jordan. The aim was to develop a base of information in the different cereal-growing areas of Jordan which could be used to devise 'best-bet' improved practices that would optimize net return to farmers.

A final report and major recommendations are in preparation. Meanwhile, some conclusions can be drawn. It is clear that the greatest impact in increasing cereal production will come from applying improved practices to the moderate rainfall, cereal-growing areas (>250 mm). These areas are managed more intensively and the chances of adoption of new practices are better, because rainfall is more reliable. Lower rainfall areas (<250 mm) will continue to be a low-input, high-risk proposition, with emphasis on barley grain and straw for animal feed. In these areas, the adoption of improved practices will be low, except for nitrogen or phosphorus applications and weed control. Some of these lands could be more useful if reverted to natural pasture and grazing areas.

The results show enough promise that the improved practices should now be tried on large plots in target areas, with the objective of encouraging adoption by an increasing proportion of farmers each year. Funding is now being sought. The Ford Foundation has generously provided a 1-year grant to continue the work during 1984, while the next proposal is being considered by other agencies.

Lebanon

ICARDA and Lebanese scientists collaborate in cereal improvement for Lebanese conditions at the main station of Terbol in the Beka'a Valley. ICARDA scientists also utilize this station as a high-rainfall (>500 mm), colder site with higher disease incidence. Results from this station are used to complement the data from Tel Hadya. During the 1982/83 season, all planned activities were carried out successfully in spite of difficulties.

Project VII: International Nurseries and Data Feedback System

One of the major objectives of the Cereal Improvement Program is to provide the national programs with superior germplasm through the international nursery network for their own breeding programs.

The international nurseries also serve as cooperative testing vehicles and provide information on the extent of adaptation of genotypes. National programs are requested to provide their promising material to ICARDA for inclusion in the international nursery testing network.

Distribution of international nurseries to cooperators is a major activity of cereals program each year.

Table 55. ICARDA international nurseries and trials, 1982/83.

Nursery or trial designation	Number of sets distributed				
	Middle East	Africa	Asia	Europe	Others
Barley					
Regional Yield Trial (RBYT)	25	18	9	7	3
Observation Nurseries (BON)	17	17	9	8	5
Crossing Block (BCB)	14	13	9	2	5
Segregating Populations (BSP)	16	12	3	3	2
Key Loc. Disease Nurseries (BKLDN)	6	6	2		
Durum wheat					
Regional Yield Trial (RDYT)	22	9	8	7	1
Regional Yield Trial Rainfed (RDYT-Rf)	24	14	5	8	2
Observation Nurseries (DON)	19	16	7	11	2
Crossing Block (DCB)	15	11	7	7	5
Segregating Populations (DSP)	15	10	3	7	2
Key Loc. Disease Nurseries (DKLDN)	5	6	2		
Bread wheat					
Regional Yield Trial (RWYT)	31	17	10	7	1
Observation Nurseries (WON)	24	18	12	9	4
Crossing Block (WCB)	15	10	8	4	4
Segregating Populations (WSP)	17	8	6	3	1
Key Loc. Disease Nurseries (WKLDN)	6	6	2		

In 1982/83, 684 sets of different types of cereal germplasm were sent upon specific requests from 83 cooperators in 42 countries. The number and types of germplasm distributed to these countries are listed in Table 55. Segregating populations provide a source of genetic diversity for selection in the local environment, and will receive increasing emphasis in the future. Some national programs, lacking manpower and material, have requested ICARDA to provide them with special crosses. The planting of segregating material in locations with specific disease pressure can also be of great use in selection for resistance to diseases of importance in certain areas.

Varieties or advanced lines are screened for resistance to important diseases in the region through the Key Location Disease Nursery (KLDN). Those lines showing acceptable disease resistance and good yield potential in the region over 2-3 years are promoted to the International Observation Nursery. There is one observation nursery for each of the cereal crops. The observation nursery is critically examined for disease reaction, tolerance to prevalent stresses in the region, and general agronomic performance. The most promising lines are then promoted to the international yield trials.

Computerization of the data of the international nurseries and trials conducted in the base program has been started. A software package (CERINT) is under development. CERINT will assist the breeding program, from the production of F_1 generation fieldbooks through programs for segregating populations up to the analysis of regional yield trials. The program will store the data from each nursery in separate files making it possible to extract information on a given cultivar from several nurseries.

The data from the 1982/83 observation nurseries have been analyzed by CERINT. Fieldbooks for the KLDN 1983/84 have been produced. CRISP, the Crop Research Integrated Statistical Package, has been further developed to analyze and summarize data from yield trials. CRISP file structure is being refined to incorporate all its analysis and utility programs in CERINT. It is hoped that this will allow faster data feedback to our cooperators.

The early analysis and summarization of 1982/83 data from international observation nurseries and international yield trials made possible the preparation of a preliminary report which was sent by the end of Nov 1983 to cooperators in the region.

Project VIII: Cereal Training

The cereal training activities for 1982/83 are described in the chapter entitled «Training» in this report.

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FOOD LEGUME CROPS IMPROVEMENT

Contents

Cover: Kabuli chickpeas, faba beans, and lentils (left to right) are the three food legumes on which research is carried out by the Food Legume Improvement Program of ICARDA.

Food Legume Crops Improvement

Introduction

Increasing the productivity and yield stability of faba beans (*Vicia faba*), lentils (*Lens culinaris*), and kabuli-type chickpeas (*Cicer arietinum*) continued to be the major objective of the Food Legume Improvement Program (FLIP). These three food crops are important as a cheap source of high-quality protein in the diets of the people in West Asia and North Africa, as well as many other developing countries in the world. Incorporation of these legume crops in cereal-based rotations improves the overall productivity of the whole cropping system and reduces its dependence on nitrogen fertilizer. The by-products of these food legumes serve as valuable animal feed.

Food legumes are a cheap source of high-quality protein in the diets of the people.

ICARDA has a world responsibility for research on faba beans and lentils. Research on kabuli-type chickpeas is a joint activity with ICRISAT (International Crops Research Institute for the Semi-Arid Tropics), based in India, which has the world responsibility for research on chickpeas. A breeder and a pathologist from ICRISAT are based at ICARDA to complement research on kabuli-type chickpeas.

FLIP's past research has demonstrated that the major constraints to higher production of faba beans, lentils, and kabuli-type chickpeas include inherently low yield potential of the existing landraces; high instability in yield because of their susceptibility to a number of diseases, insect pests, parasites, and environmental stresses; and unimproved methods of production including expensive hand harvesting and lack of mechanized harvesting techniques. The major research emphasis of the program during the 1982/83 season therefore continued to be on devising ways and means to overcome these constraints.

Research on improvement of each of the three crops was organized into specific research projects, each involving a multidisciplinary team of researchers. The major research work was carried out at ICARDA's main station at Tel Hadya, following the prevailing cropping sequences for these legumes. For the development of faba bean genotypes and production techniques for assured moisture supply conditions, the crop was provided irrigation to supplement the seasonal precipitation. A coastal subsite at Lattakia (Syria) was used for studies on resistance breeding and control of faba bean diseases and some pests, as the environmental conditions there facilitate the development of artificial epiphytotics. This and other subsites in northern Syria (Jindiress, Kafr Antoon, Breda), with the ICARDA subsite at Terbol in the Beqa'a valley of Lebanon, provided a range of environments for evaluation of the genetic material and technology being developed in the program for wider adaptation. Such an evaluation is important before the improved genotypes and production techniques are transferred to national programs through international nurseries and trials for local testing and adaptation. To reduce the time needed for developing improved genotypes, off-season nurseries were raised in summer at high-elevation sites: for lentils at Shawbak in Jordan, for faba beans at Shawbak and Bab Janneh (northern Syria), and for chickpeas at Terbol (Lebanon) and Sarghaya (Syria).

The faba bean improvement projects included: (1) development of improved cultivars and production practices for West Asia, (2) development of genetic stocks for all regions, (3) development of cultivars and agronomic practices for production under low-rainfall conditions, and (4) development of alternative plant type. The research projects on lentil improvement included: (1) development of improved cultivars and technology for different agroecological situations, (2) development of wide adaptation, and (3) development of drought tolerance. The research on kabuli-type chickpeas was conducted in two projects: (1) development of improved kabuli chickpea cultivars and production technology, and (2) development of improved kabuli chickpea cultivars and production technology for winter sowing. Scientists from the Farming Systems Program collaborated with us in economic evaluation of production practices, control of weeds (including the parasitic weed *Orobanche* spp.), symbiotic nitrogen fixation, and soil fertility and soil moisture evaluation.

Our past results from international nurseries have highlighted the need for a more decentralized approach to breeding to ensure that national programs beyond the «home region» (Syria, Jordan, Lebanon) also benefit expeditiously from ICARDA' research. Efforts are, therefore, being made to select genotypes in localities where they are to be grown. A collaborative research project on food legumes started in Tunisia in the 1981/82 season with the posting of two ICARDA legume scientists, to form a base from which a decentralized breeding strategy for the North Africa region could be started. The applied special project on faba beans in the Nile Valley continued to provide an important regional dimension for food legume research in irrigated farming systems. The identification of sites at which to develop regional programs for high-altitude environments in West Asia and in the more southernly latitudes in the Indian subcontinent will enable us to meet the needs of national programs in those regions more effectively.

To get the best pay-off from the resources available to the program, our research efforts at the Center have been mainly of an applied nature. The collaborative projects with national programs have generally placed the emphasis on adaptive research. To meet the needs of basic research, support of advanced institutions is sought, and links have already been established with several institutions in Canada, France, Italy, The Netherlands, UK, and West Germany.

Faba Bean Improvement

Germplasm

The ILB[1] collection stood at 2853 accessions in Dec 1983. A total of 523 ILB accessions from China, Cyprus, Egypt, Morocco, Spain, and Sudan were multiplied in the screenhouse for the first cycle of selfing to produce BPL[2] accessions (Table 1). Approximately 2634 new BPL accessions will be developed from the ILB accessions. Seed was increased of 330 BPL accessions, and 560 BPL accessions were advanced one selfing cycle. For ILB accessions, 661 were increased in screenhouses and 696 in the open.

As many as 1365 accessions from both ILB and BPL collections were distributed to 18 countries including Canada, Egypt, Ethiopia, Morocco, Peru, Sudan, Tunisia, UK, USA, and Yemen Arab Republic.

Some of the BPL accessions were evaluated for resistance to ascochyta blight (*Ascochyta fabae*), chocolate spot (*Botrytis fabae*), rust (*Uromyces fabae*), and stem nematodes (*Ditylenchus dipsaci*), and results are described in a later section. Cooking time was also measured. It ranged from 85 to 320 minutes.

1. ILB = ICARDA Legume Faba Beans
2. BPL = Faba Bean Pure Line

Table 1. Number of lines grown in the screenhouse from the faba bean germplasm collections at Tel Hadya, 1983.

No. of lines	Material	Purpose
523	ILB	Develop BPL accessions from ILB accessions - 2634 BPL accessions derived.
560	BPL	Generation advance one selfing cycle.
330	BPL	Increase seed supply of advanced generation BPLs.
1357[a]	ILB	Increase seed supply of ILB accessions with low seed stocks.

a. Of these 696 were grown in the open.

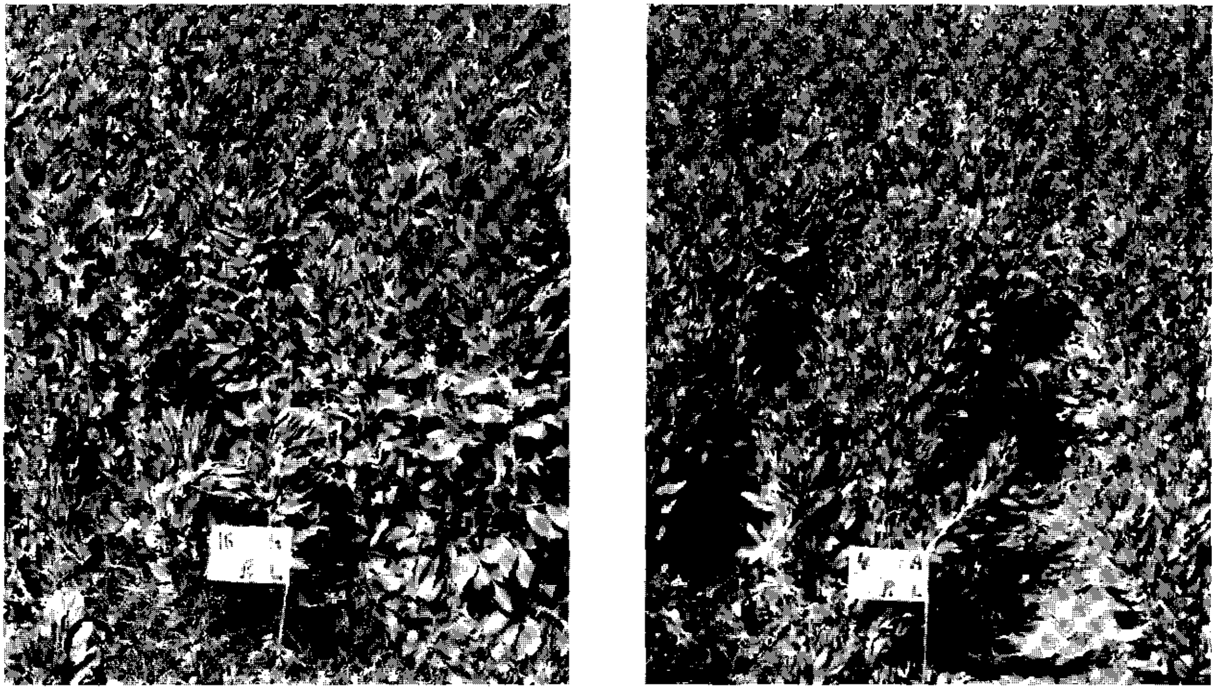
A collaborative project with the University of Reading, UK, continued to look at the possibilities of crossing *Vicia faba* with other species of the genus *Vicia*.

Improved Faba Bean Cultivars and Production Practices for West Asia

Faba beans in West Asia are grown under high rainfall/supplementary irrigation. To obtain high and stable yields, genotypes with high yield potential and resistance to *Ascochyta fabae*, *Botrytis fabae*, *Orobanche crenata*, and *Ditylenchus dipsaci* are needed. Emphasis was, therefore, placed on developing such genotypes and suitable production techniques including the control of diseases, insect pests, and weeds.

Development of Cultivars and Genetic Stocks

Sources of resistance to *Ascochyta* sp., *Botrytis* sp., and *Orobanche* sp., identified from the germplasm, have been increasingly used in the crossing program. For the 1982/83 season, 164



Crop growth in faba beans is substantially improved with irrigation. Left, more frequently irrigated; right, less frequently irrigated.

of 234 crosses involved at least one parent resistant to a parasite (Table 2). This approach of involving at least one parasite-resistant parent in each cross will continue. In addition, different sources of resistance were intercrossed for *Botrytis* (17 crosses) and *Ascochyta* (35 crosses) at Lattakia to increase levels of resistance and develop lines with resistance to more than one strain of the pathogens.

Table 2. Number of crosses made for each trait (excluding crosses for determinate plant type) at Tel Hadya, 1982/83.

Trait	Number of crosses
Orobanche spp. resistance	56
Ascochyta spp. resistance	66
Botrytis spp. resistance	42
Yield	28
Earliness	22
Drought resistance	20
Total	234

Yield potential. Replicated yield trials of 266 lines were conducted at Tel Hadya with irrigation during the 1982/83 season (Table 3). The highest yield reported in a replicated trial was 4080 kg/ha. A total of 43 entries exceeded the best check. Of these entries , 22 were large and 21 were small seeded. The number of lines tested in preliminary yield trials will be increased significantly by using two-row plots and two replicates.

At Terbol, 154 lines were tested in eight replicated trials. Plots were lost in one trial, so only seven trials were analyzed. There were 42 lines that exceeded the best check. Of these, eight were common to both Terbol and Tel Hadya.

Table 3. Summary of results from the irrigated faba bean yield trials grown at Tel Hadya in Syria and at Terbol in Lebanon, 1982/83.

Trials/nurseries (Number)	Number of lines tested	Tel Hadya: Highest yield (kg/ha)	Tel Hadya: No. of lines exceeding best check	Tel Hadya: CV (%)	Terbol: Highest yield (kg/ha)	Terbol: No. of lines exceeding best check	Terbol: CV (%)
Preliminary Yield Trials Large Seeded (2)	46	3820	6[a]	13-14	NG		
Preliminary Yield Trials Small Seeded (3)	66	4050	8[b]	12-17	NG		
Advanced Yield Trials Large Seeded (2)	43	3910	11[a]	12-13	3350	24[a,b]	21-22
Advanced Yield Trials Small Seeded (3)	42	3570	0[b]	15-16	3900	3[a]	18-21
Regional Yield Trial Irrigated	23	4070	4[a]	12	3450	8[a]	28
International Yield Trial Large Seeded	23	4080	1[a]	10	3550[a]	7	22
International Yield Trial Small Seeded	23	3680	13[c]	14	NA		
International Screening Nursery, Large Seeded[1]	30	4010	4[a]	10	NA		
International Screening Nursery, Small Seeded[1]	46	4490	16[b]	27	NA		

a. Best check was ILB 1814. b. Best check was ILB 1813. c. Best check was ILB 1812. 1. Unreplicated.
NA – Not analyzed due to loss of plots. NG – Not grown.

Thirty entries from the large-seeded and 46 *from the small-seeded* International Screening Nursery were tested at both Tel Hadya and Terbol. Data were available from the Tel Hadya trial only (Table 3). Of the tested lines at Tel Hadya, 4 and 16 exceeded the best check for the large- and small-seeded trials, respectively.

From 446 lines tested in preliminary screening nurseries for small-seeded lines, 134 were selected for testing in preliminary yield trials in 1983/84, and from 127 lines tested in large-seeded preliminary screening nurseries, 54 were selected.

Disease resistance. Most of the disease resistance work was carried out at Lattakia, where environmental conditions were conducive to the development of natural epiphytotics. To ensure proper screening, however, artificial *epiphytotics were developed.*

Ascochyta blight: Various sources of resistance were used to make 66 crosses for ascochyta blight in 1982/83 and these will be screened in 1983/84 at Lattakia. From the screening of 1080 F_4lines, 63 were found resistant with a disease score of 3 or lower on a 1 to 9 scale. Of these, 45 were increased in the off-season nursery for preliminary yield trials in 1983/84. From 2252 F_3 lines, 855 single-plant selections were made. F_2 populations were also tested and 135 single plants were selected.

Chocolate spot: Adopting a two-cycle screening technique, considerable progress was made in identifying promising sources of resistance to *B. fabae*. Of 574 F_4 lines tested, 187 rated resistant (3 or lower score) and 45 of them were increased in the off-season nursery for preliminary yield trials. From F_2 populations, 839 single-plant selections were made and will be screened in the 1983/84 season. Forty-two new crosses were made and the F_1 grown in the off-season. These will be screened at Lattakia in the 1983/84 season.

From the crossing program, lines with good resistance to diseases and with high yield potential have been identified. Of 43 lines tested in preliminary large-seeded yield trials in 1982/83 at Tel Hadya, eight had high levels of stable resistance to chocolate spot and also high yield (Table 4).

Table 4. Yield and chocolate spot resistance of lines in preliminary yield trials at Lattakia, 1982/83.

Line	Yield (kg/ha)	Disease score[1]
S 81057-5	3220 ± 185	3
S 81071-1	3150 ± 185	3
S 81066-16	3000 ± 185	3
S 81056-7	2940 ± 185	1
S 81064-15	3540 ± 276	1
S 81062-8	3270 ± 276	1
S 81055-5	3120 ± 276	3
S 81064-8	3020 ± 276	1
ILB 1814 (check)	3470 ± 348	9

1. Score of 1-9: 1 = highly resistant, 9 = highly susceptible.

Diseases and Their Control

Although faba beans in West Asia are affected by several diseases, chocolate spot, ascochyta blight, rust, and stem nematodes are the most important. Practical management of these diseases should mainly depend on the use of resistant cultivars, and efforts in that direction continue. For developing suitable protection strategies, studies are needed on the epidemiology of the diseases, variability in the pathogens, and the scope of chemical control in combination with host resistance. Some of these aspects were studied during the 1982/83 season at Lattakia.

Chocolate spot. Host-pathogen interaction studies in the past indicated the existence of pathogenic variability among different isolates of *Botrytis fabae* but the race status could not be determined because the isolates were obtained from a single lesion on a single plant. In 1982, 32 isolates from faba bean growing regions in Lattakia and Tel-Kalakh in Syria and Doha in Lebanon were examined for their virulence on chocolate spot resistant (BPL 710, 261, 1179) and susceptible (ILB 1815) genotypes using a detached leaf technique. There were significant differences among different isolates within each of the populations of the three regions. Based on the type of lesions, the isolates could be grouped into three races (Table 5). Race 1 was different from races 2 and 3 because it was able to infect BPL 1179. Race 2 was different from race 3 as it infected BPL 1179 and ILB 1815. More survey work will be carried out in 1983/84 to get a better understanding of the variablity in *B. fabae*.

Studies on chemical control of chocolate spot in the past indicated that vinclozolin (Ronilan 50 WP) was an effective fungicide. In the 1982/83 season a pot study involving artificial inoculation was undertaken to find out if the number of fungicide sprays could be reduced by relating the spray to the duration of leaf wetness rather than using a spray schedule based on phenology. A certain minimum period of leaf wetness is a prerequisite for germination of spores and initiation of disease. Results revealed

Chocolate spot, caused by *B. fabae*, is a serious disease of faba beans.

that the fungicide spray was necessary only when the leaves remained wet for 4 hours or more (Table 6).

Ascochyta blight. The combined effect of moderate host resistance and chemical treatments in controlling ascochyta blight was evaluated in a field experiment under artificial inoculation with the pathogen. Of the three fungicides tested (Table 7), Bravo 6F (chlorothalonil) resulted in the best disease control and the highest green pod yield of faba beans. Dithane M45 (mancozeb) also proved effective particularly with the moderately

Table 5. Reaction of certain genotypes of faba bean to three different isolates of *Botrytis fabae* at Lattakia, 1982/83.

Isolate and origin	Race	Disease reaction[1] of faba bean genotypes			
		BPL 710	BPL 261	BPL 1179	ILB 1815
TK Tel Kalakh	1	R	R	S	S
DOH Doha	2	R	R	MR	S
LAT Lattakia	3	R	R	R	MR

1. R = resistant; MR = moderately resistant; S = susceptible.

Table 6. Vinclozolin application as related to duration of leaf wetness to control chocolate spot in faba bean at Lattakia, 1982/83.

Treatments[1]	Disease reaction[2] BPL 710[a]	BPL 1179	BPL 261	ILB 1814
Sprayed after 0 hr LW	1.5a	2.0f	1.5k	3.0q
Sprayed after 2 hr LW	1.5a	3.0f	2.5k	3.5q
Sprayed after 4 hr LW	2.5a	3.5f	3.0k	5.0q
Sprayed after 8 hr LW	4.0b	3.5f	4.0l	6.5r
Sprayed after 16 hr LW	4.0b	5.0h	4.5m	7.5s
Sprayed after 32 hr LW	5.0b	6.0i	5.5n	8.5t
Unsprayed	5.5c	6.0i	6.0p	9.0t

1. Leaf wetness (LW).
2. Disease rating was done on a 1-9 scale.
a. Numbers followed by different letters are significantly ($P<0.01$) different according to Duncan's multiple range test.

Table 7. Influence of chemical treatments and host genotypes on severity of ascochyta blight and green pod yield in faba bean at Lattakia, 1982/83.

Fungicides and rates[1]	Giza 4[a] Disease severity[2]	Giza 4 Yield (kg/ha)	*ILB 1814* Disease severity	*ILB 1814* Yield (kg/ha)
Bravo 6F (1.5cc/1)	3.0a	6250e	2.3h	6708j
Dithane M45 (1.5g/1)	4.3b	4766f	2.3h	6316j
Benlate 50% (0.5g/1)	7.0c	1958g	5.0i	4458k
Untreated (control)	8.3d	1583g	5.6i	3791k

1. *Fungicides were applied in 600 liters of water per hectare.*
2. Disease rating was done on a 1-9 scale.
a. Within a column, different letters indicate significant differences at the 5% level ($P<0.05$) according to Duncan's multiple range test.

resistant genotype ILB 1814. Benlate 50% (benomyl) was ineffective in improving the yield, although it partly reduced the disease severity in the susceptible genotype Giza 4.

Stem nematode. The stem nematode (*Ditylenchus dipsaci*) is a destructive seed and soilborne pathogen of faba bean. Infected seeds play an important role in its survival and dissemination. The possibility of producing nematode-free seed through the use of a systemic nematicide, aldicarb (Temik 10G, at the rate of 10 kg a.i./ha), on soil infested with different population densities of the nematode, was investigated. Population densities of 0, 40, 100, 300, 720, and 6500 larvae per 1000 cc soil were established. Application of aldicarb reduced the initial population level to 0, 16, 28, 80, 240, and 2400 larvae per 1000 cc soil in the respective treatments.

As the population of stem nematode increased (Fig. 1), there was an increase in the plant and seed infection, and a decrease in the seed yield. Aldicarb application significantly decreased the plant infection and resulted in significant yield increase at population densities of 100 or more larvae per 1000 cc soil. Seeds obtained from plots treated with aldicarb were free from the nematode at all levels except the highest nematode population.

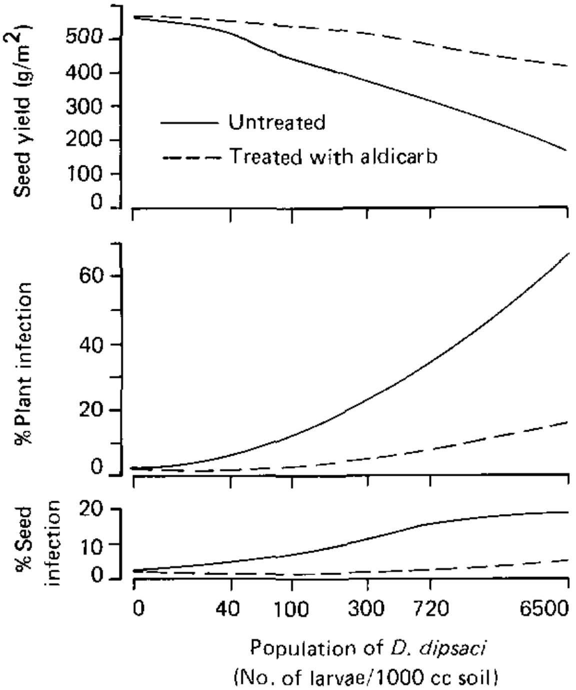


Fig. 1. Effect of aldicarb application on the percent seed and plant infection and seed yield of faba bean at different population densities of *Ditylenchus dipsaci* in soil at Lattakia, 1982/83.

Insects and Their Control

Studies were cotinued to quantify yield losses, identify the key pests damaging the crop at various growth stages, and select the most appropriate insect control technology. Chemical control of *Sitona* spp. weevil through granular insecticides and/or foliar sprays against *Apion* spp., thrips, and bruchids did not significantly increase yield (Table 8) suggesting that none of these became a major pest in the 1982/83 season. Aphids, whose occurrence is of a cyclic nature, did not appear this season. The economic analysis of this season's response to previously recommended practices for insect control (Fig. 2) suggested that the attempt to control *Sitona* spp. weevil was less profitable than sprays against foliar insects.

Table 8. Effect of different insecticidal regimes on the yields of Syrian local medium faba beans at Tel Hadya, 1982/83.

Treatment	Yield (kg/ha)	% Yield increase
Full protection (FP)[1]	3297	8.1
FP less soil insecticide	3329	9.1
FP less preflowering sprays	3207	5.1
FP less postflowering sprays	3266	7.2
Check	3051	
Recommended protection (RP)[2]	3235	6.0
RP less soil insecticide	3220	5.5
RP less foliar spray	3227	5.8
LSD (5%) for yields	NS	
CV (%)	6.0	

1. Soil insecticide (carbofuran) plus seven foliar sprays with methamidophos or endosulfan.
2. Soil insecticide (carbofuran) plus one foliar spray with methamidophos.

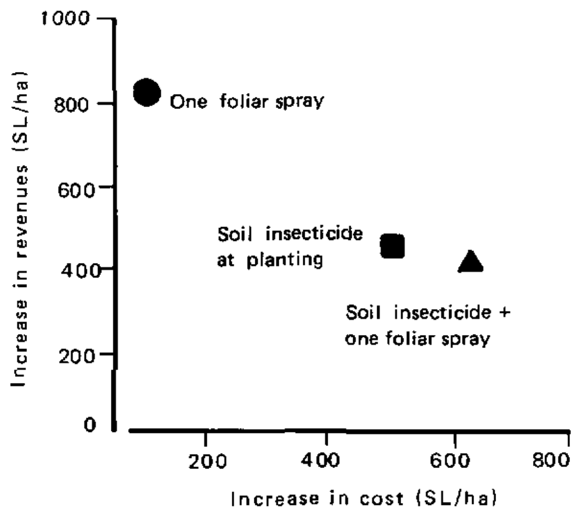


Fig. 2. Cost - benefit relationships for insect control alternatives in faba beans at Tel Hadya, 1982/83.

Since previous results on the economic importance of *Sitona* spp. weevil (mainly *Sitona limosus*) were inconsistent, a trial was conducted again to measure the yield losses due to *Sitona* spp. larval and adult damage. Even with a high population of *Sitona* spp. (up to 27% nodule damage) neither highly efficient larval control with granular insecticides nor less efficient foliar sprays against adults had a significant effect on yield (Table 9), and crop growth and nitrogenase activity (Fig. 3).

For studying the biology of stem borer (*Lixus algirus*), a technique for artificial infestation of faba bean plots was developed. The oviposition period lasted from mid-January to late April. The duration of different stages was as follows: egg, 13 to 15 days; larva, 30 to 40 days; pupa, 15 to 20 days. Attempts to control this insect should be made at the peak of adult activity, which was between mid-February and mid-March. The artificial infestation technique will be used next season to measure the yield losses due to stem borer.

Production Practices

Planting date and plant population. Response of the Lebanese Local large-seeded landrace (ILB 1816) to date of sowing and plant population was studied in a Faba Bean International Date of Planting/Plant Population Trial (FDPPT-83) at Terbol. Consistent with observations in the past, advancing the sowing date from 31 Jan to 12 Nov and increasing the population from 16.7 plants to 33.3 plants/m^2 increased the total biological yield. However, the seed yield (Table 10) was highest with an intermediate date of sowing (10 Dec). Frosty weather coinciding with the early reproductive growth of the crop sown before December nullifies the potential yield advantage of early sowing. There was no seed yield increase with increases in plant population beyond 25 plants/m^2.

Starter nitrogen. There are variable reports on the response of faba beans to starter nitrogen application. A trial was, therefore, conducted

Table 9. Efficiency of insecticidal combination to control *Sitona* spp. weevils in faba beans and their effect on yield at Tel Hadya, 1982/83.

Adult control[1]	Larval control[2]	% efficiency against adults	% efficiency against larvae	Yield (kg/ha)	% yield increase
Yes	With carbofuran	93.8	99.6	3606	11.2
No	With carbofuran	95.4	93.6	3541	9.2
Yes	With heptachlor	90.7	99.2	3481	7.3
No	With heptachlor	34.0	97.3	3345	3.1
Yes	No	67.0		3254	0.3
No	No			3243	

LSD (5%) for yields: NS
CV (%) for yields = 8.2

1. Four sprays with methidathion 0.5 kg a.i./ha.
2. With carbofuran 1.0 kg a.i./ha or heptachlor 2.0 kg a.i./ha.

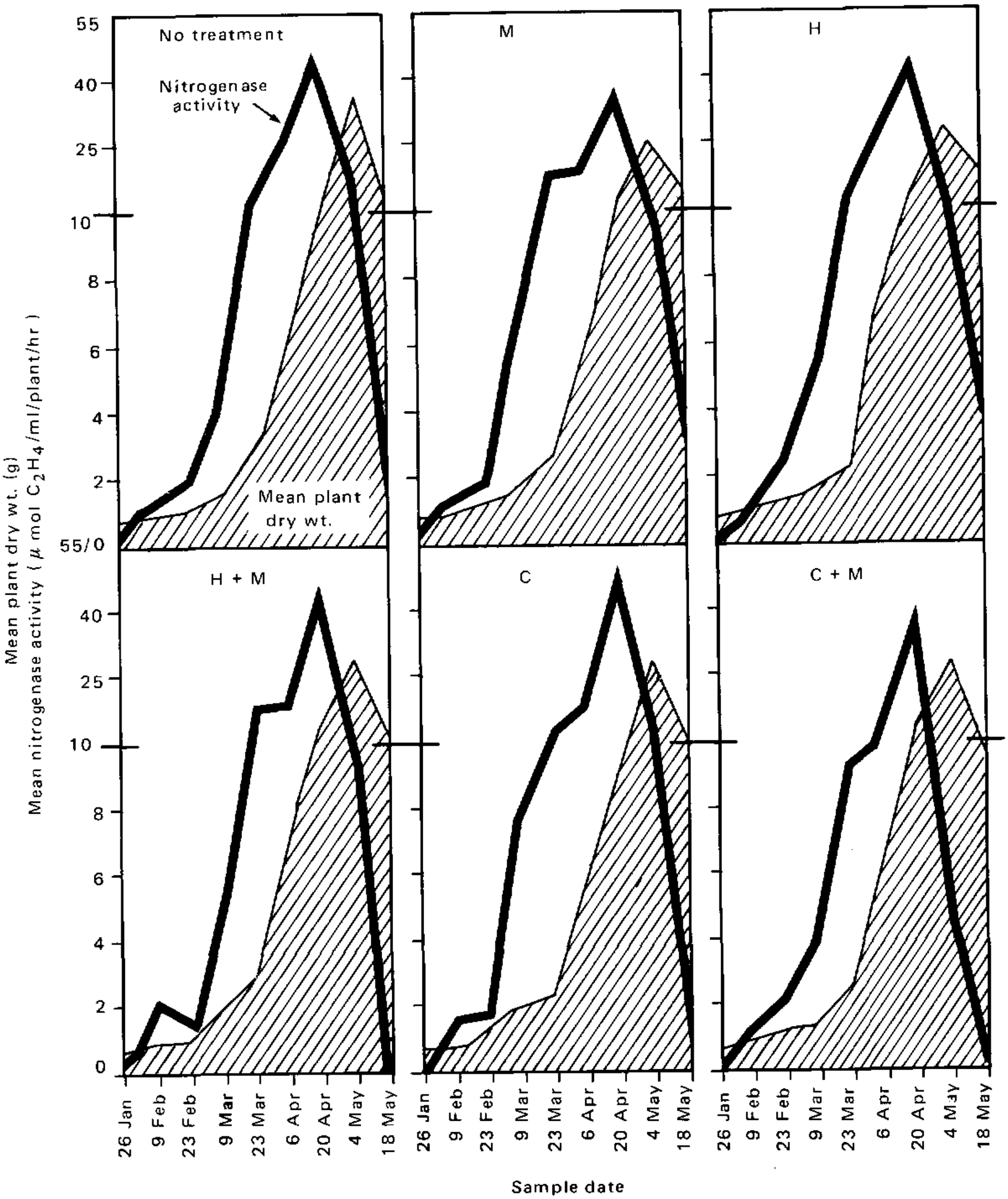


Fig. 3. A comparison of mean nitrogenase activity (C_2H_4 production) and mean plant dry weight with time for faba bean (Syrian Local Medium) where plants were treated with Heptachlor (H) or Carbofuran (C) for protection against *Sitona* spp. weevil larvae and with Methidathion (M) for adults, Tel Hadya, 1982/83.

Table 10. Effect of date of sowing and plant population on seed yield (kg/ha) of faba bean (ILB 1816) at Terbol, Lebanon, 1982/83.

Date of sowing		Plant population/m²				Mean
		33.3	25.0	20.0	16.7	
12 Nov		2865	2753	2650	2722	2748
27 Nov		2262	2742	2676	2247	2482
10 Dec		3194	2831	2770	2555	2838
31 Jan		2696	2698	2159	2548	2525
Mean		2754	2756	2564	2518	
CV (%)	Sowing date	13.5				
	Population	11.5				
LSD (5%)	Sowing date (D)	128				
	Population (P)	109				
	D X P	434				

during 1982/83 to study the nitrogen status and productivity of faba beans as affected by starter nitrogen application at 20 and 40 kg N/ha. A large-seeded genotype ILB 1814 (172 g/100 seeds) and a medium seed size genotype ILB 1813 (148 g/100 seeds) were included, as the seed size may affect the amount of nitrogen available to the seedling initially. The nitrogen concentration in the plant, studied at 45, 60, 75, 90, and 154 days after emergence, was not affected by treatments except at the first stage when it increased with starter nitrogen. Seed yield and total nitrogen accumulation per plant were decreased with the higher rate of starter nitrogen in ILB 1813 but were not affected in ILB 1814. These studies showed that the crop *did not benefit from starter nitrogen application* and that higher doses may even have a negative effect on some genotypes.

Environmental constraints to production. The cooperative study with the faba bean research group of the European Economic Community on «Growth and development of faba beans in relation to specific environmental conditions», started in 1981/82 season, was continued using two genotypes of European origin (Minica and Herz Freya) and two of Mediterranean origin (Aquadulce and Giza 3). While in 1981/82 the effects of both soil moisture and mineral nutrient supply were studied, in 1982/83 the effect of moisture supply (rainfed vs assured moisture through irrigation) only was studied. The growth season was cooler than average and temperatures below zero were recorded on 52 nights in the whole season. This affected the growth, development, and productivity of the genotypes and their response to moisture supply. The genetic differences for adaptation to temperature conditions were reflected in the reaction of the test genotypes to frost (Table 11). Giza 3, a genotype originating from a relatively warmer winter environment proved most susceptible to frost, followed by Herz Freya and Minica, the two spring types from Europe. The susceptibility of Giza 3 and Herz Freya to frost was increased under improved soil moisture supply (Table 11). The low temperature conditions of the 1982/83 season limited the overall productivity of even the well adapted genotype Aquadulce to only 5682 kg/ha (Table 12) as against more than 8000 kg/ha in 1981/82. The potential benefit of improved moisture supply was also reduced because of the unfavorable temperature conditions.

Table 11. Frost damage in four diverse faba bean genotypes in relation to moisture supply at Tel Hadya, 1982/83.

	Percent plants affected by frost in					
	Irrigated plots			Rainfed plots		
Genotype	Killed	Damaged	Total	Killed	Damaged	Total
Aquadulce	0.0	10.8	10.8	0.0	10.8	10.8
Giza 3	26.2	36.2	62.4	6.0	45.3	51.3
Herz Freya	20.0	41.6	61.6	5.6	30.1	35.7
Minica	5.8	27.5	33.3	8.1	43.1	51.2

Table 12. Total recoverable biological yield (TBY), seed yield (SY), nitrogen yield, seasonal evapotranspiration (E_T), and water-use efficiency of four diverse genotypes of faba bean under rainfed and assured moisture conditions at Tel Hadya, 1982/83.

Moisture supply	Genotypes	Yield (kg/ha)		Total N yield	E_T	Water-use efficiency (kg/ha/mm)	
		TBY	SY	(kg/ha)	(mm)	TBY	SY
Assured	Aquadulce	5682	3113	109.8	351	16.2	8.9
	Giza 3	3501	1949	78.4	356	9.8	5.5
	Herz Freya	5007	2207	104.2	439	11.4	5.0
	Minica	3280	1307	59.4	387	8.5	3.4
Rainfed	Aquadulce	5585	2192	137.6	308	18.1	7.1
	Giza 3	4228	2107	117.6	297	14.2	7.1
	Herz Freya	4262	1725	94.6	310	13.7	5.6
	Minica	3571	1698	85.7	287	12.4	5.9

Weed control. Crop losses from weeds at Hama, Lattakia, Tel Hadya, and Terbol in the International Faba Bean Weed Control Trial (FBWCT-83) amounted to 22, 57, 33, and 52%, respectively. Preemergence herbicides were also evaluated in this trial. Since some herbicide-treated plots at Lattakia and Terbol were lost, yield results for only Tel Hadya and Hama are presented in Table 13. The trial at Tel Hadya was rainfed and that at Hama was irrigated. Of the various herbicide treatments, cyanazine at 0.5 kg a.i./ha at Tel Hadya and cyanazine + pronamide both at 0.5 kg a.i./ha at Hama proved most effective and resulted in yields equal to that from the 'weed free' treatment. Since several other herbicide treatments also proved effective, there is a possiblility to choose, based on price and local availability.

Faba Bean Genetic Stocks for All Regions

The demand for genetic stocks with special traits such as adaptation to a specific environment, resistance to one or more common pathogens and pests has continued to grow. Hence development and distribution of such genetic stocks was given high priority during the 1982/83 season.

Table 13. Effect of weed control on yield of faba bean in the International Faba Bean Weed Control Trial (FBWCT-83) at Tel Hadya and Hama, 1982/83.

Weed control treatment	Yield (kg/ha)	
	Tel Hadya	Hama
Weedy check	882	4844
Weed free	1304	6144
Weeded twice	1298	6141
Chlorbromuron at 1.5 kg a.i./ha	913	5914
Methabenzthiazuron at 3 kg a.i./ha	1135	6105
Terbutryne at 2.5 kg a.i./ha	1136	6358
Cyanazine at 0.5 kg a.i./ha	1278	5952
Cyanazine at 1 kg a.i./ha	1201	5883
Chlorbromuron + Pronamide at 0.5 kg a.i./ha	1217	6105
Methabenzthiazuron + Pronamide	1136	6210
Terbutryne + Pronamide	1061	5699
Cyanazine at 0.5 kg a.i./ha + Pronamide	1200	6502
CV (%)	15.7	7.8
LSD (5%)	254	667

Disease Resistance

Work to develop disease-resistant sources included screening BPL accessions for resistance to *Ascochyta* spp., *Botrytis* spp., and *Uromyces* spp., and to stem nematode (*Ditylenchus* spp.). Also, known sources of resistance to chocolate spot, ascochyta blight, and rust were distributed in international nurseries.

Screening of pure lines for disease resistance. For chocolate spot, 200 BPL accessions were screened, but because of flooding this work will be repeated in 1983/84. For ascochyta blight and stem nematodes another 200 BPL accessions were screened and all found susceptible. Separate screening of 200 BPL accession for rust resistance enabled 81 single-plant selections to be made from one line with a rating of 3, and 35 with a 5 rating (on a 1-9 scale). Screening and selection will continue with BPL accessions in 1983/84.

Multiple disease resistance. Genetic stocks with *multiple disease resistance* would be of great importance in developing faba bean cultivars with stable yields. The 20 most promising selections made from the pure lines in the past were evaluated for resistance to five different diseases and stem nematode, and the results are presented in Table 14.

International disease screening nurseries. Seed from sources resistant to chocolate spot, ascochyta blight, and rust, identified from screening the ICARDA germplasm collection, was distributed to Algeria, Canada, Egypt, Tunisia, and UK as international disease nurseries in 1982/83. Three lines (BPL 710, 1179, and 1196) were found resistant or highly resistant to chocolate spot across three locations (Egypt, Syria, and UK) in the Faba Bean International Chocolate Spot Nursery (FBICSN-83). BPL 1196 is a new source of multilocation resistance to chocolate spot. The

Table 14. Multiple disease resistance of certain faba bean germplasm lines at Lattakia, 1982/83.

Line	BPL	Rust	*Stem-phylium*	*Alter-naria*	Chocolate spot	*Asco-chyta*	Stem nematode
Sel. 82 Lat. (31)	27	NT	NT	NT	NT	NT	MR
Sel. 82 Lat. (47)	40	NT	NT	NT	NT	NT	MR
Sel. 81 Lat. (24638)	112	NT	MR	HR	MR	NT	NT
Sel. 81 Lat. (24694)	261	NT	HR	HR	HR	NT	NT
Sel. 81 Lat. (24698)	266	MR	HR	HR	MR	NT	NT
Sel. 81 Lat. (24701)	274	MR	HR	HR	MR	NT	NT
Sel. 81 Lat. (24857)	710	MR	MR	MR	HR	NT	NT
Sel. 81 Lat. (24801)	470	MR	HR	HR	MR	NT	NT
Sel. 79 Lat. (70015)	74	NT	NT	NT	MR	HR	NT
Sel. 80 Lat. (14434)	471	NT	NT	NT	NT	HR	NT
Sel. 80 Lat. (14435)	472	NT	NT	NT	MR	HR	NT
Sel. 80 Lat. (14422)	460	NT	NT	NT	NT	HR	NT
Sel. 81 Lat. (25114)	1821	NT	HR	HR	MR	NT	NT
Sel. 81 Lat. (24996)	1538	HR	MR	HR	MR	NT	NT
Sel. 81 Lat. (25001)	1544	NT	HR	MR	MR	NT	NT
Sel. 81 Lat. (25003)	1546	NT	HR	MR	MR	NT	NT
Sel. 81 Lat. (25007)	1550	NT	MR	HR	MR	NT	NT
Sel. 81 Lat. (25011)	1556	NT	MR	HR	MR	NT	NT
Sel. 81 Lat. (25075)	1686	NT	MR	HR	MR	NT	NT
Sel. 81 Lat. (24948)	ILB 938	HR	HR	MR	HR	NT	NT

MR = Moderately resistant, HR = Highly resistant, NT = Not tested.

data returned for the Faba Bean International Ascochyta Blight Nursery (FBIABN-83) showed that several lines were resistant to moderately resistant in Syria and Canada (BPL 460, 471, 465, 2485, ILB 161, 37, and A2). Two new sources of multilocation resistance to ascochyta blight are BPL 465 and a selection from ILB 161. Data were returned from only Syria and Egypt for the Faba Bean International Rust Nursery (FBIRN-83). Ten lines were resistant or highly resistant in both countries (BPL 266, 274, 461, 1055, 1056, 1058, 1538, 1543, ILB 938, and 80 Latt 15563-3).

Recombination of disease resistance with local adaptation. The results of international trials in previous years have shown that selections made in Syria and Lebanon are of little value as direct introductions into the markedly different irrigated environment in the Nile Valley. Similarly, there has been little indication that the adaptation of selections made in West Asia will hold in rainfed conditions in North Africa. There is clearly a need to recombine identified sources of resistance with local adaptation. For example, BPL 1179, a selection from Colombian germplasm, has been found resistant to *Botrytis fabae* in Egypt, Syria, and UK. However, it is poorly adapted to each location and must be used in recombination before the source can be exploited.

At Tel Hadya, local germplasm from Egypt, Morocco, Sudan, and Tunisia was used for crossing to disease-resistant, early, and determinate lines. A total of 111 crosses were made: Tunisia 7, Morocco 27, Sudan 24, Egypt 53. F_2 bulks from these crosses will be grown in the 1983/84 season and F_3 bulks will go into the 1985 international F_3 trials. Also, F_3 progeny rows will be grown and lines fed into preliminary trials. This is in addition to selection of disease-resistant F_2 plants at Lattakia for development of disease-resistant lines for yield testing.

Resistance to *Orobanche crenata*

In 1982/83, 64 *Orobanche* spp.-resistant BPL accessions were tested at Kafr Antoon for a third year and 14 lines were identified as possessing high levels of resistance consistently for 3 years (Table 15). Those lines were used for the 1984 Faba Bean International *Orobanche* Nursery (where seed supply was adequate) for testing multilocation resistance at 10 sites.

Table 15. Number of *Orobanche* spp. shoots per faba bean plant for *Orobanche* spp. resistant BPL accessions screened for 3 years, 1980/81 to 1982/83 at Kafr Antoon.

	No. of shoots per plant		
BPL	1980/81	1981/82	1982/83
2270	0.40	0.84	0.00
2267	0.60	1.51	0.00
2235	0.90	1.54	0.00
1517	0.71	0.85	0.02
2053	0.70	1.27	0.03
2022	0.30	1.50	0.03
1636	1.26	2.50	0.03
2009	0.90	1.21	0.05
2017	1.00	3.17	0.07
2317	0.90	1.70	0.08
2170	0.60	1.94	0.08
1532	1.49	1.66	0.08
2244	1.10	2.66	0.10
2012	0.50	1.30	0.10
F 402[a]	1.05	2.19	0.72
ILB 1814[b]	9.00	6.63	2.23
LSD (5%)	2.57		0.44

a. Resistant check.
b. Susceptible check.

Resistance to *Bruchus dentipes*

In 1982/83, 810 BPL accessions were screened at Tel Hadya for resistance to *Bruchus dentipes*. The lowest infestations found were with BPL 856, 182, and 747 (7, 19, and 20% respectively). Fig. 4 shows the distribution of BPL accessions tested for *B. dentipes* infestation. Rescreening of the most promising lines will be done in 1983/84 and attempts made to determine the mode of resistance.

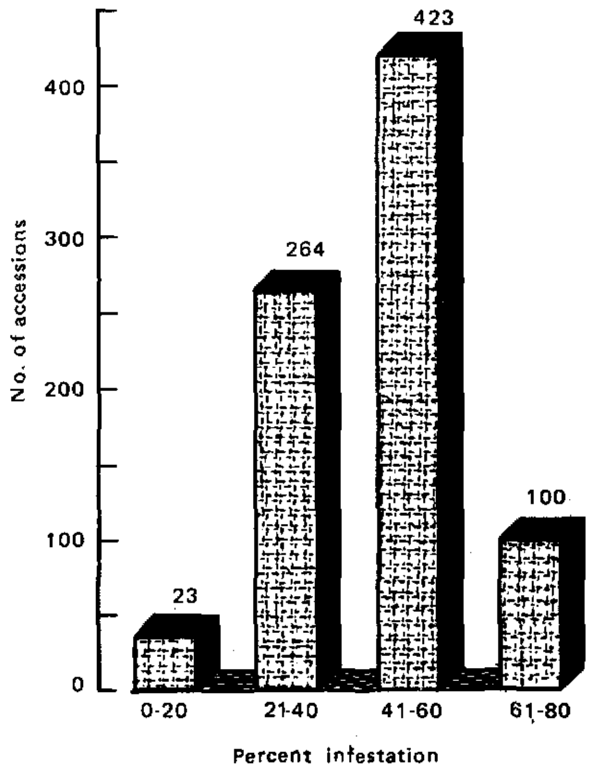


Fig. 4. Frequency distribution of 810 BPL accessions of faba beans according to percent infestation by *Bruchus dentipes* at Tel Hadya, 1982/83.

Host-plant resistance is being sought in faba beans to control the parasitic weed *Orobanche* spp.

Yield Potential over Wide Areas

Results from the Faba Bean Adaptation Trial (FBAT) conducted for four seasons, with the 1981/82 season being the fourth and last, showed few positive significant correlations between locations for yield. For example, during 1981/82 only one of 15 correlations between sites for grain yield for the international large-seeded yield trial was significant. Similarly, of the 15 correlations in the case of the small-seeded yield trial, only two were significant. This demonstrates the need for multilocation testing of material at an early stage. We have started testing the early-stage yield trials for large-seeded lines in Tunisia from the 1983/84 season. This should improve the chances of identification of lines with wider adaptability and also lines adapted to specific subregions.

Faba Bean Cultivars and Agronomic Practices for Low-Rainfall Environments

Efforts were continued to develop high and stable yielding faba bean cultivars and agronomic practices capable of producing an economic yield of dry seed in low-rainfall (300-350 mm) environments so that farmers there may get another crop option and may diversify their cropping. The total seasonal rainfall during 1982/83 at Tel Hadya was 322 mm. Faba beans are normally grown only with supplementary irrigation with this amount of rainfall.

Development of Cultivars

A total of 20 crosses were made for low-rainfall conditions with lines selected under these conditions. Seeds of these crosses were increased in the off-season and will be screened in the 1983/84 season. A total of 90 single-plant selections were made from F_2 populations in Shawbak. These will be yield-tested in the 1983/84 season along with 46 lines selected from preliminary screening nurseries.

In rainfed yield trials, 118 of 383 lines tested exceeded the best check; the highest yield in a replicated trial was 2110 kg/ha (Table 16). Work now is being concentrated on small-seeded lines suitable for low-rainfall conditions and for machine planting and harvesting.

Drought Tolerance Studies

Evaluation of a number of genotypes for drought tolerance at locations with different amounts of rainfall (Jindiress, Tel Hadya, and Breda) and at Tel Hadya with supplementary irrigation, was continued during the 1982/83 season. Soil-moisture extraction and water-use efficiency of six genotypes was studied at Tel Hadya without irrigation.

Yield data in Table 17 show that the total recoverable biological yield was closely related with total seasonal moisture supply, except at Jindiress where the yield was lower than that at Tel Hadya, in spite of higher rainfall. As in the previous season, ILB 10, 605, 1266, 1813, and 1814 tended to be less sensitive than others to the limited moisture supply at Tel Hadya. The soil-moisture recharge and discharge curves for six genotypes are shown in Fig. 5 and differences in total extractable soil moisture, evapotranspiration, and water-use efficiency are given in Table 18. The highest soil moisture extraction was recorded in ILB 1813 and one of the lowest in ILB 10. The water-use efficiency for both these genotypes was higher than in the other genotypes. Apparently, the mechanism to

Table 16. Summary of rainfed yield trials at Tel Hadya, 1982/83.

Trial/nursery	Number of entries tested	Highest yield (kg/ha)	No. of lines exceeding best check	CV(%)
Preliminary Yield Trials Small Seeded	258	2110	111[a]	11-24
Advanced Yield Trials Small Seeded	63	1910	3[b]	12-16
Regional Yield Trial	16	1780	0[b]	11
International Yield Trial Large Seeded	23	1570	0[b]	19
International Yield Trial Small Seeded	23	1590	4[a]	12
International Screening Nursery[1] Large Seeded	30	1730	4[b]	13
International Screening Nursery[1] Small Seeded	46	2400	19[a]	24

a. Check entry, ILB 1812.
b. Check entry, ILB 1814.
1. Unreplicated.

Table 17. Total recoverable biological yield (TBY, kg/ha) and seed yield (SY, kg/ha) of some selected genotypes of faba bean at Breda, Tel Hadya, and Jindiress, 1982/83.

	Breda		Tel Hadya				Jindiress	
	Rainfed (285 mm)[a]		Rainfed (322 mm)		Irrigated (472 mm)		Rainfed (429 mm)	
Genotype	TBY	SY	TBY	SY	TBY	SY	TBY	SY
ILB 1814	847	375	3459	1924	3595	2570	2303	1372
ILB 10	628	304	2282	1417	3126	2025	1900	1316
ILB 277	578	288	1886	1202	2490	1577	1569	1086
ILB 605	747	377	2168	1341	2810	1796	1460	968
ILB 1266	610	253	2240	1359	2914	1869	1353	933
ILB 1813	657	302	2522	1515	4032	2539	1937	1231
ILB 1819	572	273	2112	1212	2740	1678	1722	1178
ILB 1816	585	278	1761	1084	3237	1963	1884	1212
Mean	653	306	2304	1382	3163	2002	1766	1162
CV (%)	13.4	15.4	22.6	24.2	22.6	24.2	21.4	17.4
LSD (5%)	129	70	881	584	881	584	557	297

a. Values in parentheses are total seasonal moisture supply.

Table 18. Total extractable moisture (EM), evapotranspiration (E_T), water-use efficiency (WUE, kg/ha/mm) for total recoverable biological yield for some selected genotypes of faba bean under rainfed conditions at Tel Hadya, 1982/83.

Genotypes	ILB	EM (mm)	E_T (mm)	WUE
78S 49907	10	57.6	207.6	10.99
78S 48428	277	54.3	221.7	8.51
78S 49694	605	61.8	245.2	8.84
Aquadulce	1266	55.9	243.4	9.20
Syr. L.M.	1813	86.6	273.7	9.21
Giza 3	1819	61.6	246.7	8.56

cope with the reduced moisture supply differs in these two genotypes. The technique of evaluating genotypes simultaneously at the drier rainfed sites of Breda and Tel Hadya and comparing with their performance under assured moisture supply at Tel Hadya will be extended to a larger number of genotypes in the 1983/84 season to identify genotypes suitable for low-rainfall conditions.

Response to Residue Management and Phosphate Application

In some of the areas receiving 300-350 mm seasonal precipitation it is a common practice to burn the residues of the previous cereal crop before planting the legumes. Also, the soils in many of those areas are low in available phosphorus. A study was, therefore, started in

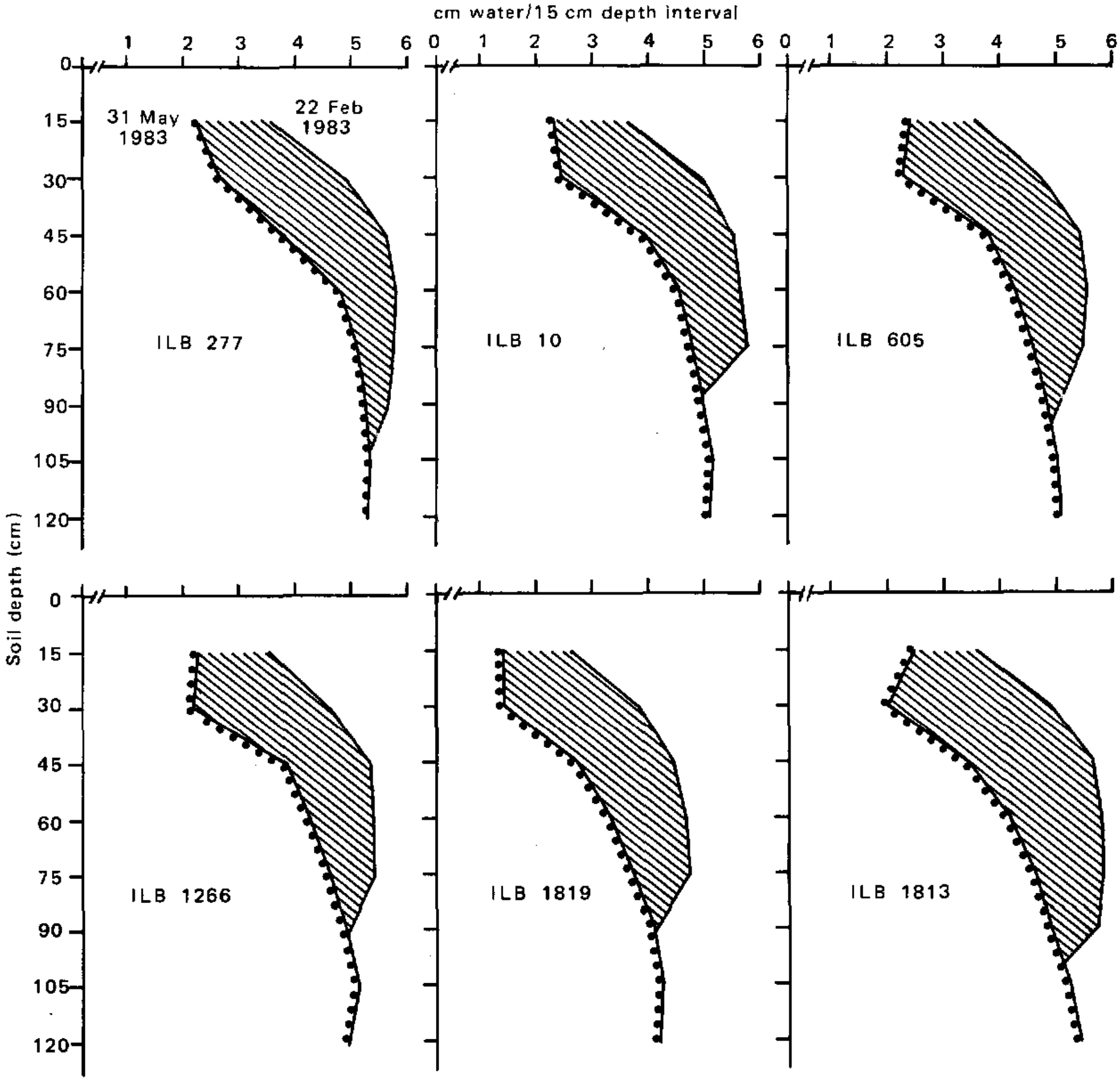


Fig. 5. Soil moisture recharge and discharge curves for six faba bean genotypes grown at Tel Hadya under rainfed conditions, 1982/83.

the 1982/83 season to compare the effect of incorporating residues into the soil and of burning them. These treatments were tested in combination with different methods of application of 50 kg P_2O_5/ha on a soil having an available phosphorus content of 1.63 ppm P in the 0-15 cm and 1.13 ppm P in the 15-30 cm soil layers at Tel Hadya.

Both the burning of straw and the application of phosphorus increased the yield of faba bean (Table 19). Placement of phosphorus with the seed or 5 cm below the seed resulted in a significant increase in yield compared with broadcast application and the control. The difference between the latter two treatments was nonsignificant. Phosphate placement improved the nitrogenase activity of the faba bean root system early in the season. The residue management, however, needs to be further studied to ascertain the way in which it affects the growth and productivity.

Development of Alternative Plant Types in Faba Bean

This project was started to develop and evaluate alternative plant types for their yield potential in different environments, investigate the relationship between different morphological characters and yield build-up, and study the pollinating system in faba beans.

Determinate Faba Bean Genetic Stocks

The determinate habit of mutants from Sweden is of potential importance in faba bean production areas which are either irrigated or highly fertile. Reducing the vegetative growth, which is often excessive under these conditions, should serve to increase the harvest index.

The determinate mutant from northern Europe is poorly adapted to the Mediterranean environment, and efforts are being made to transfer the character into an adapted background. In 1982/83, 197 crosses were made with a determinate parent and seed from these was increased in the off-season. The F_2 populations will be screened for determinate plants in the 1983/84 season. From F_3 bulks received from Italy, 30 determinate plants were selected and seed was increased in the off-season. These will be used in the crossing program in 1983/84.

From F_2 populations grown in the 1982/83 season, 150 single plants were selected for determinacy and seed was increased in the off-

Table 19. Seed yield (kg/ha) of ILB 1814 faba bean as affected by the application of 50 kg P_2O_5/ha and the method of management of residues from the previous wheat crop at Tel Hadya, 1982/83.

	Seed yield (kg/ha)		
	Straw incorporated	Straw burnt	Mean
No phosphate (control)	1727	2565	2146
50 kg P_2O_5/ha broadcasted	2085	2600	2343
50 kg P_2O_5/ha deep placed	2347	3123	2735
50 kg P_2O_5/ha mixed with seed	2477	3027	2752
Mean	2159	2829	
	Phosphate	Residue management	Interaction
CV (%)	18.1	20.5	
LSD (5%)	123	313	435

Existing determinate lines of faba bean are being improved for more reproductive nodes and less branches.

season. These will be tested in yield trials in the 1983/84 season along with 34 lines selected from the preliminary screening nursery for determinate lines.

Yield tests of 75 lines with the determinate trait were conducted in the 1982/83 season. Table 20 gives the results for the 10 best determinate lines and two checks. The determinate lines exceeded the yield of Syrian local small (ILB 1811) but not Syrian local short pod (ILB 1812). The most striking character was the plant height: all determinate lines were much shorter than the indeterminate checks. The 1982/83 season experienced a very cold and long winter which reduced the plant growth. In a normal season the height of the two checks can exceed one meter. However, the effect of the determinate gene on plant height will be seen in 1983/34. Approximately half the determinate lines were also later flowering than the indeterminate checks.

Flowering and Podding Behavior in Determinate Faba Bean

A study to compare the flowering and podding of a determinate mutant bulk (DMB) and the indeterminate ILB 1814 faba bean was carried out at two plant populations (22.2 and 50 plants/m^2). ILB 1814 produced more flowers per plant than the DMB because there were more flowering nodes per plant and more flowers per node. There was more flower abortion in ILB 1814 but the abortion of young pods was greater in the DMB. The distribution of flowers, young pods, and mature pods on dif-

Table 20. Performance of the 10 best determinate lines and checks in preliminary determinate trials grown at Tel Hadya under irrigation, 1982/83.

Line	Grain yield (kg/ha)	Flowering date (days)	Plant height (cm)
S 79022-1	2350 ± 246	122 ± 1.3	28 ± 2.9
S 79022-2	2350 ± 246	121 ± 1.3	29 ± 2.9
S 79027-1	2220 ± 246	128 ± 1.3	31 ± 2.9
82S 50447	2190 ± 246	121 ± 0.7	30 ± 2.5
L 79079-1	1980 ± 246	121 ± 0.7	33 ± 2.5
S 79187-1	1910 ± 246	122 ± 0.7	34 ± 2.5
S 79028-1	2920 ± 172	121 ± 0.9	36 ± 2.0
L 79079-2	2420 ± 172	125 ± 0.9	40 ± 2.0
L 79079-3	2400 ± 172	125 ± 0.9	33 ± 2.0
L 79079-4	2290 ± 172	124 ± 0.9	35 ± 2.0
ILB 1811	1410 ± 380	121 ± 0.7	53 ± 6.1
ILB 1812	4730 ± 861	120 ± 0.9	59 ± 1.7

ferent flowering nodes in the two plant types at the two population levels is shown in Fig. 6. The first four flowering nodes appeared to be the most important in both genotypes, although in ILB 1814 the flowers were spread over more nodes than in the DMB. The productivity per plant of the DMB was only slightly more than half that of ILB 1814 at a population of 22.2 plants/m^2 and less than half at 50 plants/m^2. To improve the productivity of the determinate type, an increase in the number of flowering nodes and a decrease in the number of young pods that abort is needed.

Studies on Outcrossing

A survey of insect pollinators in faba beans indicated that honey bees (*Apis mellifera*) and two species of solitary bees (*Eucera cincta* Fr., and *Anthophora canescens* Br.) accounted for up to 95% of the insects visiting faba bean flowers. During the 1982/83 season, honey bees were more abundant than solitary bees.

In large-scale breeding programs, outcrossing due to insect pollinators is undesirable because it makes it difficult to maintain the genetic identity of many different lines. To prevent outcrossing, cumbersome and costly methods of isolation such as widely separated plots, insect-proof cages, or individual bagging of plants with nylon nets are usually employed.

Two methods for isolation of faba bean increase plots are under study at ICARDA: first, the use of triticale as a mechanical barrier; and second, the use of *Brassica campestris* as an attractant to insect pollinators, around the faba bean plots. In the 1982/83 season, faba bean was planted in 9 x 12 m plots, each completely surrounded by 6-m wide strip of triticale or *B. campestris*. In another field, faba bean plots of the same size were surrounded by 6 m strips of bare soil to serve as a check.

Results of regular counts of honey bees and solitary bees visiting faba bean flowers made in

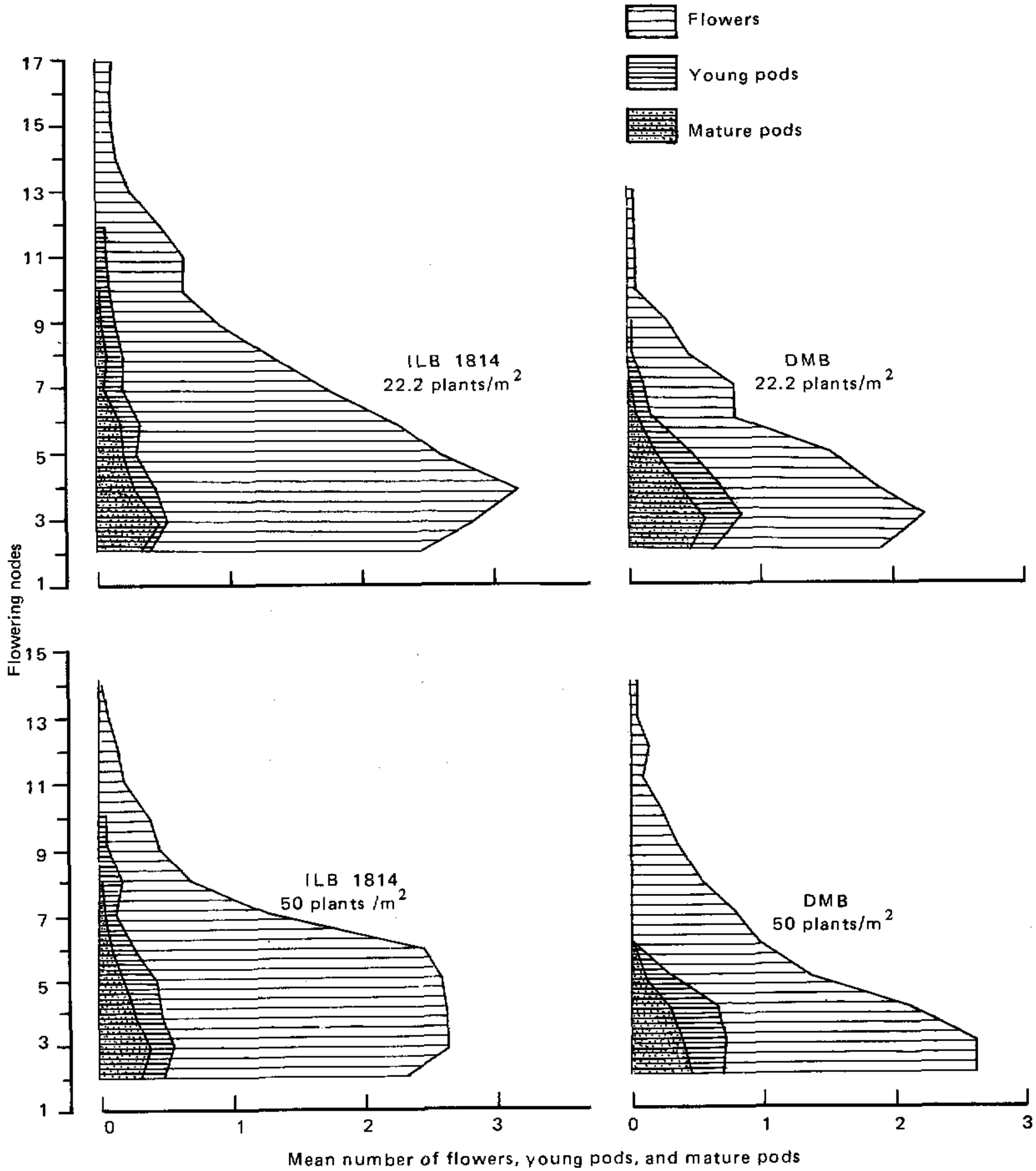


Fig. 6. Distribution of flowers, young pods, and mature pods along the flowering stems of ILB 1814 and the determinate mutant bulk (DMB) at low and high plant population levels at Tel Hadya, 1982/83.

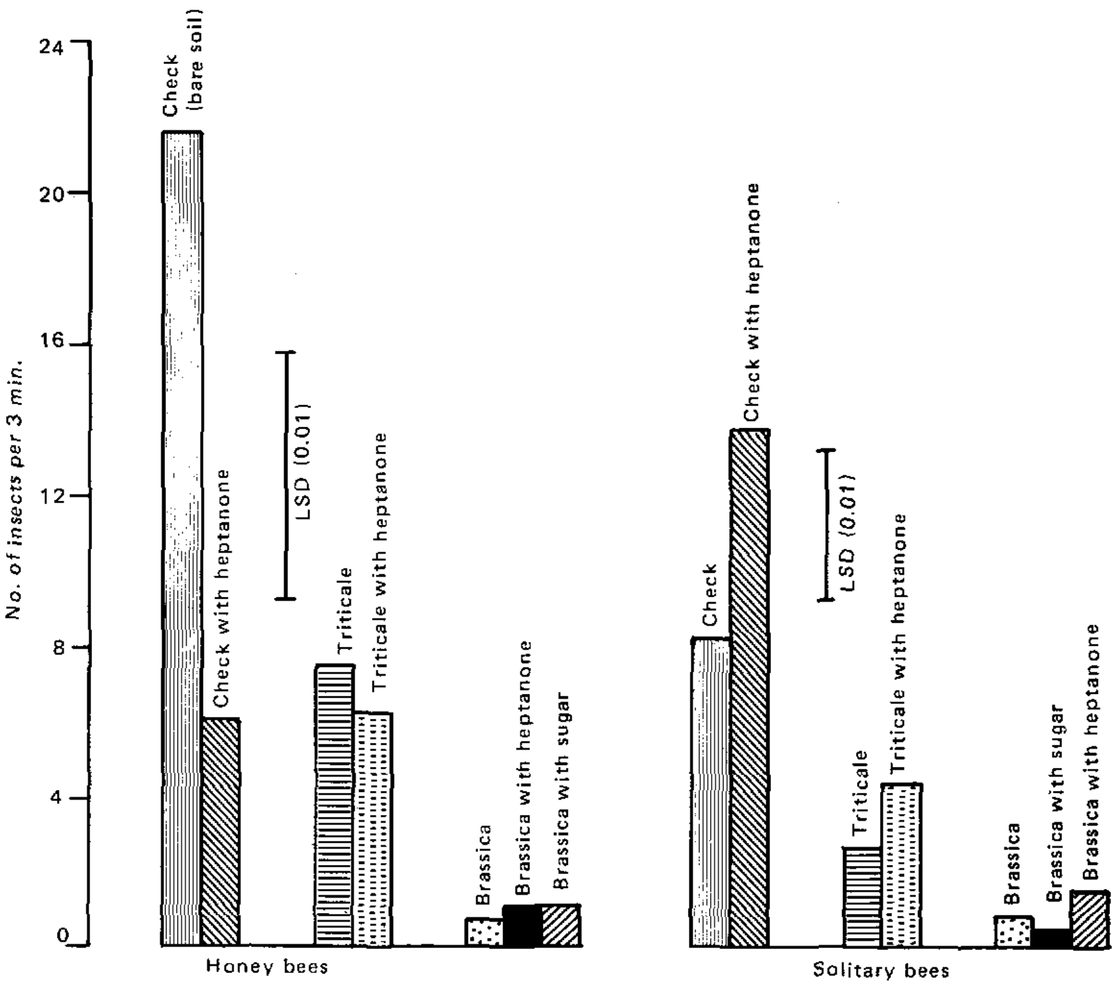


Fig. 7. Effect of isolation mechanisms on the number of honey bees and solitary bees visiting faba bean flowers in 9 x12 m plots (means of six scoring dates) at Tel Hadya, 1983.

four replications of each treatment indicated that *B. campestris* was very effective in reducing the bee activity in faba beans (Fig. 7). Triticale was less effective. Less bee activity should result in less outcrossing. To measure this, check plots were grown with Reina Blanca which has a white hilum marker. Seeds harvested from these plots will be planted and the amount of outcrossing will be estimated this year. Preliminary results from previous years showed relatively low frequencies of outcrossing in both *B. campestris* and triticale plots (7.0 ± 1.5% and 9.0 ± 2.2%, respectively). These low outcrossing values are acceptable for a pragmatic breeding program. Areas being further studied are: growing of F_2 populations and F_3 progeny rows in blocks surrounded by *B. campestris* and the reduction of the area planted to *B. campestris* to make the technique more efficient.

Lentil Improvement

Emphasis in lentil improvement continued on the development of genetic stocks or cultivars with appropriate phenology and high and stable yield for each of the three major agroecological regions of lentil production: the high-altitude region, the medium or low elevation Mediterranean region, and the region of more southernly latitudes including Bangladesh, Egypt, Ethiopia, India, Pakistan, and Sudan. In addition to high and stable yield, the specific traits needed for genotypes for the high- altitude region include cold tolerance, whereas for the Mediterranean region tolerance to *Orobanche* spp., resistance to wilt (*Fusarium* spp.), tolerance to drought during the reproductive period, and large straw yield are desired. Attributes that may facilitate mechanical harvesting are needed in genotypes for both regions. For the southern region, earliness through reduced sensitivity to photoperiod and temperature, and resistance to wilt and rust (*Uromyces fabae*) are considered important.

Germplasm

The current lentil germplasm holding comprises 5420 accessions. A lentil germplasm catalog has been produced which includes passport data on all 5420 accessions and evaluation data for 19 characters for 4550 accessions. A total of 2500 accessions were evaluated for seed protein concentration. Another 489 new accessions from 14 countries were evaluated for morphoagronomic characters. The time to flower of some accessions from seven countries is summarized in Table 21. The close relationship between the latitude of the country of origin and mean time to flower is noteworthy. Over 2000 accessions have been distributed to Canada, Chile, Pakistan, Sudan, and UK.

Table 21. Mean time to flower (days) of the new accessions originating from the listed countries at Tel Hadya, 1982/83.

Country of origin	Mean time to flower	Standard deviation	Number of accessions
Pakistan	105	4.5	5
India	109	5.4	80
Jordan	112	3.4	263
USA	122	3.3	10
Bulgaria	125	3.9	18
Italy	125	2.7	5
Spain	129	3.3	98

Improved Lentil Cultivars for Different Environments

Development of Genetic Stocks

A total of 350 crosses, including 13 three-way crosses, were made with the objectives listed above, to meet the specific needs for the three major agroecological regions of lentil production. Of the crosses made, 66% were for the Mediterranean medium-low elevation region and 34% were for the southern latitudes.

The last year's breeding material was advanced by bulk breeding through two generations at Tel Hadya in winter and at Shawbak in Jordan, in summer. Single-plant selections were made at the F_4 generation on the basis of heritable characters associated with phenology, growth habit, seed color, and seed shape. Of 10,616 progeny rows grown at Tel Hadya, 1502 rows were selected for advancement, representing a selection pressure of 14.2%. Selections from the progeny rows are promoted to preliminary screening nurseries and thence to replicated yield trials.

Yield Trials

A total of 390 selections were tested in 18 yield trials at Tel Hadya. There were 170 large-seeded entries (seed size > 4.5 g/100 seeds), of which 74 entries yielded more than the best local check. The largest yield was 1388 kg/ha. The remaining 220 selections were small seeded (< 4.5 g/100 seeds), and 35 of them yielded more than the best check. Among small-seeded entries the best yield was 1423 kg/ha. The coefficients of variation ranged from 19 to 33%, and consequently only four entries yielded significantly more than the checks. Yield trials containing 162 of the 390 selections were also conducted at Terbol, Lebanon.

Regional yield trials of both large- and small-seeded selections were conducted in cooperation with the national programs of Jordan and Syria. In Syria, in the large-seeded trial, the best ICARDA selections yielded over 1500 kg/ha averaged over five sites. This was about 24% higher than the local check which had a mean yield of 1216 kg/ha. The best entries in the regional trials are promoted to on-farm trials.

On-Farm Trials

In Syria, on-farm trials comprising ICARDA lentil selections and local checks were initiated in cooperation with the Research Directorate of the Syrian Ministry of Agriculture and Agrarian Reform, Douma, at six locations. Among the red-cotyledon entries, the best ICARDA selection, 78S 26013, gave 28% more yield on average than the local red-cotyledon check, Hurani 1 (Table 22). In the yellow-cotyledon group, the best ICARDA selection yielded 15% more than the local check, Kurdi 1.

Use of Genetic Material by National Programs

Several ICARDA lines from the international nursery program have been selected for inclusion in either on-farm trials or multilocation testing by the national programs of Australia, Ethiopia, India, Jordan, Morocco, Pakistan, Sudan, Syria, Tunisia, and USA (Table 23).

Table 22. Seed yield (kg/ha) from lentil on-farm trials in Syria, 1982/83

		Locations							
Selection	ILL	Breda	Gelline	Heimo	Izraa	Jail farm	Tel Hadya	Mean	Rank
Red cotyledon group									
78S 26013	16	443	1520	278	1942	679	1461	1054	1
76TA 66088	223	434	1120	491	1594	457	1165	877	2
Hurani 1 (local check)	2130	297	864	451	1611	462	1253	823	3
Yellow cotyledon group									
78S 26002	8	430	1780	590	2106	619	1137	1110	2
78S 26004	9	473	1687	531	2280	582	1320	1146	1
Kurdi 1 (local check)	2126	353	1620	529	1829	670	948	992	3

Table 23. ICARDA selections used/to be used in either multilocation testing or on-farm trials by national programs in 1983 and 1984.

Country	Identifier
Australia	74TA 19, ILL 707, ILL 4400
Ethiopia	ILL 355, ILL 358
India	ILL 4505
Jordan	ILL 4400
Morocco	74TA 19
Pakistan	ILL 4605
Sudan	ILL 813
Syria	78S 26002, 78S 26004, 78S 26013, 76TA 66088
Tunisia	74TA 19, ILL 4354, ILL 4400
USA	ILL 857

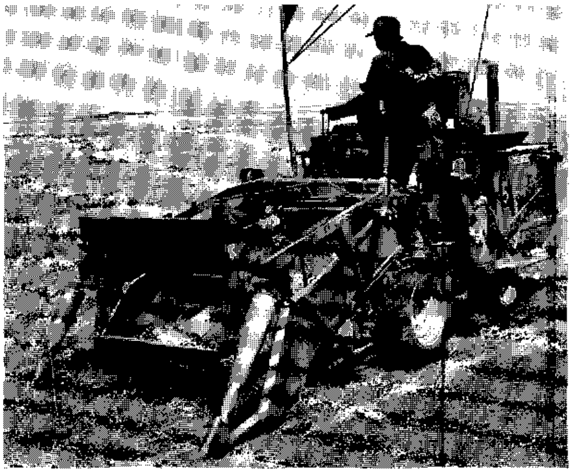
Selection for Mechanical Harvest

To facilitate selection for increased plant height, required for harvest mechanization, estimates of heritability of plant height were made in two crosses. The broadsense heritabilities were 61.6 and 7.0%, emphasizing the difference between the two crosses.

A delay in the time of harvest after 90% pod maturity results in a loss in seed yield both from pod dehiscence and pod drop. Complete maturity (90% pods mature) must be attained prior to harvesting with a combine harvester. Visual observation at Tel Hadya indicated that there were genetic differences in pod dehiscence and pod drop. Selected entries were tested in the last two seasons by measuring the yield of half the plot harvested at the normal harvest date, and by measuring the yield in the remaining plot harvested 6 weeks later. The seed loss from a delayed harvest was then calculated. The selection 74TA 550 had markedly less seed loss than any other selection in both seasons (Table 24). This was largely because of the indehiscence of the pods of 74TA 550.

Table 24. Loss in seed yield (kg/ha) from a 6-week delay in harvest date of three selections at Tel Hadya 1981/82 and 1982/83.

		Loss in seed yield	
Selection	ILL	1981/82	1982/83
74TA 260	253	595	171
74TA 276	262	871	175
74TA 550	470	250	0
Syrian local	4400		240
SE ±		94.6	62.1



Experimental evaluation of combine harvesting of lentil at Tel Hadya.

Measurement of Outcrossing

In a cooperative project with the University College of Swansea, UK, the rate of outcrossing at Tel Hadya was studied. The variation at a polymorphic aspartate aminotransferase locus was assayed for about 300 germplasm accessions. Two alleles, Aat-1^F and Aat-1^S, were detected at frequencies of 0.51 and 0.49, respectively. The frequency of outcrossing from the observed heterozygosity was estimated to be about 1%. This is higher than direct estimates of outcrossing and implicates selection in favor of heterozygous gene combinations.

Genetic Variation in Straw Quality

Lentil straw is an important livestock feed in the Middle East entering into both national and international trade. Last year (ICARDA Annual Report 1982) we reported that seed yield was positively correlated with straw yield, and that selection for increased seed yields would tend to increase straw yields also. Much attention has been focused in the past on lentil straw quantity and not on its quality. A study of the genetic variation in straw quality was, therefore, conducted at Tel Hadya. The neutral and acid detergent fiber contents of the straw varied from 55 to 64% and 38 to 45%, respectively. There were also highly significant differences among the genotypes in dry-matter digestibility, which varied from 48 to 58%. The dry-matter digestibility of the local check was 54%, on average. The overall productivity of the trial was 1414 kg/ha seed and 2464 kg/ha straw. The plants were well nodulated, and there were significant genetic differences in the protein content of both straw and seed. The straw protein content ranged from 5.9 to 8.6%, with the local checks showing a level of 6.5% protein, on average. The corresponding range for seed protein content was from 24.3 to 25.7%. The average seed protein and straw protein yields were 353 kg/ha and 171 kg/ha, respectively.

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

Genetic Variation in Nitrogenase Activity

To ascertain the differences in the nitrogen fixation potential of the genotypes included in the on-farm trials, their nitrogenase activity at Tel Hadya was assayed from the end of January to early May 1983 (Fig. 8). In general, the *macrosperma* types (78S 26002, 78S 26004, and Kurdi 1) displayed bigger nitrogen fixation profiles than the *microsperma* types (78S 26013, 76TA 66088, and Hurani 1), although differences were also evident within each group. To get a relative estimate of overall nitrogen fixation potential of the test genotypes, the nitrogenase activity (Fig. 8) was integrated over time. The highest value was for Kurdi 1. In relation to Kurdi 1, the nitrogen fixation potential of 78S 26004, 78S 26002, 78S 26013, 76TA 66088, and Hurani 1, respectively, was 93, 79, 67, 58, and 50%.

An interesting genotypic difference was the sensitivity of the nitrogenase activity to low temperature. Unlike all other genotypes, 76TA 66088 did not show any decrease in the nitrogenase activity between 24 Feb and 10 Mar in response to the very low temperature recorded on 7 Mar (-5.6°C). Also interesting was the observation that Kurdi 1 maintained higher nitrogenase activity over a longer period than other genotypes. The possibility of exploiting these genotypic differences in improving the nitrogen fixation of lentil cultivars will be examined in the 1983/84 season.

Seed Quality

Lentils are priced according to seed size, seed uniformity, and the presence of foreign material, including broken seeds. A routine sizing technique was established for *macrosperma* and *microsperma* lentils. Screens used for *macrosperma* lentils had round holes of 7, 6, 5, and 4 mm diameter. The criterion for selection considers mean seed size and the standard deviation of seed size distribution.

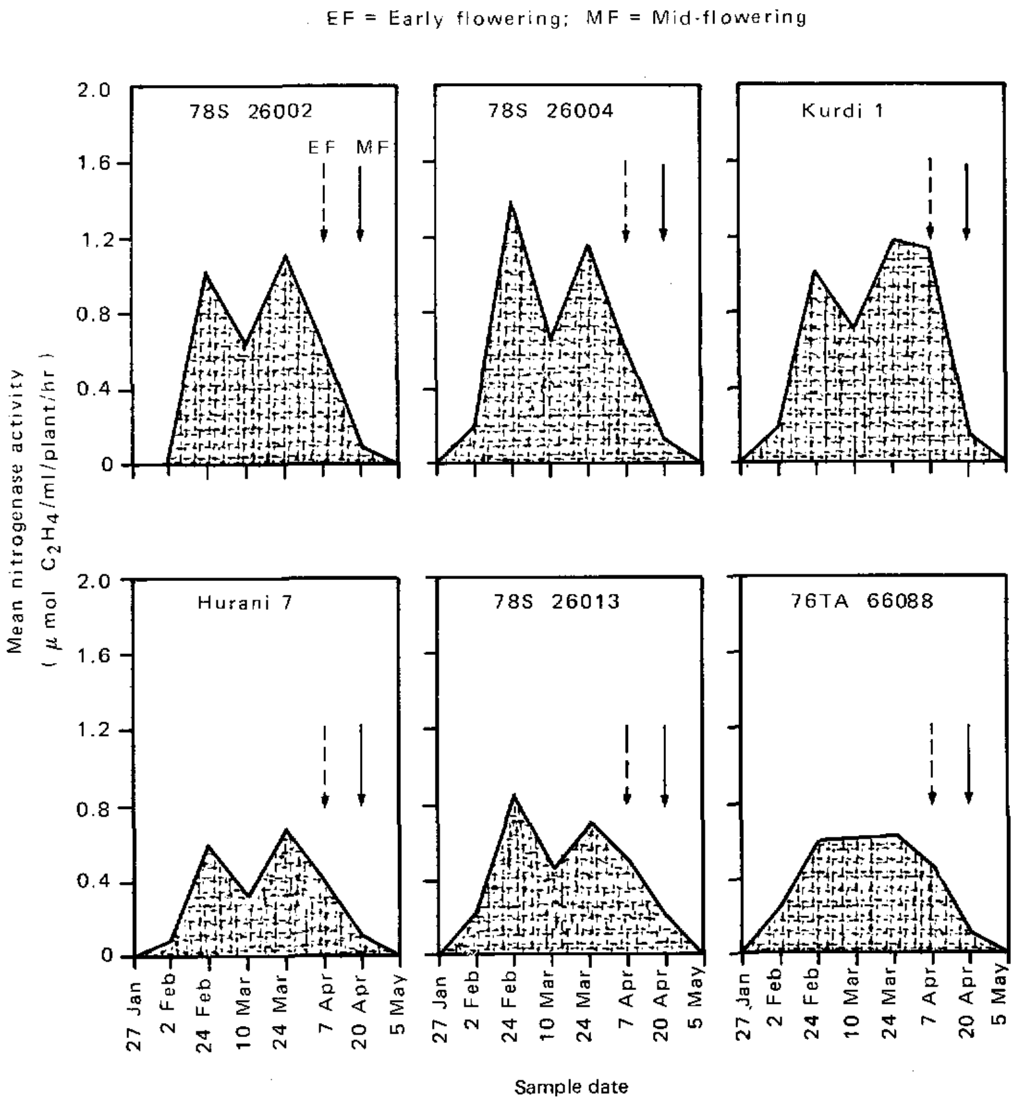


Fig. 8. Nitrogenase activity (C_2H_4 production) in six lentil genotypes at Tel Hadya, 1982/83.

Small-seeded lentils are generally decorticated and split before export. Loss in decortication is an important quality characteristic. Based on Schule laboratory-scale equipment, a laboratory decorticator has been designed and built at Tel Hadya. The decorticator consists of two circular carborundum discs. The bottom disc rotates at 700 rpm and the top disc is stationary. The distance between the discs, being adjustable, is set according to lentil seed size. Using this decorticator, preliminary work was carried out on standardizing the technique for evaluation of lentil genotypes.

An ICARDA-developed lentil decorticator is used to evaluate the seed quality of lentil genotypes.

A study to investigate the relation between seed size (ranging from 3.5 to 5 mm) and loss in decortication revealed that decortication loss was inversely proportional to seed size (Fig. 9), the coefficient of correlation being 0.95.

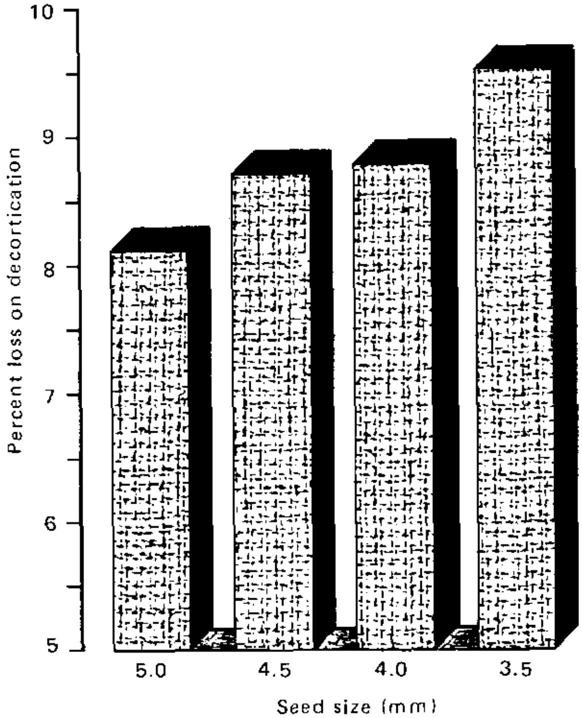


Fig. 9. Relationship between the seed size and loss on decortication in small-seeded lentils.

Production Technology

Response to Date of Planting

Our previous studies have shown that early planting of lentil (before mid-December) gave superior growth and yield. However, the results of the past 2 years have shown that the advantage of early sowing, in terms of seed yield, was not very large, probably because of the relatively severe winters in both years (Table 25). A trial was therefore conducted in the 1982/83 season to evaluate some of the new superior lentil genotypes from the breeding program, for their growth and yield under November and early-February sowing. The winter in the 1982/83 season was even colder than in 1981/82 (Table 25). The November-sown crop took 135 to 148 days to flower and 170 to 180 days to reach physiological maturity, while the February-sown crop took 82 to 87 days to flower and 110 to 117 days to reach maturity (Fig. 10). It is this difference in the duration of growth which results in the better performance of the early-sown crop; its reproductive growth is spread over a longer period when there is adequate soil moisture available.

The early growth of the November-sown crop was extremely poor because of the cold. Even so, genotypic differences could be seen. ILL 8 was superior to the rest of the genotypes from the very beginning (Fig. 10) and seemed to be better adapted for winter sowing. The total biological yield and seed yield of the genotypes under two planting dates are shown in Table 26. Whereas the average total biological yield for genotypes was significantly increased with early planting, the seed yield was not affected. November planting caused a conspicuous in-

Table 25. Mean monthly minimum temperature for 1978/79 to 1982/83 at Tel Hadya.

Year	Mean monthly minimum temperature (°C)							Mean	No. of frosty days
	Nov	Dec	Jan	Feb	Mar	Apr	May		
1978/79	2.8	5.3	4.0	6.0	7.0	9.0	14.0	6.9	15
1979/80	9.7	4.0	1.8	3.3	6.4	8.8	12.0	6.6	19
1980/81	6.8	3.4	3.7	2.8	6.3	6.9	9.6	5.6	22
1981/82	4.6	5.2	2.4	-0.6	2.3	9.7	12.2	5.2	39
1982/83	3.5	0.8	-1.3	1.0	4.3	6.8	12.5	3.9	52

Table 26. Yield of some promising genotypes of lentils as affected by sowing date at Tel Hadya, 1982/83.

Genotype	Total biological yield			Seed yield		
	Date of sowing			Date of sowing		
	27 Nov	5 Feb	Mean	27 Nov	5 Feb	Mean
ILL 8	4285	3396	3841	1300	1162	1231
ILL 9	3309	2641	2975	889	819	854
ILL 16	3538	3081	3310	1060	1095	1078
ILL 223	3242	2922	3082	1014	1007	1011
ILL 4400	3289	2962	3126	857	1049	953
ILL 4401	3049	2683	2866	850	781	816
Mean	3452	2948		995	986	
CV (%) Dates (D)		9.7				16.0
Genotypes (V)		18.6				24.1
LSD (5%)						
D		283				NS
V		606				243
V in D		857				344
D in V		827				NS

NS = Not significant.

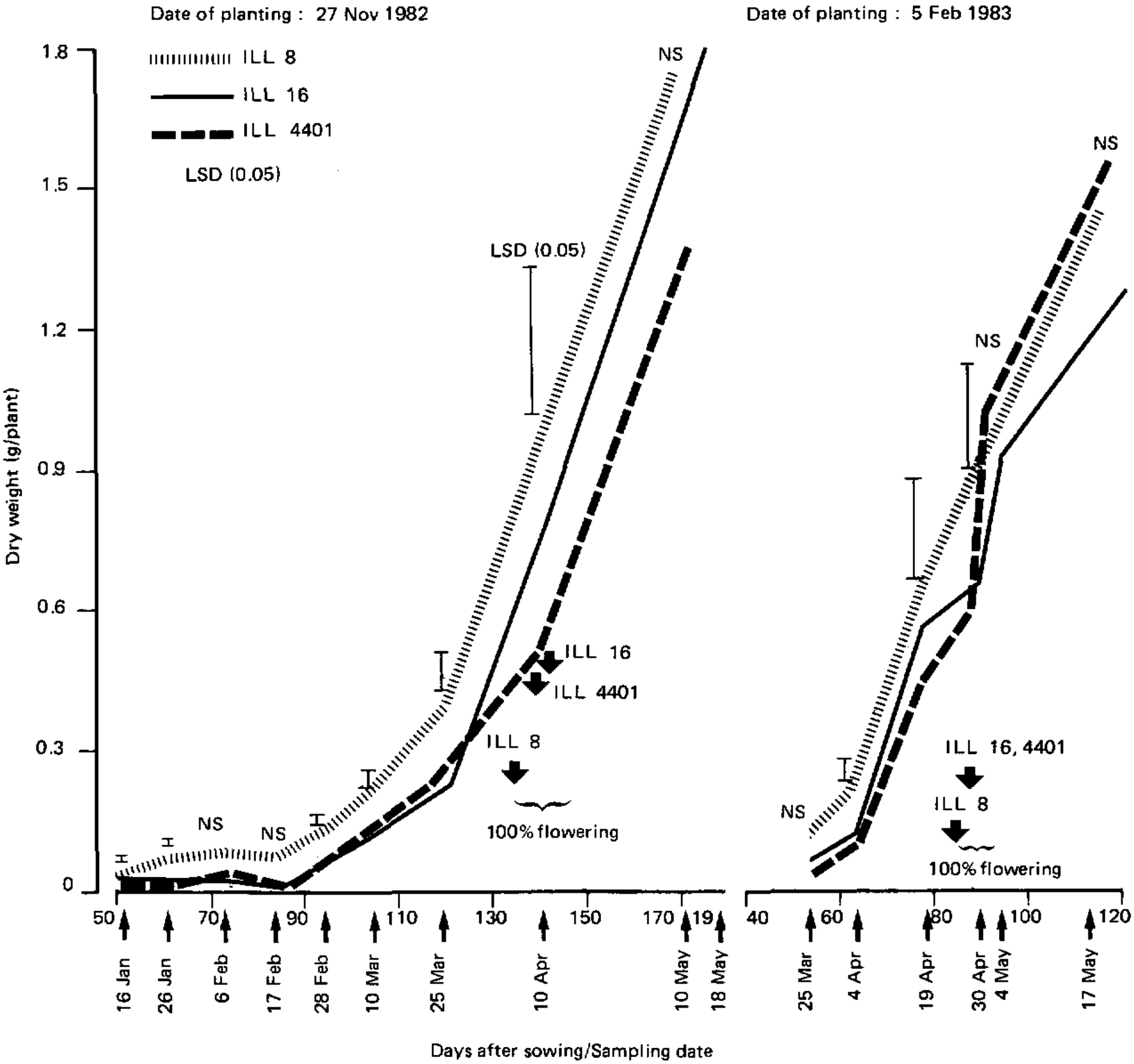


Fig. 10. Total dry-matter (g/plant) production in some promising lentil genotypes planted in November and February at Tel Hadya, 1982/83.

crease in the total biological yield of ILL 8 but had only a small effect on seed yield (Table 26). This suggests that genotypes with relatively better tolerance to cold can be identified for early planting in the low- to medium-elevation areas of the Mediterranean region.

Date of Planting and Plant Population

In a date of planting and plant population trial conducted with a new lentil genotype, ILL 223, the total dry-matter yield was again significantly improved by advancing planting date from early December to mid-November, but the seed yield was not much affected. Increasing the population from 133.3 plants/m^2 increased both seed and straw yield and the largest values were attained at 333.3 plants/m^2. The moisture extraction pattern, consumptive use of water, and water-use efficiency were studied in four selected treatment combinations of two dates of planting and two population levels (Table 27). The soil moisture changes under these treatments during the cropping season are shown in Fig. 11. Results confirmed the observations of the last season that early planting at a high plant population extracted more water, perhaps because of the deeper penetrating root system (Fig. 11). The water-use efficiency was also improved, particularly at higher population levels, with early sowing (Table 27).

Off-Station Evaluation of Early Planting

In collaboration with the Farming Systems Program, we use off-station trials on farmers' fields as a step in the process of developing profitable and appropriate techniques for Syrian farmers. On-farm trials were conducted over the past four seasons to determine the advantage of early sowing under actual farming conditions. Farms were selected at different sites each year in the high- and medium-rainfall zones of northwest Syria, where lentils are grown in rotations with cereals and summer crops.

Large differences in lentil crop revenue between sites, between years, and between zones were noticed (Fig. 12). Surprisingly, there was no consistent pattern in the effect of early vs normal sowing dates. This apparent difference in the results of on-farm trials from those on the research station is not uncommon but needs to be analyzed to identify the major constraints causing such a difference. Differences in the variety and the control of diseases and pests,

Table 27. Effect of date of planting and plant population on the productivity and water-use efficiency (WUE) of ILL 223 at Tel Hadya, 1982/83.

	P_1 (333.3 plants/m^2)			P_4 (133.3 plants/m^2)		
	Planting date			Planting date		
Particulars	15 Nov (D_1)	23 Dec (D_3)	Relative D_3/D_1	15 Nov (D_1)	23 Dec (D_3)	Relative D_3/D_1
Date of maturity	May 5	May 17		May 17	May 17	
Total E_T (mm)	280.2	247.9		247.4	224.8	
Total Eo (mm)	531.2	518.1		531.2	518.1	
Seed yield (kg/ha)	1246	1041	0.84	1111	652	0.59
Biological yield (kg/ha)	4025	2860	0.71	3114	1717	0.55
Harvest index	0.31	0.36		0.36	0.38	
WUE 1 (kg seed yield/ ha/mm E_T)	4.45	4.20	0.94	4.49	2.90	0.65
WUE 2 /kg biol. yield/ ha/mm E_T)	14.36	11.54	0.80	12.59	7.64	0.61

seed-bed preparation, and sowing methods between the research farm and farmers' fields may be the cause. Also, the number of on-farm trials, particularly in the last three seasons, has been rather small, and the margin of benefit from early sowing even at the experimental station has been relatively small because of more drastic winters (Table 25). It is therefore proposed to continue the on-farm evaluation of the early vs normal sowing date in 1983/84.

High-Density Cropping to Increase Water-Use Efficiency

A winter-sown crop of lentil at traditional plant populations usually covers less than 50% of the ground until the beginning of spring. Under such situations soil moisture is lost from the bare surface through evaporation. Whether growing a thicker stand, to start with, and thinning it down to the optimum population level later in the season could permit conversion of a greater proportion of this evaporation to transpiration and thus increase the water-use efficiency, was studied in a trial during the 1982/83 season. The treatment details are given in Table 28. To increase the scope of the trial, intercropping of barley between lentil rows was also evaluated. The total biological yield per unit area was maximized in the non-thinned crop established at 15 cm row spacing (T_1 444.4 plants/m^2) and was minimized by intercropping lentil with two

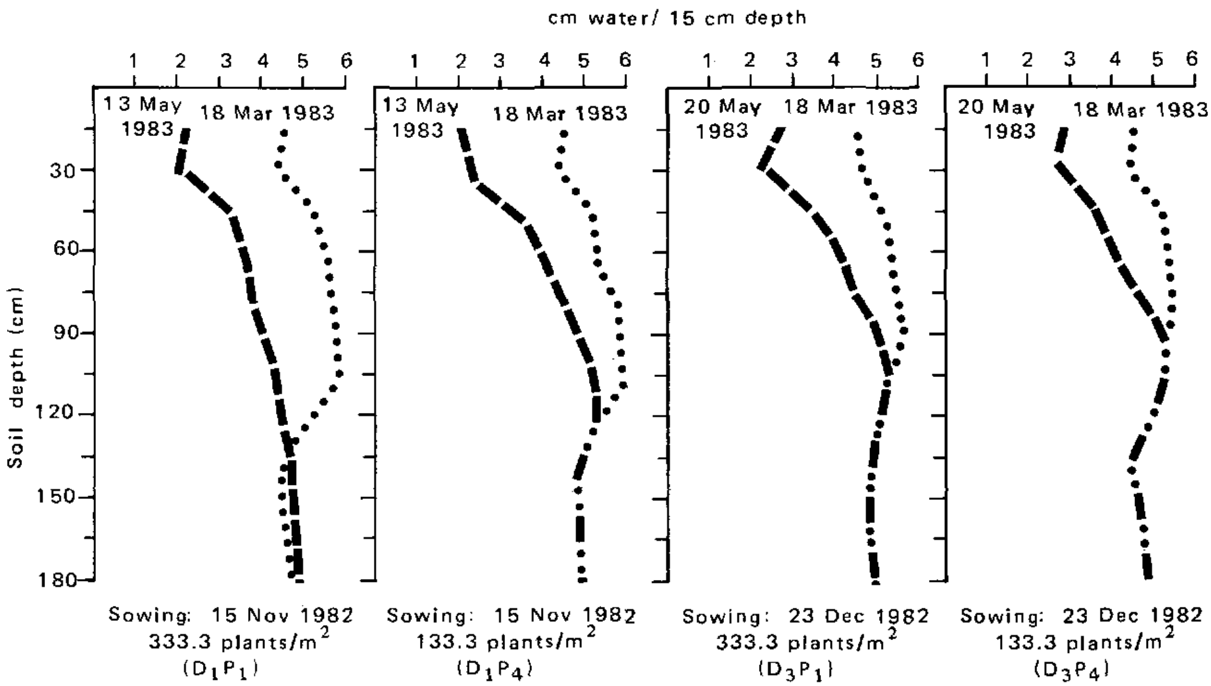


Fig. 11. Soil-moisture content in different layers at the highest recharge and at physiological maturity under ILL 223 lentil planted at two different dates and two population levels at Tel Hadya, 1982/83.

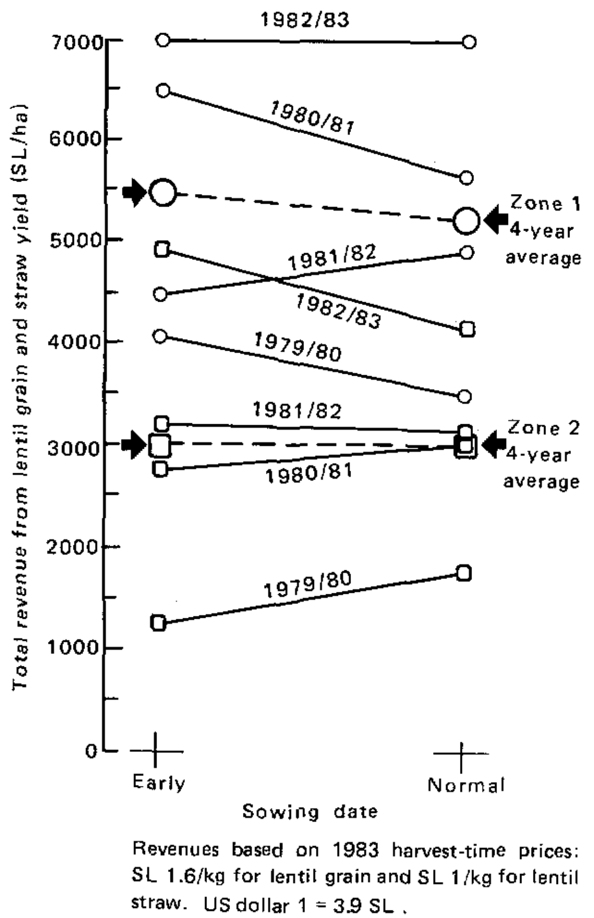


Fig. 12. Effect of sowing date on total lentil crop revenue : summary of four years of on-farm trials in two rainfall zones of northwest Syria.

rows of barley with 15 cm row width (T_9, Table 28). The total biological yield of the crop thinned to a given density was lower than that of the crop established at the same density right from planting. When the dry-matter yield from thinning was added to the total biological yield of the remaining stand, it was interesting that the total biological yield in the case of thinning of lentils from 15-cm to 30-cm row width was more than that of the non-thinned crop planted at 30-cm row spacing. It is proposed to repeat this study during the 1983/84 season to get more conclusive results.

Response to Residue Management and Phosphate Application

Studies on the effect of incorporating vs burning of the residues of the preceding cereal crop on the yield of lentil revealed that the incorporation of straw significantly increased the productivity of lentil in terms of total biological yield as well as seed yield. Application of 50 kg P_2O_5/ha either mixed with seed or placed 5 cm below the seed resulted in a significant increase in the seed and total biological yield over the no-phosphate control. Broadcast application of 50 kg P_2O_5/ha was not at all effective. The available phosphorus status of the soil was very low (1.3 - 1.5 ppm P).

Weed Control

Crop loss from weeds was assessed at Tel Hadya and Terbol where the weedy check yielded only 70 and 63%, respectively, of the weed-free treatment. Handweeding twice was as effective as the completely weed-free situation obtained by repeated handweeding. Of the various preemergence herbicides tested (chlorbromuron, prometryne, methabenzthiazuron, and cyanazine alone or mixed with pronamide), none proved promising at Tel Hadya.

At Terbol, prometryne at 1.5 kg a.i./ha gave a 62% increase in yield over the weedy check, proving as effective as handweeding. But more promising treatments were methabenzthiazuron (2 kg a.i./ha) + pronamide (0.5 kg a.i./ha) and cyanazine (1 kg a.i./ha) + pronamide (0.5 kg a.i./ha) which, respectively, gave 86 and 73% increase in seed yield over the weedy check.

Table 28. Yield estimates in lentils as affected by different cropping systems at Tel Hadya, 1982/83.

Treatment	Total biological yield (kg/ha)				Seed yield of lentil (kg/ha)
	Early veg. phase	Beginning of flowering	At maturity	Total	
T_1 - Lentil at 15 cm × 1.5 cm			5313	5313	1855
T_2 - Lentil at 30 cm × 1.5 cm			4018	4018	1491
T_3 - Lentil at 60 cm × 1.5 cm			3105	3105	1212
T_4 - *Thin from 15 to 30 cm at early* vegetative phase (St_1)	330		3833	4163	1383
T_5 - Thin from 15 to 60 cm at flowering (St_2)		924	3461	4385	1278
T_6 - Thin from 15 to 60 cm at St_1 and St_2	334	997	1990	2987	641
T_7 - Thin barley between lentil rows to make 30 cm row width at St_1	146		3657	3803	1244
T_8 - Thin barley between lentil rows to make 30 cm row width at St_2		765	3524	4289	1300
T_9 - Thin two rows of barley in two stages to leave lentil rows at 60 cm	123	113	2331	2567	910
LSD (5%)			562	483	259
CV (%)			11.1	15.5	14.1

Insect Control

Control Methods

A trial was designed to partition yield losses among crop growth stages, to identify the key pests responsible for yield losses, and to select appropriate insect control technology. When different insecticidal regimes were compared, a 23.7% *increase in yield was obtained* when a soil application of a granular insecticide to control *Sitona* spp. weevil was complemented with one foliar spray against *Apion* spp., aphids, thrips, and very low populations of *Laspeyresia* spp. and *Heliothis* spp. (Table 29). Partition of insecticidal regime indicated that *Sitona* spp. control alone significantly increased yields by 19%, whereas foliar insect control increased yield by only 4.2%. High dosage of nitrogen did not compensate for *Sitona* spp. damage. The economic analysis confirmed that *Sitona* spp. control is important and that this insect was the key pest during the past season. The best option for a farmer to prevent *Sitona* spp. damage would be the application of a granular insecticide at planting.

Determination of the Economic Importance of *Sitona* spp.

At high levels of infestation (up to 93.5% nodules damaged in check plots), the insect caused 17.7 and 14.1% losses in straw and grain yields, respectively. Both heptachlor and carbofuran applied as granules at planting significantly increased straw and grain yields (Table 30). Foliar sprays against adults were not as efficient and had a detrimental effect on

Table 29. Effect of different insecticidal regimes on the yields of Syrian Local Large lentil at Tel Hadya, 1982/83.

Treatment	Yield (kg/ha)	% Yield increase
Full protection (FP)[1]	2714	19.3
FP less soil insecticide	2639	16.0
FP less preflowering sprays	2683	17.9
FP less postflowing sprays	2734	20.2
Check	2274	
Recommeded protection (RP)[2]	2813	23.7
RP less soil insecticide	2371	4.2
RP less foliar spray	2707	19.0
Alternative practice[3]	2243	− 1.3
LSD (5%) for yields	248.0	
CV(%) for yields	6.0	

1. Soil insecticide (carbofuran) plus seven foliar sprays with methamidophos or endosulfan.
2. Soil insecticide (carbofuran) plus one foliar spray with methamidophos.
3. 100 kg N/ha plus one foliar spray with methidathion.

Table 30. Efficiency of insecticidal combinations to control *Sitona* spp. weevils in Syrian Local Large lentil and their effect on straw and grain yields at Tel Hadya, 1982/83.

		% efficiency		Yield (kg/ha)		% yield increase	
Adult control[1]	Larval control[2]	Against adults	Against larvae	Straw	Grain	Straw	Grain
Yes	With heptachlor	86.0	100	4114	2643	13.8	15.6
No	With heptachlor	72.1	100	4391	2628	21.5	15.0
Yes	With carbofuran	89.3	100	4235	2586	17.2	13.1
No	With carbofuran	87.4	100	4337	2583	20.0	13.0
Yes	No	29.8		4197	2439	16.1	6.7
No	No			3614	2286		
LSD (5%) for yields				308.1	123.3		
CV (%) for yields				4.2	4.4		

1. Four sprays with methidathion 0.5 kg a.i./ha.
2. With carbofuran 1 kg a.i./ha or heptachlor 2 kg a.i./ha.

straw yields. The economic analysis (Fig. 13) confirmed that heptachlor 4G at the relatively high dosage of 2.0 kg a.i./ha was a better alternative than carbofuran 5G applied at 1.0 kg a.i./ha. Repetitive future studies will concentrate on searching for cheaper, safer, and easier alternative methods of control.

The nitrogenase activity was assayed for all treatments (Fig. 14). Where there was no protection, nitrogenase activity fell to barely detectable levels by the 30 March sampling. Such levels for the plants treated with granular insecticides were not reached till 27 April. The combination effect between the adult control

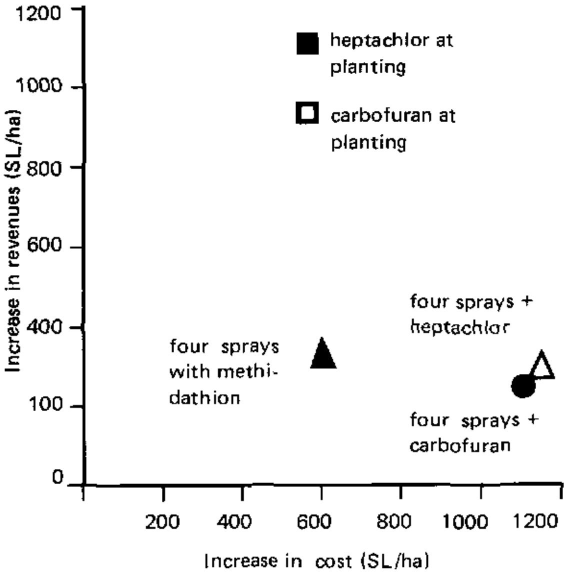


Fig. 13. Cost-benefit relationships for five alternatives of chemical control of *Sitona* spp. weevils in lentils.

(sprays) and granular products used for larval control was interesting. Foliar spray in combination with heptachlor suppressed the nitrogenase activity, but with carbofuran enhanced it. Attempts to better understand the effect of insecticidal sprays on the nitrogenase activity will be made in the 1983/84 growing season.

Development of Wide Adaptation in Lentils

Limited adaptation of most lentil cultivars has hindered their widespread use in different environments. Previous studies on the performance of lentil genotypes in the International Lentil Adaptation Trial and in greenhouse experiments at Tel Hadya have indicated that both temperature and photoperiod exert a profound influence on the phenological development of the crop and thus affect its adaptation.

In a collaborative project with the University of Reading, UK, we have started to examine the photothermal effects on flowering of diverse genotypes of lentil in controlled environments. Earlier, in the same project, we examined the suitability of different sources of artificial light for growing lentils in controlled environments so that plants of different genotypes closely resemble those grown in the field.

Simultaneously, at Tel Hadya, we continued to examine the flowering response of some diverse genotypes of lentils to photoperiod and temperature in relatively less controlled greenhouse conditions. Some new entries (ILL 1, 16, and 223) from the breeding program were added to those studied earlier because of their superior performance across several locations. In one of the two day-length treatments, the photoperiod naturally increased from 9.8 hr, at the start of the experiment, to 14.1 hr near the termination of the study. In the other treatment the normal day length was extended to 16 hr using fluorescent tubes. Two temperature regimes were established: (1) the low temperature regime as obtained naturally in the open cage, and (2) the high temperature regime obtained through the circulatory heater in the greenhouse. The mean maximum and minimum temperatures for the period by which flowering was recorded in all treatments were 28.5 and 11.3°C, respectively, for the high temperature regime, and 20.7 and 9.4°C for the low temperature regime.

The results obtained in the 1982/83 season (Table 31) confirmed our previous findings: a warmer thermal regime and a longer photoperiod hastened the onset of reproductive growth. ILL 4605 (from Argentina) again showed least sensitivity to day-length change and ILL 2526 (from India) showed no sensitivity to day-length change under the warmer

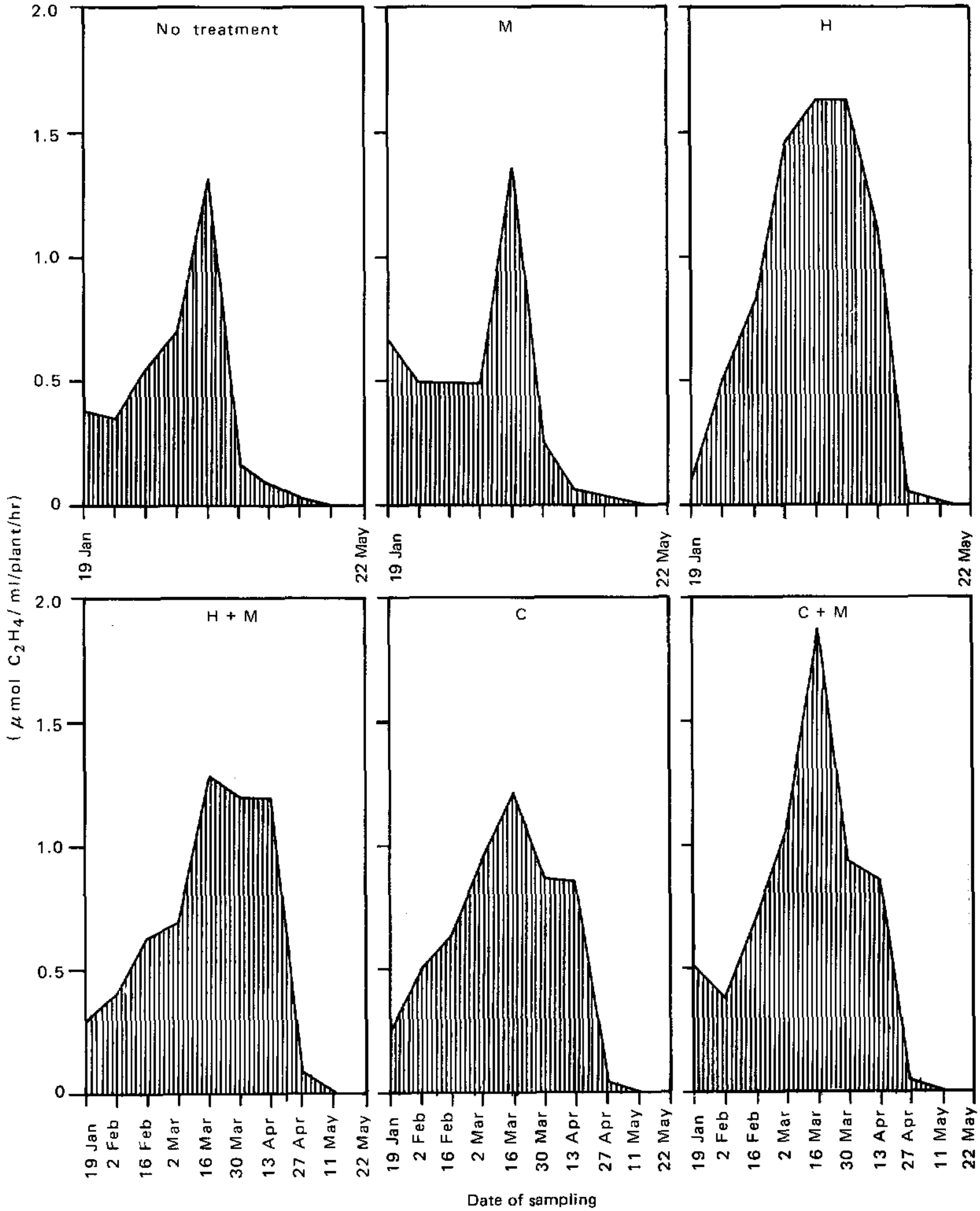


Fig. 14. A comparison of mean nitrogenase enzyme activity (C_2H_4 production) in lentils treated with heptachlor (H) or carbofuran (C), for controlling *Sitona* spp. weevil larvae and methidathion (M) for adults.

Table 31. Effect of long day (LD) of 16 hr vs normal day (ND) conditions on the days to flower bud appearance of 10 genotypes of lentil under low and high ambient temperatures in the greenhouse at Aleppo, 1982/83.

		Days from planting to first flower bud[1]			
		High temperature		Low temperature	
Genotype	Origin	LD	ND	LD	ND
ILL 1	Jordan	88.5	107.8	126.5	135.9
ILL 16	Jordan	85.5	114.3	126.3	139.3
ILL 92	USSR	94.7	124.7	133.5	150.1
ILL 204	Ethiopia	82.7	122.3	135.2	149.1
ILL 223	Iran	78.9	113.7	132.9	135.4
ILL 784	Egypt	77.8	110.7	128.6	146.6
ILL 2526	India	80.7	82.0	124.2	139.6
ILL 4400	Syria	81.1	130.2	124.6	146.1
ILL 4401	Syria	79.2	111.6	120.2	135.5
ILL 4605	Argentina	84.0	80.5	127.6	126.3

1. Mean of approximately 20 plants.

regime. Among the new entries tested, ILL 223 was the least sensitive to day-length variation at low temperature and ILL 16 under the high temperature regime.

Use is being made of genotypes such as ILL 4605 and ILL 2526 in the crossing program to develop genetic stocks for more southernly latitudes where lentil is grown in relatively shorter day lengths.

Development of Drought Tolerance in Lentils

The search for drought-avoiding genotypes which mature early enough to escape severe drought and temperature stress during the reproductive period of growth continued. The correlations between both flowering and maturity and seed yield in a dry environment (Breda) were studied in order to gauge the effect of selecting for early maturity on seed yield. Breda received 260 mm rainfall in the season up to harvest. In the regional yield trial (large-seeded) at Breda, the phenotypic correlations between seed yield, on the one hand, and time to flowering and maturity, on the other hand, were r = -0.55 and r = -0.66, respectively. In the small-seeded regional yield trial at Breda, the phenotypic correlations between seed yield and time to flowering and maturity were again significant, but lower at r = -0.42 and r = -0.38, respectively. These negative correlations show that the highest seed yields at Breda were achieved by the early flowering and maturing selections, endorsing the approach of selecting for drought avoidance through early maturity.

A screening nursery of 408 early germplasm accessions and an early yield trial were grown at both Breda and Tel Hadya to identify the early-maturing material. A few selections yielded as well as, or better than the local checks but matured significantly earlier. These entries will be retested in 1983/84. Response of 12 diverse genotypes, including some of those found superior yielding in multilocation testing, to total seasonal moisture supply was studied by growing them under rainfed conditions at Tel Hadya (seasonal rainfall 322 mm) and Breda (seasonal rainfall 260 mm) and also with supplemental irrigation (150 mm total in the form of three irrigations between early April and early May) at Tel Hadya. Intensive soil-moisture studies were carried out on eight selected genotypes to determine consumptive use of water and water-use efficiency under rainfed conditions at Tel Hadya. Also, early root growth was studied in a germinator (at 20°C) and the growth of root and shoot in pot culture in the greenhouse.

Averaged over all the genotypes, the yield was closely related to total seasonal moisture supply (Table 32). Compared with the rainfed situation at Tel Hadya, an assured moisture supply (472 mm) through supplemental irrigation increased the total biological yield of all the genotypes. But ILL 101, 793, and 16 responded most conspicuously while the response of ILL 1861, 4401, and 470 was the least. Yields of all genotypes decreased sharply when they were grown in the drier location, but the reductions were least in ILL 8, 9, 16, 1861, and 4354. Genotype ILL 16 responded positively to increased moisture supply at Tel Hadya and it was among the genotypes least affected by droughty conditions of Breda. This may partly explain its wider adaptability previously reported.

The seasonal water use and water-use efficiency of the eight selected genotypes grown rainfed at Tel Hadya are given in Table 33. The genotypes maturing latest (ILL 793 and 4349) had the highest consumptive use of water and ILL 9, a relatively earlier maturing genotype, had the lowest water use. The water-use efficiency was highest in the early genotype ILL 9. Earliness combined with higher growth rates appears to be the key factor in improving the water-use efficiency.

Table 32. Effect of total seasonal moisture supply on the seed and total biological yield of 12 diverse genotypes of lentil in northern Syria, 1982/83.

		Seed yield (kg/ha)			Total biological yield (kg/ha)		
		Breda	Tel Hadya		Breda	Tel Hadya	
Genotype	Origin	Rainfed (260 mm)	Rainfed (322 mm)	Irrigated (472 mm)	Rainfed (260 mm)	Rainfed (322 mm)	Irrigated (472 mm)
ILC 8	Jordan	518	840	1375	1646	3049	4371
ILC 9	Jordan	419	1115	1480	1685	3594	4874
ILC 16	Jordan	399	908	1749	1804	3255	5414
ILC 101	Syria	341	861	1950	1006	3130	5454
ILC 223	Iran	384	1018	1414	1283	3117	4294
ILC 470	Syria	287	1015	1196	1110	3315	4482
ILC 793	Egypt	120	846	1794	994	3134	5144
ILC 1861	Sudan	327	714	1255	1098	2784	3728
ILC 4349	USSR	90	913	1412	1206	3482	5132
ILC 4354	Jordan	429	1250	1700	1498	3655	5224
ILC 4400	Syria	163	939	1688	1078	3131	4588
ILC 4401	Syria	349	1130	1422	1202	3588	4693
Mean		319	962	1536	1301	3270	4783
CV (%)		35.8	20.2		14.7	15.4	
LSD (5%)		164	357		275	1139	

Table 33. Total extractable moistrue (EM), evapotranspiration (E_T) and water-use efficiency (WUE) for total biological yield (TBY) and seed yield (SY) of different lentil genotypes under rainfed conditions at Tel Hadya, 1982/83.

Genotypes	Date of maturity	EM (mm)	E_T (mm)	WUE (kg/ha/mm) TBY	SY
ILL 9	May 13	67.7	242.7	14.8	4.6
ILL 16	May 13	85.2	258.0	12.6	3.5
ILL 101	May 17	91.0	267.1	11.7	3.2
ILL 223	May 12	81.4	251.1	12.4	4.0
ILL 470	May 10	95.1	274.9	11.3	3.7
ILL 793	May 28	104.2	287.7	10.9	2.9
ILL 4349	May 28	103.1	289.7	12.0	3.1
ILL 4401	May 13	82.3	255.3	14.0	4.4

Of the genotypes evaluated for their early root growth, ILL 470 was the fastest. In two separate germination studies, using all the test genotypes, this was confirmed. Also, in the pot-culture study with different moisture regimes this genotype produced more roots and had a higher root-to-shoot ratio than other genotypes. In the field experiment also, among the early-maturity types, it extracted the most moisture (Fig. 15). ILL 470 is, therefore, of interest to us for further studies.

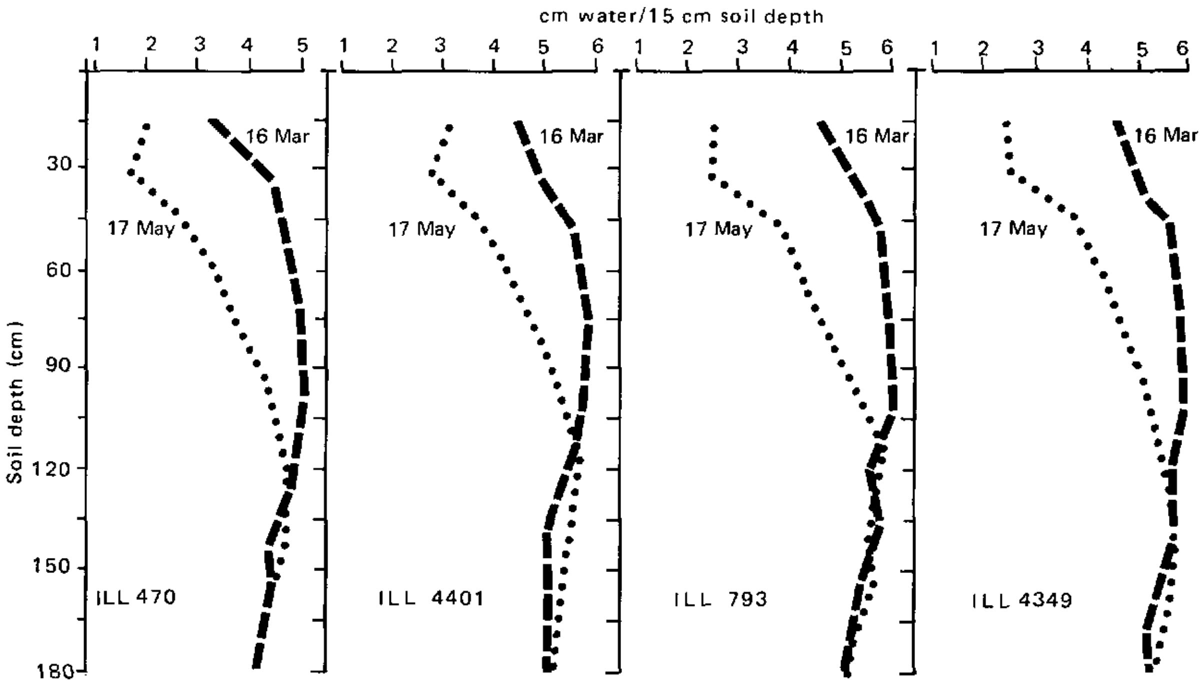


Fig. 15. Soil-moisture content in different soil layers (cm water/15-cm soil layer) at the highest recharge and at physiological maturity of some contrasting lentil genotypes under rainfed conditions at Tel Hadya, 1982/83.

Kabuli Chickpea Improvement

The overall objective of this program is to increase the production of kabuli-type chickpeas in the world through the development of superior genetic stocks and associated improved production technology and making them available to national programs. Research on kabuli chickpeas is carried out in collaboration with ICRISAT. In 1982/83 our emphasis continued to be on developing genetic stocks and cultivars with high yield, ascochyta blight resistance, less photoperiod sensitivity, and maintenance of nutritional and cooking quality.

The breeding strategy consists of making around 350 crosses of selected parents, growing the F_1 generation in the summer nursery under artificially extended day length, evaluating F_2 populations and F_4 and F_6 progenies for ascochyta blight resistance, cold tolerance, iron chlorosis, and *Orobanche* spp. tolerance at Tel Hadya, and screening F_3 progenies for less photoperiod sensitivity in the summer nursery. Due consideration is given for seed size, plant height, biological yield, and seed protein content while making selections. Uniform and promising progenies in F_5 to F_7 generations are bulked and then evaluated during winter and spring in multilocation replicated trials. This permits selection of genetic stocks for different agroecological zones.

Although chickpeas are traditionally grown during spring in West Asia and North Africa, our research in the past has established the advantage of winter sowing in low-altitude areas in the Mediterranean region. Therefore, emphasis in research on development of genetic stocks and technology for production and protection has been directed toward the spring-sown as well as the winter-sown crop.

Germplasm

The Kabuli chickpea gene bank at ICARDA has a current holding of 5340 accessions. Of these, 920 accessions were added in 1982/83. Of 5340 accessions, 840 are those developed at ICARDA through hybridization. The collection represents 34 countries, the largest numbers, in decreasing order, coming from Iran, Afghanistan, Turkey, Chile, Spain, Tunisia, and India. Obvious gaps in our collection are Algeria, Mexico, and Morocco.

Over 3300 accessions have been evaluated for 27 descriptors. The evaluation data along with passport information have been computerized using our VAX-11/780 computer system. The information has been published as a 'Kabuli Chickpea Germplasm Catalog' and distributed to scientists. Evaluation of germplasm suggests that additional collections from the USSR could be useful for ascochyta blight and frost resistance, late flowering, and tallness; from Spain for large seed size and high biological yield; from Chile for more primary and secondary branches, high harvest index, and high protein content; and from the Indian subcontinent for cold tolerance.

One of our major objectives in germplasm resources work has been to distribute the germplasm to national programs. To date, 6330 germplasm lines have been distributed.

Improved Kabuli Chickpea Cultivars and Production Technology

Development of Cultivars and Genetic Stocks

During the 1982/83 season, 375 crosses were made at Tel Hadya: 109 for development of cultivars for winter and spring sowing, 30 for large-seeded cultivars, 25 for tall types, 25 for large-seeded and tall cultivars, 12 for cold tolerance, 20 for improvement of local landraces, 48 for national programs in Tunisia and Jordan, 66 for identification and pyramiding of genes for resistance to ascochyta blight, and 40 for inheritance studies of height and seed size, cold tolerance, protein content, iron chlorosis, and resistance to leafminer. Of the total 375 crosses, 326 were single, 45 three-way, and 4 back-crosses. While the main emphasis continues to be on development of cultivars for winter and spring sowing, the breeding work has been diversified to develop cultivars to meet the varied needs of national programs, such as large seed, tall type, cold tolerance, and incorporation of adaptation from the landraces.

As the main focus of the program is to develop high-yielding and ascochyta blight resistant genetic stocks, one of the parents in all the crosses was ascochyta blight resistant. In view of the different races, we are attempting to identify genes for resistance and to pyramid them.

Segregating populations. The F_2 to F_4 generations were grown in the ascochyta blight disease nursery during winter at Tel Hadya. The F_5 to F_7 generations were grown both during winter and spring for selection at Tel Hadya. The F_1, F_3, and advanced generations were grown at Sarghaya during the off-season. The total segregating material grown during 1982/83 is shown in Table 34. The progenies found uniform and promising were bulked in F_5 to F_7. During 1982/83, 126 promising lines were bulked. These will be evaluated in 1983/84 for yield potential and adaptation during winter and spring at Tel Hadya and Terbol.

Table 34. Chickpea segregating breeding lines grown for winter (W) and spring (S), plants selected, and progenies bulked during 1982/83 main season at Tel Hadya, and 1982 off-season at Sarghaya.

Generation	No. of segregating lines grown			No. of plants selected			No. of progenies bulked
	Main season	Off-season	Total	Main season	Off-season	Total	Main season
F_1		191	191		6856[a]	6856	
F_2 Population	179 (6856 single plants)	15	194	3312		3312	
F_3 (Bulks)	27		27	505		505	
F_3 (Progenies)	2310	1007	3317	1541	1212	2753	
F_4-W	1219	1099	2318	426	1830	2256	
F_5-S	228		228	126		126	13
F_5-W	2243		2243	586		586	51
F_6-S	510		510	222		222	15
F_6-W	751		751	201		201	31
F_7-S	372		372				4
F_7-W	547		547				12

a. To eliminate selfed plants, single plants are harvested in F_1 and plant rows grown in F_2.

Yield trials. We evaluated 273 newly developed lines in five advanced yield trials (AYT) and eight preliminary yield trials (PYT) during spring at Tel Hadya. A total of 24 entries including 21 test entries and 3 checks were evaluated in each trial (Table 35). Only 10 entries exceeded all three checks. At Terbol, 189 FLIP-developed lines tested in five AYTs and four PYTs performed better than those at Tel Hadya. As many as 28 lines exceeded all three checks (Table 36).

Though most of the lines failed to produce higher yields than the checks, they exhibited resistance to ascochyta blight. Therefore, they could be expected to produce stable yields over the years in blight-prone areas. Furthermore, performance of some of these lines might be better in other chickpea-growing countries, so the promising ones will be furnished to national programs.

Large-seeded chickpeas. The progress in breeding large-seeded, high-yielding ascochyta blight resistant lines has been slow because the resistant sources have very small seed size. However, nine lines with seed size larger than 40 g/100 seeds were developed and tested in an advanced yield trial for large-seeded types during winter and spring at Tel Hadya. The results indicated that 7, 9, and 5 entries exceeded ILC 482, ILC 464, and ILC 3279, respectively, in the winter-sown trial. Only one entry was found to be better than the large-seeded check (ILC 464) in the spring-sown trial. Since not enough entries are available for incorporation in the international nursery, the newly-bred lines will be used in the crossing program.

The national program in Syria identified ILC 620 and ILC 629, two large-seeded types, for evaluation in the on-farm trial during the 1983/84 season.

International trials. We place considerable emphasis on strengthening the national programs by furnishing promising genetic materials and early-generation and advanced breeding lines. The number of nurseries distributed by ICARDA has increased from 34 sets in 1977/78 to 339 sets for 1983/84. Greater demand from national programs indicates the usefulness of the nurseries. The nursery types have also increased from two in 1977/78 to nine for 1983/84 to meet the diverse needs of national programs.

Promising lines from international nurseries have been selected and included in multilocation or on-farm trials with a view to release them as cultivars (Table 37). After initial testing, a few lines have been identified for prerelease multiplication and large-scale testing by five national programs: (i) Syria: ILC 3279; (ii) Lebanon: ILC 482; (iii) Jordan: ILC 482, ILC 202; (iv) Cyprus: ILC 3279; (v) Morocco: ILC 195, ILC 482, ILC 484. It is expected that they will be released as cultivars if they continue to maintain superior performance.

Seed Quality

During 1982/83, we evaluated 3600 lines of chickpeas for their seed protein concentration. Considering the importance of seed size in determing the price and fitness for international trade, a technique for evaluation of seed size was also developed similar to the one described for lentils. Samples of chickpeas are sieved in a stack of round-hole sieves with hole diameters of 9, 8, 7, and 6 mm for one minute by hand. Grading is based on the percentage of total seeds retained above the 8 mm sieve. Size distribution, as a test of uniformity, is also studied and its standard deviation is used to determine the grade. Samples with the largest standard deviation combined with high percentage of the

Table 35. Chickpea test entries that exceeded the yield of the checks in AYTs and PYTs at Tel Hadya, spring 1982/83.

Trial	No. of test entries exceeding check			Highest yield of test entries	Yield as percent of check			
	ILC 482	ILC 263	ILC 1929	(kg/ha)	ILC 482	ILC 263	ILC 1929	CV (%)
AYT-1	21			1757	152	95	98	16.0
AYT-2	14	2	2	1698	157	109	110	20.2
AYT-3	5	1		1420	110	101	97	11.5
AYT-4	6			1251	108	90	94	12.5
AYT-5				1375	94	92	91	13.5
PYT-1	4			1442	118	98	95	23.7
PYT-2	1	1		1539	101	108	93	24.3
PYT-3				1086	86	86	88	16.5
PYT-4	13	1	1	1036	127	108	106	24.5
PYT-5	1	1	1	1433	110	107	111	27.3
PYT-6		2	3	1256	98	107	110	21.3
PYT-7	5	14	15	1553	112	127	137	18.2
PYT-8	1	5	2	1461	102	116	111	17.5

Table 36. Chickpea test entries that exceeded the yield of the checks in AYTs and PYTs at Terbol, spring 1982/83.

Trial	No. of test entries exceeding check			Highest yield of test entries	Yield as percent of check			
	ILC 482	ILC 263	ILC 1929	(kg/ha)	ILC 482	ILC 263	ILC 1929	CV (%)
AYT-1		5		1940	100	111	97	17.0
AYT-2		4	2	2042	99	106	101	16.0
AYT-3	6	3	15	2315	116	108	128	16.0
AYT-4			9	2149	92	99	112	12.0
AYT-5	3		1	2175	108	94	103	14.2
PYT-1	9	21	5	2264	115	154	107	19.0
PYT-2	5	2	10	2681	130	125	138	19.0
PYT-3	17	9	8	2056	122	112	110	20.0
PYT-4	10	18	11	2278	123	136	129	23.0

Table 37. Promising chickpea lines included in multilocation, on-farm, and other national program trials.

Country	Line
Syria	ILC 72, 195, 202, 3279, 620, FLIP 82-64, FLIP 82-336
Jordan	ILC 484, 202
Lebanon	ILC 482, 484
Cyprus	ILC 3279
Egypt	ILC 249, 484, 1407, 2912
Sudan	ILC 1919
Tunisia	ILC 482, 484
Morocco	ILC 195, 482, 484
Pakistan	ILC 192, 195, 482
Canada	ILC 451, 464, 604
USA	ILC 90, 102, 171, 232, 517, 650

seeds retained over the 8 mm sieve are given the highest grade. Using these criteria, the chickpea genetic stocks being developed in the breeding program will be evaluated in 1983/84.

Insects and Their Control

Chickpeas have few insect problems in North Africa and West Asia. The chickpea leafminer, *Liriomyza cicerina* Rond, and the pod borer *Heliothis* spp., are the most important field pests in the region. In storage, *Callosobruchus chinensis* L. is the predominant species. A study of the pest situation during the 1982/83 season revealed that, in addition to *L. cicerina*, another leafminer, *Phytomyza atricornis* (?) was also present. Both could be reared on chickpea in the laboratory. A survey was then conducted in Syria and Jordan so as to ascertain the presence of more than one species of leafminer and the relative proportion in which they occurred. Both species were found throughout Syria and Jordan, *L. cicerina* being most prevalent and accounting for approximately 90% of the total leafminer population (Table 38). Parasitism by *Opius* spp. was low, ranging from 0 to 3.5%. *Heliothis* spp. infestation in Jordan and southern Syria was higher than in north and central Syria.

Chemical control of leafminer and pod borer. Study of selective ways of controlling leafminer and pod borer continued in 1982/83. In a winter trial, low dosages of systemic and contact insecticides were compared with the bacterial (*Bacillus thuringiensis*) and the previously recommended endosulfan treatments. Due to their inherent susceptibility to most insecticides, *Heliothis* spp. were readily controlled; *B. thuringiensis* did act selectively on *Heliothis* spp. but provided only 50% control (Table 39).

Table 38. Leafminer incidence, leafminer parasitism by *Opius* spp., and *Heliothis* spp. damage in 54 chickpea fields in Syria and Jordan, May 1983.

Location	Species composition		% parasitism	% pods damaged by *Heliothis* spp.	
	Liriomyza sp.	*Phytomyza* sp.	by *Opius* spp.	Highest	Mean
Northern Syria	89.1	7.4	3.5	11.1	1.3
Southern Syria	93.8	3.3	2.9	31.8	6.4
Northern Jordan	95.6	1.5	2.8	16.4	5.8
Central Jordan	85.0	15.0	0.0	7.4	1.9
Tel Hadya	88.1	9.6	2.3	1.9	0.6

Table 39. Leafminer populations and damage, pod borer damage, and yields of winter-planted ILC 482 chickpea as affected by organic and bacterial insecticides, Tel Hadya, 1982/83.

Treatment	Dosage (kg a.i./ha)	Leafminer adults/ 10 sweeps[1]		Leafminer damage[2]	% pods damaged by *Heliothis* spp.	Yield (kg/ha)	% yield increase
		Liriomyza sp.	*Phytomyza* sp.				
Endosulfan	0.70	13.3	15.5	1.0	0.5	2913	4.6
Bacillus sp.	1.50[a]	28.3	22.5	8.0	2.0	2817	1.1
Dimethoate	0.20	15.3	21.0	1.0	1.5	3103	11.4
Phosphamidon	0.25	26.5	14.3	2.0	0.8	3044	9.3
Monocrotophos	0.24	11.3	19.3	1.0	0.9	3367	20.9
Check		30.8	27.0	8.5	4.0	2785	
LSD (5%)		13.8	7.8	1.2	1.1	432.2	
CV (%) for yields = 9.5							

1. Average of six scoring dates.
2. On 1-9 scale; 1 = no damage, 9 = severe damage.
a. Commercial product, 3500 spores/mg.

Monocrotophos was the most efficient insecticide against both leafminer and pod borer and significantly increased yields by 20.9%.

Proper separation of leafminer and *Heliothis* spp. damage was obtained by cages which acted as physical barriers to prevent access of the pod borer. Through this device and the use of *B. thuringiensis* in comparison with dimethoate and endosulfan, yield losses due to *Heliothis* spp. damage in northern Syria were estimated at 3.0% (Table 40).

Economic thresholds for leafminer control. Rational use of chemicals for insect control requires the establishment of economic thresholds, that is to say the maximum pest level than can be tolerated before a control action should be taken to maximize net returns. The first attempt to establish such a level was made in 1982/83. Spring-planted ILC 482 chickpeas were treated with endosulfan at different leafminer damage levels. Maximum yield increases occurred when the initial spray was done at 30% mining level (Table 41); this in turn reflected on maximum net returns. The economic threshold for a crop with these production levels is between 25 and 30% mining which, to be maintained, would require two to three sprays. This level of larval damage coincided with the onset of the second generation of leafminer adults (a week before flowering). This suggested the possibility of establishing an action threshold for insecticide applications based upon simple adult counts. This will be studied in detail in 1983/84.

Host-plant resistance to leafminer. Search for sources of resistance to the chickpea leafminer continued in 1982/83. More than 4300 genotypes were evaluated. Only 13 (0.3%) of these were rated as resistant and selected for rescreening and yield testing.

Table 40. Yields and percent yield increases obtained in spring-planted ILC 482 chickpea through differential control of leafminer and *Heliothis* spp. at Tel Hadya, 1982/83.

Leafminer control	*Heliothis* spp. control	Method[1]	Yield (kg/ha)	% yield increase
yes	yes	dimethoate	2642	13.0
yes	yes	endosulfan	2519	7.8
no	yes	cage	2412[a]	3.2
no	yes	*Bacillus* sp.	2409	3.0
no	no		2338	
LSD (5%) for yields			176.3	
CV (%) for yields			8.9	

1. Dosages were as follows: dimethoate, 0.20 kg a.i./ha; endosulfan, 0.70 kg a.i./ha; *Bacillus* sp. 1.5 liters of commercial product (3500 spores/mg) per hectare.
a. Corrected for cage effect.

Table 41. Effect of chemical protection at different levels of leafminer damage on the yields of spring-planted ILC 482 chickpeas at Tel Hadya, 1982/83.

Kind of protection	No. of sprays	Yield (kg/ha)	% Yield increase	Ranking for net benefits
Full	7	2135	15.1	4
At 15% mining level[1]	4	2156	16.2	3
At 30% mining level[1]	3	2207	18.9	1
At 45% mining level[2]	1	2058	10.9	2
Never sprayed (check)	0	1855		5
LSD (5%) for yields		286		
CV (%) for yields		9		

1. Preflowering.
2. Pod setting.

The visual damage scale used for screening was tested by planting 35 previously selected accessions in different fields and in both winter and spring seasons. Rank correlation coefficients for visual damage scores between fields and seasons were highly significant, ranging from 0.931 to 0.956. The rescreening confirmed resistance ratings for all but three of the accessions, suggesting that the visual damage score was reliable for initial mass screening. Progress was also made in identifying highly susceptible materials which will be used as spreaders and as susceptible checks in yield trials.

To measure the levels of resistance detected so far, 18 lines of known reaction to leafminer attack were yield-tested under protected and nonprotected conditions. Table 42 illustrates the performance of 10 of them. Pod borer interference was minimal and thus it can be said that yield losses due to leafminer ranged from 3.9 to 23.1%, average for the 18 genotypes being 13.4%. Most lines behaved as expected, showing in some cases high levels of resistance. However, the rank correlation coefficient between visual damage scores and percent yield losses was low (r_s = 0.399; NS), suggesting that

Table 42. Visual damage scores (for 1981/82 and 1982/83), protected and nonprotected yields, and comparative yield losses in chickpea cultivars selected for varying degrees of resistance to leafminer (means of four replicates) at Tel Hadya, 1982/83.

	Visual damage scores[1]		Yields (kg/ha) 1982/83		% yield
Cultivar	1981/82	1982/83	Protected	Nonprotected	loss
ILC 726	3	3	1803	1733	3.9
ILC 2319	5	5	1670	1578	5.5
ILC 3350	3	3	1673	1555	7.0
ILC 2618	3	5	2051	1826	10.9
ILC 3307	9	9	2103	1995	5.1
ILC 2512	9	9	1966	1512	23.1
ILC 2993	9	9	1598	1263	21.0
ILC 482	7	9	2036	1612	20.8
ILC 562	9	9	2136	1709	20.0
Local	7	9	2122	1923	9.4
LSD (5%)			160.8	211.9	
CV (%)			17.0	12.0	

1. Damage score on 1-9 scale: 1 = no damage, 9 = severe damage.

visual scores, while useful for mass screening purposes, do not by themselves predict yield losses. This was best illustrated by ILC 3307. Lack of correlation between visual scores and percent yield losses has also been found with other insects in several crops. The alternative is to look for other parameters which might better explain yield and provide a clue to the possible mechanisms of resistance. Preliminary observations suggested that the rate of defoliation due to leafminer damage might be one such parameter. It was found, for example, that the most susceptible material (ILC 2512) lost 2.2 times more leaflets due to insect damage than the most resistant material (ILC 726). These studies on the mechanisms of resistance will be continued in 1983/84. Simultaneously, a small breeding program will be initiated with the resistance sources identified so far.

Host-plant resistance to bruchids. Mass screening for resistance to *Callosobruchus chinensis* continued in 1982/83. Of more than 3000 genotypes so far screened, none passed the replicated tests to be rated as resistant.

Production Agronomy

The advantage of winter planting as compared to spring planting was further evaluated at Terbol in Lebanon and, in cooperation with the Agricultural Research Centre of Syria, at Gellien in Syria. Plant populations were also varied to determine the optimum date and population combination. Advancing the date of planting from spring (March) to late winter (December) resulted in a significant increase in seed yield (Fig. 16). Advancing the sowing to early winter from late winter did not register any further advantage because of the very cold winter in 1982/83 (Table 25). Increasing the population level increased yield, the maximum being at the highest population level of 33.3 plants/m^2.

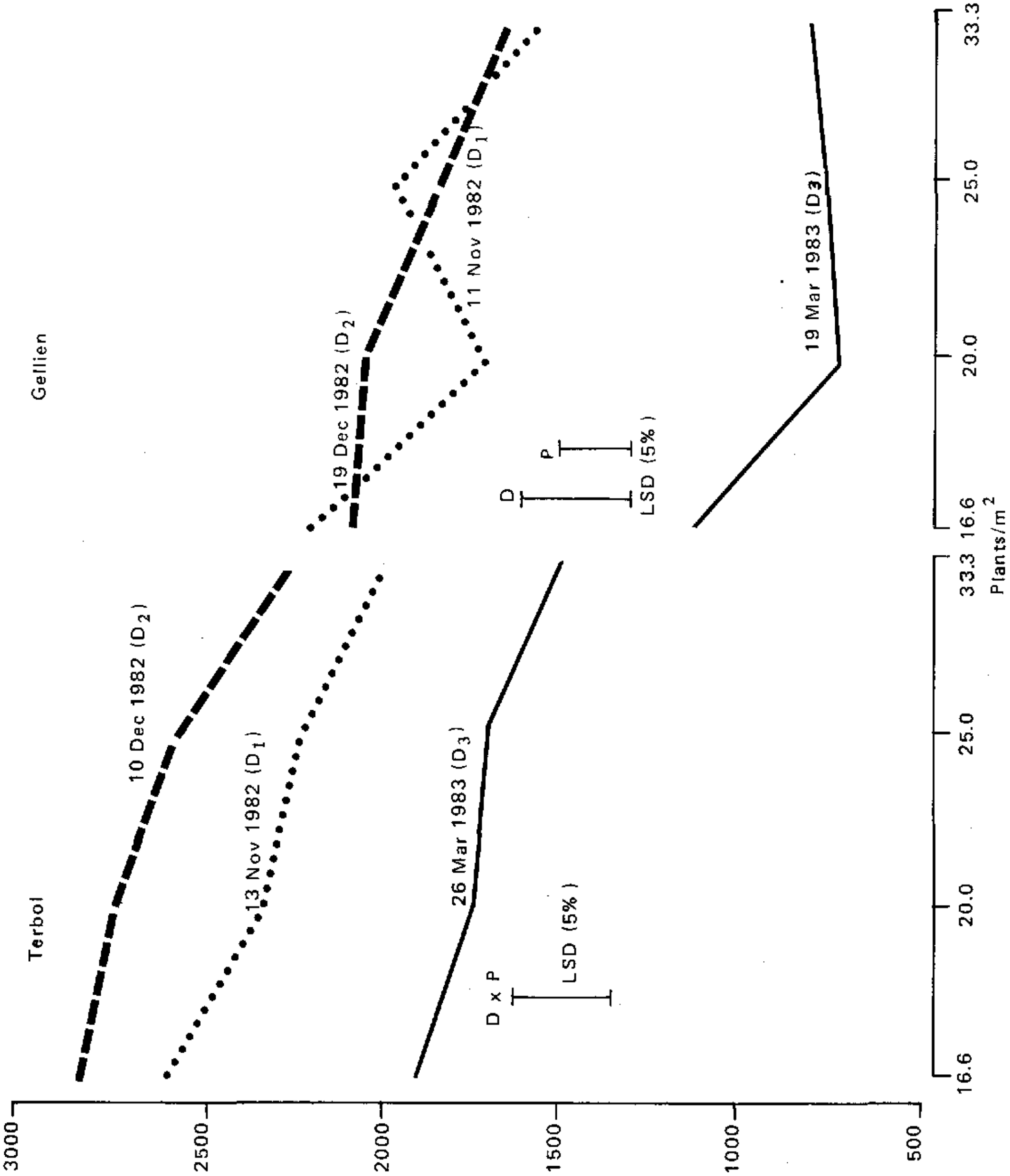


Fig. 16. Response of ILC 482 chickpea to date of planting (D) and plant population (P) at Terbol in Lebanon, and Gellien in Syria, 1982/83.

Development of Improved Kabuli Chickpea Cultivars and Production Technology for Winter Sowing

Efforts continued in 1982/83 on the development of high and stable yielding, cold-tolerant, ascochyta blight resistant cultivars and genetic stocks adapted to winter sowing in the low-elevation areas of the Mediterranean region where the crop is traditionally sown in spring. Studies on developing appropriate production and protection technology for winter sowing were also continued.

Development of Genetic Stocks and Cultivars

Since a prerequisite for success with winter sowing is tolerance to cold and resistance to ascochyta blight, efforts continued on screening germplasm and genetic stocks for these attributes.

Screening for cold tolerance. In an attempt to develop a suitable field screening technique for cold tolerance, a set of genotypes ranging from highly resistant to highly susceptible was sown on nine dates from 23 Oct 1982 to 9 Mar 1983. Fifty-two nights had sub-zero temperatures during 1982/83. Cold injury was observed only in the first four sowings but more reliable results were obtained from the first date of sowing. Data for cold tolerance were recorded when the susceptible check was completely killed. Advancing the sowing date induces more crop growth and allows greater exposure to cold and is thus more reliable for screening for cold tolerance than late sowings.

In the 1982/83 season, promising cold-tolerant kabuli lines identified during 1981/82 were sown on 23 Oct 1982 for rescreening. Ten lines were found to be highly tolerant: ILC 666, 668, 1071, 2487, 2505, 3081, 3287, 3470, 3598, and 3789.

Screening for ascochyta blight resistance. In 1982/83, a large amount of germplasm and breeding material was screened for ascochyta blight resistance over an area of 8.5 ha. All materials were tested against a mixture of four races (races 1, 2, 3, and 4) and the resistance was considered at both vegetative and podding stages. None of the 468 new kabuli germplasm accessions screened was found resistant. The resistance and tolerance of 17 and 34 germplasm lines, respectively, was confirmed in Syria. A total of 8921 breeding lines/populations were screened for blight resistance to enable selection of resistant material (Table 43).

Table 43. Breeding materials tested against ascochyta blight at Tel Hadya and Lattakia, 1982/83.

Materials tested	No. of entries tested
Tel Hadya	
International yield trials	44
Advanced and preliminary yield trials	348
Genetics of resistance F_3 progenies	607
F_2 populations	631
F_3 progeny rows	2310
F_4 progeny rows	1212
F_5 progeny rows	2167
F_6 progeny rows	708
F_7 progeny rows	546
Large-seeded F_4-F_7 progeny rows	126
Tall F_5-F_7 progenies	90
Lattakia	
International yield trials	12
Advanced yield trials	120

All yield trials were replicated.

A large-scale screening of germplasm in the plastic house aganist the most virulent race of *Ascochyta rabiei* (race 6) helped in the identification of five resistant (ILC 187, 202, ICC 3996, 6988, and Pch 128) and seven tolerant (ILC 193, 3346, ICC 3840, 3969, 4324, 4475, and 6981) lines.

As the original germplasm sources of resistance to ascochyta blight, such as ILC 72 and ILC 202, have small and intermediate type of seeds and are late maturing, the ascochyta blight resistance has been transferred into lines with good agronomic characteristics, acceptable seed size and appearance, and reduced photoperiod sensitivity (Table 44).

Through the Chickpea International Ascochyta Blight Nursery (CIABN-83), 50 kabuli and desi germplasm accessions and kabuli lines developed through hybridization at ICARDA were tested in blight endemic countries to identify the blight-resistant lines. These lines were found resistant at Tel Hadya for at least the past two seasons. A total of 40 sets of CIABN-83 nursery have been distributed and data are awaited.

Resistance to *Orobanche* spp. *Orobanche* spp. infestation has been observed in northern Syria and it might become a problem in winter-sown chickpeas. A total of 504 lines were screened at Kafr Antooon for resistance to *Orobanche* spp. during the 1981/82 season in a naturally infested field and 72 were found promising. These were rescreened during 1982/83 and 11 highly resistant lines were identified (ILC 229, 280, 348, 351, 613, 4074, ICC 170, 192, 205, FLIP 81-61, 81-293).

Yield potential. We evaluated 273 newly bred lines for yield and adaptation in five AYTs and eight PYTs at Tel Hadya in 1982/83. Three checks, namely, ILC 482, a cultivar released for winter sowing in Syria, ILC 1929, a landrace grown in spring, and ILC 3279, a tall and ascochyta blight and cold tolerant line were included in each trial of 24 entries for comparison. A total of 242 and 152 entries exceeded ILC 482 and ILC 3279, respectively. ILC 1929, being susceptible to ascochyta blight, was killed. The highest yielding entries generally produced between 2500 and 3000 kg/ha and exceeded ILC 482 by a margin of 50-121%. At Terbol 189 FLIP lines were tested in five AYTs and four

Table 44. Comparison of plant height, seed type, seed size, and days to 50% flowering of some ascochyta blight resistant germplasm accessions and genetic stocks developed through hybridization at Tel Hadya, 1982/83.

Genetic stock/ germplasm line	Ascochyta blight reaction[1]	Plant height (cm)	Seed type[2]	Seed size (g/100 seeds)	Days to 50% flowering
FLIP 82-64 (ILC 80 x ILC 72) x ILC 263	HR	58	K	34.2	149
FLIP 82-65 (ILC 72 x ILC 1922)	HR	52	K	35.3	147
FLIP 82-73 (ILC 1919 x ILC 202)	R	54	K	31.7	143
ILC 72	HR	50	I	28.6	147
ILC 202	HR	57	I	27.7	147

1. R = Resistant, HR = Highly resistant.
2. K = Kabuli, I = Intermediate.

PYTs against the same three checks. A total of 56, 53, and 62 entries exceeded ILC 482, ILC 3279, and ILC 1929, respectively. The highest yielding entries produced between 2732 and 3653 kg/ha.

The performance of the three highest yielding entries in each AYT and their reaction to ascochyta blight and cold in advanced yield trials at Tel Hadya and Terbol are summarized in Table 45. In every trial the top three ranks were occupied by newly bred FLIP entries. The yield levels were generally over 2500 kg/ha, though the 1982/83 season was one of coldest in the last 50 years. Most of the new lines had a higher level of resistance to ascochyta blight and cold than ILC 482.

Yield gain in tall types. An Advanced Yield Trial-Tall (AYT-T) was conducted with 21 newly-bred FLIP entries and three checks, ILC 482, ILC 3279, and ILC 1929, during winter and spring. Nine entries produced higher yield than the tall check, ILC 3279, and the highest yielding entries in the winter-sown trial produced 121% of the check (Table 46). Of 21 test entries, only three were tall and the remaining were mid-tall. FLIP 82-73 was the only one which was tall, true kabuli, with 36 g/100-seed weight, and resistance to ascochyta blight. This line has been produced after making over 200 crosses in the last six years. It will be exploited fully at ICARDA for producing better tall genotypes.

Notwithstanding the quality of seed, the tall type ILC 3279 in Syria and Cyprus and ILC 202 in Jordan are in final stages of testing and might be released as cultivars.

Table 45. Three highest yielding entries of chickpea in AYTs during winter at Tel Hadya (T.H.) and Terbol (Tr.), 1982/83.

		Yield (kg/ha)				Evaluation at Tel Hadya		
						AB[1]		Cold[2]
Trial/entries		T.H.	Tr.	Mean	Rank	Veg	Pod	tolerance
	AYT-1							
	FLIP 81-3	*2552*	*2536*	2544	1	2	4	2.3
	FLIP 81-4	*2610*	*2411*	2511	2	2	5	2.3
	FLIP 81-11	*2424*	*2577*	2501	3	2	5	2.3
	ILC 482	1568	*2335*	1952	23	3	7	2.8
Check	ILC 3279	2235	*2542*	2389	8	3	2	2.3
	ILC 1929	0	*2375*	1188	24	9		5.3
	SE ±	172.8	239.0					
	CV (%)	16.3	20.4					
	AYT-2							
	FLIP 81-293	*2033*	*2863*	2448	1	2	3	2.5
	FLIP 81-359	*1888*	*2881*	2385	2	2	5	2.3
	FLIP 81-304	*2298*	*2446*	2372	3	2	3	2.8
	ILC 482	1406	*2720*	2063	20	3	7	3.5
Check	ILC 3279	1830	*2571*	2201	13	3	2	3.0
	ILC 1929	0	*2589*	1295	24	9		4.5
	SE ±	155.5	210.3					
	CV (%)	17.0	17.0					

Contd.

Table 45 *contd*

Trial/entries		Yield (kg/ha) T.H.	Tr.	Mean	Rank	Evaluation at Tel Hadya AB[1] Veg	Pod	Cold tolerance[2]
	AYT-3							
	FLIP 82-20	*2407*	*2810*	2609	1	4	5	2.5
	FLIP 82-7	*2342*	*2601*	2472	2	2	6	2.0
	FLIP 82-17	*2310*	*2411*	2361	3	2	3	3.0
	ILC 482	1194	*2804*	1999	20	3	7	3.5
Check	ILC 3279	1862	*2637*	2250	7	3	2	2.8
	ILC 1929	0	*2381*	1191	24	9		4.8
	SE ±	165.1	178.1					
	CV (%)	17.5	15.0					
	AYT-4							
	FLIP 82-29	*2624*	*2929*	2777	1	2	5	2.5
	FLIP 82-32	*2376*	*3060*	2718	2	2	5	3.0
	FLIP 82-30	*2390*	*3024*	2707	3	2	5	3.0
	ILC 482	1758	*3155*	2457	15	3	7	3.3
Check	ILC 3279	*2408*	*2911*	2660	5	3	2	2.8
	ILC 1929	0	*3089*	1545	24	9		5.5
	SE ±	*160.9*	*133.0*					
	CV (%)	15.3	9.4					
	AYT-5							
	FLIP 82-53	*2406*	*2841*	2641	1	2	5	3.0
	FLIP 82-62	*2110*	*2786*	2448	2	4	3	2.7
	FLIP 82-57	*2195*	*2643*	2419	3	2	5	3.0
	ILC 482	1335	*2603*	1969	22	3	7	3.7
Check	ILC 3279	*2248*	*2444*	2346	6	3	2	3.0
	ILC 1929	0	2349	1175	24	9		5.7
	SE ±	146.1	231.2					
	CV (%)	*12.4*	*17.0*					

The italicized figures were in the top significant group.
1. AB = Ascochyta blight rating on 1-9 scale, where 1 is free and 9 dead.
2. Cold tolerance evaluated on 1-9 scale, where 1 is highly tolerant and 9 dead.

Table 46. Chickpea test entries that exceeded the yield (kg/ha) of the checks in AYT-T at Tel Hadya, winter (W) and spring (S), 1982/83.

Trial	No. of test entries exceeding check			Highest yield of test entries	Percent of check			CV (%)
	ILC 482	ILC 3279	ILC 1929		ILC 482	ILC 3279	ILC 1929	
AYT-T(W)	21	9	21	2313	184	121		17.3
	ILC 482	ILC 263	ILC 1929		ILC 482	ILC 263	ILC 1929	
AYT-T(S)	7			1513	117	97	85	15.6

On-Farm Trials with Winter Sowing

On-farm trials were jointly conducted by ICARDA and the Agricultural Research Centre of the Ministry of Agriculture and Agrarian Reform, Syria, at 24 locations during 1982/83. Three genotypes, ILC 195, ILC 202, and ILC 3279 were tested against ILC 482 during winter and all four genotypes were tested against a Syrian landrace during spring (Table 47). ILC 482 produced the highest yield both during winter (2018 kg/ha) and spring (1367 kg/ha). Thus, no genotype was found superior to ILC 482 which is a recommended cultivar for winter sowing in Syria.

ILC 3279 ranked second (1647 kg/ha). It had a better level of resistance to ascochyta blight and cold than ILC 482. Being 50% taller than ILC 482 it is more suited for mechanical harvesting, and thus has a special appeal to farmers. In on-farm trials for 2 years, it produced 1640 kg/ha average grain yield and ranked first (Table 48). The Ministry of Agriculture has identified ILC 3279 as a candidate for release after one more year of testing. In anticipation of release, they have asked ICARDA to increase its seed.

On-farm trials on winter sowing were also conducted in Jordan and Morocco national programs and the results are reproted to be promising.

Table 47. Mean performance of chickpea cultivars in on-farm trials in Syria, winter and spring seasons, 1982/83.

Cultivar	Yield (kg/ha)[1]		Percent increase of winter yields	
	Winter	Spring	Over spring	Over Syr. local
ILC 195	1616	1001	62	48
ILC 202	1586	1023	55	45
ILC 402	2018	1367	48	85
ILC 3279	1647	1074	53	51
ILC 1929 (check)	Not sown	1092		

1. Average of 24 locations.

Table 48. Yield performance (kg/ha) of ILC 3279 in on-farm trials in Syria, 1981/82 and 1982/83.

Year	Winter ILC				Spring	ILC			
	195	202	482	3279	Local	482	195	202	3279
1981/82[a]	1256	1608	1128	1632	259	806			
1982/83[b]	1616	1586	2018	1647	1092	1367	1001	1023	1074
Mean	1436	1597	1573	1640	676	1087	1001[c]	1023[c]	1074[c]

a. Average of three locations.
b. Average of 24 locations.
c. Only 1-year result.

ILC 3279 has a good level of resistance to ascochyta blight and cold. Being a tall type, it is suited to mechanical harvesting. The Syrian Ministry of Agriculture is considering to release this genotype in Syria. Syr. Local (left) was wiped out by ascochyta blight.

Diseases and Their Control

Survey of Diseases

Survey of diseases on chickpeas was made in Syria, Jordan, and Tunisia. In winter-sown chickpeas in Syria, ascochyta blight was the major disease. Plants showing the symptoms of stunt (pea leaf roll virus) and bean yellow mosaic were also observed, the incidence of the latter being much higher in 1982/83 than in the past 3 years. The incidence of root-knot, cyst, and *Pratylenchus* spp. nematodes was also observed. In Jordan, ascochyta was serious but some plants affected by stunt and other viral diseases were also observed. At Amshaqar research station, symptoms of *Pratylenchus* spp. damage were also seen. In Tunisia, wilt (*Fusarium oxysporum*) was the major disease, followed by stunt. Because of dry weather, ascochyta blight was not present on farmers' fields.

Studies on *Ascochyta rabiei*

Fifty samples of chickpeas affected by blight were collected from all over Syria and fungal isolates were studied for cultural and morphological characters and growth rates. Using a set of 18 differential genotypes, attempts were made to identify the variability in the fungus. The population was found to consist of six physiologic races (Table 49). The less virulent races (races 1, 2, and 3) were prevalent in the

Table 49. Reaction of 18 differential varieties of chickpea to six races of *Ascochyta rabiei* at Tel Hadya, 1982/83.

Differential variety of chickpea	Blight reaction					
	Race 1	Race 2	Race 3	Race 4	Race 5	Race 6
ILC 72	R	T	T	R	T	S
ILC 182	T	S	T	T	S	S
ILC 191	T	S	S	S	S	S
ILC 194	R	R	T	T	T	S
ILC 200	R	T	T	T	T	S
ILC 215	R	R	R	S	S	S
ILC 249	R	R	R	S	S	S
ILC 482	R	R	R	T	S	S
ILC 484	R	T	S	S	S	S
ILC 1929	S	S	S	S	S	S
ILC 3279	R	R	R	R	S	S
ICC 1591	R	T	S	T	T	S
ICC 1903	R	R	S	S	S	S
ICC 2232	T	S	S	S	S	S
ICC 3996	R	R	R	R	R	S
ICC 4107	R	R	R	T	T	S
C 235	R	T	R	S	S	S
F 8	R	S	S	S	S	S

R = Resistant, T = Tolerant, S = Susceptible.

farmers' fields, whereas more virulent races (races 4, 5, and 6) were detected in the experimental sites only. The isolates while accumulating genes for virulence were found to lose their sporulating ability. Many lines when infected by matching virulent isolates showed considerable residual effects of the defeated resistant genes.

In a cooperative project with the University of Reading, UK, we continued to study the pathogenic variation in isolates of *A. rabiei* obtained from throughout the chickpea-growing regions.

A field experiment to study blight development in relation to temperature and relative humidity showed that between the mean relative humidity levels of 51.5 and 84.4%, the minimum and maximum temperatures were critical. Blight started to increase rapidly only when minimum and maximum temperatures rose above 5 and 15°C, respectively. The mean temperature had to be above 15°C (Fig. 17). Providing 100% relative humidity (RH) only for 2 days after inoculation with ascochyta blight was enough to kill a susceptible cultivar at 15-20°C. A minimum period of 100% RH for at least 4 hr was needed for infection to occur in a susceptible genotype at a temperature of 15-25°C. An experiment under controlled conditions revealed that with race 3 of *A. rabiei* the incubation period was least (2 days) at 25°C and maximum (10 days) at 10°C. The maximum disease development and sporulation of the fungus were recorded at 20°C.

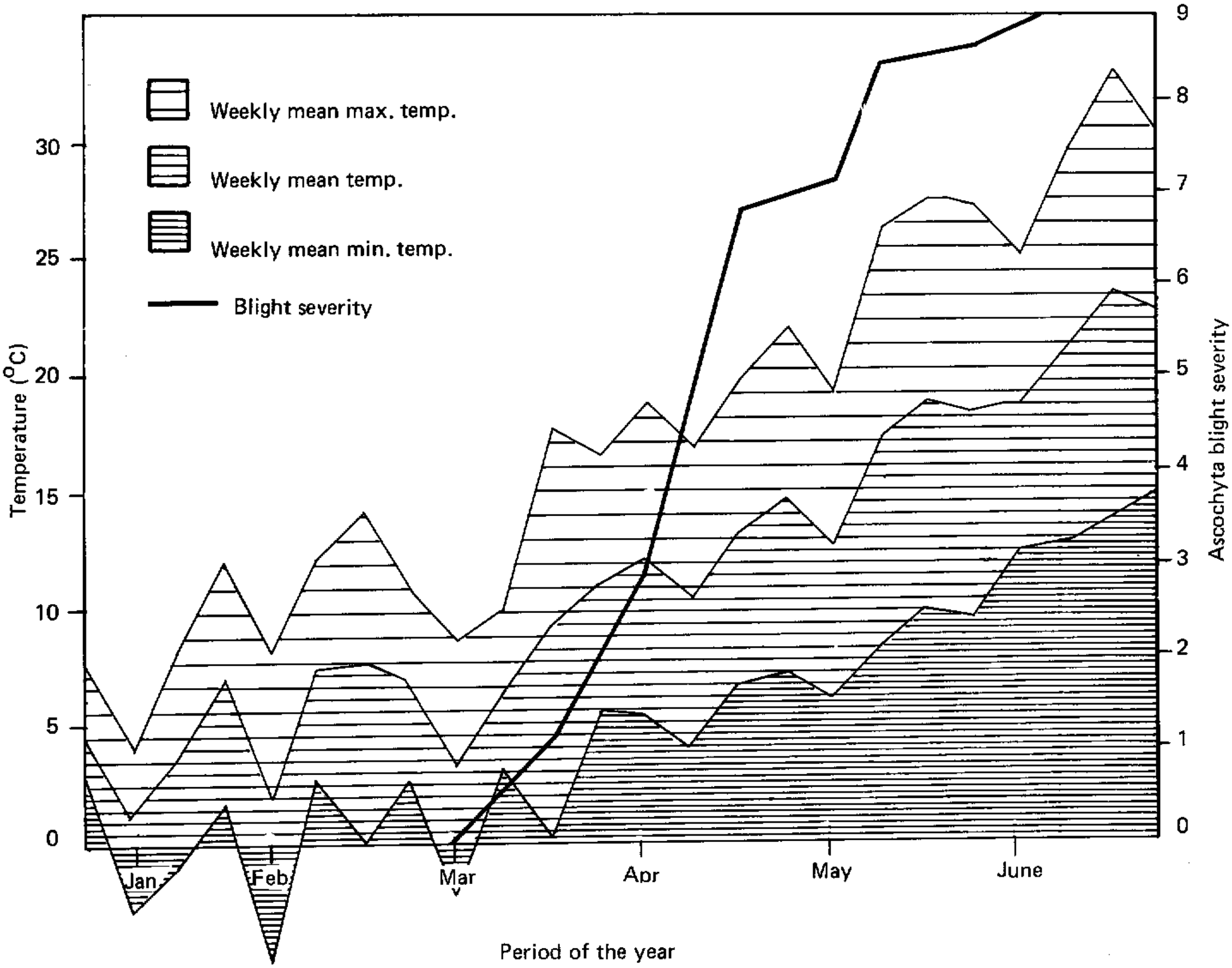


Fig. 17. Development of ascochyta blight of chickpea in relation to temperature and relative humidity at Tel Hadya, 1983.

Attempts to locate or induce the perfect stage of the ascochyta blight pathogen, *Mycosphaerella rabiei*, did not succeed.

Chemical Control

One foliar application of chlorothalonil (Bravo 500) during the early podding stage of a cultivar with a good level of vegetative resistance but poor pod resistance gave good control of pod infection by ascochyta blight.

For eradicating the seedborne infection of *A. rabiei*, seed dressing with thiabendazole (Tecto 60) was more effective than Calixin M. Even at higher doses Tecto did not have any phytotoxic effect.

Production Agronomy

Planting Date

A study to examine growth and yield response of five new chickpea genotypes of diverse growth habits and seed type to winter vs spring sowing was started in the 1981/82 season. During the 1982/83 season, it was repeated using only two dates of sowing (2 Dec and 11 Feb). The seed and total biological yields of the conventional (ILC 482) and tall (ILC 195, 202, and 3279) winter-type chickpeas were higher with December than with February sowing although the differences were of smaller magnitude than in the previous year. The total biological yield of the large-seeded genotype (ILC 464) was not affected by sowing date and the seed yield was decreased in the December sowing in contrast to the February sowing. The higher susceptibility of ILC 464 to frost was probably the main reason for this difference. The total dry-matter production per plant in relation to crop age, however, confirmed the pattern obtained last year: the large-seeded chickpea (ILC 464) had higher total dry matter per plant than the other genotypes (Fig. 18), the difference being par-

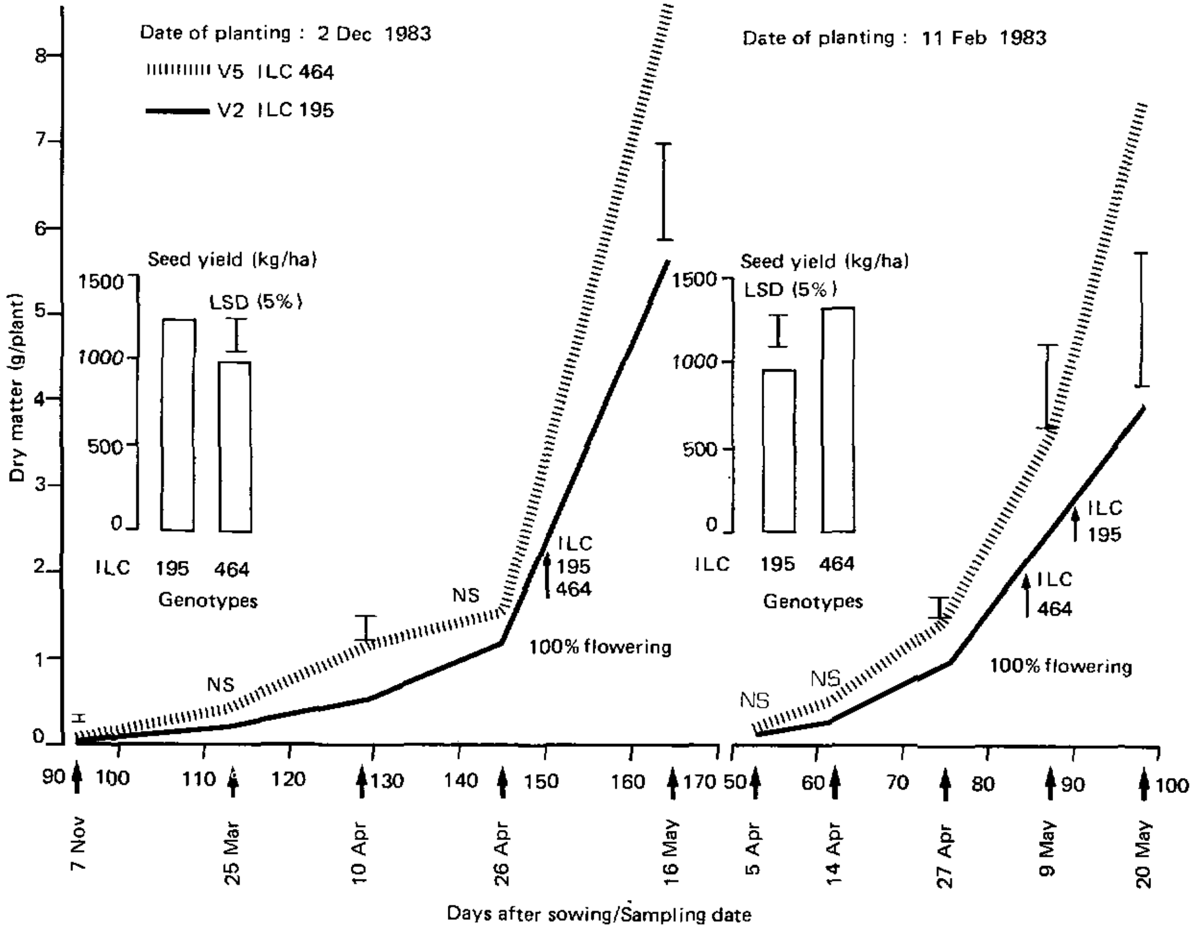


Fig. 18. Total dry-matter production (g/plant) curves of chickpea genotypes, when planted at two different dates, Tel Hadya 1982/83.

ticularly conspicuous in the February sowing. This growth difference was also reflected in the highest yield of ILC 464 in the February sowing.

Plant Population and Planting Geometry

The effect of plant population (30, 50, and 75 plants/m^2) and planting geometry (1:1, 1:2, 1:3) was studied using a conventional-type (ILC 482) and a tall-type (ILC 3279) chickpea (Fig. 19). In the case of ILC 482, 1:1 planting geometry was superior to rectangular geometry (1:2 or 1:3), particularly at the lowest population level (30 plants/m^2). But when the population was raised to 75 plants/m^2 the seed yield was highest and the differences in planting geometry were not significant. In the tall type, rectangular geometry of 1:2 proportion was better and significantly superior to 1:1 geometry particularly at the highest population (75 plants/m^2) which resulted in the highest yield (Fig. 19).

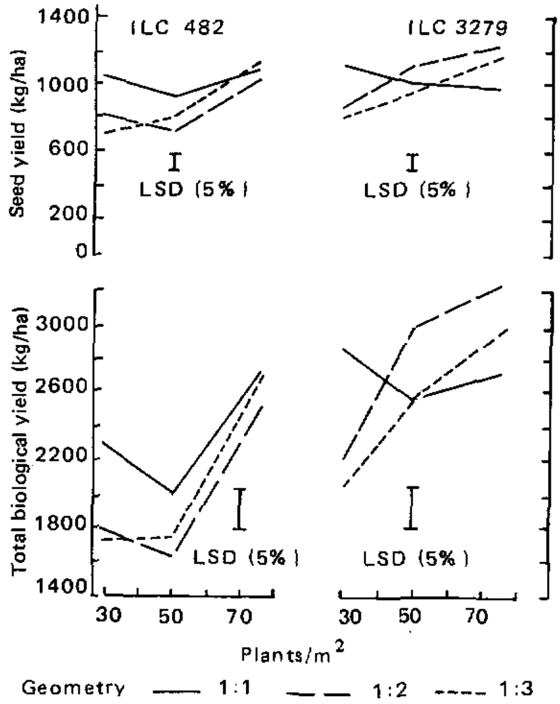


Fig. 19. Total biological yield and seed yield of ILC 482 and ILC 3279 as affected by plant population and planting geometry, Tel Hadya, 1982/83.

Residue Management and Phosphate Application

Incorporation or burning of the residues of the preceding cereal crop had no effect on the performance of winter-sown ILC 482 chickpea (Table 50). Placement of 50 kg P_2O_5/ha as triple superphosphate either along with seed or 5 cm below the seed resulted in a significant increase in yield when compared to either broadcast application or the no-phosphate control. The available soil phosphorus in the top 15-cm soil layer in this trial ranged from 1.3 to 1.5 ppm.

The nitrogenase enzyme activity of the root system was studied on 31 Mar and 24 Apr, when the *growth differences due to phosphate* application started to become conspicuous. The data *revealed that the nitrogenase activity* increased with placement of phosphate below the seed.

Weed Control

The importance of controlling weeds in the winter-sown crop was evident from the fact that weedy check plots yielded 28.6, 61.9, 62.8, and 76.2% of the yields obtained under weed-free conditions at Tel Hadya, Terbol, Jindiress, and Prison Farm, respectively. Preemergence application of cyanazine at 1.0 kg a.i./ha proved very effective in controlling weeds and increas-

Table 50. Total recoverable biological yield (TBY, kg/ha) and seed yield (SY, kg/ha) of ILC 482 as affected by different methods of applying P fertilizer and by different methods of straw management of the previous wheat crop at Tel Hadya, 1982/83.

Phosphate treatment (P)	TBY			SY		
	Straw incorporated	Straw burnt	P means	Straw incorporated	Straw burnt	P means
T_0 control	5575	4767	5171	2689	2527	2608
T_1 50 kg P_2O_5/ha broadcasted	5724	5538	5631	2862	2878	2870
T_2 50 kg P_2O_5/ha deep placed	6610	6750	6680	3602	3398	3500
T_3 50 kg P_2O_5/ha mixed with seeds	6460	5902	6181	3290	3062	3176
Straw management mean (B)	6092	5739		3111	2966	
CV (%)	main plot (B) = 8.1			B = 6.9		
	subplot (P) = 12.7			P = 10.9		
LSD (5%)	B = NS, P = 788, P in B = 1114			B = NS, P = 348, P in B = 492		

ing yield at Jindiress and Prison Farm and chlorbromuron at 1.5 kg a.i./ha at Tel Hadya. Terbutryne at 3.0 kg a.i./ha proved promising at Terbol.

Role of Food Legumes in Dryland Agriculture

Studies on this aspect have been conducted in the program since 1978/79. Results have consistently shown that a well managed legume crop not only gives high protein yield but also benefits the following cereal crop; a cereal crop following legume yields nearly the same as a cereal crop following fallow and significantly higher than the yield of a cereal following cereal. In the final cycle of this trial, legumes were again planted during 1982/83 to study their residual effect during the 1983/84 season. The production of dry matter, seed yield, and total nitrogen yield under different treatments is presented in Table 51.

Carbofuran application marginally improved the lentil seed yield but improved straw yield by 16.8%. Sowing chickpea in winter in contrast to spring increased straw and grain yield by a margin of 59 and 27%, respectively. These dry-matter increases were also reflected in total nitrogen yields from these crops.

Highest nitrogen yields were obtained from lentil followed by those from peas, faba beans, and winter-sown chickpeas. Spring chickpea gave the lowest nitrogen yield. An estimate of N derived from symbiotic fixation was obtained by the difference method: deducting the nitrogen yield of wheat fertilized with 20 kg N/ha from that of the legumes which were also fertilized with 20 kg N/ha. Among the pure legumes, maximum 'fixation' was obtained in case of lentil and minimum in case of spring chickpea. Of course the values of 'fixed nitrogen' in case of intercropped treatments were lower than in the pure spring chickpea.

During the 1983/84 season, the residual effect of the legume treatments of the 1982/83 season

Table 51. Straw, grain, and total recoverable biological yield, total nitrogen yield, and yield of nitrogen derived from fixation (as estimated by 'difference' method) from different legumes grown rainfed at Tel Hadya, 1982/83.

Treatments[1]	Yield (kg/ha)			Total N yield	N fixation (kg/ha)
	Straw	Grain	Total	(kg/ha)	
Lentil (ILL 4401)	4457	1876	6333	120.3	88.0
Lentil with carbofuran (1.5 kg a.i./ha)	5206	1887	7093	131.6	99.3
Winter-sown chickpea (WCP, ILC 482)	2305	1884	4189	63.4	31.1
Spring-sown chickpea (ILC 482)	1450	1477	2927	48.6	16.3
Faba bean (ILB 1814)	1306	1809	3115	81.2	48.9
Peas (local)	3469	1518	4987	81.4	49.1
WCP intercropped with wheat[2]	2791	1301	4092	43.6	11.3
WCP intercropped with barley[2]	2867	1954	4821	44.3	12.0
Wheat (Norteno x S311) with 20 kg N/ha	4588	1055	5643	32.3	
Wheat with 60 kg N/ha	8146	1426	9572	65.5	
CV (%)	15.0	12.0	11.0	13.8	
LSD (5%)	813	279	861	14.2	

1. Crops in all treatments received 46 kg P_2O_5/ha. Treatments 1-9 received 20 kg N/ha.
2. The yield data are total of chickpea and cereal yield.

will be studied at three rates of directly applied nitrogen (0, 30, and 60 kg N/ha). At the 30 kg N/ha level, the estimate of nitrogen enrichment of soil from the previous season's legumes will be made using the ^{15}N dilution technique.

Collaborative Projects

International Testing Program

We continued to coordinate the international cooperative program on faba beans, lentils, and kabuli chickpeas. The kabuli chickpea program was run in collaboration with ICRISAT. The main objective of the program is to provide a mechanism for multilocation testing of genetic material of these legumes from ICARDA and from national programs. The testing aims at evaluating genotypic performance for both yield and reaction to biotypes of locally occurring pests and diseases. It will help in (1) identifying superior genotypes adapted to specific environments or those with wide adaptation, (2) reducing the number of seasons that a breeder requires for genotype evaluation prior to cultivar release, and (3) disseminating elite germplasm and segregating populations to interested scientists for selection and development of superior cultivars well adapted to local environments. Through the distribution of agronomic trials we hope to generate information on optimum practices for different environments.

A total of 925 sets of 34 different types of nurseries of the three legumes were sent to national programs in more than 40 countries for the 1982/83 season. For the 1983/84 season, a total of 937 sets of 38 different nurseries were dispatched in August 1983 to cooperators in 49 countries. Even this number fulfilled only 80% of the demand from cooperators. The continuous rise in the types of trials and number of sets supplied (Fig. 20) is an indication of the growing awareness of national programs to the importance of these trials and nurseries.

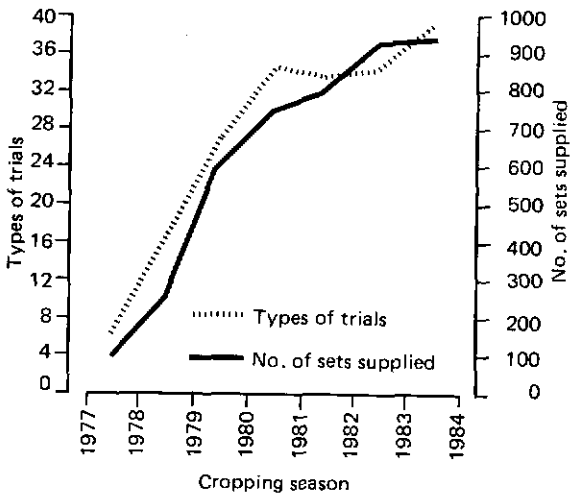


Fig. 20. Growth of the international testing program on food legumes at ICARDA, 1977-84.

The results of these trials are analyzed at ICARDA and reports printed and distributed. Reports up to the 1980/81 season have already been distributed. The one for the 1981/82 season is in preparation.

Nile Valley Special Project

During the 1982/83 season, Phase I of this special project was completed and the first of the 3 years of Phase II started. The objective of this project is to test the recommended cultivars and cultural practices of faba beans in farmers' fields in the Nile Valley of Egypt and Sudan, identify constraints to their adoption, and carry out any back-up research to remove the constraints. A multidisciplinary team of national scientists from the two countries is responsible for the planning and execution of the project with technical and logistical support from ICARDA, using funds provided by IFAD. During the 1982/83 cropping season, a component of research on lentils was also included in the program of work for Sudan, in view of the increasing demand and limited supply of this important food legume there.

On-Farm Trials in Egypt

At 28 sites in Kafr El-Sheikh and 18 sites in Minia provinces of Egypt, on-farm trials were carried out to test the recommended levels of plant population, fertilizer, weed control, irrigation, and disease control. A set of factors was evaluated in different trials depending on the special agronomic needs of different areas of faba bean production.

The recommended package of plant population and fertilizer showed a significant increase in seed yield at several sites. Averaged over cotton-faba bean and corn-faba bean rotations, increases with the improved package were of 480 kg seed and 820 kg straw/ha. In another trial in a rice-faba bean rotation, the average improvement in seed and straw yield with the recommended package was 660 kg and 1210 kg/ha under tilled conditions in contrast to 430 kg and 1170 kg, respectively, under untilled conditions.

Use of Igran to control weeds increased yield. On an average of four trials in cotton and eight trials in rice rotations, the increase in yield with Igran was 240 kg seed and 430 kg straw/ha. Ronilan fungicide to control *Botrytis fabae* in the on-farm trials in Kafr El-Sheikh increased seed yield by 230 kg/ha under the tilled system and by 330 kg/ha under the zero-tillage system.

Economic analysis of the on-farm trial results was also carried out. In most of the trials the recommended package gave a higher net benefit than the farmers' practices and the increase ranged from Egyptian Lira 18.9 to 207.8/ha. Recommended levels of seed and fertilizer rates combined had the highest contribution in Samalot and Kafr El-Sheikh districts. This was followed by weed control in Motobus and Samalot districts.

On-Farm Trials in Sudan

Both farmer-managed and researcher-managed on-farm trials were conducted in the irrigation schemes of Aliab, Selaim, and Zeidab areas in northern Sudan. Significant increase in yield and economic returns was obtained in farmer-managed trials (Table 52) in which planting date, irrigation, insect control, and weed control at the recommeded level were compared with farmers' practice. Effect of factorial combination of two levels (recommended and farmers') of each of seed rate, planting method, and weed control was evaluated in the Aliab and Shendi areas, using seven and six sites, respectively, in researcher-managed trials. At Aliab, significantly higher yield was obtained with the combination of the recommeded levels of planting and weed control and farmers' level of seed rate. At Shendi the effect was non-significant.

Back-Up Research in Egypt and Sudan

Back-up research was carried out in 10 disciplines in Egypt and 11 in Sudan. Most of the studies were carried out at research stations. Emphasis in the back-up research in Sudan was on the development of agronomic practices and identification of suitable genotypes of faba bean for expansion of faba bean cultivation to non-traditional areas south of Khartoum. Also, studies were carried out on different aspects of improvement of lentils with emphasis on production practices.

Table 52. Grain yield (kg/ha) and economic returns from recommended (R) vs farmers' (F) level of management of date of planting, irrigation, and insect and weed control in farmer-managed trials in three irrigation schemes in Sudan, 1982/83.

Location	No. of trials	Treatments	Seed yield (kg/ha)	Economic returns[1] (SL/ha)
Aliab	7	R	2831	1229 ± 344
		F	2316	1054 ± 223
		R-F	515	175 ± 217
SE ±			116	
Zeidab	6	R	3583	1846 ± 518
		F	2464	1314 ± 515
		R-F	1119	532 ± 267
SE ±			143	
Selaim	4	R	3439	1942 ± 55
		F	2875	1694 ± 187
		R-F	564	249 ± 163
SE ±			142	

1. SL 1 = 0.78 US $

ICARDA/Tunisia Cooperative Project

In this cooperative project between ICARDA and the Institut National de la Recherche Agronomique de Tunisie (INRAT), a food legume breeder from ICARDA and a Tunisian legume scientist worked together to identify superior genotypes and production techniques for all three food legumes.

Faba Bean Improvement

Aside from the disease nurseries, in which very little disease development occurred, the program carried out the testing of 46 advanced breeding lines and 23 F_3 populations in ICARDA-derived international yield trials, and 66 entries in advanced and preliminary yield trials. Within the ICARDA-derived trials only six small-seeded lines at one of three test locations significantly outyielded the local check (Table 53). In the AYTs and PYTs only one large-seeded entry at one of the two test locations showed a significant improvement over the check (Table 53).

The above results are some improvement on those of 1981/82, in which no entry significantly exceeded the local check, but the performance of the F_3 populations was particularly disappointing in 1982/83. The aim of these F_3 population trials is to supply a pool of genetic variation for selection under local conditions, but their usefulness was limited as not only did none significantly outyield the local check at three locations but many were considerably poorer yielding. Both seasons have involved the testing of either genetic material selected at ICARDA for inclusion in international yield trials or imported cultivars from Europe. The failure of this strategy to produce significant and consistent yield improvements suggests that faba bean genotypes/cultivars exhibit a limited

Table 53. Seed yield (SY) in kg/ha and as percent of local check of superior yielding faba bean entries in international (IYT), preliminary (PYT), and advanced (AYT) yield trials, in Tunisia, 1982/83.

		Location							
		Beja		El Kef		Mateur		Mean	
Trial	Entry	SY	%	SY	%	SY	%	SY	%
	ILB 1217	*2269*	152	2509	135	2700	103	2493	125
	ILB 1820	*2144*	144	2400	129	1931	73	2158	108
	ILB 146	*2800*	187	2228	120	2038	77	2355	118
	ILB 1816	*2244*	150	2412	130	2788	106	2481	124
IYT	ILB 407	*2325*	156	2400	129	1094	42	1940	97
	ILB 5	*2138*	143	2175	117	2106	80	2140	107
	Tunisian local	1494	100	1862	100	2631	100	1996	100
	SE ±	203.9		133.8		292.1			
	CV (%)	20.5		12.2		18.7			
	ILB 398	*2531*	138	2012	101			2272	108
AYT	Tunisian local	1840	100	2000	100			1920	100
and	SE ±	241.5		174.1					
PYT	CV (%)	26.6		20.5					

Values italicized significantly exceeded the local check.

adaptation. To overcome this, the future breeding strategy must involve the testing and selection under local environmental conditions of a wide range of early-generation breeding lines and populations, and of material contained in ICARDA's germplasm collection.

However, yield improvements *per se* will be of little value if not combined with resistance/tolerance to the commonly occurring diseases. Thus, in the future, disease screening work will receive greater emphasis.

Chickpea Improvement

Although ICARDA's work in Syria and neighboring countries has shown that winter planting of chickpeas can produce large yield increases over spring planting, this was not evident in Tunisia last season owing to the confounding effect of diseases. However, in 1982/83, at one location (El Kef) where diseases were not a problem, an agronomic trial, comparing winter and spring sowing of three genotypes, showed that winter sowing gave 91% yield advantage over spring sowing. However, ascochyta blight resistant genotypes are a prerequisite for successful winter planting, but in 1982/83 the nearly complete absence of naturally occurring blight precluded any screening for resistance, both in disease nurseries and winter-planted yield trials.

The only significant improvement in seed yield over the local check in winter-planted trials occurred in one of the two F_3 population trials (A and B). In trial B, 14 of 15 test entries significantly outyielded the check at El Kef, whereas only one did so at Beja; yield data for the six highest yielding entries across locations is given in Table 54. In two other international and one advanced yield trial one entry significantly exceeded the local check, but several outyielded the check at more than one location, and the performance of five highest yielders across locations is given in Table 55. Further testing of the superior entries and populations is required.

Mild to severe symptoms of wilt caused by *Fusarium* spp. are commonly observed in farmers' fields, and this pathogen is considered to be as big a constraint to increasing chickpea

Table 54. Seed yield (SY) in kg/ha and as percent of local check of superior yielding F_3 populations of chickpea in the F_3 population trial B in Tunisia, 1982/83.

Entry	Location					
	Beja		El Kef		Mean	
F_3 population	SY	%	SY	%	SY	%
X 81 TH 29	1550	132	*1859*	149	1705	141
X 81 TH 48	*1763*	150	*1954*	157	1859	154
X 81 TH 171	1563	133	1563	125	1563	129
X 81 TH 203	1200	102	*2111*	169	1656	136
X 81 TH 123	1288	110	*1796*	144	1542	127
X 81 TH 190	1075	91	*2025*	163	1550	128
Tunisian local	1175	100	1246	100	1211	100
SE ±	188.3		162.8			
CV (%)	23.3		14.9			

Values italicized significantly exceeded the local check.

Table 55. Seed yield (SY) in kg/ha and as percent of local check of superior yielding chickpea entries in an international yield trial in Tunisia, 1982/83.

	Location					
	Beja		El Kef		Mean	
Entry	SY	%	SY	%	SY	%
ILC 195	1965	115	2133	136	2049	125
ILC 482	1850	108	2506	160	2178	133
ILC 484	2215	129	2199	141	2207	135
FLIP 81-41W	2253	132	2048	131	2151	131
FLIP 81-56W	2203	129	2365	151	2284	139
Tunisian local	1713	100	1563	100	1638	100
SE ±	195.0		207.8			
CV (%)	20.3		20.1			

production as ascochyta blight. It was therefore encouraging that in two spring-planted international yield trials at Beja, where the land is heavily infested with wilt, there were six entries which showed a significant improvement over the local check for both *Fusarium* spp. resistance (1 to 9 scale; 1 = resistant, 9 = complete kill), and seed yield (Table 56). However, the significant yield advantage of these entries was not maintained at other locations where *Fusarium* spp. symptoms were not evident.

Of particular interest were the two entries, ILC 136 and ILC 237 (Table 56). In wilt-infested land at Beja, ILC 136 outyielded the local check in 1981/82 by 89% and in 1982/83 by 154%, and had a 100-seed weight of 60.2 g, which was 38% heavier than that for the Tunisian cultivar Amdoun (which was the local check in the trials). Much of the material derived from ICARDA's crossing program, and tested in international trials and nurseries, is too small seeded to meet consumer preference in Tunisia. Thus, this genotype could be particularly useful as a source of wilt resistance and increased seed size.

The longer-term aim is to breed a cultivar combining resistance to ascochyta blight and *Fusarium* spp. wilt. The entry ILC 237 was a parent of one of the populations in the F_3 population trial A, the other parent being an ascochyta-resistant type. There is thus the possibility of selecting within this population plants combining the two types of resistance, and a start will be made in 1983/84.

It was also encouraging to note that progenies from single plants that were selected in 1981/82 for resistance to *Fusarium* spp. wilt within a population of the local cultivar Amdoun, maintained a high level of resistance in 1982/83 in a wilt-sick plot. These progenies can therefore be considered as a source of material that could provide a future replacement for the local cultivar.

Lentil Improvement

In last season's trials, 21% of the entries tested in international yield trials showed considerable and significant yield increases over the local check. This was somewhat unexpected as lentils

Table 56. *Fusarium* spp. resistance rating (FR), seed yield (SY) in kg/ha and as percent of the local check of superior yielding chickpea entries in two international yield trials (IYT-1,-2) in Tunisia, 1982/83.

		Location								
		Beja			El Kef		Mateur		Mean	
Trial	Entry	FR	SY	%	SY	%	SY	%	SY	%
IYT-1	ILC 237	1.5	*1450*	346	1575	101	1756	127	1594	142
	ILC 493	3.8	*1138*	272	1481	95	1431	103	1350	120
	FLIP 81-52	4.0	*1194*	285	1488	97	1600	115	1427	127
	FLIP 81-54	3.5	*1656*	395	1369	88	1479	107	1501	134
	FLIP 81-65	3.3	*1619*	386	1519	98	1344	97	1494	133
	Tunisian local	5.0	419	100	1556	100	1388	100	1121	100
	SE ±	0.31	92.7		169.0		124.1			
	CV (%)	11.7	26.5		24.5		16.5			
IYT-2	ILC 136	2.0	*1000*	254	1194	100			1097	138
	Tunisian local	5.0	394	100	1194	100			794	100
	SE ±	0.58	113.0		106.7					
	CV (%)	14.3	53.3		19.2					

Values italicized significantly exceeded the local check.

are generally considered to have a relatively narrow adaptation, but the 1982/83 results have amplified those of the 1981/82 season.

In an international yield trial of 20 entries, 20 and 14 entries significantly outyielded the local check at Beja and El Kef, respectively, although none did so at a third location. The seed yield of the five highest yielders across locations is shown in Table 57. Furthermore, in an advanced and a preliminary yield trial, nine entries showed a significant yield increase over the local check at one or more locations; the performance of the top five is shown in Table 58.

Although quality considerations of seed size and color can eliminate some entries, it would seem clear that there is a range of genetic material that, after further testing, could be considered as a replacement for the existing cultivar(s). A start has also been made to try and improve the mechanical harvesting attributes of the crop by screening 60 entries which are tall enough to be harvested with a cutter bar. The best of these will be tested in replicated yield trials in 1983/84.

Performance Across Locations

In the above data presented for the ICARDA/INRAT cooperative project for the three crops, a number of entries did not show a consistent yield performance across locations in relation to the local check. To investigate this further a combined analysis of variance across locations was undertaken on the seed yield of all entries in a number of trials of each crop. The results of these analyses are summarized in Table 59, which shows the number of trials for each crop that attained a particular level of probability (P) for the interaction mean square (entry x location).

Table 57. Seed yield (SY) in kg/ha and as percent of local check of superior yielding lentil entries in a large-seeded international yield trial in Tunisia, 1982/83.

	Location							
	Beja		El Kef		Mateur		Mean	
Entry	SY	%	SY	%	SY	%	SY	%
ILL 8	*1449*	129	1363	120	*2917*	285	1910	197
ILL 20	*1625*	216	1388	123	*2883*	281	1965	202
ILL 193	*1449*	192	1280	113	*3000*	293	1910	197
ILL 4523	*1400*	186	1483	131	*2917*	285	1933	199
ILL 4606	*1500*	199	1671	147	*2525*	246	1899	196
Tunisian local	754	100	1133	100	1025	100	971	100
SE ±	65.5		138.1		357.8			
CV (%)	8.1		17.3		28.1			

Values italicized significantly exceeded the local check.

Table 58. Seed yield (SY) in kg/ha and as percent of the local check of superior yielding genotypes in a preliminary yield trial in Tunisia, 1982/83.

	Location					
	Beja		El Kef		Mean	
Entry	SY	%	SY	%	SY	%
ILL 241	*2311*	155	1249	115	1780	138
ILL 346	*2400*	161	*1371*	126	1886	146
X 75TA 49	*2128*	143	1304	120	1716	133
ILL 857	*2166*	146	*1443*	133	1805	140
ILL 7	*2211*	149	*1455*	134	1833	142
Tunisian local[1]	1487	100	1088	100	1288	100
SE ±	140.5		103.4			
CV (%)	13.4		14.1			

Values italicized significantly exceeded the local check.
1. Mean of four different local checks.

Table 59. Number of trials of each crop that attained a particular level of probability for the interaction mean square in an analysis of variance for seed yield, 1982/83.

Probability level of the interaction mean square	Crop		
	Faba bean	Chickpea	Lentil
>0.10	3	4	1
<0.10 ->0.05	2		
<0.05 ->0.01			
<0.01 ->0.001	1		
<0.001	2	1	2
Total number of *trials analyzed*	8	5	3

The results must be treated with some caution as in some cases the error variances did differ markedly between locations. However, on the assumption that an interaction has some practical significance at $P<0.10$, the analysis suggests that genotypes of both faba beans and lentils are more likely to exhibit a varied performance across locations than those of chickpeas. Although more such analyses are required, the results reinforce the need to ensure adequate multilocation testing of breeding material.

ICARDA/ARC (Syria) Cooperative Project

During the 1982/83 season, 70 trials on different aspects of improvement of faba beans, lentils, and kabuli chickpeas were conducted in this cooperative project between ICARDA and the Agricultural Research Centre (ARC) of the Syrian Ministry of Agriculture and Agrarian Reform. In addition to the joint experiments conducted on research stations of the ARC in different agroecological regions in Syria, on-farm trials were also jointly conducted on winter sowing of chickpeas with ascochyta blight resistant/tolerant cultivars and on promising genotypes of lentils. Results of these experiments were jointly evaluated in the Research Coordination Meeting held at ICARDA, 3-6 Sept 1983. A program of collaborative reseach for the 1983/84 season was also developed. It is hoped that this collaborative project will help expedite the identification of superior genotypes and production technology for Syrian farmers.

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PASTURE AND FORAGE CROPS IMPROVEMENT

Contents

Cover: More nutritive pasture and forage crops are being developed to increase the livestock productivity.

Pasture and Forage Crops Improvement

Introduction

The Program's objectives are to increase the availability of pastures and forages to livestock, and, through the use of adapted legumes, improve soil fertility and ultimately yields of cereals. Its activities have been grouped into four projects: (1) annual forages to replace fallows, (2) annual pastures to replace fallows, (3) improvement of marginal lands, and (4) evaluation of genetic resources. Results from the genetic resources project are reported with the other three projects.

Forages are defined as annually resown crops for hay or grazing, and pastures as self-regenerating communities used primarily for grazing.

The research focus is on utilizing land which would otherwise be fallow. The fallows leave half of many farms idle each year. Even if farmers grow cereals every year, yields decline. One of the ways to avoid the decline in cereal yield, and at the same time using the entire farm, is to grow annual forage crops or pastures. Indeed, if this is done, cereal yields may ultimately increase, as the crop will utilize the increased soil fertility resulting from fixation of atmospheric nitrogen by the legume forages or pastures.

Medicago rigidula, a wild species, has been identified as an annual pasture legume adapted to the soil and climate of northern Syria.

Improving the productivity of marginal lands can result in substantial economic benefits. ICARDA has defined marginal lands under two categories: those within the cereal zone, unsuitable for cultivation; and those between the cereal zone and the dry steppe. In both cases, the marginal lands are often degraded through overstocking and soil erosion. Their improvement involves finding solutions to many technical and social problems, such as methods to control soil erosion, identification and introduction of adapted plants, formulation of suitable grazing systems, and acceptance of better management by village communities.

The Program's major achievement to date has been the identification of *Medicago rigidula* as an annual pasture legume adapted to the soil and climate of northern Syria. *M. rigidula* is a species not previously used in commercial agriculture. Its important attributes include its ability to survive cold winters, form nodules in conditions in which commercial medics fail to nodulate, and produce large herbage yields. The Program has also extensively developed hay-producing systems using local pea and vetch cultivars, and has identified and defined the importance of several diseases affecting both forage and pasture legumes.

In 1982/83 the Program suffered a shortage of staff severely limiting its activities, especially in the marginal lands project. However, the staff position will improve in the coming year and it is hoped to greatly increase research. The main experiments in 1982/83 were in the annual forage project where both pea and vetch selection projects were continued; the effect of grazing on hay yield was measured; the effect of time of cutting on yield, quality, and voluntary feed intake of hay was studied; and work on the effect of seed rate, and ratio of legume to cereal, on hay quality and yield proceeded. Important collaborative work with the national program in Syria was continued.

Selection in *M. rigidula* continued and, for the first time, large amounts of seed were produced, in four genotypes, more than 100 kg. Important experience in harvesting pasture seed was obtained, and it is hoped to produce even more seed of *M. rigidula* and other species in future. As a result of last year's harvest relatively large areas of pasture can be sown which will facilitate the study of grazing management of annual pastures and the integration of livestock into pasture farming systems.

Project I: Annual Forages to Replace Fallow

Provision of adequate feed supplies for the rapidly growing livestock population is essential in ICARDA region. Earlier, natural rangelands provided almost the entire feed for animals, but overgrazing of those lands during the last two decades has made them severely degraded, leading to feed shortages.

Feed shortages are acute especially during late summer and early winter. The shortages can be alleviated by growing suitable forages on existing fallows (over 40 million hectares in ICARDA region) in rotation with cereal crops. The forages can be grazed during winter or harvested for hay in spring to extend the feed supply. Annual legumes (vetch and peas) grown in mixture with forage cereals (barley, triticale, and oats) offer good prospects for the production of good quality hay.

Evaluation of Forage Legumes

Extensive selection of two forage legumes, *Vicia sativa* (vetch) and *Pisum sativum* (pea), was carried out for early maturity, large dry-matter production, and large seed yield. Potentially productive lines were planted in 24 m^2 plots in triple lattice design, at a sowing rate of 80 kg seed/ha and with 40 kg P_2O_5/ha. The experiments were duplicated: in one set, dry matter was measured; in the other, seed was harvested. The whole plots were harvested in both cases.

In vetch, the check had the highest yield of both dry matter and seed; the dry-matter yield was not significantly greater than that of the next four best lines, but the seed yield was significantly larger than all but one of the other lines (Table 1). Seed and dry-matter yields were closely related (r = 0.79, P < 0.01), indicating that the two parameters were constrained by the same variables. That the limitation was associated with the onset of summer drought was indicated by the close relationship of dry matter and 100% flowering (r = −0.64, P < 0.05, Fig. 1), and seed yield and 100% flowering (r = −0.79, P < 0.05). The large production of the local check was thus due to its early maturity. The results indicate a clear need to search for earlier maturing lines originating from within the ICARDA region.

Date of maturity had less effect on the dry-matter and seed yields of peas. Although late-maturing lines had low seed yields, early-maturing lines did not necessarily yield well. Dry matter was not related to date of maturity. Evidently the constraints to pea yield were not associated with the onset of summer drought.

Several pea lines were as good as the local check, though none was significantly better (Table 2). Peas generally had lower dry-matter and seed yields than vetch (3200 vs 4200 kg/ha and 900 vs 2500 kg/ha, respectively). But such differences do not persist throughout the region as discussed in this report later.

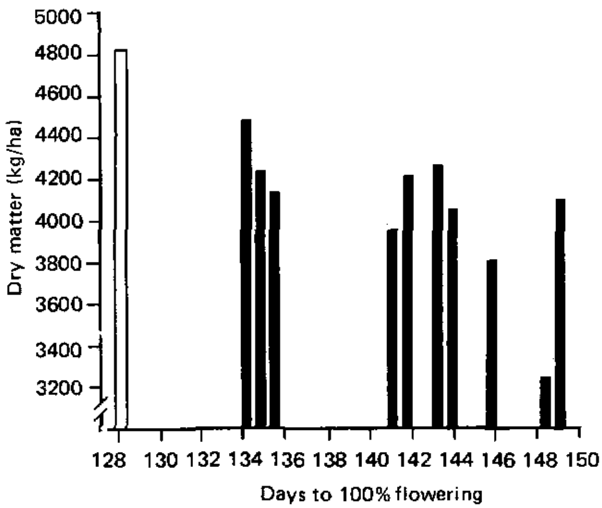


Fig. 1. Relationship between dry matter and days to 100% flowering, vetch advanced trials at Tel Hadya, 1982/83.

Table 1. Dry matter (DM) and seed yield of selected lines of vetch in the advanced yield trial at Tel Hadya, 1982/83.

Origin	Selection No.	Dry matter			Seed yield		
		kg/ha	Rank	% control	kg/ha	Rank	% control
Syria	Check (2541)	4817	1	100	4284	1	100
Italy	2083	4482	2	93	2757	3	64.3
Turkey	1136	4405	3	91.4	2079	10	48.5
DDR	2019	4246	4	88.1	2559	5	59.7
DDR	2062	4236	5	87.9	3711	2	86.6
Turkey	845	4201	6	87.2	2547	6	59.4
Turkey	2057	4169	7	86.5	2195	8	51.2
Italy	2109	4124	8	85.6	2202	7	51.4
Italy	2086	4057	9	84.2	2566	4	59.8
Italy	2106	3955	10	82.1	2162	9	50.4
Italy	2108	3811	11	79.1	1902	11	44.3
DDR	2096	3251	12	67.4	1210	12	28.2
LSD (5%)		640.6			617.7		
SE ±		378			364		

Selection of peas in microplots.

Table 2. Dry-matter (DM) and seed yield of selected lines of peas in the advanced yield trial at Tel Hadya, 1982/83.

Origin	Selection No.	Dry-matter yield kg/ha	Dry-matter yield Rank	Dry-matter yield % control	Seed yield kg/ha	Seed yield Rank	Seed yield % control
Syria	175	3953	1	104	819	7	54.3
Italy	446	3814	2	101	1045	4	69.3
Syria	Check	3766	3	100	1507	2	100
Italy	493	3676	4	97.6	699	8	46.3
Italy	496	3572	5	94.8	1586	1	105
Afghanistan	92	3284	6	87.2	697	9	46.2
Afghanistan	61	3209	7	85.2	641	11	42.5
Italy	469	3197	8	84.8	575	12	38.1
Italy	466	2972	9	78.9	648	10	42.9
Italy	454	2918	10	77.4	827	6	54.8
Italy	440	2391	11	63.4	567	13	37.6
Canada	166	2389	12	63.4	929	5	61.6
Canada	100	2244	13	59.5	1203	3	79.8
LSD (5%)		1152			469		
SE ±		683			278		

Agronomy of Forage Crops

The objectives of agronomy research during 1982/83 were to (1) investigate the possibility of using forage mixtures for grazing during winter, to be followed by hay making at the end of the season, (2) define optimum time for harvesting forage mixtures for hay, in relation to yield, quality, voluntary feed intake by sheep, and *in vivo* digestibility, (3) validate the previous results by again investigating the effect of seed rate and seed ratios on yield and quality of different forage mixtures, and (4) investigate, in collaboration with Syrian national programs, using multilocation trials, the potential of different forage crops for hay production.

Forage Mixtures for Grazing and Hay Making

In previous studies six lines of forage barley and four lines of forage triticale were identified for their ability to regrow after cutting. In 1982/83 these lines were planted in mixtures (60:40) with one line of vetch and one of pea. Separate but adjacent trials were established for barley/vetch and barley/pea, while triticale/vetch and triticale/pea were included in a third trial. The mixtures were sown at 160 kg/ha in November and fertilized with 40 kg P_2O_5/ha in the form of triple superphosphate. Half of the area of each trial was grazed to ground level by sheep in Feb 1983 when plants were 15-20 cm high. Measurements included percent forage composition (by hand separation), dry matter consumed by grazing animals (the difference in herbage before and after grazing), total dry-matter (DM), crude protein (CP), and digestible dry-matter (DDM) yields.

The type of legume affected the grazing pattern of forage mixtures early in the season. Although the dry-matter consumption by animals from barley/vetch and barley/pea was approximately the same (310 and 333 kg/ha, respectively), animals preferred vetch (24% of the total feed consumed) to pea (10%) (Table 3). Similarly, grazing of triticale/vetch and triticale/pea showed a higher percentage of vetch (23%) in the dry matter consumed than pea (17%). In all cases the cereal (barley or triticale) constituted the remainder.

Table 3. Dry-matter and percent composition of barley/legume and triticale/legume forage mixtures consumed by grazing animals at Tel Hadya, early winter 1983.

Forage mixtures	DM consumed (kg/ha)	Legume (%)	Cereal (%)
Barley/vetch	310	24	76
Barley/pea	332	10	90
Triticale/vetch	288	23	77
Triticale/pea	299	17	83

Values represent means for six lines of barley or four lines of triticale.

In barley/pea and barley/vetch, the legume contents of grazed treatments at the time of harvest were, respectively, 44 and 18% higher than ungrazed treatments (Table 4). The DM, total CP, and total DDM yields at the end of the season were reduced by grazing by 21, 0.5, and 20%, respectively, in pea mixtures, and by 35, 27, and 29% in vetch mixtures. There were no significant differences in total DM, total CP, and total DDM for barley/pea after grazing, while there were significant reductions in total DM and DDM in barley/vetch (Table 5). There were only small differences between cereal lines, so the results are presented as averages of all lines of each cereal species.

In the triticale mixtures, vetch resulted in higher values of percent legume, total CP, and total DDM of hay than pea. But although higher overall, vetch appeared to be more affected by grazing: dry matter, CP, and total

Table 4. Effects of grazing treatments on DM, total CP, total DDM yields (kg/ha), and percent composition of hay of different forage mixtures at Tel Hadya, 1983.

	Grazed					Ungrazed				
Forage mixtures	DM[1]	Legume (%)	Cereal (%)	Total CP	Total DDM	DM	Legume (%)	Cereal (%)	Total CP	Total DDM
Barley/pea	3520	39	61	406	2043	4459	27	73	408	2562
Barley/vetch	2650	44	56	343	1527	4085	37	63	473	2156
Triticale/pea	3412	30	70	342	2224	4092	37	63	385	2561
Triticale/vetch	3588	40	60	478	2601	4778	43	57	603	3347

1. Does not include the amount consumed by grazing animals early in the season.

DDM of vetch were reduced by 25, 21, and 22%, respectively, compared with 17, 11, and 13% for pea (Table 4). However, apart from total DM, differences associated with grazing were not significant (Table 5).

The results from this study suggest that barley/pea or triticale/pea mixtures are suitable for a combination of early grazing and hay making.

Effects of Seed Ratios on Yield and Forage Quality

The objective of this study was to define optimum management for maximum hay production and forage quality in legume/cereal mixtures. The results of earlier seasons indicated that high seed rates (160-180 kg/ha) produced larger hay yields, and that the use of vetch or pea at low proportion (20-40%) resulted in significant forage quality improvement without substantial reduction in yield.

In 1982/83, six forage mixtures (vetch/barley, pea/barley, vetch/triticale, pea/triticale, vetch/oats, and pea/oats) were sown at three seed rates (120, 160, and 200 kg/ha) and five legume/cereal seed ratios (0:100, 33:66, 50:50, 66:33, and 100:0).

A split-plot design was used with seed rates as main plots and seed ratios as subplots, with three replicates. Fertilizer was applied in the form of triple superphosphate at 40 kg P_2O_5/ha.

Plots were harvested when the legumes reached 100% flowering. Samples from each treatment were separated into their components and oven dried (70°C). Subsamples of oven-dried material were used for Kjeldahl N analysis and for *in vitro* digestibility.

Table 5. Effects of winter grazing on total DM, total CP, and total DDM yields (kg/ha) of barley/legume and triticale/legume forage mixtures at Tel Hadya, 1983.

Treatment	Barley/pea			Barley/vetch			Triticale/legume[1]		
	DM	CP	TDDM	DM	CP	TDDM	DM	CP	TDDM
Grazed[2]	3850	476	2284	2960	415	1775	3794	476	2665
Ungrazed	4459	408	2562	4085	473	2156	4435	495	2954
LSD (5%)	NS	NS	NS	1145.3	NS	172.9	590.7	NS	NS

1. Values represent mean for triticale/vetch and triticale/pea in the same trial.
2. Values include amounts consumed by grazing animals.

In all mixtures, DM was increased with seed rate but differences were not statistically significant. Further, in all mixtures except pea/triticale, DM production was greater than that of the legume or cereal component grown alone (Fig. 2). The differences were statistically significant in vetch/barley and pea/barley. Contrary to the results of previous seasons, yields in 1982/83 improved with a higher proportion of legume in the mixture. At all seed ratios, the yield of cereal was larger in mixtures containing pea than in those containing vetch. This was probably due to more nitrogen being fixed by peas and hence less competition for soil nitrogen with the companion cereal.

Crude protein and DDM yields were compared for four of the six mixtures (Fig. 3). Both increased as the legume proportion was increased. Pea mixtures had lower DDM yields than vetch mixtures, due to the lower digestibility of peas.

Hay Yield and Quality in Relation to Time of Cutting

The success of introducing the annual forage crops depends partly upon the economic value of the forage crop either for grazing or for hay. The economics of hay making in turn depends upon yields, harvesting losses, nutritive value of hay, and its suitability as an alternative to straw and concentrates.

We investigated the optimum stage for harvesting forage mixtures in relation to total yield, harvesting losses, quality, feed intake, and digestibility.

Cereal/vetch mixtures (60:40) sown at 160 kg seed/ha with 40 kg P_2O_5/ha were harvested for hay on three dates related to vetch maturity. The nutritive value of hay was determined by feeding it to sheep in digestibility crates. During the first harvest, rain interrupted operations, providing an opportunity to compare the nutritive value of hay damaged and undamaged by rain. Regrowth after the first and second harvest was measured.

Hay yields increased with crop maturity (Table 6), particularly with the mixture containing oats which matured later than barley or triticale. Harvesting losses were proportionately smaller for all mixtures at the 100% flowering stage. At the 10% flowering stage, losses represent unharvestable stubble, respiration losses during drying, and rain damage. At the full-pod stage, leaf shatter and pod loss mainly cause losses. In an on-farm situation grazing animals would be able to utilize a proportion of the stubbles, fallen leaves, and pods. Substantial

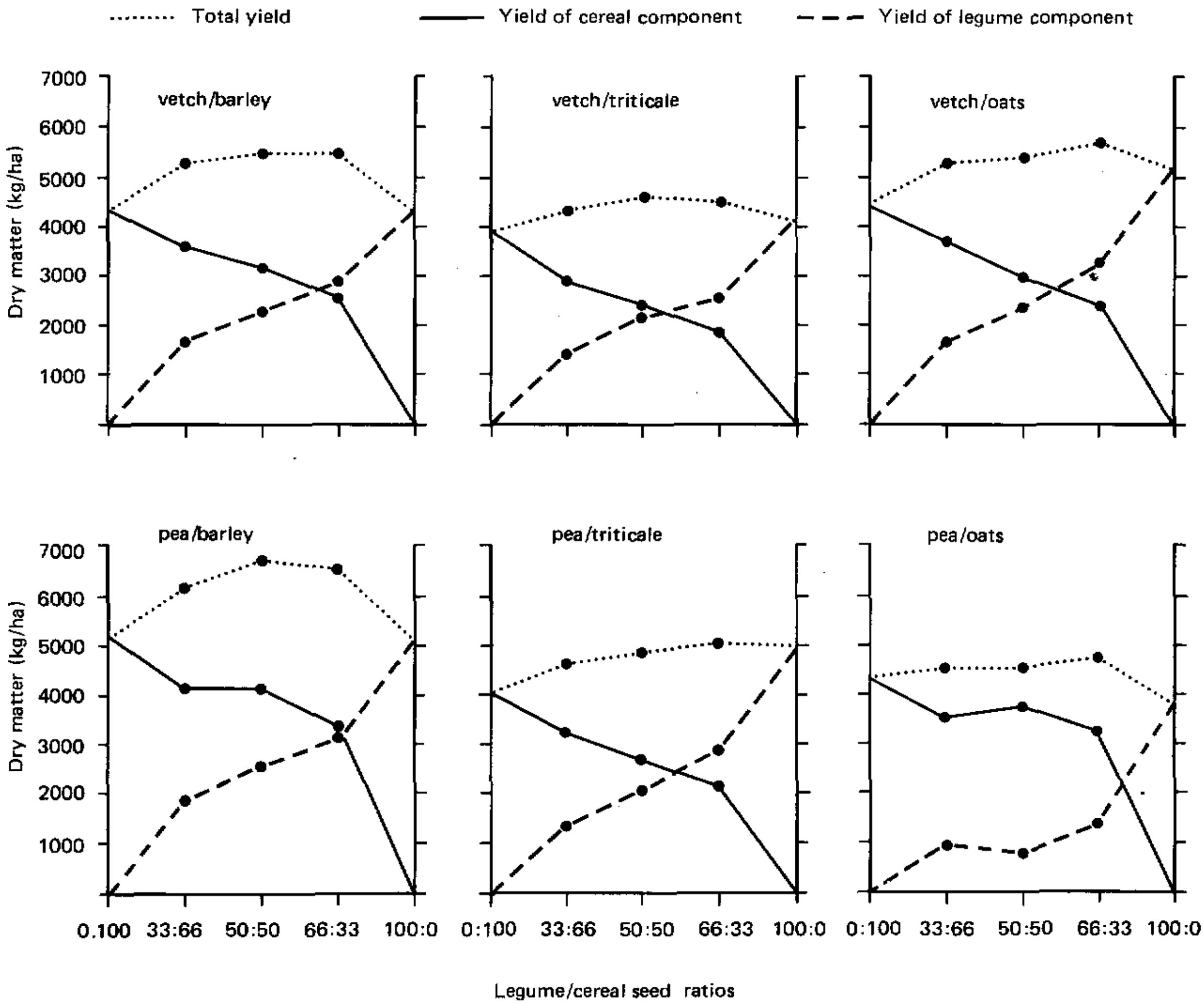


Fig. 2. Effects of seed ratios on total yield, yield of the cereal component, and yield of the legume component in cereal/legume mixtures at Tel Hadya, 1982/83.

regrowth occurred only following early hay making. Its quality was only slightly less than the original crop.

Reduction in digestible crude protein in the later maturing hays was associated with higher proportion of cereal. The animals found mature triticale very unpalatable probably because of the spiky awns on seed heads (Table 6).

The effect of a single shower of rain (16.6 mm) on the nutritive value of hay was slight (Table 7). Digestibility was lower but with all mixtures there was a small increase in palatability.

The optimum stage of harvest of forage mixtures also depends upon the cereal component and the animal production objectives of the

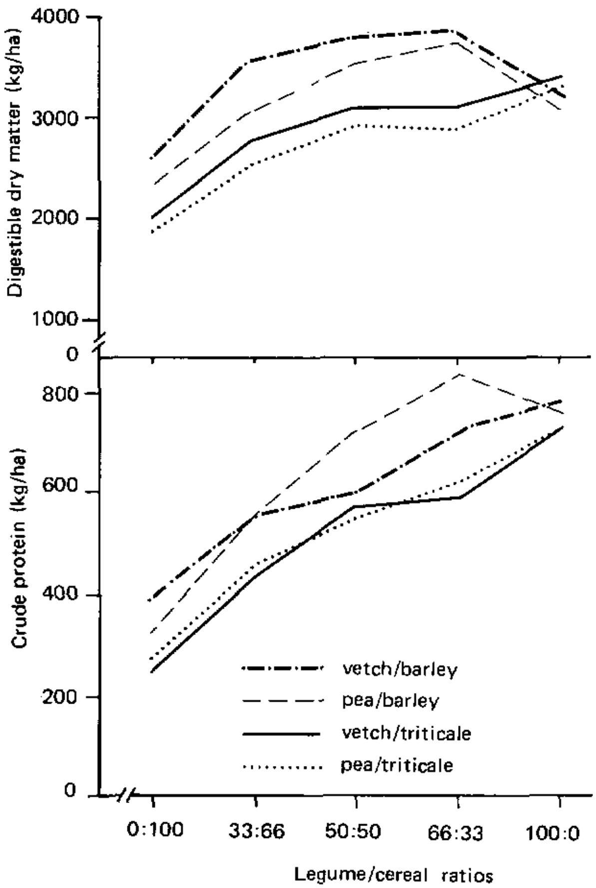


Fig. 3. Total crude protein and digestible dry matter yields of four forage mixtures with different legume/cereal ratios at Tel Hadya, 1983.

farmer. With barley/vetch there was little to choose between early harvesting plus grazing the regrowth and late harvesting in terms of total animal production potential. The late-maturing oat mixture was best harvested at a later stage. Palatability of oaten hay appears to increase with maturity. Triticale hay palatability reduced with maturity; thus nutritive value is likely to be greatest prior to heading.

Hays fed alone (except triticale/vetch harvested at full-pod stage) resulted in the pro-

Table 6. Cereal/vetch hay production in relation to maturity stages at Tel Hadya, 1983.

Stage of harvesting[1]	Barley/vetch			Oat/vetch			Triticale/vetch		
	a	b	c	a	b	c	a	b	c
Dry-matter yield (kg/ha)	3356	4781	8147	2154	3873	8670	3149	3799	7117
Harvestable hay (kg/ha)	2300	3731	4377	716	2849	4285	1724	3130	4366
Loss on harvesting (%)	31.5	22.0	46.3	66.8	26.4	50.6	45.3	17.6	38.7
Proportion of cereal in hay (%)	65.4	65.5	72.4	46.5	39.7	72.5	55.3	53.1	73.3
Yield of regrowth (kg/ha)	1905	650	Nil	2622	714	Nil	1959	407	Nil

1. a, b, and c represent harvesting at 10% flowering, 100% flowering, and at full pod stage, respectively.

Table 7. Hay quality in relation to maturity stages in different forage mixtures at Tel Hadya, 1983.

	D	Barley/vetch[1]			Oats/vetch			Triticale/vetch		
		a	b	c	a	b	c	a	b	c
Dry-matter intake (kg/45 kg sheep/day)	1.662	1.525	1.388	1.457	1.373	1.515	1.430	1.699	1.447	0.590
Digestible organic matter (kg/kg dry matter)	0.618	0.626	0.588	0.596	0.670	0.639	0.574	0.636	0.606	0.616
Estimated metabolizable energy intake (MJ/day)	15.4	14.3	12.2	13.0	13.7	14.5	12.3	16.1	13.2	8.7
Digestible crude protein intake (kg/day)	0.177	0.142	0.074	0.058	0.087	0.095	0.047	0.221	0.111	0.029

1. D, average value for rain-damaged hay from the three mixtures at stage a; while a, b, and c are the harvesting stages (see Table 6).

duction of 0.75-1.25 kg milk/day from a 45 kg ewe. This illustrates the potential of hay making as a technique for conserving nutrients in a favorable year. Some caution in interpreting the results is necessary however, as hays made at Tel Hadya under adverse conditions in 1982 averaged only 0.51 kg digestible organic matter per kg dry matter, necessitating heavy concentrate supplementation to meet the needs of lactating ewes. In these circumstances the economic value of hay making may be in doubt.

Collaborative Research and Multilocation Testing

Joint research activities between the Pasture and Forage Improvement Program and the Syrian Agricultural Research Council and Steppe Directorate, were continued through 1982/83. A total of 37 trials were carried out at 13 locations covering seven provinces. The trials included multilocation testing for new lines of vetches and peas, comparative studies evaluating hay from different forage mixtures, rotation trials studying the impact of forage crops on subsequent cereal crops, and on-farm trials in which forage crops were introduced to farmers. The details of these experiments are included in the second annual report of the project (in Arabic) entitled: Collaborative Research Projects Between ICARDA and the Syrian Ministry of Agriculture 1982/83 (in press). Only a few of the experiments are highlighted here.

Six vetch lines and five pea lines were evaluated for DM yields at four locations (Qamishly, Hama, Salamieh, and Izraa). At each location, lines of each legume were planted in mixtures with cereals (barley or wheat) in randomized complete block design with three replicates. Phosphate fertilizer (40 kg P_2O_5/ha) was applied at sowing. Observations were made on rainfall, maximum and minimum temperatures, crop establishment, frost damage, and disease occurrence. The plots were harvested for hay when the legume component reached 100% flowering. Subsamples were taken, weighed, oven-dried, and total DM yields determined.

The largest vetch dry-matter production was at Hama (7000-8300 kg/ha) and Izraa (6000-9000 kg/ha) where rainfall was also highest (Table 8). Yields of 1300-2300 kg/ha were recorded at the driest site, Salamieh. Unlike previous years, yields were comparatively small at Qamishly, ranging between 2000 and 2900 kg/ha. The line 1361/1448, previously identified for its desirable non-shattering characteristic, was comparable in yield to the other high-yielding lines at all sites.

Pea yields were highest at Hama and Izraa (Table 9). At Izraa, pea yields were generally smaller than those of vetches, probably because of powdery mildew, which was more serious on peas.

Table 8. Evaluation of selected lines of vetch in mixture with cereal[1] for hay production (kg/ha) at four locations, 1982/83.

		Qamishly	Hama	Salamieh	Izraa
	Rainfall	314.8 mm	372.4 mm	292.1 mm	366.5 mm
	Av. max. temp.	18.5°C	19.1°C	18.7°C	19.4°C
Vetches	Av. min. temp.	2.2°C	-0.5°C	-1.7°C	-1.9°C
Acc. No./Sel. No	Av. temp.	10.4°C	9.8°C	8.5°C	8.8°C
2/1134		2880	6989	1355	7935
7/1135		2501	8015	1899	6078
2541/Syria		2394	8316	1777	8849
0709		2390	7484	2268	9019
0715		2364	7062	1969	8319
1361/1448		2085	7334	1672	7543
LSD (5%)		1573.18	2672.01	1539.20	2363.40

1. Wheat (Senator Capelly) was used in Hama and Qamishly while local barley was used in Salamieh and Izraa.

Table 9. Evaluation of selected lines of peas in mixture with cereal[1] for hay production (kg/ha) at four locations, 1982/83.

Peas Acc. No./Sel. No	Qamishly[2]	Hama	Salamieh	Izraa
2903/325	3433	7804	1363	7204
205/Syria	3292	9327	1201	6442
3209/321	2393	9589	1824	5779
3208/320	2372	8668	1811	6273
3207/319	2026	7334	1492	6141
LSD (5%)	1585.27	1599.74	510.3	NS

1. Wheat (Senator Capelly) was used in Hama and Qamishly while local barley was used in Salamieh and Izraa.
2. For climatic data see Table 8.

At Qamishly, mixtures of vetch and peas with triticale, oats, and wheat were compared at three seed rates (120, 160, and 200 kg/ha) and five seed ratios. The experiments were laid out in a split-plot design with seed rates as main plots and seed ratios as subplots. Phosphate fertilizer at 40 kg P_2O_5/ha was applied at sowing in November. The experiment was similar to the seed ratio/seed rate experiment at Tel Hadya.

In all six mixtures there were no significant differences between rates of seeding, contrasting with the effect of seed ratio, which was highly significant (Fig. 4). In vetch/triticale and vetch/oats mixtures, DM production was significantly larger than either the legume or cereal components grown as monocultures. In the vetch/wheat mixture maximum yields were recorded at 50:50 and 66:33 ratios which were significantly larger than the vetch grown in pure stand. The results are strikingly similar to those at Tel Hadya, described earlier.

Pea yields in monocultures were less than half those of vetch. For this reason the effect of peas on the yield of mixtures was slight and there were no significant differences between mixture yields and pure cereal.

The yields of both legumes at Qamishly were much less than those of cereals, possibly indicating the lack of suitably adapted rhizobia.

Pathology

Diseases of Forage Crops

The quantitative survey of diseases in the region, which was started in Apr 1981 in Syria and Lebanon, was completed this season by covering Jordan, Morocco, and part of Tunisia. The survey was conducted in 63 locations (Jordan 13, Lebanon 2, Morocco 24, Syria 24) in

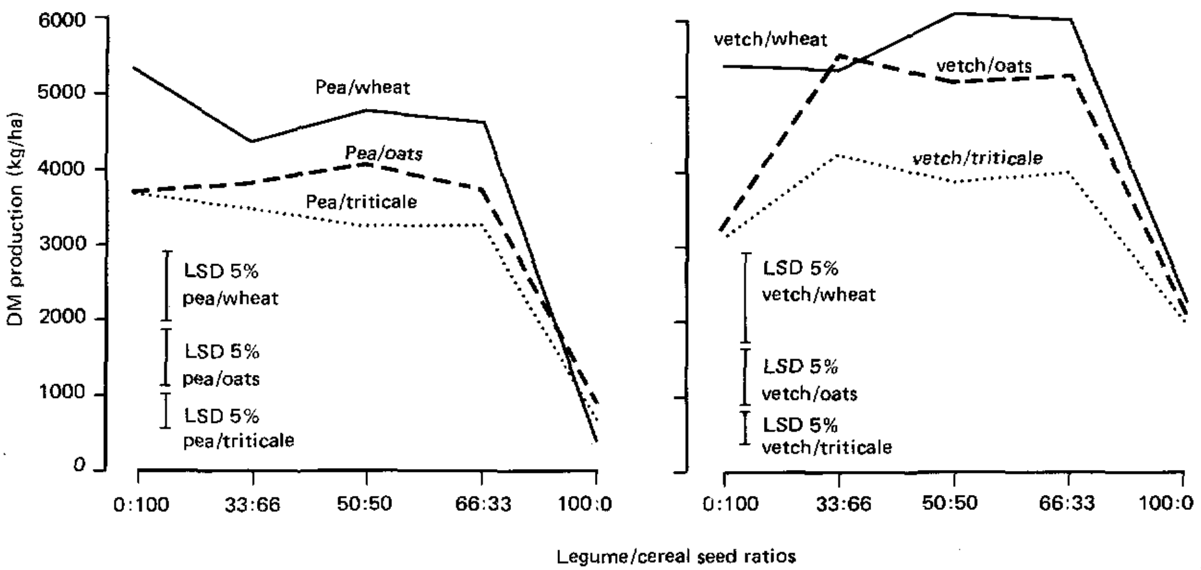


Fig. 4. Dry-matter yield of different legume/cereal mixtures as affected by seed ratios at Qamishly, 1982/83.

different agroecological zones. A list of diseases detected and their identified causal agents has been prepared, and is available from the Pasture and Forage Improvement Program.

Major diseases of forage crops are ascochyta diseases (*Ascochyta pisi*, *Mycosphaerella pinodes*, *Phoma medicaginis* var *pinodella*), bacterial stem blight (*Pseudomonas pisi*), and powdery mildew (*Erysiphe pisi*) on peas; and downy mildew (*Peronospora viciae*), ascochyta (*Ascochyta* sp.), and powdery mildew (*E. pisi*) on vetches. These diseases were determined to be important on the basis of frequency of occurrence, prevalence, and time of first appearance and consequent effect on herbage or seed production. Field assessments of crop loss were carried out to confirm the economic importance of the major diseases.

Table 10. Performance of promising lines of peas and vetches against the major diseases in the region.

Entry	Ascochyta blight	Bacterial blight	Powdery mildew	Downy mildew
Peas				
325	2.8	3.7	5.0	
local	3.1	4.0	5.0	
319	3.7	4.2	4.0	
321	3.7	3.9	4.0	
320	4.0	4.2	5.0	
(452)[a]	4.5			
(254)[a]		3.2		
(515)[a]			5.0	
Vetches				
1135	3.8		4.7	1.0
1448	1.8		4.0	1.0
715	1.2		4.3	1.4
1134	2.6		4.3	2.6
local	2.6		3.0	2.5
709	3.2		3.7	3.0
(2006)[a]				4.7
(2009)[a]	4.0			
(2004)[a]			4.7	

Score: 1 = Resistant; 5 = Highly susceptible.
a. Susceptible indicator lines.

Screening for Disease Resistance

As in the previous season, all breeding material (1890 genotypes) was screened under natural field infections. This preliminary screening aims to exclude highly susceptible and susceptible genotypes from the improvement programs.

Promising lines were screened for resistance to the major diseases in the region, under natural high disease pressure in the coastal areas and under artificial epiphytotics at Tel Hadya. The results are summarized in Table 10. None of the pea selections proved resistant or tolerant to all diseases. Two selections, the local line and 325, had some tolerance to *Ascochyta* sp., but they were susceptible or highly susceptible to bacterial blight and powdery mildew. In vetch, selections 1448, 715, 1134, local, and 709 showed some tolerance to both downy mildew and *Ascochyta* sp. However, with the exception of the local line, all were susceptible or highly susceptible to powdery mildew.

Powdery mildew. Powdery midew is one of the major diseases of peas, vetches, and annual medics in the region. The pathogen, *Erysiphe pisi*, is known to exist in three forms: f. sp. *pisi* on *Pisum* spp., f. sp. *Vicia sativae* on *Vicia* spp., and f. sp. *Medicaginis sativae* on *Medicago* spp. No information is available on specialization of this pathogen or composition of the natural inoculum at Tel Hadya. The pathogenicity test conducted in growth chambers with different sources of inocula (Table 11) showed that the pea pathogen attacked only peas, i.e., it is a

Table 11. Pathogenicity of powdery mildew (*Erysiphe pisi*) on peas, vetches, and *Medicago rigidula* at Tel Hadya, 1983.

Inoculated crop	Inoculum from pea	vetch	*M. rigidula*
Pea	+	–	+ +
Vetch	–	+ +	+ +
M. rigidula	–	–	+ +

– no infection.
+ positive infection.
+ + positive infection by repeated testing.

specialized form, confined to its host. The same result was obtained on vetches, but the powdery mildew isolate from *M. rigidula* cross-infected all three hosts.

Screening for resistance to powdery mildew in peas began in 1981/82 using field infections in the Jableh nursery. Of the 125 accessions tested, only 12 were resistant or tolerant. These 12 lines, and 105 others, were tested in 1982/83 in growth chambers using inoculum from pea plants (Table 12). Three accessions, 49, 48, and 93, were tolerant and three others, 91, 164, and 30, were intermediate in their reaction to powdery mildew; the remaining 111 were susceptible or highly susceptible. A systematic screening of many more accessions is needed.

Nutritive Value of Cereal and Legume Straws

In semi-arid cropping areas straws are an important component of sheep diets and their nutritive value will have significant consequences for livestock productivity.

Analyzing straw samples for their nutritive value.

Within the drier parts of ICARDA region the most important straws for livestock feeding are of barley and lentils, followed by bread and durum wheat, chickpeas, and faba beans. The value of straw may even exceed the value of grain.

Table 12. Reaction of 117 genotypes of several pea species to powdery mildew (*Erysiphe pisi*) in growth chambers, 1982/83.

Species	Score 1	2	3	4	5	Total
P. sativum	0	3[a]	3[b]	13	77	96
P. arvense	0	0	0	0	4	4
Pisum spp.	0	0	0	4	13	17
Total	0	3	3	17	94	117

Score: 1 = Resistant; 5 = Highly susceptible.
a. Genotypes: 49, 48, 93.
b. Genotypes: 91, 164, 30.

Numerous factors affect quality including genotype, moisture, fertilizer, date of seeding, and method of harvesting. More than 1500 samples have been collected and are being analyzed for their nutritive value. At the time of writing, the results were not available.

Biological Nitrogen Fixation

The results of these studies, together with those on annual medics, are presented with the results of Project II below.

Project II: Annual Pastures to Replace Fallow

Selection of Adapted Genotypes

A total of 169 annual medic (*Medicago* spp.) accessions were screened in nursery rows in a cubic lattice design with three replications. In this preliminary adaptation trial, the accessions were visually scored for establishment, winter and spring growth, seedling vigor, leafiness, growth habit, flowering date, and reaction to diseases. Nine species were screened; as in earlier years, accessions of *M. rigidula* were the most promising (Table 13). However, selections were made on considering that some other species may be more productive than *M. rigidula* in other parts of Syria and in other countries in the region.

As a result of previous screening in nursery rows, 64 accessions were tested for dry-matter yield and seed production in microplots. The selections from seven different species were planted in microplots arranged in a cubic lattice design with six replicates, three for dry-matter determination and three for seed yield.

The best 25 lines from the 1981/82 microplots were tested in advanced yield plots arranged in a triple lattice design with six replicates; three replicates were harvested for dry matter and three for seed. The sowing rates for both sets of

Table 13. Evaluation of medic observation rows at Tel Hadya, 1982/83.

Species	No. of accessions	No. selected	Selections as % of each species	Selection as % of total species	Range and mean selection score of selected accessions[1]
M. rigidula	82	41	50.6	19.9	3.3 - 4.7
M. aculeata	13	3	23.0	1.8	3.3 - 3.8
M. noeana	1	1	100	0.6	3.8
M. rotata	16	2	12.5	1.2	3.5 - 3.8
M. polymorpha	1				
M. truncatula	26				
M. constricta	12	2	16.6	1.2	3.5 - 4.3
M. turbinata	12	1	8.3	0.6	3.5
M. littoralis	6				
Total	169	50		29.8	

Mean selection score of control 3.8 (*M. rigidula*).

1. Selection score 1 = poor, 5 = very good.

trials were 15 kg/ha, and 40 kg P_2O_5/ha was applied during seed-bed preparation. Plot size was 24 m^2 in the advanced yield test and 3.5 m^2 in the microplots.

Results from the microplots indicate that some accessions of *M. rigidula*, *M. rotata*, and *M. noeana* produced large yields of both dry matter and seed (Table 14). All other species ranked lower than the control (*M. rigidula*). It seems that these other species are not adapted to Tel Hadya; however, they may be adapted to other sites in the region. *M. truncatula* (barrel medic), from which the most widely adapted Australian cultivars have been developed, continued to perform poorly at Tel Hadya. The outstanding selections which combined large dry-matter and seed yields are shown in Table 15. Two *M. rotata* accessions are included in this group.

The nine lines (and the control) with the best combination of dry-matter and seed yields in the advanced yield trial are shown in Table 16. As in earlier seasons *M. rigidula* performed best, but one line of *M. noeana* shows promise. *M. noeana* is a species whose natural distribution is restricted to parts of Iraq, northeastern Syria, and Turkey. Its success here is another demonstration of the value of selections from local species compared with exotic cultivars.

Table 14. Dry-matter (DM) and seed yield of medic selections in microplots at Tel Hadya, 1982/83.

Species	No. of accessions	DM yield (kg/ha) range of means	Seed yield (kg/ha) range of means
M. rigidula	30	861 - 4448	646 - 1178
M. aculeata	10	184 - 503	475 - 1160
M. turbinata	11	156 - 1026	204 - 936
M. truncatula	6	221 - 924	268 - 615
M. rotata	3	1107 - 2792	1099 - 1581
M. noeana	2	4311 - 4428	915 - 821
M. blancheana	1	2091	922
Control (*M. rigidula* 1304)	1	1969	1019

Table 15. Dry-matter and seed yields of the best five medic lines in the microplots at Tel Hadya, 1982/83.

Species	Selection No.	DM yield			Seed yield		
		kg/ha	Rank	% control	kg/ha	Rank	% control
M. rigidula	2033	3684	5	187	1102	8	108
M. rigidula	2058	2365	17	120	1126	7	111
M. rigidula	2038	2063	22	105	1027	15	101
M. rotata	2120	2792	14	142	1409	2	138
M. rotata	2123	2037	23	104	1581	1	155
M. rigidula (check)	1304	1969	24	100	1019	16	100

Total No. of lines = 64.
Number of selected lines = 5.
SE of difference between DM crop means = ± 274.3.
SE of difference between seed yield means = ± 105.3.

Table 16. Dry-matter and seed yield of high yielding medics from the advanced yield trial at Tel Hadya, 1982/83.

Species	Selection No.	DM yield			Seed yield		
		kg/ha	Rank	% control	kg/ha	Rank	% control
M. rigidula	1868	4062	1	143	665	12	122
M. rigidula	1915	3917	2	138	571	18	104
M. rigidula	1902	3712	3	131	721	6	132
M. noeana	1938	3632	4	128	680	9	125
M. rigidula	1900	3603	5	127	738	4	135
M. rigidula	1913	3366	6	119	717	7	131
M. rigidula	1569	3320	7	117	672	10	123
M. rigidula	1865	3183	8	112	672	11	123
M. rigidula	1851	3114	9	110	475	23	87
M. rigidula (check)	1304	2833	10	100	541	20	100

Total No. of lines = 25.
Number of selected lines = 9.
SE of difference between DM crop means = ± 382.31.
SE of difference between seed yield means = ± 16.65.

Medic Ecology

The natural regeneration of medics after a crop year is critical to their success in cereal-medic rotations. Survival during the cropping phase depends on the ability of seeds to remain dormant for a whole season before germinating. In medics this is achieved through seed coat impermeability – the ability of some seeds to resist imbibition of water in moist soil. Seed impermeability is both genetically and environmentally controlled.

Ideally all seeds should be impermeable at the end of the summer after they are produced, and most should become permeable by the end of the next summer. However, it is generally considered that if 70% remain impermeable after the first summer an adequate population of permeable seeds will be present after the second summer. A study was therefore initiated to investigate the seed coat permeability characteristics of selected lines of *M. aculeata*, *M. truncatula*, *M. constricta*, *M. rigidula*, and *M. noeana* at Tel Hadya.

Random samples of medic pods from 97 high-yielding accessions were collected from replicated experimental plots at monthly intervals from Aug to Dec 1982. The pods were placed on moist filter paper in petri dishes, and transferred to a refrigerator for 5 days at 5°C. The dishes were then transferred to a germination cabinet at 20°C and after 10 days the percentage of seeds not germinated was calculated.

Variation in seed permeability of *M. aculeata*, *M. truncatula*, *M. constricta*, *M. rigidula*, and *M. noeana* is shown in Table 17 and the pattern of change in permeability in Fig. 5. Many genotypes of *M. rigidula*, two of *M. constricta*, and one of *M. truncatula* could be selected on the basis of 70% impermeability in December. *Medicago aculeata*, however, exhibited a high proportion of permeable seeds, only two accessions being between 60 and 70%. It is possible that accessions of this species may be used for continuous grazing.

Table 17. Variability in the permeability of seeds in five species of annual medics at Tel Hadya, 1982.

Hard seed (%)	Number of entries				
	A	B	C	D	E
0 - 10					
11 - 20					
21 - 30					
31 - 40	1				
41 - 50	2				
51 - 60	2	3			
61 - 70	2	2			
71 - 80		1	2	11	
81 - 90				39	1
91 - 100				29	2
Total	7	6	2	79	3

A = *M. aculeata*, B = *M. truncatula*, C = *M. constricta*, D = *M. rigidula*, E = *M. noeana*.

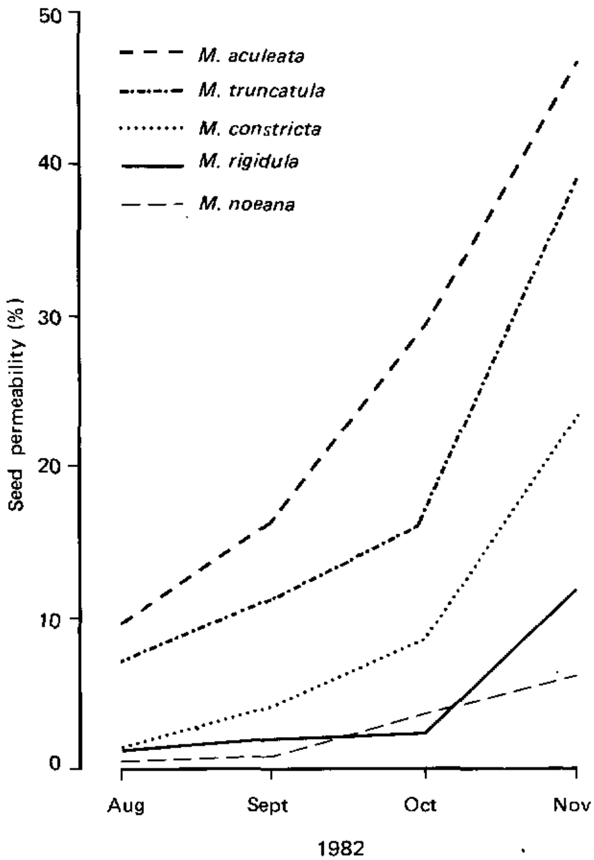


Fig. 5. The relation between seed permeability and time of year in five species of annual medics at Tel Hadya, 1982.

Medic Regeneration in a Two-Course Rotation

The regeneration of four Australian medics (snail medic, Jemalong and Cyprus barrel medics, and Harbinger strand medic) and one subterranean clover (Clare), was evaluated during the third year of a two-course rotation at three locations in Syria: Hama (360 mm rainfall), Qamishly (315 mm), and Salamieh (290 mm).

The trials were established in 1980/81 when the five legumes were sown in 100 m² plots in randomized complete blocks with three replicates. Plots were sown during the second season with cereals (wheat at Hama and Qamishly, and barley at Salamieh). At the beginning of the third season, Nov 1982, the plots at all locations received shallow cultivation and were fertilized with 40 kg P_2O_5/ha. Dry-matter and seed production were estimated by harvesting two quadrats of 1 m² each in May and June, respectively.

Snail and Jemalong were the most productive at all three locations (Table 18). However, dry-matter yields were small, especially from clover (Clare), ranging between 80 and 1696 kg/ha, compared to 1200-1600 kg/ha in 1980/81. A similar reduction in seed yield was observed.

Yield of *M. rigidula* at Different Sites in Syria

In collaboration with the Syrian Agricultural Research Council and Steppe Directorate, five entries of *M. rigidula* and *M. truncatula cv* Jemalong were evaluated for establishment and

Table 18. Third-year production of four Australian medics and one clover at three locations in Syria, 1982/83.

Species/ Variety	DM production (kg/ha)			Seed production (kg/ha)		
	Qamishly	Hama	Salamieh	Qamishly	Hama	Salamieh
Snail	715	1696	837	62	210	173
Jemalong	405	1073	500	60	201	140
Harbinger	340	719	345	11	117	64
Cyprus	332	951	412	12	204	122
Clover (Clare)	142	147	80	21	22	14
LSD (5%)	146.6	378.6	124.2	8.9	86.0	46.6

productivity at four locations in Syria: Qamishly, Hama, Salamieh, and Izraa (370 mm rainfall) during 1982/83. Medic was sown at 15 kg/ha in plots 4.2 × 5 m in a randomized complete block design with three replicates. Fertilizer was applied at 40 kg P_2O_5/ha at the time of sowing.

All five *M. rigidula* lines outyielded Jemalong at all locations except Izraa (Table 19). Best performances were recorded at Hama, with yields of over 6000 kg/ha. Similarly, seed yields of *M. rigidula* were much higher than Jemalong at all locations except Izraa. The maximum seed yield of all medics was at Hama.

Agronomy Studies

Previous studies by the Pasture and Forage Program focused on evaluation of both indigenous species and commercial cultivars of annual medic, with the objective of identifying suitable pasture legumes and their introduction to the existing cropping system of the region.

Table 19. Evaluation of *M. rigidula* and Jemalong (*M. truncatula*) at four sites in Syria, 1982/83.

Acc. No./Sel. No.	DM (kg/ha)			
	Qamishly	Hama	Salamieh	Izraa
835/1295	4671	6646	1686	2780
1783/ 734	4450	6531	1705	2058
1075/1304	4343	6621	1071	1586
281/1310	3957	5242	1533	1718
811/ 716	3268	6282	1717	4184
Jemalong	318	4465	780	2728
LSD (5%)	1547.2	1124.1	984.1	1555.9
	Seed production (kg/ha)			
835/1295	463	821	210	724
1783/ 734	415	674	277	495
1075/1304	591	940	277	878
281/1310	412	684	383	489
811/ 716	495	1083	330	775
Jemalong	68	501	133	681
LSD (5%)	187.5	358.1	139.8	325.8

Results from these studies have shown that the indigenous species of medic (*M. rigidula*, *M. aculeata*, and *M. noeana*) were outstanding in their herbage and seed yield performance.

In our evaluation work, emphasis is now changing to management and technology needed to integrate medic pastures in a cereal-pasture rotation that will ensure pasture regeneration in alternate years.

Effect of a Barley Cover on Medic Pasture at Tel Hadya

Cereal volunteers during winter on fallow land is a common feature in the region, attributed to grain losses at the time of mechanical harvesting of the preceding cereal crop. Regenerating medic pasture during the fallow phase is therefore expected to interact with these volunteers. Apart from providing palatable grazing early in the season, it is also expected that these volunteers will provide shelter against the cold and therefore improve medic establishment and productivity during winter.

Two Australian medics (Snail and Jemalong) and one local medic (*M. rigidula*) were planted at Tel Hadya on land which had been fallowed for two consecutive years. The medics were sown at 20 kg seed/ha in pure stand and in mixtures with low seed rates of barley (5, 10, and 20 kg/ha), simulating different plant populations of cereal volunteers. The treatments were arranged in a randomized complete block design with three replicates. The plots received 60 kg P_2O_5/ha at sowing in November. They were grazed by sheep in March when barley was at the tillering stage (before medic flowering). Measurements included forage composition (by hand separation), total DM production in March (before grazing), and yield of medic seed in May.

Barley at 20 kg seed/ha significantly improved forage yield early in the season especially with the Australian cultivars (Table 20). However, presence of the cereal at all seed rates resulted in less medic compared with the pure stand. Similarly, the presence of barley at all seed rates reduced medic seed yields (Table 21).

The poor seed yield of Australian cultivars was attributed to frost damage during winter which resulted in poor establishment. The data from this study suggest that the only advantage of growing cereal with medic is to provide grazing during the cold winter.

Table 20. Total dry-matter production (kg/ha) of medic in pure stand and in mixtures with barley early in the season (Mar 1983) at Tel Hadya.

Medic lines	Pure stand	+ 5 kg cereal	+ 10 kg cereal	+ 20 kg cereal
Medicago rigidula	192	160 (131)[a]	192 (131)	300 (163)
M. truncatula cv. Jemalong	63	79 (47)	125 (54)	210 (57)
M. scutellata	72	70 (27)	52 (15)	222 (36)

LSD (5%) between 2 means (not in parentheses) = 79

a. Values in parentheses represent DM yield of medic component.

Table 21. Medic seed yield (kg/ha) grown in pure stand in mixtures with barley at Tel Hadya, 1982/83.

Medic lines	Pure stand	+ 5 kg cereal	+ 10 kg cereal	+ 20 kg cereal
M. rigidula	636	439	311	300
M. truncatula cv. Jemalong	48	25	13	23
M. scutellata	45	33	15	13
LSD (5%) = 110				

Effect of Phosphate on Medics

The effect of phosphate on medics was studied at two locations: Tel Hadya (322 mm rainfall) and Breda (278 mm rainfall).

Three medics, snail medic, Jemalong, barrel medic, and *M. rigidula* 490/S994 were tested at Tel Hadya, and one, *M. rigidula* at Breda. At both sites three phosphate rates were used (0, 40, and 80 kg P_2O_5/ha), and the experiments were laid out as randomized complete blocks with three replicates. The fertilizer was incorporated at the time of sowing in December.

At Tel Hadya, phosphate at 40 kg P_2O_5/ha significantly improved the yield of *M. rigidula* (Table 22). The Australian medics were apparently seriously affected by frost. Highest seed yield was recorded from *M. rigidula*.

At the relatively drier site (Breda), both dry-matter and seed yield of *M. rigidula* were small compared with Tel Hadya and the fertilizer did not result in any significant improvement.

Pathology

The critieria used for sorting out major diseases of annual medics were the same as those used for peas and vetches. Major diseases of medics in the region are: spring black stem and leaf spot (*Phoma medicaginis* var *medicaginis*), powdery mildew (*Erysiphe pisi*), and common leaf spot (*Pseudopeziza medicaginis*).

Promising lines of *M. rigidula* were screened for resistance to these diseases (Table 23). Selections 1154, Jemalong, 716, 1304, and 1925 were resistant or tolerant to all three diseases.

Table 22. Dry-matter and seed yields (kg/ha) of medic in relation to phosphate application at Tel Hadya, 1982/83.

	Dry matter			Seed yield		
	Fertilizer rates (kg/ha)			Fertilizer rates (kg/ha)		
Crop	0	40	80	0	40	80
M. rigidula	2197	2769	2350	613	587	616
M. truncatula cv. Jemalong	269	292	375	88	73	98
M. scutellata	97	159	101	23	48	60
LSD (5%)		260			109	

Table 23. Response of promising lines of *Medicago rigidula* to major diseases in the region (disease nurseries 1982/83).

Entry	Spring black *stem*	Common *leaf spot*	Powdery *mildew*
1295	1.5	2.3	2.5
734	2.0	2.1	3.0
1154	1.8	1.1	1.0
716	2.5	1.5	1.9
1304	2.5	2.3	2.0
1310	4.0	3.3	2.7
1613[a]	4.2		
1868[a]		3.8	
1542[a]			2.9

Score: 1 = Resistant; 5 = Highly susceptible.
a. Susceptible indicator lines.

Selection 1310 was susceptible to common leaf spot, spring black stem, and powdery mildew, while selection 734 was highly susceptible to powdery mildew but tolerant to common leaf spot and spring black stem.

Biological Nitrogen Fixation

Forage and pasture plants have different causative microbes for nitrogen fixation: *Rhizobium leguminosarum* for vetch and peas and *R. meliloti* for medics. Of these only the former is present in the naturalized soil flora of fallows in the region, the latter being not only absent but strains used for inoculation in 1982/83 were found to be non-competitive with natural rhizobia populations. The result of this non-competitiveness is the rapid decline in number of *R. meliloti* to less than 25/g of soil in inoculated soils and their virtual absence in non-inoculated soils.

Medic was investigated in three trials: volunteer medic growth at Tel Hadya; medic in pure stands and mixed with barley at Tel Hadya; and medic grown under a range of phosphate regimes at Breda and Tel Hadya.

From a comparison of the nitrogenase activity and plant growth of volunteer medics, it appeared that nitrogen available from fixation had little, if any, bearing on the plants' final dry matter. Indeed, maximum nitrogenase activity (0.52 μmol/ml/plant/hr) occurred when the plants had reached approximately 4% of their mean maximum dry weight (1.59 g).

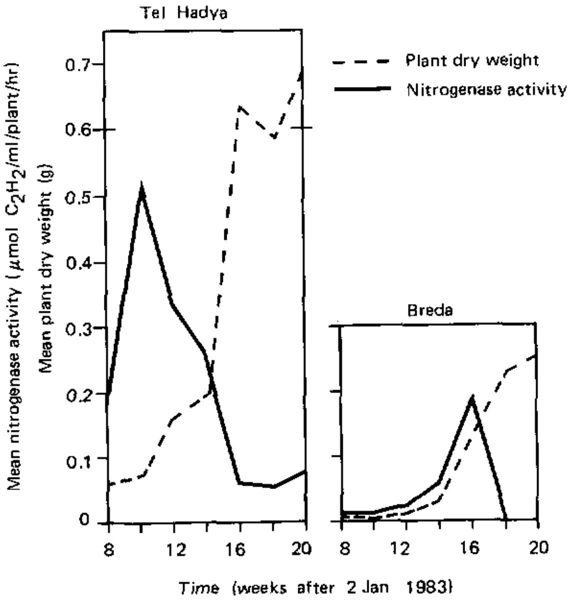


Fig. 6. Comparison of mean nitrogenase activity (C_2H_2 reduction) and mean plant dry weight (medic) with time at Tel Hadya and Breda, 1982/83.

There was a location effect on the plant/organism interaction (Fig. 6). At Tel Hadya, peak nitrogenase activity occurred 10 weeks after the start of sampling while at Breda the peak was at 16 weeks. Although nitrogen-fixing activity is related to plant health and stage of maturity, the 6-week interval between peak activities, and their relationships to plant dry weight values, indicate that the nitrogenase system was influenced by some unknown factors.

Fig. 7 compares the nitrogenase activity and plant dry weight accumulation under three phosphate regimes at Breda. Addition of 40 kg P_2O_5/ha was most beneficial to nitrogenase activity but 80 kg/ha produced the largest amount of dry matter.

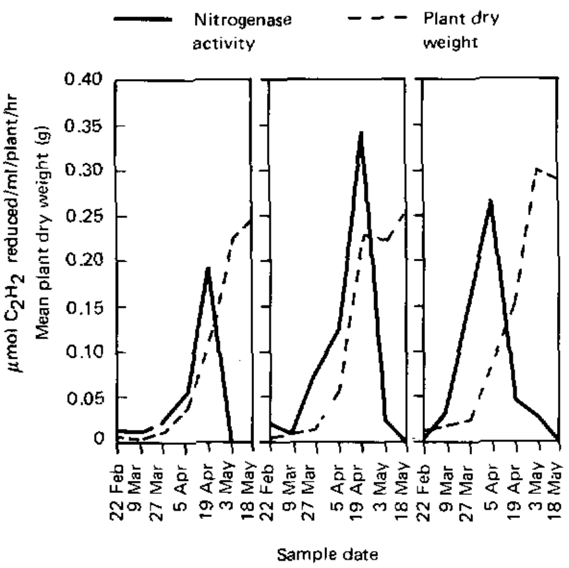


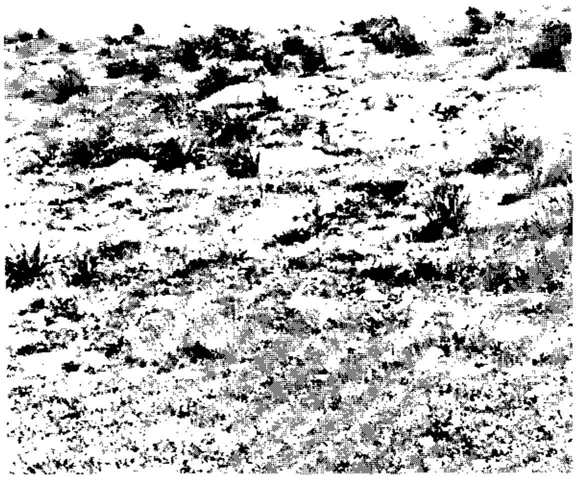
Fig. 7. A comparison of mean nitrogenase activity (C_2H_2 reduction) and mean plant dry weight, with time, of a medic species treated with zero, 40, and 80 kg P_2O_5/ha at Breda, 1982/83.

Mixing of medics with barley at barley seed rates greater than 5 kg/ha severely inhibited nitrogenase activity (Fig. 8). This inhibition however was not a result of inadequate nodulation but of the inability of the medic to compete with barley at higher seed rates when the mixture was not grazed.

Project III: Improvement of Marginal Lands

As was mentioned earlier the marginal lands project was severely restricted by lack of staff. In fact only one experiment was completed in 1982/83.

Plants required to improve marginal lands will differ in one important respect from those required to create annual pastures in cereal rotations: they will form a permanent pasture and will need to regenerate in the year after sowing instead of in alternate years. It is therefore likely that adapted genotypes will have more permeable seed coats than those adapted to cereal rotations.



Efforts are being made to introduce suitable pasture crop species to improve the productivity of marginal lands.

Marginal lands are usually grazed heavily in spring, which is the critical time for seed setting. An experiment was therefore designed in which permeable-seeded medics received heavy simulated grazing on three occasions during spring: at 100% flowering, 100% podding, and maturity. Its objective was to measure the effect

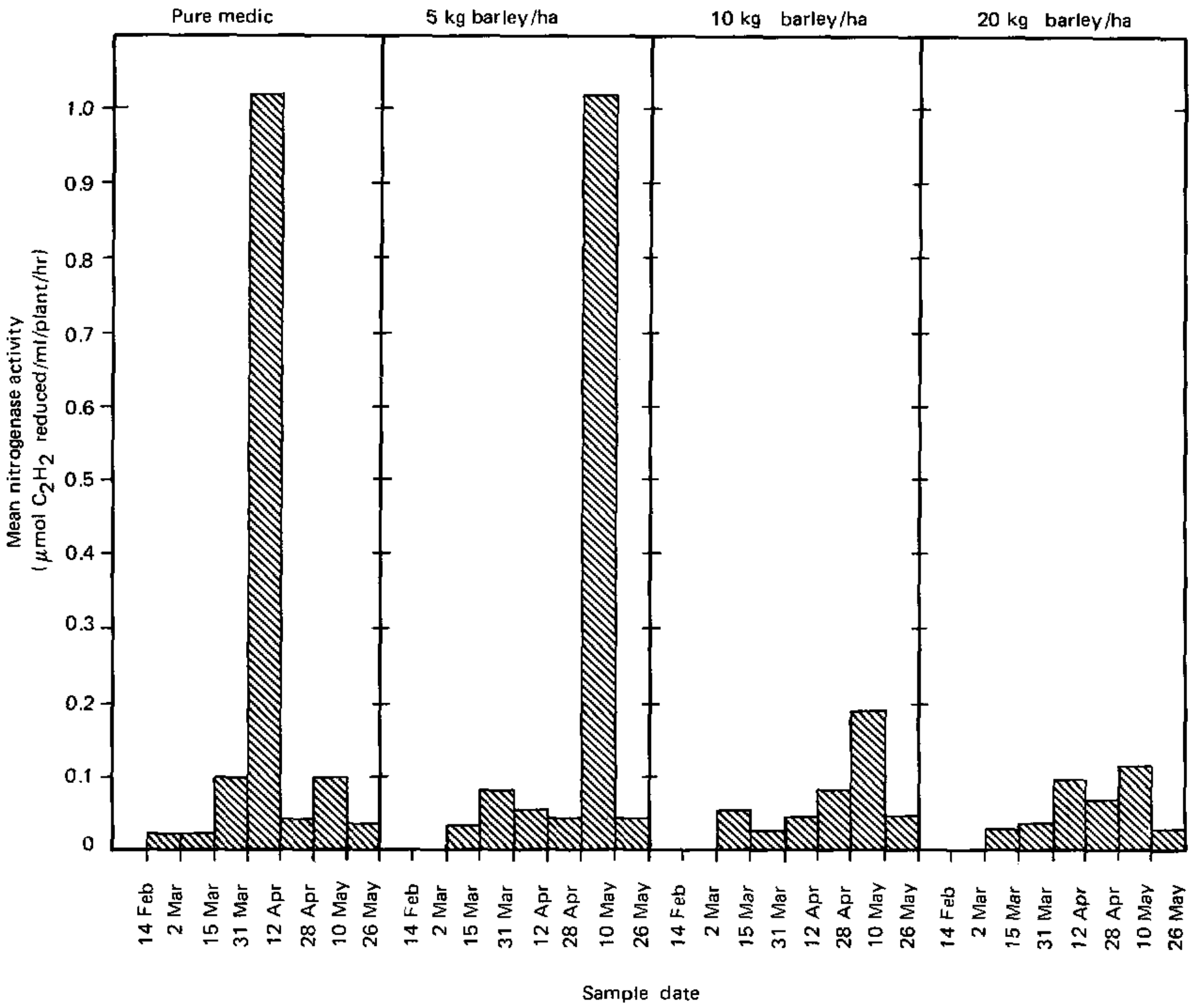


Fig. 8. Mean C_2H_2 reduction values of pure medic and of mixed barley/medic stands at Tel Hadya, 1982/83.

of heavy grazing on the yield of herbage and seed of medics potentially adapted to the marginal lands, and to study their regeneration and persistence.

Twenty-five permeable-seed medics (23 lines of *M. rigidula* and 2 lines of *M. aculeata*) were sown in strips 1 × 39 m in 1981/82 at Tel Hadya. The experiment was laid out as a randomized complete block with three replicates. At the beginning of the second season, Nov 1982, the plots were fertilized with 40 kg P_2O_5/ha and plowed at shallow depth to incorporate the fertilizer. Each plot was then subdivided into three equal subplots (1 × 13 m) on which the three clipping treatments were imposed. At each stage the forage was cut at 5 cm above ground, using a reciprocating mower and subsamples were oven dried to estimate DM yield. Seed yield on each subplot was estimated

Table 24. Effects of simulated grazing on herbage and seed yields on the mean of 23 lines of *M. rigidula* and two lines of *M. aculeata* at Tel Hadya, 1982/83.

Stage of «grazing»	Herbage yield (kg/ha)	Seed yield (kg/ha)
100% flowering	1519	101
100% podding	2090	112
Mature	1694	166
LSD (5%)	147	18

in quadrats of 1 × 0.5 m. The data were analyzed for a split-plot design with medics as main plots and time of «grazing» as subplots.

Differences were observed regarding time to reach 100% flowering which varied from 149 days in early lines to 164 days in late lines. Similarly, at 100% podding there was a difference of 10 days between early and late lines.

Average DM-production was significantly higher at 100% podding than at 100% flowering or maturity (Table 24). On the other hand, «grazing» at 100% flowering or 100% podding did not result in significant differences in seed yield, whilst «grazing» at maturity resulted in highest seed yield, apparently due to the fact that many pods were already on the ground. There was also a significant correlation ($r = -0.70$, $P < 0.001$) between herbage yield at 100% flowering and seed yield: this was not so between herbage at 100% podding or maturity.

It was also noticed that all early lines of *M. rigidula* produced more seed than late lines when harvested at 100% flowering. On the other hand, the two lines of *M. aculeata*, although both late in flowering, were high in seed yield whether clipped at 100% flowering or at 100% podding. It seems therefore that these lines offer more flexibility for grazing without serious reduction in seed yield.

Publications

Journal Article

Osman, A.E., Nersoyan, N. and Somaroo, B.H. 1983. Effects of phosphate, seed rate, seed ratio and harvesting stage on yield and quality of legume-cereal mixtures. Forage Research Journal (submitted).

Conference Paper

Osman, A.E. and Nersoyan, N. 1983. Prospects of using forage mixtures for grazing by sheep in winter and for hay making afterwards. Second International Rangeland Congress, 13-18 May 1984, Adelaide, Australia (accepted).

Miscellaneous

Osman, A.E., Nersoyan, N., Moudaress, Z. and Ghassaly, F. 1983. Productivity and forage quality of vetch and pea in mixtures with barley under dryland conditions. Progress Report-Clovers and Special Purpose Legumes Research. Dept. of Agronomy, Univ. of Wisconsin, Madison, USA.

Rihawi, S., Williams, P.C. and Somaroo, B.H. 1983. A note of changes in potential nutrition efficiency of different legumes at different stages of maturity. Progress Report-Clovers and Special Purpose Legumes Research. Dept. of Agronomy, Univ. of Wisconsin, Madison, USA.

Genetic Resources Unit

A separate Genetic Resources Unit (GRU) was established in Jan 1983 to serve as a center for the collection, characterization, documentation, maintenance and conservation, and distribution of germplasm of ICARDA's mandate crops. Previously each of the crop improvement programs had independent genetic resources activities. A considerable amount of agronomic evaluation work was done by the programs, but the systematic collection, documentation, and conservation of germplasm did not receive enough attention. The GRU now has full responsibility for the organization and conduct of germplasm collecting missions, the documentation and storage of active and base collections, and the distribution of germplasm for all ICARDA's mandate crops.

Status of Present Collection

ICARDA has assembled a substantial number of accessions of its mandate crops. Most of the accessions have come from other germplasm centers, but for some crops, such as faba beans and medics, much of the collection has come from collection missions. The total number of accessions and their sources are given in Table 1. There are probably some duplicates, particularly in durum wheat and *Pisum* spp., but they will be identified as soon as full documentation facilities become available.

New Germplasm in 1982/83

Efforts continued during 1982/83 to collect geographically and genotypically representative germplasm of ICARDA's mandate crops.

A forage germplasm collecting mission to Morocco sampled coastal areas southwest of Rabat, inland sites south of Rabat to Marrakesh and highland areas south-southeast of Rabat. Altogether 294 accessions were obtained from 94 sites in rainfall zones ranging from 200 to 650 mm. Of these, 270 were of 13 different annual medics species (*Medicago* spp.).

A total of 2274 accessions from 39 countries was added to the germplasm collection in 1983 (Table 2).

Germplasm Evaluation

A total of 5000 barley accessions were characterized in the field and in the laboratory for 21 quantitative and qualitative traits recommended in the IBPGR barley descriptor list. The work was a joint effort with the Cereal Improvement Program and is a continuing project on the evaluation and documentation of ICARDA's barley germplasm, funded partly by IBPGR. The addition of this information to agronomic data on yield, and to tolerance to salt and drought, greatly increases the value of the barley germplasm collection.

The crop breeding programs continued to evaluate accessions for agronomic traits and quality characteristics. Yield data and information on other characteristics are being collected and collated from several sites in diverse ecological areas in Syria and other countries of the region.

Table 1. Germplasm collection status at ICARDA and major sources of the accessions.

Crops	No. of accessions	Major source
Cereals		
Barley	14140	USDA; Germplasm Inst., Bari, Italy.
Durum wheat	15960	USDA; Germplasm Inst., Bari, Italy.
Bread wheat	562	ICARDA breeding lines.
Wild spp.	208	ICARDA collections.
Food Legumes		
Lentil	5486	Regional Pulse Improvement Project, Iran. Univ. of Agric. and Tech., Pantnagar, India. Plant Introd. Sta., Pullman, Washington.
Chickpea	5350	ICRISAT; ALAD/ICARDA collections.
Faba bean	3091	ALAD/ICARDA collections. Manitoba Univ., Canada; Spain; Cyprus.
Forages		
Medic spp.	2871	ALAD/ICARDA collections. SADAF South Australia.
Pisum spp.	3220	Bari, Italy; John Innes Institute, UK
Vicia spp.	2731	Bari, Italy; East Germany. ICARDA collections.
Trifolium spp.	805	ICARDA collections. Beltsville, Maryland, USA.
Trigonella spp.	137	ICARDA collections; Egypt.
Astragalus spp.	287	ICARDA collections. Beltsville, Maryland, USA.
Onobrychis spp.	731	Beltsville, Maryland, USA. ICARDA collections. Montana State Univ., USA.
Alfalfa	855	Beltsville, Maryland, USA. Lebanon collections. ICARDA collections.
Lathyrus spp.	500	East Germany; Ethiopia. ICARDA collections.
Triticale	1565	CIMMYT; Manitoba, Canada.
Barley	1719	USDA; Germany.
Avena spp.	530	Beltsville, Maryland, USA; Germany.
Grasses	600	USA; ICARDA collections.

Documentation

In 1983 the Food Legume Improvement Program prepared and published a Kabuli Chickpea Germplasm Catalog containing passport and evaluation data for 3300 accessions. Subsequently, a lentil germplasm catalog was prepared, with the assistance of GRU, which incorporates data for 26 descriptors for the crop, and will soon be published. For barley, GRU is collating and registering information on 3000 accessions. A catalog with data on 21 descriptors for 8000 accessions in the barley collection will be produced late in 1984. Priority is being given to the documentation of existing passport and evaluation data for the entire germplasm collection.

Table 2. Germplasm distributed and received during 1983.

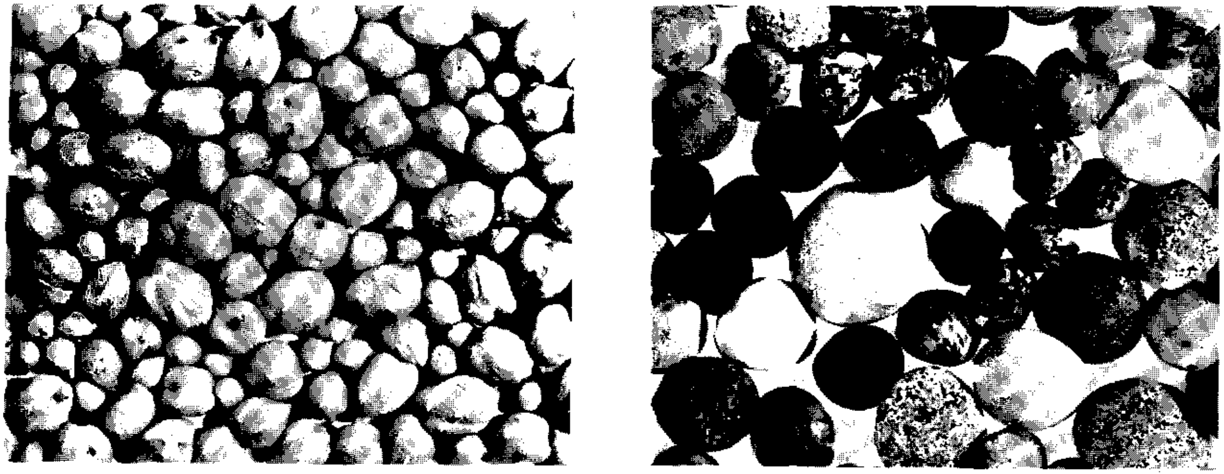
Crops	Number received		Number distributed	
	Accessions	Countries	Accessions	Countries
Chickpea	850	7	79	6
Lentil	62	12	5	2
Faba bean	200	5	188	12
Barley	423	1	68	7
Durum wheat	1	1	3450	1
Wild species[1]	156	2	295	7
Medics	428	2	72	10
Pisum spp.	1	1	389	10
Vicia spp.	4	1	49	9
Forage legumes	116	3	134	14
Forage cereals	25	1	104	6
Forage grasses	8	3	71	8
Total	2274	39	4904	92

1. *Hordeum spontaneum* and *Aegilops* spp.

Rejuvenation, Conservation, and Distribution

Seed stocks for most of the germplasm collection are below the minimum quantities required for medium- and long-term storage. During the next 2-3 years the stocks will be rejuvenated. This work began in 1982/83 and 800 lines of medics were rejuvenated.

The distribution of germplasm to interested scientists worldwide is an important service provided by ICARDA. In 1982/83, 4904 accessions were distributed to scientists in 92 countries (Table 2).



Variability in seed characteristics of kabuli chickpea (left) and lentil (right).

Physical Facilities

The physical facilities for GRU in the near future will include a cold storage for 60,000-70,000 accessions. The active collections will be placed in storage at Tel Hadya, Aleppo. A low-temperature chamber for long-term conservation of the base collection, and other facilities will become available when the construction of the GRU permanent quarters, funded by the Italian Government, is completed. In the meantime, the base collections will be maintained in deep freezers.

Future Work

The GRU is developing a 5-year program of work which will emphasize:

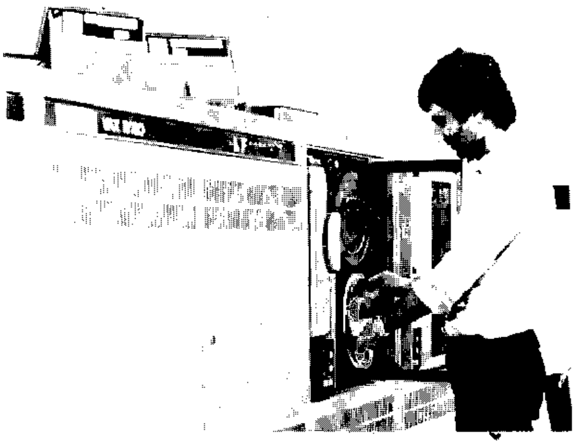
1. Documentation of information on collecting missions, passport data, and evaluation results for all ICARDA mandate crops.
2. Rejuvenation of all ICARDA germplasm.
3. Medium- and long-term storage of the entire germplasm in controlled conditions.
4. Collection of new germplasm to fill gaps in the present collection.

A training program to meet the needs of national programs is being developed.

Computer Services

The first stage of the development of Computer Services was completed in 1983, about 2 years after the establishment of the Aleppo Computer Center with a PDP-11/34A computing system, and 14 months following the establishment of the Harry S. Darling Computer Center with a VAX-11/780 computing system at Tel Hadya.

The Computer Services has now met the (1) major routine and non-routine program development requirements, (2) established the technical and organizational structures to deal with such additional needs, and (3) laid the foundation for dealing with more advanced use of the computing systems.



VAX-11/780 is the mainstay of the Harry S. Darling Computer Center at Tel Hadya.

The first stage of development took place within the context of three main projects: (1) General System Software Development, (2) Statistical Analysis and Experiment Aids, and (3) Administrative Application, in addition to the general systems management and operation of the computer centers at Tel Hadya and Aleppo.

General System Software Development

This project is concerned with the production of integrated program packages. Each package is a collection of interrelated modules, which perform specific tasks on either the data itself, or the data structures defining the packages' file system.

The packages produced in 1983 are at different levels of development, but the underlying design allows for their use, in the current form, while development of additional modules continues.

There are two main types of modules in each package: general utility and package-specific.

General utility modules required in a package are usually added to ICARDA's library of utility subprograms (ICALIB), or file management library (ICAFIL), for use in other program systems. Package-specific programs are generally unique in that they relate to the application itself. A further step in rationalization was, however, possible. By identification of the common requirements of the planned packages, modules which constitute a foundation for all such packages formed ICADET (ICARDA's Data Manager).

ICADET's initial version (Version 1.0) was used successfully in 1982. This included, for example, ICAGEM, the Genetic Resources Data Management System, and ICAREP, the Crop Abstracts Information System. In 1982/83 ICADET was installed on the VAX-11/780, and the large-scale development of ICADET Version 1.1 was started. ICADET is under continuous development in response to requests for additional facilities and for more advanced techniques for handling data or data structures.

At present ICADET supports six packages:

ICAGEM: Genetic Resources Data Management System
ICALAB: Laboratory Data Capture and Analysis System
ICAREP: Crop Abstracts Information System
MAILER: General Mailing List System
METEOR: Meteorological Data Processor
CERINT: Cereal International Nurseries Data Processor

Additional modules are being developed for these packages. The following packages are planned for 1984:

ICACAI: Computer-Assisted Training System
LIBMAN: Library Management and Control System
FARMER: Farm Management and Plot History System

Development usually starts with the elaboration of the file system requirements and creation of the database from the data previously collected, if any, followed by defining the package-specific requirements. Finally, a development schedule is set up. Emergent modules are released as soon as they satisfy testing and performance analysis criteria.

The lifetime of a system software package is ultimately determined by the extent of its flexibility to meet additional and possibly changing requirements. In addition to flexibility, a further constraint at ICARDA is to maintain complete compatibility between the computing systems at Aleppo and Tel Hadya.

These constraints dictate the design, programming, and other system considerations, and call for extreme care in the development of package-specific and other modules. The process guarantees not only a more rapid production cycle, but also the establishment of a standard approach, with all the attendent benefits of rationalization and integration.

Appropriate solutions to some of the problems of analysis, design, programming, coding, testing, and performance analysis were developed in conjunction with users and through internal discussions and technical notes.

In 1982/83, users were trained individually in view of the diversity of the packages and the differing needs of the user groups. The number of users continued to grow.

Documentation in this project relates at present to the common modules in ICADET's User and Reference Manuals. Additional documentation is scheduled for 1984, by dealing with each package at its current level of development.

We now plan to exploit the computer power for detailed analysis of specific problems as an additional aid to scientific decision making. A case in point is the development with the Cereal Improvement Program scientists of a 'Parents' file system as a part of CERINT to trace the use of parents in cultivar development. Another example is the development of a suitable technique for handling nursery data from various locations, already under way.

ICADET supports an on-line search facility of crop abstracts and the production of diverse catalogs.

Identification of microbes in crops is now carried out rapidly, using a derivative of ICADET. This facility should provide a better understanding of microbiological and pathological factors in crop improvement.

Statistical Applications and Experiment Aids

The project is centered around CRISP (Crop Research Integrated Statistical Package), the early version of which was obtained from ICRISAT, India. Currently, Version 1.2 of CRISP operates under VMS, and supports 127 utility and analysis modules. Version 1.1 operates under RSTS/E with 107 modules. Compatibility between the two versions is assured by maintaining, for the time being, a common file structure.

In its current version, CRISP is essentially a breeder package. Some 4000 runs were carried out on CRISP's utility and analysis modules in 1983. Currently it supports all the breeding work in the three crop programs, and some of the work of the Farming Systems Program. Modules were written specifically for the analysis of international nurseries, for the production of overall performance tables, and for selection across locations of best cultivars.

More sophisticated regression facilities are planned for 1984. At present CRISP data files can be used in other packages, including ICADET-based packages. The file system of CRISP was redesigned to allow a complete compatibility with ICADET-based systems, and hence enrich all such systems with diverse statistical analysis tools. CRISP would then possess comprehensive data management facilities available currently in ICADET and its associated packages.

Contacts with ICRISAT, the original developers of CRISP, were maintained in 1983. At a meeting of computer directors of various centers in Cairo in Jan 1983, further areas of development of CRISP were discussed, including exchanges of separately developed modules.

Acquired packages (SPSS-X, SHAZAM, BMDP, GENSTAT, and CSMP) were used extensively for the processing of survey, livestock, and agroclimatic data by the Farming Systems Program and the processing of passport and evaluation data by the Genetic Resources Unit.

ICARDA acquired and installed a version of the Crop Modelling Program produced at IFDC, after converting it to operate under VMS.

Administrative Applications

This project was centered around MAS, Management, Accounting, and Information System. The first stage of MAS included: (1) General Ledger, (2) Voucher Entry System, (3) Personal Account Sub-System, (4) Budget Preparation Sub-System, (5) Manpower Deployment Sub-System, (6) Payroll System, (7) A Comprehensive, Comparative Report Generation Facility, and (8) Personal Services Budget and Expenditure. All are in active use, and some have been in operation for over 13 months.

The development of a comprehensive management information system to draw upon the acquired financial and administrative data is already in preparation, and some of its modules are currently in use as a part of the Report Generation Facility.

Training

As part of the training activities of the Cereal and Food Legume Improvement Programs, two short courses were organized at the Harry S. Darling Computer Center on «Computing Methods in Agricultural Research». Nineteen trainees processed data from their own experiments. Two of them were then given a more comprehensive course.

Individual training was conducted on ICARDA-developed as well as acquired packages, especially CRISP and the word-processing facility.

Part of the training in crop improvement is a course in computer methods.

Systems Development

The number of interactive users increased in 1983, and reached the maximum capacity of 32 user-processes for the VAX-11/780 and 13 for the PDP-11/34A in the harvest and planting seasons. The expansion of the Administrative Applications Project accounts for most of the usage of the PDP-11/34A system.

Central Processor Unit time was fairly evenly divided between the programs, with the Farming Systems Program occupying a time-independent band across the year.

Shortage of terminal devices was more evident during the harvest time. In 1983, batch processing (running tasks under the sole control of the operating system rather than jointly with the user behind a terminal device) was resorted to, to alleviate the pressure. The number of terminal services will be increased in Jan 1984, by expanding the User Area at the Harry S. Darling Computer Center, and the addition of more terminal devices at the various work stations already established at the farm. This in turn calls for expansion of the memory banks which will take place at the same time.

Disc capacity is running continuously at 80% of the available disc space, with an increase during harvest season and experiment planning time. Daily transfer of files to tape storage was resorted to, to create sufficient working space. A third disc unit will be brought into commission in 1984 to increase the disc space available by 1/3 of the current level.

In late 1984, ICARDA will experiment with the creation of «local intelligence» in strategic locations at the farm. This will allow the use of a local system, with back-up from the main computer systems at the farm. This approach will reduce the load on the existing systems, as well as obviate the need for inordinate growth of the central systems. The purpose of the experiment also relates to the possibilities of providing national programs with such equipment and back-up for their agricultural research.

A number of portable 'micro-computers' (micro-processor driven compact computing structures) for data capture in the field were evaluated. The selected device will be subject to extensive tests of endurance of the climate and dust conditions early in 1984. This technique will reduce the amount of manual handling of field data. The 'micro-computer' will be loaded with specific programs and randomization tables, and the data collected will be off-loaded onto the computing systems in Tel Hadya or Aleppo.

Word processing and text management took over 6% of the current level of utilization of the computing systems at both centers. This is a high ratio, and reflects a definite demand. The comparatively low speed of the current printing devices (55 characters per second) accounts for a large part of such utilization of system resources. The addition of typesetting equipment should help to reduce this ratio and add versatility to the layout and form of ICARDA publications. However, camera copies of several ICARDA publications were produced for the Communications and Documentation Program as well as private publishers.

The possibilities for automatic data recording from laboratory instruments were considered in 1983. Pilot experiments will be carried out on recently acquired instruments for the GRU laboratory. If successful, the use of such instruments for certain categories of experiments will be recommended.

Training

ICARDA attaches high priority to training activities. To fulfil the objectives set, some changes in the organization of training activities were made in 1983. Training activities became an integral part of research activities within the various research programs and the training officers were located in the concerned research programs. This allowed the research programs to be more closely involved in training activities and a closer contact between trainees and ICARDA scientists. During the year, training officers were appointed for the Cereals and the Pasture and Forage Improvement Programs. A head of training will join in early 1984. He will address center-wide issues concerning the development of training, such as overall planning, budgeting, relationship with national, regional, and international institutes, and follow-up measures.

ICARDA extended its training activities in 1983 by conducting in-country courses as well as assisting national programs in conducting their own training activities. Improvements were made in the quality of the educational training material, and several new audio-visual aids were developed.

Group Training

Six-month General Courses

In the 1983 cropping season, three 6-month (Jan-July) residential courses in the improvement of cereals, food legumes, and pasture and forage were conducted at Tel Hadya. Forty-five trainees participated in those courses (Table 1).

Table 1. Number of participants in 6-month residential training courses at ICARDA, 1983.

Country	Cereal Improvement	Food Legume Improvement	Pasture and Forage Improvement
Pakistan	1	2	
Egypt	3	2	1
Syria	4	3	2
Tunisia	1		1
N. Yemen	1	1	
S. Yemen	2	1	
Libya	2		
Somalia	1		
Sudan	1	4	1
Djebouti	1	1	1
Afghanistan	1		
Chile		1	
Jordan			2
Ethiopia		1	1
Iran		1	
Total	18	17	10

Group training in the laboratory.

The participants were trained in the field and laboratory research techniques, with some class-room lectures. Training publications and visual aids were provided as reference material.

Individual requirements were met by assigning an experiment to each trainee to give them experience of planning, conducting, analyzing, and reporting of simple experiments. In assigning experiments, variability in the academic background of the trainees (B.Sc. levels to senior technicians) was taken into consideration.

Faba Beans in the Nile Valley: Course II

A 2-week course on faba bean improvement was held at Sakha Research Station, Egypt, Mar-Apr 1983, as part of the ICARDA/IFAD Nile Valley Project. Eleven technicians from Egypt and six from the Sudan attended this course.

The course was practically oriented with some relevant theoretical background. The focus was on faba bean improvement techniques in the field and laboratory. Egyptian Sudanese, and ICARDA scientists instructed the trainees.

Individual Training

Individual scientists from various national programs were also trained at ICARDA during 1983 (Table 2). They worked with ICARDA scientists for short periods focusing on specific topics relevant to their research in their national programs.

Degree training, where the student registers at a university and conducts thesis research at ICARDA, was offered by the crop improvement programs:

Table 2. Participants in individual non-degree training at ICARDA during 1983.

Training category	Subject	Duration	Country	Number
Senior Research Fellow	Legume microbiology	One month	Sudan	1
	Legume entomology	One week	Jordan	1
Training Research Associate	Legume agronomy	One month	Tunisia	1
	Legume agronomy	One week	Jordan	1
	Legume pathology	Two weeks	Egypt	2
	Cereals pathology	One month	Tunisia	1
	Cereals planting machinery	One month	Tunisia	1
	Cereals improvement	Two weeks	Kenya	1
	Farm operation	One week	Egypt	11
	Livestock management	Six months	Syria	2
	Farming systems	Six months	Jordan	1
Total				23

Program	No. of students/Degree		Assoicated Universities
Cereals	1	Ph.D.	Aleppo, Bonn
	1	M.Sc.	
Food Legumes	4	Ph.D.	Aleppo, Bonn
	1	M.Sc.	Reading.

Individualized training in the field.

Farming Systems Training

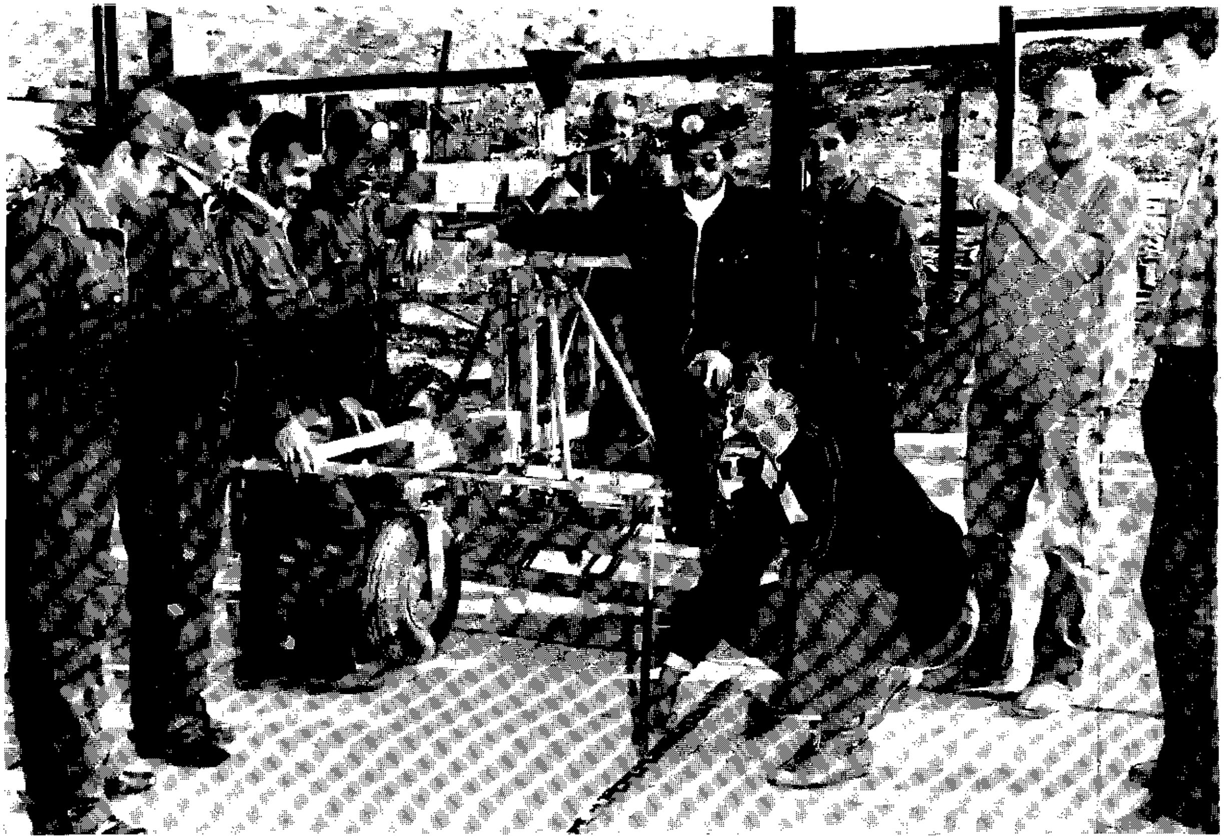
Training in farming systems research increased substantially during 1983. As farming systems research differs from crop improvement research, the training focused on short, specialized courses and individual training (both degree and non-degree).

Six scientists from Tunisia and 11 from Egypt were introduced to farming systems research approach during 1983. One participant from Jordan worked with ICARDA's farming systems scientists for 6 months on socioeconomics.

Various training workshops were offered by the Farming Systems Research Program. A regional workshop, sponsored by ICARDA/IDRC, on «Economics in the design, execution and analysis of on-farm trials» was held in Cairo. It was attended by 12 scientists from the Nile Valley Project. A regional farming systems workshop, sponsored by ICARDA/Ford Foundation, was held at Aleppo 1983. It hosted 20 participants from various countries in the region.

The following table shows the students conducting thesis research within the Farming Systems Program.

Name	Degree	Associated University	Subject
A. Wehbe	Ph.D.	Reading, UK	Root development
Y. Sabet	Ph.D.	Paris, France	Soil erosion and tillage
E. Rashed	Ph.D.	McGill, Canada	Crop rotational agronomy
M. Mokbel	Ph.D.	Massachusets, USA	Human nutrition
A. Rassam	M.Sc.	W. Ontario, Canada	Female labor in agricultural systems
S. Dozom	M.Sc.	Aleppo, Syria	Crop rotational agronomy
M. Wahoud	M.Sc.	Aleppo, Syria	Forage barley agronomy



Group training in mechanization (Syrian national program).

Assistance in National Training

ICARDA supports training conducted by national programs and tries to respond to requests for assistance whenever possible. The assistance is in the form of scientists delivering lectures, supply of educational material, and training the staff who are coordinating these activities, i.e., training the trainers. During 1983, three national training courses were conducted in collaboration with the Syrian national research program (Table 3). Scientists from ICARDA and the Ministry of Agriculture participated in instructing the trainees. These courses were practically oriented with the relevant theoretical background. ICARDA supplied teaching manuals as well as visual aids.

Table 3. Joint ICARDA/Agricultural Research Centre, Syria, training courses, 1983.

Course	Duration	Place	Number of trainees
Improvement of field crops	24 Apr-9 May	Lattakia	17
Mechanical harvesting of cereals and legumes	28 May-3 June	Aleppo	7
Mechanical planting of field crops	6-17 Nov	Aleppo	7

Communications and Documentation

The Communications and Documentation Program continued to publish and disseminate information on ICARDA's scientific activities.

Communications

We continued to emphasize the translation of ICARDA publications to Arabic; this 1983 Annual Report will also be published in Arabic. We have now produced 25 publications in Arabic, including the 1982 Research Highlights. IDRC provided a grant to translate RACHIS, the cereals newsletter, into Arabic. News stories from the Program on ICARDA's activities were published in the English and Arabic media.

Documentation, printing, photography, and graphic-art staff received training during 1983, which has increased the quality of ICARDA's publications.

Printshop production was expanded 25%. In 1983 a new printing press was ordered, which will enable us to increase the quantity and quality of in-house publications.

The ICARDA mailing list was revised and put on the Center's computer, using the MAILER program developed by the Computer Services. This will facilitate the distribution of ICARDA publications.

The Communications and Documentation program expanded in 1983 with the addition of a science editor; a science writer will join in Jan 1984.

The program published two workshop proceedings, a germplasm catalog, nursery reports for the crop improvement programs, training material, and a number of special publications. These are listed in a new ICARDA Publications List.

Documentation

This was the second year of an International Development Research Center (IDRC) grant for the Faba Bean Information Service (FABIS) and Lentil Experimental News Service (LENS). Both newsletters were published twice during 1983.

Two issues of RACHIS (Wheat, Barley, and Triticale Newsletter) were also published in 1983.

An agreement was made with FAO, whereby articles from the three newsletters are being input to the Agricultural Information Service (AGRIS) data base.

Progress was made on the computerized storage and retrieval of information relating to faba bean and lentil. During 1983, the world literature was scanned, and reprints requested of all papers on the two crops to strengthen ICARDA's data base.

The first edition of a Farming Systems Research newsletter was published in 1983.

Library

A 3-year plan for the development of the library was produced in 1983.

The library staff continued to scan the world literature, and send for reprints of works related to ICARDA's mandate. Some 2000 reprints were received in 1983 and included in Current Awareness, a periodical publication giving information on the new holdings of the ICARDA library. Current Awareness was published six times in 1983, with a 45% increase in abstracts and listings.

The library's holdings now stand at 1700 books and 200 journals.

Visitors' Services

In 1983 ICARDA received 1150 official visitors from 42 countries. Of these, 713 visitors were from outside Syria and represented some 56 universities and national, international, and private organizations. Among the visitors were Dr. Curtis Farrar, the Executive Secretary of the CGIAR, Dr. Ivan Head, President of IDRC, and members of the ACSAD Board of Trustees.

During the year, 10 program events were held including field days for Syrian farmers, members of Syrian Government organizations, and members of the Diplomatic Corps. ICARDA was honored by visits of Mr. Ammash Jede'a, Minister of Agriculture and Agrarian Reform, Syria, and Mr. Mohamed Nour Mawaldi, the Governor of Aleppo.

ICARDA's «Guest of the Year» was Dr. Omond Solandt, OBE. Dr. Solandt has been associated with ICARDA since its conception in the early 1970s, and he was the vice-chairman of the Board of Trustees for 6 years.

Collaborative Research Projects with Advanced Institutions

	Subject	Cooperating institutions	Funding organization
1.	Replacement of fallow by forage crops	McGill University, Canada	CIDA
2.	Studies on rural labor	University of Western Canada, Canada	Population Council
3.	Root studies on barley ad chickpeas	University of Reading, UK	ODA
4.	Phenology and productivity modelling in wheat	University of New England, Australia	UNDP
5.	Precipitation and temperature analysis	University of Reading, UK	ODA
6.	Evaporation from sparse barley crops	Institute of Hydrology, UK	Inst. Hyd./ODA
7.	Nitrogen fertilizer efficiency using ^{15}N	International Fertilizer Development Center, USA	IFDC/UNDP
8.	Nitrogen fixation studies using ^{15}N	International Atomic Energy Agency, Austria	IAEA
9.	Photothermal relations in barley, faba beans and lentils	University of Reading, UK	ODA
10.	Collection & evaluation of barley & durum wheat germplasm	University of Saskatchewan, Canada	NSERC
11.	Cooperative project on salt tolerance of cereals	University of Munich, W. Germany	
12.	Cereal, food legume & forage quality evaluation	Canadian Grain Commission	
13.	Recurrent selection in barley, using male sterility	Montana State University, USA	
14.	Studies on nematodes affecting chickpeas, peas & forage legumes in the Mediterranean region	Institute of Nematology, Bari. Italy	CNR
15.	Resistance to Bruchids in faba beans	University of Reading, UK	FF
16.	Faba bean adaptation studies	European Economic Community, Belgium	EEC
17.	Faba bean breeding methodology studies	University of Manitoba, Canada	IFAD
18.	Inter-specific crossing	University of Reading, UK	ODA
19.	Studies on the resistance of faba beans to *Botrytis fabae*	Plant Breeding Institute, Cambridge, UK	
20.	Studies on ascochyta blight of faba beans	University of Manitoba, Canada	IDRC
21.	Physiologic variation in *Ascochyta rabiei*	University of Reading, UK	ODA
22.	Phosphate & iron use efficiency in chickpeas and lentils	University of Hohenheim, W. Germany	GTZ
23.	Measurement of out-crossing in lentil	University College of Swansea, UK	
24.	Screening for cold tolerance in lentil	University of Perugia, Italy	CNR
25.	Ecogeographic survey & collection of natural populations of forage legumes	International Board for Plant Genetic Resources	IBPGR

26.	Nutritive value of hays and straws	Tropical Development and Research Institute, UK	ODA
27.	Studies on *Rhizobium* carrier systems	University of Manitoba, Canada	IDRC
28.	Screening for salt tolerance in barely and durum wheat and development of cultural practices for salt-tolerance areas.	University of Munich, W. Germany	GTZ
29.	Evaluation of forage shrubs (*Medicago arborea*) in the Mediterranean region	Plant Breeding Institute, Bari, Italy	CNR
30.	Aphid resistance in faba beans	University of Bonn, W. Germany	GTZ
31.	Stem nematode studies in faba beans	University of Bonn, W. Germany	GTZ
32.	Agronomy studies on dry peas	University of Giessen, W. Germany	GTZ

Acronyms and Abbreviations

ACSAD	Arab Centre for Studies of the Arid Zones and Dry Lands
ADYT	Advanced Durum Yield Trial
AOAD	Arab Organization for Agricultural Development
ARC	Agricultural Research Centre of the Syrian Ministry of Agriculture and Agrarian Reform
ATYT	Advanced Triticale Yield Trial
AYT	Advanced Yield Trial
AYT-T	Advanced Yield Trial - Tall (Chickpea)
BCB	Barley Crossing Block
BKLDN	Barley Key Location Disease Nursery
BON	Barley Observation Nursery
BPL	Faba Bean Pure Line
BSP	Barley Segregating Population
CAB	Commonwealth Agricultural Bureaux
CGIAR	Consultativé Group on International Agricultural Research
CIDA	Canadian International Development Agency
CIABN	Chickpea International Ascochyta Blight Nursery
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo
CNR	Consiglio Nazionale delle Recerche, Italy
DAAD	Deutscher Akademischer Austauschdienst
DCB	Durum Crossing Block
DKLDN	Durum Key Location Disease Nursery
DMB	Determinate Mutant Bulk
DON	Durum Observation Nursery
DON-IRR	Durum Observation Nursery-Irrigated
DON-Rf	Durum Observation Nursery-Rainfed
DSP	Durum Segregating Population
FBAT	Faba Bean Adaptation Trial
FBIABN	Faba Bean International Ascochyta Blight Nursery
FBICSN	Faba Bean International Chocolate Spot Nursery
FBIRN	Faba Bean International Rust Nursery
FBWCT	International Faba Bean Weed Control Trial
FDPPT	Faba Bean International Date of Planting/Plant Population Trial
FF	Ford Foundation
FSP	Farming Systems Program
FSR	Farming Systems Research
GTZ	Deutsche Gesellschaft für Technische Zuzammenarbeit
IBPGR	International Board for Plant Genetic Resources
ICC	ICRISAT Chickpea
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IDA/IBRD	International Development Agency/International Bank for Reconstruction and Development
IDRC	International Development Research Centre
IDYT	Initial Durum Yield Trial
IFAD	International Fund for Agricultural Development
IITA	International Institute of Tropical Agriculture
ILB	ICARDA Legume Faba Beans
ILC	ICARDA Legume Chickpea
ILL	ICARDA Legume Lentil
IYT	International Yield Trial
KLDN	Key Location Disease Nursery
ODA	Overseas Development Administration (UK)
OPEC	Organization of Petroleum Exporting Countries
PDYT	Preliminary Durum Yield Trial
PFIP	Pasture and Forage Improvement Program
PTYT	Preliminary Triticale Yield Trial
PYT	Preliminary Yield Trial
QQR	Quinquennial Review
RBYT	Regional Barley Yield Trial
RDYT	Regional Durum Yield Trial
RDYT-Rf	Regional Durum Yield Trial-Rainfed
RWYT	Regional Wheat Yield Trial
SL	Syrian Lira
SNP	Seeding rate, Nitrogen, and Phosphorus trial
UNDP	United Nations Development Programme
UNU	United Nations University
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
WBON	Winter Barley Observation Nursery
WBWON	Winter Bread Wheat Observation Nursery
WCB	Wheat Crossing Block
WDON	Winter Durum Observation Nursery
WKLDN	Wheat Key Location Disease Nursery
WON	Wheat Observation Nursery
WSP	Wheat Segregating Population

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* *Left ICARDA during 1983.*

Appendix 1

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