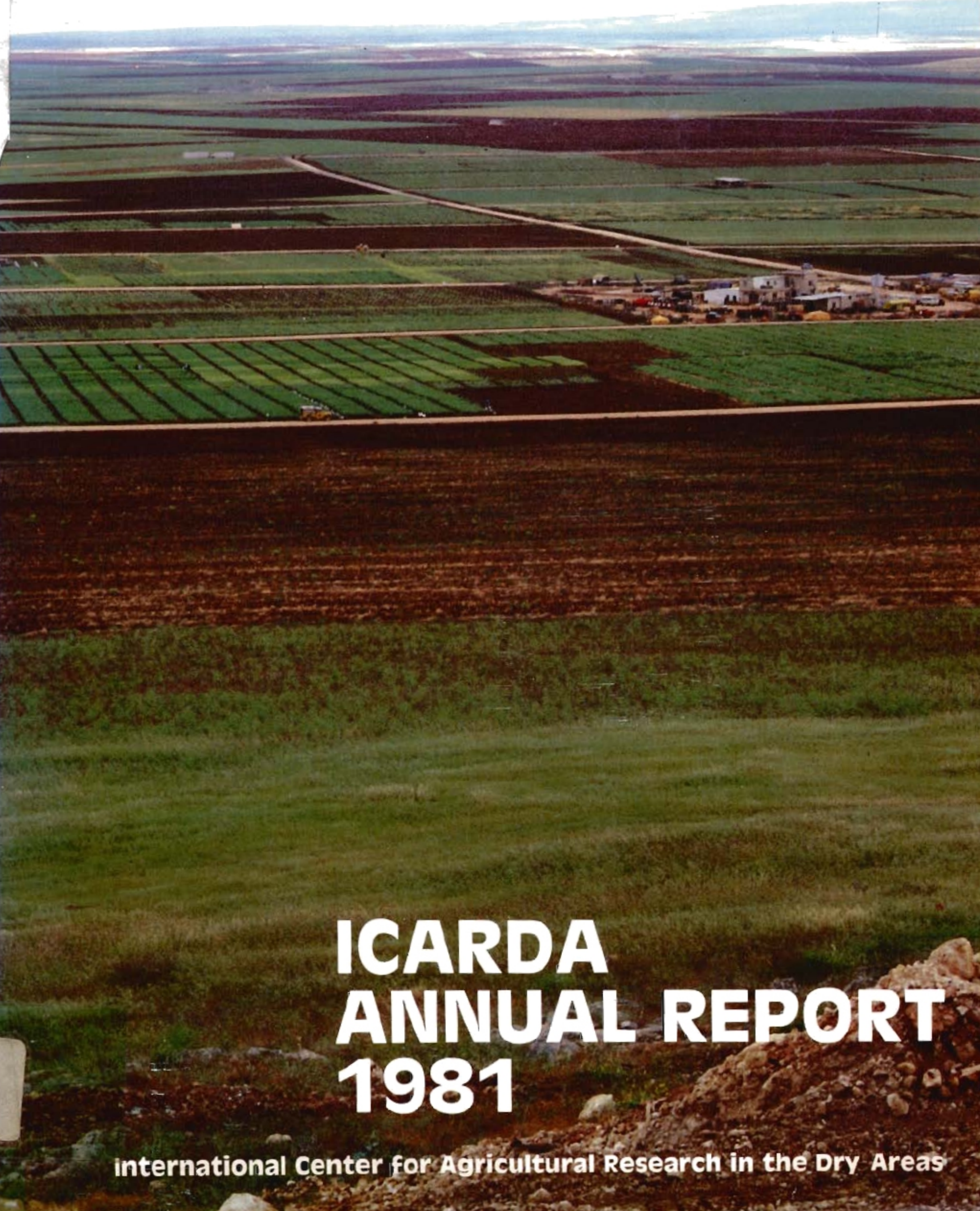

ICARDA ANNUAL REPORT 1981

International Center for Agricultural Research in the Dry Areas

Covers:

Two views of ICARDA's 948-hectare principal experiment station at Tel Hadya, Syria, 30 km south of Aleppo on the Damascus-Aleppo highway. The view on the front cover looks toward the south from the top of a hill near the main buildings, the back cover shows a view to the north.

International Center for Agricultural Research in the Dry Areas

ICARDA ANNUAL REPORT 1981

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CONTENTS

ICARDA: ITS FUNCTION AND MANDATE

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

ICARDA's principal involvement is with rainfed agricultural systems. Investigational work may be extended into irrigated areas where it is logical and cost-effective to do so, but the policy of the Center remains to give first place to the problems of the rainfed sector, which has always tended to be at or near the bottom of any research priority list for the region.

The ICARDA region extends from Morocco in the west to Pakistan in the east. From Turkey in the north it stretches south to the northern provinces of the Sudan. It includes Cyprus and Afghanistan and comprises 22 individual countries with a total population of more than 300 million people. Food shortages, intensified by current political tensions, are a continuing fact of life throughout the region. In spite of considerable mineral wealth in a few of the countries, the region remains a major food deficit area.

Within the framework of working towards increasing agricultural productivity, the Center has five principal objectives:

(1) Conduct research into and develop improved cropping, livestock and crop-livestock systems.

(2) Serve as an international center 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 (CGIAR).

(3) Serve as a regional center, in cooperation with other appropriate international agricultural research centers, for research in other crops of major importance to the region, such as wheat in collaboration with CIMMYT and chickpeas in collaboration with ICRISAT.

(4) Collaborate with and foster cooperation and communication among other national, regional, and international institutions in the development, adaptation, testing, and demonstration of improved crops and farming and livestock systems.

(5) Foster and support training in research and other activities in furtherance of its objectives.

To achieve its objectives, ICARDA is organized into five main programs: Farming Systems Research, Cereal Crops Improvement, Food Legume Improvement, Forage and Pasture Crops Improvement, and Training and Communications.

BOARD OF TRUSTEES

FOREWORD

Over its first five years, ICARDA has grown to become a recognized International Research Center in West Asia and North Africa—the region which it seeks to serve. From its bases in Syria and Lebanon, the Center's activities have spread out to include most of the 22 countries in its region. ICARDA has been providing substantial support for the efforts of the national research programs through the distribution of improved crop germplasm and other breeding material, training, exchange visits of scientists, conferences and seminars, information and documentation services, and increasingly through direct cooperative research activities.

This publication presents the main research findings of ICARDA in 1981, a year which also saw several significant changes in personnel and in the structure of the Center. On June 30, Dr. Harry S. Darling retired from his post as the first Director General, a position he had held since 1977. Also during the year, Dr. Heinrich Weltzien, the Director of Research, left ICARDA to return to the Plant Protection Institute in Bonn, West Germany. He was succeeded late in the year by Dr. Peter Goldsworthy who was previously leader of the grain legume program at the International Institute of Tropical Agriculture (IITA) Ibadan, Nigeria. Two other senior appointments will soon be effective: Dr. Geoffrey Hawtin—former Food Legume Program Leader in ICARDA—will fill the position of Deputy Director General (International Cooperation), and Mrs. Joan Joshi of the International Institute of Education (IIE) New York will become Director of Administration.

Another major change in 1981 was the decision of the Board of Trustees in April to move the main ICARDA office from Beirut in Lebanon to Syria. Now most of the scientists and support staff are centered at ICARDA's main site at Tel Hadya, about 30 kms south of Aleppo. The moves from Beirut to Aleppo and from the city to the site have improved the efficiency of the Center and reduced expenses. Most of the offices and laboratories of Tel Hadya are still located temporarily in buildings intended ultimately for different purposes, pending construction of more permanent buildings on the main site. During 1981, the first substantial contributions were pledged in support of the development of permanent buildings. The OPEC Fund for International Development agreed to provide a grant of $3.165 million to build the first permanent laboratory complex, and later in the year the International Fund for Agricultural Development (IFAD) pledged a grant of $3.5 million for constructing the main training and communications building. ICARDA is deeply grateful to both of these organizations for their very generous support. Already our traditional donors (listed in this publication) have expended some $50 million in the ICARDA capital and operational programs, most of which went to develop our principal station at Tel Hadya. ICARDA and the region owe a singular measure of gratitude to them.

In August 1981, a Digital Equipment Corporation PDP 11/34 computer was installed at the main office in Aleppo. Although of only limited capacity, its acquisition gave ICARDA a substantial expansion in its computing power. However, the full needs of the Center will not be met until the installation of the VAX 11/780 main computer which is scheduled in 1982.

Several new cooperative ventures were launched during the year. In an effort to strengthen collaboration with the national programs in North Africa, and particularly with Tunisia, a food *legume breeder was posted to Tunis to join the ICARDA barley pathologist already stationed there. These scientists work alongside their counterparts in the national programs and form an effective link between the research in North Africa and that back at the main ICARDA Center.*

Links with our host governments in Syria and Lebanon were also strengthened in 1981. An agreement was signed between ICARDA and the Syrian Ministry of Agriculture to undertake a collaborative research project. As a result, more than 200 joint trials on cereals, food legumes, and forages were sown in the latter part of the year. They were planted at all the main research stations in the country, and ICARDA has assigned a senior scientist to coordinate the projects on a full-time basis.

ICARDA sponsored a conference on crop production at Chataura, Lebanon in December. It was attended by many scientists from different organizations in Lebanon and from ICARDA. The action recommendations of the conference will form the basis of the Center's future collaboration with Lebanese scientists.

A small collaborative research project on cereals was also started at Quetta in Baluchistan Province of Pakistan. From this beginning, it is planned to develop a more comprehensive project to serve the needs of that area.

The joint ICARDA/ICRISAT chickpea program was expanded in 1981 by the posting of a senior pathologist by ICRISAT to Aleppo to work with the ICARDA breeder on the important research on Ascochyta *blight. Two other sister institutions—CIMMYT and IBPGR—also continued their much valued support on breadwheat and genetic resources. Many other new activities and special projects were started in 1981, and some continued to function from earlier years. The details are outlined in this annual report.*

The research results and other activities described in this publication would not have been possible without the support given by the Consultative Group on International Agricultural Research (CGIAR) and by the many international, regional, and national donors who have given so generously to the Center. To all we express our most sincere thanks.

This Annual Report is the first of its kind that ICARDA has produced. Earlier documents—with the same title—portrayed highlights and summaries of work covered in the respective years. The contents stem primarily from program and project documents prepared for our In-house Review of 1981. A great deal of editorial work went into those documents in an endeavor to obtain a measure of uniformity in presentation. Several staff members contributed to this arduous exercise, particularly the Program Leaders and the Deputy Director General (Research). The final editing was done by Dr. Geoffrey Hawtin. A word of gratitude also goes to our consultant Professor William Ward of Cornell University for supervising the document through the printing stages.

It is our hope that this publication will be a source of useful information on ICARDA's current research programs and progress. As a first attempt, it was a hard exercise to complete, and we know already how to make notable improvements in future reports. But I earnestly seek your views and criticisms so we may take them into account as we proceed to prepare future Annual Reports.

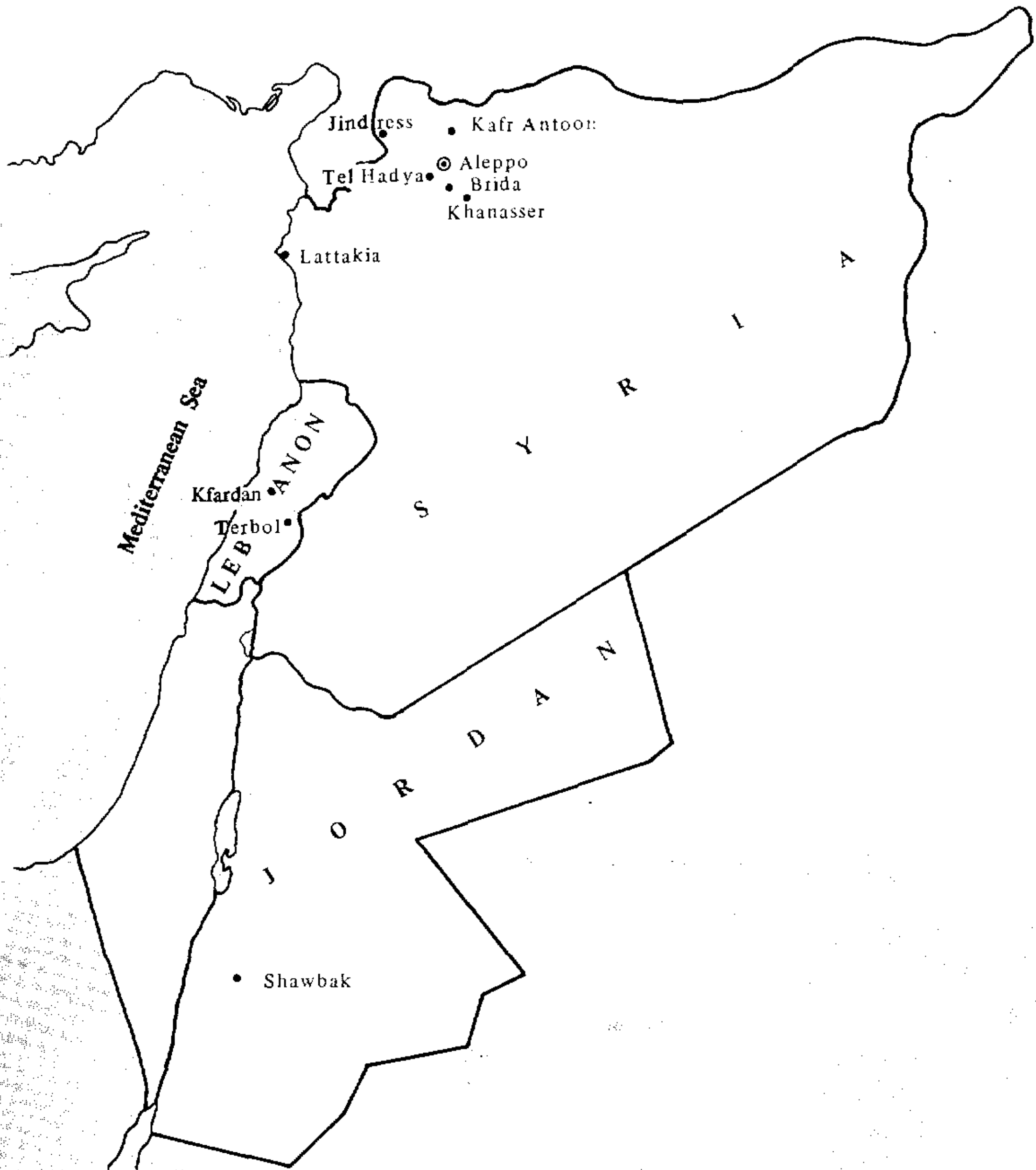
Mohamed A. Nour
Director General

LIST OF DONORS

Work of ICARDA during 1981 was made possible by the generous donations of the following organizations and countries:

- ***Arab Fund for Economic and Social Development***
- ***Australia***
- ***Belgium***
- ***Canada***
- ***Denmark***
- ***Ford Foundation***
- ***Germany, FDR***
- ***International Development Research Centre (IDRC)***
- ***International Fund for Agricultural Development (IFAD)***
- ***Italy***
- ***Mexico***
- ***Netherlands***
- ***Norway***
- ***OPEC Fund for International Development***
- ***Spain***
- ***Sweden***
- ***United Kingdom***
- ***United Nations Development Program (UNDP)***
- ***United States Agency for International Development (USAID)***
- ***World Bank***

In addition, the work at ICARDA was supported by three other CGIAR-sponsored institutions: CIMMYT, IBPGR, and ICRISAT.



Locations of ICARDA's experimental work in three out of 22 countries in West Asia and North Africa which make up the ICARDA region.


FARMING SYSTEMS

Contents

(Photo on previous page: Investigating plant moisture stress.)

FARMING SYSTEMS RESEARCH

Introduction

Scientists at ICARDA have a commitment to develop appropriate technologies which, when integrated into existing farming systems, will increase the quality and quantity of food. It is intended that this will improve rural well-being and the quality of life in the region, particularly for farmers of low resources and small areas of land. The Farming Systems Program seeks to find strategies that will add stability to and improve the farming systems in the region, by increasing the technical and economic efficiency of the available resources, with particular emphasis on soil and water, combined with improvements in crop and livestock husbandry.

The ICARDA region is large and diverse and contains many different farm systems, and improvements in these systems are necessarily location specific. One major long-term objective of the Farming Systems Program is to develop methodologies that can be used to increase agricultural productivity in particular agro-climatic and socio-economic areas rather than to develop a new production system or technology with wide applicability and/or adaptability.

A second long-term objective, of equal importance, is to expose scientists in the region to farming systems research, including the methodology developed in the Program, and to train them to use it. Currently the Program is refining and testing methodologies under the agricultural conditions in Syria, where a set of production strategies for improving productivity in different rainfall zones is being considered.

FOUR STAGES. The research of the Farming Systems Program is perceived as a process of four stages:

(1) Diagnostic stage represents an initial and recurring process in which a complete system is studied to understand the socio-economic as well as the agro-climatic environment surrounding agricultural production, and to identify constraints to, or potential areas for, increasing agricultural productivity.

(2) Design or experimental stage when scientists conduct research on problems identified in stage 1 on research stations, substations, or farmers' fields, in an effort to find one or more feasible solutions or strategies that will improve agricultural production.

(3) Testing stage in which promising strategies developed in stage 2 are tested under farmers' conditions, with production decisions

At the diagnostic stage, the Farming Systems program seeks production and socio-economic information from farmers and their families.

being made initially by the scientist and farmer. Trials managed wholly by the farmers themselves are then undertaken.

(4) Extension stage involves the diffusion of successful technologies.

This process is dynamic and iterative, since it is frequently necessary to return to earlier stages to clarify points as knowledge is gained, problems confronted, and research alternatives considered. The boundary between stages is not sharply defined, as there is much overlap and several stages can be studied simultaneously.

In essence, farming systems research can be seen as an effort to find new solutions to present agricultural development problems in situations where old solutions have been found to be less effective than desired.

RATIONALE AND DESCRIPTION OF MAJOR CROP RESEARCH LOCATIONS. In order that the interactions between crop, crop management, soil type, rainfall, and other environmental variables could be properly investigated, four major off-station research sites were established on a semi-permanent basis in 1979. Advantage was taken of the steep isohyetal gradient which exists in Aleppo Province, and the four 10 ha sites were established at Jindiress (long-term average rainfall 479 mm), Kafr Antoon (444 mm), Brida (278 mm), and Khanasser (215 mm).

Grade A meteorological stations have been set up at each location. (See data for 1980/81 season at the end of this section of the Annual Report.) The sites are divided into four 2.5 ha blocks which are farmed in a rotation typical of the environment they represent, enabling trials on cereals, grain, and forage legumes to be conducted on land in the correct rotational sequence. A detailed description of the management and soils of these stations is given in ICARDA Project Report No. 3 entitled, "Soil Water and Nutrients Research 1979–80."

In addition to Tel Hadya, almost all the cropping research work of the Farming Systems Program, as well as much of the work reported by other programs, was conducted at these four sites.

Barley Agronomy Studies

Agronomy trials were carried out during 1981 at five sites in northern Syria (Khanasser, Brida,

Harvesting a barley agronomy trial at Brida, Syria.

Tel Hadya, Kafr Antoon, and Jindiress). They were a continuation, with modifications, of the previous year's trials, the results of which are reported in detail in ICARDA Project Report No. 3. The main trial was a study of the effect of two sowing methods, in combination with different rates of seed, nitrogen, and phosphorus. In a second experiment, the residual effects of phosphorus applied in a trial in the previous year were measured.

Sowing Method x Nitrogen x Phosphorus Trial

At each site, two replicates of a split plot, modified central composite factorial design were laid down. The sowing method treatments formed the main blocks, and within blocks there were 16 treatment combinations of seed rate, nitrogen, and phosphorus as shown in Table 1. The effects of the treatments on yield components grain and total dry matter production are shown in Tables 2, 3, and 4, with Tables 3 and 4 being in the form of regression equations. These equations were used to predict the values for the yield components at three levels of each of seed, nitrogen, and phosphorus (Tables 5 to 7).

During growth, it was observed that the higher seed rates caused earlier and more serious lodging at the three wetter sites (Kafr Antoon, Jindiress, and Tel Hadya) but there was little or no lodging at Brida and Khanasser. Nitrogen showed similar though less clear-cut effects, while phosphorus did not appear to affect lodging. Higher seed rates accelerated the attainment of full ground cover. Unfertilized treatments

Table 1. **Summary of the treatments applied in the seed, nitrogen, and phosphorus rate trials.**

Treat. no.	Treatment matrix S	N	P	Treatment applied (kg/ha) Seed	Nitrogen	Phosphate	N applic. time Planting	Top dress
1	−1	−1	−1	60	30	30	10	20
2	−1	−1	1	60	30	90	10	20
3	−1	1	−1	60	90	30	20	70
4	−1	1	1	60	90	90	20	70
5	1	−1	−1	120	30	30	10	20
6	1	−1	1	120	30	90	10	20
7	1	1	−1	120	90	30	20	70
8	1	1	1	120	90	90	20	70
9	−2	0	0	30	60	60	20	40
10	2	0	0	150	60	60	20	40
11	0	−2	0	90	0	60	0	0
12	0	2	0	90	120	60	20	100
13	0	0	−2	90	60	0	20	40
14	0	0	2	90	60	120	20	40
15	0	0	0	90	60	60	20	40
16	−2	−2	−2	30	0	0	0	0

were retarded at Jindiress, Kafr Antoon, and Khanasser, while phosphorus advanced maturity by seven to ten days at most sites. Low seed rates without fertilizer gave slower early growth, and these treatments gave lower yields than other treatments.

DRILLING. Table 2 shows that on average drilling increased grain yields by 0.4 t/ha—a gain of 13.9% over hand-sowing. In the previous season, drilling gave yields of 0.24 t/ha or 9% in excess of yields from hand-sowing. The largest increases were obtained at Kafr Antoon and Tel Hadya, while smaller increases occurred at the two drier sites. The yield differences were due mainly to more kernels/spike in the drilled plots.

SEED RATE. Increasing the seed rate had the following significant effects:

- Increased the number of emerged plants, the number of tillers and the number of spikes, and reduced the number of tillers/plant and the number of spikes/tillers.
- Decreased kernel weights at four sites, and reduced the kernel number/spike.
- Increased the kernel numbers/ha at the two driest sites, and reduced them at Tel Hadya.

Table 2. **Effects of two sowing methods on yield components in seed, nitrogen, and phosphorus rate trials at five sites.**

Site	Sowing[1] method	Emerg. plants (M./ha)	Tillers/ plant	Tillers (M./ha)	Spikes/ till	Spikes/ plant	Spikes (M./ha)	Kernels/ spike	Kernel no. (M./ha)	Wt./ kernel (Mg.)	Grain yield (t/ha)	Total dry M. (t/ha)	Harvest index
Jindiress	H	1.63	2.67	4.36	0.67	1.79	2.92	25.5	74.6	46.4	3.46	8.14	0.43
	D	1.49	2.85	4.24	0.61	1.73	2.58	30.3	78.2	46.7	3.65	8.99	0.41
Kafr Antoon	H	1.52	3.18	4.83	0.67	2.12	3.22	26.1	84.1	46.0	3.87	9.47	0.41
	D	1.52	3.49	5.31	0.62	2.18	3.31	31.8	105.2	46.0	4.84	11.72	0.41
Tel Hadya	H	1.62	3.40	5.51	0.66	2.23	3.61	25.8	93.0	38.5	3.58	9.04	0.40
	D	1.44	3.92	5.64	0.61	2.38	3.43	31.6	108.4	37.9	4.11	10.45	0.39
Brida	H	1.70	3.13	5.32	0.48	1.50	2.55	22.2	56.8	35.2	2.00	6.08	0.33
	D	1.61	3.02	4.87	0.48	1.45	2.34	26.1	61.0	35.9	2.19	6.53	0.34
Khanasser	H	1.69	3.17	5.36	0.41	1.29	2.18	19.5	42.4	34.4	1.46	3.51	0.42
	D	1.36	3.42	4.65	0.39	1.34	1.82	24.0	43.6	36.0	1.57	3.55	0.44
Means	H	1.63	3.12	5.08	0.57	1.78	2.90	24.7	71.6	40.1	2.87	7.25	0.40
	D	1.48	3.34	4.94	0.55	1.82	2.70	29.9	80.7	40.5	3.27	8.25	0.40

[1]*Sowing method: H = Hand-sowing in local fashion; D = Drilling with Oyjord plot planter.*

Table 3. **Effects of seed rate, nitrogen, and phosphorus on grain yields of barley (t/ha).**

Regression coeffts.		Individual sites				
		Jindiress	K. Antoon	Tel Hadya	Brida	Khanasser
Adj. mean		3.83	4.37	3.61	2.40	1.71
S		0.01	−0.03	−0.15**	0.11***	0.12***
N		0.29***	0.19**	−0.12*	−0.10***	−0.01
P		0.15***	0.16**	−0.03	0.26***	0.22***
S.N		0.01	0.08	−0.06	−0.01	−0.07
S P		−0.01	−0.07	−0.07	0.05	0.03
N P		−0.01	−0.03	−0.09	0.01	0.04
S^2		−0.01	0.02	0.07	−0.03	−0.01
N^2		−0.01	0.02	0.07	−0.03	−0.01
P^2		−0.06	0.05	0.09	−0.10	−0.08
		Analysis of variance–Mean square and F-test significances				
Source	d.f.					
Blocks	1	0.02	0.16	4.54	0.70	0.14
Methods	1	0.56	15.18*	4.36	0.59	0.19
Error 1	1	0.03	0.06	0.19	0.17	0.01
Sub Tmt Regrn	9	0.88***	0.54*	0.36*	0.72***	0.51***
Sub lack of fit	6	1.05***	0.64**	0.32	0.75***	0.59***
SubxMain Regrn	9	0.05	0.17	0.09	0.06	0.07
Sub Lack of fit	6	0.02	0.07	0.09	0.06	0.03
Error 2	30	0.10	0.18	0.16	0.05	0.06
TOTAL (M.S.)	63	(0.29)	(0.50)	(0.32)	(0.24)	(0.17)

Table 4. **Effect of seed rate, nitrogen, and phosphorus on total dry matter yields of barley (t/ha).**

Regression coeffts.		Individual sites				
		Jindiress	K. Antoon	Tel Hadya	Brida	Khanasser
Adj. mean		9.16	11.27	8.97	7.74	4.05
S		0.04	0.13	−0.11	0.38**	0.33***
N		0.97***	0.76	−0.03	0.17	0.04
P		0.51***	0.82	0.34**	0.99***	0.58***
S.N		−0.06	0.21	−0.13	−0.10	−0.15
S P		−0.00	−0.12	−0.19	−0.15	0.09
N P		−0.13	−0.02	−0.16	0.15	0.04
S^2		−0.10	−0.13	0.28	−0.26	−0.02
N^2		−0.19	−0.26	0.23	−0.38	−0.14
P^2		−0.07	−0.04	0.34	−0.49	−0.19
		Analysis of variance–Mean square and F-test significances				
Source	d.f.					
Blocks	1	0.11	0.15	1.31	4.22	0.15
Methods	1	11.57	80.67	31.82	3.30	0.02
Error 1	1	0.23	0.24	11.75	0.41	0.01
Sub Tmt Regrn	9	8.88***	9.72	1.79*	9.62***	3.62***
Sub Lack of fit	6	7.84***	8.71	3.19**	9.78***	3.18***
SubxMain Regrn	9	0.45	1.57	1.02	0.22	0.49
Sub Lack of fit	6	0.28	1.07	2.10*	0.29	0.24
Error 2	30	0.82	1.50	0.70	0.87	0.35
TOTAL (M.S.)	63	(2.68)	(4.55)	(1.95)	(2.89)	(1.08)

Table 5. Predicted yield parameters for low, medium, and high seed rates in five seed rate, nitrogen, and phosphorus trials on barley.[1]

Site	Treatment level[2]	Emerg. plants (M./ha)	Tillers/ plant	Tillers (M./ha)	Spikes/ till	Spikes/ plant	Spikes (M./ha)	Kernels/ spike	Kernel no. (M./ha)	Wt./ kernel (Mg.)	Grain yield (t/ha)	Total dry M. (t/ha)	Harvest index
Jindiress	L	0.54	6.24	3.37	0.69	4.30	2.32	35.0	81.1	47.2	3.83	9.16	0.42
	M	1.56	3.11	4.85	0.61	1.90	2.96	28.0	82.9	46.2	3.83	9.16	0.42
	H	2.58	2.10	5.41	0.62	1.29	3.34	24.8	82.9	46.2	3.83	9.16	0.42
Kafr Antoon	L	0.56	7.57	4.24	0.68	5.14	2.88	31.7	91.4	47.8	4.37	11.27	0.39
	M	1.52	3.55	5.39	0.63	2.24	3.41	29.1	99.1	44.1	4.37	11.27	0.39
	H	2.48	2.53	6.27	0.60	1.51	3.75	26.1	98.0	44.6	4.37	11.27	0.39
Tel Hadya	L	1.03	4.45	4.58	0.67	3.05	3.14	33.7	105.9	39.3	4.16	8.97	0.46
	M	1.53	3.59	5.49	0.63	2.25	3.44	28.9	99.4	36.3	3.61	8.97	0.40
	H	2.03	3.52	7.15	0.58	2.06	4.18	23.5	98.4	36.4	3.58	8.97	0.40
Brida	L	0.53	7.91	4.19	0.50	3.92	2.08	29.2	60.8	33.7	2.05	5.96	0.34
	M	1.65	3.62	5.97	0.45	1.61	2.66	26.8	71.2	33.7	2.40	7.74	0.31
	H	2.77	2.64	7.31	0.45	1.18	3.27	22.7	74.2	33.7	2.50	7.47	0.33
Khanasser	L	0.96	4.18	4.01	0.43	1.81	1.74	22.6	39.3	36.6	1.44	3.28	0.44
	M	1.52	3.90	5.93	0.36	1.42	2.16	23.0	49.7	34.4	1.71	4.05	0.42
	H	2.64	2.67	7.04	0.41	1.10	2.91	20.0	58.1	32.7	1.90	4.62	0.41

[1]These predictions are for the middle rates of N & P_2O_5, i.e., 60 kg/ha.
[2]Treatment levels for seed rates, kg/ha: Low = 30, Med. = 90, High = 150.

Table 6. Predicted yield parameters for low, medium, and high nitrogen rates in five seed rate, nitrogen, and phosphorus trials on barley.[1]

Site	Treatment level[2]	Emerg. plants (M./ha)	Tillers/ plant	Tillers (M./ha)	Spikes/ till	Spikes/ plant	Spikes (M./ha)	Kernels/ spike	Kernel no. (M./ha)	Wt./ kernel (Mg.)	Grain yield (t/ha)	Total dry M. (t/ha)	Harvest index
Jindiress	L	1.56	2.38	3.72	0.52	1.24	1.94	29.9	58.1	48.2	2.80	6.46	0.43
	M	1.56	2.11	4.85	0.61	1.90	2.96	28.0	82.9	46.2	3.83	9.16	0.42
	H	1.56	2.94	4.59	0.72	2.10	3.29	26.8	88.1	45.2	3.98	10.36	0.38
Kafr Antoon	L	1.52	3.55	5.39	0.51	1.81	2.75	29.5	81.1	47.5	3.85	11.27	0.34
	M	1.52	3.55	5.39	0.63	2.24	3.41	29.1	99.1	44.1	4.37	11.27	0.39
	H	1.52	3.55	5.39	0.63	2.24	3.41	30.6	104.3	44.3	4.62	11.27	0.41
Tel Hadya	L	1.53	3.59	5.49	0.63	2.25	3.44	28.9	99.5	41.9	4.17	8.97	0.46
	M	1.53	3.59	5.49	0.63	2.25	3.44	28.9	99.4	36.3	3.61	8.97	0.40
	H	1.53	3.59	5.49	0.63	2.25	3.44	30.7	105.7	34.9	3.69	8.97	0.41
Brida	L	1.65	2.89	4.77	0.56	1.61	2.66	23.1	61.4	36.8	2.26	7.74	0.29
	M	1.65	3.62	5.97	0.45	1.61	2.66	26.8	71.2	33.7	2.40	7.74	0.31
	H	1.65	3.65	6.03	0.44	1.61	2.66	21.4	56.9	32.5	1.85	7.74	0.24
Khanasser	L	1.52	3.90	5.93	0.36	1.42	2.16	23.0	49.7	34.4	1.71	4.05	0.42
	M	1.52	3.90	5.93	0.36	1.42	2.16	23.0	49.7	34.4	1.71	4.05	0.42
	H	1.52	3.90	5.93	0.36	1.42	2.16	23.0	49.7	34.4	1.71	4.05	0.42

[1]These predictions are for the middle rates of seed (90) and P_2O_5 (60 kg/ha).
[2]Treatment levels for nitrogen, kg/ha: Low = 0, Med. = 60, High = 120.

Table 7. Predicted yield parameters for low, medium, and high phosphorus rates in five seed rate, nitrogen, and phosphorus trials on barley.[1]

Site	Treat-ment level[2]	Emerg. plants (M./ha)	Tillers/ plant	Tillers (M./ha)	Spikes/ till	Spikes/ plant	Spikes (M./ha)	Kernels/ spike	Kernel no. (M./ha)	Wt./ kernel (Mg.)	Grain yield (t/ha)	Total dry M. (t/ha)	Harvest index
Jindiress	L	1.56	2.10	3.27	0.74	1.55	2.42	29.8	72.2	45.4	3.28	7.84	0.42
	M	1.56	3.11	4.85	0.61	1.90	2.96	28.0	82.9	46.2	3.83	9.16	0.42
	H	1.56	3.71	5.79	0.58	2.16	3.37	24.6	82.8	47.0	3.89	9.88	0.39
Kafr Antoon	L	1.52	2.97	4.51	0.69	2.05	3.12	28.9	90.1	47.3	4.26	11.27	0.38
	M	1.52	3.55	5.39	0.63	2.24	3.41	29.1	99.1	44.1	4.37	11.27	0.39
	H	1.52	4.11	6.24	0.66	2.69	4.09	26.1	106.8	45.8	4.89	11.27	0.43
Tel Hadya	L	1.53	3.03	4.65	0.69	2.10	3.21	31.0	99.4	36.3	3.61	9.63	0.37
	M	1.53	3.59	5.49	0.63	2.25	3.44	28.9	99.4	36.3	3.61	8.97	0.40
	H	1.53	3.89	5.95	0.63	2.44	3.73	26.6	99.4	36.3	3.61	11.00	0.33
Brida	L	1.65	1.84	3.04	0.62	1.13	1.87	23.3	43.6	33.7	1.47	3.81	0.39
	M	1.65	3.62	5.97	0.45	1.61	2.66	26.8	71.2	33.7	2.40	7.74	0.31
	H	1.65	3.51	5.79	0.49	1.72	2.84	26.1	74.2	33.7	2.50	7.75	0.32
Khanasser	L	1.52	1.86	2.82	0.52	0.97	1.47	17.8	26.1	36.8	0.96	2.11	0.45
	M	1.52	3.90	5.93	0.36	1.42	2.16	23.0	49.7	34.4	1.71	4.05	0.42
	H	1.52	4.18	6.35	0.33	1.39	2.12	25.1	53.3	34.7	1.85	4.44	0.42

[1]These predictions are for the middle rates of seed (90) and Nitrogen (60 kg/ha).
[2]Treatment levels for Phosphate, kg/ha: Low = 0, Med. = 60, High = 120.

- Increased yields at two driest sites, decreased them at Tel Hadya, and had no effect at the two wettest sites.
- Increased total dry matter produced at the two driest sites and had no effect at the three wettest places.

These results conform well with those obtained in the previous season in the seed rate x nitrogen trials at the same locations.

NITROGEN. Increasing the nitrogen application rate had the following significant effects:

- Increased the number of tillers at two sites (and had the same tendency at the other three), increased the numbers of spikes/tiller at the two wettest sites and decreased them only at Brida.
- Increased the spike numbers at the two wettest sites only.
- Decreased kernel weights at all sites except the driest one, and increased kernel number at the three wettest sites, having little effect at the dry sites.
- Increased grain yields at the two wettest sites, but decreased them at Tel Hadya and Brida, and had no effect at Khanasser.
- Increased dry matter produced only at the wettest site.

Compared with the yield responses in the previous year's trials at these sites, nitrogen had a smaller positive effect at the two wetter sites. Again, it had a negative effect at Tel Hadya and Khanasser. The significant negative response at Brida contrasts with a good positive response in the previous season.

PHOSPHORUS. Increasing the phosphorus application rate had the following significant effects on the directly measured parameters:

- Increased stem and spike numbers at all sites and decreased the number of spikes/tiller at the wetter sites.
- Increased kernel weights at Jindiress and decreased them at Kafr Antoon and Khanasser (and non-significantly at Tel Hadya).

- Increased kernel numbers at all sites except Tel Hadya.
- Increased grain yields at all sites except Tel Hadya.
- Increased total dry matter produced at all sites except Kafr Antoon.

Table 8 shows that the response of barley to phosphate application at Brida was very profitable. The benefit-cost ratio of using 60 kg/ha of phosphate was 2.55. This is solid evidence of the economic, as well as agronomic, potential of phosphate in barley production.

***Table 8.* Partial budget for phosphate application on barley at Brida (1980/81 season).**

	0kg P_2O_5	60 kg P_2O_5
INCOME		
Grain yield (tons)	1.47	2.40
Grain revenue (SL)	882.	1,440.
Straw yield (tons)	2.34	5.34
Straw revenue (SL)	468.	1,068.
TOTAL REVENUE (SL)	*1,350.*	*2,508.*
EXPENSES (SL)		
Fertilizer		
P_2O_5 x price	—	130
Labor for application	—	10
Credit	—	13
Harvesting		
Labor, equipment, transport, bags, etc.	—	173
TOTAL CHANGE IN EXPENSE	0	326
NET BENEFIT (SL)	1,350	SL 2,182

SL: Syrian Lira
Cost of P_2O_5: 2.17 SL per kg.
Price of barley grain: 0.70 SL per kg.
Price of barley straw: 0.20 SL per kg.
Labor for broadcasting: 10.00 SL per 120 kg of TSP fertilizer.
Both trials received 60 kg of N at a seed rate of 90 kg Beecher barley.

Residual Phosphate Trial

A uniform crop of barley was planted on the plots where the time of nitrogen application x phosphorus trial had been laid down in the previous season. The aim was to obtain data on the residual phosphorus responses. No phosphorus was applied in 1981, except at Tel Hadya where the plots were in a field given an overall phosphorus application. Yields alone were measured in the second year. The responses (in t/ha) to 60 kg of P_2O_5 applied in the first year are shown in Table 9, along with the residual responses in the second year, the cumulative effects, and the response per kg of P_2O_5.

The negative response at Tel Hadya is anomalous and at present inexplicable. However, the responses at the other four sites were very similar to those of the previous year and indicate that residual responses are very large. This has considerable implications for the economics of phosphorus use, particularly in areas like Khanasser.

Cereal Physiology, Water Use, and Soil Nutrients Research

To provide a greater understanding and to help characterize the major fertilizer x site x cereal yield interaction so clearly demonstrated in the agronomy trials, detailed studies were undertaken on the growth, water use, and nutrient dynamics of fertilized and unfertilized wheat (at Tel Hadya) and barley (at Brida).

The major objective of this work is to study in detail the effect of fertilizer (60 kg/ha of N & P_2O_5) on the growth, water use, and nutrient uptake of cereals at the two contrasting locations. Nitrogen fertilizer (ammonium nitrate) was tagged with ^{15}N to assess both fertilizer use efficiency and to follow the dynamics of applied nitrogen in both the plant and soil. Crop green area and dry matter production were measured by weekly sampling, and crop moisture use was followed using the neutron probe technique. Nutrient dynamics under fallow land were also measured to help interpret the parallel studies under cropped land.

Table 9. **Responses of barley over two seasons to 60 kg P_2O_5 applied in the first season.**

Sites:	Response (t/ha) to 60 kg P_2O_5 applied in 1979–80 season: Jindiress	K. Antoon	Tel Hadya	Brida	Khanasser
1979/80 season	.20	.32	.24	.32	.84
1980/81 season	.28	.30	.76	.24	.44
TOTAL	.48	.62	—	.56	1.28
kg barley per 1 kg P_2O_5	8	10.3	—	9.3	21.3

Results of Crop Physiology Studies

The yield components of wheat at Tel Hadya and barley at Brida are given in Table 10. Radiant energy interception and efficiency of conversion data are reported in Table 11. Green area development curves are given in Figures 1 and 2. In the vegetative and early reproductive phases, fertilization gave greater canopy development and thus higher radiant energy interception, resulting in approximately 30% more productive tillers. Grain numbers per hectare are generally determined in the four-week period before anthesis. Radiant energy interception in this period was considerably higher in the fertilized treatments (Tel Hadya 80 to 95%, Brida 44 to 77%) than in the unfertilized treatments (Tel Hadya 60 to 80%, Brida 33 to 55%). This

Measuring the soil moisture status and water use of barley with the Neutron Probe technique.

Table 10. **Components of yield of cereals at Brida (barley) and Tel Hadya (wheat) for fertilized and unfertilized crops.**

	Brida		Tel Hadya	
	Fo[1]	F+[2]	Fo	F+
Seed yield (kg/ha)	1720	2130	3560	3770
Above ground dry matter production (kg/ha)	3550	4940	9460	10830
Harvest index	0.486	0.433	0.379	0.350
1000 grain weight (gm)	38.1	32.5	34.8	31.5
Spikes/m^2	173.1	231.7	268.2	340.8
Seeds/spike	26.1	28.4	38.1	35.1
Seeds/m^2	4518	6568	10228	11976
E_t (Germ. Maturity)(mm)	250	248	360	375
WUE (T.D.M. kg/ha/mm)	14.2	19.9	26.3	28.9
WUE (Seed yield kg/ha/mm)	6.9	8.6	9.9	10.1

[1] F_o = Unfertilized.
[2] F+ = 60 kg N/ha and 60 kg P_2O_5/ha.

Table 11. **Radiant energy interception and efficiency of conversion into dry matter at crop maturity in wheat (Tel Hadya, TH) and barley (Brida, BR).**

	Seasonal interception of radiant energy (MJ)	Proportion of incoming radiant energy intercepted	Average rate of conversion of intercepted radiation (g/MJ)	Average efficiency of conversion of intercepted radiation (%)
TH + Fert.	1056	0.498	1.12	2.0
TH O Fert.	844	0.384	1.14	2.0
BR + Fert.	785	0.369	0.79	1.4
BR O Fert.	486	0.217	0.91	1.6

higher interception resulted in increases of 17% (Tel Hadya) and 45% (Brida) in grain number/hectare.

Radiant energy interception at Tel Hadya by the wheat crop was greater than that by barley at Brida. The seasonal average efficiency of conversion of intercepted radiant energy was largely unaffected by fertilization but was higher in wheat at Tel Hadya (2.0%) than in barley at Brida (1.5%).

Plant water potentials in the post anthesis phase were very low at both sites in the fertilized treatments. Values lower than −4.0 MPa were common in the diurnal cycle. Unfertilized treatments gave values up to 1.5 MPa higher. Photosynthetic activity in the grain filling phase was seriously inhibited in the fertilized treatments. This difference was exaggerated by a combination of early maturity in fertilized treatments and very late rains which enabled photosynthesis to continue for longer in the unfertilized treatments, resulting in higher 1000 grains weights.

Overall, fertilization gave seed yield increases of 24% at Brida and 6% at Tel Hadya (Table 10).

Results of Soil Moisture Studies

The soil profile moisture recharge and discharge patterns are given in Figure 3 and crop moisture use (E_t) and water use efficiencies in Table 10. In Figure 3, the dotted line on the profile discharge graph indicates the moisture status at the start of the 1980/81 season before any rainfall. It can be seen that at Tel Hadya, where wheat followed a summer crop of sesame, the final levels of moisture at harvest (28/5/81) within discrete depth intervals were considerably lower than at the start of the season. This indicates that there was a substantial amount of residual available moisture left after the summer crop of 1980. The fertilized crop used more (50 mm) of this moisture than the unfertilized crop (35 mm). At Brida, where barley followed fallow, the results indicate that no available moisture was stored in the profile at the start of the season.

At both sites, fertilizer application caused greater canopy development during vegetative growth and hence higher rates of E_t. Resulting from this greater moisture use prior to anthesis, there was less moisture available for crop uptake during grain filling and this is reflected in the higher plant water potentials and 1000 grain weight of the unfertilized treatment. Total water use from germination to maturity was little affected by fertilizer application.

There were large differences in water use efficiency between germination and anthesis, ranging from 15.4 to 31.4 kg/ha/mm. These differences appeared to be related to the green area duration at anthesis. During this vegetative period of growth, the addition of nitrogen and

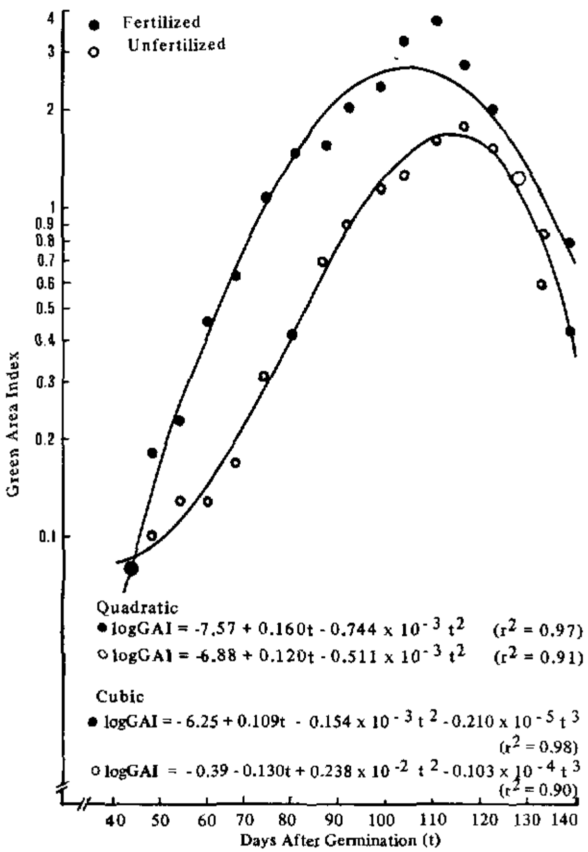


Fig. 1. Variation in green area index of barley grown at Brida under fertilized and unfertilized conditions.

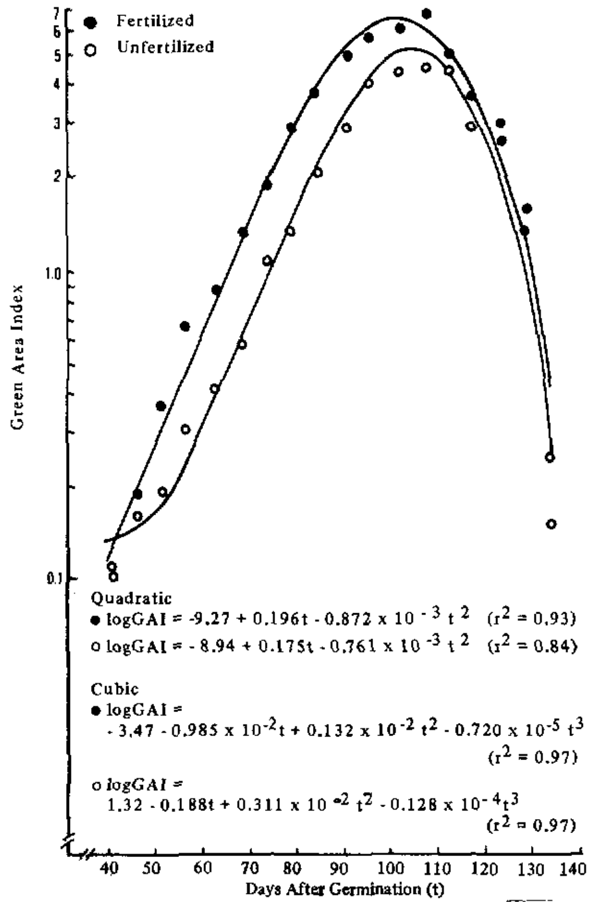


Fig. 2. Variation in green area index of wheat grown at Brida under fertilized and unfertilized conditions.

phosphorus fertilizer increased water use efficiency. After anthesis, water use efficiencies decreased markedly, reflecting both the greater internal water stress of the plants during this period and the increasing proportion of E_t being lost through soil evaporation as leaf area decreased due to senescence.

Fertilizer application increased the water use efficiency of grain production of barley at Brida but had little effect on wheat at Tel Hadya.

Results of Soil Nutrient Studies

SOIL CLASSIFICATION. Soils at Tel Hadya (two soil pits) and Brida (one soil pit) were described and classified according to the FAO system and the new US Department of Agriculture system. The soil at Brida was classified as a Calcic Xerosol (FAO) or Typic Calciorthid (USDA). The soils at Tel Hadya were classified as Luvisols (FAO) or Alfisols (USDA) transitional to Vertisols. One soil was classified as a Vertic (calcic) Luvisol (FAO), and one as Chromic Luvisol (FAO). In the USDA-system these soils were classified as Chromoxerertic Rhodoxeralf and Calcic Rhodoxeralf, respectively.

SOIL STRUCTURE. The structure of the soil at Brida was found to be prismatic below the surface horizon. Soil aggregates contained many fine pores, and varying amounts of fine roots.

The relatively high porosity of these soils would allow rapid infiltration and an even distribution of rainwater, whereas a relatively large proportion of the stored soil moisture would be available to the crop. The structure of the Tel Hadya soils is angular blocky near the surface, and prismatic below. Soil aggregates are covered with clay coatings, which merge into pressure skins and slickensides at depth. Aggregates contain few fine pores, and roots are mainly on the surface of the structural aggregates. Many of the soils form deep cracks in spring and summer, which would promote the loss of moisture from the soil. Infiltrating rainwater initially would follow the deep cracks, and slowly penetrate into the aggregates. Soil moisture contained in the aggregates would be less available to the crop than in Brida soils.

SOIL TEXTURE. The texture of the soils at Brida is clay loam in the surface horizon, merging into silty clay and silty clay loam at depth. The texture of the soils at Tel Hadya is clay throughout the profile (Fig. 4). Soils at Tel Hadya are

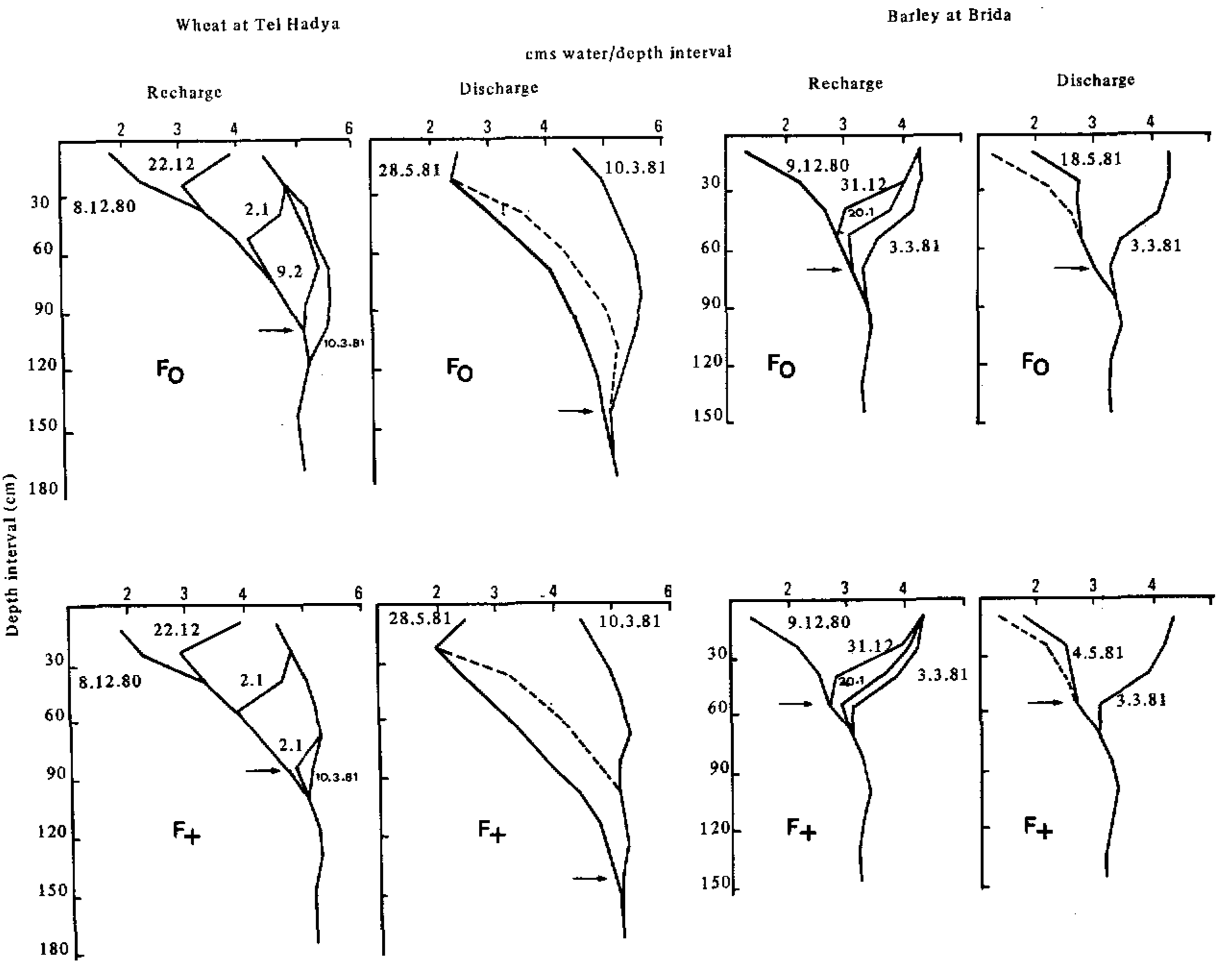


Fig. 3. Soil moisture profile recharge and discharge patterns under wheat at Tel Hadya and barley at Brida in the presence (F_+) and absence (F_0) of nitrogen and phosphorus fertilizer.

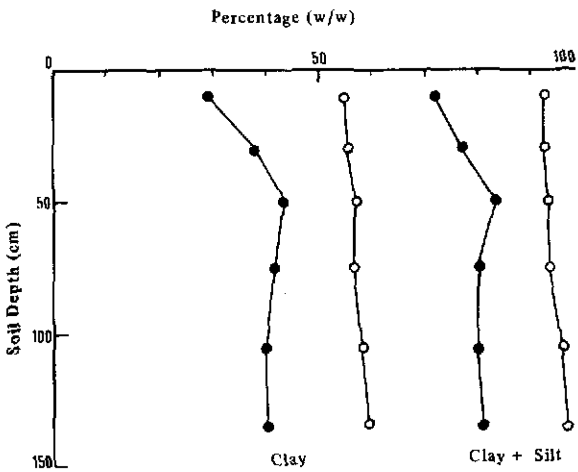


Fig. 4. Clay and silt contents of soils at Tel Hadya (○) and Brida (●).

difficult to cultivate when dry, and the surface rises in the rainy season, because of the presence of swelling clay minerals. Soils at Brida are liable to surface-sealing during heavy rainfall, because of their relatively high silt content.

LIME. Soils at Tel Hadya and Brida are calcareous. Lime contents at Tel Hadya are lower than in Brida soils, reflecting the higher rainfall at Tel Hadya, and possibly differences in parent materials. Soils at Tel Hadya have a horizon with redistribution of lime (soft lime spots), but no accumulation of lime in the soil profile. Soils at Brida have a calcic horizon, with a maximum at 60–70 cm depth, reflecting the average depth of infiltration of rainwater. The presence of lime in these soils results in a high pH and may limit the availability of phosphorus and a number of micronutrients, such as zinc and iron.

pH AND ELECTRICAL CONDUCTIVITY. The pH of soils at Tel Hadya and Brida is high, due to the presence of lime. The electrical conductivity (EC) of extracts of soils at Tel Hadya was found to be low at all depths, whereas at Brida EC increased with depth, due to the presence of gypsum. Salt contents of soils at Tel Hadya and Brida are not expected to have adverse effects on crop growth.

ORGANIC CARBON AND TOTAL NITROGEN. Organic carbon contents in soils at Tel Hadya and Brida are low: 0.4 to 0.6% in the top 20 cm of the soils. Organic carbon decreases more markedly with depth in soils at Brida than at Tel Hadya (Fig. 5). Total nitrogen is also low at both sites: 0.050 to 0.065% in the top 20 cm of the soils. The C/N ratio is quite constant with depth at both sites, decreasing from 9.7 to 8.3 at Brida, and increasing from 7.3 to 8.6 at Tel Hadya. The slightly lower C/N ratios in Tel Hadya soils could result in more mineral nitrogen being released upon decomposition of organic matter.

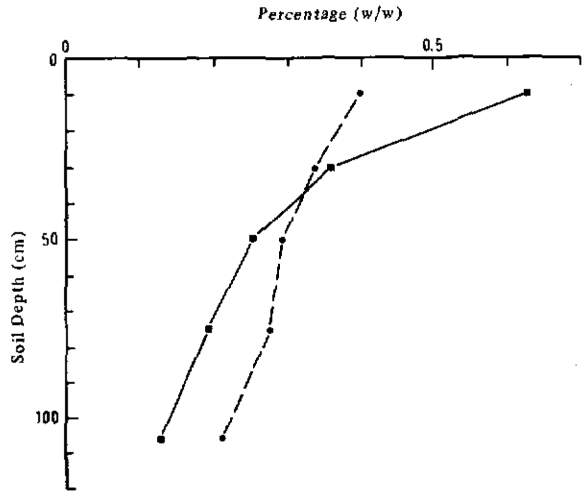


Fig. 5. Organic carbon contents of soils at Tel Hadya (●) and Brida (■).

MICRONUTRIENTS. Soils were extracted with a diethylene triamine penta-acetate (DTPA) solution for the determination of extractable zinc, copper, iron, and manganese. Zinc contents were low at both sites (below 0.5 ppm). Therefore, zinc deficiencies can be expected to occur in sensitive crops. Copper contents are relatively high at both sites, and deficiencies would not be expected. Copper contents in Brida soils decrease more strongly with depth than in Tel Hadya soils. This may reflect a correlation between copper and organic carbon in these soils. Iron contents are close to 5 ppm at both sites and quite constant with depth. Sensitive crops may suffer from iron deficiency, since the deficiency level in soils is approximately 5.0 ppm. Manganese contents are rather high at both sites and decrease with depth. Manganese deficiency would not be expected.

PHOSPHORUS. $NaHCO_3$-extractable phosphorus contents were found to be low to medium in the top 20 cm of the soils and decrease with depth to well below 3 ppm (Fig. 6). The deficiency limit for phosphorus in soil is about 5 ppm; i.e. for phosphorus contents below 5 ppm one would expect a response to phosphorus fertilizer in most crops. The low phosphorus contents of Brida soils were confirmed by a significant response of the barley crop to phosphorus fertilizer. The decrease in extractable phosphorus with depth at both sites could cause phosphorus deficiency late in the season, when the surface soil dries out.

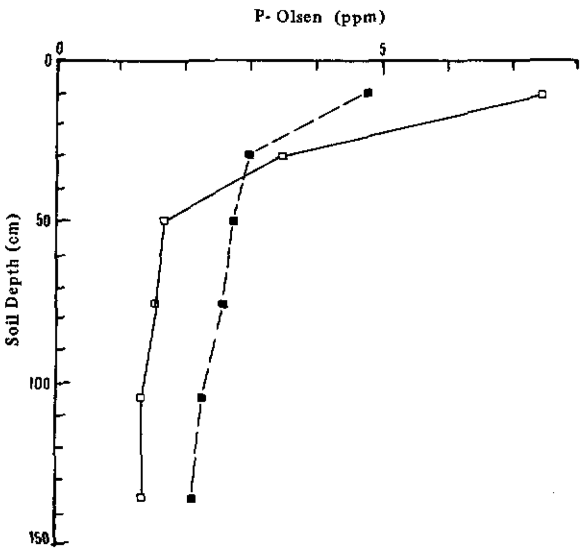


Fig. 6. Sodium bicarbonate-extractable phosphorus (P-Olsen) contents in soils at Tel Hadya (□) and Brida (■).

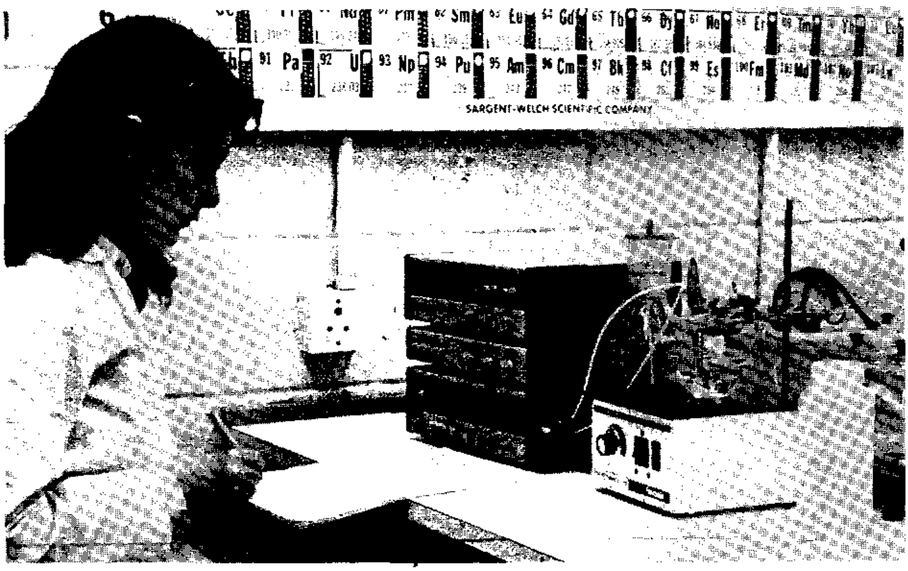
MINERAL NITROGEN. Potassium chloride-extractable nitrogen includes adsorbed (ammonium) and dissolved (nitrate) forms of nitrogen in soil. The sum of ammonium and nitrate (plus nitrite) is referred to as mineral nitrogen, which is an estimate of plant-available nitrogen. Figure 7 shows that at harvest in May to June 1980 fallowed plots were significantly higher in mineral nitrogen than cropped plots at both sites. At planting in 1980, the soils at Tel Hadya contained high amounts of mineral nitrogen (about 80 kg N/ha in the top 40cm) mainly in the form of nitrates. This accumulation of nitrates could be due to capillary rise of soil moisture during the summer. At Brida the mineral nitrogen contents at planting resembled those at harvest. The difference between curves B and C (in particular at depth) may reflect spatial variability.

At the start of the growing season, most of the mineral nitrogen in soils at Tel Hadya and Brida was in the form of nitrate-nitrogen. Nitrates were leached down with infiltrating rainwater to a depth of 30 cm (fertilized cropped plots) to 50 cm (unfertilized cropped plots and fallow plots) at Brida, and to a depth of 60 cm (fertilized and unfertilized cropped plots) to 110 cm (fallow plots) at Tel Hadya. By the end of March, most of the nitrates accumulated in soils in cropped plots had been taken up by the crop.

After the onset of the rains, during December and January, there was a strong increase in ammonium in soils at both sites, as a result of mineralization of organic matter. Although nitrification occurred during this period, the rate of mineralization exceeded the rate of nitrification. During February the amount of ammonium decreased, presumably as a result of nitrification, although ammonium may also have been immobilized in the biomass of the soil, and volatilization of ammonia may have occurred near the soil surface.

Plants at Brida did not take up appreciable amounts of nitrogen from below 60 to 70 cm depth, but at Tel Hadya plants appeared to take up nutrients from as deep as 150 cm. This observation closely reflects the moisture extraction patterns given in Figure 3.

Analysis for soil nitrogen using an automatic titration unit.



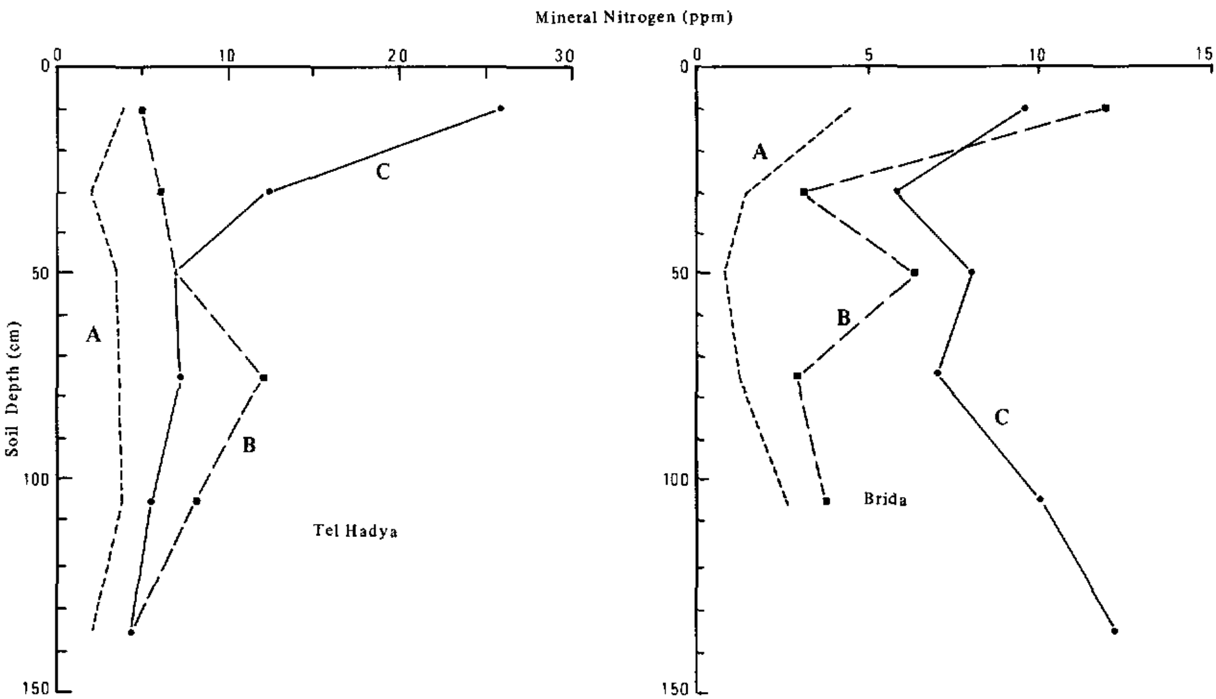


Fig. 7. Distribution of mineral nitrogen with depth in soils at Tel Hadya and Brida. Curves "A" represent the mineral-nitrogen status of cropped plots sampled at harvest 1980 (May); at Tel Hadya wheat followed summer crop and at Brida barley followed fallow. Curves "B" represent the mineral-nitrogen status of fallow plots sampled at harvest 1980; at Tel Hadya fallow followed summer crops and at Brida fallow followed fallow. Curves "C" represent the mineral-nitrogen status of plots sampled at planting 1980 (November); at Tel Hadya the land had been under summer crops and at Brida the land had been fallowed.

Physiology, Moisture, and Soil Nutrient Limitations to Wheat Yield

The objective of this experiment was to collect field data necessary to aid the development and calibration of a model of development, growth, and yield of spring wheat. This is the second year of data collection, and in 1982 the Ph.D. student responsible for this trial will work at the University of New England (Australia) where the model is being developed.

Three spring wheat varieties of different maturities were used in the main experiment: Sonalika (early), Mexipak (medium), and Novi Sad (NS 2568/2, late). They were planted at the following sites: Brida (dry, short season), Tel Hadya, Jindiress, and Kafr Antoon (wet, long season). The treatments are listed in Table 12. Seed rates for the individual varieties were adapted for seed weight and seed viability.

Water use, plant development and crop growth were measured at regular intervals during the season. Plant samples were taken at anthesis and at final harvest to determine nitrogen uptake by above ground plant parts. Soil samples were taken at final harvest for key treatments in Tel Hadya. The fertilized and unfertilized Mexipak crops at Jindiress and Kafr Antoon, together with the fallow, were sampled at monthly intervals as part of the nitrogen mass balance study.

The effects of temperature and day length on the development of breadwheats were examined in another experiment at Tel Hadya in which 16 varieties (spring, spring/winter and winter types) and different planting dates, were studied.

PLANT DEVELOPMENT. The main experiment was planted during the last week of November except at Brida where planting was done in the middle of December. Germination at the four sites was initiated by the first significant rainfall of the season during the second week of December. All crops emerged between December 25 and January 2, which was 19 days later than in the 1979/80 season. An example of the phenological events observed in this experiment is given for Tel Hadya in Table 13. Increasing temperatures towards the end of the season caused a decrease in maturity differences between the varieties. The differences ranged from 21 days at floral initiation to eight days at maturity. All growth stages of the irrigated crop (W2) occurred at about the same date as the previous

Table 12. **Treatments applied to three breadwheat varieties (Sonalika, Mexipak, and Novi Sad) at four locations.**

Location	Treatments[6]	Previous crop
Brida	N^0 60 kg P[1]	Fallow
	N^+ 60 kg P + 60 kg N[2]	
Tel Hadya	N^0 60 kg P + 30 kg N[3] W_0 no irrigation	Wheat
	N^+ 60 kg P + 120 kg N[4] W_0 no irrigation	
	N^+ 60 kg P + 120 kg N[4] W_1 157 mm irrigation	
	N^+ 60 kg P + 120 kg N[4] W_2 236 mm irrigation	
	Fallow	Wheat
	Fallow	Fallow
Jindiress	N^0[5] 0 kg P	Summer crop
&	N^0 60 kg P	
K. Antoon	N^+ 60 kg P + 60 kg N[2]	
	Fallow	

[1]Phosphate applied at planting.
[2]20 kg at planting and 40 kg top dressing.
[3]Top dressing.
[4]20 kg at planting and 70 + 30 kg top dressings.
[5]Mexipak only.
[6]Treatments applied in three replications.

Table 13. **The timing of phenological events of three breadwheat varieties planted at Tel Hadya.**

Phenological event	Timing[1]	Sonalika (early)	Mexipak (medium)	Novi Sad (late)
Floral initiation	Date	2 Feb.	15 Feb.	23 Feb.
	Days after germination	54	67	75
	GDD after germination	420	530	605
Heading	Date	7 Apr.	18 Apr.	22 Apr.
	Days after germination	118	129	133
	GDD after germination	1100	1250	1325
Anthesis	Date	13 Apr.	19 Apr.	23 Apr.
	Days after germination	124	130	134
	GDD after germination	1175	1266	1340
Maturity	Date (resp. W_0 and W_2)	14 May–21 May	19 May–26 May	22 May–28 May
	Days after germination	155 162	160 167	163 169
	GDD after germination	1700 1840	1785 1915	1850 1975

[1]*Time elapsed after germination on December 10, 1980 is expressed in calendar days and growing degree days (GDD, accumulated daily mean temperature).*

year, except floral initiation of Sonalika, which occurred 12 days later in 1981. The thermal lengths (GDD) of the growing periods, therefore, were shorter (80–120 GDD) than those of the previous season. This suggests that changes in day length also influenced the rate of development.

In an environment where the length of the growing season may be limited by temperature and moisture availability at both the beginning and end of the season, crops will have the potential to set at least some grain prior to the onset of the end-of-season stresses. Water stress shortened that grain filling period by 130 GDD (Table 13). Nitrogen stress had a similar effect but was only visible at Tel Hadya. There was little difference in rate of development between the N_0 and N_1 treatments at the other locations. Phasic development was delayed most in the treatments without phosphate at Jindiress and Kafr Antoon, especially in the early stages of crop growth.

The phasic development of the crops at Jindiress was almost the same as at Tel Hadya. In general, this was four to eight days earlier at Brida and at Kafr Antoon 10 to 16 days later than at Tel Hadya and Jindiress. The period between heading and anthesis varied in length from zero to seven days, being shortened by water, temperature, and/or nutrient stress. Under extreme conditions the head flowers when only partially out of the flagleaf sheath. This occurred in Brida with Novi Sad and to a lesser extent with Mexipak.

Between germination and floral initiation new leaves are initiated at the shoot apex, starting with three leaves, the number generally present in the embryo of the seed. The rate of leaf initiation was similar at all sites for all varieties and was 0.0148 leaf/GDD. Differences in duration of the leaf initiation period caused differences in leaf number between varieties and between sites. Table 14 gives some plant characteristics for the crops at Tel Hadya. Leaf number of Sonalika, Mexipak and Novi Sad varied between sites from 7 to 8.5, 8.8 to 10, and 10.9 to 11.5, respectively, with the lowest number at Brida and the highest at Kafr Antoon.

Tillering in Mexipak and Novi Sad at Tel Hadya was not as high as in the previous year. Sonalika performed slightly better. Tillering started slowly, probably because of low nitrogen availability in January due to nitrogen fixation by the residue of the previous wheat crop. More tillers survived in 1981 because of a lower initial plant population. The final number of spikes per unit area was similar for both years. Few tillers survived in the N_0 treatments at Tel Hadya.

Table 14. **Some characteristics of source and sink sizes from three breadwheat varieties grown at Tel Hadya.**

		Sonalika		Mexipak		Novi Sad	
		N_0	N_1	N_0	N_1	N_0	N_1
Source							
Number of leaves/mainstem		7.6	8.0	9.5	9.9	10.1	11.0
Leaf area/mainstem (cm^2)		86	110	114	174	103	208
Number of visible tillers/mainstem		0.7	0.8	0.6	1.2	0.4	1.3
Surviving tillers/mainstem	W_0	0.3	0.7	0.1	0.7	0	0.4
	W_2	—	0.8	—	1.0	—	0.7
Sink							
Number of spikelets/spike		12.5	14.7	19.5	20.1	22.2	23.3
Numbr of florets/spike		46	64	80	98	90	116
Number of fertile florets/spike		27	42	46	63	58	78
Number of kernels/spike	W_0	25	27	30	41	27	36
	W_2	—	36	—	42	—	39

The rate of leaf appearance was similar at all sites (0.0011 leaf/GDD), with Mexipak showing a slightly lower rate of leaf appearance than the other varieties. It is clear from Table 14 that longer season varieties develop a larger crop canopy, and therefore have a greater photosynthetic area, or "source," than the earlier type.

Initiation of new spikelets was observed in the period between floral initiation and jointing. The spikelet initiation rate was 0.067 spikelet/GDD for Sonalika and Novi Sad. The number of initiated spikelets and florets increased with longer season varieties. Longer season varieties therefore combine a larger source with a potentially larger sink size and thus have the highest yield potential. The actual size of the sink is determined around anthesis and environmental conditions (especially temperature) at that stage play a crucial role. Not all florets bore kernels. The kernel number at harvest was only a fraction of the number of kernel sites (florets) that were initiated during spike development (Table 14). The earlier varieties (Sonalika and Mexipak) realized a greater proportion of their yield potential than did the late one (Novi Sad). The effect was more marked under less favorable conditions of moisture, temperature and/or nutrients.

CROP GROWTH AND YIELD COMPONENTS. Table 15 summarizes some of the results of the growth analysis carried out for all treatments at the four sites. Ranking of the sites according to increasing production under dryland conditions is as follows: Brida, Tel Hadya, Jindiress, Kafr Antoon. This is the expected order based on climatic characteristics of the sites, including a dry, short season at Brida and a wet, long season at Kafr Antoon.

Grain yield of Mexipak at Jindiress and Kafr Antoon was reduced by the occurrence of yellow rust during part (half and three-quarters, respectively) of the grain-filling period. The rust was more severe at Kafr Antoon than at Jindiress and fertilized plots were more affected than unfertilized plots.

Irrigation increased production at Tel Hadya slightly above that at Kafr Antoon. Dry matter production and grain yields obtained under irrigation were similar to those of the previous year at Tel Hadya. Maximum kernel weights were almost the same for the two years: Sonalika 46.5/46.3g, Mexipak 36.2/36.6g, and Novi Sad 47.0/38.1g for 1980/1981. These values reflect probably genotypic differences in potential kernel weight of the three varieties.

Nitrogen did not increase yields at Brida where water was the major limiting factor. Mexipak and Novi Sad showed effects of severe water stress (Table 15). Dry matter accumulation and total water uptake in the N_0 plots were five to seven days behind the N_1 plots early in the season, but these differences were not apparent at the end of the season. There was a large replicate variation in the N_1 in Jindiress, indicating that 60 kg N/ha was probably not sufficient to obtain maximum yields.

The crop growth rates (kg/ha/day and kg/ha/GDD, respectively) during the period of stem elongation for the N_1 treatments were: 100 and 8.1 (Brida), 182 and 5 (Tel Hadya), 177 and 11 (Jindiress) and 192 and 12.9 (Kafr Antoon). Total green area index (GAI) reached a maximum in this period, and was 2.5 to 4 (Brida), 4 to 5.5 (Tel Hadya), 3.7 to 4.5 (Jindiress) and 5 to 6.5 (Kafr Antoon).

CROP WATER USE. Measured crop water use data are also presented in Table 15. The

Table 15. **Plant growth and water use data from three breadwheat varieties grown at four sites. (For treatments applied see Table 12.)**

				Sonalika (early)		Mexipak (medium)		Novi Sad (late)	
Location				N_0	N_1	N_0	N_1	N_0	N_1
Brida	W_0	Total dry matter[1]	(g/m^2)	543	543	473	501	520	511
		Total grain yield[2]	(g/m^2)	194	191	142	143	136	134
		Harvest index		0.36	0.35	0.30	0.29	0.26	0.26
		1000 kernel weight	(g)	37.2	35.2	26.5	25.4	32.2	33.3
		Kernels/m^2	($x10^3$)	5.2	5.4	5.4	5.6	4.2	4.0
		Spikes/m^2		250	248	242	231	222	237
		Water use[3]	(mm)	241	243	242	237	241	239
Tel Hadya	W_0	Total dry matter	(g/m^2)	480	958	495	979	397	860
		Total grain yield	(g/m^2)	192	347	192	342	154	315
		Harvest index		0.40	0.36	0.39	0.35	0.39	0.37
		1000 kernel weight	(g)	36.7	38.4	31.0	28.7	30.0	33.5
		Kernels/m^2	($x10^3$)	5.2	9.0	6.2	11.9	5.1	9.4
		Spikes/m^2		213	334	209	291	192	260
		Water use	(mm)	305	331	320	363	296	336
	W_2	Total dry matter	(g/m^2)	—	1291	—	1264	—	1034
		Total grain yield	(g/m^2)	—	493	—	504	—	454
		Harvest index		—	0.38	—	0.40	—	0.44
		1000 kernel weight	(g)	—	46.3	—	36.6	—	38.1
		Kernels/m^2	($x10^3$)	—	10.6	—	13.8	—	11.9
		Spikes/m^2		—	350	—	333	—	309
		Water use	(mm)	—	442	—	482	—	462
Jindiress	W_0	Total dry matter	(g/m^2)	700	1093	735	1116	581	1017
		Total grain yield	(g/m^2)	264	433	251	395	207	389
		Harvest index		0.38	0.40	0.34	0.35	0.36	0.38
		1000 kernel weight	(g)	45.0	45.4	34.3	32.5	32.5	35.0
		Kernels/m^2	($x10^3$)	5.9	9.5	7.3	12.2	6.4	11.1
		Spikes/m^2		221	315	229	272	218	262
		Water use	(mm)	377	417	352	448	363	412
Kafr Antoon	W_0	Total dry matter	(g/m^2)	1070	1170	791	1134	960	1085
		Total grain yield	(g/m^2)	394	484	322	394	384	436
		Harvest index		0.37	0.41	0.41	0.35	0.40	0.40
		1000 kernel weight	(g)	44.0	41.7	32.3	29.5	34.5	33.3
		Kernels/m^2	($x10^3$)	9.0	11.6	10.0	13.4	11.1	13.1
		Spikes/m^2		287	335	255	322	276	307
		Water use	(mm)	426	443	369	479	406	424

[1]*Above ground parts.*
[2]*Zero percent moisture.*
[3]*From planting to maturity date of Novi Sad.*

values reflect the seasonal rainfall at each site: Brida 264 mm, Tel Hadya 334 mm, Jindiress 435 mm, and Kafr Antoon 413 mm. The accumulative evaporation readings of bare soil were similar until the middle of February (Brida, Tel Hadya, Jindiress) or early March (Kafr Antoon). After that evapotranspiration increased rapidly at all sites.

The depth of water loss due to evaporation from fallowed plots at Tel Hadya was 85 cm at the end of May and 110 cm at the end of August. At harvest time (mid to late May) accumulated evaporation from the fallow was approximately 60% of the accumulated crop evapotranspiration at all sites.

Redistribution of soil moisture was measured with a neutron probe and tensiometers in a saturated profile covered with plastic. After 144 days drainage was still occurring over the whole profile at the rate of 0.1 mm/day. In early June, the plastic cover was removed, resulting in a rapid loss of moisture in the upper profile due to evaporation. Drainage from the bottom of the profile continued at a rate of 0.15 mm/day.

NITROGEN UPTAKE. Total nitrogen uptake by above-ground plant was determined at harvest. The average nitrogen uptake (kg/ha) for dryland crops under treatment N_0 and N_1 respectively was: 50 and 63 (Brida), 38 and 92 (Tel Hadya), 45 and 97 (Jindiress), and 79 and 107 (Kafr Antoon). Nitrogen was applied at 120 kg/ha at Tel Hadya and 60 kg/ha at the other sites (Table 12). Novi Sad removed slightly less nitrogen than either Sonalika or Mexipak. Irrigation at Tel Hadya increased the uptake to 114 kg/ha.

An average of 75% of the nitrogen in the plant tops was found in the grain. However, in Mexipak and Novi Sad, which suffered severe water stress at Brida, only 65% and 60%, respectively, of the nitrogen was present in the grain.

CONCLUSION. It is clear from the results from two seasons that the differences in yield and 1000 kernel weight at harvest between the three types were not great, despite a large difference in yield potential prior to anthesis. The degree to which the yield potential is maintained in the reproductive phase can be considered as a measure of adaptability of the variety, and of the potential productivity of the environment. There appeared to be an environmentally determined upper limit which is independent of variety for the three varieties used. All varieties adapted to stress first by a reduction in tiller number, followed by a reduction in the number of kernel sites on the remaining tillers. The maximum number of kernels/m^2 at harvest in dryland plots was between 13,000 and 15,000 in both years, and was in the same range for irrigated treatments at Tel Hadya even when irrigation began before anthesis.

Growth, Water Use, and Yield Physiology of Beecher Barley

Fertilizer treatments were selected from the agronomy work for the close monitoring of growth, phenology, water use and the determination of yield components. Foliar nutrients were applied in one of the treatments with the aim of increasing nutrient supply to the crop during late stem extension. A fallow treatment was also included to provide a reference for the interpretation of crop water use data. This work is the first year of an ongoing Ph.D. research program, and the results will be fully evaluated at the end of the second year. However, some general observations can be made.

GENERAL RESULTS. The foliar nutrient treatment had no significant effects on dry matter accumulation or final grain yield at any site. In the absence of fertilizer application, the delaying effect observed in phenological development started in the early stages of crop growth soon after emergence,tiller emergence being delayed until early spring.

The final number of kernels per unit ground area was largely determined by the time of early grain-filling. Fertilizer application boosted the maximum number of fertile florets produced per unit ground area, principally through tiller development. Final kernel number appeared to be largely determined during the rapid phase of tiller and floret death in the few weeks leading up to early grain-filling.

At the two drier sites, Brida and Khanasser, the increased leaf area development and grain yield achieved through fertilizer application caused no increase in total water use by the crop. However, at Jindiress (the wettest site) fertilizer application increased total water use as well as grain yield, but still resulted in a net increase in total water use efficiency.

Physiological and Moisture Use Studies in Chickpeas

In the Mediterranean region, winter planted chickpeas usually become heavily infected with Ascochyta blight which can result in complete crop failure. To avoid this severe risk, farmers traditionally plant their crop in the spring when the warmer, less humid conditions do not favor the establishment of Ascochyta blight. However, with the selection of blight resistant lines, winter planting (and the considerable yield advantage this confers) has now become feasible.

The objective of this research was to investigate in more detail the interaction between the growth and yield of winter and spring sown chickpeas and pervailing environmental variables, principally moisture supply. A blight resistant winter chickpea (ILC 482) with a spreading growth habit was planted in winter and spring at Jindiress, Tel Hadya, and Brida. In addition, another blight resistant line (ILC 72) with an erect growth habit was also winter-planted at two population levels. Detailed phenological and growth measurements were made on all treatments, coupled with soil moisture and crop moisture-use studies.

PHENOLOGY. Microscopic apical dissection revealed that floral induction occurred in cultivar ILC 482 approximately 10 to 14 days before it occurred in ILC 72. Under the typical cool spring temperature conditions experienced in northern Syria, this was associated with photoperiodic threshold values of 10 hours 57 minutes (ILC 482) and 11 hours 24 minutes (ILC 72) excluding civil twilight.

CANOPY DEVELOPMENT AND DRY MATTER PRODUCTION. *Crop dry matter production* is directly dependent upon the amount of radiant energy intercepted by the crop canopy. Considerable variations were observed at all sites within the peak values achieved by the active crop photosynthetic surface (green area index, Table 16). In this regard the densely planted ILC 72 treatment consistently developed its canopy faster, and to a greater extent, than standard density plantings of either cultivar. At the standard density the spreading cultivar ILC 482 generally achieved higher values than the erect cultivar ILC 72. However, it was only at Jindiress that there was an effective canopy

Table 16. **Canopy development and dry matter (DM) production of winter sown chickpeas.**

Site	Max.[2] Green Area Index (GAI)	Max.[2] above ground DM Prod. (t/ha)	DMP ÷ GAI
Jindiress			
ILC 482	4.7	7.9	1.69
ILC 72	4.4	7.2	1.64
ILC 72 (Dense)[1]	5.4	9.1	1.68
mean			1.67
Tel Hadya			
ILC 482	2.6	3.6	1.38
ILC 72	1.9	3.3	1.74
ILC 72 (Dense)[1]	3.0	4.7	1.56
mean			1.56
Brida			
ILC 482	1.7	2.5	1.47
ILC 72	1.3	1.9	1.46
ILC 72 (Dense)[1]	1.9	2.7	1.42
Mean			1.45

[1] = *Stand density approximately 600,000 pl/ha.*
[2] = *Values extracted from curves fitted by hand.*

cover. Green area index values need to be greater than 4 for canopies to approach full closure.

Maximum dry matter production values (Table 16) reflect these trends in canopy development. However, the differences in proportion between maximum green area index and maximum dry matter production values for Jindiress (max. DMP = approx. 1.67 max. GAI) and for Brida (max. DMP = approx. 1.45 GAI) suggest that a reduction in the efficiency of conversion of intercepted radiation into dry matter may have occurred.

EVAPOTRANSPIRATION AND WATER USE EFFICIENCY. Accumulated evapotranspiration data for selected dates are presented in Table 17. Evapotranspiration and evaporation from bare soil were similar until mid-March. Thus growth of the winter planted crop up to that date was "free" in terms of moisture use when compared with the traditional spring sown crop.

***Table 17.* Accumulated water use by spring and winter planted chickpea at three locations in northern Syria (mm. germination-maturity).**

Jindiress

Treatment	22/1	4/2	5/3	8/4	11/5	1/6	14/6	Maturity date	Total Et. Germ.→Mat.	WUE [1]	WUE [2]
ILC 72 (Dense)[3]	89	99	142	231	390	443	454	3/6/81	445	18.83	7.28
ILC 72	93	106	145	225	379	449	455	4/6/81	450	14.80	5.93
ILC 482	94	104	139	221	377	424	428	25/5/81	422	18.75	9.95
ILC 482[5]	93	107	145	204	294	384	413	14/6/81	413	7.97	4.55
E_0	91	119	185	324	496	617	744	—	—	—	—
Rainfall[4]	237	274	338	401	456	456	456	—	—	—	—

Tel Hadya

Treatment	13/1	29/1	1/3	13/4	19/5	2/6	11/6	Maturity date	Total Et. Germ.→Mat.	WUE [1]	WUE [2]
ILC 72 (Dense)[3]	48	71	110	189	299	317	319	3/6/81	317	12.21	4.35
ILC 72	51	73	108	180	296	313	316	1/6/81	311	10.16	4.28
ILC 482	52	74	108	173	299	311	311	25/5/81	311	11.42	6.73
ILC 482[5]	52	71	109	154	251	290	300	8/6/81	297	5.25	2.69
E_0	59	82	158	350	623	775	989	—	—	—	—
Rainfall[4]	158	189	247	305	351	357	357	—	—	—	—

Brida

Treatment	20/1	8/2	3/3	2/4	7/5	21/5	9/6	Maturity date	Total Et. Germ.→Mat.	WUE [1]	WUE [2]
ILC 72 (Dense)[3]	34	57	82	153	233	253	262	9/6/81	262	8.13	1.07
ILC 72	35	57	80	150	224	247	256	9/6/81	256	6.21	1.21
ILC 482	34	56	77	147	226	250	257	22/5/81	252	9.37	3.97
ILC 482[5]	37	58	82	130	207	236	249	5/6/81	246	5.57	3.01
E_0	61	100	148	268	478	583	786	—	—	—	—
Rainfall[4]	115	125	174	223	274	277	277	—	—	—	—

[1]WUE = kg/ha/mm. Total biological yield (above ground).
[2]WUE = kg/ha/mm. Seed yield.
[3]= Stand density approximately 600,000 pl/ha.
[4]= Rainfall accumulated from onset of season.
[5]= Spring sown crop from companion experiment.

Total moisture use at maturity was found to be largely comparable under all treatments but spring-sown crops used their moisture at a later date.

The water use efficiency of both total dry matter and seed production was calculated in terms of kg/ha/mm of moisture used (Table 17). Considering the water use efficiency of total dry matter production, the densely planted ILC 72 and winter sown ILC 482 treatments achieved very similar WUE values at any given site, but were higher than the standard density ILC 72 treatments. All winter sown crops achieved much greater WUE values than spring sown crops, particularly at the two wettest sites (Jindiress and Tel Hadya).

In terms of seed yield, winter planting of ILC 482 gave a far higher water use efficiency than spring planting, resulting in 119, 150 and 32% increases in WUE at Jindiress, Tel Hadya and Brida respectively. The spreading cultivar (ILC 482) gave a consistently better WUE than the erect types at all sites.

Water use efficiency decreased from the wettest to the driest site. This was associated with poor canopy development at the drier sites where more water was lost as evaporation.

DEPTH OF MOISTURE EXTRACTION BY CHICKPEA. In traditional chickpea growing areas, chickpea crops usually follow wheat in the three course rotation system of wheat-grain legume (lentil or chickpea)-summer crop. At Jindiress and Tel Hadya, the trial was planted within this rotation, but at Brida, the land was fallow in the previous season. Only soil depth intervals recharged by current rainfall contain moisture which is available for uptake by the chickpea crop.

Figure 8 shows the distribution of soil moisture during profile recharge and discharge for winter sown ILC 482 at the three sites. It is clear that the chickpea crop was only able to extract moisture from the soil profile from depth intervals which had been recharged by the 1980-81 season's rainfall. The results in Figure 8 are the

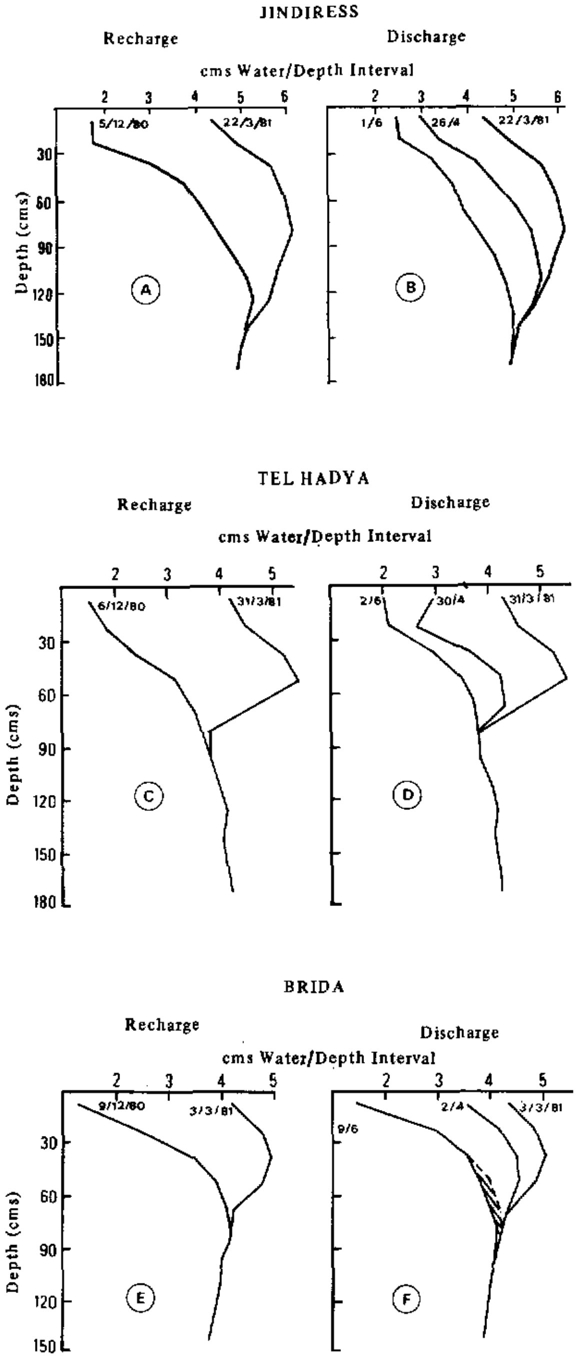


Fig. 8. Soil moisture recharge and discharge patterns under winter sown chickpeas (var. ILC 482) at three locations in Northern Syria.

mean of four replicates, but examination of individual replicates indicated that there was a large variation in depth of profile recharge between replicates. This resulted in parallel variations in the maximum depth of observed moisture extraction. Such a variation in depth of profile recharge was caused by differences in the initial moisture status of the profile. This within-treatment variation in depth of moisture extraction was greatest at Jindiress but also occurred to a lesser extent at Tel Hadya and Brida.

It is interesting to note that a similar trend occurred at Brida, where the chickpea crop followed a fallow (Fig. 8.e and f). This indicates that in the fallow there was very little additional moisture stored which was available for the chickpea crop. In Figure 8.f, the dotted line represents the moisture status of the start of the season, and thus the shaded area represents moisture (6 mm only) stored under the fallow which was available for uptake by the crop.

At the two driest sites, Tel Hadya and Brida, the re-charge front did not extend beyond 90 and 75 cm respectively (Fig. 8.c, d, e, f) and thus the rooting depth of the crop was greatly restricted compared with Jindiress. Where root development was not restricted by the depth of the recharge front (as at Jindiress), the winter sown crop developed a deeper rooting system than the spring sown crop. This is illustrated by careful examination of the temporal distribution of moisture in discrete soil layers (Fig. 9). Particular attention is paid to the period of crop maturity, when a clear discontinuity in the slope of the line indicates that root uptake of moisture has ceased. Such depths are marked with arrows.

YIELD AND YIELD COMPONENTS. The potential productivity of winter chickpeas in northern Syria appears to be high under favorable environmental conditions such as those at Jindiress (Table 18). Seed yields of 3 to 4 t/ha at current local prices would ensure a considerable profit to the grower. However, it is clear from the data in Table 18 that environmental conditions have a significant effect on yield and that cultivar and genotype/environment interactions combine to influence productivity levels.

STRESS FACTORS ASSOCIATED WITH INADEQUATE MOISTURE SUPPLY. The yield of individual cultivars in Table 18 shows that a reduction in the total season's rainfall from 456 mm to 277 mm reduced seed yield con-

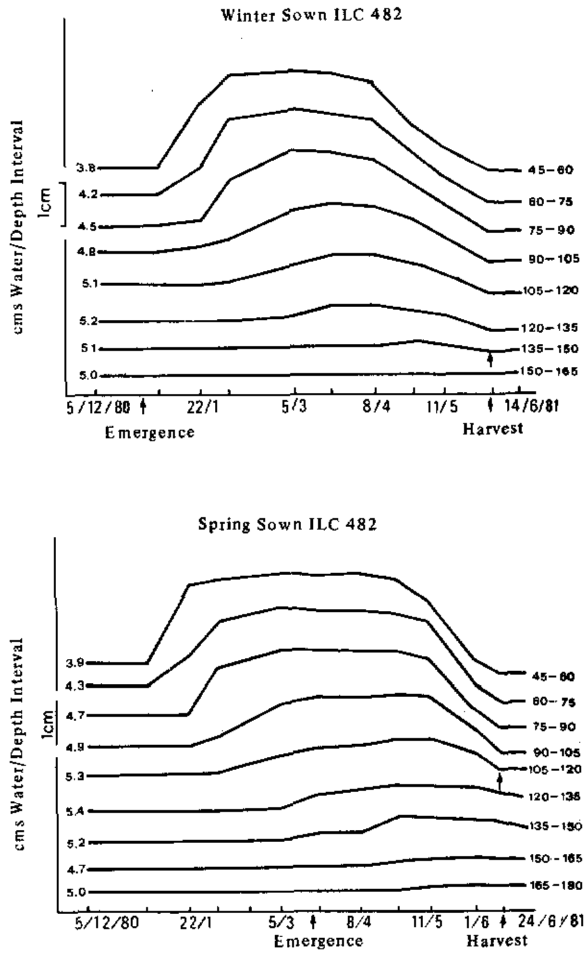


Fig. 9. Temporal distribution of moisture within discrete soil horizons under winter and spring sown chickpeas at Jindiress.

Table 18. **Productivity of winter sown chickpeas.**

Site	Seed[2] yield (t/ha)	Total above ground dry matter at harvest (t/ha)	Harvest index	100 seed weight (gm)	Number pods per plant	% empty pods
Jindiress						
ILC 482	4.20	7.91	0.531	24.7	72.6	17.2
ILC 72	2.67	6.66	0.401	25.0	44.7	22.5
ILC 72 (Dense)[1]	3.24	8.38	0.387	25.7	24.9	21.5
ILC 482[3]	1.88	3.29	0.571	23.4	31.1	22.4
Tel Hadya						
ILC 482	2.09	3.55	0.589	27.0	27.6	4.6
ILC 72	1.33	3.16	0.421	25.5	17.0	12.7
ILC 72 (Dense)[1]	1.38	3.87	0.357	25.7	9.3	13.2
ILC 482[3]	0.80	1.56	0.512	23.2	17.1	17.5
Brida						
ILC 482	1.00	2.36	0.424	28.1	13.7	6.7
ILC 72	0.31	1.59	0.195	20.5	9.6	46.4
ILC 72 (Dense)[1]	0.28	2.13	0.131	17.3	5.6	51.9
ILC 482[3]	0.74	1.37	0.540	19.2	17.1	20.1

[1]= *Stand density approximately 600,000 pl/ha.*
[2]= *Seed yields adjusted for minor insect damage.*
[3]= *Spring sown crop from companion experiment.*

siderably. Two mechanisms appear to be prominent in causing this yield reduction.

(1) It was shown in Table 16 that maximum canopy development was severely affected by location and that complete cover was only achieved at Jindiress. This implies directly that the proportion of incident radiant energy intercepted was reduced and total dry matter production was thus lower at the two drier sites. The reduced canopy development may have been due to the crop's inability to meet a short term atmospheric demand for moisture. This would have resulted in decrease in photosynthetic activity. Alternatively, the decreasing moisture content of the surface soil may have forced the crop to draw water from deeper soil deficient in essential nutients. This may have caused nutrient stress. It is likely that both effects occurred simultaneously, the net result being a reduction in the size of the crop's pod bearing structure and in the level of stored photosynthate available for pod filling. The influence of both effects is implicit in the water use efficiency values which were shown above to be severely reduced at the drier locations.

(2) The early maturing characteristic will generally give ILC 482 a yield advantage over ILC 72 under the Mediterranean environmental conditions of northern Syria for two reasons. Firstly, early maturity is achieved without a reduction in the duration of the reproductive phase which is critical in a crop with a potentially indeterminate growth habit. Secondly, as evaporative demand increases significantly in the late spring and early summer (the period of crop reproductive development), an early maturing cultivar is exposed to less extreme moisture stress which occurs at a late stage in its phenological development.

The beneficial effect of the early maturing characteristic on seed yield was most clearly demonstrated at Brida where seed yields of ILC 72 were reduced below the values expected from the maximum dry matter production achieved (Table 18). This is illustrated by the atypical harvest index values shown by both density treatments. The probable cause of the low seed yield seems to have been flower and seed abortion induced by moisture stress. This stress appears to have been above critical values during the sensitive flowering and early pod formation phase.

Winter sown ILC 482 appears to have been less affected by this stress. It retained a higher number of pods per plant and managed to fill amost all the pods set which was clearly not the case with ILC 72 (Table 18). However, the reduction in harvest index in winter sown ILC 482 at Brida, from the values of more than 0.5 at the other two sites, suggests that a 20% yield reduction occurred even in this cultivar from stresses experienced in the reproductive phase of development.

In ILC 72, the data for 100 seed weight further suggests that moisture stress effects at Brida restricted the filling of pods from either concurrently derived or translocated photosynthate. As this was not the case in winter sown ILC 482 it appears to be further evidence of the benefit of early maturity which allows escape from the most severe effects of moisture stress.

MORPHOLOGICAL AND CROP DENSITY FACTORS. The results given in Table 18 show that, under favorable (Jindiress) or intermediate (Tel Hadya) environmental conditions the erect type of chickpea (ILC 72), when winter sown at 30 plants/m^2, was less productive than the spreading type (ILC 482) in terms of both dry matter and seed yield. This was more pronounced for seed yield, and it appears that although the development of a tall stem structure may reduce canopy size (Table 16), it also has an effect in reducing the conversion efficiency of dry matter to seed yield. This was evident from harvest index values for the erect cultivar close to 0.41 as compared to values close to 0.55 for the winter sown spreading cultivar. This reduced efficiency of dry matter conversion to seed yields is evident in the yield results for the densely planted treatment (60 pl/m^2).

Table 18 shows that increased density of ILC 72 gave comparable or higher dry matter production than ILC 482 but the seed yield of ILC 72 was consistently lower. Harvest index was apparently reduced by increased density of ILC 72 thereby exaggerating the difference between cultivars. This suggests that increasing planting density in erect cultivars may not necessarily be an efficient way to increase yield, but it is clear that erect cultivars would give better yields at higher plant populations at the standard density (30 plants/m^2) when moisture conditions are favorable (Table 18).

CONCLUSION. It has been shown that winter planting of chickpea crops in the wetter regions of northern Syria is likely to be very productive. Even at the drier sites, such as Brida, where chickpeas are not currently grown, at current market prices this crop would be competitive with the traditionally grown barley. Nevertheless, the data suggest that chickpeas are sensitive to moisture stress which could lead to greater instability of yield and farmer income than that associated with barley.

Rotation Trials at Brida and Khanasser

Both these locations are situated in zones where barley is commonly grown. The traditional rotation in such areas of N. Syria is barley fallow. During the past 20 years, however, continuous barley is being more commonly grown, and a general decline in yield is observed. Other studies have indicated that in these dry areas (< 300 mm) little if any storage of water in the fallow years is achieved by farmers, but nutrient availability (particularly nitrogen) increases. This rotation trial has been laid down to investigate the long term effect of alternative two course rotations on crop yield and soil conditions. The basic rotations examined are: barley/fallow, barley/barley, barley/vetch forage, barley/lentil, and barley/winter chickpea. Different levels of fertilizer management are imposed on these rotations. A phased entry randomized block design with three replications is used.

As an integral part of this study on the barley/fallow rotation, additional detailed studies were conducted on moisture conservation under fallow land.

During previous years, moisture studies were conducted on barley crops grown under different management practices in the 250–300 mm rainfall zone, and the results of these moisture studies to date clearly show that no moisture conservation occurred during the fallow period for subsequent use by the barley crop. However, this observation was made on fallows managed according to farmers' practice and there appeared to be two major factors contributing to the lack of moisture storage:

(1) In these areas the rainfall seldom penetrated to below 75 to 90 cm depth making moisture conservation difficult.

(2) In general the fallow land is only cultivated once in the spring (and possibly again in the summer) with a single or double bank of duckfoot cultivators. The resultant "mulch" is cloddy, ridged, and often shallow and by no means ideal for conserving moisture under these difficult conditions.

During the 1980/81 season, moisture studies were conducted on fallow land at Tel Hadya, Brida, and Khanasser. In these studies, it was decided to assess potential moisture storage under the different rainfall levels by applying what was judged to be an optimum soil mulch rather than a farmer's normal mulching practice. This was achieved using a hand operated rotavator which produced a fine, level tilth about 20 cm deep. This was applied in mid-April and thereafter the plots were hand-weeded where necessary throughout the summer. Two moisture accession tubes were placed in each fallow plot, and the plots were replicated three times and randomly distributed within a major cereal agronomy study at each location. Moisture measurements were made with a neutron probe at 15 cm depth intervals throughout the season to a maximum depth of 180 cm at Tel Hadya and 150 cm at Brida and Khanasser.

At Tel Hadya soil moisture tensiometers were installed in each replicate at 15 cm depth intervals to a depth of 135 cm and were read twice a week during the summer.

RESULTS. At both locations the land used in these trials was under fallow during the preceeding two years, thus no "rotational" effects could be observed in the first year. The yield data, water use and water use efficiencies of the crops for the first year are presented in Table 19.

At both sites the addition of 60 kg/ha P_2O_5 advanced the maturity of barley by nine days. This reduction in length of the growing season offset the increased moisture use during vegetative growth resulting in no increase in moisture use following fertilizer application. At Brida, where late rains were used by the immature nonfertilized crop, but not by the mature fertilized crop, moisture use was reduced by the application of phosphorus.

At both sites there was a large yield response to fertilizer application, both in barley (nitrogen and phosphorus) and the vetch/barley mixture (phosphorus only).

Water use efficiencies were dramatically increased by the application of fertilizer in the barley and vetch/barley crops and were quite similar at the two sites. Water use efficiencies of lentil and chickpea were considerably lower than barley and barley/vetch.

Winter chickpeas at Brida gave a more profitable return than barley. Assuming a market price of 0.65 SL/kg for barley and 3.60 SL/kg for chickpeas, the water use efficiency of chickpeas can be expressed as 11.51 SL/ha/mm compared with 5.55 SL/ha/mm for fertilized barley. This simple economic expression does not allow for differential costs of crop management.

Moisture Conservation Under Fallow Land

The results of this study are summarized and presented in Figures 10 and 11. In Figure 10,

Table 19. **Yield data, water use, and water use efficiencies of various crops grown in rotational trials at two sites.**

Treatment	Grain yield (kg/ha)	Total biol. yield (kg/ha)	Evapo-transpiration (germ-maturity)	WUE (1) (kg/ha/mm)	WUE (2) (kg/ha/mm)
		Brida	(mm)		
Barley (0N 0P)	1346	2770	242	5.56	11.44
Barley (60N 60P)	1949	4501	228	8.55	19.74
Vetch/barley (0N 0P)	—	2130	185	—	11.51
Vetch/barley (0N 60P)	—	3330	192	—	17.34
Winter chickpea (60P)	790	1603	247	3.20	6.49
Lentil (60P)	615	1741	232	2.65	7.50
		Khanasser			
Barley (0N 0P)	951	2426	211	4.51	11.50
Barley (20N 60P)	1540	3969	211	7.30	18.81
Vetch/barley (0N 0P)	—	1649	165	—	9.99
Vetch/barley (0N 60P)	—	2935	181	—	16.21
Winter chickpea (60P)	340	963	207	1.64	4.65
Lentil (60P)	431	1604	206	2.09	7.79

(1) Seed yield.
(2) Total biological yield.

the moisture distribution on the following three dates is given for each location:

(1) At the start of the season (dotted line).

(2) At maximum profile recharge (in March/April 1981).

(3) At the end of the summer period. The shaded area represents the moisture stored.

At no location was moisture stored in the 0–15 cm horizon. The amount of moisture stored (whether expressed as a total or as a percentage of winter rainfall) was related to the rainfall received and the depth of penetration of that rainfall. At both Tel Hadya and Brida there was a downwards re-distribution of moisture at depth by slow drainage during the summer months.

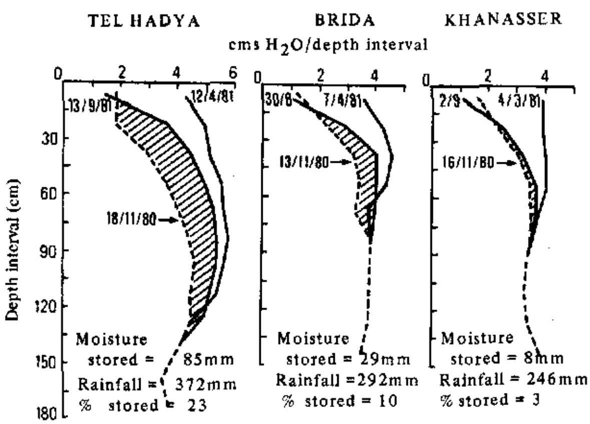


Fig. 10. Moisture loss under fallow during the summer months of 1981 at three locations.

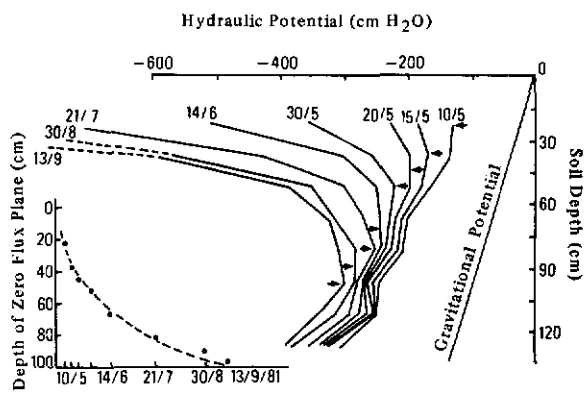


Fig. 11. Variation of hydraulic potential with soil depth and the variation in depth of zero flux plane through the summer months of 1981 under fallow at Tel Hadya.

Significant moisture loss occurred, by upward movement and subsequent evaporation, to a depth of at least 60 cm at each location. Figure 11 shows the vertical distribution of the hydraulic potential in the fallow at Tel Hadya for selected dates during the summer.

When the hydraulic potential in one soil layer becomes lower than the layer immediately below it, moisture moves upwards from the deeper layer in response to the hydraulic gradient. The depth at which the hydraulic gradient is zero is defined as the Zero Flux Plane (ZFP) (marked with arrows in Fig. 11). Above the ZFP moisture moves upwards and is lost by surface evaporation; below the ZFP moisture movement is by downward drainage.

On May 10, 1981, all movements of water below the 15–30 cm horizon was downwards as slow drainage, but as the summer progressed the depth from which moisture was lost increased. By the end of summer (September 13) moisture was being lost by upward movement and surface evaporation from as deep as 90–105 cm. The change in depth of the ZFP with time is given in the inset in Figure 11. The slow drainage that occurred during the summer months at Tel Hadya is confirmed by the moisture distribution patterns where it can be seen that moisture accumulation occurred in the 120–135 cm horizon between April 12 and September 13.

Livestock Studies

The livestock studies in the Farming Systems Program are designed to identify problem areas and suggest solutions relevant to the regional farming community and to ICARDA's research programs.

The survey of livestock systems in the steppe region of SE Aleppo Province, where annual rainfall averages 200 mm and below, ended in September 1981 after three seasons. Two highlights from a preliminary analysis of the survey are presented.

SUPLEMENTARY FEEDING OF STEPPE-BASED FLOCKS. One finding of the survey was the apparent high dependency of steppe-based flocks on supplementary feed (barley, cotton-seed-cake, wheat bran, and straw) from November until March (Table 20). Feeding of supplements started over 20 years ago following a series of drought years that severely reduced the size of the national flock. The practice was initiated with Government backing in an effort to strengthen the nutritional basis of the sheep industry.

***Table 20.* Intake of metabolizable energy as supplementary feed of 15 steppe flocks relative to metabolizable energy requirements (1978–81).**

	Season of survey:	78/79	79/80	80/81
Suppl. feed as percentage of requirement[1]		163	98	144
–as barley	%	35	21	57
–as cereal straw	%	76	37	25
–as sugar beet pulp	%	—	22	31
–other supplements	%	52	18	31

[1]From November until March mean daily metabolizable energy required equals 9.6 MJ for 45 kg ewe producing 65 kg milk per lactation and having a single lamb.

According to Government statistics, sheep numbers recovered from about 3 million in 1961 to between 5 and 6 million from 1964 to 1973. Since then they have increased dramatically to 8.1 million in 1979. The introduction of supplementary feeding probably helped to generate the initial recovery. Preliminary analysis shows that supplementary feed covered all the metabolizable energy needs of the pregnant and lactating ewes in the sample in the dry 1978–79 season (Table 20). This feeding practice therefore paralleled an increase in sheep numbers even in a dry year. The policy of providing supplementary feed to farmers who are members of the cooperatives may therefore have exceeded its objective of stabilizing sheep numbers and may have been responsible for the recent expansion in numbers.

Grazing wheat stubble in a three course rotation trial at Tel Hadya, Syria.

One consequence of the expansion in sheep numbers is that problems of over-grazing may be aggravated.

UTILIZATION OF CEREAL STUBBLE BY SHEEP. Barley, and to a lesser extent wheat, are major components of the diet of sheep in the ICARDA region, whether as grain, stubble, or straw. Stubbles make an important contribution to sheep production in Syria by relieving grazing pressure on range and steppe areas, and providing a source of low cost feed in the summer. Flushing of ewes on good quality stubbles is possible.

Results from the livestock survey show that stubbles are rented for grazing from May until August at 0 to 75 SL/ha in poor years and up to about 25 SL/ha at other times. Standing crops can cost from 100 to 200 SL/ha. In good years, only a small area of standing crop is left for grazing so that stubbles provide a relatively larger part of the sheep diet. Cereal straw also represents from 25% to 50% of the supplementary feed dry matter given to sheep in winter, the level being largely dependent on the rainfall which affects the availability of natural grazing.

Preliminary results obtained at Tel Hadya indicate the liveweight changes of ewes grazing cereal stubbles. Non-supplemented and supplemented sheep grazed the cereal stubbles on the traditional and improved unit farms respectively. The supplemented flock received extra feed in order to study the effect of liveweight changes on conception rates. The results are shown in Table 21. The supplemented ewes gained 83 g/day even at a 30% higher stocking rate.

ON-SITE STUDIES. The on-site livestock studies at Tel Hadya in 1981 were divided into two closely integrated projects. One project addressed the question of the interaction between nutrition and fertility, and the second was a study of the possibility of increasing animal production within a cropping framework by improving husbandry practices and introducing forage crops. Two of the three flocks of sheep

Table 21. **Stocking rates and average daily gain of non-supplemented and supplemented sheep grazing stubbles at Tel Hadya (1981).**

	Non-suuple-mented sheep	Supple-mented sheep
Area (ha)	5.4	4.1
No. sheep[1]	52	51
Days of measurement	42	42
Stocking rate (ewes/ha)	9.6	12.4
Average daily gain (g)	−31	83

[1]Including some yearling lambs which are expressed as ewe equivalents.

used in the first project were attached to the unit farms used in the second project.

NUTRITIONAL-REPRODUCTIVE INTERACTION. Under and imbalanced nutrition are responsible for reduced fertility in sheep. It was demonstrated at Tel Hadya in the 1980–81 winter lambing season that lambing percentages of village and steppe based flocks are lower than the potential of the Awassi breed. Farm income could be markedly increased if the potential prolificacy of the breed were better exploited. A long term project was initiated in June 1981 to study more closely simple husbandry strategies which will allow improvements in ewe fertility.

Preliminary results (Table 22) indicate that during the premating phase, cycling activity of ewes in body weight stasis (but which are grazing rangeland) was higher than for ewes gaining 89 g daily, grazing stubble and receiving a barley grain/vetch hay supplement. However, liveweight-losing ewes, fed on stubbles alone, showed reduced cycling activity. This result suggests that dietary composition may be as significant a factor affecting ewe reproductive mechanisms (and therefore fertility) as body condition.

During the mating phase which started on July 20 and continued for 42 days, the flock fed on cereal stubbles alone gained nearly as much body weight as the supplemented flock. But the conception rate of the two flocks differed markedly. The poorly husbanded flock showed no increase in body weight but showed a similar conception rate as the supplemented flock. It is

Table 22. **Daily liveweight changes and conception rates during 1981 mating season.**

		Level of flock husbandry		
		Poor	Average	Good
Flock size		39	38	39
Feeding regime		Rangeland	Cereal stubble	Cereal stubble + supplements
Premating phase				
Liveweight change	g/d	−1	−24	89
Oestrus cycles per ewe (max. value = 2.5)[1]		0.87	0.26	0.51
Mating phase				
Liveweight change	g/d	−1	153	162
Conception rate at first mating	%	74	34	79
Conception rate at second mating	%	18	58	13
Conception rate at third mating	%	3	5	3
Non-pregnant	%	5	2	5

[1]Vasectomized rams with ewes from June 8 until July 20, i.e., 42 days or about 2.5 oestrus cycles.

suggested that the intensity of cycling activity in the pre-mating phase was a more important factor affecting conception rates at first mating than was liveweight gain during the mating phase.

UNIT FARMS. These farms provide a useful cropping foundation for assessing the impact of improved sheep husbandry practices on whole farm productivity. Of particular interest is the effect on net revenue of introducing forages into the farming system in place of lentils and fallow. This change makes possible an increase in the stocking rate on the improved unit farm. Table 23 shows the net revenue of the crops in the 1979/80 and 1980/81 seasons.

There was a low revenue from lentils compared with wheat and barley. Watermelon appears to be an unprofitable crop, even when yields are high as in the 1980/81 season. The poor performance of forage hay in the 1980/81 season was due to low yields. But averaged over two years, forage hay gave a considerably higher new revenue than lentils.

The net revenues from forage for grazing by growing lambs indicate the potential of this practice which is designed to replace fallow in areas with shallow and/or stony soils. The large annual differences in net revenue of forage for grazing is the result of two factors. Firstly, there was a poor crop and therefore a short grazing season of one month in the 1979/80 season, compared with two months in the 1980/81 season. The liveweight yields were 138 and 232 kg/ha in 1979/80 and 1980–81, respectively. Secondly, meat prices per kg liveweight increased by 43% in 12 months from one season to the next.

Introducing improved varieties, agronomic practices, and forages into the crop rotation considerably increased net revenue of the two unit farms. The improvement was small in 1980/81 because of the poor yield of the forage hay.

The unit farms provide a framework for testing novel types of forage crops and the problems of grazing or conserving them. New and promising varieties of cereals and food legumes can also be tested under cultural practices closely similar to the real farm situation.

Socio-economic Research

A study of sheep cooperatives in Syria was conducted in cooperation with the Ministry of Agriculture and Agrarian Reform (MAAR) for the World Bank (Bank for International Reconstruction and Development). The principal objective of this study was to make recommendations to the National Feed Revolving Fund (NFRF) on the allocation of credit for feed purchase and the determination of interest rates to be charged on that credit.

Table 23. **Crop net revenues on the unit farms (SL/ha)[1].**

	Traditional unit		Improved unit	
	1979/80	1980/81	1979/80	1980/81
Area (ha)	14.1	14.1	10.9	10.9
Stocking rate (sheep per cultivated ha)	—	2.3	—	3.0
Wheat	644	1077	1392	1642
Barley	352	941	621	1189
Lentils	459	142	—	—
Melon	−12	148	−38	299
Forage (for hay)	—	—	1345	312
Forage (for grazing)	—	—	754	2137
MEAN VALUE[2]	311	577	840	1536

[1]SL: Syrian Lira.
[2]Excludes forage for grazing.

In the 1978/79 season, a survey of cooperative members was conducted to gain insights that would help achieve this objective. A questionnaire was given to the heads of 51 range and sheep cooperatives and 45 fattening cooperatives and a second questionnaire to 132 individual cooperative members.

RESULTS. The main findings of the study relevant to interest rates and preferential treatment were:

(1) The two sub-sectors—range and sheep cooperatives and fattening cooperatives—are characterized by extreme variability in animal numbers, production practices, animal productivity, and family income, both among cooperatives and among members. (Table 24).

(2) An accurate measurement of production parameters is difficult and estimating income even more difficult; neither is a practical measure to use in allocating preferential interest rates.

(3) Feed prices are subsidized by the Government Organization of Feed (GOF) to such an extent that interest rates in the 5½% to 7½% range would play no role in allocating scarce credit and/or scarce feed (Table 25).

(4) The difference of two percentage points for interest rates, which was suggested in the project appraisal as a way to equalize incomes among cooperative members, amounts to a very small amount of money in proportion to total operating costs. Such a difference would have little effect in distributing incomes more equally in the sheep sub-sector (Table 26).

(5) In the case of the range and sheep cooperatives, the study did not clearly identify

***Table 24.* Significant variables relating to net income from sheep fattening.**

	Winter batch	Summer batch	Pooled
	(Linear Regression Estimates)		
Dependent variable:			
1. Net income			
Independent variables:			
1. Lamb price differences Sales price/kg—purchase price/kg	41.938**	31.598**	40.013**
	(62.6)[1]	(152.3)	(212.5)
2. Weight gain	7.467**	7.691**	7.786**
	(53.6)	(233.5)	(208.1)
3. Feed cost/day	-103.372**	-86.335**	-91.467**
	(55.8)	(133.2)	(159.8)
4. Percent of members with share arrangements	- 14.182	0.765	6.983
	(1.27)	(0.018)	(1.087)
5. Percent of members that own land	- 12.688	9.8941	—
	(0.989)	(2.124)	—
6. Percent of income earned of farm	- 14.759	- 3.958	- 7.905
	(0.421)	(0.234)	(0.524)
7. Average batch size	0.050	- 0.340	—
	(0.359)	(0.724)	—
8. Number of members in coop	- 0.019	0.035	0.019
	(0.048)	(0.601)	(0.192)
Constant term	36.479	- 9.618	5.547
R^2	85.9	91.5	91.8
F	26.67	47.35	72.72
n	44	44	88

***Significant p ≤ 001.*
[1]F Value given in parentheses.

Table 25. **Feed price differences between GOF and the market (1978/79).**

	Price (kg)		Price ratios
	Market	GOF	Price MKT/Price GOF
Cotton seed hull	.728	.342	212.9
Wheat bran	.444	.232	191.9
Barley	.678	.574	118.1
Cotton seed cake	.840	.623	134.8

determinants of production costs or revenue. Thus, there are no obvious variables that would help in deciding who should receive preferential interest rates.

(6) For fattening cooperatives, it was easier to explain revenue levels, but only one of the variables—animal number—is directly related to the question of preferential treatment.

(7) Existing credit sources are complex and oriented toward profit (and risk) sharing rather than simple cash loans for interest.

(8) The study was not successful in estimating the current private market rate for financial loans and only partially successful in determining the supply of credit from private sources.

(9) Cash requirements, particularly in fattening crops, are significantly higher for animal purchases in comparison to feed purchases, and the lack of credit to finance these larger purchases is likely to be a constraint to improving the productivity and stability of the system (Table 26).

(10) Feed conversion ratios indicate that there is a tremendous opportunity for increasing efficiency (Table 27).

(11) Not all animals owned by members are registered with the cooperatives.

(12) Income from sources other than sheep production can be important, particularly in the fattening cooperative sub-sector.

(13) Stabilizing total intra-and inter-annual feed availability and thus stabilizing animal numbers is more important than an increase in the availability of supplemental feeds.

(14) Concentrating on the interface between the two cooperative sub-sectors may be the best way for the Ministry of Agriculture and Agrarian Reform to solve the major problem of instable animal production and producer incomes.

Table 26. **Income and expense statement 1978/79 in Syrian Lira per head (Fattening Cooperatives).**

	Winter batch	Summer batch
Incomes		
Sales	459.45	330.51
Less purchases	307.36	222.01
TOTAL INCOME	152.09	108.50
Expenses		
Barley	55.80	45.52
Cotton seed cake	11.89	11.89
Wheat bran	2.91	2.52
Vetch	9.15	7.57
Wheat	9.18	6.03
Minerals: fish oil	17.00	3.80
Salt	.24	.22
Roughage: legume straw	10.48	5.82
cotton seed hull	6.06	5.61
TOTAL COSTS	122.66	87.50
Net returns to other factors	29.4	21.00
Average daily cost of feed per head 90 days fattening	1.36	0.97

Table 27. **Feed consumption and conversion ratios per head.**

	Winter batch	Summer batch
	Quantity (kg)	Quantity (kg)
Barley	97.84	81.52
Cotton seed cake	19.09	18.05
Wheat	12.59	9.05
Vetch	11.48	10.38
Wheat bran	12.45	11.09
SUB-TOTAL	153.45	130.09
Legume straw	20.75	16.22
Cotton seed hull	16.16	14.06
Fish oil	3.57	.78
Salt	.57	.59
TOTAL	194.50	161.74
Weight gain	16.80	15.56
Conversion ratio, concentrate	1:9.13	1:8.36
Conversion ratio, total	1:11.58	1:10.39

It was recommended that a single interest rate be charged to all producers requiring credit to purchase feeds and that other measures be considered to equalize incomes. Also it was thought that other schemes would be either impractical or ineffective. The project appraisal's suggestion of giving preferential rates to families with annual incomes less than 3,500 SL is a good example. It is impractical because of the difficulty of calculating such a figure and would be very expensive to administer.

The results of this research have been accepted by the Bank and the Ministry of Agriculture and Agrarian Reform. The single interest rate has already been put into effect in administering the credit scheme of the Project. In addition, a number of other results have generated interest and discussion.

Meteorological Data

***Table 1.* Summary of meteorological data from ICARDA's Tel Hadya Research Station during the 1980/81 cropping season through to the end of the 1981 calendar year.**

Location: Longitude 36°55′ E; Latitude 36°00′ N; Altitude 282.0m a.s.l.

Month	Air temp. °C Max.	Air temp. °C Min.	Average soil temp. °C (20 cm depth)	Average evap. Class A (mm/day)	Total precip. (mm)	Average relative humidity (%)	Average wind run (km/day)	Average sunshine (h/day)	Average radiation (MJ/m²/day)
Oct.	28.0	12.7	23.4	7.02	10.6	50.0	153.9	8.10	13.71
Nov.	20.6	6.8	16.8	2.74	17.4	62.4	126.5	6.40	10.13
Dec.	13.9	3.4	11.0	1.90	93.0	71.5	118.6	4.10	7.17
Jan.	11.7	3.7	9.3	1.50	69.8	81.2	228.7	2.99	6.70
Feb.	14.1	2.8	10.0	2.43	55.3	72.8	240.0	4.12	9.50
March	18.6	6.3	12.8	4.04	51.8	71.0	279.0	6.00	13.93
April	22.6	6.9	15.9	6.62	27.1	58.0	288.2	7.43	19.30
May	26.7	9.6	20.9	8.40	31.9	53.5	269.4	9.81	22.27
June	34.4	17.2	26.4	14.83	14.8	44.0	376.5	11.84	24.67
July	37.4	20.0	28.9	16.60	—	41.8	441.9	12.13	24.70
Aug.	36.6	20.8	29.7	15.76	—	47.0	481.0	11.62	22.29
Sep.	35.5	16.4	28.4	12.03	—	38.0	307.7	10.15	18.40
Oct.	29.9	12.2	24.3	7.15	4.6	43.0	179.8	8.49	14.00
Nov.	17.1	4.6	15.5	2.60	69.4	65.0	201.3	5.62	8.86
Dec.	14.4	5.2	12.0	1.39	53.4	77.4	186.2	3.80	6.53

***Table 2.* Summary of meteorological data for Tel Hadya and four major off-station sites in Aleppo Province, Syria, in the crop season 1980/81.**

Climatic variable	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Seasonal *total*	Long term *average*
Mean Air Temperature °C											
Jindiress	20.0	13.7	8.4	7.8	8.6	13.0	15.1	18.6	25.3		
Kafr Antoon	19.0	11.0	5.1	4.6	5.9	10.2	13.2	16.3	24.3		
Tel Hadya	20.4	13.7	8.7	7.7	8.5	12.5	14.8	18.2	25.5		
Brida	18.3	12.5	6.3	6.8	8.7	12.3	15.1	19.1	26.4		
Khanasser	16.7	11.6	6.2	6.3	7.4	13.3	16.1	20.1	28.1		
Precipitation mm											
Jindiress	11.2	15.6	91.4	151.5	58.9	49.1	41.0	35.0	18.0	472	479
Kafr Antoon	8.6	20.0	85.4	112.6	68.4	65.4	41.2	27.6	37.8	467	444
Tel Hadya	10.6	17.4	93.0	69.8	55.3	51.8	27.5	31.9	14.8	333	342
Brida	8.6	6.2	70.8	39.3	48.6	49.0	22.0	32.4	15.0	292	278
Khanasser	9.8	3.2	72.0	50.6	39.1	34.5	18.0	14.8	4.0	246	215.4

It was recommended that a single interest rate be charged to all producers requiring credit to purchase feeds and that other measures be considered to equalize incomes. Also it was thought that other schemes would be either impractical or ineffective. The project appraisal's suggestion of giving preferential rates to families with annual incomes less than 3,500 SL is a good example. It is impractical because of the difficulty of calculating such a figure and would be very expensive to administer.

The results of this research have been accepted by the Bank and the Ministry of Agriculture and Agrarian Reform. The single interest rate has already been put into effect in administering the credit scheme of the Project. In addition, a number of other results have generated interest and discussion.

Meteorological Data

***Table 1.* Summary of meteorological data from ICARDA's Tel Hadya Research Station during the 1980/81 cropping season through to the end of the 1981 calendar year.**

Location: Longitude 36°55′ E; Latitude 36°00′ N; Altitude 282.0m a.s.l.

Month	Air temp. °C Max.	Air temp. °C Min.	Average soil temp. °C (20 cm depth)	Average evap. Class A (mm/day)	Total precip. (mm)	Average relative humidity (%)	Average wind run (km/day)	Average sunshine (h/day)	Average radiation (MJ/m²/day)
Oct.	28.0	12.7	23.4	7.02	10.6	50.0	153.9	8.10	13.71
Nov.	20.6	6.8	16.8	2.74	17.4	62.4	126.5	6.40	10.13
Dec.	13.9	3.4	11.0	1.90	93.0	71.5	118.6	4.10	7.17
Jan.	11.7	3.7	9.3	1.50	69.8	81.2	228.7	2.99	6.70
Feb.	14.1	2.8	10.0	2.43	55.3	72.8	240.0	4.12	9.50
March	18.6	6.3	12.8	4.04	51.8	71.0	279.0	6.00	13.93
April	22.6	6.9	15.9	6.62	27.1	58.0	288.2	7.43	19.30
May	26.7	9.6	20.9	8.40	31.9	53.5	269.4	9.81	22.27
June	34.4	17.2	26.4	14.83	14.8	44.0	376.5	11.84	24.67
July	37.4	20.0	28.9	16.60	—	41.8	441.9	12.13	24.70
Aug.	36.6	20.8	29.7	15.76	—	47.0	481.0	11.62	22.29
Sep.	35.5	16.4	28.4	12.03	—	38.0	307.7	10.15	18.40
Oct.	29.9	12.2	24.3	7.15	4.6	43.0	179.8	8.49	14.00
Nov.	17.1	4.6	15.5	2.60	69.4	65.0	201.3	5.62	8.86
Dec.	14.4	5.2	12.0	1.39	53.4	77.4	186.2	3.80	6.53

***Table 2.* Summary of meteorological data for Tel Hadya and four major off-station sites in Aleppo Province, Syria, in the crop season 1980/81.**

Climatic variable	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Seasonal total	Long term average
Mean Air Temperature °C											
Jindiress	20.0	13.7	8.4	7.8	8.6	13.0	15.1	18.6	25.3		
Kafr Antoon	19.0	11.0	5.1	4.6	5.9	10.2	13.2	16.3	24.3		
Tel Hadya	20.4	13.7	8.7	7.7	8.5	12.5	14.8	18.2	25.5		
Brida	18.3	12.5	6.3	6.8	8.7	12.3	15.1	19.1	26.4		
Khanasser	16.7	11.6	6.2	6.3	7.4	13.3	16.1	20.1	28.1		
Precipitation mm											
Jindiress	11.2	15.6	91.4	151.5	58.9	49.1	41.0	35.0	18.0	472	479
Kafr Antoon	8.6	20.0	85.4	112.6	68.4	65.4	41.2	27.6	37.8	467	444
Tel Hadya	10.6	17.4	93.0	69.8	55.3	51.8	27.5	31.9	14.8	333	342
Brida	8.6	6.2	70.8	39.3	48.6	49.0	22.0	32.4	15.0	292	278
Khanasser	9.8	3.2	72.0	50.6	39.1	34.5	18.0	14.8	4.0	246	215.4

CEREAL CROPS IMPROVEMENT

Contents

(Photo on previous page: Promising barley lines at ICARDA's principal experiment station at Tel Hadya.)

CEREAL CROPS IMPROVEMENT

Introduction

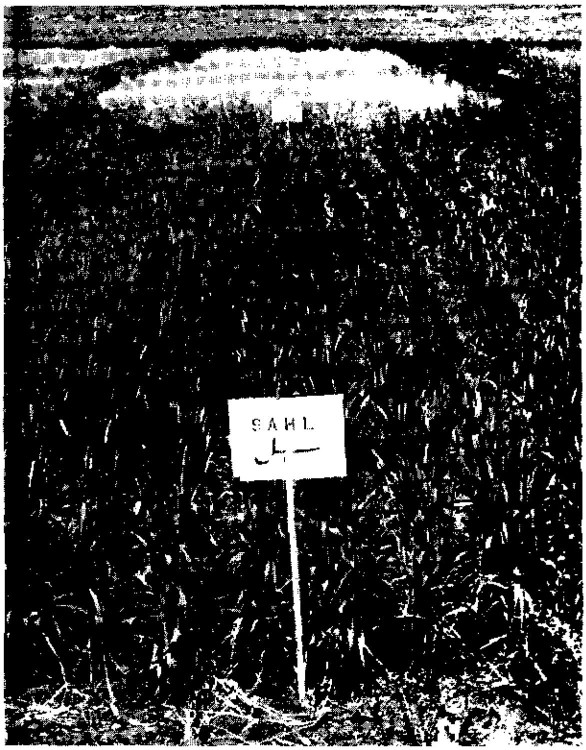
Winter cereals—wheat and barley— constitute the most important group of cultivated crops in the West Asia and North Africa region. However, the production has lagged behind the total requirement of the region resulting in the net import of 15 million tons of wheat grain in 1980. Within the region there is considerable diversity in agro-climatic conditions. The region can be primarily characterized by its low rainfall, which occurs mainly during the winter months, and it can be broadly classified into two somewhat distinct zones: the low elevation or littoral zone and the high elevation (1000 to 3000 meters a.s.1.) zone.

DURUM WHEAT. In many of the countries of West Asia and North Africa, durum wheat occupies the majority of the wheat area, particularly in the drier areas where it has generally proved to be better adapted than breadwheat. However, little work has been done on durum wheat improvement in the region, and local unimproved varieties and traditional agricultural methods still prevail. There is, therefore, ample scope for ICARDA to make an impact on durum wheat production in the region.

The development of durum wheats that possess the genetic potential to perform satisfactorily under limited soil moisture levels, as well as the capacity to respond well when water and nutrition become less limiting, is a major objective in the durum program. Material has been developed that has significantly outyielded the widely grown local variety Haurani.

The use of genetically diverse lines possessing desirable traits, locally adapted lines as well as agronomically superior lines, has resulted in very good base material for the region. Crosses between spring and winter habit lines have also provided promising progenies. Waha, Sahl, Stork "S," and Bittern "S" are being considered for release in several countries in the region. The first two varieties have been identified and are under seed multiplication in Syria, Jordan, and Lebanon. Slowly durum lines are catching up with breadwheats in grain yield, disease resistance and adaptability in the region. The development of durum varieties with improved disease and insect resistance is receiving high priority.

Increased attention has been paid to grain quality during selection. The quality requirements for macaroni,spaghetti, and other pasta products are known, while quality parameters for local consumer uses such as khobz, chapati, couscous, and burghul are not. The cereal grain quality laboratory is developing tests of suitability for these products. Lines with below average protein content are discarded during selection.



Sahl—a new durum wheat variety—is being multiplied in Syria.

BREADWHEAT. Overall breadwheat ranks first among the food crops grown in the ICARDA region, with about 90% of the crop being grown under rainfed conditions. It has been estimated that over half of the breadwheat crop is grown in areas receiving less than 400 mm precipitation annually. Recently developed high yielding varieties are more suitable for irrigated and high fertility conditions, and therefore ICARDA has a special responsibility for developing varieties and production technologies appropriate to the lower rainfall areas. To stabilize the production potential of the higher rainfall zones, the Cereal Improvement Program at ICARDA also emphasizes the incorporation of resistance to the most important diseases prevalent in the region. The work on breadwheat at ICARDA is conducted in close collaboration with CIMMYT.

BARLEY. In the region, barley ranks as the next most important cereal crop after wheat. It covers an area of about 10 million hectares annually. Barley is especially suitable for the drier areas and is an important source of animal feed and, in many cases, human food.

There is only limited work on barley breeding in the region. With a few exceptions, most national programs give a higher priority to work on wheat because of limited resources. The value of ICARDA's help in strengthening the barley work in Tunisia is an example of what can be done in these circumstances. There is now need to provide similar support in other countries. With this in mind, ICARDA proposes to aim at a less centralized organization of its work on barley, with closer links to national programs and will try to provide support in research areas not covered by national programs. (For example, in barley physiology and breeding for drought and other stresses.) The program has achieved some notable success having made a major input into the development and testing of the varieties Beecher and Badiya which are now being multiplied by the Government of Syria. Badiya is also being distributed in Tunisia.

TRITICALE. Work on triticale is now largely confined to lines that have a full complement of rye chromosomes. Like rye, these usually have a high lysine content in the grain. The first aim is to improve yield. Lines with sub-standard protein content are discarded, but no routine amino-acid analysis is done. More attention is paid to qualities that affect consumer acceptance than to protein content. To make primary triticales, locally adapted wheats and rye are used from the region where the triticale is destined to be grown. Triticale is doing well in Tunisia where it may replace imported maize grain for poultry feed.

HIGH ELEVATION RESEARCH. ICARDA has a responsibility for crop improvement in the high plateau areas of Turkey, Iran, Afghanistan, Pakistan and the Maghreb countries of North

Africa. Here, wheat and barley are extensively cultivated and provide basic food for millions of people living at altitudes of 1000 to 3000 meters and above. These areas are characterized by low temperatures and snow cover in winter, and in many cases by hot summers, shallow soils, and low rainfall.

Crosses between winter x winter, winter x spring, and winter-spring x winter-spring, wheat, barley, and triticales were made at Aleppo. Early generations, as well as the germplasm collected from different sources, are being tested at three high elevation locations in Baluchistan (Pakistan), Sarghaya (Syria), and at two locations in the Atlas mountains in Morocco.

GERMPLASM. Diseases seriously limit cereal production in the ICARDA region. The most effective means of controlling diseases is through the incorporation in breeding material of genes that confer disease resistance under field conditions. Cereal research at ICARDA includes the identification of these genes in the germplasm collections and its incorporation in new cultivars.

ICARDA has a responsibility for the collection, maintenance, and distribution of germplasm material of cereals and other crops. A germplasm bank is being developed in collaboration with other organizations, including IBPGR.

TOLERANCE. Selection among barley and durum lines for tolerance to saline soils has revealed useful diversity. Many barley lines found to be tolerant come from Lake Mariut in Egypt, and many of the tolerant durum lines come from areas of saline soils in Ethiopia. Salinity problems are locally important in the ICARDA region, and they are common on irrigated land. Work on salt tolerance represents only a small part of ICARDA's work, and it is not intended to develop it as a main thrust.

NITROGEN. Agronomy trials have shown that there are significant differences between varieties in the efficiency with which they take up nitrogen and in the grain yield increase per unit of nitrogen taken up. These findings are of importance in influencing the development of new varieties for cereal producers in less favorable environments where resources are limited and the returns on use of fertilizers less certain.

COLLABORATIVE PROJECTS. Interaction with national programs in the region has continued to strengthen, with a significant increase in the distribution of improved material. About 900 cereal nurseries are distributed annually, and the number of lines with superior yield and disease resistance has increased steadily.

There are growing collaborative cereal projects in Syria, Jordan, Tunisia, Morocco, Cyprus, Pakistan, and Lebanon. Now, in Syria alone, more than 60 cereal trials are conducted in cooperation with the Agricultural Research Center of the Ministry of Agriculture.

Barley Improvement

The general objective of the barley improvement work at ICARDA is to raise the average yield on the 10 million hectares of barley grown in the region, above a level of 100 kg/ha. The actual yields achieved by farmers are far below the potential productivity of the environment and, this gap tends to be greater in poorer environments. Often in such environments, which are too harsh for other cereal crops, a barley-fallow rotation, integrated with sheep production, is one of the few farming activities.

As with all ICARDA programs, the barley work is still young. To date the main activities of the program have been to:

(1) Increase genetic diversity through the introduction, collection and screening of cultivars; intercrossing to break linkages and to generate diversity and the generation of crosses based on widely adapted cultivars.

(2) Identify within the germplasm pool, plant types and traits associated with high yield, yield stability and adaptation to the environ-

ments prevailing in the region. In Syria, for example, plant types are needed having some of the following morphological and physiological characteristics: medium to long pre-anthesis period; cold tolerance in the pre-anthesis phase; a short period between heading and maturity; plump seed with either high tillering or many seeds per spike and rapid early growth. The latter can be an advantage in certain years but a disadvantage if the rainfall is concentrated in the early part of the season because after a large leaf area has developed the soil may be unable to meet the evaporative demand of the canopy.

(3) Collect a large body of data to make future choices based on reliable information.

(4) Give general training to scientists and technicians involved in the work.

BREEDING STRATEGIES. Two breeding procedures are followed: the modified pedigree method and the backcross method. The latter is used only when correcting deficiencies such as the introduction of disease resistance genes and for the improvement of certain traits, such as height and kernel size. The modified scheme of the pedigree method of breeding is summarized as follows:

Year 1	Spring:	Crossing of A x B.
	Summer:	F_1 generation (summer nursery).
Year 2	Spring:	F_2 grown at Tel Hadya and plant selection.
	Summer:	F_3 grown, generation advancement but no selection.
Year 3	Spring:	F_4 grown at Tel Hadya; plant selection and bulk of some crosses done for transfer of highly heritable traits.
	Summer:	Possible growing of F_5 generation at Njoro, Kenya and disease testing.
Year 4	Spring:	F_5 or F_6 grown; plant selection continued and bulking for moderately heritable traits.
Year 5	Spring:	F_6 and F_7 plant selection and bulking for all desirable traits.

The work is planned so that two generations are grown per year with minimum summer nursery effort. Intensive plant selection takes place in F_2, F_4 and F_6 generations. Generation advance and seed increase take place in F_1, F_3, and F_5 generations. Yield testing begins in the fourth year. Early bulks are tested beginning in year 4 in non-replicated initial yield trials. Promising F_5 and later generation bulks are included directly in preliminary yield trials (three replications, six-row plots, each row 2.5 m). In both initial and preliminary yield trials, promotion of lines for subsequent testing is done on the basis of yield performance in comparison with three checks, and on plant and seed score. This includes the following steps:

- Testing in advanced yield trials; plots are of six rows, 5 m long and with three replications.
- Regional testing in observation nurseries.
- Regional testing in yield trials.
- On-farm trials.

DEVELOPMENT OF IMPROVED BARLEY VARIETIES AND PRODUCTION TECHNOLOGY FOR LOWER RAINFAILL AREAS. This project is the basis of the barley improvement work. The main objective is to develop barley germplasm with high yield potential, disease resistance, and which is adapted to low rainfall environments but also responsive to higher rainfall years.

The environmental conditions that prevailed at Tel Hadya during the last three seasons (1978/79 to 1980/81) were typical of the environments encountered in the region and thus were extremely valuable to the plant breeder. The rainfall in these growing seasons can be described as follows:

	1978/79	1979/80	1980/81
Autumn	normal	rainy	below normal
Winter	normal	rainy	normal
Spring	dry	normal	rainy
Total rainfall	242 mm	420 mm	374 mm

The 1978/79 season favored short cycle cultivars, 1979/80 season medium maturity duration cultivars, and 1980/81 season late maturing.

These variable environmental conditions have permitted the identification of genotypes adapted to a given environment. However, some lines showed a remarkable stability of performance across the three year period. A good example is 2762/Beecher-6L. For this reason, it was chosen as the improved check. It was also the highest yielding line in the on-farm trials during the 1980-81 season.

The general development of yield levels among the 20 best entries in the advanced yield trials of the last three cropping seasons is presented in Table 1. Among this elite material, lines were selected and promoted to the international nurseries. Yields ranged from 3868 kg/ha to 4486 kg/ha in 1978/79; from 4203 to 5234 kg/ha in 1979-80; and from 4923 to 5963 kg/ha in 1980/81. This evolution corresponds to an increase of 1.5 t/ha over a three year period, or a raise in the general yield level of 0.5 t/ha/year. Although not all the increase was due to genotypic effects, it does illustrate the rapid progress from selection that can be made in the initial stages of a crop improvement program.

The yields of the best entries in the crop season 1980/81, are presented in Table 2. Fifteen lines had an average yield exceeding 6000 kg

***Table 1.* Evolution in yield levels among highest yielding entries in advanced yield trials during the three growing seasons (1978–81).**

Rank	Cross/pedigree	Yield	%Check[2]
	(1978/79)		
1	Comp.Cr.89	4486	156.7
5	Arizona 5908/Aths CYB 8-16A-2A-2A-0A	4255	140.9
10	Esp./1808-4L	4137	136.6
15	Esp./1808-2L	4046	115.8
20	9120/CI 13280	3868	121.7
	(1979/80)		
1	Impala	5234	168.24
5	Impala/11012.2	5023	161.45
10	DL69/Sultan	4478	143.94
15	H252	4651	129.77
20	CI 13871	4203	140.61
	(1980/81)		
1	Mari/CM67 CMB 72-140-8Y-1B-3Y-1B-1Y-0B	5963	150.12
5	Rihane[1]	5670	143.07
10	Harmal"S"	5361	159.36
15	Matnan[1]	5346	134.90
20	Rihane"S"	4923	127.80

[1]*ICARDA cross barley.*
[2]*Checks were different from year to year. In addition, the actual yields of the checks have not been included as lines were selected from different yield trials. However, the yields of the checks varied as follows during the 1980–81 crop season: Arabic Abied: 3364 to 4148 kg/ha; Beecher: 3744 to 4787 kg/ha; 2762/Beecher-6L: 3855 to 5052 kg/ha; Minn 126/CN67: 3463 to 4210 kg/ha; WI 2197: 4330 to 4910 kg/ha.*

per hectare. These research station yields should be compared with an average yield of less than one ton/ha over 10 million hectares in the ICARDA region. Again not all the difference is due to variety effects but it does illustrated the gap that exists between actual farmer's yields and potential yields of a large portion of the environments encountered in the ICARDA region.

The gain from selection in the international nurseries parallels that obtained at ICARDA stations. During the growing season 1978/79, the yield in the RBYT (Regional Barley Yield Trial) varied from 2749 to 3378 kg/ha for the twenty barleys in that trial, in comparison with a yield of 2719 kg/ha for the national barley check, a mean yield of 2846 kg/ha for the triticale check and a mean yield of 2242 kg/ha for the durum wheat check. Table 3 gives a brief summary of the last three crop seasons' RBYT results.

In the 1980-81 RBYT, the yield over 22 locations ranged from 4951 kg/ha to 3421 kg/ha for the barley genotypes included in the trial. The overall rank of the national check was 3.

Table 2. **Yield levels of highest yielding entries in preliminary yield trials in the 1980/81 season at Tel Hadya and Kfardan.**

Rank	Cross/Pedigree	Yield	%Check
1	Emir//Esp./Sv.Mari L 68-3S-4S-0AP-3AP-0AP	6605	121.17
2	*Beecher/Briggs*[1]	6463	131.20
3	WI 2349	6358	125.45
4	Arizona 5908/Aths	6185	130.98
5	Bco.Mr/As54/3/Bco.Mr//Ds/Apro/4/2163 /Emmer V01141-587-409-Zaga CMB 76A-485-1AP-1AP-0AP	6173	128.55
6	Jha 33/M 66.85 *CMB 74A-721-73-9S-3AP-2AP-0AP*	6167	133.92
7	Mari/CM67 CMB 72-140-18Y-1B-3Y-3B-0Y	6142	130.07
8	Mzq/Aths CMB 74A-58-2B-2Y-1B-500Y-0B	6105	130.24
9	Aurore/Esp. 1B-2L-9L	6105	129.29
10	*Cerise*	6099	110.15
11	WI 2197/CI 13520 ICB 76-14-3AP-0AP	6093	134.83
12	Bco.Mr/Mzq CMB 73A-33-2B-1Y-1B-2Y-0B	6086	118.22
13	WI 2269	6025	119.69
14	Magnif 102/Tokak TC 74-7-4AP-1AP-0AP	6000	140.45
15	As46//Avt/Aths[1] 2L-1AP-3AP-0AP	6000	130.12

[1]*ICARDA cross barley*

Table 3. **Summary of mean yields (kg/ha) of entries in the Regional Barley Yield Trials (RBYT) in three seasons.**

	1978/79	1979/80	1980/81
Best barley line	3378	4150	4951
Poorest barley line	3010	3267	3337
National barley (check)	2719	3414	4521
Durum check	2242	3424	3917
Triticale check	2846	3397	4270
LSD (0.05)	578	611	509

At every location, several lines outyielded the local check significantly, indicating that in every country of the ICARDA region, potential barley yield can be improved. Barley variety ER/Apm ranked number one in overall yield. It was selected in 19 of the 22 locations. Line Emir/Nordgard 265 (entry No. 19) ranked second.

The entry CI 8887/CI 5761 SEA-13-20S-1S-0S showed good resistance to five diseases (yellow rust, leaf rust, powdery mildew, net blotch and scald). Several other lines exhibited resistance to three of the five diseases. Menuet and Ky 63-1294 gave the highest yield among the entries with multiple resistance.

Prior to their inclussion into the regional nursery system, lines are selected to fit the various crop growing conditions of the region. In the advanced trials, days to heading varied from 106 to 140 days and for days to maturity the variation went from 142 to more than 165 days under Tel Hadya conditions.

The 10th Preliminary Observation Nursery (PON), conducted in 1980/81, comprised 150 entries. Beecher was incuded as a check, and there were eight triticale lines. Based on data received from 18 locations, three lines originating from crosses made at ICARDA were among the ten most frequently selected lines. These are two sister lines from the Atlas 46/Arivat//Athenais cross, designated as Rihane and Rihane "S" and one line from CM67/Baladi 16 cross. (Table 4).

The line Lima Monterio/Beka//Aurore/3/Mari (No. 44) was the most frequently selected entry. It was selected at 9 locations. Two lines, As 46//Avt/Aths (No. 55) and M.E.H.11.4/Apm/Dwarf 21//Par/IB65 (No. 124), were selected at 8 locations. Protein contents ranged from 7.2% to 12.93.%

During the 1980/81 growing season, several Male Sterile Facilitated Recurrent Selection Populations (MSFRSPs) were grown at Tel Hadya and Lattakia. These populations were:

- RSP-5Rrs. Resistant to *Rhyncosporium secalis* (scald).
- RSP-5Rpt. Resistant to *Phyrenophora teres* (net blotch).

Table 4. **The ten most promising lines in the 1980/81 preliminary observation nursery (PON-B).**

Entry no.	Cross/Pedigree	FR[2]	DH[3]	DM[4]	Pl.Ht.[5] (cm)	PM[6]	Sc[7]	NB[8]
44	Lima Monterio/Beka//Aurore/3/Mari	9	120	163	77	2	2	2
55	Rihane[1]	8	119	165	86	2	2	2
124	M.E.M.111.4/3/Apm/Dwarf 21//Par/IB65 CMB 73A-867-3369-4AP-2AP-0AP	8	115	160	77	4	3	1
24	Gitane	7	122	163	83	0	1	1
26	Lignee 527	7	123	166	76	1	0	1
27	Lignee 640	7	121	166	76	0	2	1
43	6Berac/Bera	7	123	164	83	2	2	2
49	Api/CM67//Por/U.Sask 1766 CMB 75A-115-500Y-500B-0Y	7	110	160	73	2	5	1
56	Rihane"S"[1]	7	119	164	87	3	2	2
71	CM67/Bal.16[1] ICB 76-23-1L-5AP-0AP	7	115	160	73	1	3	2

[1]*Barley crosses made at ICARDA.*
[2]*FR = Frequency of selection, 15 locations.*
[3]*DH = days to heading, 14 locations.*
[4]*DM = days to maturity, 11 locations.*
[5]*Pl.Ht. = plant height, 13 locations.*
[6]*PM = powdery mildew, 2 locations.*
[7]*Sc = scald, 5 locations.*
[8]*NB = net blotch, 5 locations.*

RSP-5Reg.	Resistant to *Erisiphe graminis* (powdery mildew)
CC30F-DRO	for drought tolerance.
CC30F-EAR	for earliness.
CC33A	for resistance to barley yellow drawf virus (BYDV) and with short, stiff straw.
CC33B	also for resistance to BYDV.

The emphasis in these populations was placed on disease resistance and drought tolerance. During the past season, the populations were made more dynamic by intercrossing with high yielding, adapted types having good plant characteristics and the required disease resistance for which the population has been built. This was helped through hand crossing, although natural hybridization was also taking place. Plants with the male sterile gene were tagged.

DEVELOPMENT OF DUAL-PURPOSE BARLEYS (GRAIN AND GRAZING). In the North Africa and West Asia region, barley is often grazed by sheep during the winter months. In the drier areas, and especially in dry years, grazing of the barley crop can be a significant source of feed during the October to January/February period.

The aim of this project is to identify potential dual purpose genotypes and to:

(1) Assess the effect to different intensities of grazing at different growth stages in low, medium and high rainfall areas and

(2) Identify morphological and physiological characteristics to be used in early generation selection for dual-purpose barley types.

During the season, 69 genotypes were studied in replicated trials with C63 (an improved barley selection) as check. Grazing was simulated by cutting with a mower at the late tillering stage. Tillers were counted prior to heading, with dry matter being estimated using a rising plate meter at the jointing stage. Regrowth was estimated visually prior to maturity on a 1 to 5 scale with 1 representing no loss of yield and 5 a visual estimate of loss in excess of 60%.

There was a general decline in grain and dry matter yields following cutting (Table 5). The relationship between dry matter at cutting and grain yield may be used to separate forage, grain and dual-purpose barley types. At ICARDA this classification is made in relation to environmental indices for grain and dry matter yield. An index of 1.0 for either character represents

Table 5. **Grain yield on uncut plants and after cutting, and dry matter yield of selected barley genotypes from 1980/81 trials.**

Cross/pedigree	Yield, uncut (kg/ha)	Yield, cut (kg/ha)	Dry matter (kg/ha)
Grain types			
WI 2197	5059	2092	4761
Lignee 1242	4784	3685	4143
Hexa	5596	4194	2877
Gerbel	5062	3407	4243
Europa	5389	2565	5397
Lignee 131	5278	2657	4930
Dual-purpose types			
Comp.Cr.29	5546	3074	6178
Celaya/CI 3909.2	4586	2343	6470
WI 2198	5605	1935	5539
11016.2/Weeah	5414	2056	5491
Seed Source-72 Sal.	5426	1296	6230
As54/Tra//2*Cer/Toll/3/2*Avt/Ki//Bz /4/Vt/5/Pro	5552	370[1]	6409
Forage types			
Bco.Mr/Mzq	3562	1704	6889
RM1508/Por	3448	1713	6337
M75-12	3062	1500	6142
Api/CM67/3/Apm/Dwarfll-1Y//Por/Kn27 /4/RM1508/11012.2	3960	1139	6201
Asse/Nacta	3469	1574	6100
Windser	2886	704[1]	5808

[1]*Herbicide damage caused a dramatic decrease in yield after cutting.*

the overall mean yield of all genotypes in all environments (Fig. 1). Genotypes having higher grain yields but lower dry matter yields than 1.0 are considered grain types; those having higher grain and dry matter than 1.0 are considered dual-purpose types; and those with dry matter yields higher than 1.0 but grain yields less than 1.0 are considered forage types. Genotypes having both yields below the mean indices are discarded.

DEVELOPMENT OF NAKED BARLEY VARIETIES. Several naked barley genotypes were selected from nurseries and segregating populations and were yield tested. Many lines had an acceptable plant type, but only Api/Cm67//Ds/Apro and Patty (A) were significantly better than the check.

There is an urgent need for greater genetic diversity for several morphological characters associated with the hulless attribute. Naked barleys are inferior to hulled in disease resistance and adaptation to drier areas. The principal negative trait is the exposed position of the seed germ on the kernel, for which no satisfactory genetic diversity has yet been found.

Durum Wheat Improvement

It is estimated that more than half of the area under durum wheat in West Asia and North Africa receives less than 400 mm precipitation annually. A major objective of ICARDA's durum wheat improvement work is to generate germplasm, develop fixed lines and assist national programs in identifying cultivars to meet the needs of low rainfall and non-irrigated conditions. It is highly desirable to develop duram wheat germplasm that can perform satisfactorily under

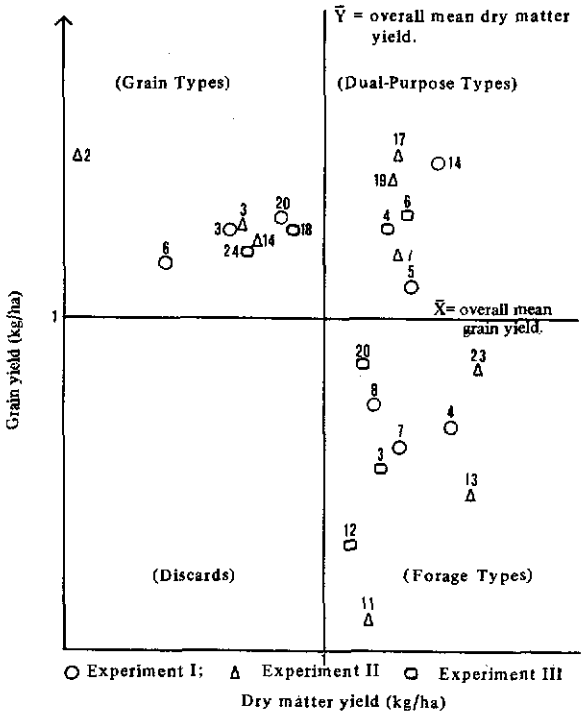


Fig. 1. Grain types, dual-purpose types, and forage types of barley identified during the 1980/81 season.

limited soil moisture levels, as well as having the capacity to respond well when water and nutrients become less limiting.

CROSSES. Approximately 2100 crosses (single, three-way and double) were made during the 1980/81 season. In 12% of the crosses, 'exotic' (e.g. land races, and cultivars from countries outside the region, and wild species) plants were used to broaden the genetic diversity of the breeding stock. Segregating populations were grown under both rainfed and under supplementary irrigation (2 sprinkler irrigations of about 50 mm each) so that a bifurcated testing and selection procedure could be practiced. When lines are sufficiently homogeneous, yield trials are carried out under both rainfed and supplementary irrigated conditions.

The first indication of yield potential in breeding material is taken from initial yield trials which constitute non-replicated yield testing in 3 m^2 plots. The highest yielding lines with the best agronomic characters are promoted to the preliminary yield trials (3 replications, 3 m^2 plot size). The best lines from these trials are then tested in advanced yield trials (3 replications, 6 m^2 plot size) before elite lines are sent for testing to national programs in the region. The numbers of entries in the three yield trials over the past two seasons are given in Table 6.

In replicated yield trials the local check is the widely grown variety Haurani (yield level 100%), and the improved check variety is Stork. Promising lines originated from CIMMYT (Mexico) are also evaluated in the yields trials.

***Table 6.* The number of entries tested in initial (IDYT), preliminary (PDYT), and advanced (ADYT) durum yield trials at Tel Hadya over two seasons.**

	Season	
Yield trial	1979/80	1980/81
IDYT	630	1023
PDYT	682	572
ADYT	176	220
TOTAL	1488	1815

PERFORMANCE. The yield performance of the breeding lines in the advanced yield trials of the 1979/80 and 1980/81 seasons is represented in Figure 2. The charts show the frequency distribution of the yields of the lines as relative values of the check variety Haurani. The figures show that there is an effect of the season on the size of cultivar differences. The difference in yield between Haurani and Stork was smaller in 1980/81 compared to 1979/80. It is encouraging that almost all lines were superior in yield to Haurani. In the 1980/81 season, a few lines gave yields almost twice of the local check variety. The improved check Stork was outyielded more frequently than in 1979/80.

The correlation between the yield performance under rainfed and under supplementary irrigation

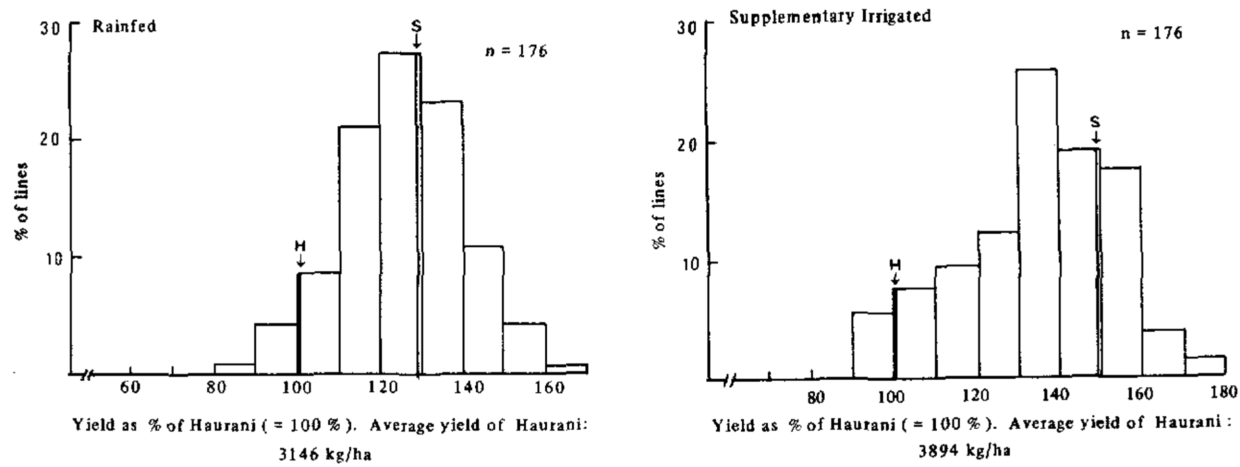
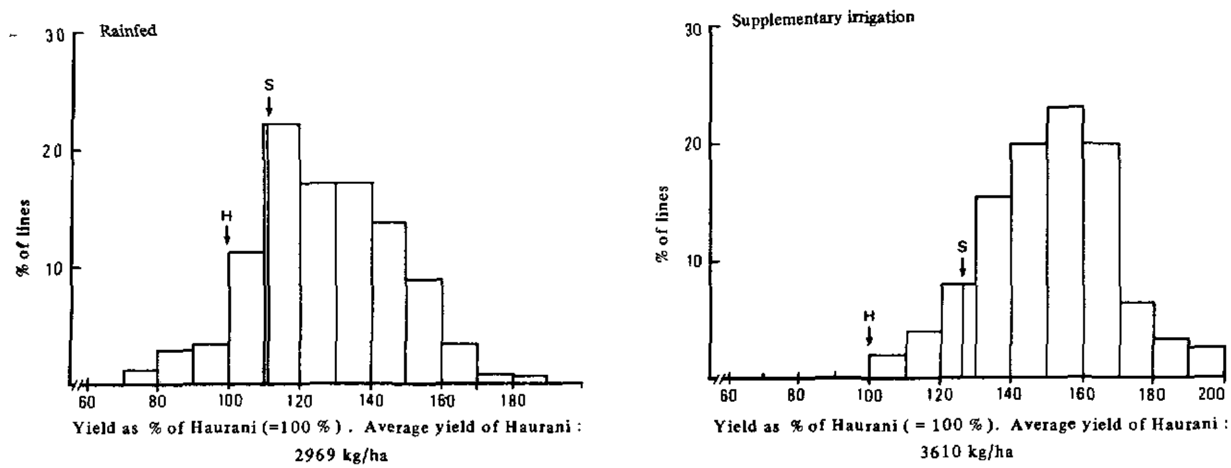


Fig. 2. Frequency distribution of the performance of the breeding material in the advanced yield trials at Tel Hadya station under rainfed and supplementary irrigation in 1979/80 (top charts) and 1980/81 (lower charts). The yields are expressed as percentage of check variety Haurani (H) (=100%). The yield level of improved check variety Stork (S) is also indicated.



was moderate in 1979/80 (r = 0.49) and low in 1980-81 (r = 0.27). The bifurcated selection system enabled lines with very high yields under both rainfed and irrigated conditions to be distinguished from lines giving high yields under supplementary irrigation but low yields under rainfed conditions. One line (Rabi's'/Fg'S', ICD 74108-1L-1AP-OAP) gave a relative yield of 180% under both conditions. Lines that are high yielding under both conditions are expected to be best adapted in the ICARDA region where there are large fluctuations in annual precipitation.

An important aspect of the durum wheat improvement work is the distribution of improved germplasm throughout the region. Within the region there is a large range of environmental conditions. The factors that vary include soil type, elevation, day length, annual precipitation, and pathogen population. To test the elite breeding lines under these conditions, international testing nurseries are distributed. These include observa-

Table 7. **Durum wheat entries selected at 11 or more locations in the 1980/81 season (Preliminary Observation Nursery grown at 25 locations).**

PON entry no.	Cross/pedigree	FR[1]	Protein (%)	Disease score[2] Yellow rust	Leaf rust	Stem rust
6	D.dwarf S-15/Cr's'					
	D33312-7Y-2M-1Y-0M	12	8.3	14	4	9
14	Jo/Cr//Gs/3/Pg					
	CD7474-10Y-2M-0Y	13	11.2	21	9	6
26	Mexi's'//Chap/21563					
	CD1894-3Y-1Y-8M-1Y-0M	11	10.0	25	8	8
28	Gre'S'	13	9.0	1	9	35
29	D.dwarf S-15/Cr'S'					
	D33312-7Y-4M-1Y-0M	12	9.3	4	10	6
65	Ato'S'/Candeal II					
	ICD7476-4L-2AP-0AP	13	10.5	11	15	37
68	Fg'S'/Jo'S'/3/Gu'S'/61-130//Lds					
	L0558-3L-2AP-0AP	12	12.3	4	1	0
69	Fg'S'/Jo'S'/3/Gu'S'/61-130//Lds					
	L0558-3L-3AP-0AP	11	11.7	13	18	13
71	Cr'S'//T.dic.v.vernum/G11's'/3/ Cit 71					
	L0584-1L-2AP-0AP	12	10.6	9	2	1
111	Candeal II/Gs'S'					
	CM9630-1L-1AP-0AP	11	8.9	26	4	2
130	Erpel'S'/Ruso					
	CD10437-7M-1Y-0M	11	10.7	11	3	15

[1]FR: Number of locations in which the entry has been selected for further use.
[2]Score ≤ 5 indicates satisfactory resistance.

tion nurseries and yield trials. The data received from cooperators are used to evaluate the adaptability of lines and discover additional characteristics in breeding material.

PRELIMINARY OBSERVATION NURSERIES. Lines giving high yields in yield trials in Syria and Lebanon and that appear well adapted and which exhibit satisfactory disease resistance at a large number of locations in the region are promoted to one of the two preliminary observation nurseries (PON); PON-durum or PON-rainfed. PON-rainfed is usually planted without supplementary irrigation and in low fertility conditions. The 1980/81 PON-durum consisted of 138 promising durum lines and five triticale lines. Every 20th entry was a durum wheat check variety. In the 1980/81 season, 64 of the 150 entries in the PON-rainfed were experimental durum wheat lines; the remainder were bread-wheat lines, checks, and a few triticale lines.

The experimental design was the same for both nurseries. Entries were sown in two rows, each 2.5 m long with 30 cm row spacing. Notes were taken on disease severity, number of days to heading and maturity and plant height. Seed quality was also tested. Cooperators indicated which lines appeared interesting for further use in their testing or breeding programs. The frequency with which a line was selected gave an indication of the adaptability of the line.

Tables 7 and 8 list the most frequently selected lines in the observation nurseries. These lines, which are considered of interest in at least 40% of the locations, are believed to be much better adapted to the varying environmental conditions than entries selected at only one or two locations. It appears possible to combine wide adapt-

Table 8. **Durum wheat entries selected at nine or more locations in the 1980/81 season (Preliminary Observation Nursery [rainfed] grown at 22 locations).**

PON-Rf entry no.	Cross/pedigree	FR[1]	Protein (%)	Disease score[2] Yellow rust	Leaf rust	Stem rust
64	Pg'S'//Chap/21563	9	11.2	14	4	0
66	21564/Cr'S'//Fg'S' CM7491-11Y-1M-0Y-0Ke	9	11.8	3	7	0
68	Waha'S'//D.dwarf S15/Cr'S' 10448-9SK-0SK	9	11.7	1	2	1
69	Cr'S'/Tag.B.Bal//Pg'S' /Ralle'S' CD14334-G-2Y-3M-0Y	9	11.5	1	1	17
71	Gdo512/Cit'S'//Ruff'S'/Fg'S'	9	11.3	4	1	0
72	Mexi'S'/Fg'S' CD1895-12Y-0Y-2E	10	10.6	25	0	2
73	6710/6780//Pt1'S' CM17512-2M-1Y-0AP	10	11.8	1	2	3
76	Gdo vz 469/Garza CM549-2S-2S-2S-0S-0Ke	9	12.7	3	0	0
77	Plc'S'/Ruff'S'//Gta'S'/D6715 CM17904-D-3M-1Y-0Y	9	11.7	5	9	0
78	BD1543-Inrat69/Coot'S'	9	10.8	0	4	8
84	Cr'S'/Gs'S'/3/2F/Lds/ Koback2916/61-130 L63-2AP-1AP-0AP	9	11.7	0	12	5
117	Magh'S'/Jo'S'/3/G11'S' //61-130/Lds -4AP-0AP					

[1]FR: Number of locations in which the entry has been selected for further use.
[2]Scores ≤ 5 indicate satisfactory resistance.

ability with high protein content and disease resistance.

PON entry No 68 (Table 7) and PON-rainfed entry No 76 (Table 8) had relatively low disease scores and almost the highest protein contents of the durum wheat lines tested.

REGIONAL FIELD TRIALS. The lines with the best scores for the characters listed above are promoted to one of two regional yield trials: regional wheat yield trial (RWYT) or the rainfed wheat yield trial (RFWYT). Both trials comprised 24 entries in 1980–81. Eleven of these were durum wheats, including one durum wheat check variety. Entry No. 24 represents the national program check variety which can be breadwheat or durum wheat.

The 24 entries were planted in four replications. Each plot consisted of six rows, 2.5 cm long with 30 cm row to row spacing. The yield of each line was measured, as were those characteristics recorded in the PON's. Some of the results of the regional wheat yield trial are presented in Table 9. The durum wheat line with the highest average yield was Bittern'S'. At 18 of the 29 locations this line was among the ten highest yielding entries. However, the average yield of Bittern'S' ranked only 7th, behind one triticale line, four breadwheat lines, and the national check. This stresses the need to focus improvement efforts on raising the yield potential of durum wheat. The two lowest ranking durum wheat entries (Nos. 15 and 16) were also the latest in heading and maturity. Medium-early lines

Table 9. **The mean performance of durum wheat lines in the regional wheat yield trial (RWYT) in the 1980/81 season. (Grown at 29 locations.)**

Entry no.	Cross/pedigree	Yield (kg/ha)	Rank	Days to heading	Protein (%)
2	Bit'S' CM9799-126M-1M-5Y-0Y	3241	7	116	14.8
4	Cr'S'-USA-S02229 CM18882-2Y-0Y	2912	20	113	14.5
6	D.Coll.124(Cr's'(21563/ 61-130 x Lds))Fg'S' CD13570-E-2Y-5M-0Y	2889	21	116	16.1
8	Cit'S'-Fg'S' CD3568-8Y-0M-0ke	2985	19	117	13.0
10	Fg'S'-Palest.20C-606 x Mexi'S'/Rabi'S' CD10438-4M-1Y-0M	3191	11	115	13.3
12	Jori (Check)	2993	18	117	14.6
13	(Vz-Cp x Vz 156/Hau-AD-5-77) Rabi'S' x D.dwarf S15-Cr'S' CD4775-N-9Y-8M-0Y-0Ke	3240	8	113	15.3
15	Valnova	2867	22	122	15.7
17	Valgerardo	2549	24	125	15.3
19	Misri-Mexi'S'(Plc'S'-Cr'S'/2B-LK x 60-120/G11'S' CD10662-N-14M-3Y-4M-0Y	3085	14	114	15.9
21	Snipe'S'/Jo'S'-Cr'S' x Gs'S'-AA'S' = Furat ICD74119-2L-0AP	3012	16	118	13.3
24	National check	3280	5	113	14.0

tend to perform better than late lines in the region. Entry No. 6 had the highest protein content (16.1%) of the 24 entries.

Table 10 contains some of the results of the rainfed wheat yield trial. The highest yielding durum line, Cr'S' (T.Pol.185.309 x T.P), had a higher average yield than all others. This line was among the ten highest yielding entries at 11 of the 21 locations. It had also been included in PON-Rf in 1979/80 where it was the most frequently selected durum wheat entry (at 14 out of 28 locations). The entries in the RfWYT did not show much variation in earliness and protein content.

The recording of additional data for individual lines is only one of the benefits of the international nurseries. These nurseries are also a means of spreading diverse and valuable lines throughout the region. Cooperators in national programs select the lines that are best adapted to the local circumstances.

Breadwheat Improvement

Breadwheat is the most important cereal crop in the ICARDA region. Together with durum wheat it provides more than a half of the energy and protein in the diet of people living in the region. Breadwheat imports into the region have recently increased, and now average around 15 million tons annually. Under rainfed conditions, breadwheat production averages less than 1 ton per hectare in the lower rainfall areas.

The aim of the breadwheat breeding work is to develop high yielding varities and germplasm with stability of yield under both low and high rainfall conditions, with resistance to cold, heat and drought and adapted to the grain maturity

Table 10. **The mean performance of durum wheat lines in the rainfed wheat yield trial (RfWYT) in the 1980/81 season at 21 locations.**

Entry no.	Cross/pedigree	Yield (kg/ha)	Rank	Days to heading	Protein (%)
2	Fg'S'-Bo'S'				
	CM17147-7M-10Y	3109	14	123	14.1
4	Mexi'S' x Gs'S'-Cr'S'/Ibis'S'				
	CD4504-G-3Y-5M-0Y	3022	21	123	15.4
6	Cit-Fg				
	CM9927-1S-2S	2996	23	123	13.7
8	D.S.15-Geier				
	CD523-3Y-1Y-2M-0Y	3097	15	121	13.3
10	D68-11/G11^2 x T.dic.v.Vernum				
	CD8642	3233	3	122	14.9
12	*Cocorit (Check)*	3162	7	120	14.6
13	Cr'S'(T.Pol.185.309xTP)	3314	1	122	13.0
15	S15-Cr'S'[Cr'S'(21563/61-130 x Lds)]				
	CD7454-15Y-1M-1Y-2M-0Y	3090	17	124	13.5
17	Ruff'S' x Jo - Cr				
	CM18537-1Y-0Y	3040	20	124	14.7
19	Mexi'S' x Chap-21563				
	CD1894-18Y-0Y	3052	18	123	15.5
21	Ch67-Jo'S' x Cr'S'				
	CM12857-10Y-2M-1Y-0Y	3126	12	125	13.6
24	National check	3152	10	121	13.1

requirements of the different agro-climatic zones of the region. The germplasm developed should have resistance to the diseases and pests of the region, be resistant to shattering and lodging and have nutritional and grain quality suitable for consumer uses.

Breadwheat breeding is a joint ICARDA/CIMMYT endeavor. By co-ordinating the breeding work of both Centers, complementary facilities and expertise can be used to accelerate germplasm development and eliminate duplication of efforts.

Breeding of winter sown spring breadwheat has benefited from more than 15 years of international testing and exchange of material. As a result there is now a good base of breeding material, and of high yielding, widely adapted varieties with good resistance to rust diseases and with improved *Septoria tritici* resistance. Breeding work needs to continually upgrade resistance to diseases as new biotypes develop and should add to the overall base of resistance to all crop hazards.

The breadwheat improvement work is organized in accordance with conventional pedigree breeding methods. Parental selection employs the regional network of ICARDA and CIMMYT testing sites to identify specific parents for special and general characteristics. Crossing includes single, top and double crosses with limited backcrossing. Disease resistant selections are made from both naturally occurring and artificial epidemics and growing segregating populations in locations where disease, insect or environmental hazards occur regularly. Plant selections are made in F_2 to F_5 or F_6 before bulking for yield testing. Yield testing is done for two years before material is sent to regional nurseries. Regional and international distribution includes advanced selections, segregating populations and parental material adapted to the conditions of the region.

STRESS FACTORS. Segregating populations and yield trials are grown at Tel Hadya and at the Terbol and Kfardan stations in Lebanon. Observation and segregating populations are grown in special sites in Syria to identify disease and drought reactions and other stress factors. At Tel Hadya all populations are grown under rainfed conditions, both with and without supplementary irrigation. Disease and insect resistance studies are co-ordinated with pathology and entomology work in the development of artificial epidemics and the evaluation of material.

A major emphasis in breadwheat breeding is on improving stability and resistance to drought, heat, and cold, resistance to stripe and leaf rust, *Septoria tritici*, common bunt, and sawfly.

Visual grading of seed is practiced in all generations of segregating material and on advanced lines. Complete quality testing for milling and baking is done on lines selected from yield trials.

The 1980–81 growing season was favorable for both good plant development and stripe rust. Leaf rust developed late in the season. Heavy frost damage occurred on April 1st, particularly on the irrigated yield trials. Selection pressure was applied for stripe rust, shattering and late frost damage. There was low selection pressure on leaf rust.

Frost damage and late rains with relatively cool temperatures favored late maturing varieties. A special effort was made to select early lines that performed well under these adverse conditions.

During the 1980/81 season 1150 crosses were made. These concentrated on resistance to drought, stripe and leaf rust, *Septoria tritici*, common bunt and sawfly. In all crosses one parent had high yield and/or adaptation to the rainfed environment. From more than 20,000 selections made, 8,555 were saved. Half of the populations saved was from F_2 segregating populations. These data are given in Table 11.

YIELD TRIALS. International yield nurseries help to identify germplasm having superior yield, disease resistance and agronomically desirable characteristics. The trend in regional yield results over the period 1978 to 1981 indicates an increase in wide adaptability. Since the check used (Mexipak) is a high-yielding, widely adapted variety, no dramatic yield increase over the check is expected unless disease epidemics occur. Data for the international yield nurseries are presented in Tables 12 and 13.

Table 11. **Summary of the number of lines of breadwheat grown at Tel Hadya in the 1980/81 season and planted at the beginning of the 1981/82 season.**

Type of nursery	No. of lines 1980/81	1981/82
ICARDA international yield trials	82	20
Other international yield trials	110	218
ICARDA yield trials	2008	1370
ICARDA international nurseries	212	125
Other international nurseries	3084	1983
National nurseries	747	72
Segregating populations F_2 - F_8	11270	8555
F_1 populations	650	1310

The yield differences averaged over four years show that the average of the top yielding lines exceeded Mexipak by 185 kg/ha and the local check by 265 kg/ha (Table 12). In Table 13 it can be seen that the average of the top yielding lines showed yield increases of 161 kg/ha and 100 kg/ha over Mexipak and the local check respectively in the regional rainfed wheat yield trial. The yield increases over Mexipak in each of the last two seasons were more than 400 kg/ha in the regional trials and slightly less than 200 kg/ha in the rainfed yield trials. This indicates a trend in more recent material towards greater adaptation.

In Tables 14 and 15 data are presented for the regional wheat yield trial and the rainfed wheat yield trial for the 1980/81 season. The top varieties showed substantial yield increases of 200 to 400 kg/ha in the regional yield trial over the two checks, but only HD2172 showed adequate rust resistance. In the rainfed yield trial, only Moncho 's' combined high yield with good rust resistance.

***Table 12.* Yield of the two highest yielding breadwheat lines in the regional wheat yield trials compared to the two breadwheat check varieties over four crop seasons (1978–81).**

	Yield (kg/ha)				
	1977/78	1978/79	1979/80	1980/81	Average
Mexipak	3278	3510	4004	3814	3652
National check	3477	2830	4139	3843	3572
Top breadwheat line	3477	3180	4434	4255	3837
2nd breadwheat line	3469	3140	4323	4229	3790
No. of locations	24	31	20	19	

***Table 13.* The yield of two highest yielding breadwheat lines in the rainfed wheat yield trial compared to the two breadwheat check varieties over four crop seasons (1978–81).**

	Yield (kg/ha)				
	1977/78	1978/79	1979/80	1980/81	Average
Mexipak	2603	3069	3790	3609	3268
National check	3045	3067	3529	3516	3289
Top breadwheat line	3040	3021	3849	3806	3429
2nd breadwheat line	3008	2975	3788	3621	3348
No. of locations	20	31	12	15	

***Table 14.* A comparison of the three best yielding breadwheat varieties with Mexipak and the national check grown in the 12th regional wheat yield trial (1980/81) at 19 locations.**

Variety or Cross	Yield (kg/ha)	Rank	Freq.	Stripe rust	Leaf rust	Stem rust
Mexipak	3814	15	9	7	38	10
National check	3843	13	7	3	13	7
Hugo 1	4428	2	12	14	16	2
Nacozari"s"	4425	3	12	14	10	8
HD2172	4012	9	11	0	2	4

***Table 15.* A comparison of the three best yielding breadwheat lines with Mexipak and the national check grown in the 9th rainfed wheat yield trial (1980/81) at 15 locations.**

Cross or Variety	Yield (kg/ha)	Rank	Freq.	Stripe rust	Leaf rust	Stem rust
Mexipak	3609	7	5	—	29	0
National check	3519	15	2	—	29	0
Moncho"s" CM 8288-A-3M-6Y-5M-1Y-0M	3806	1	9	0	1	0
Tob-8156xKal CMB 782-0L-5L-3L-2L-0Ke-0SK-0AP	3621	6	6	—	39	0
Cno's'-Pj62xG11/Pci"s" CM 35044-0L-1AP-0AP	3575	10	8	—	1	0

Table 16. **A comparison of the three top yielding breadwheat lines in the advanced preliminary and initial yield trials as a percentage of the yield of Mexipak grown under rainfed and irrigated conditions at Tel Hadya (1980/81).**

	AWYT		PWYT		IWYT
	Irrigated	Rainfed	Irrigated	Rainfed	Rainfed
No. of entries	189	189	630	819	1000
Mean yield of Mexipak (Mxp.)	3496	3072	4648	3355	3208
No. lines significantly greater than Mxp.	56	8	38	21	20
Percent of Mxp., best line	137	113	124	113	127
Percent of Mxp., 2nd line	131	110	118	108	122
Percent of Mxp., 3rd line	126	110	113	106	119

In Table 16 results are given for advanced, preliminary, and initial yield trials under both rainfed and irrigated conditions. The irrigated trials received pre-emergence irrigation and a second irrigation in April giving a total of about 125 mm additional water. Table 16 shows that a greater number of lines significantly outyielded Mexipak under irrigated compared to rainfed conditions. This was due in part to there being more stripe rust on irrigated Mexipak combined with increased shattering. Several lines showed good resistance to stripe rust and shattering in the 1980–81 yield trials.

The results of trials at Tel Hadya and of the regional trials over the past four years indicate that greater resistance to stripe and leaf rusts are needed. The new material selected in 1980/81 under good stripe rust conditions should improve the level of resistance to this disease. There are also a large number of winter x spring crosses included in the high yielding lines under both rainfed and supplementary irrigation conditions. These lines carry good resistance to rust and also appear to have good potential for drought resistance.

TRITICALE IMPROVEMENT

Triticale is derived from a cross between wheat (*Triticum*) and rye (*Secale*). It has been developed with the aim of producing a cereal crop which combines the yield potential and grain use of wheat with rye's tolerance to environmental stresses such as drought, frost, heat, poor soils, and its resistance to disease.

During 1981, a total of 456 triticale lines were tested for yield at Tel Hadya under rainfed conditions and at Terbol in Lebanon—a high rainfall and fertile environment. Lines were also screened at seven other locations under varying agroclimatic conditions. These sites were:

- Khanasser, Syria: an arid site with frost damage possible during the anthesis and grain filling stages.
- Brida, Syria: a semi-arid to arid site, with low fertility and drought conditions.
- Kfardan, Lebanon: a semi-mountainous environment.
- Laxia, Cyprus: an environment where early genotypes are successful.
- Beja, Tunisia: a high rainfall, fertile environment where natural diseases are prevalent.
- Njoro, Kenya: a site suited for agronomic and disease screening, especially for rusts.
- Shaubak: a site used as a summer nursery and for screening for seed plumpness.

Such testing is important in building up adequate genetic plasticity in triticale so the crop can face the erratic climatic conditions in the region.

The following high yielding and widely adapted varieties were used as checks at Tel Hadya and Terbol: 2762/Beecher-6 (barley), S-311/Norteno (breadwheat), Sahl (durum wheat), Beagle (triticale), Mapache (triticale).

Table 17. **The yield of the best triticale lines grown at Tel Hadya and Terbol (1980/81).**

	Yield (kg/ha)			
	Tel Hadya	% of the best check[1]	Terbol	% of the best check
1- Drira outcross	3500	132	5167	115
2- Ram'S'	3267	132	4978	111
3- 1A/M2A//Pi62/3/Bg1	2894	109	5122	114
4- Bcm/Addax	2744	104	4511	101
5- H507-11A/Bg12	2744	104	4767	106
6- SH Sel AT7-76 WOR	2661	101	4844	108
7- Juanillo 89	2772	105	4500	100
[1]*Checks: Sahl*	*2444*	*92*	*3500*	*78*
S-311/Norteno	*2650*	*100*	*4480*	*100*
Beagle	*2461*	*93*	*3937*	*88*
Mapache	*2021*	*77*	*3030*	*68*

Several lines were identified as high yielding at Tel Hadya and at Terbol. They were also widely adapted because they were selected at different sites throughout the region. The majority of these lines had a full set of rye chromosomes showing the importance of rye germplasm in triticale's background in the West Asia and North Africa region. These lines also out-performed the wheat and triticale checks. Few lines were found to outyield barley in the rainfed conditions of 1981. The lines which yielded more than the wheat and triticale checks at Tel Hadya and Terbol are shown in Table 17.

The water deficit in the early part of the season affected triticale crop establishment and vigor to a great extent. Important genetic variability in growth vigor in triticale germplasm was found. Also, there was a significant positive correlation between vigor and grain yield in 1981 ($r = +0.71$).

Results obtained during the three previous cropping seasons indicated that earliness in triticale genotypes is related to yield. However, several high yielding genotypes in 1981 were identified as medium-to-late in heading. This indicates that genotypes with different maturities should be produced to meet the varying requirements of the region.

The 1000 kernel weight, tiller number, and spikelet number measurements showed consistent and positive correlations with grain yield. The number of grains/spikelet showed a negative correlation with yield (Table 18).

Table 18. **Correlations between yield and yield components of triticale grown at Tel Hadya (1980/81).**

	TKW[1]	Tillers	Spikelets	Grain/ Spikelet
TKW[1]	—			
Tillers	+0.0365	—		
Spikelet	+0.2879**	+0.3589***	—	
Grain/ Spikelet	−0.0906	+0.0328	−0.4046***	—
Yield	+0.2843**	+0.4350***	+0.5049***	−0.1918*

[1]*Thousand kernel weight.*
*$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$; $n = 109$.*

INDUSTRIAL AND NUTRITIONAL QUALITY. Several triticale lines were found to combine high yielding capacity, high protein percentage and high test weight (Table 19). A wide range of variability was found to exist for wheat meal fermentation time and particle size index, or hardness, suggesting that improvement can be achieved in the industrial quality of triticale grain.

DUAL PURPOSE TRITICALES. In general triticale can tolerate and grow under the low winter temperatures of the Near East and North Africa. The crop uses the moisture available during the winter period efficiently. Dry matter

Table 19. **High yielding triticale genotypes with high protein content and high test weight grown at Tel Hadya (1980/81).**

Cross/pedigree	Yield (kg/ha)	Protein (%)	Test weight
Delfin	2828	14.9	74
Ptr//Octo Bulk/Bush	2772	14.5	74
Drira/Zaragosa//Soltane	3239	15.0	77
Rm'S'/Bza//Cml	3084	14.5	73
Trm/Bensing Turkestan// Rm'S'	2713	15.6	74
Pnd/Rm	2961	14.7	76
FS477/MA	3339	14.9	72
Cin/Pi//Pato/3/Bgl	2911	14.5	78

produced during the early stages of the season can also be used for animal feed.

The ability of triticale to regenerate and produce grain yield following cutting was evaluated in 118 lines. Dry matter protein content was also tested. Correlations were calculated between dry matter, protein content, grain yield after cutting, grain yield without cutting and total biological yield (Table 20).

Table 20. **Correlations between different characters in dual purpose triticale lines.**

	Protein (%)	Grain yield (after cut)	Grain yield (uncut)
Dry matter	0.9307**	0.2114*	0.3636**
Protein %	—	0.3434**	0.4637**
Grain yield (after cut)		—	0.4682**
Grain yield (uncut)			—

$^*p \leq 0.05$; $^{**}p \leq 0.01$; $n = 116$.

GENETIC VARIABILITY. As triticale is basically dependant in its genetic advances on three different cereal crops (durum wheat, breadwheat and rye), the incorporation of local adaptation to frost, drought and diseases is important. It is also important to meet local nutritional and technological requirements. Triticale improvement work at ICARDA includes improvements in rye in order to increase lodging resistance, improve plant architecture, increase self-fertility and to produce seed of good type, size and colour. The following crosses were made during 1981:

		No.
(1) Intraspecific crosses:	simple cross:	317
	3-way cross:	100
	4-way cross:	100
(2) Interspecific crosses:	breadwheat x triticale:	30
	triticale x durum wheat:	31
	durum wheat x triticale:	11
	durum wheat x breadwheat:	30
	triticale x rye:	186
	F_1 triticale x rye:	70
(3) Intergeneric crosses:	breadwheat x rye:	117
	durum wheat x rye:	194

One hundred inbred rye populations were used for crossing. Two of these had good seed type and a high 1000 kernel weight. Different selections were made for height and good yield parameters.

High Elevation Research

The ICARDA region has vast mountainous and sub-mountainous areas with an elevation of 1000 to 3000 meters. The people and the crops there endure severe winters and hot summers. Extensive areas of this type exist in south west Asia, Turkey, Iraq, Iran, Afghanistan, and Pakistan, and they extend to northern parts of India and Nepal. The north African countries of Tunisia, Algeria, and Morocco also have extensive areas with similar agro-climatic conditions (Fig. 3).

Approximately 109 million people inhabit the mountainous or sub-mountainous areas of their respective countries and of these the majority are engaged in agriculture (Table 21). Agriculture has been traditionally neglected in these areas, except in Turkey, and has generally received few inputs from research and agricultural technology, The technologies developed for lowland agriculture in various ecological zones of the region are not applicable to the dryland farming communities of the mountainous and submountainous zones.

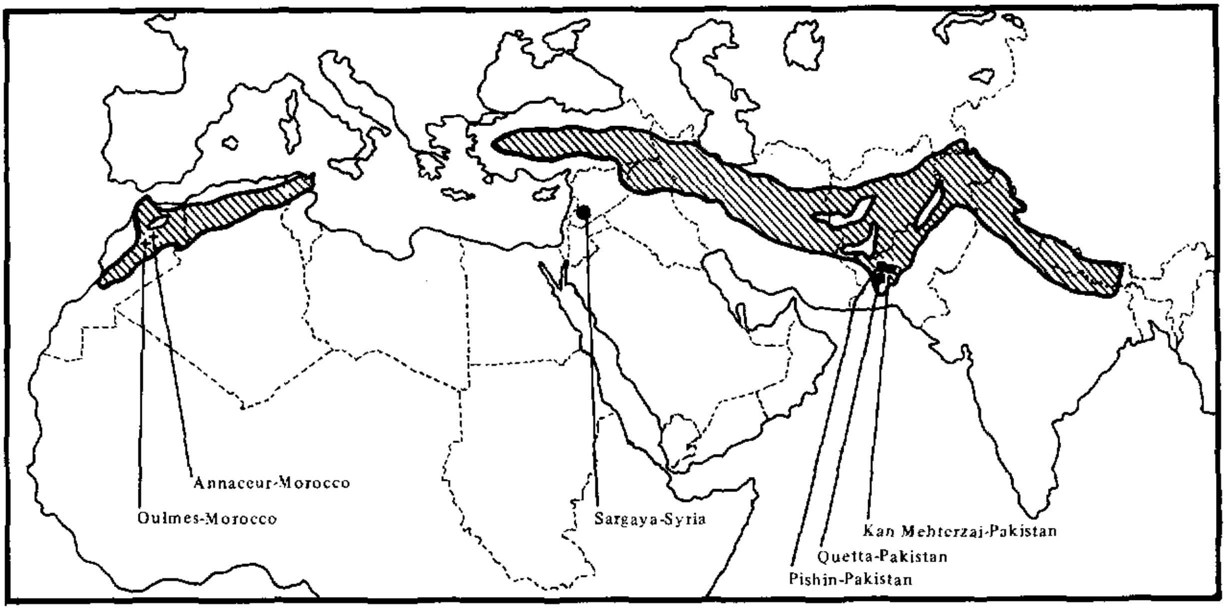


Fig. 3. High elevation areas in the West Asia and North Africa region and the testing sites used during the 1980/81 season.

Table 21. **Human population and wheat production in the mountainous and sub-mountainous areas of South West Asian and North African countries. (Source:FAO.)**

Country	Population (millions)	% of pop. engaged in agric.	Pop. in mt. areas (millions)	Wheat area[3] D[1]	BW[2]	Total	Prod. (m.ton)	Yield (kg/ha)
Afghanistan	21.5	78	12.9	0.2	2.2	2.4	2.2	917
India	678.3	64	19.0	2.2	29.1	31.3	32.0	1502
Iran	36.9	39	11.0	0.04	4.4	4.5	5.2	1156
Iraq	12.6	41	1.1	0.3	1.0	1.3	1.3	989
Nepal	13.9	93	8.3	0.0	0.4	0.4	0.4	1164
Pakistan	79.8	54	27.9	0.0	6.7	6.7	10.8	1608
Turkey	44.2	56	17.7	2.15	6.5	8.6	18.0	2093
Algeria	18.0	51	4.5	1.4	0.8	2.2	1.4	636
Morocco	19.6	52	4.9	1.3	0.4	1.7	1.8	1078
Tunisia	6.2	41	1.6	1.1	0.1	1.2	0.8	678
Total	931.0		109.0	8.8	51.6	60.3	73.9	

[1]*D: Durum*
[2]*BW: Beadwheat*
[3]*Areas in millions of hectares.*

CONSTRAINTS. In these areas, cereal crop yields are low. (A broad average is 650 kg/ha.) Water availability is a serious deficiency, but extremes of climate such as excessive heat and cold, diseases, and the lack of improved production technology and suitable varieties all contribute to low yields.

Agro-climatic data is being collected to better understand the agricultural problems and practices of the high elevations. Pakistan not only has a large population (28 million) inhabiting these areas, but a high percentage of its total land mass is in this category. In the higher elevation areas of the country, including Swat (in the Himalayan valley) and Quetta, there is a need for greater research inputs. The production of cereals could be increased substantially by developing suitable varieties coupled with improved production practices. In general, these high plateaus have characteristic cold temperatures during winter, low rainfall, and rapid rises in temperature during the spring. Shallow soils are widespread. Therefore, a research project for Quetta in Pakistan and for Morocco was developed with its base at ICARDA's Tel Hadya site.

MAJOR CROPS. The winter cereals (breadwheat, durum wheat and barley) are the major crops of the high plateaus. They are not only the primary sources of human food but also provide animal feed. The whole economy of these areas revolves around cereals and animals (sheep). The cereal varieties used by farmers are mostly very old land races which are low yielding, susceptible to lodging, prone to diseases (especially stripe rust and common bunt), and unsuitable for modern agriculture. Due to the great agro-climatic diversity of these areas, two types of varieties are successful. These are winter types for autumn planting which can withstand severe winters and short duration spring types for late winter or early spring planting which can escape or tolerate moisture stress during the grain filling stage.

Rye (*Secale cereale*) is another cereal crop grown commercially in some areas of Turkey and Morocco. This crop has several desirable characteristics such as superior winter hardiness, drought and disease tolerance, and short day length (8 hours) requirement in the reproductive phase. Thus, there is a need to explore the potential of triticale in the high plateaus which combines the desirable characteristics of wheat and rye.

A multilocation testing and screening approach is being followed to develop suitable varieties for agro-climatically diverse high elevation regions. Material from the F_1 stage up to the yield trial stage of breadwheat, durum wheat, barley, and triticale was planted at three high elevation locations in Pakistan. These were Quetta (1676 m), Pishin (1700 m), and Kan-Mehterzai (2500 m). Material was also planted in the high Atlas mountains in Morocco, principally at Annaceur (1345 m) and Oulmes. Some lines were also planted at Sargaya (1445 m) in Syria.

A set of all material was planted at Tel Hadya for seed increase and to develop further basic material through winter x winter, winter x spring, and top and double crosses.

GERMPLASM SCREENING. Out of 4500 lines in the USDA durum wheat collection, 1966 with acceptable winter hardiness and disease tolerance have been selected for further screening in Turkey. Some of these lines were employed in the crossing program to generate better germplasm. Similarly 186 lines of breadwheat and 32 of durum wheat were selected out of 2000 lines and/or varieties after testing at five locations in Turkey. With further selection pressure during the 1980/81 season, only 15 lines have been retained.

To broaden the genetic base, 100 lines and/or varieties of barley, 28 of breadwheat, and 1170 of durum wheat were collected from the mountainous and sub-mountainous areas of the region and other countries of the world where winter habit cereal crops are grown. These were evaluated and further utilized in cereal improvement work during the 1980/81 season. A strong selection pressure was exercised to reduce the number of genotypes for the future. Out of 3300 durum wheat and breadwheat lines, only 130 have been retained for further testing and evaluation.

EXPANSION OF THE GENETIC BASE. A substantial crossing program involving winter x winter, spring x winter, spring-winter x spring-winter combinations in barley, breadwheat, durum wheat, and triticale was carried out at Tel Hadya to expand the genetic base of these crops to develop better genotypes suitable for the mountainous and sub-mountainous areas of the ICARDA region (Table 22).

Table 22. **Numbers of new crosses and genotypes selected for high elevation areas from breadwheat, durum wheat and barley material in 1980/81.**

Generation	Breadwheat	Durum	Barley
F_1	1017	544	579
F_2	565	—	100
F_3	437	156	—
F_4	—	—	—
F_5	—	81	—
F_6	—	90	—

Agronomic and Physiological Studies

The gap between cereal crop yields in farmers' fields and the potential yields for the West Asia and North Africa region is rather high. A large part of this gap can be closed through an improvement in agronomic practices. The size of the yield gap is generally smaller in the higher rainfall and irrigated areas where inputs of fertilizer, machinery and herbicides result in lower risks to farmers.

However, experience in the region suggests that equally good yield improvements can be made in the rainfall zones with less than 350 mm precipitation, where a large proportion of the durum wheat and barley crops are grown. Many of these crops receive very low inputs in terms of fertilizer, machinery, and herbicides. Many varieties are still grown that are susceptible to diseases and lodging and which have low yield potentials.

While the size of the yield gap in the region is large, climatic uncertainty in rainfed areas and the consequent risks are also high. This necessitates careful analysis of both spatial and temporal variability in response to production practices before advice can be confidently given to farmers. The purpose of this research is to provide some of these data as the basis for economic evaluation of production inputs.

Six types of experiments conducted in the 1980/81 season are described below.

NITROGEN x PHOSPHORUS RATES. These experiments included five rates of each fertilizer and were grown in farmers' fields in the different rainfall zones of northern Syria (two sites per zone). The levels of each fertilizer were varied according to the rainfall zone as was the crop. (Barley below 250 mm rainfall, durum wheat from 250 to 350 mm and breadwheat above 350 mm and under irrigation.)

The 1980/81 season was the second year for this set of experiments. The data for two years have been included in Table 23. The variability of the responses so far, even within rainfall zones, indicates the need for more replication of this work. The negative response to nitrogen at one low rainfall site was associated with a very high initial soil nitrogen level in an area where crop failures are quite common. The negative response to nitrogen at one irrigated site was recorded on land with a long history of high levels of fertilizer application. Phosphate responses were similarly variable and could in future be linked to a soil test at sowing. These data should eventually lead, after economic analysis, to improved fertilizer recommendations for cereal production.

Table 23. **Nitrogen and phosphate responses of barley, durum wheat, and breadwheat grown in northern Syria in the 1979/80 and 1980/81 seasons.**

Rainfall zone	No. sites	N response range (kg/ha)	P_2O_5 response range (kg/ha)
250 mm (barley)	4	negative to over 80	20 to over 80
250–350 mm (durum)	4	40 to 80	0 to 30
over 350 mm & irrigated (breadwheat)	6	negative to 240	0 to 120

"IMPROVED" PRACTICES. These experiments were sown at the same locations as the N x P experiments. The treatments were all combinations of two levels ("improved" x "farmers") of each of three production practices (fertilizer, variety and weed control).

Responses to fertilizer in the low rainfall zone (less then 250 mm, barley) were greater than the responses to chemical weed control, but the yield increase due to variety was insignificant. This result was similar to the results of the previous year. In the medium rainfall zone (250 to 350 mm, durum wheat), the mean yield responses to fertilizer and weed control were 21 and 17% respectively, and there was no response to variety. In the previous year there had been no response to chemical weed control. In bread-wheat, there was no mean yield response to any improved practices under irrigation.

While the number of sites studied so far is too few for meaningful economic analysis, if these two years' results are confirmed it appears that cereal grain yields in the low and medium rainfall areas can be improved by the use of both fertilizers and chemical weed control. However, the "farmers'" fertilizer level used in these experiments for irrigated conditions was higher than the "improved" level, and it may therefore be possible that farmers can improve profitability by reducing their fertilizer application rates. Yield increases due to "improved" varieties may well change as more adapted varieties are produced through breeding.

NITROGEN RATES ON GRAZED CEREALS. An exploratory experiment using three rates of nitrogen on two barley varieties and one wheat variety was grown at Tel Hadya under grazed and ungrazed conditions. Half of each plot was grazed at the tillering stage by sheep. Dry matter production at tillering was significantly influenced by variety and nitrogen rate (Table 24). The highest yields of dry matter were obtained with C-63 at 60 kg N/ha. When no nitrogen was used, C-63 outyielded Arabic Abied in dry matter, but when 60 to 120 kg N/ha was applied the difference was not significant. Grain yield was also influenced by nitrogen and variety (Table 25). Arabic Abied yielded significantly more under both the grazed and ungrazed conditions than both C-63 and Gezira 17 to 0 and 60 kg N/ha. The yield of Arabic Abied in the ungrazed conditions was significantly lower at 120 compared to 60 kg N/ha, whereas it was not significantly different from the 60 kg N/ha treatment in the grazed condition.

EFFECT OF STAGE OF GROWTH AT GRAZING ON GRAIN YIELD. Two barley varieties and one wheat variety were subjected to grazing by sheep at the early tillering, the late tillering or the jointing stage, or were left ungrazed. The relationship between grain yield and dry matter taken by successively later grazings (Fig. 4) shows that, under the seasonal conditions of this experiment, even grazing at the late stem extension stage did not prevent some grain production in all three varieties. Thus, under similar conditions a farmer's decision on the timing of grazing will depend on his relative need for grazing compared to grain, and not on purely biological considerations. Differences

Table 24. **The effect of nitrogen and variety on dry matter yield (kg/ha) of durum wheat and barley at tillering (1980/81 season).**

	Nitrogen rate (kg/ha)		
Variety	0	60	120
Gezira 17 (durum)	517	569	661
Arabic Abied (barley)	436	751	863
C-63 (barley)	612	876	880

LSD (0.05)–N means for the same variety –128 kg/ha.
–Variety means for the same N rate–127 kg/ha.

Table 25. **The effect of variety, nitrogen, and grazing on grain yield (kg/ha) of durum wheat and barley (1980/81 season).**

	Ungrazed			Grazed		
Variety	0 N	60 N	120 N	0 N	60 N	120 N
Gezira 17 (durum)	2357	3413	3126	1846	2615	2886
Arabic Abied (barley)	3408	4205	3690	2778	3404	3646
C-63 (barley)	2001	3463	3940	2013	2834	3287

LSD(0.05)–N means for the same variety–468 kg/ha.
–Variety means for the same N rate–311 kg/ha.

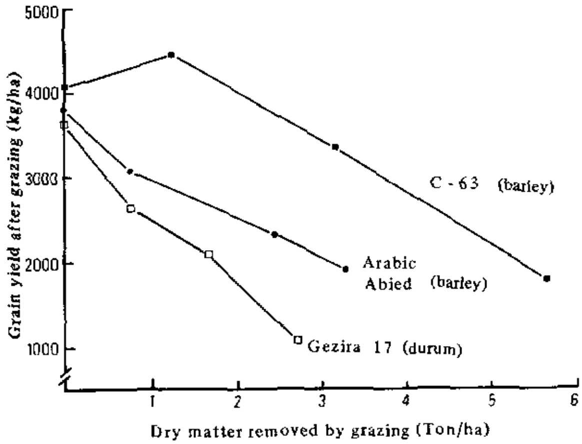


Fig. 4. Effect of dry matter removed by grazing on grain yield of one durum wheat variety and two barley varieties.

between varieties for grain yield were significant (LSD, 0.05 = 650 kg/ha) under all grazing treatments but not ungrazed. Differences between varieties for dry matter yield at the times of grazing were also significant (LSD, 0.05 = 240 kg/ha for early grazing, 542 kg/ha for medium and late grazing).

PLANT POPULATION OF TRITICALE. A widely adapted triticale variety (Beagle) was grown using five plant densities under three water regimes (rainfed, one and two irrigations) and at three times of sowing at Tel Hadya. Analysis of the grain yield (Table 26) indicates that for the early sowing date (December 3) the "optimum" seed rate was 150 kg/ha, corresponding to about 260 plants/m^2. For the medium and later sowings (December 22 and February 2) where there was some water restriction (rainfed or one irrigation) there was no significant yield increase over 50 kg/ha (about 90 plants/m^2). However, for the late sowing where water restriction was less (one or two irrigations) the optimum seed rate was 100 kg/ha (180 plants/m^2).

These results, which are among the first for triticale in the region, imply that under longer season conditions where water is not a seriously limiting factor, seed rates of up to 150 kg/ha can lead to significant yield increases. Under shorter season conditions, where water may be a limiting factor, seed rates greater than 50 kg/ha do not result in increased yields unless the water supply is also increased.

***Table 26.* The effect of sowing date, water regime, and seed rate on the yield of triticale (1980/81 season).**

Seed rate (kg/ha)	Yield (kg/ha) Rainfed	One irrigation	Two irrigations	Mean
T1–Sown 3/12/80				
50	5321	5774	5835	5643
100	5399	6496	5584	5826
150	6112	7032	6399	6514
200	5242	6858	5998	6033
250	5088	5680	5408	5392
Mean	5432	6370	5845	5882
T2–Sown 22/12/80				
50	3242	4977	4108	4109
100	3909	5261	5714	4961
150	3846	5470	5138	4818
200	3770	5583	5033	4795
250	3665	5071	5340	4692
Mean	3686	5272	5067	4675
T3–Sown 2/2/81				
50	2117	2917	3036	2690
100	2790	3291	3918	3333
150	2786	3446	3946	3393
200	2832	3568	4282	3561
250	2828	3554	4412	3598
Mean	2671	3355	3919	3315

LSD (0.05) for seed rate means with the same water treatment and sowing date = 746 kg/ha.

Neither sowing date nor water regime significantly affected the production of fertile tillers in this experiment. This suggests that the correct choice of seed rate to suit the environment is important in triticale since the crop did not adjust to the prevailing conditions by producing tillers.

SALINITY AMELIORATION IN BARLEY PRODUCTION. Arabic Abied barley was sown in a set of combinations of ridge and furrow sowings in a salt lake bed using Arabic Abied barley. The crop was sown with and without phosphate and both before and after the first rains. Soil

Table 27. **The effect of some amelioration treatments on barley plant stand, yield, and head size in a salt-affected soil.**

Treatment	Plants/m^2	Total yield (g/m^2)	Grain yield (g/m^2)	Seeds/ head
Ridge sown before rains + P_2O_5	101	59.3	22.9	5.2
Ridge sown before rains	73	51.2	18.6	4.8
Ridge sown after rains + P_2O_5	112	74.1	30.9	5.1
Ridge sown after rains	117	67.1	26.6	4.3
Furrow sown before rains + P_2O_5	119	75.2	29.7	5.3
Furrow sown before rains	100	43.8	14.3	3.9
Furrow sown after rains + P_2O_5	121	55.5	16.2	3.3
Furrow sown after rains	115	38.5	12.1	3.4
Mulched with barley straw	108	36.9	12.6	3.1
Mulched with wheat straw	114	40.3	12.6	2.4
Gypsum (2 tonnes/ha)	101	37.9	12.6	3.6
Control	86	34.9	11.9	3.7
LSD (0.05)	8	7.5	3.6	0.5

salinity levels ranged from 20 to 100 mmhos at the site. Significant differences between the treatments were found for plants/m^2, total biological yield, grain yield and number of seeds per head (Table 27). Differences in plant establishment were not consistently related to yield. However, differences in total biological yield were related to differences in grain yield which in turn were consistent with differences in head size (number of seeds per head). While this experiment was preliminary in nature it did indicate that sowing on ridges or furrows was better than on the flat, even in the presence of straw mulches or gypsum. It also showed that the addition of phosphate increased yields in most cases. It is likely that further investigation of simple agronomic techniques could increase yields of barley in salt-affected soils.

Cereal Genotype x Environment Interactions

A long-term method of improving cereal crop yields is through an understanding of the response of various genotypes to relevant factors of the environment. The first challenge of this method is to find ways of characterizing genotypic differences that are not readily visible. The second challenge is to adapt these methods for rapid, cheap screening of large numbers of plant breeders' lines. Finally, it is necessary to determine the heritability of measured, desirable characters and to incorporate them into genetic stocks.

One of the effective philosophies of plant breeding has implied that wide geographical adaptation and stability of performance over time are important in raising average crop yields. This has led to testing under a wide range of conditions and selecting widely adapted genotypes which, however, may not be especially well adapted at particular locations. It is considered that while this approach has served cereal breeding well in the past, further advances will most likely come from seeking adaptation to specific environments.

The new approach demands that more be known about the characteristics of both specific environments (sociological, economic, meteorological, edaphic) and of the available genotypes. The experiments described in this project were aimed to assist in characterizing some genotypic responses to some factors of the environment of the region.

Five types of experiments conducted by ICARDA are described below.

DROUGHT TOLERANCE. Seven barley, seven durum wheat, six breadwheat and one triticale variety were grown at four levels of soil water (0, 1, 2 and 3 irrigations). Soil moisture was measured using a neutron probe, and some measurements were made of leaf diffusive resistance, transpiration rate and leaf temperature, attributes thought to be related to water stress in plants. Grain yield and yield components were also measured.

Values of leaf diffusive resistance were linearly related to transpiration rates so that it appears that only one of these measurements is necessary. Leaf temperature differences between varieties were not large or consistent, so the value of this measurement in drought screening is doubtful. However, differences in diffusive resistance measurements taken in the unstressed, vegetative stage (Table 28) did appear to be sufficiently large and were sufficiently consistent to be useful.

The total rainfall in the season was about 420 mm; consequently, the grain yield response to increased water was not great. However, there was a significant ($P \leq 0.05$) yield increase with one irrigation (approx. 70 mm of added water), particularly in the durum wheats, and there were significant interactions between water treatment and variety. It thus seems possible that with a wider range of water inputs in the future, differences in response to water stress may be found among varieties that will be useful in breeding for drought resistance.

NITROGEN EFFICIENCY. Twenty cereal genotypes were grown with the addition of 0, 30, 60, 120, and 240 kg N/ha following the removal of an unfertilized, irrigated maize crop. Grain yield and yield components and nitrogen uptake in the grain and straw were measured. Various indices of nitrogen efficiency were calculated. The grain yield levels in unfertilized plots were very low, even though irrigation was applied to reduce the likelihood of water limiting yield (Table 29). There were, however, some signif-

Table 29. **The yield of some cereal varieties under five rates of applied nitrogen.**

Variety	0	30	60	120	240
Beecher	1326	3017	4128	4541	4534
C-63	1845	2722	4047	5262	4712
R.T.Ramage 11-13	938	2399	3840	4892	3796
Martin	1945	3435	4805	4797	4802
Roho	1364	2410	3476	4007	3737
Esp./1808-4L	1747	2574	3685	4976	4035
Yecora 70	827	1635	2833	3193	4652
Arvand	1562	2976	3764	5330	5923
Haramoun	1249	2207	3786	4796	5296
Fl.Aurore	1258	2303	3055	3336	4492
Moncho'S'	1157	2074	3342	4291	5358
Ciano'S'	1146	2411	3384	4505	5601
Beagle	1324	2184	3940	5507	6698
Cocorit 71	1358	2486	4007	5553	5856
Stork	1110	2101	3479	4437	5150
Jori	1213	2171	3595	4886	6127
Haurani	1327	2323	3685	4256	3659
Waha	1280	2432	3885	5122	7129
Sahl	1466	2511	3936	5603	6520

LSD (0.05) for varieties within N levels = 847 kg/ha.

Table 28. **Mean diffusive resistance (sec/cm) of some barley, durum wheat, and breadwheat varieties at Tel Hadya.**

Barley	MDR[1]	Durum wheat	MDR	Breadwheat	MDR
Antares	1.57	Sahl	1.27	Arvand	1.31
Beecher	1.53	Haurani	1.24	Yecora 70	1.22
Martin	1.48	Cocorit	1.18	Fl.Aurore	1.22
Esp./1808-4L	1.31	Jori	1.14	Ron x CC	1.15
Arabic Abied	1.24	Stork	1.10	Haramoun	1.13
R.T.Ramagell-13	1.12	Waha	1.10	Beagle (Triticale)	1.10
Roho	1.10	Cimarron-Sari Bursa	1.07	Cno'S'-PJ62xGa110 /Pic'S'	0.95

[1]MDR = mean diffusive resistance. Readings were taken on March 10 and March 18, 1981.

icant yield differences at 0 kg N/ha. Differences in the amount of nitrogen fertilizer required to give maximum grain yield were also evident. In general, barley required less nitrogen for maximum grain yield than did wheat. This effect was related to efficiency with which applied nitrogen was utilized in grain production. Some examples of contrasting varieties are given in Table 30.

Table 30. **The nitrogen required for maximum grain yield and the net yield per unit of applied nitrogen for some cereal varieties.**

Variety	Crop	N(kg/ha) applied for max. grain yield	Net grain yield/N applied (kg/kg N)[1]
Roho	Barley	120	22
Martin	Barley	60	48
Arvand	Breadwheat	240	18
Ciano'S'	Breadwheat	240	19
Beagle	Triticale	240	22
Haurani	Durum	120	24
Waha	Durum	240	24

[1]*Net grain yield = max.yield−yield at zero applied N.*

Significant differences in total plant nitrogen uptake at maturity were more apparent at levels of 60 kg N/ha and above. However, there was an overall reduction in gross nitrogen utilization efficiency (actual grain yield/total N uptake at maturity) at higher rates (Table 31). The durum wheats and Beagle (triticale) had higher gross utilization efficiencies than the barleys and breadwheats, but there were significant differences between genotypes at all nitrogen levels. Sahl (durum wheat) and Beagle (triticale) showed high efficiency at all levels, but Martin (barley) showed high efficiency only at the lower levels.

These results, which agree in general with those of the 1979–80 season, could lead to an improvement in the profitability of nitrogen fertilizer application to cereal crops grown in both low and high fertility soils, and may be especially important where nitrogen fertilizers are either unavailable or very expensive due to the increasing cost of manufacturing fuels. The data provide an additional criteria for plant breeders in the selection of parents for the production of high yielding and input-efficient varieties.

Table 31. **The gross nitrogen utilization efficiency (grain yield/N uptake, kg/kg N) of some cereal varieties at five rates of applied nitrogen.**

	Applied N rate (kg/ha)				
Variety	0	30	60	120	240
Barleys					
Beecher	48	54	48	42	27
C-63	50	49	47	44	27
R.T.Ramage 11-13	48	50	43	39	29
Martin	53	57	45	42	22
Roho	41	46	42	37	28
Esp./1808-4L	50	49	46	42	28
Breadwheats					
Yecora 70	40	41	40	38	28
Arvand	58	65	50	54	34
Haramoun	53	51	45	42	37
Fl.Aurore	54	51	36	43	26
Moncho'S'	53	53	46	48	36
Ciano'S'	51	47	45	44	37
Beagle (triticale)	63	59	56	56	46
Durums					
Cocorit 71	54	56	46	56	41
Stork	57	63	54	48	45
Jori	47	50	46	39	36
Haurani	49	50	46	37	26
Waha	52	58	53	54	47
Sahl	61	68	61	63	47

LSD (0.05), varieties within N levels = 7.

SCREENING OF DURUM GENOTYPES FOR NITROGEN RESPONSE. Forty-five durum wheat lines likely to be used as parents in the durum wheat breeding work were grown with irrigation using ten nitrogen rates, following the removal of an unfertilized maize crop. Yield and nitrogen uptake were measured. Selected preliminary estimates of some nitrogen efficiency criteria are shown in Table 32. They indicate that, for the varieties shown, those giving high yield when no nitrogen was applied had a low efficiency of utilization of applied fertilizer, and a high nitrogen requirement for maximum yield. These data indicate that the field screening technique may be useful in selecting parents for use in breeding more nitrogen efficient varieties.

GRAIN YIELD RESPONSE OF BARLEY VARIETIES FOLLOWING GRAZING. This experiment was carried out in collaboration with

Table 32. **Yield response characteristics of selected durum genotypes.**

Variety	Yield with zero applied N(g/m^2)	Maximum yield/(g/m^2)	N rate at max. yield (g/m^2)	Net grain yield/ gN applied (g/g)[1]
Cando	450	725	8.5	32
Bittern'S'	400	850	18.0	25
Faisca	450	725	22.5	12
D-Dwarf	250	725	6.5	73
Oviachic/Amarelejo	350	775	7.0	61
Timgad 73	300	625	5.5	59

[1] *Net grain yield = max.yield−yield at zero applied N.*

the Pasture and Forage Improvement Program. Eight barley varieties, selected for their high forage and hay yields, were either grazed or left ungrazed and their dry matter and grain yields were compared. The genotypes used in this experiment had been selected for high hay production by the Pasture and Forage Improvement Program but had not previously been tested for both dry matter yield at the tillering stage (grazing time) and subsequent grain production after grazing. Dry matter yields at tillering were in general about 1000 kg/ha more than those of some dual-purpose and grain types grown under similar conditions in an adjoining experiment. The grain yields after grazing were not significantly lower than the yields from ungrazed plots, and significant differences ($p. \leq 0.01$) were found between varieties both in the grazed and ungrazed condition.

PLANT IDEOTYPE STUDIES. Four pairs of breadwheat varieties chosen for their high and low tillering, high and low 1000 kernel weight, high and low head fertility, and their large and small head size, were grown using plant densities of 50, 100, 200, 400 and 800 plants/m^2. Yield and yield components were measured.

Significant ($P \leq 0.01$) yield differences were measured between varieties. However, two varieties (Sonalika and Ciano-67) were affected by late frost at anthesis and one variety (Orofen White) shattered badly before harvest. There were no significant differences among the average yields (over all populations) of the other varieties, nor were there significant differences in the highest yields achieved by these varieties. The populations at which highest yields were obtained ranged from about 40 to 60 plants/m^2. Differences between varieties in their yield components were greatest at the lower plant density, but were in most cases not significant at the higher densities.

In this experiment, the interaction of frost with maturity had a far greater effect on yield than plant population or yield component characteristics. Data from this type of experiment, accumulated over a range of conditions, should assist plant breeders in determining the effectiveness of selection for the various yield components to assist in yield improvement, adaptability and stability.

Disease Resistance and Control

Wheat and barley diseases cause considerable yield losses in countries of the ICARDA region. Although national and international centers have made some progress in breeding for resistance, especially for wheat rusts, diseases still decrease yields considerably. Some diseases have also been either under-estimated or completely neglected, including common bunt and bacterial diseases in wheat and covered smut and bacterial diseases in barley.

Incorporating Disease Resistance

The level of disease resistance in breeding materials in breadwheat is generally more satis-

Incorporating multiple disease resistance in new wheat and barley lines has a high priority in ICARDA's breeding programs.

factory than in durum wheats and barleys. This makes upgrading the level of resistance and broadening the genetic base in these two crops a high priority in ICARDA breeding programs.

The cereal pathology program aims to assist breeders in ICARDA and the region in incorporating resistance to the major cereal diseases. Screening, identifying and utilizing new genes for resistance and sources of broad-based and long lasting resistance is the back-bone of this program. The development of genetic stocks of barley and wheat with different types of genes for resistance and/or gene combinations, along with germplasm characterized by resistance to different diseases (i.e. multiple disease resistance) are the main thrust of this program.

Identified sources of resistance are made available to national programs in the region through the international nursery system.

EVALUATION OF LINES. Evaluation for diseases starts in the same year that breeders evaluate for yield potential. Lines yield tested for the first time in the initial yield trials are automatically included in the initial disease nursery (IDN) and grown at Tel Hadya in the plastic house as well as in the disease nursery in the field. They are also grown at Lattakia (Syria) as well as in Terbol (Lebanon). These lines are evaluated to the three rusts, powdery mildew, and common bunt in wheats in addition to powdery mildew, scald, leaf rust, and covered smut in

Table 33. **Key Location Disease Nurseries (KLDN) sites and diseases.**

	Spring barley								Spring wheat							
Location	Sc[1]	PM	Hel.	LR	YR	SR	CS	BB	LR	YR	SR	PM	Hel.	SLB	CB	BB
Morocco	*	*	*	*	*				*	*	*	*	**	**		
Tunisia	*	*	*	**	*	*			*	**	*	**	**	**		
Egypt		**	*	**		**			**	**	**					
Syria	*	**		**			*	*	*	**	*	*			**	*
Lebanon	*	**		**	*				*	*	*	*				
Turkey	*	*	*	**		*			*	**	**		*	*		*
Pakistan	*	*	*	*	**	*			*	**	*		*			
Yemen	*	*	*	**		**				**	**	*				
Ethiopia	**	*	*	**	**	**			*	*	**			**		
Kenya	**		*	*	**	**				**	**					
TOTAL	9	9	8	10	6	7	1	1	8	10	10	5	4	4	1	2

[1]*SC = Scald, PM = Powdery mildew, Hel.* = Helmithosporium spp.
LR = Leaf rust, YR = Yellow rust, SR = Stem rust, CS = Covered smut.
BB = Bacterial blight, SLB = Septoria leaf blotch, CB = Common bunt.
**Severe disease development.*
***Very severe disease development.*

barley. Superior lines are then promoted to the preliminary stage of yield test and are automatically included in the Key Location Disease Nursery (KLDN) grown in hot spot locations in the region for disease evaluation (Table 33). Entries promoted to the third year of yield testing (advance yield trials) are also automatically included in the KLDN. Lines having good yield potential and adequate disease resistance are then made available to cooperating national programs in the region through the international nursery system.

Moreover, lines generated in the international nurseries and grown under a wide range of agroclimatic conditions are categorized for their resistance to diseases of importance in the region. A pattern analysis is conducted for the majority of the diseases of importance and representative varieties from each group are selected on the basis of their better yield performance and adaptability in the region. These are then intercrossed to combine the different sources of genes together. On the other hand, varieties showing a broad base of resistance are identified same as those showing multiple disease resistance.

During the current crop season, 1980/81, a total of 3874 barley, 3522 durum and triticale, and 5260 breadwheat lines were screened for diseases in the plastic house and in disease nurseries at Tel Hadya, Gebla (near Lattakia), and Terbol stations. Breadwheats and durums were evaluated for their reaction to the three rusts and powdery mildew while barleys were screened for leaf rust, powdery mildew, and scald. Yellow rust inoculation and development were quite severe this year on wheat and to a lesser extent leaf rust at both Tel Hadya and Gebla. In barley, leaf rust, powdery mildew, and scald reached a satisfactory level at these locations. This material has been scored for the different diseases and lines showing adequate levels of resistance have been selected for further use in the breeding programs.

A set of 1700 advanced breeding lines of barley in different stages of yield testing was evaluated to a composite collection of covered smut collected from Syria. The same was done with 2400 durums and 3351 breadwheats to common bunt. The data show that in general durum wheats are more resistant than breadwheats. The average percentage of infection of all entries in the KLDN-BW (1200 entries) was 60.5%, compared with 41.5% in the IDN (1153 entries). The percentage of lines showing high resistance (O-T) in the former set was lower than that in the latter (Table 34). This is mainly due

Table 34. **Number and percentage of entries in common bunt disease categories. Breadwheat disease screening nurseries (Aleppo 1980/81).**

Nursery	Disease category, number, and average percentage of infection (API) of entries[1]															
	0-Trace		T–5%		5–10%		10–20%		20–30%		30–50%		50–70%		70–100%	
	No	API	No	API	No	API	No	API	No	API	No	API	No	API	No	API
KLDN*	98	8.70	39	3.46	46	4.09	56	4.97	50	4.44	194	17.23	329	29.22	314	27.89
OSN*	302	26.51	101	8.87	82	7.20	97	8.52	79	6.94	213	18.70	166	14.57	99	8.69

[1]*Average percentage of infection of all varieties–KLDN (60.5%), IDN (41.5%).*

Table 35. **Breadwheat and durum lines with good resistance to six collections of common bunt.**

Var. no.	Designation	Collection and average % of infection[1] 1	2	3	4	5	6	Overall average
22	Paha = Suwon92-Omar	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	P101	0.0	0.1	0.0	0.2	0.0	0.0	0.1
12	Neugaines	0.6	0.0	0.0	0.0	0.0	0.0	0.1
13	Kirac 66	0.7	0.3	0.0	0.3	0.2	0.2	0.3
40	Haurani	0.8	0.6	1.1	0.3	1.1	0.9	0.8
33	Lancofen	1.3	0.0	0.2	2.8	0.6	0.4	0.9
8	Cimarron/Sari Bursa7118 YE 1134-6E-0E	2.4	0.5	0.4	2.9	0.4	0.5	1.2
42	MC Dermid	0.8	0.0	2.5	1.6	1.2	1.2	1.2
66	(Cj54-36896xGb56^2)Yalta-Mxp	0.3	2.1	0.0	2.8	1.9	0.6	1.3
17	Luke	1.5	0.9	1.1	1.5	2.2	1.5	1.4
34	HD 2169	3.6	0.2	0.5	3.5	0.3	0.0	1.6
23	Superx/Cardinal L 122-3L-2L-0AP	1.5	2.7	0.9	4.3	1.5	0.5	1.9

[1]*Collection: 1 Syria, 2 Turkey spring wheat area, 3 Turkey winter wheat area, 4 Lebanon, 5 Tunisia, 6 Iran.*

to the selection pressure made in selecting for common bunt resistance in addition to the use of resistance sources in the breeding program.

An attempt was made to identify sources of broad-based resistance to six common bunt collections, from Syria, Turkey (spring and winter wheat areas), Lebanon, Tunisia, and Iran. The material inoculated comprised sources of resistance to this disease used in ICARDA or in other wheat improvement programs in the region.

The results obtained showed that some of the varieties tested confer a good level of resistance to all six (Table 35).

There were significant differences in the virulence of the collections. The overall average percentage of infection of all varieties was 20.95% with the Lebanese collection in the first sowing date compared to 7.46% with the Iranian. In the second sowing date it was 14.33% and 3.58%, respectively (Table 36).

Some of the varieties used show a differential reaction to the common bunt collections (Table 37).

Table 36. **Mean percentage of infection of all varieties to different common bunt collections.**

Collection source	Sowing date and av. % of infection: First sowing date	Second sowing date
Iran	7.46	3.58
Turkey(WW)	11.93	9.59
Turkey(SW)	12.30	9.20
Tunisia	15.62	14.19
Syria	19.53	14.61
Lebanon	20.95	14.33
LSD 0.05	3.33	4.06

Table 37. **Varieties showing differential reaction to common bunt collections (Aleppo, 1980/81).**

Variety	Collection and average % of infection					
	Syria	Turkey (SW)	Turkey (WW)	Lebanon	Tunisia	Iran
First Sowing Date (LSD 0.05 = 27.25)						
Tob/8156//Kal	8.1	1.6	1.7	56.7	4.9	0.0
CM8783-0L-5L-3L-2L-0ke-0SK-0AP						
Fn/Th/K58/N/3/My54/N10B//An/4/Rfn/Cofn	5.1	0.5	1.4	41.2	0.3	1.4
SWD70031-02W-1H-1H-0P						
Cno^2-Tob66/Dga	23.8	1.0	0.0	33.0	0.7	0.4
II-30466-0M-2S-1S-0S						
Ron70-71-Int4775	55.0	0.0	0.0	27.4	12.4	0.0
SE476-3S-5S-0S						
Cno-$Inia^2$(Y54/N10BxNar59)	2.1	4.5	0.0	40.8	8.3	0.0
Hugo 1	12.3	3.1	0.0	36.6	4.0	0.9
Jar-Cut"S"	0.0	4.2	2.3	51.7	2.3	0.0
SE804-2S-1S-3S-0S						
Second Sowing Date (LSD 0.05 = 33.27)						
Tob/8156//Kal	4.2	1.7	1.4	70.2	0.0	2.0
CM8783-0L-5L-3L-2L-0Ke-0SK-0AP						
H604	12.0	0.7	66.7	0.7	2.2	0.0
Fn/Th/K58/N/3/My54/N10B//An/4/Rfn/Cofn	7.3	0.0	1.8	75.1	1.8	0.0
SWD70031-02W-1H-1H-0P						
Hugo 1	13.5	1.8	0.6	41.8	1.9	0.8

KEY LOCATION NURSERIES. Emphasis was given in 1981 to the key locations disease nursery (KLDN) which included all advance breeding lines at the preliminary and advanced stages of yield testing in each of the four crops. The nurseries comprised 1200 entries each of barley, durum wheat, triticale, and breadwheat. The aim was to select resistant material to these diseases and to evaluate the adaptation of the lines prior to their promotion to the international nurseries. All locations were visited and data taken except North Yemen, Ethiopia, and Kenya. However, good disease data have been received from these locations.

Leaf rust on barley was very severe at Izmir (Turkey), yellow rust and scald at Islamabad (Pakistan), and leaf rust, powdery mildew and scald at Tel Hadya and Gebla (Syria). Ninety-seven barleys showed good resistance to leaf rust at Izmir. Out of these, 68 showed also good resistance to yellow rust and scald at Islamabad while only 47 showed resistance to scald, powdery mildew and stem rust as well across all locations. In addition, a few varieties, showing a very low severity of susceptible reaction to leaf rust were selected, based on Izmir data, whenever they were found resistant to other diseases at other locations. These will be further tested for slow rusting.

Similarly, in the KLDN-Durum, Debre Zeit (Ethiopia) is known to be a location where stem rust virulences on durums are prevalent. The data from this location indicated that out of the 915 durum lines tested twelve were resistant to stem rust, 246 showed a moderate susceptible reaction coupled with very low severity (Trace), 95 showed a 5MS severity/type reaction, and 562 showed either a susceptible reaction or a moderately susceptible reaction coupled with high severity. For leaf rust, 181 lines were resistant and 64 out of these showed a moderate susceptible type reaction to stem rust with a very low severity. On the other hand, all the triticale lines tested were resistant to both leaf and stem rusts at Debre Zeit.

In ILDN-BW, 273 entries showed good resistance to all three rusts across locations.

DATA ANALYZED. Disease data on the barley, breadwheat, and durum material generated in the different international nurseries have been analyzed. The aim is to identify lines with different resistance genes to these diseases and also to identify those with multiple disease resistance. Information on lines with multiple disease resistance during 1980/81 season was checked against the previous year's results and was then made available to breeders during the crossing period. Twenty-five lines were identified for durum, 24 for barley, and 19 for breadwheats. Examples of these lines are presented in Tables 38 and 39. Several of these sources have been used in the breeding programs. In addition, lines with different sources of genes for resistance to a particular disease have been intercrossed with the aim of bringing these sources together (Table 40), and other crosses have been made to develop germplasm with multiple disease resistance (Table 41).

Chemical Control

To develop conditions conducive to disease development at Tel Hadya, attempts were made to study the methodology of disease development, evaluation, and inoculum preservation of diseases of importance in the region. The chemical control of two diseases (covered smut of barley and common bunt on wheat) was also attempted in an aim to devise management strategies of use to national programs in the region.

The effect of soil vs. seed borne spores of common bunt of wheat as a source of infection was studied. Seeds of twelve susceptible breadwheat varieties which differed in earliness were used. Half of the seed was inoculated at the rate of 5 gms spores/kg seed and the half was uninoculated. The seed was planted at three different sowing dates: 18/11/80, 14/12/80 and 9/1/81. The results showed that at least in some varieties (BW 4, Kal-Bb and Inia-RL 4220X 7c/Yr "S") soil borne spores are a source of infection and that early planting resulted in a higher infection percentage.

In a study on the effect of different fungicides as seed treatments in controlling common bunt of wheat, the results showed that Hexachlorobenzine, Dithane S60, and Vitavax 200 are superior to Kenolate 15. In the case of covered smut of barley Vitavax 200, Dithane S60 and Kenolate 15 were significantly better than Hexachlorobenzine.

Insect Pest Resistance

WHEAT STEM SAWFLY. The resistance of 296 durum wheat, 231 breadwheat and 27 barley lines to wheat stem sawfly was studied in 1981.

Screening for resistance to stem saw fly in wheat.

***Table 38.* Durum lines with multiple disease resistance for crossing program (1980/81).**

Variety/line	YR	LR	SR	PM	Sept.	TS	BB	Bunt	BYDV	Sawfly[1]
Bittern "S"										
CM 9799-126M-1M-5Y-0Y				*	*		*		*	
D-dwarf S 15-Cr"S"										
D 33312-501Y-0M	*								*	*
Cit "S"/Fg"S"										
CD 3568-5Y-1M-0Y	*	*		*				*	*	
Ruff"S"/Fg"S"										
CM 9880-25M-3Y-1M-0Y	*	*	*	*					*	
Gta"S"/Fg"S"										
CM 10145-15M-1Y-0M	*	*	*	*	*					
61-130-Akb,253/39										
C 24-42E-1E-1E-1E-0E	*		*	*	*		*			
T.K.S.Sel 111		*	*		*	*				
Tunisian Durum 8	*	*	*	*	*					

[1]YR: Yellow Rust; LR: Leaf Rust; SR: Stem Rust; P.M: Powdery Mildew; Sept.: Septoria Tritici; TS: Tan Spot. BYDV: Barley Yellow Dwarf Virus.

***Table 39.* Barley lines with mutliple disease resistance at Tel Hadya (1980/81 season).**

Variety or cross and pedigree	YR	LR	SR	PM	SC	NB	Stripe	BB	BYDV	BSMV	Cyst.N.[1]
CI 8887-CI 5761, SEA13-23S-3S-0S	*			*	*	*					
Menuet	*	*		*					*		
Martin		*									*
5Cr 276-92 (9/20/CI 13280)				*	*		*		*		
Asse	*	*	*	*	*	*					
Cr 355/8 (Giza 120/NS43)					*	*		*			
Alouette	*	*	*	*		*					
Imperial CI 4271										*	

[1]SC = Scald; NB = Net Blotch; Stripe = Stripe disease; BSMV = Barley Stripe Mosaic Virus; Cyst.N. = Cyst Nematode.

***Table 40.* Examples of durum crosses made to combine different types of resistance genes to disease.**

Cross/pedigree	Resistant to:[1]
Cr'S'USA.502229//Bit'S'	YR,LR
ICD 80.602	YR,PM, Sept., Bact.bl., BYDV
Ruff'S'/Fg'S'//Afn	YR,LR,SR,PM,BYDV
ICD 80.910	YR
Reichenbachi/BD1645//P66-270	LR, SR
ICD 80.1022	YR, LR, SR, Bact.bl.
Ch67/Egypt local No.8	LR, PM
ICD 80.1725	LR, SR,Sept.

[1]Diseases underlined represent different sources of resistance in parental varieties.

***Table 41.* Some of the durum crosses made to build germplasm with multiple disease resistance.**

Cross/pedigree	Resistant to:
Ch67/Parana66-270	PM
ICD 80.100	YR, LR, SR, Bact.bl.
Mexi75/Bit'S'	SR
ICD 80.176	YR, PM, Sept., Bact.bl., BYDV
P66-270//Cr'S'/Pic'S'	YR, LR, SR, Bact.bl.
ICD 80.210	YR, PM, BYDV, Sawfly
Roussia/BD1419//Bit'S'	SR
ICD 80.219	YR, PM, Sept, Bact.bl., BYDV
Bit'S'//Ruff'S'/Fg'S'	YR, PM, Sept, Bact.bl., BYDV
ICD 80.327	YR, LR, SR, PM, BYDV

These lines were selected in previous years for their resistance to natural and artificial infestation of wheat stem sawfly. Table 42 summarises the results of this study. After four years of evaluation, several durum wheat and breadwheat lines have been selected as promising for their resistance to the wheat stem sawfly (Table 43).

Lines and cultivars used in the farmers' field verification trials were also evaluated for wheat stem sawfly damage. Percentages of infestation differed with location, species of cereal crop and cultivar or line. However, some consistently resistant material was identified.

Table 42. **The number of cereal lines tested for resistance to wheat stem sawfly at Tel Hadya and the percentage of resistant lines found.**

Crop	No. of lines tested	Range of infestation	No. & (%) resist. lines
Durum	296	0–32.3	81(27.4)
Breadwheat	231	0.6–45.9	9(3.9)
Barley	27	0– 4.6	6(22.2)

Table 43. **Promising durum and breadwheat lines selected for their resistance to wheat stem sawfly (1980/81 season).**

Cross/pedigree	No. years tested	Range of infestation	Average infestation
Durum			
D.Dwarf 's'15xCr's'	4	0.72–6.64	2.54
Cr's'(21563/61-130xLds) M 225-2M-1Y-0M-0Y	4	0.34–11.35	4.06
Gerardo VZ 469-Cr's' CM 459-2S-2S-1S-0S	3	0– 2.27	0.92
D-2	3	0.85–1.66	1.19
D-25	3	0– 3.46	1.35
PI 272552 Provinciale	2	0– 0	0
PI 192845 Mourisco 7746 V79	2	0 –0.70	0.35
CI 15258 Gerardo 517	2	0.54–0.71	0.92
D-Dwarf's–15/Cr's' D 33312-7Y-4M-1Y-0M	1		1.17
Rabi's'/Fg's'/GdoVZ 466 ICD 7437-4L-1AP-0AP	1		1.68
Breadwheat			
MT 777-CI 9294/Fortuna	4	0.61–4.60	1.74
MT 773-CI 9294/Fortuna	4	0.51–4.66	1.99
Fortuna	4	0.42–5.09	3.50
Tob's' P156xY50E-KJ[3] CM 15624-3S-2S-2S-0S	3	1.85–5.41	3.58
Ti 71-TobxAlandra's' CM 33217- Q-4M-1Y-0M	1		3.0

CEREAL APHIDS. Screening for resistance to aphids was conducted at Tel Hadya during 1981. Two durum wheat lines were rated as highly resistant. These were PI 158733 ASA DE CORVO and PI 134921 2869. After two years of evaluation the following breadwheat lines have been selected for aphid resistance: MT 7710 = CI 11490/Fortuna, MT 772 = CI 9321/Resaie, MT 777 = CI 9294/Fortuna, MT 779 = CI 11490/Fortuna, Santoun.

Weed Control

SELECTION OF GENOTYPES. The purpose of this experiment was to select the most competitive genotypes and to develop cultivars which could suppress weeds in regions where other means of weed control are not feasible. From the 1980–81 preliminary observation nurseries, 340 genotypes were tested. Results were based on the total dry weight of weeds (TDW) in each of the four crops. Barley showed the highest competitive ability, followed by triticale, breadwheat, and durum wheat. Heights of plants were measured and the mean tiller number/plant were counted. However, there were no significant correlations between them and the competitive ability of the plant. Good competitors among the four crops were identified.

COMPETITION STUDIES ON WHEAT AND BARLEY. Results showed that there were no significant correlations between yield, seed-rate, and competitive ability of eleven varieties of each of breadwheat and durum tested at two seeding rates: 120 and 180 kg/ha. Nine varieties of barley were tested at two seeding rates: 100 and 150 kg/ha. However, the results were similar to those obtained with wheat.

Table 44. **Cereal tolerance to three different herbicides.**

CROP		Phytotoxicity in EWRC Scores[1] Cyanazine 0.5 kg ai/ha	Dinoseb-acetate 2.5 kg ai/ha	MCPA 1.5 kg ai/ha
Breadwheat	(Mean of 32 entries)	3.64	1.36	1.06
Durum	(Mean of 32 entries)	3.34	1.72	1.02
Barley	(Mean of 85 entries)	3.31	1.75	1.30
Triticale	(Mean of 40 entries)	4.68	1.49	1.28

[1]EWRC: European Weed Research Council. The score is from 1 to 9; 1 represents no phytotoxicity and 9 represents complete kill.

Herbicides for Broadleaf Control

POST-EMERGENCE HERBICIDES. Two trials were conducted. The purpose was to retest the herbicides which gave the best results during the previous season. Nine herbicides were applied individually and in mixtures on breadwheat and barley. Results showed that bentazone + MCPA (1.0 + 0.5 kg a.i./ha) was the best mixture on breadwheat followed by bentazone (1.0 kg a.i./ha) and bentazone + MCPA (1.0 + 0.25 kg a.i./ha). On barley, the most effective herbicide was bentazone (1.0 kg a.i./ha), followed by bentazone + MCPA (1.0 + 0.25 kg a.i./ha), and bentazone (1.5 kg a.i./ha).

A similar experiment was conducted at Terbol using different rates of five herbicides. Results showed that cyanazine (0.4 kg a.i./ha) was the most effective, followed by methabenzthiazuron (2.0 kg a.i./ha) and dinoseb-acetate (2.0 kg a.i./ha).

CEREAL TOLERANCE SCREENING. The tolerance to three herbicides of 190 genotypes in the 1980/81 preliminary observation nurseries was tested. Results showed a large variability in tolerance among genotypes within a species. No such variability was noticed between crops. Table 44 shows that MCPA was best tolerated by all four crops, followed by dinoseb-acetate. Cyanazine caused rather heavy symptoms of phytotoxicity, especially on triticale.

Herbicides for Broadspectrum Control

POST-EMERGENCE HERBICIDES. Four experiments were conducted with an objective to select the most efficient herbicides for the control of broadleaves and grasses in breadwheat, durum wheat, barley, and triticale. Five mixtures of broadleaf herbicides and grasskiller were used. Significant effects on yield were only measured in durum and barley. All herbicide combinations significantly reduced yields of durum wheat. The best control in barley was from difenzoquat + bromoxynil.

Two similar experiments on breadwheat were conducted under higher rainfall—one at Himo research station at Kamishly, Syria and the other at Terbol in Lebanon. The best mixture at Himo was found to be diclofop-methyl + metribuzin + bromoxynil (1.0 + 0.15 + 0.25 kg a.i./ha) followed by dicofop-methyl + bromoxynil (1.0 + 0.5 kg a.i./ha). At Terbol, the most effective mixture was difenzoquat + metribuzin + bromoxynil (1.0 + 0.5 + 0.25 kg a.i./ha), followed by diclofop-methyl + bromofenoxium (1.0 + 1.5 kg a.i./ha).

BROADSPECTRUM HERBILIZER (HERBICIDE-FERTILIZER MIXTURE). Among seven herbicides applied individually and in mixtures, as spray and as herbilizer, the best was bromoxynil + diclofop-methyl (0.5 + 1.0 kg a.i./ha) applied as herbilizer, followed by Brominal plus (1.51/ha), also applied as an herbilizer.

PRE-MIXED VERSUS FRESH-MIXED HERBICIDES. The herbicide bromoxynil was mixed with six different herbicides to form six mixtures. They were prepared five months prior to spraying and compared with similar mixtures prepared at the time of spraying. Table 45 shows that a mixture with flamprop-isopropyl gave much better results when applied just after mixing because it precipitated during storage. Mixtures of bromoxynil with dicamba precipitate immediately after mixing, and therefore was not effective.

Table 45. **Mean wheat yields as affected by pre-mixed and fresh-mixed herbicides.**

Chemical[1]	Yield(kg/ha)	% of check	Rank	SS**
bromoxynil+MCPA	3664.06 a[2]	111.8	1	a
bromoxynil+picloram	3356.77 bc	102.5	4	bc
bromoxynil+dicamba	3268.23 cd	99.8	9	cd
bromoxynil+diclofop-m	2731.77 e	83.4	14	e
bromoxynil+difenzoquat	3351.56 bc	102.3	6	bc
bromoxynil+flamprop-iso	3236.98 cd	98.8	10	cd
bromoxynil+MCPA	3354.17 bc	102.4	5	bc
bromoxynil+picloram	3427.08 bc	104.6	3	bc
bromoxynil+dicamba	2843.75 de	86.8	13	de
bromoxynil+diclofop-m	2960.94 de	90.4	12	de
bromoxynil+difenzoquat	3036.46 d	92.7	11	d
bromoxynil+flamprop-iso	3520.83 ab	107.5	2	ab
Handweeded	3302.08 bc	100.8	7	bc
Control (unweeded)	3276.04 c	100.0	8	c

[1]Treatments 1–6 premixed; 7–12 mixed at spraying.
[2]Numbers followed by the same letter are not significantly different, $p \leq 0.05$.

Grain Quality

The cereal quality laboratory provides service facilities to cereal plant breeders for determining the lines and/or varieties which have the best grain quality characteristics.

SCREENING AND EVALUATION OF THE GRAIN QUALITY OF WINTER CEREALS. The segregating populations of the four cereal crops (breadwheat, durum wheat, barley and triticale) were subjected to quality tests. Advanced lines were also tested. Table 46 summarizes the numbers of samples tested during the period October 1980 to September 1981 for all cereal crops and all test methods. The choice of quality test depended on the generation and availability of seeds. Table 47 summarizes the cereal quality screening program at ICARDA; tests are not listed in order of importance.

In addition to the routine tests, the cereal grain quality nursery (CQN) was started in the 1980/81 season. The CQN aims to determine stability of performance for grain quality characters under different crop growing conditions. A total of 36 entries were planted, comprising durum wheat and breadwheat lines. Selection was based on protein content and percentage of vitreous kernels. Grain, harvested from Terbol, Kfardan, Tel Hadya rainfed, Tel Hadya irrigated, was used in the CQN tests. This material was tested for protein, 1000 kernel weight, hardness (PSI), wheat meal fermentation time (WMFT) and, in durum wheat lines, vitreousness. Correlation studies were also made between the various characteristics, and population distributions were calculated.

The significant correlations between CQN tests were as follows:

- Tel Hadya rainfed, durum wheat lines, df = 17
  - r-protein/vitreousness = 0.736
  - r-protein/PSI = −0.563
  - r-PSI/vitreousness = −0.737
- Tel Hadya rainfed, breadwheat lines, df = 14
  - r-WMFT/PSI = −0.408
  - r-WMFT/1000 kw = 0.619
- Tel Hadya irrigated, breadwheat lines, df = 14
  - r-WMFT/PSI = −0.467
  - r-WMFT/1000 kw = 0.519
- Terbol, breadwheat lines, df = 14
  - r-WMFT/PSI = −0.444
  - r-WMFT/1000 kw = 0.616

Table 46. **Number of cereal varieties and lines tested for various qualitative seed characteristics at Tel Hadya (1980/81 season).**

Test	No. of entries tested				
	Barley	Breadwheat	Durum	Triticale	Total
Protein Kjeldahl	144	105	539	130	918
Protein N.I.R.	1434	1039	5392	1301	9166
1000 kernel weight	1132	1030	2453	145	4760
Vitreous kernel	—	—	2453	—	2453
Plump kernel count	264	—	—	—	264
Hardness	—	112	134	202	448
Pelshenke	—	102	114	1036	1252
Mixograph	—	42	5	36	83
Farinograph	—	42	5	36	83
Khobz baking	—	25	8	2	35

Table 47. **Summary of the quality screening and evaluation tests carried out on cereal crops.**

Test	F_2–F_4				F_5–Advanced and Parental			
	Breadwheat	Triticale	Durum	Barley	Breadwheat	Triticale	Durum	Barley
1000 kernel weight	x	x	x	x	x	x	x	x
Appearance		x		x		x		x
Size distribution				x				x
Vitreous, %			x				x	
Hardness	x	x			x	x		
Protein	x	x	x	x	x	x	x	x
Lysine						x		
Wheat meal ferm.	x	x			x	x		
Millability					x	x	x	
Farinograph					x	x	x	
Bake *Khobz*					x	x	x	
Bake tannour[1]					x	x	x	
Diastatic power								x
Make pasta[2]							x	

[1]*Baked from 100% whole meal in blends.*
[2]*Spaghetti equipment to be installed May 1982.*

- Kfardan, breadwheat lines, df = 14
  r-WMFT/PSI = −0.369
  r-WMFT/1000 kw = 0.538
- *Mutual correlations between location and* hardness (breadwheat lines) were very high (r = 0.892-0.853).
- Mutual correlations between location and 1000 kw (breadwheat lines) were also very good (r = *0.706-0.783).*
- Mutual correlations between location and WMFT (breadwheat lines) were significant (r = 0.540-0.783).

The increase in vitreous kernel and protein percentages were probably *due to increased fer*tilizer in association with irrigation. Under rainfed conditions, significant correlations between protein, vitreous kernel and hardness were observed. The varietal effect on hardness, 1000 kw and WMFT *(in breadwheat lines) appeared* to be unaffected by environment.

MILLING AND BAKING QUALITIES. A large scale survey was initiated to investigate the forms in which cereals are consumed in the

ICARDA region. The main cereal foods used in the countries of the region include single and double layered flat bread, raised breads, couscous and pasta products. To date, fairly comprehensive knowledge has been accumulated concerning the principal forms of breads, pastas and other foods consumed in Tunisia, Egypt, Jordan, Lebanon and Syria. Baking tests were specifically aimed at testing advanced germplasm for suitability as food in the ICARDA region.

The milling and baking laboratory was designed and built at Tel Hadya. It contains a full-scale baking facility and a milling room. A Buhler experimental mill was installed, together with a bran finisher. A milling procedure was established based on the tempering and milling of 1200 g samples of wheat or triticale. A furnace-type oven was built to provide commercial-type *khobz* bread as the final stage in the evaluation of breadwheats and durum wheats. It is also possible to prepare *baladi* bread and North African baguettes in the same oven. There is also a set of commercial-type sheeting rolls for the preparation of the traditional flattened dough pieces.

A judging system was established, based on color, texture (internal crumb and 'bitability') and odor. Baking procedure was based on commercial practice. Baking formulae and recipes have been collected from about 40 bakeries in five countries of the region.

Bread baking studies have been carried out with small local bakeries to compare different wheat varieties for consumer uses.

Flour extractions, obtained using the Buhler mill, range from 65 to 72% for breadwheat and from 50 to 71% for triticale, depending on the hardness. There appeared to be a strong correlation between first break flour and hardness ($r = 0.9$). This relationship is well-established for Buhler-milled flour. Flour ash figures ranged from 0.44 to 0.57% for breadwheats and from 0.50 to 0.62% for triticales.

Before the baking laboratory was built in 1981, three baking studies were carried out in collaboration with two Aleppo bakeries—one fully automated, the other a traditional bakery. The first study was made to compare wheat types and the second to compare different wheat varieties with different protein contents. Both studies were made on fully automated baking equipment. The third study was conducted in a small bakery to compare wheat types.

The conclusions of the baking studies were as follows:

- Weaker wheats make the best *khobz*.
- Extremes of low and high protein are not conducive to good *khobz*, and flours with 10 to 11.5% protein appear to be the most satisfactory.
- Pure durum wheat flours are generally unsuitable, and need to be blended with at least 50% of a "carrying" flour made from breadwheat.

A potential exists for making good *khobz* flours from triticales. Thirty-five lines of durum wheat, breadwheat and triticale were baked. S311 x Nortino and Mexipak made excellent *khobz*, and Panda 'R' produced very good *khobz*.

Farmers' Field Verification Trials

ICARDA's Cereal Improvement Program assisted the Syrian Ministry of Agriculture and

Agrarian Reform in organizing and conducting a series of verification trials on farmers' fields throughout Syria. These trials were started in the 1977/78 season and were designed to assess the yielding ability, stability of performance and disease resistance of promising varieties of breadwheat, durum wheat, and barley when grown by farmers in relatively large plots with a suggested package of agronomic practices. A total of 29 cereal variety trials were successfully harvested in 1981 in Syria. In addition, 14 experiments dealing with agronomic practices were also harvested. The sites were chosen as representative of the distribution of farm size and climatic conditions in Syria.

The objectives of the farmers' field verification trials were to:

- Test the yielding ability, disease resistance and adaptation of promising breadwheat, durum wheat and barley lines and to study their relative performance under farm conditions.
- Acquaint farmers with new and improved farming practices and cultivars, as well as to develop personal relationships between farmers, scientists, and officials of the Ministry of Agriculture and Agrarian Reform.
- Assist Syria in developing and disseminating technology for increased wheat and barley production and to strengthen the national network for testing new lines and management practices.
- Assess whether or not new technology is superior to traditional methods under farm conditions, and, if so, to demonstrate to farmers that new technology works on their land.
- Identify the yield limiting factors and to allow farmers to select their own technology.

The trials have been conducted for four seasons on three cereal crops over three rainfall zones under both rainfed and irrigated conditions. The varieties used were selected for their superior performance in yield trials throughout the West Asia and North Africa region.

Several improved commercial varieties were included in the trials as checks. All trials were planted during November and the first half of December by a joint team from ICARDA and the Ministry of Agriculture and Agrarian Reform. An experimental plot drill was used. The seed rate used was 100 kg/ha for breadwheat and barley and 125 kg/ha for durum wheat. The plot size was 6.5 m x 15 m (97.5m^2) with two replications. The row spacing was 27 cm. Pre-sowing cultivation and seed bed preparation was left to the individual farmer and thus varied considerably depending on the farmer's established practice. Herbicides were applied when needed. Farmers field days were organized prior to heading.

The trials were combine-harvested in the presence of ICARDA and Ministry personnel, as well as the farmers concerned, to allow valid yield comparisons. Areas of the farmer's adjacent cereal crop were also harvested at the same time as each trial. Table 48 lists the sites and the number of farmers' field verification trials during the 1980/81 season, and the yields recorded at sites in zone C are given in Table 49.

***Table 48.* The sites and the number of field verification trials carried out in the 1980/81 season.**

Locations	Irrig. trials	Zone A	Zone B	Zone C + D	Agron. trials
Aleppo	—	2	2	2	C4+A2+B2
Idleb	—	2	1	1	B2+A2
Hama	1	—	2	—	Irr 2
Al-ghab	—	3	—	—	—
Homs	—	—	1	1	—
Damascus	1	—	—	—	—
Raqqa	1	—	—	—	—
Hassakeh	—	2	1	1	—
Darra	—	1	1	—	—
Tel Hadya	—	1	1	1	—
TOTAL	3	11	9	6	14

RELEASE OF VARIETIES. A major result of the farmers' field verification trials has been the acceptance for release of six varieties: two breadwheat (S 311 x Norteno and HD 2172), two durum wheat (Sahl and Waha's'), and two barley

Table 49. The yield and rank (R) of barley and triticale varieties in the field verification trials in zone C in Syria (1980/81 season).

Locations / Varieties	ZONE C, (6) Locations.													
	Al-Mojarja (kg/ha)	R	Tel Hadya (kg/ha)	R	Khanasser (kg/ha)	R	At-Aran (kg/ha)	R	Chenchar (kg/ha)	R	Hawa (kg/ha)	R	Average (kg/ha)	R
A-Abied (check)	3718	5	3098	4	998	2	1985	5	1195	7	2734	3	2288	3
Beecher	3413	9	2595	9	811	6	1836	6	1349	3	2810	1	2136	7
Esp/1808-4L	3406	10	3385	7	875	4	2072	4	1395	2	2459	5	2265	4
2762xBeecher-6L	4529	1	2657	8	780	7	2088	3	1208	6	2751	2	2336	2
Composite 29	4308	2	3174	3	841	5	1836	6	1098	9	1705	9	2160	6
Cr 366-13-2	3728	4	2769	7	508	9	1605	8	1218	5	1618	10	1908	9
Martin	3467	8	3390	1	1003	1	2439	1	1490	1	2334	6	2354	1
Minn 126/CM 67	3641	6	2569	10	493	10	1606	7	1036	10	1744	8	1848	10
Composite CM 89		3	2893	5	585	8	1431	9	1139	8	2093	7	2024	8
WI 2198		7	2836	6	892	3	2236	2	1313	4	2564	4	2235	5
Triticale														
Beagle	3375	–	2759	–	798	–	–	–	–	–	1574	–	2127	–
M_2A-Bgl x 15733-1N-0M	4716	–	2559	–	872	–	–	–	–	–	1590	–	2435	–

varieties (Beecher and Badia). They were chosen on the basis of adaptation, high yield, and disease resistance and will be released to farmers if the 1981/82 data confirm previous results.

Collaborative Projects in the Region

JORDAN. The third year of the mutual cereal project (1980/81 season) was average in terms of rainfall and its distribution. Twenty variety and agronomic trials and seven "traditional" vs. "improved" farming practice trials were planted in Jordan during the season. (In zone A nine sites were established, in zone B eight, and in zone C three.) Plot size, layout, and general treatments were the same as in previous years. The trials included the following:

- Variety verification trials (durum wheat, barley and triticale).
- Seeding rate trials.
- Rates of nitrogen trials.
- Rates of seeding trials.
- "Traditional" vs. "improved" farming practice trials.

These trials and demonstrations were carried out jointly by research workers of the Ministry of Agriculture and the Faculty of Agriculture at the University of Jordan with the assistance of an ICARDA project specialist. Results indicate that durum wheat and barley varieties with improved yields and stability of performance have now been identified and can be made available to farmers. The effects of seed rate, date of planting, fertilizer application, and the effects of some local farming practices have become better understood.

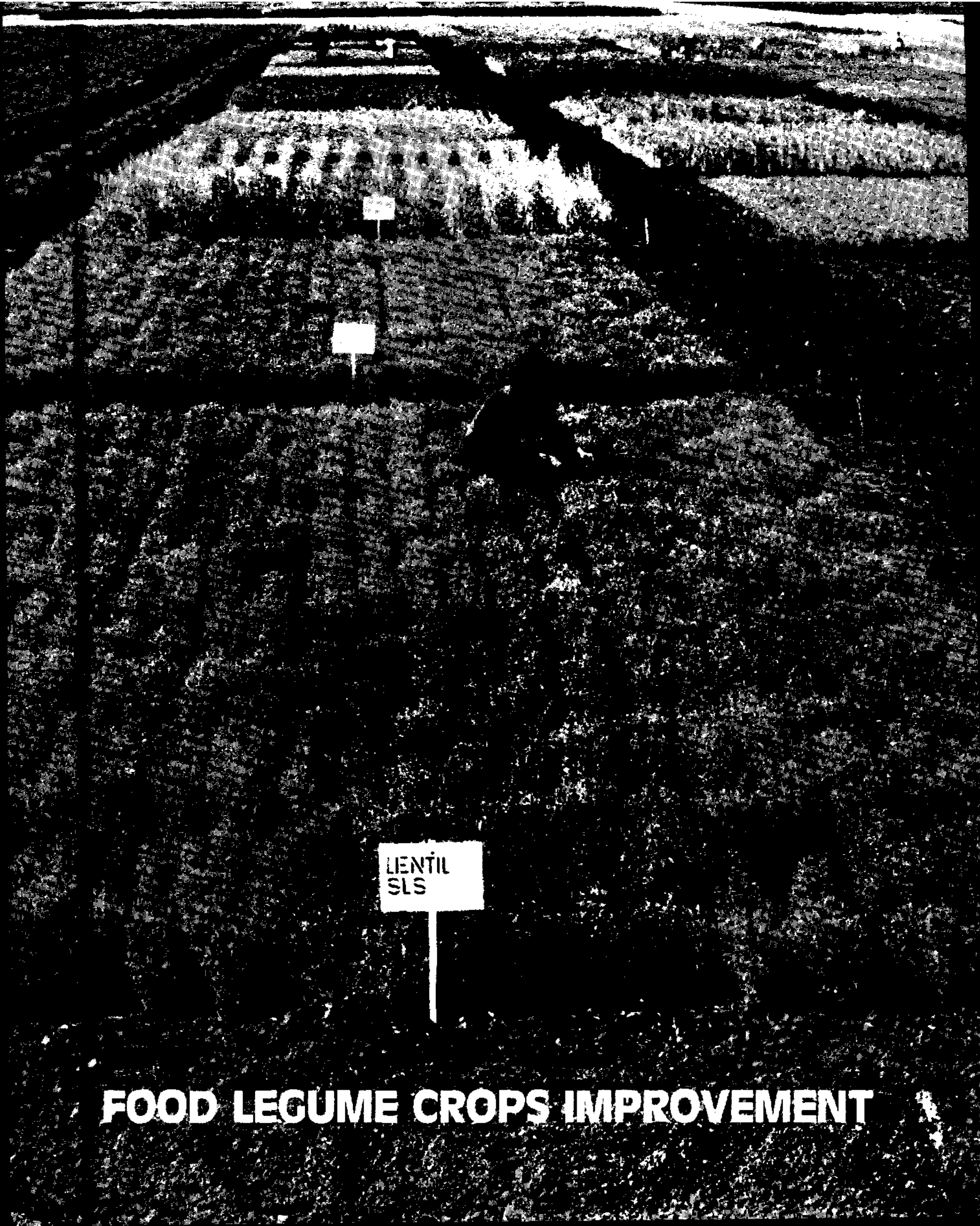
TUNISIA. The cereal project with Tunisia started in 1980 with the objective of strengthening the overall cereal improvement effort in that country, particularly in the improvement of barley and cereal disease resistance. The work has been carried out in close collaboration with

INRAT, INAT, and scientists of the Office des Cereals. From this base in Tunisia, it is also planned to serve Morocco and Algeria by focusing on problems common to the Maghreb countries of North Africa.

Through the next five year plan, Tunisia intends to increase cereal production. The government is encouraging the expansion of barley into the central and southern regions of the country. Emphasis is being placed on developing durum wheat and breadwheat varieties and production technologies for northern Tunisia and on the development of barley suited to the lower rainfall zones of central and southern Tunisia.

ICARDA scientists are assisting the Tunisian cereal program in establishing a sound barley project aimed at the improvement of the following: adaptability to moisture and heat stress, stability of grain and straw production, and disease resistance. A limited number of crosses were made, and ICARDA has sent special germplasm for screening on request. Nurseries were planted at the following locations representing the different agro-climatic areas of the country: Le Kef, Hendi Zitoun, Beja, Mateur, Bou Salem, Sidi Bouzied, and Kasserine. Results to date show that some of the barley lines tested performed well in central and southern locations.

CYPRUS. A number of barley, durum wheat, breadwheat and triticale lines were screened under Cyprus conditions which require earlier heading and maturity because of the milder winters compared to ICARDA's stations in Syria and Lebanon. Crosses made in Cyprus and subsequent selections were tested at Tel Hadya to identify varieties suited to countries with shorter crop duration requirements.



FOOD LEGUME CROPS IMPROVEMENT

Contents

(Photo on previous page: Lentil experimental plots at Tel Hadya.)

FOOD LEGUME CROPS IMPROVEMENT

Introduction

The general aim of the Food Legume Improvement Program at ICARDA is to improve the productivity of faba beans, lentils, and kabuli type chickpeas within and outside the ICARDA region and thereby contribute to:

- **Increasing the total food production and improving the availability of better quality protein in the diet of populations that largely depend on these crops.**
- **Increasing rural income.**
- **Improving soil fertility, thereby decreasing the dependence on fertilizer nitrogen in the cropping system.**

More specifically, the program seeks to encourage and support national research efforts through:

(1) Collection, maintenance, evaluation, and distribution of germplasm.

(2) Development and distribution of advanced lines, segregating populations and other genetic material for the development of cultivars having:

- Increased seed as well as total biological yield potential and yield stability.
- Appropriate phenology to make the best use of the growing period in different parts of the region.
- Resistance to common diseases, pests, *Orobanche,* and the common environmental stresses.
- Acceptable and improved seed quality in terms of nutritive value, cooking properties, and other physical traits for which there is consumer preference.
- Resistance to lodging, pre-harvest pod shedding, and grain shattering.

(3) Development of appropriate cultural practices for different genotypes and agroecological conditions,

(4) Conducting of relevant research in pathology, entomology, microbiology, weed management, crop physiology, genetics, seed quality, economics, and mechanization in support of the work on the development of cultivars and agronomic practices.

(5) Training of scientists from national programs in food legume improvement and the development of an international network of food legume scientists.

Table 1. Summary of the results of the irrigated faba bean yield trials at Tel Hadya (TH) and Terbol (T) in the 1980/81 season.

Trial location	No. of test entries	Heaviest yield (kg/ha)	No. of entries exceeding check yield	No. of entries significantly exceeding check yield[1]	CV (%)
PYT-large seed (T.H.)	40	3899	4	0	11.9–26.7
PYT-large seed (T)	40	4679	16	0	10.4–19.8
PYT-small seed (T.H.)	264	4421	254	169	9.4–18.5
PYT-small seed (T)	176	4222	143	49	9.4–14.9
BIYT-large seed (T.H.)	15	5942	11	2	16.0
BIYT-large seed (T)	15	3783	3	0	18.1
BIYT-small seed (T.H.)	23	5069	9	0	12.0
BIYT-small seed (T)	23	4310	5	0	11.5
BISN-YT-large (T.H.)	63	6355	7	0	14.5
BISN-YT-small (T.H.)	59	5088	50	24	14.7
AYT-large (T.H.)	23	4652	1	0	12.1
AYT-large (T)	23	2290	6	0	16.1
AYT-small (T.H.)	33	3804	26	1	16.6
AYT-small (T)	33	1792	29	2	31.0

[1]*$P \leq 0.05$ on LSD test.*

Faba Bean Improvement

Cultivars and Production Technology for Dry Seed Use

One of the principal objectives of this project is to develop cultivars and other genetic stocks for the production of faba beans under high rainfall and irrigated conditions with a range of maturity periods to fit different agro-ecological zones and seed characteristics preferred by consumers. Researchers also seek the following attributes:

- High and stable dry seed yield.
- Resistance to *Asochyta* blight, chocolate spot, *Orobanche*, aphids, lodging, and pod shattering.
- More efficient growth habit.
- Autofertility.
- Maintained and/or improved nutritional and cooking quality.

Another objective is to develop appropriate agronomic practices for existing and improved cultivars.

Development of Cultivars and Genetic Stocks

BREEDING FOR YIELD. During the 1980/81 season, 520 entries were evaluated in replicated yield trials under irrigated conditions at Tel Hadya, and 320 entries were evaluated at Terbol (Table 1). Yields at Tel Hadya exceeded 6 t/ha in a replicated large seeded yield trial (BISN-YT-L) which comprised entries sent to co-operators in the international screening nursery. In the international large seeded yield trial (BIYT-L), 11 of the 15 entries outyielded the local check (ILB 1814) which gave 4,565 kg/ha.

The performance of some of the best entries from the BIYT-L at other locations and in the previous year is shown in Table 2. In general, yields at Terbol were slightly lower than at Tel Hadya, largely as a result of a severe infestation by stem borers (*Lixus* spp.).

During the season, a total of 232 crosses were made in the screen houses at Tel Hadya and 46 crosses at Terbol. Also, 223 F_2 populations were grown under irrigation at Tel Hadya and 247 at Terbol. A total of 173 and 62 F_3 popula-

Table 2. **The seed yield of some faba bean genotypes (as percentage of check yield) in Syria (Tel Hadya) and Lebanon (AUB and Terbol) in the 1979/80 and 1980/81 seasons.**

	1979/80			1980/81			
Entry	Tel Hadya (irrig.)	Tel Hadya (rainfed)	Terbol	Tel Hadya (irrig.)	Tel Hadya (rainfed)	Terbol	AUB
74TA 59	107	86	108	114	100	96	106
74TA 63	105	91	93	118	109	106	107
Aquadulce	106	98	76	108	108	94	98
Reina Blanca	—	—	—	115	109	89	121
39 MB	113	101	105	111	103	87	80
Elegant 5 MCI	112	101	113	130	102	102	100

tions were grown at Tel Hadya and Terbol, respectively.

RESISTANCE TO *ASCOCHYTA* BLIGHT. The major disease work on *Ascochyta* blight and chocolate spot was conducted at Lattakia. Of 49 promising lines evaluated, eight were rated as resistant or highly resistant. Eleven selfed plants and 28 open-pollinated plants were selected for further evaluation. Forty-nine F_2 populations were grown at Lattakia. Nine populations produced a high proportion of promising segregants for resistance. The progenies of four single plants selected from 80SL 15563 were rated as resistant to both *Ascochyta* blight and rust. Thirty-four crosses were made at Tel Hadya involving 12 promising sources of resistance to *Ascochyta* blight.

RESISTANCE TO CHOCOLATE SPOT. A total of 526 BPL accessions were evaluated for resistance to chocolate spot. Fourteen were rated 1 and 148 rated 3 on a 1 to 9 scale, where 1 = highly resistant and 9 = highly susceptible. A total of 332 single plant selections were made for further evaluation. In a replicated trial, the entries BPL 112, ILB 938 and ILB 438 were very promising. Ten single plant selections were made. The line ILB 938, originally identified as resistant by the Egyptian national program, has also shown a good level of resistance in the UK. There are also reports from both Egypt and Canada that this accession may possess additional genes conferring resistance to rust.

RESISTANCE TO *OROBANCHE*. Screening for resistance to *Orobanche crenata* was carried out at Kafr Antoon. Of 420 BPL accessions evaluated in four replications, 43 had lower infestation than the most resistant check cultivar, Family 402. In a re-evaluation of the 28 most promising lines identified in previous seasons, all were found to be significantly better than the local susceptible check cultivars and six had lower mean infestation than Family 402. Many entries appear to be highly promising, especially BPL 561, BPL 587, BPL 811, and Family 402. A total of 2,800 single plants were selected in F_2 populations grown at Kafr Antoon, and 31 of the 96 F_3 progenies grown were also selected. A total of ten crosses were made at Tel Hadya, involving six *Orobanche* resistance sources, with the aim of improving the sources and incorporating resistance into adapted genetic backgrounds.

RESISTANCE TO APHIDS. The accessions BPL 213 and BPL 222 again showed significantly less infestation by aphids than the check. Other promising sources of resistance to aphids include cvs Rstatt, 81S 1183, 81S 1232, BPL 642, BPL 687, and BPL 1085.

DETERMINATE GROWTH HABIT. Work continued in 1981 on the development of lines having determinate growth. This characteristic is considered to be potentially important especially in high rainfall and irrigated regions of high fertility where excessive vegetative growth may

Determinate plant type in faba beans has promise for conditions of assured moisture supply.

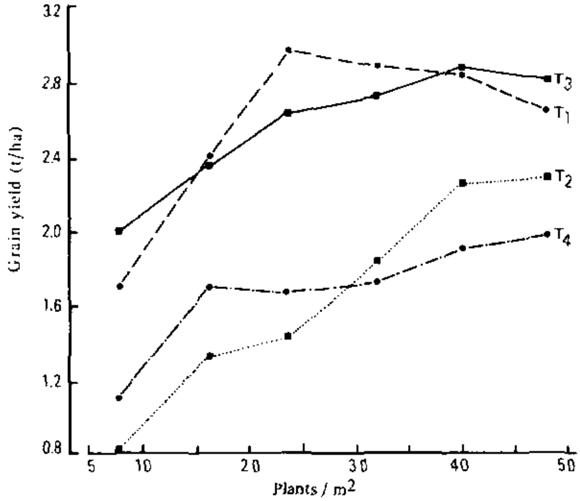


Fig. 1. Effect of plant population on grain yield in four artificially created plant types.

occur. Twenty crosses were made at Tel Hadya, and selection was carried out within and/or among 79 F_2 populations, 819 F_4 progenies, and 334 F_4 bulks.

Production Physiology *and Agronomy*

POPULATION RESPONSE OF PLANT MODELS. Studies on identifying an appropriate plant ideotype for the growing conditions at Tel Hadya were continued during the 1980–81 season. Monostalked (T_2), triplestalked (T_3), and multiple-stalked (T_1) plants models with indeterminate growth habit and a multiple-stalked determinate plant model (T_4) were evaluated for their yield performance at increasing plant population levels from 8 to 48 plants/m^2. Results (Fig. 1) showed that all population levels models T_1 and T_3 were superior to T_2 and T_4. The mono-stalked indeterminate model (T_2) responded positively to increased plant density up to 48 plants/m^2 although the increase in yield with rise in population from 40 to 48 plants/m^2 was small.

SOURCE—SINK RELATIONSHIP. In another study aimed at providing information on plant ideotypes, sink size was varied by either detopping or removing the flower buds at various nodes with a view to studying the effect on pod retention and yield. Detopping above the 16th flowering node as soon as anthesis occurred on the 10th flowering node, removing flowers above the 16th flowering node as soon as anthesis occurred on the first 10 flowering nodes, or retaining only 16 flowers on 16 flowering nodes resulted in heavier yields than those obtained when sink size was not altered.

DATE OF PLANTING AND PLANT POPULATION. Studies on the response of 12 promising genotypes to dates of planting in the 1980/81 season at Tel Hadya confirmed the results of the 1979/80 season. In spite of late frost in early April, the earliest dates of planting in October and early November gave the heaviest yields. A local large seeded land race (ILB 1814) gave the most stable performance by showing the lowest reduction in yield with delay in planting. Studies at Terbol also showed the advantage of an early date of planting, the yield levels being 2795, 2787, 1878 and 1635 kg/ha for October, November, December, and January plantings respectively.

Populations of 25 to 33.3 plants/m^2 resulted in the highest yields both at Tel Hadya and Terbol.

The response of eight promising genotypes of different plant types, including a determinate bulk, to increasing plant populations up to 50 plants/m^2 was studied at Tel Hadya. The increase in yield with increase in plant population was of a much higher order in 1981 than in 1980, the mean yields being 1778, 1508, 1068, and 738 kg/ha at 50, 33.3, 22.2, and 13.3 plants/m^2 respectively. Seville Giant, New Mammoth, ILB-1814, and the determinate bulk showed an almost linear increase in yield with increase in plant population.

INOCULATION WITH *RHIZOBIA*. Evaluation of faba bean *Rhizobium* strains at Tel Hadya indicated that an increase of 24.6% in yield could be obtained with one of the strains included in multi-locational testing. The improved efficiency of the introduced strains in dinitrogen fixation, using the acetylene reduction technique, was confirmed with Green Windsor cultivar. Addition of nitrogen fertilizer reduced the nitrogenase activity of the nodules. Faba bean *Rhizobium* strain BB 48a was again found to be tolerant to the herbicide Tribunil.

RESPONSE TO FERTILIZER APPLICATION. The application of phosphorus up to 50 kg P_2O_5 per ha increased both nodulation and yield in a soil containing 3.5 ppm available P. Application of 20 kg N/ha had little influence on nodulation, but higher rates showed a conspicuous reduction.

Faba Beans for Green Vegetable Use

The objectives of this project include the development of appropriate agronomic practices for local and improved cultivars, plus the development of cultivars and other genetic stocks of faba beans for green or dual purpose green/dry use with the following characteristics:

- High and stable yield.
- Disease, insect and *Orobanche* resistance to ensure both high and stable yields and good quality.
- Pod development starting early but spread over a long period of time.
- Long pods with high number of seeds/pod and large seeds.
- Ability to yield well at low populations to ensure easy access for picking.

DEVELOPMENT OF CULTIVARS AND GENETIC STOCKS. In the 1980/81 season, 91 entries were evaluated for green pod production including 10 entries from the international large seeded yield trials (BIYT-81). The yield of the best entries exceeded 8 tons/ha of green beans. A total of 16 crosses were made among parents selected for high numbers of seeds per pod and long pods.

In the process of breeding cultivars for vegetable use, green pods are picked and weighed—a time-consuming and destructive process. Assessment is also made more difficult because the stage at which a given plot is harvested green has to be decided on a somewhat arbitrary basis. Farmers may pick pods while they are still small for consumption as a whole pod, or may delay picking until the pods are larger, when only the green seed is consumed after shelling. Because of the difficulties inherent in estimating green bean yields, it was decided to investigate whether or not there is a relationship between green bean and dry seed yields. Significant correlations were found between the two traits in 1980 and in two of the three trials conducted in 1981 (Table 3).

***Table 3.* Correlations between dry seed yield and green bean yields of faba beans in the 1980/81 season at Tel Hadya.**

		Correlation coefficients between dry seed yield and green pod yield with:		
Trial	No. of entries	One picking	Two pickings	Three pickings
BIYT-L-81	10	0.41	0.72*	0.88**
BPL-collection	56	0.42**	0.43**	0.48**
ILB-collection	25	0.01	—	−0.9

*Correlation significant $p \leq 0.05$.
**Correlation significant $p \leq 0.01$.

Table 4. **Summary of the rainfed faba bean yield trials at Tel Hadya (TH) and Terbol (T) in the 1980/81 season.**

Trial (location)	No. of test entries	Heaviest yield (kg/ha)	No. of entries exceeding check yield	No. of entries significantly exceeding check yield[1]	CV (%)
PYT-small seed (TH)	110	3485	100	51	14.4–24.5
PYT-small seed (T)	66	4173	44	4	15.4–17.4
BIYT-large seed (TH)	15	4907	8	0	23.1
BIYT-small seed (T)	23	3882	19	5	14.8
AYT-large seed (TH)	19	3562	0	0	14.9
AYT-large seed (T)	19	3327	13	0	10.5
AYT-small seed (TH)	15	3101	9	6	18.6
AYT-small seed (T)	15	3426	11	3	22.7

[1] *$P \leq 0.05$ on LSD test.*

CROP MANAGEMENT STUDIES. The study on the effect of frequency of picking and plant population level as varied by intra-row plant distance in rows spaced 50cm apart with the local large (ILB 1814) and local medium long pod (ILB 1813) land races confirmed the results of 1980. The green bean yield increased with increasing frequency of picking and with increase in plant population. The total oven dry weight of the seed harvested as green pods and residual dry beans under different treatments, however, showed a reduction with increasing frequency of picking indicating that the plants could not compensate for the loss of green pods by producing additional pods.

Drought Tolerance and Production Technology for Rainfed Faba Beans

Objectives of this project are to:

(1) Develop high yielding and stable faba bean cultivars capable of producing an economic dry-seed yield under conditions of 300–400 mm rainfall. In addition, the cultivar developed should have resistance to major pests, diseases, and *Orobanche*, and resistance to pod shattering and adequate nutritional value.

(2) Develop appropriate agronomic practices for producing faba beans under low rainfall conditions.

In the 1980/81 season, 10 lines which had shown a good yield potential under rainfed conditions at Tel Hadya in previous seasons were used as parents in 22 crosses. Ten F_2 populations from the 1980 crossing block were grown under rainfed conditions at Tel Hadya; 167 single plants were selected. A total of 282 entries were grown in replicated rainfed yield trials at Tel Hadya, of which 100 entries were also tested at Terbol. The results of the yield trials are summarized in Table 4. The highest yields recorded at Tel Hadya were about 1.4 tons/ha less than the best entries in the irrigated trials.

Production Physiology and Agronomy

SCREENING FOR DROUGHT TOLERANCE. The performance of 12 genotypes, including those which performed well under rainfed conditions at Tel Hadya during previous seasons, were evaluated at three different rainfed sites (Brida, Tel Hadya, and Jindiress) and also with supplemental irrigation at Tel Hadya. Detailed soil moisture extraction studies were carried out

Table 5. **Performance of some selected faba bean genotypes grown at different locations in northern Syria during the 1980/81 season.**

		Brida		Tel Hadya				Jindiress	
		Rainfed (310mm)[1]		Rainfed (345mm)[1]		Irrig. (395mm)[2]		Rainfed (443mm)[1]	
Genotype	ILB	Yield (kg/ha)	Rank	Yield (kg/ha)	Rank	Yield (kg/ha)	Rank	Yield (kg/ha)	Rank
78S 49907	10	344	5	1513	3	1575	7	2152	2
78S 48821	269	316	10	1208	11	1575	7	1800	8
78S 49395	407	327	8	1266	9	1397	11	2029	3
78S 49694	605	316	10	1875	2	1819	3	1947	5
Seville Giant		381	4	1114	12	1141	12	1594	12
Syr.Loc.L.	1814	580	1	2266	1	2621	1	2215	1
Leb.Loc.S.	1816	323	9	1229	10	1403	10	1735	9
78S 49892	1817	316	10	1300	7	1486	9	1669	10
78S 49896	1817	342	6	1320	6	1697	4	1881	7
Giza 3	1819	342	6	1368	5	1681	5	1915	6
Aquadulce		392	3	1284	8	1647	6	1638	11
	277	463	2	1513	3	1878	2	1965	4
Mean		370.0		1438		1660		1878	
LSD 0.05		100.5			334.9			401.1	
C.V. (%)		18.9			21.6			14.8	

[1]Seasonal rainfall.
[2]Seasonal rainfall + Irrigation.

under rainfed conditions at Tel Hadya using the neutron scattering technique. Overall productivity of the crop improved as the moisture supply was raised through rain and/or through supplemental irrigation (Table 5).

Screening faba bean genotypes for low rainfall conditions.

The local improved land race (ILB-1814) was the genotype which consistently performed the best at all sites. ILB-277 also showed a good performance whereas ILB-1816 and Seville Giant gave poor yields. The moisture status at the highest moisture recharge stage and at the time of physiological maturity of some of the selected genotypes is shown in Figure 2. It is evident that ILB-1814 could extract moisture deeper than other genotypes.

RESPONSE TO FERTILIZER APPLICATION. Rainfed faba beans responded very well to inoculation with faba bean *Rhizobium* in the multilocation strain screening studies. Mineral nutrition, particularly the supply of adequate levels of available phosphorus, was a major limiting factor at the driest site (Brida) of the faba bean test and also at Tel Hadya. The available phosphorus in the top 15 cm soil was 2.0 and 1.5 ppm at these two sites respectively, whereas the available potassium was adequate. Application of 50 kg P_2O_5/ha either alone or in combination with *Rhizobium* inoculation resulted in significant yield increases at both locations (Table 6).

NITROGEN FIXATION. Symbiotic N_2-fixation of rainfed faba beans was studied using ^{15}N labelled fertilizer nitrogen with wheat as non-nodulating crop. Shoots of ILB-1814 (local, large seeded, improved faba bean land race from Syria) yielded 90 kg of symbiotically fixed nitrogen per hectare. This amounted to about 90% of the total shoot nitrogen.

***Table 6.* Effect of fertilizer application and *Rhizobium* inoculation on the grain yield of rainfed faba beans (ILB-1814) at Brida and Tel Hadya (1980/81 season).**

	Grain Yield (kg/ha)	
Treatment	Brida	Tel Hadya
Control	476	1170
50 kg P_2O_5 / ha	684	1749
60 kg K_2O / ha	566	1365
Inoculation	438	1042
Inoc. + P	715	1659
Inoc. + K	431	1233
Inoc. + P + K	747	1347
100 kg N + P + K	847	1559
LSD (0.05)	196.8	464.9
CV (%)	21.7	24.0

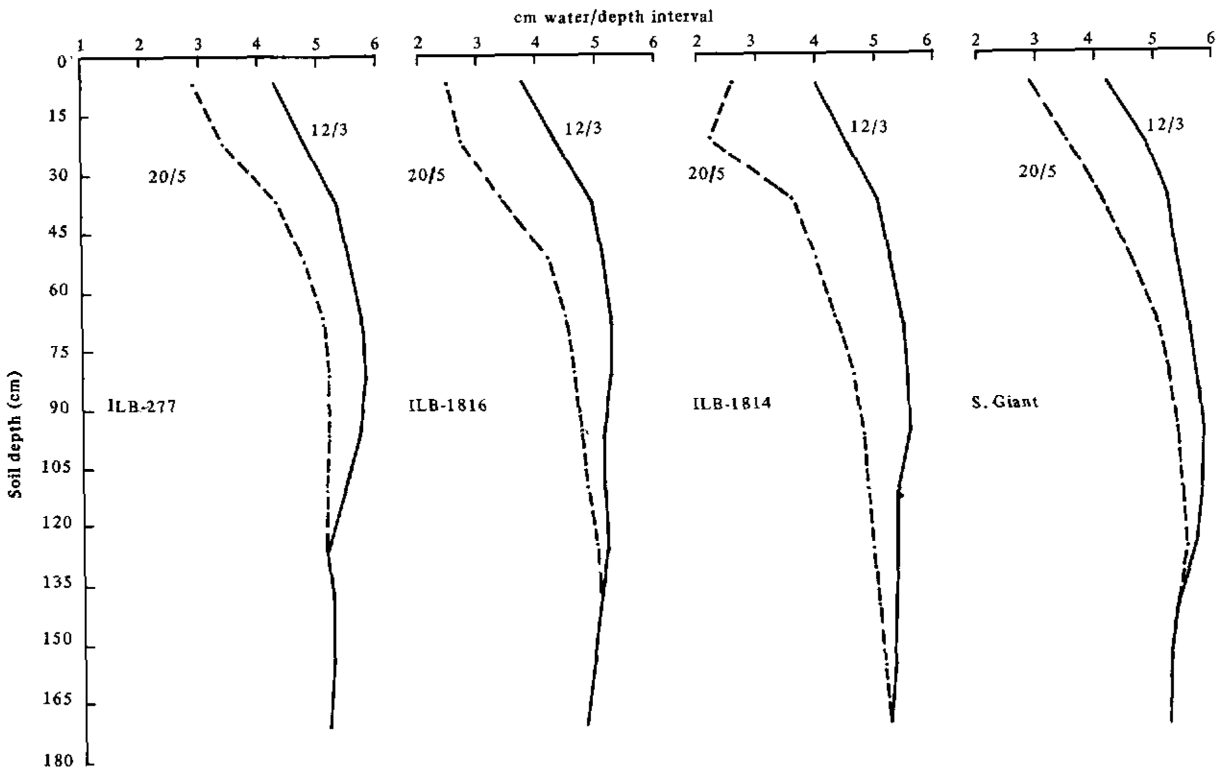


Fig. 2. Soil moisture content in different soil layers (cm water/15 cm soil layer) at the stage of maximum recharge (solid line) and at physiological maturity (broken-line) of four faba bean genotypes grown at Tel Hadya (1980–81 season).

Crossing lentils in the field.

Lentil Improvement

Improved Lentil Cultivars and Technology for Different Agro-ecological Situations

The objectives of this project are to:

(1) Develop cultivars or genetic stocks with appropriate phenology and high and stable yields for each of the three major agro-ecological regions of lentil production with maintained improved cooking and nutritional quality and nitrogen fixing ability. The additional specific traits required for the different regions are as follows:

- High altitude region: Cold tolerance for winter planting and attributes to facilitate harvesting (tall, erect, non-lodging growth habit and both good pod retention and indehiscence).
- Middle to low elevation areas in the Mediterranean region: high biological yield, tolerance to broomrape (*Orobanche* sp.) and *Sitona* weevil, resistance to root rot/ wilt complex, and attributes to facilitate harvesting.

- Region of more southern latitudes (including Egypt, Sudan, Ethiopia, India, Pakistan): Earliness through insensitivity/reduced sensitivity to photo-period and temperature, resistance to root rot/wilt complex and rust.

(2) Develop appropriate agronomic practices for existing and improved cultivars.

Development of Cultivars and Genetic Stocks

BREEDING FOR YIELD. Results obtained to-date from the international yield trials conducted since 1979 in different countries reveal that consistent increases in yield over the best local check cultivar are being made in Egypt, Jordan, Lebanon, Syria and Turkey through some of the entries developed in the project (Table 7). In Lebanon, ILL 4400 and ILL 1880 have consistently given heavier yields. Genotypes 76TA 66026 and 76TA 66088 have proved promising in Jordan.

A total of 440 selections, most of which came from populations developed following hybridization, were tested in local yield trials at Terbol and Kfardan sites in Lebanon and at Tel Hadya in Syria. Results (Table 8) show that a number of selections exceeded the best check. Selection ILL 346 from Mexico gave 11% and 24% heavier yields than the best check at Tel

***Table 7.* Seed yield of some promising lentil entries grown in international yield trials (1979/81) expressed as a percentage of the best local check.**

		Seed yield as percentage of best local check						
		Large seeds			Small seeds			
Country	Location and year	74TA 19 ILL 28 Syria	Syr.L.L. ILL 4400 Syria	78S 26002 IL8 Jordan	76TA 66026 ILL 29 Syria	W.R.51 ILL 1880 Turkey	76TA 66088 ILL 223 Iran	76TA 66054 ILL 99 Morocco
Algeria	Sidi-Bel-Abbes-79	71	75	—[1]	—	74	—	—
	Sidi-Bel-Abbes-80	103	94	—	—	—	—	—
Egypt	Sids-79	64	51	—	—	16	—	—
	Mallawi-80	—	—	—	61	44	96	121[2]
	Mallawi-81	—	—	—	103	57	160	119
Jordan	Jubeiha-79	44	66	—	—	59	—	—
	Jubeiha-80	—	—	—	—	—	—	95
	Jubeiha-81	90	81	99	121	104	—	—
	Marrow-81	51	67	79	126	76	100	96
	Hisban-81	—	82	—	119	111	119	65
Lebanon	Terbol-79	328	347	—	—	292	—	—
	Terbol-80	137	108	—	113	134	108	70
	Terbol-81	172	192	137	137	128	69	89
	Kfardan-81	89	126	99	139	106	150	112
Syria	Tel-Hadya-79	103	100	—	—	111	—	—
	Tel-Hadya-80	111	60	120	85	112	115	106
	Tel-Hadya-81	87	83	123	86	101	104	91
Turkey	Diyarbakir-79	101	143	—	—	100	—	—
	Diyarbakir-80	108	66	—	—	100	—	—
	Diyarbakir-81	154	79	151	—	—	—	—

[1]— indicates absence of entry in trials.
[2]Figure underlined indicates that an entry has consistently outyielded the best local check.

***Table 8.* Summary of local lentil yield trials grown in Syria and Lebanon (1981).**

Trials	No. of test entries	Heaviest yield (kg/ha)	No. of entries exceeding best check	CV (%)
LYT-small seeded Tel Hadya (15 trials)	330	2183	34	18.4
LYT-large seeded Tel Hadya (5 trials)	110	2320	11	18.4
LYT-small seeded Terbol (5 trials)	88	1592	3	23.2
LYT-large seeded Terbol (4 trials)	88	1592	3	26.6
LYT-small seeded Kfardan (6 trials)	176	1071	15	19.8

Hadya and Terbol respectively, with yield levels of 2061 kg/ha and 1972 kg/ha.

DEVELOPMENT OF TALL CULTIVARS. Tall, erect genotypes have been identified, but because most of them are both late and low yielding they are being used in hybridization with adapted, elite material. A total of 67 crosses with tall, erect parents were made in 1981. The average plant height of bulk segregating populations in the F_2 generation from crosses made in the previous years and grown at Tel Hadya in 1981 was 35 ± 0.7cm with a mean of 118 ± 1.7 days to flowering as against a height of 31cm for ILL 4400 (Syrian Locar Large) which took 116 days to flower. Considerable progress has already been made in selecting tall, erect, and high yielding material which can be harvested mechanically. One selection—78S 26002 (ILL 8) from Jordan—yielded 20% and 23% more than the best check at Tel Hadya in 1980 and 1981, respectively.

RESISTANCE TO *OROBANCHE*. Progress has been made on the identification of lentil genotypes showing markedly less infection by *Orobanche crenata* in heavily infested soil. Genotypes ILL 3047 and 3112, both of which originated in India, had 1.8 and 2.2 *Orobanche* haustoria/m^2, respectively, compared to 19.8 and 16.8 haustoria/m^2 in the check genotypes ILL 4400 and 4401.

TOLERANCE TO COLD. For the high altitude areas, 25 crosses were made with cold-tolerant parents.

CULTIVARS AND GENETIC STOCKS FOR SOUTH ASIA. A total of 91 biparental crosses were made between genotypes adapted to South Asia. A significant advance has also been made in identifying a *Macrosperma* type for low latitude countries of South Asia where most of the large seeded types from West Asia cannot be grown because they take too long to flower. A new germplasm accession—ILL 4605 (Precoz) from Argentina with large seeds (5.2 g/100 seeds)—flowered in 60 days in New Delhi and yielded 79% more than the local check on a single row basis. This appears to be the first *Macrosperma* genotype identified with a phenology suited to conditions in South Asia.

Production Physiology and Agronomy

PLANTING DATE AND PLANT POPULATION RESPONSE. Studies with local land races in Syria (Tel Hadya), Lebanon (Kfardan and Terbol), and Jordan (Jubeiha) revealed that delaying the planting beyond the end of December caused a conspicuous reduction in yield. Advancing the date ahead of December had little effect, unlike previous years when significant increases were obtained with advancing the planting date to November. Perhaps the late frost in the beginning of April was responsible for this. The highest population level of 333.3 plants/m^2 resulted in the heaviest yield at Tel Hadya and Jubeiha. But at Kfardan and Terbol about 200 plants/m^2 proved optimum. Seeds from an early spring-planted crop took less time to cook than those from winter planting.

RESPONSE TO FERTILIZER APPLICATION AND INOCULATION. A positive response to phosphorus application was obtained at Tel Hadya where the available phosphorus content

***Table 9.* Effect of different production practices on lentil (ILL 4401) yields at Tel Hadya (1981).**

Treatment	Yield (t/ha) grain	Yield (t/ha) straw	Nodules/20 plants healthy	Nodules/20 plants damaged
Normal date of planting (ND) + farmer's method of planting (FMP)	0.87	1.65	150	210
Early date of planting (ED) + FMP	0.80	1.68	286	228
ED + FMP + Carbofuran @ 1.5 kg a.i./ha (C)	1.41	2.50	512	228
ED + drill planting (D)	1.58	2.40	484	8
ED + C + D + 50 kg P_2O_5/ha as TSP	2.13	3.39	575	13
LSD (0.05)	0.41	0.58	157	160
CV (%)	16.1	13.4	21	9

***Table 10.* The mean effect of different production practices on lentil yields and nodule production in the on-farm-trials grown at 13 locations in northern Syria (1980/81 season).**

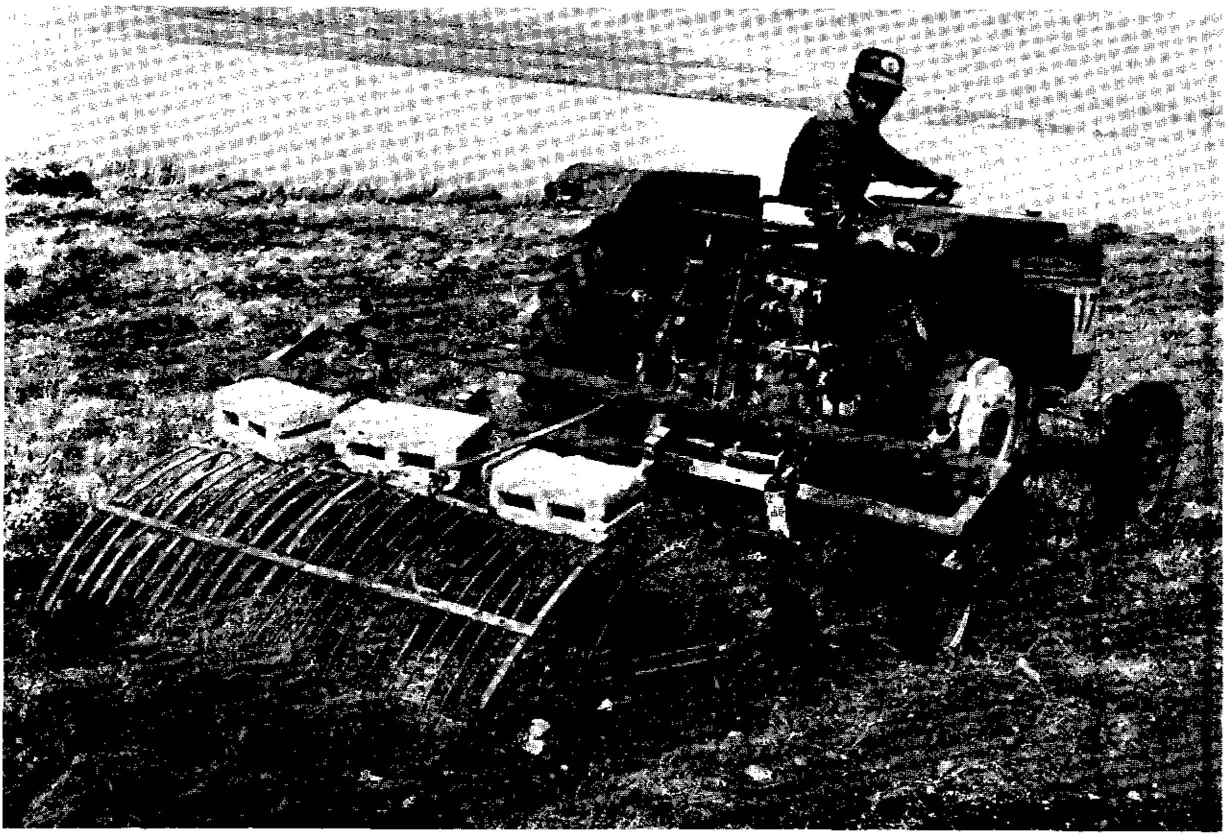
Treatment	Total yield	Straw yield	Seed yield	%	% range[1]	Nodule/20 plants healthy no.	healthy %	damaged no.	damaged %
Normal date of planting (ND) + farmer's method of planting(FMP)	3.95	2.95	0.99	100	—	200	100	150	100
Early date of planting(ED) + (FMP)	4.32	3.16	1.15	116	57–204	191	96	194	129
ED + FMP + Carbofuran (C)@ 1.5kg a.i./ha	4.78	3.61	1.17	118	67–468	307	154	68	45
ED + C + drill planting (D)	4.90	3.62	1.28	129	88–558	259	130	77	51
ED + C + D + 50kg/ha P_2O_5 as T.S.P.	4.75	3.46	1.29	130	75–323	248	124	85	56

[1]Range = range of lightest and heaviest seed yields across the 13 locations.

of the top 1 to 15 cm layer was only 1.5 ppm. No such response was obtained at any of the locations in Jordan or at Kfardan in Lebanon where available phosphorus was high. Available potassium status was high at all these locations and therefore no yield differences were evident from the application of potassium. Inoculation with *Rhizobium* improved the performance of lentil at Ramtha and Hisban in Jordan by a small margin.

Under low phosphorus status, application of phosphorus improved the frost tolerance of lentils as judged by visual observations and as reflected in yield data in a fertility/inoculation trial and a practice trial (Table 9) at Tel Hadya.

ON-FARM TRIALS OF PRODUCTION PRACTICES. The evaluation of such lentil practices as shown in Table 10 on farmers' fields at 13 locations in Aleppo province revealed that advancing the date of planting from the farmers' conventional planting date resulted in a 16% mean increase in seed yield. The application of Carbofuran to control *Sitona* weevil damage to nodules along with early planting resulted in a 22% mean increase in straw yield, but only an 18% mean increase in seed yield. The latter increase could be expected to be larger in the absence of a late frost which severely affected some trials. In spite of the relatively small mean increases from these treatments, the range of response given for seed yield across the 13 locations (Table 10) indicates that the response to individual treatments varied considerably between locations. Although total nodule production was similar for all five practices, there was a marked increase in the number of healthy nodules in the practices that included Carbofuran.



Simple mechanical harvesting system for lentils using blades.

NITROGEN FIXATION. The contribution of symbiotic nitrogen fixation to total nitrogen yield through shoots of lentils was evaluated using ^{15}N-labelled fertilizer nitrogen and wheat as a standard non-nodulated crop. Results showed that more than 86% of total shoot nitrogen in the case of lentils grown for dry seed, and 92% in the case of lentils harvested for hay at the advanced podding stage, came from symbiosis. When a seed crop of lentils was grown with application of 1.5 kg Carbofuran per ha to control *Sitona* larvae, the contribution of symbiotic N_2 to total shoot nitrogen yield was 90%. The absolute amount of shoot nitrogen derived from symbiosis was 84, 83, and 107 kg/ha in the three treatments, respectively.

HARVEST MECHANIZATION IN LENTILS. Lentils are harvested by hand in the Middle East, where the high cost of harvest labor is discouraging some farmers from growing the crop. In North America, however, the crop is either directly harvested by combine or swathed in windrows and then picked up by a harvester. In view of the value attached to lentil straw as a livestock feed in West Asia, economic methods of harvesting both grain and straw must be found. Rocky and uneven soil surfaces planted with short, lodging cultivars are additional factors mitigating against the direct transfer of harvest technology from America to the region.

During the 1981 harvest, six different methods of harvesting were tested on contrasting culti-

Table 11. **A summary of the results of the lentil adaptation trial from selected locations.**

	Country and location				
	Egypt Mallawi	Ethiopia Debre Zeit	Pakistan Faisalabad	Pakistan Islamabad	Syria Tel Hadya
Latitude (°N)	30	9	31	33	37
Photoperiod (h)[1]	10.4	12.2	10.9	10.9	12.2
Mean temp. (°C)[2]					
Max.	—	24	—	19	16
Min.	—	13	—	6	6
Mean Yield (kg/ha)					
Test entries	1594	480	627	145	782
Local checks	2354	824	2854	78	792
Mean time to flower(days)					
Test entries	92	69	—	138	100
Local checks	76	56	—	121	98

[1]*Photoperiod was measured one week before the first flower, and included the twilight period.*
[2]*Temperatures are averages taken over the month prior to flowering.*

vars and different management practices at Tel Hadya. The methods were hand harvesting, use of scythe, tractor-mounted side mower, bean blades, and both forage and combine harvesters. The bean blade was the most promising method and gave a high yield of both straw and grain. The cutter-bar methods were most effective on unlodged tall cultivars grown on rolled land.

Development of Wide Adaptation in Lentils

Objectives of this project are to:

(1) Develop separate high yielding and stable genetic stocks with wide adaptability for each of the following lentil growing regions: high altitude region, middle to low elevation Mediterranean region, and southern latitude region (Africa/Asia).

(2) Study the physiological basis for wide adaptation.

The lentil adaptation trial (LAT), which comprises cultivars from the main lentil growing areas of the world, was started in 1979 and has revealed differences in adaptation between these cultivars and also similarities and dissimilarities between growing environments in different countries. Phenological data from these trials are useful in defining different regions of adaptation in lentils.

There is a discontinuity in the adaptation of lentils in the northern hemisphere of the Old World. Genotypes originating from West Asia and South Europe are very late in flowering when grown in South Asia at photoperiods of less than 11 hours; so much so that they produce few or no pods because of the onset of adverse environmental conditions during their period of reproductive growth (Table 11). The results from the LAT further suggest that high temperatures during the vegetative period can partly offset the effect of short photoperiods in these latitudes.

Studies on the interaction between the photoperiod and ambient temperature and their effects on the phenology of nine diverse genotypes of lentil were carried out in the plastic house in 1980/81 using the same procedure as in 1979/80. Planting was done on January 1, 1981, and the plants receiving natural day length and temperature grew under increasing photoperiods and low but increasing temperatures. The plants receiving an extended day were grown under a 16-hour photoperiod. The results on days to first flower bud, as an average of four to eight replications, are shown in Table 12. It is clear that there is general hastening in the onset of reproductive growth because of an extended photoperiod or increased temperature. However, genotypes ILL-784 (from Egypt) and ILL-2526 (from India) showed less sensitivity than others.

In an attempt to identify genotypes with more stable yield and wider adaptability, the performance of six promising but diverse genotypes was studied at five planting dates equally spaced between December 4, 1980 and February 23, 1981. Genotypes ILL 4400, 4401, and ILL-253 showed good yield stability.

***Table 12.* Effect of "longdays" (LD) of 16-hour vs. normal day (ND) conditions on the days to flower bud appearance of nine genotypes of lentil under low and high ambient temperature conditions.**

		Days from planting to first flower bud			
		High temperature		Low temperature	
Genotype	Origin	ND[1]	LD[2]	ND	LD
ILL 58	Iraq	91.4	67.7	102.2	89.5
ILL 92	USSR	97.4	74.4	113.0	92.7
ILL 183	Turkey	97.0	73.4	105.7	88.2
ILL 204	Ethiopia	92.0	69.2	106.7	83.5
ILL 784	Egypt	72.0	64.5	76.5	71.2
ILL 4401	Syria	87.2	64.6	91.7	74.0
ILL 4349	USSR	102.6	73.6	106.0	86.0
ILL 2526	India	72.6	64.6	76.7	73.5
ILL 854	Algeria	97.0	69.1	106.0	88.2

[1]*ND = normal day length conditions.*
[2]*LD = long (16-hr) day length conditions.*

Development of Drought Tolerance in Lentils

Objectives of this project are to:

(1) Develop cultivars and genetic stocks capable of producing an economic and stable yield under low rainfall situations through a tolerance to drought and heat stress during the reproductive period of growth.

(2) Develop appropriate agronomic practices for increasing the water-use efficiency of promising cultivars under low rainfall conditions.

During the 1980/81 season, the focus of research was on the development of a reliable method of screening for drought tolerance. Twelve geographically diverse genotypes of lentil were grown at Tel Hadya under three moisture regimes: M_1 = adequate moisture supply assured by supplementary irrigation (405 mm of total moisture); M_2 = rainfed conditions (345 mm of total moisture); and M_3 = 300 mm of total moisture supply obtained by excluding additional rain through the use of plastic sheets.

Yield data are shown in Table 13. Variations in moisture supply significantly affected the performance of the crop. Genotypic differences in response to the moisture supply were not statistically significant, however genotypes ILL 101, 470, 793, 4354, and 4401 appeared to show less sensitivity to reduced moisture supply than the rest of the genotypes.

Trends for grain yield were similar to those for the total biological yield (Fig. 3). The yield under reduced moisture supply (M_2 or M_3), as a percentage of yield under assured moisture supply (M_1), when correlated with days from planting to maturity under M_1, showed a positive and significant ($P \leq 0.05$) correlation ($r = 0.59$). Thus, the lower apparent sensitivity of some genotypes to reduced moisture supply in the present study could not be explained by drought escape.

Chickpea Improvement

Improved Kabuli Chickpea Cultivars and Production Technology

Objectives of this project are to:

(1) Develop cultivars and genetic stocks with a range of maturities to fit different agroecological situations, with kabuki seed characteristics desired by the consumer and with high and stable yield, resistance to *Ascochyta* blight, and suitable for earlier planting.

(2) Develop appropriate agronomic practices for existing and improved cultivars.

(Chickpea research at ICARDA is carried out jointly with ICRISAT.)

Table 13. **The effect of total seasonal moisture supply on the grain yield of some diverse genotypes of lentils grown at Tel Hadya during the 1980/81 season.**

			Yield (kg/ha)			
Genotype	ILL	Origin	M_1[1]	M_2[2]	M_3[3]	Mean
V1	4401	Syria	1340	1161	981	1161
V2	793	Egypt	1121	849	1040	1003
V3	1861	Sudan	882	842	858	861
V4	2501	India	936	765	786	829
V5	1877	Turkey	958	805	790	851
V6	4349	Russia	915	789	697	800
V7	101	Morocco	1186	1062	1185	1144
V8	4400	Syria	1468	1081	1249	1266
V9	1744	Ethiopia	775	475	428	559
V10	470	Syria	1066	1055	1006	1042
V11	223	Iran	1466	805	935	1069
V12	4354	Jordan	1108	896	1000	1001
	SE ±			131.2		23.6

[1] M_1 = *adequate moisture supply assured by supplementary irrigation.*
[2] M_2 = *rainfed conditions (345 mm of total moisture).*
[3] M_3 = *300 mm total moisture.*

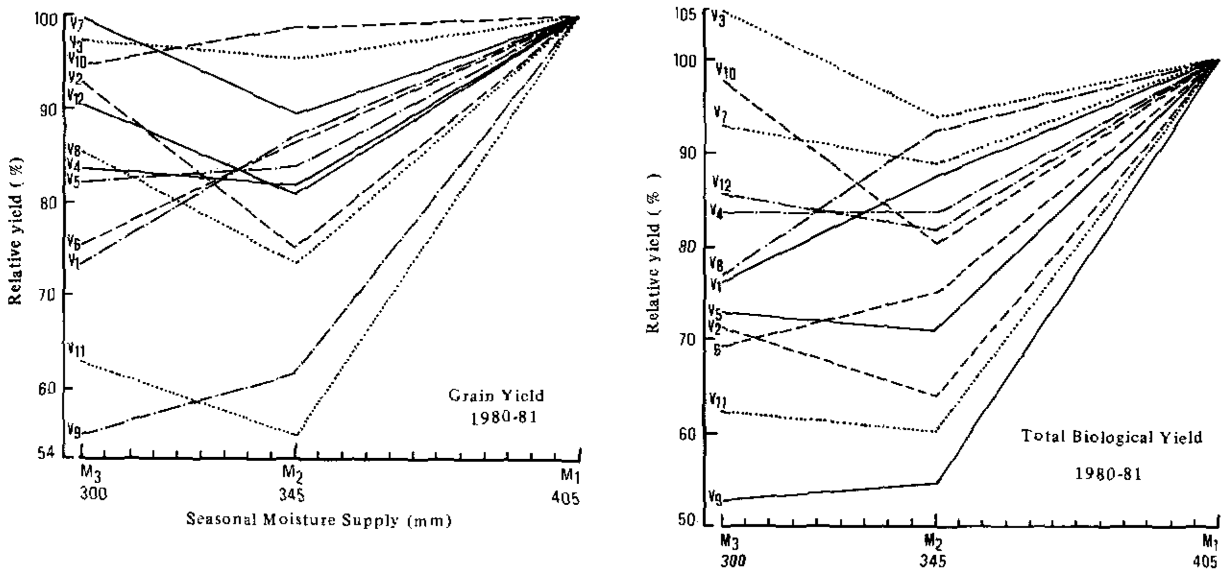


Fig. 3. Relative yield of lentil genotypes as affected by moisture supply. (Grain yield on the left, total biological yield on the right.)

Development of Cultivars and Genetic Stocks

SPRING TYPE. Approximately 300 crosses were made. These included some crosses made at the request of the Syrian, Turkish, and Egyptian national programs. Most were simple crosses but a few back-crosses were made with ILC 482 and ILC 484, two high yielding and widely adapted cultivars, and ILC 3279—a tall genotype with a high level of resistance to *Ascochyta* blight.

Advanced breeding lines in the F_5 and F_6 generations were evaluated in the initial evaluation yield trial using an augmented design. The results indicated that 203 out of 2490 lines at Tel Hadya and 110 out of 2469 lines at Terbol in Lebanon were significantly better than the best check. A few lines performed better than the local check at both Tel Hadya and Terbol. The best lines exceeded the local check by over 40%.

Two hundred and seven lines were tested in replicated yield trials at Tel Hadya and Kfardan (Table 14). Although only two lines at Tel Hadya and eight at Kfardan yielded significantly better than the check, 87 lines at Tel Hadya and 114 at Kfardan exceeded the check.

Lines supplied through the international nurseries have been selected by several national programs for inclusion in on-farm or multi-location trials. These include:

Syria:	ILC 263
Egypt:	ILC-480, -610, -673, -1919 and -1922 (in the 1980–81 season) ILC-249, -482, -1407, -2912 (in the 1981–82 season)
Pakistan:	NEC 138-2, ICC 1772, ICC 5127
U.S.A.:	ILC-237, -263, -1298

LARGE SEEDED TYPE. Twenty-five crosses were made with the aim of combining extra large seeds (100 seed weight greater than 40 g) with high yield and resistance to *Ascochyta* blight. The number of progenies in F_3, F_4 and F_5 generations sown during the spring were 212, 122, and 243, respectively. Thirty-four F_4 and 46 F_5 progenies were bulked for replicated yield trials in the 1981–82 season.

A modified bulk method has been adopted for the development of large seeded and *Ascochyta* blight resistant cultivars. Sixteen large seeded F_3 populations were sown in the *Ascochyta* blight disease nursery during the winter season. Plants susceptible to blight were rejected and the remaining plants were bulk harvested and seeds larger than 40 g/100 seeds were sieved in the laboratory. Forty-six lines were evaluated in advanced yield trials at Tel Hadya and Terbol and another 69 lines were evaluated in preliminary yield trials at Tel Hadya. Although 44 lines outyielded the Syrian local landrace, only three did so significantly.

***Table 14.* Performance of new chickpea entries evaluated in Tel Hadya and Kfardan during the 1980/81 season.**

Location	No. of trials	No. of entries tested	Entries exceeding check	CV (%)
Tel Hadya	9	207	87	13.9–28.3
Kfardan	9	207	114	12.3–17.5

QUALITY. The protein content of over 3000 germplasm accessions and breeding lines was analyzed using a Neotec FQA 51 analyzer. Protein content in germplasm accessions varied from 16.0 to 24.8%. The cooking time test (total time for 90% of the sample to be cooked; TTS 90) was evaluated and the procedure standardized. TTS 90 ranged from 55 to 195 minutes. Desi chickpea types were significantly shorter in cooking time than kabuli types. The same effect was observed with seed size, the small types being significantly shorter in cooking time than the intermediate and large-seeded types. The range of variability observed within the kabuli types was from 65 to 195 minutes in the 1981 crop year and 60 to 170 minutes in lines tested from the 1980 harvest.

Crop Management and Physiology

DATE OF PLANTING AND GENOTYPE INTERACTION. In a date of planting study with some improved winter and spring season cultivars, the superiority of ILC 262 for spring planting was confirmed. This genotype proved to be poor yielding when planted before February because it was seriously damaged by *Ascochyta* blight. ILC 482 performed well in both winter and spring seasons.

RESPONSE TO FERTILIZER APPLICATION AND INOCULATION. A positive response to application of 50 kg P_2O_5/ha was obtained with spring planted ILC 482 at Kafr Antoon, where the available soil phosphorus was 1.5 ppm in the 0 to 15cm soil layer. Although inoculation with *Rhizobium* along with phosphorus application improved the yield, the highest yield (1.56 t/ha compared to 0.97 t/ha for the control) was obtained when 100 kg of nitrogen was applied with phosphorus. An application of potassium at 60 kg K_2O/ha had no effect.

***Table 15.* The effect on grain yield of chickpeas of different levels of plant population in winter (W) and spring (S) plantings at various sites in northern Syria.**

Treatment Genotype	Plants/m²	Brida (kg/ha)	Kafr Antoon (kg/ha)	Tel Hadya (kg/ha)	Jindiress (kg/ha)
ILC 482	50	552	981	2425	3666
(W)[1]	33.3	549	426	1617	3291
	25	479	588	1065	2701
	20	421	778	1097	2830
	16.6	394	718	613	1435
ILC 482	50	223	823	919	1593
(S)[2]	33.3	133	760	693	1214
	25	115	736	840	1047
	20	110	621	622	1218
	16.6	115	616	735	1132
ILC 202	50	379	921	1841	2411
(W)	33.3	330	663	1683	1550
	25	394	767	1306	1516
	20	289	692	1258	1337
	16.6	307	656	1082	1511
ILC 202	50	72	926	779	650
(S)	33.3	70	771	804	657
	25	61	680	582	332
	20	73	659	485	648
	16.6	26	605	457	636
Location mean		255	720	1045	1569
CV (%) for Su.[3]		26.2	25.53	26.73	32.26
LSD (5%)					
M[4]		134.9	N.S.	420.4	344.1
Su.		55.6	152	232.9	393.9
MxSu.		N.S.	N.S.	465.8	N.S.

[1]*W = Winter planting.*
[2]*S = Spring planting.*
[3]*Su. = Sub plot (plant population).*
[4]*M = Main plot (date of planting).*

PLANT POPULATION RESPONSE OF DIFFERENT PLANT TYPES. Studies on the response of ILC 482 (semi-spreading type) and ILC 202 (tall type) cultivars to variations in plant population from 16.6 to 50 plants/m^2 in the spring season revealed that the differences were small, although at wetter sites a trend of increased yield with increased population was evident (Table 15).

PHOTOPERIODIC RESPONSE OF GENOTYPES IN OFF-SEASON NURSERY. Generation advance of late maturing types during the summer off-season is limited by the short day-length conditions. To induce flowering the day length was extended by artificial light and this resulted in good reproductive growth and uniform maturity.

Improved Kabuli Chickpea Cultivars and Production Technology for Winter Planting

Objectives of this project are to:

(1) Develop high and stable yielding, cold tolerant, *Ascochyta* blight resistant cultivars and genetic stocks of kabuli chickpeas adapted to winter planting in areas of the Mediterranean region where the crop is presently spring planted and where the climatic conditions permit winter planting.

(2) Develop appropriate agronomic practices for existing and improved cultivars for winter planting.

***Table 16.* Some characteristics of kabuli chickpea lines resistant to *Ascochyta* blight at Tel Hadya.**

ILC no.	Pedigree	Maturity	Habit	Seed color	Origin
72	Lot No. 4	late	tall-erect	light orange	Spain
182	Armenia 1207	medium	semi-erect	light orange	USSR
183	Armenia 1207	medium	semi-erect	light orange	USSR
187	Uzbekistan 16	late	semi-erect	light orange	USSR
191	Krasvadar Territory 1286	late	semi-erect	beige	USSR
194	Krasvadar Territory 1286	medium	semi-erect	beige	USSR
200	Krasvadar Territory 1335	late	semi-erect	light orange	USSR
201	Krasvadar Territory 1403	late	tall-errect	light orange	USSR
202	Krasvadar Territory 1403	late	tall-errect	light orange	USSR
236	Coll.No.K1713 Kabul Bazzar	late	semi-erect	beige	Afghan.
482	Acc.No.26780-68 Adapazari	early	semi-erect	beige	Turkey
484	Acc.No.26783-68 Bursa	early	semi-erect	beige	Turkey
2380	P9655	medium	semi-erect	beige	USSR
2506	Uzbekistan 16	late	semi-erect	light orange	USSR
2548	P9657	medium	semi-erect	beige	USSR
2956	12-071-10032	late	tall-erect	light orange	USSR
3001	Collection No. 731 C	medium	semi-erect	yellow-green	Afghan.
3279	Krasvadar Territory 1335	late	tall-erect	light orange	USSR
3340	S.N.166 (P1 315781)	late	semi-erect	beige	India
3342	S.N. 88 (P1 212595)	late	semi-erect	beige	Afghan.
3346	Unknown	late	tall-erect	light orange	USSR
3400	77MS	late	semi-erect	beige	ICARDA

Development of Cultivars and Genetic Stock

WINTER TYPES. Following the development of a large-scale field screening technique for *Ascochyta* blight a systematic evaluation of kabuli accessions maintained at ICARDA and desi accessions from ICRISAT is being made. To date, 9405 accessions (3400 kabuli and 6005 desi) have been evaluated and 153 (22 desi and 131 kabuli) have been found resistant to Tel Hadya isolates. The details of some of the resistant kabuli lines are given in Table 16. Most of these lines originated from germplasm introduced from U.S.S.R., Afghanistan, and Turkey while the desi types were from Iran, India, Afghanistan, and Pakistan. Most of the resistant kabuli lines were small seeded and late maturing, while most of the resistant desi types were black seeded.

Lines found resistant at Tel Hadya were included in the Chickpea International *Ascochyta* Blight Nursery. Entries in this nursery have also shown resistance in other countries in West Asia, North Africa and the Indian sub-continent (Table 17).

The results of the winter chickpea international yield trials (CIYT-W) were returned from eight locations. Many entries produced yields of more than 3 t/ha. Co-operators in the following countries have started using ICARDA material for winter planted on-farm trials or multi-location trials with a view to identifying cultivars for release for general cultivation:

Syria:	ILC 195, ILC 215, ILC 482
Lebanon:	ILC 482, ILC 484
Jordan:	ILC 482, ILC 484, ILC 202
Tunisia:	ILC 482, ILC 484
Morocco:	ILC 482, ILC 484

As a rule, only those lines which were found resistant to *Ascochyta* blight at Tel Hadya were

***Table 17.* Chickpea lines resistant to *Ascochyta* blight in different regions when tested in the Chickpea International *Ascochyta* Blight Nursery from the 1978 to the 1980/81 season.**

Region	Country	Resistant lines
West Asia	Syria	Large number including: ILC-72, -191, -196, -2380, -2959, -3279
	Lebanon	34 entries including: ILC -72, -191, -196, -2380, -2956, -3279
	Jordan	Large number including: ILC -72, -191, -196, -2380, -2956, -3279
	Turkey	ILC -72, -191, -196, -201, -202, -2380, -2956, -3279, Pch 128
North Africa	Algeria	Large number including: ILC -72, -191, -196, -2380, -2956, -3279
Indian Sub-continent	Pakistan	ILC -72, -191, -194, -196, -484, -2380, -2956, -3279, ICC -1903, -5127, -7514, Pch -15

distributed in the region. However, the majority of them were found susceptible to the pathotypes prevalent in Turkey and Pakistan. Tel Hadya is a location where infection may be high on pods of resistant lines, and for the last two seasons pod infection was recorded. An association was observed between pod reaction to the disease at Tel Hadya and vegetative reaction in Turkey or Pakistan.

Segregating material sown at Tel Hadya included: 73 F_1's, 115 F_2 bulks, F_3 bulks and 99 F_3 progenies, 30 F_4 bulks and 1121 F_4 progenies, and 194 F_5 and 412 F_6 progenies. A total of 5990 single plants were selected and 99 progenies bulked. Tolerance to late frost is an important attribute in cultivars for winter sowing. All the segregating materials that showed susceptibility to the frost in the first week of April 1981 were rejected.

F_4, F_5, and F_6 progenies were sown in an augmented design with three checks repeated in a block of 20 entries. Many progenies were uniform, resistant to *Ascochyta* blight and exceeded the local check seed yield. The highest yields exceeded 3 t/ha. The performance of the ten highest yielding bulked lines is shown in Table 18.

TALL TYPES. Over 30 tall lines have been assembled and a few of them possess a broad

Pod infection of *Ascochyta* blight on a susceptible chickpea line.

***Table 18.* Performance of the best ten bulked chickpea progenies grown at Tel Hadya during the winter of the 1980/81 season.**

Pedigree	Yield (kg/ha)	% increase over ILC 482	Disease reaction[1] Veg.	Pod
ILC 51xILC 200	3600	93	3	2
ILC 618xILC 194	3293	66	3	3
ILC 523xILC 183	3333	86	3	2
ILC 1929xILC 200	3328	7	3	3
ILC 1929xILC 200	4848	30	5	5
ILC 72xILC 897	3471	100	3	3
ILC 72xILC 897	3977	17	3	3
ILC 72xILC 897	3502	38	3	3
ILC 201xILC 571	3302	31	3	3
ILC 202xILC 893	3373	23	3	3
Average	3603	40		

[1]Disease reaction: 1 = disease-free; 9 = killed by disease. Scored on vegetative parts (Veg.) and pods.

spectrum of resistance to *Ascochyta* blight and remain the best sources of resistance. To observe the yield of tall types at close plantings, six tall, two medium, and two conventional types were grown in a spit-plot design at two population levels: 33 and 50 plants/m^2. The yields generally increased when the lines were planted at the close spacing, but these differences were small except for the mid-tall group (Table 19). Interestingly, the conventional type produced the highest yield and the tall type the lowest at both population levels.

Segregating material for tall types included 90 F_3, 13 F_4, 471 F_5, 38 F_6 and 29 F_7 progenies. Fourteen promising uniform progenies were bulked. Twenty-seven plants from F_3 and 163 from F_5 were chosen.

The recovery of tall types was low from tall x conventional types. Crosses between tall x tall and (tall x conventional) x tall were made to overcome this problem. Fifty crosses were made during 1981.

Table 19.* Mean performance of six tall, two mid-tall, and two conventional types of chickpea grown at normal and close spacing at Tel Hadya during the winter of the *1980/81 season.

Growth habit	Yield (kg/ha)		% increase of high over normal population
	33 pl/m^2	50 pl/m^2	
Tall	1804	1950	8.1
Mid-tall	1947	2514	29.1
Conventional	2865	3102	8.3

On-farm Trials

This was the second year of the on-farm trials jointly run by the Directorate of Agricultural Research of the Ministry of Agriculture and Agrarian Reform (Syria) and ICARDA. As in 1980, ILC 482 maintained its superior performance (Table 20). The performances of ILC 482 and Syrian Local, sown during winter and spring in two seasons, are presented in Table 21.

Crop Management

RESPONSE TO DATE OF PLANTING AND PLANT POPULATION. In a study on the response of some promising genotypes to dates of planting, ILC 484 yielded 1.91, 1.46, 1.16, 0.94, and 0.50 t/ha when planted on the 20th day of November, December (1980), January, February, and March (1981), respectively. The corresponding values for ILC 202 were 1.82, 1.56, 1.08, 0.85, and 0.40 t/ha. Thus, the advantage of advancing the date of planting from the traditional spring date (February to March) to early spring or winter was again confirmed.

Studies on the response of winter-planted genotypes to increasing populations from 16.6 to 50 plants/m^2 revealed that the heaviest yields were obtained at the highest plant population at Tel Hadya as well as at Jindiress (Table 15). At the drier site of Brida, there was no such response. The winter crop of chickpea at Kafr Antoon was severely damaged by *Orobanche* resulting in smaller treatment differences.

RESPONSE TO PLANT POPULATION AND PLANTING GEOMETRY IN TALL AND SPREADING TYPES. Studies on the interaction between planting geometry, plant population level, and the growth habit of winter planted chickpeas indicated that at plant population levels up to 50 plants/m^2 there was no conspicuous difference between the three planting geometry treatments: 1:1, 1:2, and 1:3. At the highest population level of 70 plants/m^2, which also gave the heaviest yield, the square (1:1) planting geometry proved the best. Even at the highest plant population level, the tall genotype (ILC 202) did not yield as much as the genotype with a conventional growth habit (ILC 482).

RESPONSE TO INOCULATION WITH *RHIZOBIUM*. The inoculation of winter-planted chickpeas (genotype ILC 482) with *Rhizobium* increased the yield from 1.3 t/ha to 2.0 t/ha at Tel Hadya. A study of the dinitrogen fixing efficiency of winter planted chickpeas with eight

***Table 20.* Seed yield and disease rating (DR) of chickpea cultivars sown during the winter and spring of the 1980/81 season in farmers' fields and experiment stations in Syria.**

	Winter				Spring			
	ILC 482		Syr.Local		ILC 482		Syr.Local	
Location	Y[1]	DR[2]	Y	DR	Y	DR	Y	DR
Hama Station	3990	—	0	9	—	—	3580	4
Hama	2617	—	0	9	—	—	1442	3
Izraa	798	—	438	—	—	—	—	—
Homs Station	703	—	0	9	—	—	350	—
Ibbin	1525	3	1391	5	774	3	897	5
Ram Hamdan	1534	3	294	7	880	3	686	3
Ras Alein	493	3	43	9	409	3	293	3
Kafr Yahmoul	2175	3	0	9	1978	3	728	5
Tel Tokan	631	3	561	5	640	3	369	5
Ishkibar	2083	3	1547	5	1649	3	1438	3
Zeitan Al-Masmia	1132	3	576	5	360	3	401	3
Qurbe	2698	3	1464	7	1242	3	897	5
Ataareb	2539	3	1113	7	760	3	727	5
Deir Qaq	832	3	144	7	415	3	283	5
Alqamieh	1230	3	1169	3	1138	3	1186	3
Azez	902	3	0	9	852	3	Grazed	7
Jindiress	2276	1	804	8	—	—	0	9
Kafr Antoon	873	1	512	5	—	—	1177	1
Brida	534	—	0	9	—	—	0	9
Tel Hadya	2337	3	0	9	1681	3	2	8
Boustan El-Basha	4311	3	0	9	—	—	1511	3
Mean	1724		479		983		798	

[1]Y = seed yield in kg/ha.
[2]DR = disease rating; 1 = disease-free; 9 = killed by disease.

***Table 21.* Mean performance of ILC 482 and Syrian local chickpea grown during the winter and spring on farmers' fields and experiment stations in Syria.**

	Grain yield (kg/ha)			
	Winter		Spring	
Year	ILC 482	Syr. Local	ILC 482	Syr. Local
1979/80[1]	1839	988	—	973
1980/81[2]	1724	479	983	798
Mean	1782	734	983	886

[1]Average of 18 locations.
[2]Average of 21 locations.

strains of *Rhizobium*, fertilizer nitrogen and an uninoculated control was made with the actelyene reduction assay. There was a 100% increase in the amount of nitrogen fixed per plant by the most promising strains compared to the uninoculated control (Table 22).

Winter chickpea (ILC 482) inoculated with *Rhizobium* fixed 75 kg N/ha as against 42.3 kg N/ha fixed by the spring-planted crop. These amounts of fixed nitrogen account for 85% of the total nitrogen harvested in the shoots. The technique of assessment of N_2-fixation was the same as that described earlier for faba beans and lentils, i.e. using ^{15}N labelled fertilizer.

Role of Food Legumes in the Rainfed Crop Rotation

Besides being a source of high quality protein, food legumes are also highly valued for their

***Table 22.* Effect of *Rhizobium* inoculation and nitrogen fertilization on nodulation, nitrogenase activity, N_2-fixation and grain yield of chickpea (cv. ILC 482) grown at Tel Hadya in the 1980/81 season.**

Treatment	Nodule no./plant	Nod. dry wt. (mg/plant)	$\mu M\ C_2H_4$ /plant/hour	$\mu M\ C_2H_4$ /g nodules/hour	mg N fixed /plant/day	Yield (kg/ha)
Uninoc.	5.3	161.4	11.7	78.3	2.6	2170
IC - 26	18.9	329.2	27.4	137.2	6.2	2700
CP - 27a	15.9	215.9	27.5	137.2	6.2	2855
120 kg N/ha	4.9	94.9	15.3	85.8	3.6	2158

***Table 23.* Effect of different legumes and fallow on the productivity of wheat in two-course rotations on deep soil under rainfed conditions at Tel Hadya (1979–81).**

Crops in the rotation		Total shoot phytomass (t/ha)	Grain yield (t/ha) of Haurani wheat in 1980/81 with nitrogen applications				
1979/1980	1980/1981	in 1979/1980	0 kg/ha	30 kg/ha	60 kg/ha	90 kg/ha	Mean
Lentil (uninoc.)	Wheat	6.31 ± 0.26	1.58	2.20	2.36	2.35	2.12
Lentil (inoc.)	Wheat	6.11 ±0.95	1.62	1.98	2.21	2.41	2.06
Lentil (inoc. + carbofuran)	*Wheat*	6.46 ± 0.36	1.55	1.82	2.02	2.23	1.91
Lentil (+100kg N/ha)	Wheat	5.17 ± 0.40	2.08	2.08	2.04	1.85	2.02
Lentil (harvested for hay)	Wheat	5.81 ± 0.30	2.14	2.52	2.82	2.39	2.47
Faba beans (uninoc.)	Wheat	6.25 ± 0.24	1.95	2.50	2.64	2.91	2.50
Faba beans (inoc.)	Wheat	6.76 ± 0.31	1.68	2.39	2.42	2.17	2.16
Winter chickpea (uninoc.)	Wheat	0.50 ± 0.13	2.24	2.90	3.25	3.23	2.91
Winter chickpea (inoc.)	Wheat	1.59 ± 0.19	1.63	1.86	2.73	2.63	2.21
Mid-winter chickpea (inoc.)	Wheat	1.91 ± 0.15	1.64	1.99	1.68	1.95	1.80
Spring chickpea (inoc.)	Wheat	1.77 ± 0.30	1.65	2.14	2.40	2.40	2.14
Faba beans (wide rows)	*Wheat*	2.23 ± 0.25	2.10	3.10	3.19	3.67	3.02
Spring chickpea (wide rows)	Wheat	0.43 ± 0.26	2.71	3.13	8.14	3.74	3.18
Fallow	Wheat	—	1.72	2.79	2.91	3.20	2.66
Wheat (0kg N/ha)	Wheat	1.89 ± 0.67	1.04	1.90	2.26	3.04	2.06
Wheat (60kgN/ha)	Wheat	6.23 ± 0.96	0.83	1.13	1.46	1.88	1.33
LSD (0.05)			0.493				0.286

role in the maintenance of the fertility status of the soil. As a result of symbiotic nitrogen fixation, they may enrich the soil by leaving nitrogen-rich crop residues. Studies were initiated in 1978 to evaluate the effect of different crops, including legumes, wheat, and fallow, on the subsequent crop of wheat in a rainfed two-course rotation at Tel Hadya.

The results of 1980 cropping treatments in terms of total biomass production in that season and the subsequent effect of these treatments on the performance of wheat in 1981 are shown in Table 23. The annual precipitation was 428 mm in the 1979/80 season and 345 mm in the 1980/81 season. The results clearly show that the yield of wheat following lentils or faba beans was as good as that following fallow and significantly better than the yield of wheat following wheat at both rates of nitrogen application.

Since the relative response of a residual wheat crop to nitrogen application in 1981 was smaller in "legume-wheat" sequence than that in "wheat-wheat" and "fallow-wheat" sequences, it is clear that a part of this beneficial residual effect of legumes was the improved nitrogen supply to the residual crop of wheat. Thus, well-managed legumes have a definite beneficial residual effect for subsequent cereal crops in the rainfed two-

Table 24. **Distribution of food legume trials and nurseries over five seasons (1977–81).**

Season	Total No. of sets distributed			No. of different trials			No. of countries		
	Faba beans	Chick-peas	Lentils	Faba beans	Chick-peas	Lentils	Faba beans	Chick-peas	Lentils
1977/78	19	34	33	2	2	2	9	15	15
1978/79	67	84	81	5	5	5	14	17	15
1979/80	194	180	184	10	8	9	19	21	19
1980/81	197	246	224	11	10	8	30	25	23
1981/82	133	346	249	10	12	11	25	33	27

course rotation and can, therefore, replace "fallow" at least in situations where the rainfall does not fall much below 300 mm.

International Cooperation

Objectives of this project are to:

(1) Provide for the widespread dissemination of:

- Elite lines that could have potential as released cultivars in West Asia.
- A range of genetic stocks to other regions for identification and utilization of the best adapted stocks by national programs.
- Early generation segregating populations for selection under local conditions.
- Material exhibiting special characteristics for evaluation and testing under local conditions.

(2) Characterize the major environments in which food legumes are grown.

(3) Obtain information on the agronomic factors which limit crop growth in different regions.

DISTRIBUTION OF GENETIC MATERIALS. One way that ICARDA has attempted to strengthen food legume research at the national level has been the distribution of genetic material in various types of trials to co-operators in many countries. The number of trials distributed in five seasons from 1977 is given in Table 24 for the three legume crops. The progressive increase in the number of trials and the countries to which they have been sent suggest an increased awareness in the countries served by ICARDA of the future importance and past neglect of legumes and the role ICARDA can have in stimulating and assisting legume research.

DIVERSIFICATION. Table 24 also shows a progressive increase in the number of types of trials available for distribution. This partly results from the division of faba bean and lentil trials into large and small seeded categories, and more recently the addition of large seeded kabuli chickpea trials. But this also reflects an increase in the type of breeding and agronomy trials available. The breeding trials originally comprised yield trials and screening nurseries, but now also include segregating population and adaptation trials. International agronomy trials were first distributed in 1978. There are now three types of trials available for each crop: date of planting and population, fertility/inoculation, and weed control.

A recent analysis of three years' data from international yield trials conducted in the region indicated that genotype x environment and genotype x year interactions may be expected to be common phenomena. In spite of this it has been shown in the individual crop reports that genotypes selected at Tel Hadya and Terbol have performed well in countries in West Asia, whereas success has generally been more limited outside this region. Accordingly, the current breeding policy of the Program is to attempt to select genotypes that could have immediate potential as cultivars in West Asia. For the other regions the aim is to supply a range of genetic stocks within which national programs can identify and utilize the best adapted material.

To pursue this strategy, the area served by ICARDA has been divided into several regions, each of which will ultimately receive trials specifically designed for that region. This division and the number of trials distributed to each region for the 1981–82 season is given in Table 25. Meanwhile, the recognition of a relatively narrow adaptation in lentils has already resulted in the supply of trials containing genetic material specifically developed for the regions shown in Table 26.

Table 25. **Distribution of trials and nurseries to six regions in the 1981/82 season.**

Crop	Region* 1	2	3	4	5	6
Faba beans	28	5	23	40	6	31
Chickpeas	67	27	60	31	68	93
Lentils	50	27	29	24	67	52

**Region 1 West Asia - Syria, Lebanon, Jordan, Iraq, Cyprus.*
Region 2 High altitude - Turkey, Iran.
Region 3 North Africa - Tunisia, Morocco, Algeria, Libya.
Region 4 Nile Valley - Egypt, Sudan, Ethiopia.
Region 5 Indian sub-continent - India, Pakistan, Bangladesh, Nepal.
Region 6 North and South America, China, Arabian Peninsula, Europe.

Table 26. **Diversification of international and regional lentil trials distributed in the 1981–82 season together with their target regions.**

Type of trial	Region[1] 1	2	3	4	5
Yield trials	├ 2[2] ┤				
	├──	2	──┤		
Screening nurseries	├ 1 ┤				
	├──	2	──┤	├	1 ┤
F_3 segregating populations	├──	1	──┤	├	1 ┤
Adaptation trial	├──	──	1	──	──┤

[1]Regions 1 to 5 are as described in Table 25.
[2]Each number in the table gives the number of trial types distributed in one or more regions.

Germplasm Collection, Evaluation, Maintenance, and Distribution

Objectives of this project are to:

(1) Collect germplasm from the region and elsewhere.

(2) Evaluate the germplasm for various characteristics and to document the information.

(3) Maintain and distribute the germplasm to scientists throughout the world on request.

(4) Collect and evaluate the usefulness of *Vicia, Lens,* and *Cicer* species as possible donors for desirable characters.

(5) Study the crossability of wild species with cultivated species.

FABA BEANS. The BPL collection now comprises approximately 3500 accessions. One thousand BPL accessions were evaluated for morphological and agronomic characters at Tel Hadya; 750 new ILB accessions were grown in the screen houses.

LENTILS. The lentil collection now comprises 5070 accessions of which 359 were added during 1981. The new material came largely from East Germany, Hungary, Jordan, Spain, U.S.S.R., and the Yemen Arab Republic but includes a wide range of genetic variability with origins in 27 different countries. Five hundred accessions were screened for resistance to broomrape (*Orobanche crenata*) in heavily infested soil; 500 germplasm accessions were sent to each of three countries—Bangladesh, Egypt, and Pakistan.

CHICKPEAS. With the addition of 1100 accessions during the year, the kabuli collection now stands at over 4500 accessions; 4000 desi accessions from ICRISAT were screened for *Ascochyta* blight resistance. A total of 3367 kabuli and 6005 desi accessions have now been screened, of which 22 kabuli and 131 desi lines have shown resistance to *Ascochyta* blight. Two

Table 27. Faba bean host differential set developed on the basis of disease reaction and the number of pycnidia per unit area counted on 20 randomly selected *Ascochyta* blight infected leaves.

Pedigree	No. of pycnidia per 10mm^2 of lesion	Disease rating[1]	Host status
Sel.80 - LAT (14435-3)	0–10	1	very resistant
Sel.80 - LAT (F_6X75TA46)	0–10	1	very resistant
Sel.80 - LAT (ILB 37)	11–25	3	resistant
Sel.80 - LAT (Large Syr.Loc.)	26–50	5	moderately resistant
Sel.80 - LAT (77MS 87002)	26–50	5	moderately resistant
Giza - 4	51–100	7	susceptible
Sel.80 - LAT (77MS 87200)	51–100	7	susceptible
BPL 161	101 or more	9	highly susceptible
BPL 165	101 or more	9	highly susceptible

[1]*Visual disease assessment on a 1–9 scale; 1 = disease-free; 9 = killed by disease.*

thousand kabuli accessions were screened for resistance to damage from late frost (April), and many resistant lines have been found. Over 2500 accessions were distributed to national programs.

Disease Resistance and Control

Objectives of these studies are to:

(1) Survey the distribution and importance of food legume pathogens in the region.

(2) Identify sources of resistance and, in cooperation with the breeding programs, develop cultivars having single or multiple resistance to major pathogens.

(3) Develop alternative control measures.

(4) Study epidemiology, environmental factors affecting disease development, disease nursery techniques, etc., in support of objectives 2 and 3.

Results dealing with the identification of sources of resistance and the incorporation of resistance for developing improved cultivars have been reported in earlier sections. Results of other studies are presented here.

Faba Beans

ASCOCHYTA FABAE. With a view to studying physiological variation in *Ascochyta fabae*, a preliminary host differential set consisting of nine different genotypes, based on number of phycnidia and disease reaction, was developed (Table 27). Employing host plants known to be resistant, new virulences in the local population of *A. fabae* were detected (Table 28).

Table 28. Pathogenicity of certain isolates of *Ascochyta fabae* on resistant and susceptible faba bean genotypes.

	Disease rating[2] on genotypes		
Isolates[1]	Lattakia-1	Lattakia-2	Local
A	2.0	7.0	8.5
B	2.0	6.5	8.0
C	1.5	2.5	8.0

[1]*Isolate A was isolated from ILB 37, B from BPL 230, C from ILB 1814 in Lattakia.*
[2]*Visual disease assessment on a 1 to 9 scale; 1 = disease-free, 9 = killed by disease.*

UROMYCES FABAE. Faba bean rust, caused by *Uromyces fabae*, was the most widespread faba bean disease during 1981. The efficiency of nine fungicides in controlling the disease was tested on a local large seeded land race that was artificially inoculated. Fungicides were sprayed every 15 days, starting in early January and ending in early May. Dithane M-45, difolatan, and trimiltox treatments provided the best control, followed by bravo-6F, topsin-M, calixin, and bavistin. These chemicals provided significantly better ($p \leq 0.01$) rust control than other treatments.

ROOT ROT AND WILT COMPLEX. Root rot/wilt symptoms were present in 77% of faba bean fields surveyed in 1977. Several pathogens have been suggested as causal agents. An attempt was made to investigate the rot/wilt complex at Lattakia. Isolations made from 50 root samples from diseased plants yielded predominantly two genera of fungi: *Fusarium* sp. and *Rhizoctonia* sp. These were confirmed by the Commonwealth Mycological Institute to be *Fusarium moniliforme* and *Rhizoctonia solani*; the former causing wilt and the latter root rot.

STEM NEMATODE. A field survey on the distribution and economic importance of stem nematode, *Ditylenchus dipsaci*, on faba beans in Syria was undertaken during March and June 1981, and 109 fields were examined; 45.9% of the fields were infested with the nematode. Signs of nematode damage were seen most frequently along the coast, less frequently behind the coastal mountains, and were absent in the north-eastern part of Syria. The measurement of the length of the nematodes indicated that the "Giant Race" is predominant on faba beans in Syria. *Ranunculus arvensis* and *Convolvulus arvensis* were two common weed species heavily infested with the nematode and serving as alternate hosts. Estimates in pot trials of the effect of the stage of growth at which nematode infection occurred revealed that yield reduction was 20% when infection occurred eight weeks after sowing. However, when one-week-old seedlings were infected the yield reduction was 85%.

Lentils

The incidence of various diseases at 15 "on-farm" locations in Aleppo Province was surveyed. Major diseases were *Ascochyta* blight, downy mildew, leaf spot, and root rot. Progress in the development of root rot/wilt complex was followed in the plot used for screening genotypes for resistance to the complex. Disease incidence increased through the season and reached a level of 73.4% before harvest. Sixteen isolates were made from the lower stem region of the affected plants. Twelve of these isolates proved pathologic in an inoculation test on lentils. The fungus was identified as *Fusarim oxysporum*.

Chickpeas

A survey of the prevalence of diseases in on-farm trials in Aleppo Province revealed that *Ascochyta* blight (caused by *Ascochyta rabiei*) and root rot were the major diseases on winter chickpeas. Diseases of minor importance were *Alternaria*, *Cledosporium*, and *Stemphylium*.

***ASCOCHYTA* BLIGHT.** For developing artificial field epiphytotics of *Ascochyta* blight, plant debris was compared with a suspension of spores as a source of inoculum. The suspension of spores was prepared from a pure culture of the fungus and from freshly infected plants in the field. When debris was used, the disease development was slightly faster.

The final severity of *Ascochyta* blight was not affected whether the whole plot or only the spreader rows (appearing after every two or four test rows) were inoculated. The disease spread was fastest, however, when the whole plot was inoculated. The spread also occurred faster when every third row rather than every fifth row was the spreader. The stage of plant growth at which inoculation was done had no effect on the reaction of the lines to *Ascochyta* blight.

Disease ratings of different genotypes when inoculated with different isolates (Table 29) indicate that there are variations in virulence within

Table 29. **Pathogenicity of different isolates of *Ascochyta rabiei* on resistant and susceptible chickpea genotypes.**

	Disease rating[2] on genotypes ILC								
Isolate[1]	184	190	195	202	215	249	482	3279	1929
A	7	5	5	1	7	7	5	3	9
B	7	7	5	3	7	7	5	3	9
C	7	5	5	1	7	7	5	3	9
D	4	3	3	2.5	4	3	2.5	2	9

[1]*Isolate A was obtained from ILC 249, B from ILC 482, C from ILC 195, and D was a mixture of field collections of* A. rabiei.

[2]*Disease rating was on a 1 to 9 scale; 1 = disease free; 9 = killed by disease.*

Table 30. **Major insect pests found on faba beans in the Idleb, Tartous, Lattakia, and Homs regions of Syria on April 4, 1981.**

	Black bean aphid	Green aphid	Thrips	Sitona adults	Stemborer adults	Stemborer larvae	Apion larvae	Leaf midge larvae
% of fields infested	84.6	15.4	69.2	69.2	76.9	53.9	23.1	23.1
Mean % of plants infested	67.5	—	—	80.0	96.0	42.9	5.0	—

the local population of *Ascochyta rabiei.*

Studies on the control of *Ascochyta* blight with fungicides reconfirmed that bravo-6F and dithane-M45 were effective in controlling the type-4 sporulating lesions which appeared in Lattakia on some resistant genotypes.

Insect Pest Resistance and Control

Objectives of these studies are to:

(1) Survey the region to determine the major and minor insect pest species of food legumes, their distribution, life cycles and economic importance.

(2) Identify sources of resistance to major pests, particularly aphids (faba beans), *Sitona* weevil (lentils), pod borer and leaf miner (chickpeas) and storage insects (all legumes).

(3) Develop alternative control measures if economically justified.

(4) Study insect pollinators in faba beans with a view to developing more effective methods of using insects for cross-pollination in the breeding program and develop more effective methods of reducing cross-pollination under field conditions.

Faba Beans

Thirteen faba bean growing areas in Idleb, Tartous, Lattakia, and Homs governorates in Syria were surveyed in 1981. The frequency and mean percentage infestation of the major insect pests are shown in Table 30.

BRUCHUS DENTIPES. Screening of 510 BPL lines from the 1980 crop (Tel Hadya), for seed infestation by *Bruchus dentipes* adults, showed that infestation of seeds ranged from 0 to 70% of the seeds. Preliminary results indicated that seed size and color may influence the infestation. The least infestation was observed in small and dark colored seeds.

***Table 31.* Effects of soil and foliar insecticides on controlling insect pests on lentils at Tel Hadya during the 1980/81 season.**

Treatment	% Infestation of: Nodules by *Sitona* Larvae (21/4/81)	% Infestation of: Leaflets by *Sitona* Adult (12/1/81 to 6/4/81)	% Infestation of: Plants by *Apion* Adult (21/4/81)	% Infestation of: Plants by *Apion* Larvae (21/4/81)	% Infestation of: Plants by Thrips (21/4/81)	% Infestation of: Plants by Aphids (21/4/81)	% Infestation of: Pods by Pea moth (27/5/81)	% Infestation of: Pods by Pod borer (27/5/81)	No. of aphids/m^2: Pea aphids (5/5/81)	No. of aphids/m^2: Black aphids (5/5/81)	100 seed wt. (g)	Grain yield[3] (kg/ha)
Check	97	26	98	8	80	35	4	2	309	27	6.9	1513 (b)
Furadan 5%[1]	3	7	83	10	90	43	4	4	481	28	7.3	1758 (ab)
Decis 25%[2]	92	24	73	13	8	5	0.1	0.2	15	2	7.6	1946 (a)

[1]*Furadan 5% applied at 1.5 kg a.i./ha at planting.*
[2]*Decis 25% applied at 38 g a.i./ha foliar spray at fortnightly intervals from 8/3/81 to 12/5/81.*
[3]*Yield figures followed by the same letter are not significantly different at the 5% level.*

The influence of four planting dates on the infestation of 12 BPL lines by *Bruchus* was studied. Early planting in October resulted in the lowest seed infestation, while plants sown in November and December were most infested. BPL lines with early flowering also gave the lowest *Bruchus* infestation. No correlation was found between infestation and the width, length, and hairiness of pods. Deltamethrin (Decis) and endosulfan (Thiodan) were used in four applications as foliar sprays for controlling *Bruchus* on faba beans in the field. The number of eggs per pod was three times greater in untreated plots. The infestation of seeds by larvae decreased significantly from 48% in untreated plots to 5% in endosulfan and 13% in deltamethrin treated plots.

Lentils

In studies on *Sitona* weevils, it was found that attack on leaflets by adults was highest after the earliest planting date (October). Nodule damage by *Sitona* larvae ranged from 6% to 28%. Seventy-five plots in 15 off-station agronomy trials were scored in late March 1981 for insect attack. Special attention was given to the leaflet damage caused by *Sitona* adults. *S.macularius* (*crinita*) was found in most fields, while *S.limosus* was present in five fields. There were on average 204 leaflets/plant in early planted lentils, 9% of which were attacked by *Sitona* adults. In the late planted material, there were 103 leaflets/plant of which 18% were damaged. *Hypera subvittata* and *H.variabilis* were observed causing damage in four fields. Early infestation by *Acyrthosiphon pisum* and *Aphis craccivora* was observed in four fields. *Heliothis* larvae, *Bruchus* adults, *Apion* adults, semi-looper (*Plusia*) larvae, and leaf midge were also recorded.

CHEMICAL CONTROL OF LENTIL INSECTS. In a chemical control trial, the application of five foliar sprays of Decis (deltamethrin) at fortnightly intervals beginning in early spring resulted in a significant yield increase of 29% (Table 31).

***SITONA* WEEVIL.** The relative damage to genotypes, found to differ in previous seasons in their susceptibility to *Sitona*, was studied under insect-free conditions and natural infestation at three sites in northern Syria. Carbofuran at seeding and supracide as a foliar spray increased seed yield by up to 40%. The infestation of root nodules by *Sitona* larvae decreased from 82%–93% in untreated plots to 0–3% in plots treated with carbofuran. The results for four of the ten genotypes tested are shown in Table 32. No direct relationship between nodule damage by larvae and leaflet damage by adults could

***Table 32.* Percentage leaflet infestation and nodule infestation by *Sitona*, and the grain yield of four treated and untreated lentil genotypes.**

Genotype	Grain yield (kg/ha)		% Leaflet infestation (adults)		% Nodule infestation (larvae)	
	untreated	treated[1]	untreated	treated[1]	untreated	treated[1]
ILL 4401[2]	854	1267	25.1	4.8	83.2	0.0
ILL 38[2]	1282	1458	26.8	3.6	90.4	0.0
ILL 342[3]	791	1178	33.8	8.2	92.8	2.4
ILL 372[3]	1033	1524	31.8	7.4	88.7	1.5

[1]*Treated with Carbofuran (1.5 kg a.i./ha) at planting, followed by Supracide (500 g a.i./ha) as foliar spray at fortnightly intervals from 8/3/81 to 12/5/81.*
[2]*Tolerant line.*
[3]*Susceptible line.*

be established. Leaflet infestation increased rapidly after germination and reached a peak in February. However, when the plant growth rate increased in spring the percentage of leaflets infested fell, even though the total number of infested leaflets per plant continued to rise. At Kafr Antoon, 540 lentil lines were scored for leaflet infestation by *Sitona* adults. None of the lines were free of infestation. About 40 lines had 10% to 20% of leaflets damaged, 160 lines had 21% to 40% damaged, and the remaining lines had over 41% leaflet infestation.

PLANT PREFERENCE. Greenhouse studies on the feeding preference of *S.macularius* and *S.limosus* adults on lentil, faba bean, and chickpea plants were carried out at Tel Hadya. The adults of *S.macularius* showed the strongest preference for lentils followed by faba bean and chickpeas. The number of leaflet notchings were 18 (lentils), 4.2 (faba bean), and 0.1 (chickpea)/ 5 pairs of adults/11 days of feeding. Five pairs of *S.limosus* caused 17.9 notchings (lentil) and 13.1 notchings (faba bean)/11 days when fed separately on lentil and faba bean plants. They caused 4.1 notchings (lentil) and 14.3 notchings (faba bean)/11 days when they were fed on mixed lentil and faba bean plants. *S.limosus* did not feed on chickpeas if the crop was planted with lentils and faba beans.

CALLOSOBRUCHUS. Seeds of 10 lentil lines were tested in open petri dishes for *Callosobruchus chinensis* infestation. Levels ranged from 80% to 94% in all lines. In separate closed petri dishes, ILL 804 from Egypt was the least attacked with 2.5% seed infestation/5 females and the Syrian local small land race was the most susceptible with 85% seed infestation/5 females.

Chickpeas

Chickpea entomology studies were conducted with the assistance of a pulse entomologist from ICRISAT.

Surveys conducted on off-station trials and farmers' fields in Syria showed that leaf miner infestation occurred in 12% to 65% of plants and pod borers infested from 0% to 8% of the pods.

CHEMICAL CONTROL. Trials were carried out at Tel Hadya on the control of leaf miners and pod borers—the main insect pests of both winter and spring chickpeas. Spraying was started in early April and was continued at fortnightly intervals until pod maturity. The results are shown in Table 33. In the early spring, infestation by leaf miner was greater on winter-planted than on spring-planted chickpeas. However, by April, 100% of plants from both planting dates were infested in untreated plots whereas insecticides reduced infestation to 0–17.5%

SCREENING FOR LEAF MINER RESISTANCE. A study of 10 ILC lines in spring-

Table 33. **The yield of winter and spring planted chickpeas following application of two insecticides.**

Treatment	Spring planting		Winter planting	
	No. sprays	grain yield (kg/ha)	No. sprays	grain yield (kg/ha)
Thiodan 35% (700g a.i./ha)	5	952.1	4	2004.0
Supracide 40% (500g a.i./ha)	5	945.8	4	1899.2
Check	—	785.7	—	1682.9

planted plots indicated that ILC 215 was the most susceptible to leaf miner infestation, followed by ILC 52, local and ILC 263, with 23% to 46% leaflet infestation. ILC 190, ILC 202, ILC 482, and NEC 2305 were less susceptible with 10 to 17% leaflet infestation. Forty-five spring-planted and 1240 winter-planted accessions were screened for leaf miner damage. Fifteen of the spring and 41 of the winter sown lines showed low susceptibility.

HELIOTHIS SPP. *Heliothis armigera* adults were trapped in chickpea and cotton fields in pheromone traps. The adult catch increased steadily from February to July in chickpea fields. In cotton fields, moth catches declined from July to November. Few moths were caught in December. The catch in cotton fields was 10 times greater than in chickpea fields. Light trap studies in chickpea fields from April to June indicated that *Heliothis viriplaca* moths were more abundant than *H.armigera* or *H.peltigera*. Pupae collected from both lentils and chickpeas showed a similar predominance of *H.viriplaca* (Table 34).

Table 34. Heliothis **species associated with chickpea and lentil crops grown at Tel Hadya (1980 to 1981).**

Heliothis species	% of each *Heliothis* species			
	1980		1981	
	Chickpea	Lentil	Chickpea	Lentil
H. armigera	72.4	5.9	0	0
H. peltigera	3.5	0	0	0
H. viriplaca	24.1	94.1	100	100

In trials to determine feeding habits, young *Heliothis* larvae showed a preference for leaves followed by tender pods, whereas older larvae in general preferred flowers and maturing pods and showed least preference for leaves. Only *H.viriplaca* among the *Heliothis* species showed pupal aestivo-hibernation.

CALLOSOBRUCHUS. In laboratory experiments, 25 accessions were tested and ILC 501 was found to be the least susceptible to *Callosobruchus chinenis*.

Weed Control

Objectives of these studies are to:

(1) Survey the weed problem in the region and assess the crop yield losses caused by weeds.

(2) Identify suitable selective herbicides for the control of broad-leaved and grassy weeds and to develop systems for weed management.

(3) Screen food legume genotypes for their tolerance to *Orobanche* spp. and to develop control measures.

Results of screening genotypes for their tolerance to *Orobanche* have been described in earlier sections. Other results are presented here.

Faba Beans

INTERNATIONAL WEED CONTROL TRIALS. International faba bean weed control trials were initiated in 1981. The reductions in yield in Egypt, Lebanon, and Syria due to weeds were 23%, 47% and 54% respectively. Methabenzthiazuron (3.5kg a.i./ha) provided the best chemical weed control in Syria; terbutryne (3kg a.i./ha) was best in Egypt.

BROAD SPECTRUM WEED CONTROL. For broad spectrum weed control, broad-leaved weed

Table 35. **Effects of two herbicides and methods of application on *Orobanche* infestation in faba bean (Syrian Local Large land race) grown at Tel Hadya in the 1980/81 season.**

Treatment	No. of *Orobanche* spikes (No./m²)	No. of *Orobanche* spikes (% of control)	Dry weight of *Orobanche* spikes (kg/ha)	Dry weight of *Orobanche* spikes (% of control)
Pronamide 3.75 kg a.i./ha complete plot spray, post-em.	17.6	57.1	310.7	66.9
Pronamide 3.75 kg a.i./ha spray plants only, post-em.	21.3	69.2	378.7	81.5
Pronamide 3.75 kg a.i./ha spray soil only, post-em.	23.6	76.6	385.7	83.0
Pronamide 3.75 kg a.i./ha watering post-em.	21.4	69.5	343.3	73.8
Pronamide 5 kg a.i./ha Watering, post-em.	11.2	36.4	246.4	53.0
Glyphosate (0.08 kg a.i./ha) (3 times starting post-em. at 15 days interval)	9.1	29.5	112.8	24.3
Glyphosate (0.08 kg a.i./ha) (3 times starting early flowering at 15 days interval)	3.8	15.3	36.4	7.8
Control, untreated.	30.8	100	464.5	100
LSD (0.05)	9.4		179	

killers were mixed with the grass killer pronamide in trials at Tel Hadya. The best results were obtained from the mixture methabenzthiazuron 2.0 + pronamide 0.5kg a.i./ha. It resulted in a yield increase of 94% over the weedy check. Cyanazine (1.25kg a.i./ha) and chlorbromuron (1.0kg a.i./ha) both in combination with pronamide (0.5kg a.i./ha) also gave good broad spectrum weed control. However, the triple mixture methabenzthiazuron + cyanazine + pronamide gave a high crop phytotoxicity. All the combinations controlled volunteer wheat.

***OROBANCHE* CONTROL.** Pronamide and glyphosate herbicides were tested on faba beans for their efficiency in reducing *Orobanche* infestation. Pronamide application did not significantly increase faba bean seed yields. Glyphosate, on the other hand, controlled *Orobanche* and gave increased seed yields (Table 35). The application of glyphosate at 0.08 kg a.i./ha three times every 15 days, starting at the early flowering stage, resulted in higher yields compared to a similar schedule starting earlier when faba bean plants were 10 to 15 cm high.

Lentils

INTERNATIONAL WEED CONTROL TRIAL. Yields were reduced by 89% and 61% by weeds at Bahteem (Egypt) and Kfardan (Lebanon), respectively, in the lentil international weed control trial. Prometryne was promising in controlling weeds in Egypt, Lebanon, and Syria. Cyanazine at 1.0 and 1.5kg a.i./ha was included in the trial at Tel Hadya and gave good weed control.

BROAD SPECTRUM WEED CONTROL. For controlling volunteer cereals in lentils, pronamide at 0.5kg a.i./ha as pre-emergence application gave 95% control of volunteers. Fusilade (PP 009) as a post-emergence treatment also gave adequate control. A line applicator was devised to control weeds between lentil rows early in the season with gramoxone in 1:20 v/v water solution. Studies on the application of herbicides in

Table 36. **Effects of two herbicides and methods of application on *Orobanche* infestation in lentil (Syrian Local Small land race) grown at Tel Hadya in the 1980/81 season.**

Treatment	Seed yield (kg/ha)	Seed yield (% of control)	No. of *Orobanche* spikes (No./m²)	No. of *Orobanche* spikes (% of control)	Dry weight of *Orobanche* spikes (g/m²)	Dry weight of *Orobanche* spikes (% of control)
Pronamide 2.0 kg a.i./ha spray post-em.	398	159	21.5	50.6	9.3	48.2
Pronamide 1.0 kg a.i./ha watering post-em.	384	154	24.5	57.6	14.3	74.1
Pronamide 2.0 kg a.i./ha watering post-em.	276	111	29.7	70.0	15.2	78.8
Pronamide 3.0 kg a.i./ha) watering post-em.	382	153	12.7	30.0	5.7	29.8
Glyphosate (0.02 kg a.i./ha) (3 times starting post-em. with 15 days interval)	331	133	18.0	42.4	8.0	41.5
Glyphosate (0.08 kg a.i./ha) spray complete flowering	172	69	25.5	60.0	11.4	58.9
Glyphosate(0.16 kg a.i./ha) spray complete flowering	252	101	7.0	16.5	3.7	19.4
Control, untreated	250	100	42.5	100	19.3	100
LSD (0.05)	144		11.9		7.8	

mixture with superphosphate fertilizer as a carrier showed that this formulation gave good weed control and less crop phytotoxicity than did spray applications with the same chemical and rate. Tolerance testing of lentils showed that among broadleaved weed killers cyanazine at 1.0kg a.i./ha gave the lowest phytotoxicity on a range of genotypes.

***OROBANCHE* CONTROL.** Both pronamide *and glyphosate were evaluated for their control* of *Orobanche* on lentils. Glyphosate applied at flowering at 0.16 kg a.i./ha tended to reduce lentil yields. Pronamide applied at 2.0kg a.i./ha increased lentil yields significantly, (Table 36). Ethyl dibromide (EDB) was used to control *Orobanche* on lentils as a granular application (1.25 and 2.50 ml/linear meter) and as a spray (3, 6 and 12m/linear meter) at planting. The grain yield of the control was only 99 kg/ha because of severe *Orobanche crenata* infestation. EDB increased yields significantly to 342 kg/ha. Since there were no significant differences between concentrations and methods of EDB application, the granular application at 1.25 ml/m (linear) was the most economic and the easiest to apply. There was a low level of *O.aegyptiaca* in the trial, but EDB had no apparent effect on the incidence of this species.

Table 37. **Mean seed yield of chickpeas in International Weed Control trials at Tel Hadya (planted on three dates).**

Treatment	Rate (kg a.i./ha)	Winter (22/11/80) (kg/ha)	Early Spring (8/2/81) (kg/ha)	Spring (16/3/81) (kg/ha)
Weedy check	—	914	757	492
Weedfree	—	1717	827	556
Handweeding	—	870	797	485
Chlorbromuron	1.5	966	773	659
Chlorbromuron	2.0	1174	639	476
Chlorbromuron	3.0	865	571	450
Methabenzthiazuron	2.0	1076	856	572
Methabenzthiazuron	3.0	904	732	492
Methabenzthiazuron	3.5	763	663	555
Terbutryne	2.0	1170	792	513
Terbutryne	3.0	943	679	458
Terbutryne	4.0	826	521	557
Cyanazine	0.5	1051	845	615
Cyanazine	1.0	1165	736	623
Cyanazine	2.0	994	322	529

Chickpeas

The chickpea international weed control trial was planted at Tel Hadya at three dates from winter through spring. The yield reduction in the winter crop due to weeds was 46.8% compared to 11.5% in the spring planting (Table 37). Cyanazine at 0.5 and 1.0kg a.i./ha and chlorbromuron at 1.5kg and 2.0kg a.i./ha were the most promising herbicides. Combinations of broadleaved weed killers and grass killers were tested on winter planted chickpeas. The best combination was cyanazine at 0.5 and pronamide at 0.5kg a.i./ha. Pronamide controlled cereal volunteers in chickpeas as well as in lentils and faba beans.

Nile Valley Faba Bean Project

This project, supported by the International Fund for Agricultural Development (IFAD), started in 1979 in cooperation with the national programs in Egypt and Sudan. Its objectives are to:

(1) Test recommended cultivars and cultural practices on farmers fields in Egypt and Sudan to evaluate both the practicality and potential contribution of these factors at the farm level and to provide feed-back to the scientists on areas requiring further research.

(2) Conduct back-up research on experimental stations to improve current recommendations and to solve new problems identified in the on-farm trials and surveys.

(3) Encourage a multi-disciplinary approach to research and to increase collaboration between the various research organizations in Egypt and Sudan.

(4) Strengthen the capacity of the national programs to undertake research, through training, visits, consultancies, conferences, meetings, and literature exchange.

(5) Provide the necessary equipment, supplies, and facilities required to meet the above objectives.

On-farm Trials in Egypt

On-farm trials were continued in the two districts of Minia Province and a further series of trials were conducted in Kafr El-Sheikh Province in the northern Delta of Egypt. Minia accounts for about 30% of the total faba bean production in the nation while Kafr el-Sheikh, although of less importance, is typical of the northern Delta region where ecological conditions are poorer and fungal diseases are prevalent.

The recommended plant population gave significant seed yield increases (from 0.61 to 0.97 t/ha) over the farmers' practice in six out of the 16 on farm trials in Minia. At eight other sites the same trend was observed, although the yield increases were not statistically significant. At recommended levels of nitrogen and phosphorus fertilizers, increases in seed yield were observed at seven sites and in straw yield at 20 sites. However, several farmers had applied a greater level of fertilizer than that recommended.

In Kafr El-Sheikh Province, the recommended plant population resulted in improved seed yields at seven of the 14 sites. However, farmers' populations were generally higher than in Minia, and at a few sites exceeded the recommended level. At these sites the higher plant populations proved superior.

By applying the recommended level of nitrogen and phosphorus, increases in seed yield ranging from 0.02 to 0.82 t/ha were obtained at 11 of the 14 sites. Although foliar diseases appeared only late in the 1980/81 season, at 11 sites there was a positive response to the fungicide dithane M45 which gave a mean seed increase of 9.6% compared to the unsprayed control.

On-farm Trials in Sudan

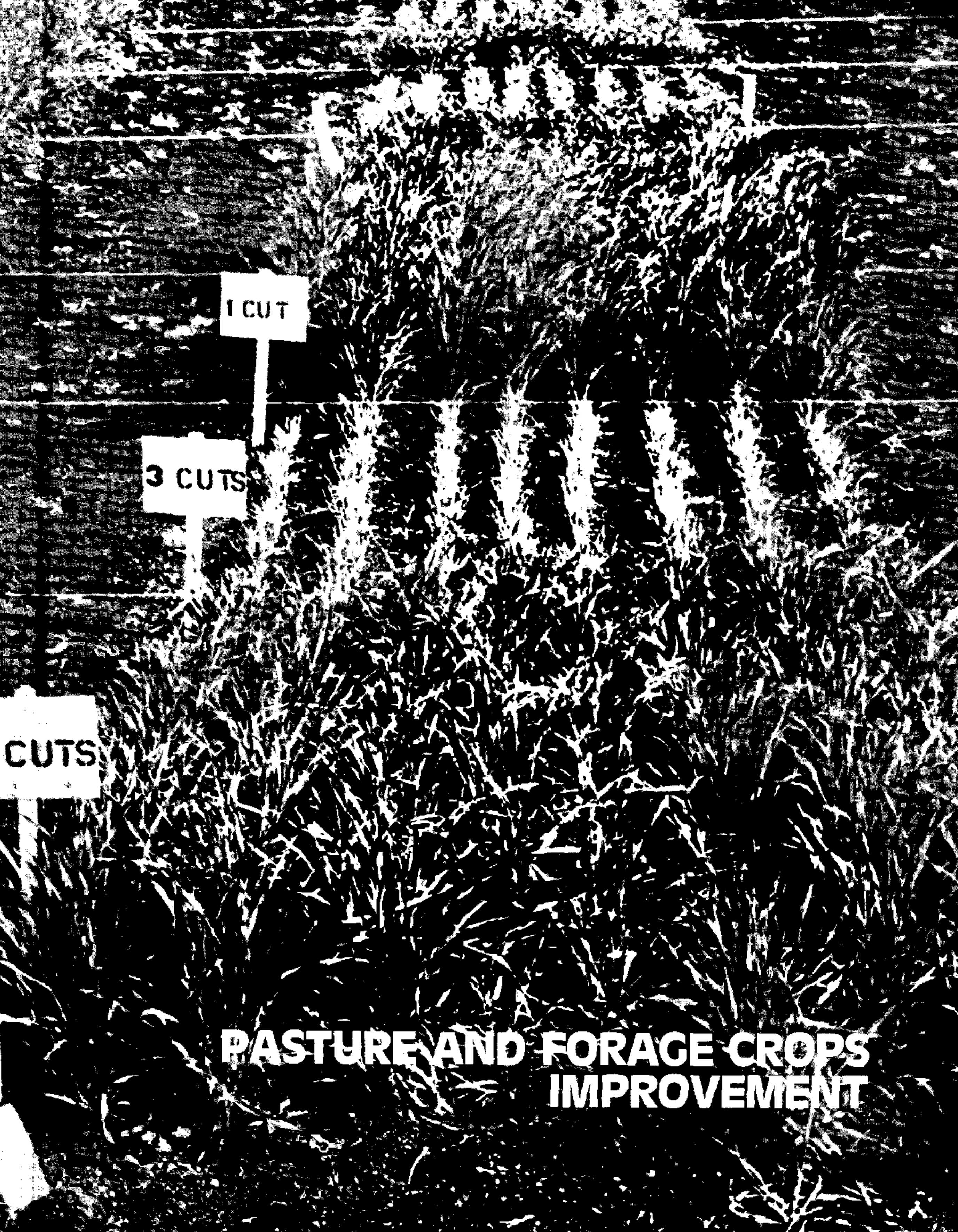
On-farm trials were conducted at seven sites in Zeidab, five in Aliab and five at Selaim schemes in the Northern Province of Sudan. Factors evaluated included date of planting, cultivar, irrigation frequency, weed control, method of planting, and pest control. Significant treatment differences were obtained at Zeidab and Aliab but not at Selaim. A combination of all six factors at the recommended level resulted in a 1.21 t/ha (64%) yield increase over the farmers' practice at Zeidab and a 1.34 t/ha (89.8%) increase in yield at Aliab.

At both sites, increasing irrigation frequency was the major factor responsible for the yield increases while at Zeidab early and improved methods of planting were also important. Pest management contributed substantially to higher yields at Aliab. At all locations the recommended cultivar—Hudeiba 72—showed little or no superiority over the local farmer's cultivar.

A factorial trial comparing the recommended sowing date, cultivar, irrigation frequency, and weed control with standard farmers' practices was conducted at Hudeiba, Shendi, and Shambat. Across the three locations date of planting and irrigation frequency showed the greatest effects on yield with mean increases of 23.5% and 22.8%, respectively. The other two factors and all interactions were non-significant.

Back-up research in Egypt and Sudan

During the 1980/81 season, a total of 47 trials in Egypt and 17 in Sudan were conducted as part of the "back-up" research. These included investigations into aspects of agronomy, genetic improvement, water use, nodulation, diseases, pests, weed control, and seed quality. In addition, socio-economic surveys of faba bean production were conducted in Minia and Kafr El-Shiekh Provinces in Egypt and on the Zeidab and Aliab schemes in Sudan. A survey of the incidence of favism and the frequency of G-6PD deficiency was carried out in Cairo, Assiut, and Aswan. A consumer preference survey was conducted in Sudan.



PASTURE AND FORAGE CROPS IMPROVEMENT

Contents

(Photo on previous page: Response of barley to different cutting regimes.)

PASTURE AND FORAGE CROPS IMPROVEMENT

Introduction

This program was established to improve the supply of pasture and forage for animal production and so promote a rational and effective land use system. Limited land resources can be better utilized by the integration of livestock and crop production. This integration can be achieved by selecting and developing a range of multipurpose forage species for different climatic ecozones and encouraging pasture and fodder production on both cropping areas and on marginal lands.

Continued emphasis has been placed by the program on the development of suitable pasture and forage species. Evaluation of the annual species has progressed to the stage of advanced yield testing. Work has been initiated to study the hardseeded characteristics of selected annual *Medicago* species (medics). A limited hybridization effort in *Vicia sativa* has been attempted in an effort to incorporate the non-shattering characteristics of pods into the more productive ecotypes. Screening of forage cereals has continued with increased emphasis on the appraisal of forage oats as a component in the cereal/legume mixture for hay production.

The evaluation of pasture grasses—both annuals and perennials—received greater attention than in previous years. New germplasm materials were studied and promising grass species tested in grazing trials for the first time.

The main aim of the forage agronomy research during the 1980–81 cropping season was to obtain basic information on the establishment and management of forages for hay production by investigating seeding rates, fertilizer application and harvesting regimes. Off-station trials in Syria were conducted on farmers' fields to validate results, identify constraints, and to alert farmers about new practices of forage production, hay making, and pasture establishment.

Pasture species suitable for the revegetation of marginal lands were evaluated. Observations were continued on several grass species established in 1979.

A grazing trial to investigate ways to produce and then use forage/cereal mixtures suggested that if a high seed rate is used the mixture can be grazed early in the season when feed is scarce. Later it will still give a good yield of hay.

A broadscale survey of the incidence of diseases on forage and pasture plants and increased research efforts to identify suitable herbicides for weed control constituted new and very important dimensions to the program of work. Fetilizer-*Rhizobia* interactions, studied on a number of forage species, provided valuable results which were useful in the selection of *Rhizobia* strains and fertilizer application practices.

Pasture and Forage Crop Improvement for Year-Around Food Supply

The aim of this work is to screen, select, and breed productive annual pasture and forage plant species that will contribute to a year-around supply of feed for livestock.

Large areas of the countries of the West Asia and North Africa region are left fallow each year. Many of these areas could be used for annual pasture or for the production of high quality hay. Annual *Medicago* species, which are indigenous throughout the countries of the region, show promise for the establishment of annual self-regenerating pasture in a wheat-pasture rotation. Mixtures of legume and cereal crops show promise for high quality hay production. Within such mixtures the following species have excellent potential: *Vicia* spp., *Pisum* spp., *Lathyrus* spp., barley, triticale, and oats.

The evaluation of a wide range of annual *Medicago* spp. (medics), *Vicia sativa, Pisum sativum* and *Lathyrus sativus* was carried out in observation rows, micro-plot trials and advanced yield trials. New germplasm collections were first evaluated in single rows in a cubic lattice design. Selected accessions from observation rows of the previous season (1979–80) were evaluated in replicated micro-plots ($3.5m^2$) to measure dry matter production and seed yield. A cubic lattice design was also used for these trials. The best entries from micro-plots of the 1979–80 season were then grown in larger plots in advanced yield trials to check their performance once more. The medics were grown in a randomized block experiment, and *Vicia sativa, Lathyrus sativus* and *Pisum sativum* were all included in one lattice experiment.

Annual *Medicago* (Medics)

A total of 343 accessions were screened in observation nurseries and 95 accessions were selected from 10 of the 14 species planted (Table 1). Sixty-one selections were made from *M.rigidula*—a species which had shown considerable vigor and productivity during the two previous years. Some of the accessions of three other species—*M.turbinata, M.rotata,* and *M.noeana*—also performed very well and were selected to broaden the variability, range of adaptation, and utilization.

The determination of dry matter production and seed yield was carried out on 125 entries in microplot trials, and 23 accessions were selected (Table 2). Ten *M.rigidula* accessions have been noted as potential elite lines because of their high performance and suitable agronomic characteristics.

To obtain a manageable number of high performing lines of medics for multilocation testing, 49 accessions selected from the microplots of 1980 were tested in an advanced yield trial. A total of 15 lines were selected (Table 3). These were again all *M.rigidula.* Three "elite" lines (selection Nos. 768, 1303, and 733) were earmarked as possible cultivars, and extensive multiplication of the seeds of these lines should enable rapid and widespread multilocation testing.

Seed Permeability Studies in Medics

Many annual *Medicago* species (medics) exhibit a characteristic feature of regeneration from seeds once they are sown in pastures. Some genotypes have a high percentage of seeds which absorb water and regrow or regenerate vigorously from one year to the next. Others have a high percentage of hardseeds which do not

***Table 1.* A summary of the evaluation of medic observation rows grown at Tel Hadya in the 1980/81 season.**

Species	No. accessions	No. accessions selected	Selections as % of *no. of accessions* for each species	Range of mean selection score of the selected accessions
Medicago rigidula	184	61	33.2	3.3–5.0
Medicago aculeata	29	4	13.8	3.3–3.7
Medicago truncatula	34	2	5.9	3.3–3.3
Medicago turbinata	18	7	38.9	3.3–3.7
Medicago rotata	43	13	30.2	3.3–4.0
Medicago noeana	6	3	50.0	3.3–4.0
Medicago polymorpha	5	0	—	
Medicago murex	4	1	25.0	3.3
Medicago blanchiana	4	1	25.0	3.3
Medicago scutellata	3	1	33.3	3.3
Medicago littoralis	4	0	—	
Medicago radiata	4	0	—	
Medicago constricta	4	2	50.0	3.3
Medicago rugosa	1	0	0	
TOTAL	343	95	—	

*Mean Selection Score of Control 3.3 (*M. rigidula*).* [1]*Selection score: 1 = poor; 5 = very good.*

***Table 2.* Dry matter (DM) and seed yields of selected lines of medics from a microplot trial grown at Tel Hadya (1980/81).**

		DM yield			Seed yield		
Species	*Select no.*	*(kg/ha)*	*Rank*	*%Control*	*(kg/ha)*	*Rank*	*%Control*
M.rigidula	control	8240	29	100.0	1505	2	100
M.rigidula	1559[1]	11726	1	142.3	1302	15	85
M.rigidula	1531	10342	2	125.5	1176	23	77
M.rigidula	1542	10175	4	123.5	1408	4	92
M.rigidula	1561	10051	5	122.0	1332	14	87
M.rigidula	1564	9744	7	118.2	1345	12	88
M.rigidula	1547	9681	8	117.5	1363	10	89
M.rigidula	1535	9542	10	115.8	1208	20	79
M.rigidula	1569	9259	14	112.4	1182	22	77
M.rigidula	1552	9197	15	111.6	1383	6	90
M.rigidula	1546	8971	19	108.9	1546	13	87
M.constricta	1620	8840	21	107.3	1168	24	76
M.rigidula	1555	10297	3	124.9	1013	48	66
M.rigidula	1563	9815	6	119.1	775	68	51
M.rigidula	1534	9641	9	117.0	623	86	41
M.rigidula	1549	9430	11	114.4	640	83	42
M.constricta	1622	9405	12	114.1	1041	43	68
M.rigidula	1556	9346	13	113.4	609	89	40
M.rigidula	1566	9175	16	111.3	792	66	52
M.rigidula	1524	9080	17	110.2	1164	25	76
M.noeana	1639	8991	18	109.1	606	91	40
M.rigidula	1533	8922	20	108.3	1070	37	70
M.rigidula	1553	8711	22	105.7	651	80	42
M.rigidula	1562	8587	23	104.2	735	75	48
LSD (0.05)		2643			505		

[1]*Selection numbers 1559 to 1546 are elite lines.*

***Table 3.* Dry matter (DM) production and seed yield in selected lines of medics grown in the advanced yield trial at Tel Hadya (1980/81).**

Species	Select no.	DM yield kg/ha	DM yield Rank	DM yield %Control	Seed yield kg/ha	Seed yield Rank	Seed yield %Control
M.rigidula	Control	2978	31	100	595	35	100
M.rigidula	768[1]	5125	1	172	885	2	149
M.rigidula	1303	4404	3	148	848	5	143
M.rigidula	733	4123	7	138	913	1	154
M.rigidula	716	3992	10	134	839	6	141
M.rigidula	740	3968	11	133	801	8	134
M.rigidula	975	3717	14	125	809	7	136
M.rigidula	976	3678	15	124	860	4	145
M.rigidula	754	3290	22	110	883	3	148
M.rigidula	734	4589	2	154	659	24	111
M.rigidula	1310	4398	4	148	638	27	107
M.rigidula	994	4356	5	146	691	19	116
M.rigidula	956	4221	6	142	646	25	109
M.rigidula	953	4116	8	138	723	15	122
M.rigidula	960	4021	9	135	663	28	106
M.rigidula	1295	3851	12	132	761	10	128
LSD (0.05)		1065			238		

[1]Selection numbers 768, 1303, and 733 are elite lines.

absorb water readily and regenerate only after being in the soil for about a year. Annual medics with a high percentage of soft seeds are ideally suited for pasture establishment of marginal lands. Genotypes with a high percentage of hard seed are selected for use in rotations alternating with cereals.

Researchers investigated seed permeability characteristics of two promising medic species. Random samples of medic pods from 43 lines of *M.aculeata* and 53 lines of *M.rigidula* were collected from experimental plots at monthly intervals starting at the end of July 1980 to the end of November 1980. The pods were placed in petri dishes containing moistened filter paper and left in a refrigerator for 5 days at 5°C. The petri dishes were afterwards transferred to a germinator at 20°C. After 10 days in the germinator, the percentage of seeds not germinated was calculated to determine hardseededness. Results indicate that there is considerable variability for seed coat permeability in both of the species investigated (Fig. 1 and 2). Good possibilities exist for the selection of desirable cultivars for both marginal lands and for annual pastures in rotation with

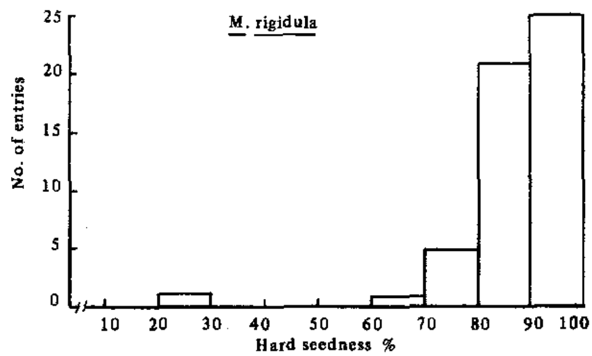


Fig. 1. Variability of the hardseed character in *M. rigidula*.

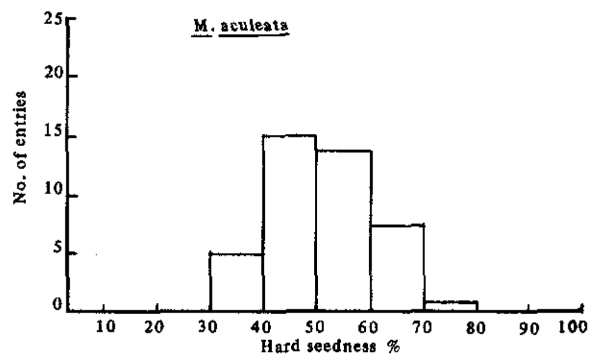


Fig. 2. Variability of the hardseed character in *M. aculeata*.

cereals. *Medicago rigidula* has a higher percentage of genotypes with hardseed characteristic than *M.aculeata*. Therefore, *M.aculeata* has a higher potential for use in permanent pasture establishment on marginal lands.

Vicia, Lathyrus, Pisum

The appraisal of nursery rows was carried out for both *Vicia sativa*, and *Pisum sativum* in separate trials. A total of 109 entries of *V.sativa* and 124 entries of *P.sativum* were selected on the basis of visual estimation of dry matter and seed yield, as well as for other agronomic traits. Figures 3 and 4 show that there is a wide genetic variability in the germplasm of these two species. This variability has been fully documented for reference and future exploitation.

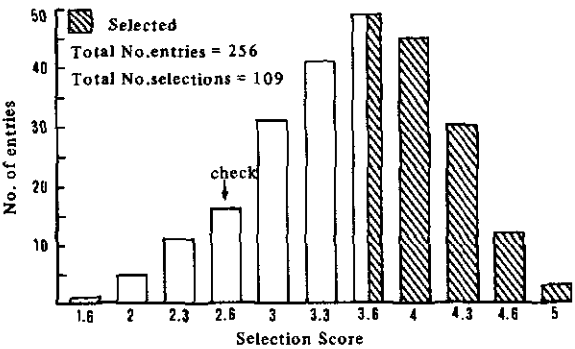


Fig. 3. Variability in *Vicia* germplasm observation rows, 1980/81.

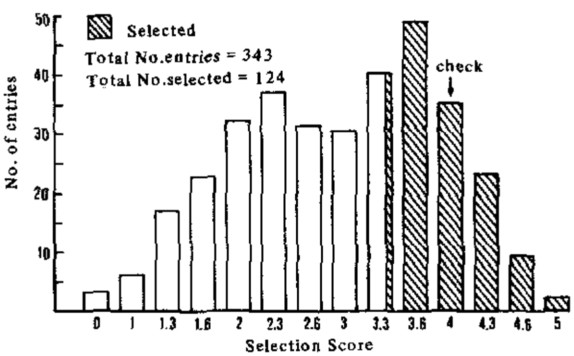


Fig. 4. Variability in *Pisum* germplasm observation rows, 1980/81.

Quantitative determination of both dry matter and seed yield in *Pisum*, *Vicia*, and *Lathyrus* was made in microplot trials, and it was possible to identify some lines combining both high dry matter and high seed yields (Tables 4, 5, and 6). Except for *Lathyrus* spp., it would appear that early flowering is related to both high dry matter yield and high seed yield.

Twenty-seven high performing lines selected from microplot trials were planted in a replicated trial to compare the yield data for the three species. Seeding rate was regulated so that a similar plant population was grown for each line of each species. Comparative yield data are given in Table 7. On the basis of the data obtained and additional information from microplot trials, three lines each of *Pisum* sp. and *Vicia sativa* were identified for more intensive evaluation and for seed multiplication. It is interesting to note that the dry matter yield of *Pisum sativum* was substantially higher than the other two legumes. *Pisum* also has earlier winter growth than both *Vicia* and *Lathyrus* and therefore is highly suitable as a legume component for a legume-forage cereal mixture.

***Table 4.* Dry matter (DM) and seed yield of selected lines of *Pisum sativum* grown in microplot trials, at Tel Hadya (1980/81).**

	DM yield			Seed yield		
Selection no.	(kg/ha)	Rank	%Control	(kg/ha)	Rank	%Control
124	5677	1	125	2088	5	105
320	5540	2	122	2039	8	103
321	5291	3	116	2213	2	112
248	5232	5	115	2044	7	103
325	5092	6	112	2098	4	106
455	4902	9	108	2377	1	120
Control	4553	15	100	1980	10	100
280	5267	4	116	1934	13	98
305	5037	7	111	1744	21	88
240	4981	8	109	1866	15	94
312	4798	10	105	1279	46	65
306	4790	11	105	1615	25	82
279	4705	12	103	1615	25	82
318	4614	13	101	1830	17	92
323	4590	14	101	1946	11	98
274	4329	22	95	2065	6	104
320	4274	25	94	1946	11	98
LSD (0.05)	1197			1173		

***Table 5.* Dry matter (DM) and seed yield of selected lines of *Vicia sativa* grown in microplot trials at Tel Hadya (1980/81).**

	DM yield			Seed yield		
Accession no.	(kg/ha)	Rank	%Control	(kg/ha)	Rank	%Control
716	5166	1	110	2358	1	114
control	4697	2	100	2077	2	100
1350	4692	3	100	747	27	36
405	4479	4	95	1761	3	85
7	4464	5	95	929	19	45
1361	4268	6	91	1581	6	76
715	3959	13	84	1385	9	67
507	3900	14	88	1022	14	49
2	3744	15	80	1132	13	55
1386	3683	17	78	929	19	45
1314	3621	20	77	1320	11	64
1319	3427	21	73	942	18	45
709	3300	22	70	1630	5	78
LSD (0.05)	1772			635		

***Table 6.* Dry matter (DM) and seed yield of selected lines of *Lathyrus* grown in microplot trials, at Tel Hadya (1980/81).**

Selection	DM yield			Seed yield		
no.	(kg/ha)	Rank	%Control	(kg/ha)	Rank	%Control
Control	1690	50	100	397	55	100
435	5482	1	324	809	27	204
436	5392	2	319	574	46	146
475	4874	3	288	1299	3	327
462	4638	4	274	610	41	154
448	4505	5	267	864	23	218
385	4496	6	266	386	56	97
433	4219	7	250	856	24	215
447	4180	8	247	1128	9	284
476	4029	9	238	1187	5	299
479	3999	10	237	1223	4	308
471	3900	11	231	619	40	155
444	3795	12	225	899	17	226
LSD (0.05)	2267			505		

***Table 7.* Dry matter (DM) and ranking of selected lines of *Pisum sativum, Vicia sativa,* and *Lathyrus* grown in the advanced yield trial (1980/81).**

		DM yield			Seed yield		
Species	Sel. no.	(kg/ha)	Rank	%Control	(kg/ha)	Rank	%Control
Pisum	control	5400	1	100	2400	2	100
Pisum	175	5144	2	95	1881	5	78
Pisum	155	5024	3	93	2498	1	104
Pisum	124	4730	4	88	2028	4	84
LSD (0.05)		811					
Vicia	control	3425	1	100	1797	1	100
Vicia	895	2728	2	80	1650	2	92
Vicia	847	2703	3	79	631	8	35
Vicia	1136	2645	4	77	1000	5	55
LSD (0.05)		911					
Lathyrus	control	1348	8	100	504	8	100
Lathyrus	384	2752	2	204	1450	3	287
LSD (0.05)		999					

Evaluation of *Vicia sativa*

The shattering of ripened pods of *V.sativa* severely restricts the use of this species as a legume component in forage mixtures for hay production. Late harvesting of the *Vicia* hay crop grown on fallow lands can cause severe "*Vicia* weed" problems in the subsequent cereal crops. Also, many difficulties are experienced in producing seeds of *V.sativa* because of the pod shattering characteristics.

Work was initiated in 1979–80 to screen germplasm of *V.sativa* for non-shattering pods, and 21 entries were tentatively identified. During the 1980/81 season, these 21 entries were studied in a plastic house where the intense summer heat was more conducive to pod shattering. Visual scoring of pod shattering was done using

Selecting *V. sativa* for non-shattering pods.

a scale where 0 indicated complete shattering and 5 indicated about 90% non-shattering. Scoring done toward the end of the summer (September 1981) revealed highly desirable non-shattering behavior in nine accessions which were given scores of 4 and 5 (Table 8).

Table 8.* Evaluation of the pod-shattering characteristic in *Vicia sativa.

No. of acc.	Score[1]	Accession number
2	5	1416; 1361
5	4	793; 1403; 1969; 1349; 7114
6	3	1390; 1887; 1337; 1332; 719; 1383
6	7	1878; 1771; 1856; 1886; 1336; 1306
2	1	1357; 1439
2	0	2541 (control) 716

[1]*Score: 0 = complete shattering; 5 = non-shattering.*

Two entries (Accession Nos 1416 and 1361) compared very favorably in dry matter production with the control (No. 2541) (Table 9). Accession 1361 may have potential of a cultivar since the yield is also satisfactory. Successful attempts were made in crossing these two non-shattering types with two highly productive lines (Accessions 2541 and 716). Seed set was obtained for a total of 142 crosses (Table 10).

Table 9.* Dry matter (DM) and seed yield of two non-shattering accessions of *Vicia sativa.

Acc. no.	DM (kg/ha)	% Control	Seed (kg/ha)	% Control
1416	4241	90.3	826	39.8
1361	4268	90.9	1581	76.1
2541	4697	100.0	2077	100.0

***Table 10.* The number of pods set in *Vicia sativa* crosses at Tel Hadya (1980–81).**

Crosses	Pod set (no.)
716 x 1416	87
2541 x 1416	17
716 x 1361	38
TOTAL	142

***Table 11.* The dry matter (DM) yield of forage barley harvested three weeks before heading (early cut) and at 50% heading (late cut).**

Lines	DM yield (kg/ha) Early	Late
244	4282	6601
213	3518	5105
209	3409	6569
222	3339	6767
225	3226	6735
208	3008	6003
221	2924	6681
228	2875	6083
9995	2855	6200
47	2711	5953
Local	2566	5163
LSD (0.05)	196	377

Selection of Forage Cereals

A large number of genotypes of forage barley, forage triticale, and oats were screened during the 1980/81 season with the aim of identifying superior lines to be grown in mixture with annual legumes. A total of 974 lines of barley, 1177 lines of triticale, and 30 lines of oats were evaluated.

The yield trials were grown in a complete randomized block design with systematic control. The dry matter yields of forage barley and oats were compared with a locally grown barley known as Arabic Abiad in "early" and "late" cuts. The early cut was made two to three weeks before heading, and the late cut at 50% heading. In the trials with triticale the dry matter yield was measured only in one cut, corresponding to the late cut for barley and oats.

Table 11 shows the dry matter yield (kg/ha) of the ten top lines of barley evaluated in the advanced yield trials in 6 m^2 plots. In this trial 45 lines were evaluated, eight of which significantly out-yielded the local barley in dry matter yield at both the early and the late cuts. The lines for which sufficient seed is available have been selected to be tested in mixture with vetch in order to screen for compatibility.

In a preliminary yield trial (with a plot size of 3 m^2), 65 barley lines obtained from Europe were compared with the local barley (control). The dry matter yield of the top yielding lines is shown in Table 12. Only one line (No. 1013) yielded significantly more than the control in the early cut, and only two (Nos. 989 and 1035) yielded significantly more than the control in the late cut.

In an advanced yield trial of forage triticale, 20 lines were compared with the local barley (Table 13). Only one (No. 246) was significantly superior to the control, giving a dry matter yield of more than 8 t/ha. In a preliminary yield trial with 320 triticale lines (Table 14), only one line produced significantly more than the local barley. Because of its very high dry matter potential, this line will receive much greater attention next season.

Evaluation of the available oats cultivars was initiated in the 1980/81 season. Results (Table 15) show that the yield potential of this species appears higher than barley and triticale for environments with an annual rainfall of 250 mm or more. The best oats lines will be tested in mixtures with annual legumes.

***Table 12.* The results of the preliminary yield trials of barleys from northwest Europe.**

	Dry matter yield (kg/ha)	
Lines	Before heading	50% heading
1036	1686	9170
984	2163	5630
1035	1263	5540
1023	1985	5339
1013	2461	5286
995	1991	4951
1034	1682	4857
Local barley	1943	5070
LSD (0.05)	231	390

***Table 13.* The dry matter (DM) yield of forage triticale compared with local barley (control).**

Lines	DM yield (kg/ha)
246	8602
2302	7251
242	7249
2304	7104
2299	6981
2298	6804
689	6623
2296	6587
2301	6538
610	6531
332	6451
314	6368
2297	6245
2303	6145
Local barley	7715
LSD (0.05)	320

***Table 14.* The dry matter (DM) yield of the best 10 triticale lines and a local barley evaluated in a preliminary yield trial.**

Acc.	DM yield (kg/ha)
945	11976
332	7390
862	6707
1007	6516
947	6332
266	6149
1006	5422
310	5344
957	5265
Local barley	7546
LSD (0.05)	348

***Table 15.* The dry matter yield of forage oats harvested three weeks before heading (early cut) and at 50% heading (late cut).**

	Dry matter yield (kg/ha)	
Lines	Early	Late
34	2917	8687
40	2911	8311
39	2861	8103
5	2601	6799
32	2534	8489
24	2485	8172
Local barley	2484	7164
LSD (0.05)	208	528

Perennial Forage Crops Development

Research on perennial forage crops at ICARDA is aimed at identifying species suitable for:

(1) Revegetation of marginal, non-arable soils.

(2) Utilization of hill slopes which are too fragile an ecosystem to be used for arable crops.

(3) Incorporation in long-term rotations in cereal growing areas on the high plateaus.

The benefits of introducing perennial forage crops into these ecosystems should include:

(1) Production of additional sources of animal feed.

(2) Relieving of the present grazing pressure on the arid and semi-arid rangeland which is the largest, the least used, and the most rapidly deteriorating land resource in the region.

(3) Soil protection and the prevention of further erosion.

The early stages of the research work on perennial forage crops, many of which are native to the region, have been confined to an evaluation of the adaptation of varieties and ecotypes grown under rainfed conditions.

SUMMER DORMANCY AND WINTER REGROWTH OF PERENNIAL GRASSSES. Two adaptation trials were evaluated in 1981. The first had been established in 1979 in an augmented design and included 80 accessions of the 12 perennial grasses listed in Table 16. The main attributes scored on this material were summer dormancy, evaluated in September 1980, and winter regrowth evaluated twice in January

Perennial grasses in observation rows.

***Table 16.* Summer dormancy (measured on September 14–16, 1980), winter regrowth (January 12 and 28, 1981) and dry matter yield (December 6, 1981 and in the period December 1981 to March 1982) of 12 species of perennial grasses.**

Species	No. of varieties and/or ecotypes	Summer[1] dormancy	Winter Regrowth[1]		Dry Matter Yield (g/m^2)		No. of varieties and/or ecotypes actively growing by March '82
			Jan. 12, '81	Jan. 28, '81	Dec. 6, '81	Winter '81/'82	
Phalaris aquatica	9	0.8 ± 0.1	2.6 ± 0.3	3.9 ± 0.3	0.0	205.6 ± 27.3	9
Lolium perenne	5	0.3 ± 0.1	0.6 ± 0.2	0.8 ± 0.4	0.0	6.3	1
Poa pratensis	9	1.3 ± 0.3	1.1 ± 0.1	1.1 ± 0.1	0.0	0.0	0
Bromus inermis	7	4.4 ± 0.2	0.7 ± 0.3	1.1 ± 0.1	0.0	0.0	0
Festuca arundinacea	4	3.1 ± 0.8	1.5 ± 0.5	2.3 ± 0.5	0.0	14.0 ± 11.1	2
Festuca ovina	4	2.8 ± 1.2	3.0 ± 0.8	3.5 ± 0.9	6.9	95.5 ± 20.1	4
Dactylis glomerata	27	1.6 ± 0.2	2.4 ± 0.3	3.1 ± 0.3	9.1 ± 2.6	91.7 ± 17.7	18
Agropyron cristatum	4	2.3 ± 0.5	2.8 ± 0.6	3.5 ± 0.9	0.0	10.3 ± 6.3	2
Agropyron libanoticum	4	2.1 ± 0.5	2.3 ± 0.3	2.8 ± 0.3	0.0	46.1 ± 19.7	4
Agropyron elongatum	3	2.5 ± 0.8	2.7 ± 0.3	4.0 ± 0.6	0.0	56.5	1
Agropyron desertorum	3	1.2 ± 0.4	3.3 ± 0.3	4.1 ± 0.1	0.0	31.5 ± 6.7	3
Agropyron intermedium	2	1.8 ± 0.3	2.0 ± 1.0	3.0 ± 1.0	0.0	70.2 ± 38.0	0

[1]Summer dormancy and winter regrowth scored 0 = no growth (dormant); 5 = all plants growing.

1981. Both summer dormancy and winter regrowth were scored on a 0 to 5 scale where 0 = no growth (dormant) and 5 = all plants actively growing during the spring of 1981. Seed of the more promising accessions was grown for multiplication. After seed harvest, plants were clipped 5 cm above the ground, and during the winter (1981/82) dry matter yield was measured wherever herbage height reached 10 to 15 cm.

The results of this trial are summarized in Table 16. The species which showed the most active growth after two summers were *Phalaris aquatica, Festuca ovina, Dactylis glomerata,* and *Agropyron intermedium.* Some ecotypes of *D.Glomerata* and *F. ovina* showed some regrowth at the beginning of December when animal feed was particularly scarce. The data given in Table 16 also suggest that a relationship exists between the level of summer dormancy and winter regrowth. The correlation coefficients between the two attributes (Table 17) show that species with a higher level of summer dormancy tend to have a higher winter regrowth but not necessarily an early regrowth.

***Table 17.* Simple correlation coefficients between summer dormancy and winter regrowth[1] of 12 species of perennial grasses.**

	Summer dormancy (1980)
Winter regrowth (Jan. 12, 1981)	$-.79^{*}$
Winter regrowth (Jan. 28, 1981)	$-.78^{**}$
Dry matter yield (Dec. 6, 1981)	$-.07$
Total dry matter yield (Dec. '81–March '82)	$-.64^{*}$

$^{*}P \leq 0.05$; $^{**}P \leq 0.01$.
[1]Summer dormancy and winter regrowth scored: 0 = no growth (dormant); 5 = all plants growing.

The relationship between summer dormancy and winter regrowth within a species was analysed in *D.glomerata* because there was a greater number of populations available in this species. As shown in Table 18, the variability within *D. glomerata* for winter regrowth is significantly associated with variability in summer dormancy (i.e. a negative correlation). The populations of D.glomerata possessing higher levels of summer dormancy show higher dry matter yields early in the winter. Locally collected ecotypes of this species were superior to varieties or ecotypes originating from areas with different climatic conditions (Table 19). Table 19 also shows that the adapted materials are characterized by higher levels of summer dormancy.

Table 18.* Simple correlation coefficients between summer dormancy and winter regrowth[1] in 27 varieties and/or ecotypes of *Dactylis glomerata.

	Summer dormancy (1980)
Winter regrowth (Jan. 12, 1981)	$-.58^{**}$
Winter regrowth (Jan. 28, 1981)	$-.63^{**}$
Dry matter yield (Dec. 6, 1981)	$-.67^{**}$
Total dry matter yield (Dec. 1981–March 1982)	$-.78^{**}$

$^{**}P \leq 0.01$.
[1]Summer dormancy and winter regrowth scored: 0 = no growth (dormant); 5 = all plants growing.

ANNUAL GRASSES. A second adaptation trial was established in November 1980. This included 49 accessions of two annual grasses (*Lolium rigidum* and *Bromus mollis*) and 35 perennial grasses: *Phalaris aquatica, Festuca arundinacea, Dactylis glomerata, Erharta calycina, Phalaris arundinacea, Festuca ovina,* and *Agropyron* sp.

The plants were clipped on six occasions from March 11 to July 20, and summer dormancy on six occasions from July 4 to September 22. Winter production after the first summer was evaluated on December 5, 1981, and January 10, February 28, and March 23, 1982. On the last date, survival was evaluated as the percentage of plants in each plot showing active growth. Results of this trial (Table 20) show that the most productive species in the establishment year were *Lolium rigidum* (cv. Wimmera), *Phalaris aquatica* (cv. Sirosa), and *Bromus mollis* (cv. Blando). Of particular interest was the seasonal distribution of dry matter yield and the regrowth of the perennial species after the summer.

The distribution of dry matter yield was similar in all species. After a slow regrowth in the

Table 19. **Summer dormancy (measured on September 14–16, 1980), winter regrowth (*January 12 and 28, 1981*), *dry matter* (DM) yield (December 6, 1981) and total dry matter yield (in the period December 1981 to March 1982) of 27 populations of *D.glomerata*.**

Origin	No. of popula-tions	Summer dormancy[1]	Winter Regrowth[1] Jan. 12, '81	Jan. 28, '81	DM yield (g/m^2)	Total DM yield (g/m^2)
Foreign varieties	9	2.6b	1.2b	1.4b	0.0b	2.1b
Syria	12	1.1a	3.0a	4.1a	14.1a	141.7a
Jordan	4	0.5a	3.8a	4.3a	19.2a	186.5a
Turkey	2	2.5b	1.0b	3.0ab	0.0b	5.7b

Means followed by the same letter are not significantly different ($P \leq 0.05$).
[1]*Summer dormancy and winter regrowth scored: 0 = no growth (dormant); 5 = all plants growing.*

Table 20. **Total dry matter (DM) yield of the most productive species and accessions of forage grasses established in November 1980 (average of 400 plants).**

Species	Cultivar or country of origin	Total DM yield (g/plant)
Lolium rigidum	Wimmera	25.2
Phalaris aquatica	Sirosa	18.4
Bromus mollis	Blando	16.3
Phalaris aquatica	Australia	14.0
Phalaris aquatica	Sirocco	13.9
Phalaris aquatica	Seedmaster	13.0
Festuca arundinacea	Demeter	11.5
Dactylis glomerata	Porto	11.5
Festuca arundinacea	USSR	10.0
Festuca arundinacea	USSR	9.8
LSD (0.05)		2.0

winter of the establishment year, the highest production was reached in the spring and production declined quickly with the end of the rainy season. Dry matter yield was always very low in summer and autumn but increased in the second winter after planting. Several species which showed some growth during the summer, such as *D.glomerata* cvs Phyllox and Potomac and *F.arundinacea* (USSR No. 14), did not show any regrowth in winter. Other species are able to produce a very limited amount of forage during the summer and to regrow in winter. Only two species—*Agropyron dasystachyum* and *A.cristatum*—were able to combine active growth in summer with early regrowth in autumn. However, in both cases productivity was very low.

The relationship between summer dormancy and survival (evaluated as a percentage of plants showing regrowth by the end of the 1981–82 winter) is shown in Fig. 5 for *Phalaris aquatica* and *Dactylis glomerata*. Major differences exist within species, not only for the final level of summer dormancy, but also for the timing of summer dormancy. It also appeared that the level of dormancy was related to survival. Varieties of both species showing the highest levels of dormancy showed the lowest levels of mortality.

GRAZING TRIALS. At the beginning of November 1980, a grazing trial was also established using a plot size of 1.2 x 40 m. The seed, broadcast by hand, was incorporated using a corrugated roller and rolled with a flat roller. The trial was grazed five times from March 16 to May 31. At each grazing dry matter yield was assessed by the "mowing strip" method. Observations were also made on emergence, ground cover and plant height. Although the first regrowth was observed in the third week of October (1981) in *Phalaris aquatica*, the first winter cut was taken on January 17, 1982. This was followed by two cuts on March 7 and 28.

Results of the grazing trial (Table 21) show that the annual grasses (*Lolium rigidum* and

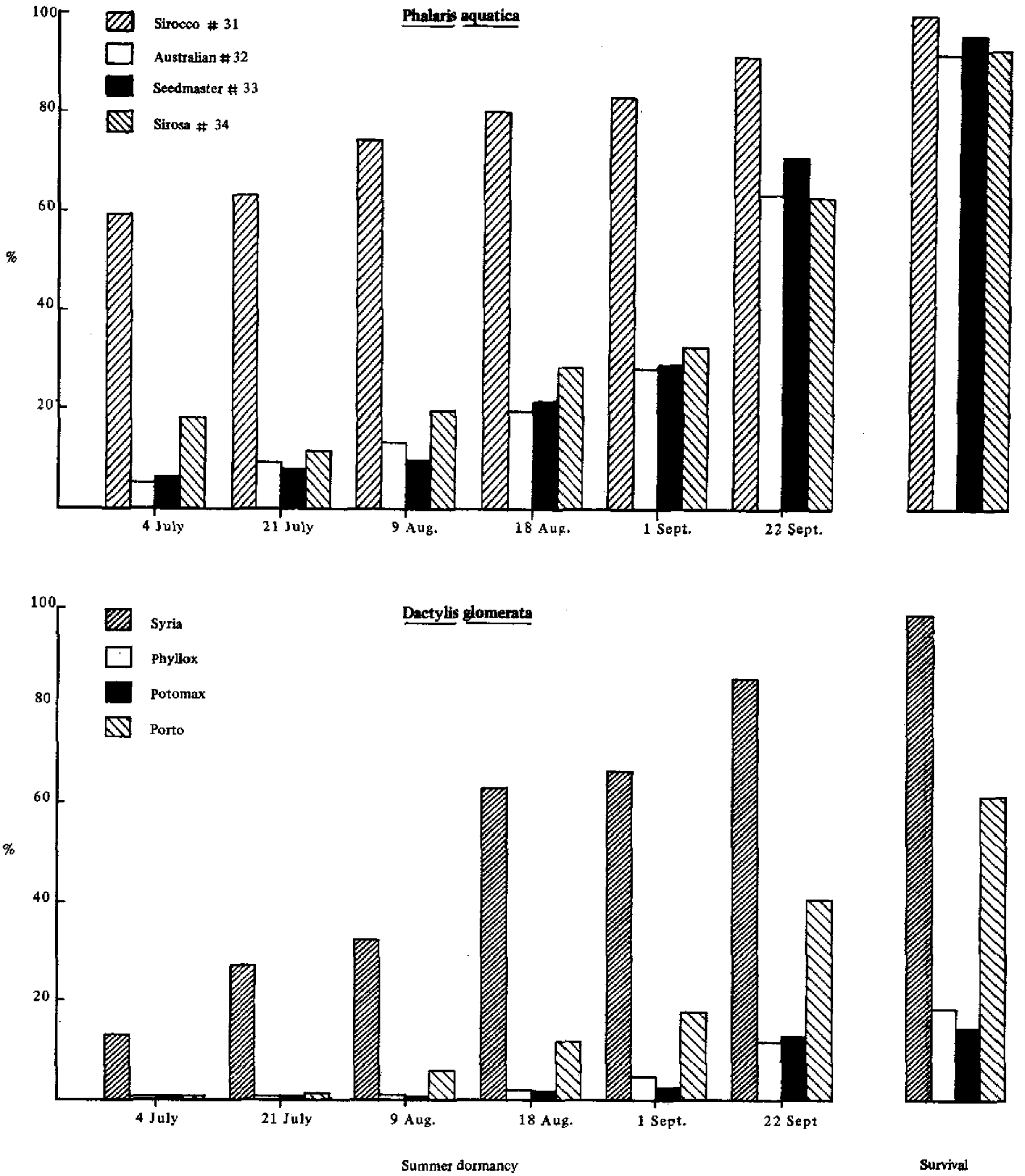


Fig. 5. Summer dormancy (% of plants completely dry) measured at six different dates, and percentage survival (% of plants showing regrowth on March 23, 1982) in *Phalaris aquatica* and *Dactylis glomerata*.

***Table 21.* Emergence, ground cover, total dry matter (DM) yield in the establishment year, and dry matter (DM) yield in the second winter of 18 forage grasses.**

Species	Variety or country of origin	Emergence (days from Dec. 1, '80	Ground cover %		Total DM yield (kg/ha)	DM yield (kg/ha) winter 1981–82
			8/3/81	17/4/81		
Lolium rigidum	Merredin	15.5	69.1	80.3	3,854	437
Lolium rigidum	Wimmera	15.8	64.2	84.5	3,462	247
Lolium multiflorum	Combita	14.0	66.8	82.9	3,348	—
Lolium multiflorum	Prego	15.0	60.1	76.6	3,198	—
Lolium perenne	Verna	28.3	23.6	64.4	1,934	—
Lolium perenne	Semperweide	32.5	17.3	43.6	1,601	—
Lolium perenne	Victoria	16.4	50.3	81.5	2,063	90
Lolium perenne	Kanagaroo	16.6	46.9	81.8	2,689	138
Dactylis glomerata	Currie	30.3	9.7	22.4	322	—
Dactylis glomerata	Porto	29.8	12.4	25.9	495	—
Dactylis glomerata	Turkey	26.3	24.6	48.7	722	—
Bromus inermis	Turkey	26.3	16.0	32.4	587	—
Festuca arundinacea	Demeter	24.9	20.5	46.9	1,188	—
Phalaris aquatica	Sirocco	23.8	29.4	57.7	1,108	770
Phalaris aquatica	—[1]	26.0	22.4	47.4	992	277
Phalaris aquatica	Australia	25.0	28.7	58.8	1,200	277
Phalaris aquatica	Seedmaster	26.0	31.1	53.8	1,262	248
Phalaris aquatica	Sirosa	22.8	32.4	56.5	1,479	632
LSD (0.05)		2.1	7.0	7.1	560	141

[1]*Origin unknown.*

Lolium multiflorum), as well as the two Australian cultivars of *Lolium perenne,* were characterized by a rapid emergence followed by good establishment. As expected, the two annual grasses were the most productive species, followed by the two Australian cultivars of *L. perenne. Phalaris aquatica* showed a slower establishment than the two annual grasses and produced about 1 ton of dry matter. Among the other perennial grasses, the productivity of *D. glomerata* and *B. inermis* was very low, while *F. arundinacea* was comparable with *Phalaris aquatica*. In the second winter (1981/82), some species failed to regrow (e.g., *L multiflorum*) while the stand of others thinned out drastically.

Both the adaptation trials and the grazing trial indicated that *Phalaris aquatica* is the most promising perennial grass under the climatic conditions of northern Syria.

Agronomic Studies

The aim of the agronomy work is to identify factors limiting forage crop and pasture production and establishment, and to develop agronomic practices aimed at optimizing digestible dry matter yields per hectare. All trials were conducted at ICARDA's Tel Hadya site.

RESPONSE OF FORAGE LEGUMES TO PHOSPHATE AND NITROGEN FERTILIZERS. Six legume lines (two *Pisum sativum, one Lathyrus sativus* and two *Vicia sativa*), were evaluated for dry matter yield under increasing rates of P_2O_5 (0, 40, 80 and 120 kg P_2O_5/ha) and two levels of nitrogen (0 and 20 kg N/ha) in a replicated factorial experiment. The legume lines responded differently to the phosphate treatments. The two *Pisum* lines (P.S. 46 and P.S. 99) produced most dry matter at all phosphate levels, while *Lathyrus sativus* showed the least response. The highest increments in dry matter over the control as a result of phosphate fertilization were recorded with *Pisum sativum* (P.S. 46) and *Lathyrus ochrus* (L.O. 101) (Fig. 6). Application of 20 kg N/ha resulted in no significant dry matter increase over the control in any of the six legume lines (Table 22).

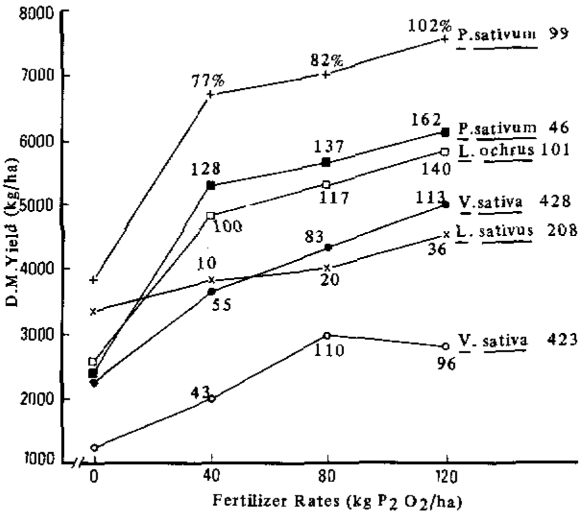


Fig. 6. The response of six legume lines to phosphate expressed as a percentage dry matter increment compared to the control.

***Table 22.* The effect of nitrogen on dry matter yield (kg/ha) of six selected legume lines.**

Legum species and accession number		N rates (kg/ha) 0	20
P.sativum	No. 46	5003	4913
P.sativum	No. 99	6422	6309
L.sativus	No. 208	4181	3691
L.ochrus	No. 101	4661	4787
V.sativa	No. 428	3696	4072
V.sativa	No. 423	2266	2379
Mean		4371	4358

EFFECT OF SEED RATE AND N FERTILIZER ON BARLEY. The possibility of maximizing hay production using high seeding rates was studied in two trials using two barley lines grown in pure stand and in a mixture with vetch (*Vicia sativa*). Barley in pure stand was sown at the rates of 40, 80, 120, 160, and 200 kg/ha and nitrogen fertilizer was applied at the rates of 0, 30, 60, and 90 kg N/ha.

Barley in a mixture with *Vicia sativa* was sown at total seed rates of 90, 120, 150, and 180 kg/ha in such a way that the corresponding cereal-legume ratio in the above seed rates were 0.5:1, 1:1, 1.5:1, and 2:1. Nitrogen fertilizer in the form of ammonium nitrate was applied at three rates (20, 40, and 60 kg N/ha) either as a single dose at the time of sowing or in two equal dressings at sowing and 2½ months later. All treatments were arranged in a randomized complete block design with four replications.

No significant differences in hay production were recorded due to the different seeding rates in the range of 80 to 200 kg/ha in forage barley grown in pure stand (Fig. 7). Nitrogen application significantly improved dry matter yield, but the increment per kg of fertilizer used decreased sharply with higher levels (Fig. 8).

In the mixtures where barley was sown with vetch, the total dry matter yield was significantly

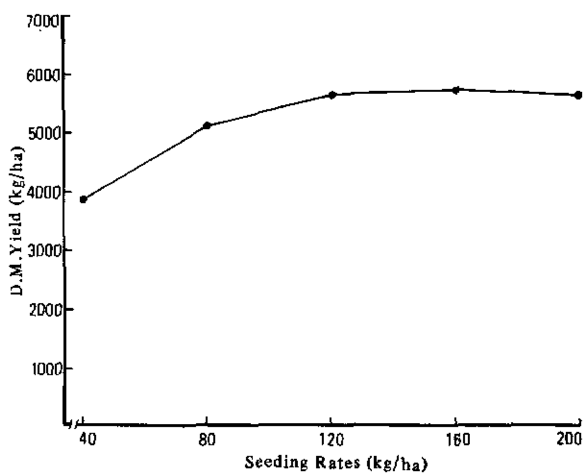


Fig. 7. Effect of seeding rates on hay production of barley.

improved by increasing the seed rate (Fig. 9). The cereal component in the mixture appears to be the more important in determining the level of dry matter yield production.

A single application of nitrogen gave better dry matter yields from the forage mixture when a low rate (20 kg N/ha) was used. However, at high rates (40 and 60 kg N/ha) a better response was recorded when the fertilizer was applied in two doses (Fig. 10). It was also noted that split application of the nitrogen fertilizer resulted in a higher proportion of legume in the mixture. The legume proportion in forage mixtures generally decreased with increased levels of applied nitrogen, regardless of the method of application (Table 23).

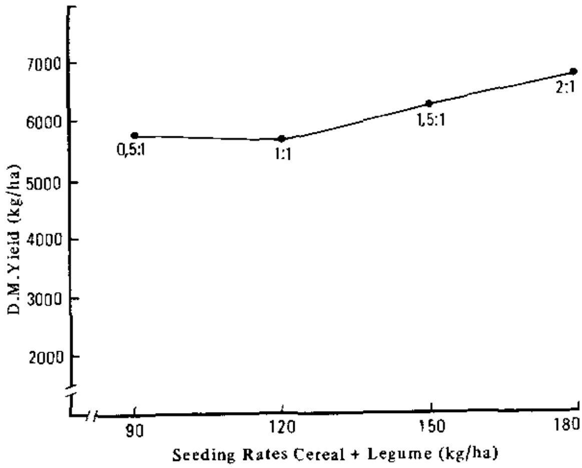


Fig. 9. Effect of seed rate and proportion of cereal-legume components (by weight) on total dry matter production of barley- *Vicia* forage mixture.

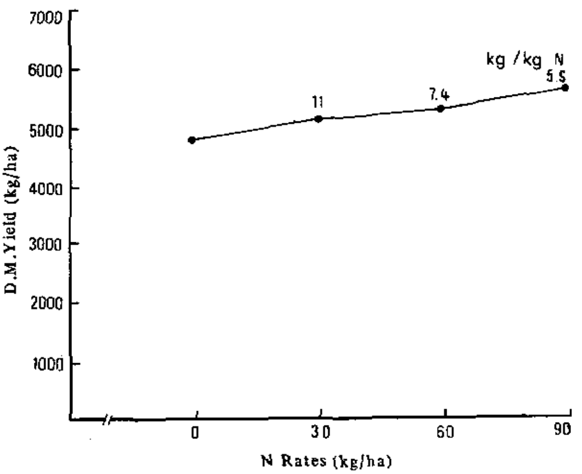


Fig. 8. Effect of nitrogen fertilizer on hay production of barley.

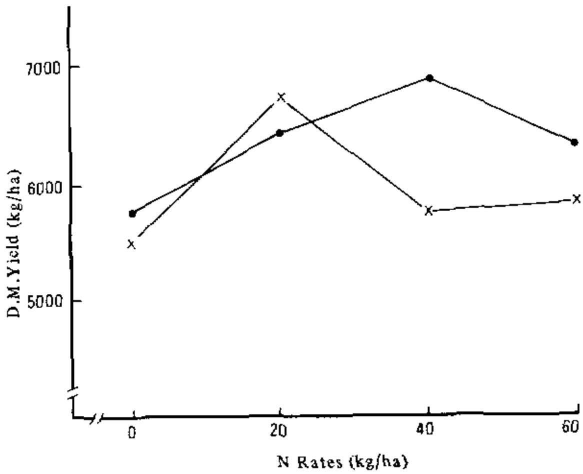


Fig. 10. Dry matter yield of a barley-*Vicia* mixture under single (x) and two dose (0) applications of nitrogen fertilizer.

***Table 23.* Effect of nitrogen rates and method of application on the yields (kg/ha) and composition of a barley/*Vicia* mixture.**

	Split application				Single application			
Fertilizer (kg/ha)	Barley	*Vicia*	Total	% Vicia in mixture	Barley	*Vicia*	Total	% *Vicia* in mixture
0 N	4489	1112	5601	19.8	4227	1235	5462	22.6
20 N	5259	1086	6345	17.1	5774	828	6602	12.5
40 N	5585	1137	6722	16.9	4862	809	5671	14.2
60 N	5357	756	6113	12.3	5182	599	5781	10.3

Results of this experiment suggest that the use of high seed rates in barley-legume mixtures can result in higher hay production.

PERFORMANCE OF FORAGE BARLEY AND TRITICALE IN PURE STAND AND IN MIXTURE WITH ANNUAL LEGUMES. Ten lines of forage barley and ten lines of triticale were evaluated for dry matter yield by growing them in pure stand and in mixture with four legumes: *Vicia sativa, Vicia dasycarpa, Pisum sativum* and *Lathyrus sativus.* The aim of this study was to test the possibility of selecting cereal and forage lines for their performance in a mixture on the basis of their forage yield in a pure stand.

Two experiments were established—one for evaluating the barley lines and the other for triticale. Barley was sown at 100 kg/ha in pure stand. In the mixtures, a constant seeding rate of 60 kg/ha was used. Legumes in mixtures with each barley line were sown at variable seeding rates, ranging between 40 to 80 kg/ha for *P.sativum*, 30 to 70 kg/ha for *L.sativus,* 20 to 60 kg/ha for *V.sativa,* and 10 to 30 kg/ha for *V.dasycarpa.* Similarly, triticale lines were evaluated in pure stand and in mixtures with the four legumes, except that higher seeding rates of 125 kg/ha for pure stand and 70 kg/ha for mixtures were used.

Lines of both forage barley and triticale which produced high dry matter yields in pure stand also did so in mixtures (Table 24 and 25). These results conform with those of the previous year when the same forage lines were used.

PRODUCTIVITY OF ALFALFA UNDER RAINFED CONDITIONS IN RELATION TO CUTTING REGIMES. The objectives of this experiment were to investigate the potential of alfalfa under rainfed conditions and to identify the best management practices for maximum yield and crop persistence. The experiment was established in 1979, when five alfalfa ecotypes (Cyprus, Turkey, Iran, Aleppo, and Damascus) were sown in the main plots (20 m x 10 m) and four cutting heights were assigned to sub-plots. The experiment was sown in August 1979 under supplementary irrigation (10 mm) using sprinklers every two weeks until the end of October 1979. Thereafter no irrigation was applied. In March 1980, all plots were cut to 15 cm in height, then cutting height treatments were imposed on the sub-plots when alfalfa reached 10% flowering. Sampling was discontinued in June 1980 and resumed for a second season in March 1981. Two cuts were taken during each season in April and May.

Close harvesting at 5 and 10 cm resulted in maximum total dry matter production in all ecotypes (Fig. 11). Three ecotypes (Aleppo, Cyprus, and Damascus) out of five were less winter dormant and therefore produced high dry matter yields during the first cut in March when compared with the two winter dormant ecotypes (Turkey and Iran). The latter produced very little material for harvesting, especially at 15 and 20 cm cutting heights. However, following a second cut in May a much faster growth was recorded in the winter dormant types which were able to produce more total dry matter yield than "Damascus" in three out of four cutting treatments.

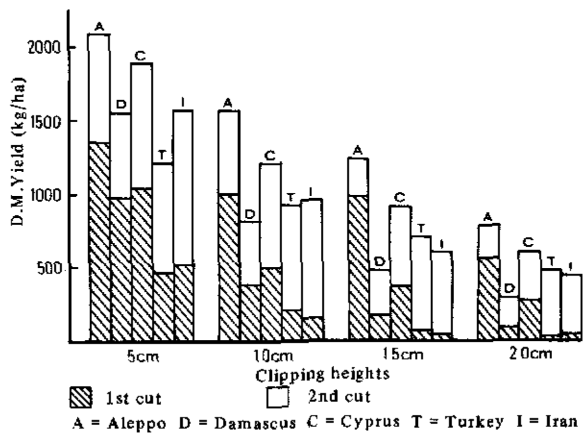


Fig. 11. Dry matter yields (kg/ha) of five alfalfa ecotypes clipped twice at different heights during 1981.

Table 24. **Dry matter yields and their rank of some barley lines grown in pure stand and in mixture with legumes.**

Barley acc. no.	Barley in pure stand (kg/ha)	Rank	Total barley + legume forage yield (kg/ha)	Rank	Barley component in mixture (kg/ha)	Rank	% of total yield
50	9899	6	7995	8	7372	8	92
52	9164	8	9133	6	8374	7	92
4	10501	3	10112	2	9557	2	95
9	10047	5	9132	7	8405	6	92
71	9751	7	9350	5	8709	5	93
46	10234	4	9427	4	8712	4	92
157	6377	10	6395	10	5317	10	83
146	8981	9	7859	9	6982	9	89
49	10558	2	10784	1	10417	1	97
143	11001	1	9890	3	9337	3	94
LSD (0.05)	1969		1786		1697		

Table 25. **Dry matter yields and their rank of some triticale lines grown in pure stand and in mixture with legumes.**

Triticale acc. no.	Triticale in pure stand (kg/ha)	Rank	Total triticale + legume forage yield (kg/ha)	Rank	Triticale comp. in mixture (kg/ha)	Rank	% of total yield
332	10309	1	8725	4	7944	4	91
314	9672	3	10225	1	9439	1	92
739	8610	6	7997	6	7197	6	90
246	9157	5	7649	7	7042	7	92
689	10246	2	8910	3	8249	2	93
724	6867	9	7378	8	6303	8	85
310	8075	7	9070	2	8225	3	91
287	9524	4	8364	5	7528	5	90
665	6769	10	6352	10	5350	10	84
680	6885	8	6839	9	5958	9	87
LSD (0.05)	1621		1698		1644		

Marginal Land Improvement

Marginal lands (or non-arable lands) are a grossly under-utilized land resource in the ICARDA region. Decades of overgrazing have led to severe erosion and to a dramatic decline in productivity.

The objective of this project, now in its preliminary stages, is to evaluate possibilities for the improvement of marginal lands located in the higher rainfall areas (350 mm annual rainfall or more). Introduction of perennial species is one of these possibilities. This, however, needs the identification of adapted species. Therefore, the emphasis at this stage is on improvement through agronomic techniques.

A replicated trial was established on November 17, 1980, on a very shallow and stony soil. The trial included the following five treatments.

(1) Control = native pasture.

(2) Furrowing (furrows 10cm deep at 50cm distance).

(3) Furrowing + 50 kg/ha of nitrogen.

(4) Furrowing + 50 kg/ha of P_2O_5.

(5) Furrowing + 50 kg/ha of both nitrogen and P_2O_5.

RESULTS. The plots were sampled for dry matter yield on May 8 and June 14, 1981. The results (Table 26) show that either furrowing alone or furrowing plus fertilizer application increased the productivity of the natural vegetation by 2 to 2.5 times over the control. The data indicate that at the rate of fertilizer used the beneficial effect of furrowing is far greater than the effect of the fertilizer. The application of both nitrogen and phosphate was superior to the application of either one of the two fertilizers separately.

Table 26. **Effects of furrowing and fertilizer application on dry matter yield of a native pasture.**

	Dry matter yield (kg/ha)		
Treatment	8/5/81	14/6/81	Total
Control	269 c[1]	101 a	370 c
Furrowing	566 ab	170 a	736 ab
Furrowing + N	422 bc	101 a	603 bc
Furrowing + P_2O_5	456 bc	145 a	601 bc
Furrowing + N + P_2O_5	721 a	199 a	920 a

[1]Numbers followed by the same letter do not differ significantly. $P \leq 0.05$.

Animal Husbandry in Relation to Development, Management, and Use of Forage Plants

The aim of this work is to evaluate and screen pasture plants under grazing pressure and to develop management techniques for the best use of forage.

Forage evaluation was carried out using grazing by sheep in addition to a simulated grazing technique. A sheep grazing experiment was conducted to study the effect of grazing on plant recovery. A forage mixture of barley and vetch was used. The experiment included three sowing rates of local barley (40, 60 and 80 kg/ha), each sown in a mixture with three rates of *Vicia sativa* (40, 60 and 80 kg/ha) in plots of size 6m x 4.2m in November 1980. In early February, one half of the experiment (representing all treatments) was grazed by sheep. Quadrat samples were taken immediately prior to the grazing treatment and at the end of the season in June 1981 to estimate the amount of forage consumed and the amount produced during plant recovery after grazing. The total forage production (dry matter) on grazed and ungrazed plots was compared at the end of the season.

The simulated grazing experiment included 16 lines of forage barley and four lines of triticale sown in plots of size 6m x 1.4m and fertilized with 40 kg N/ha and 40 kg P_2O_5/ha at the time of sowing in November 1981. Each plot received one of three harvesting treatments:

(1) One harvest at the end of the season (control).

(2) One early cut plus a final harvest.

(3) Two early cuts plus a final harvest.

(Early cuts were made when plants were 20cm in height, the final harvest at crop heading.)

RESULTS. In all grazing treatments, forage recovery after grazing ranged from 86% to 87% of total forage produced (grazed + recovery). There was high forage recovery after grazing when high seeding rates were used (Fig. 12). Results suggest that forage barley can be grazed early in the season and still produce a high forage yield, especially when high sowing rates are used. The reduction in the forage yield (30% to 35%) under grazing treatments compared with the control (no grazing) could be justified in terms of the 2.5 t/ha green fodder (0.5 tons dry matter) harvested by grazing animals early in the season when green forage was scarce and expensive.

The average total dry matter produced by 16 lines of barley was 92% of the control when harvested once early in the season followed by final harvest and 82% of the control when harvested

Evaluating medics in grazing trials.

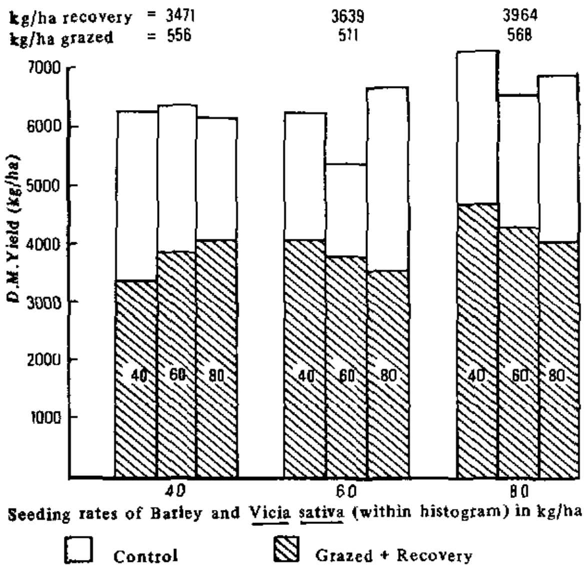


Fig. 12. Effect of cereal-legume seeding rates on hay production following early grazing treatment.

twice early in the season followed by final harvest. Corresponding values for triticale were 87% and 76% (Table 27).

It is interesting to note that early harvesting treatments improved the total dry matter production in 5 out of 16 lines of barley (Table 28).

Germplasm Collection, Maintenance and Seed Multiplication

It is essential to manipulate and exploit broad-based genetic diversity to develop productive pastures and forage species with cold tolerance, disease, and insect resistance, and other desirable agronomic characteristics. Therefore, the objectives of this project are to:

- Enlarge the pasture and forage germplasm collection in order to have a ready source of genetic variability.

- Maintain the working collection under proper storage conditions.
- Multiply seeds of selected and elite lines for more intensive evaluation.

The germplasm base is developed by assembling germplasm through direct collection and by means of exchange with other scientific institutions.

In the 1980–81 season, germplasm collecting activities were given a low priority in preference to the multiplication of existing materials. Two short-duration collecting trips were made—one in Jordan, the other in Syria. A total of 91 accessions were obtained, of which 47 were medics (mainly *M.rigidula*), 22 *Vicia* spp., and 13 grass species. A substantial number of new entries (1697) was added to the existing collection. These were acquired from research organizations, forage scientists, and commercial sources. The total germplasm collection now stands at 16,053 accessions.

The screening, cleaning, and packaging of seeds for both medium-term and long-term storage were continued. To date, 700 entries of *Pisum* and 8,945 entries of eight other species have been placed in long- and medium-term storage, respectively. Considerable efforts were directed to the increase of germplasm accessions having limited seed quantities and to germplasm regeneration and seed multiplication (Table 29).

Table 27. **Effect of different harvesting treatments on total dry matter production of barley and triticale.**

Harvesting treatment	Barley[1] Total DM production (kg/ha)	Barley[1] % of control	Triticale[1] Total DM production (kg/ha)	Triticale[1] % of control
One final harvest (control)	7742	—	8766	—
One early cut plus final harvest	7128	92	7657	87
Two early cuts plus final harvest	6383	82	6737	76
LSD (0.05)	458		745	

[1]*Each value is an average of 72 samples for barley and 16 samples for triticale.*

Table 28. **The total dry matter production of 16 lines of barley under simulated grazing conditions.**

Acc. no.	One final harvest (kg/ha)	One cut + final harvest (kg/ha)	Two cuts + final harvest (kg/ha)
250[1]	6638	6571	6885
249	7151	8906	6951
253	8085	6857	7099
3	8998	8403	6393
251[1]	7141	7520	6056
48	8970	7000	6395
58	8197	7650	6297
259	7119	6526	6800
41	9677	6926	5300
264	7892	6169	5110
162[1]	6007	7091	6923
85	6517	6894	5648
148	7038	5366	5850
248	8029	6287	7186
167	8531	7140	6114
9[1]	8372	8734	7126

[1]*Lines where early cutting improved total DM production.*

Table 29. **Summary of germplasm increase, regeneration, and seed multiplication of forage crops at Tel Hadya in the 1980/81 season.**

Genus	Germplasm No. of acc.	Germplasm No. of species	Seed multiplication No. of acc.	Seed multiplication No. of species
Medicago (annual)	172	17	270	13
Pisum	3184	3	107	2
Vicia	170	5	161	2
Lathyrus	2	—	73	13
Brassica	—	—	10	1
Hordeum	186	1	764	1
Triticale	—	—	960	1
Avena	436	5	35	1
Medicago (Perennial)	23	—	—	—
Onobrychis	22	—	—	—
Trifolium	23	—	—	—
Others[1]	67	—	—	—
TOTAL	4285	31	2380	34

[1]Agropyron, Elymus, Hedysarum, Astragalus, Coronilla, Lotus, Melilotus.


Demonstration of harvesting a cereal/legume mixture for hay production in an off-station trial.

Off-station Activities

Off-station testing is carried out each year in collaboration with the national research program of the Ministry of Agriculture and Agrarian Reform in Syria and at ICARDA's sub-station site at Terbol in Lebanon. The aim of these activities is to compile information and gain knowledge on the performance and suitability of different forage crops identified at ICARDA's Tel Hadya research station. Other activities are also conducted with the aim of alerting farmers in Syria to the new practices of growing forage for hay production and the establishment of annual pastures as an integral part of crop rotation. The latter activities in 1981 included growing and managing forage crop mixtures on farmers' fields and demonstrations of machinery for hay making.

Research activities were carried out in Syria during 1981 at three locations: Kamishly (450 mm average annual rainfall), Salamieh (250 mm average rainfall), and Hama (400 mm average rainfall).

Triticale Evaluation

Ten lines of forage barley and 10 of forage triticale were grown in pure stand and in mixture with four legumes (*Vicia sativa, Vicia dasycarpa, Pisum sativum* and *Lathyrus sativus*) at Kamishly and Salamieh research stations, as well as at Tel Hadya. The objectives, treatments, and experimental design were the same as those described in the agronomic studies section for Tel Hadya.

In general, the most productive barleys in pure stand were also very productive in mixtures (Table 30). The least productive lines (146 and

Table 30. **Rankings[1] of dry matter yields of some barley lines grown in pure stand and in mixture with legumes at three locations.**

Barley acc. no.	Tel Hadya			Salamieh			Kamishly		
	Pure stand	Mix-ture	B.[2] Comp.	Pure stand	Mix-ture	B.[2] Comp.	Pure stand	Mix-ture	B.[2] Comp.
50	6	8	8	5	3	3	3	6	5
52	8	6	7	10	8	8	4	3	7
4	3	2	2	6	5	5	8	7	6
9	5	7	6	7	4	4	5	5	4
71	7	5	5	4	6	7	9	8	8
46	4	4	4	1	2	2	2	2	2
157	10	10	10	9	10	10	7	10	10
146	9	9	9	8	9	9	10	9	9
49	2	1	1	3	1	1	6	1	1
143	1	3	3	2	7	6	1	4	3

[1]1 = highest yield; 10 = lowest yield.
[2]Barley component in mixture.

157) in pure stand were consistently the least productive in mixtures at all three sites. The triticale lines behaved in a similar manner, although more genotype-environment interactions were observed with triticale than with barley.

EVALUATION OF MEDICS AND SUB-TERRANEAN CLOVER. Four Australian medic cultivars (Jemalong, Cyprus, Harbinger and Snail) and one sub-terranean clover (Clare) were studied at Kamishly, Salamieh, and Hama research stations. At each location the five legumes were fertilized with 60 kg P_2O_5/ha in a randomized complete block design. Dry matter yield and seed production were assessed at the end of the season by harvesting quadrats of size 1 m x 1 m in each plot.

The best crop establishment was observed for Snail medic at all three locations. The highest dry matter yield of 12 t/ha was recorded at Hama (Fig. 13). High dry matter yields of between 7 and 10 t/ha were obtained with all medic cultivars at Kamishly. Seed production was highest with Snail medic at Salamieh and Hama, and with Snail and Cyprus at Kamishly (Fig. 14).

Results suggest that annual legumes such as medic cultivars, which are suitable for pasture, can be successfully established in many locations in Syria.

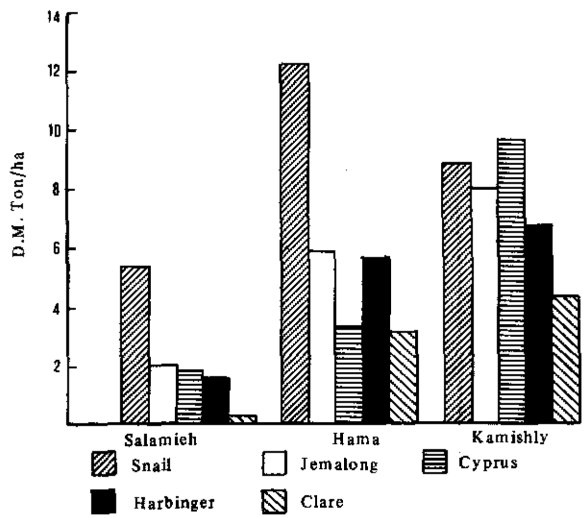


Fig. 13. Dry matter yield of four Australian medic cultivars and a sub-terranean clover (Clere) grown at three sites in Syria (1980/81).

A preliminary evaluation of 514 lines of medic was carried out in 1981 at Terbol, Lebanon. The material was planted in single rows, 5 m in length. Single plant selections and row selections were made on these lines based on the overall plant performance such as establishment, vigor, disease resistance, and seed yield (Table 31).

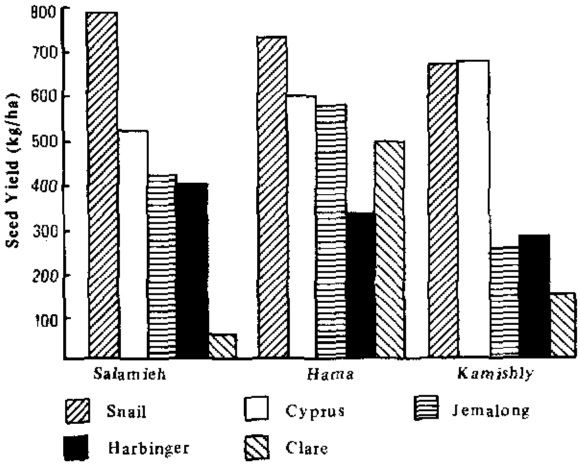


Fig. 14. Seed yield of four Australian medic cultivars and a sub-terranean clover (Clare) grown at three sites in Syria (1980/81).

Table 31. **Summary of selections made from medic observation rows grown at Terbol, Lebanon (1980–81).**

Species/ cultivar	No. of lines	No. of acc. selected	Selections as % of acc.	No. of single plants selected
M. rigidula	170	52	30.5	17
M. aculeata	15	12	80	4
M. truncatula	83	24	28.9	12
M. littoralis	24	6	25	8
M. noeana	6	3	50	—
M. blancheana	3	3	100	—
M. rotata	32	22	68.7	—
M. turbinata	22	8	36.3	3
M. polymorpha	81	8	9.8	2
M. minima	11	—		—
M. constricta	15	—		2
M. tornata	16	—		—
M. preacox	5	—		—
M. coronata	6	—		—
M. scutellata	3	2	66.6	—
M. radiata	2	—		—
M. murex	3	—		—
M. lacciniata	2	—		—
M. disciformis	4	—		—
M. rugosa	1	—		—
Circle Valley	1	—		—
Serena	1	—		—
Sapo	1	—		—
Sair	1	—		—
M. species	6	—		—
TOTAL = 25	514	140		48

Nitrogen Fixation in Forage Plants

The effect of phosphate and nitrogen fertilizer application on nodulation and growth of the different forage legume crops were examined during the 1980-81 growing season. Major objectives of these studies were to:

- Determine the optimum rate of phosphate fertilizer required for maximum nodulation and nitrogen fixation.
- Find out whether application of some nitrogen fertilizer is necessary for maximum nodulation and N_2-fixation.
- Identify superior strains of *Rhizobium* for low phosphate and high nitrogen conditions.

Several rates of phosphate (0, 25, 50 and 75 kg P_2O_5/ha) and nitrogen (0, 20, 40 and 60 kg N/ha) fertilizers were applied to uninoculated and inoculated forage legume crops (*Vicia sativa, V.ervilia, V.narbonensis, Pisum sativum, Lathyrus sativus, Medicago truncatula* and *M.littoralis*).

Two highly effective strains of *Rhizobium*, previously identified, were used in a separate trial for each crop. Nodulation was monitored at the early vegetative and flowering stages. Forage yield was recorded at maturity.

RESPONSE. The different forage legume species varied in their response to both phosphate and nitrogen fertilizer application. In general, phosphate fertilizer application increased both nodulation and forage production whether the crops were inoculated or not. All the forage species, except *Pisum* spp., produced maximum nodule mass and forage dry matter at 50 kg P_2O_5/ha. The inoculated plants had higher nodule mass and forage dry matter than the uninoculated plants in the different phosphate treatments. These differences were greater at lower levels of phosphate treatment, i.e. 0 and 25 kg P_2O_5/ha.

With increases in the amounts of nitrogen fertilizer applied, nodule weight gradually decreased whether the plants were inoculated or not. In the absence of artificial inoculation, most of the forage crops responsed positively to added nitrogen fertilizer in terms of forage dry matter production. Addition of nitrogen fertilizer had little influence on the inoculated crop, i.e. the plants with inoculation alone produced similar forage dry matter to the plants receiving inoculum as well as 60 kg N/ha. It was also possible to identify some strains of *Rhizobium* which would produce better nodulation in different forage crops under low phosphate and high nitrogen regimes.

Because in phosphate deficient soils *mycorrhizae* can play an important role in phosphate nutrition of different forage legume crops (especially in enhancing symbiotic N_2-fixation), studies were initiated to examine the association between the native mycorrhizal fungi and the different forage legume crops. Mycorrhizal development in the roots was monitored by staining with trypan blue in lactophenol at the early vegetative and at early pod filling stages. It was observed that most of the forage crops were highly mycorrhizal, especially *Lathyrus* and *Vicia* species. The results also gave a strong indication that phosphate fertilizer application to the different forage legume crops could be economic, even at low rates of application.

Disease Resistance and Tolerance

Pathology research activities started late in the 1980–81 season and were intended primarily to monitor the disease situation in Syria and in other countries of ICARDA's region and to screen available breeding material for disease tolerance, or resistance. Research work in 1981 focused on the disease of these crops: peas (*Pisum* spp.), alfalfa (*Medicago sativa*), annual medics (*Medicago* spp.), sainfoin (*Onobrychis* spp.), rough pea (*Lathyrus* spp.), vetch (*Vicia* spp.), and clover (*Trifolium* spp.).

DIAGNOSIS AND IDENTIFICATION. A field and laboratory study was conducted during the period April 13 to August 30, 1981, to identify diseases of forage crops and their occurrence to determine disease prevalence and severity and to evaluate breeding material. Foliage diseases were tentatively diagnosed in the field and specimens of diseased plants were brought into the laboratory for further diagnosis and identification of the causal agent. For soil borne diseases (collar rot, root rot, wilt) only plants showing above ground disease symptoms were diagnosed. Identification of the viral and bacterial diseases was done mainly on disease symptoms.

Prevalence (incidence) of a disease in a field, expressed as a percentage, was calculated from the number of accessions checked and the numbers attacked. Disease severity of each accession was estimated according to a severity scale and a disease index for all accessions in a field was calculated. The severity scale was expressed on a scale from 1 to 4:

1 = Disease initial on few scattered plants.
2 = Moderate disease severity; disease present on scattered plants.
3 = Disease severe; disease present on a majority of plants.
4 = Disease very severe; disease present on a majority of plants causing apparent damage.

LOCATIONS SURVEYED. Results obtained from this study are summarized in Tables 32 and 33. The diseases are ranked according to their occurrence in the different locations surveyed (Table 33). Studies on their prevalence and severity are in progress.

Peas grown in the locations surveyed were attacked by *Ascochyta* diseases, root rot, powdery mildew, viruses, bacterial stem lesion, and rust. Diseases found on alfalfa and medics were the spring black stem and leaf spot, common

***Table 32.* Observed diseases on forage legume crops ranked in order of occurrence at Tel Hadya, Lattakia, Jableh, Hama, and Salamieh in Syria (April 13–June 3, 1981).**

Peas	Alfalfa	Medics	Sainfoin	Rough Pea	Vetch	Clover
Ascochyta	spring BSS	*Stemphylium*	PM	DM	*Ascochyta*	CLS
	CLS	CLS				rust
Root rot	PM	spring BSS	rust	*Ascochyta*	PM	
	wilt	PM				
		DM				
PM	DM	wilt	root rot	PM	DM	
Viruses	collar rot	*Ascochyta*	collar rot	collar rot	*Stemphylium*	
bac. lesion	*Ascochyta*	rust		root rot	root rot	
		collar rot			collar rot	
		root rot				
Rust	*Stemphylium*	anthracnose	*Stemphylium*		scl. blight	
	DM	*Ascochyta*	wilt			
	viruses					
	rust					
	anthracnose		anthracnose		viruses	
	summer BSS		*Ascochyta*			

Ascochyta: Ascochyta *blight and/or leaf spot.*
PM: Powdery mildew.
Spring BSS: Spring black stem and leaf spot.
CLS: Common leaf spot.
DM: Downy mildew.
Summer BSS: Summer black stem and leaf spot.
Scl. blight: Sclerotinia *blight.*

***Table 33.* Classification of breeding material according to its susceptibility to diseases[1] in the 1980–81 season.**

		Number of Genotypes (and%)			
Crop	Source	Disease-free	Attacked by one disease	Attacked by several diseases	Total
Peas	Germplasm nursery	2475 (67.8%)	904 (24.8%)	272 (7.4%)	3651 (100%)
	Nursery	35 (6.1%)	457 (79.3%)	84 (14.6%)	576 (100%)
	Microplots	10 (16.7%)	22 (36.7%)	28 (46.7%)	60 (100%)
Alfalfa	Nurseries	110 (19.9%)	306 (55.4%)	136 (24.6%)	552 (100%)
	Microplots	3 –	– –	24 –	27 –
Medics	Germplasm nursery	5 –	3 –	– –	8 –
	Microplots	18 (9.0%)	110 (54.7%)	73 (36.3%)	201 (100%)
Sainfoin	Nursery	129 (22.3%)	199 (34.4%)	250 (43.2%)	578 (100%)
Rough pea	Microplots	11 (18.3%)	31 (51.7%)	18 (30.0%)	60 (100%)
Vetch	Germplasm nursery	9 –	7 –	2 –	18 –
	Microplots	– –	27 (42.9%)	36 (57.1%)	63 (100%)

[1]Orobanche *not included.*

leaf spot, *Stemphylium* leaf spot, wilt, powdery mildew, downy mildew, collar rot, root rot, *Ascochyta* leaf spot, viruses, summer black stem, leaf spot, and rust. Pathogens causing serious diseases on alfalfa and medics, which were isolated from plant specimens in the laboratory but not evaluated in the field, were *Colletotrichum* spp (causal agent of anthracnose) and *Sclerotium rolfsii* (causal agent of collar rot and root rot).

Diseases of sainfoin found in the surveyed locations were: powdery mildew, rust, root rot, collar rot, *Stemphylium* leaf spot, wilt, anthracnose, and *Ascochyta* leaf spot. Diseases found on rough peas in the surveyed locations were: downy mildew, *Ascochyta* leaf spot, powdery mildew, collar rot, and root rot. Vetch species in the surveyed locations were attacked by *Ascochyta* diseases, powdery mildew, downy mildew, *Stemphylium* leaf spot, root rot, collar rot, viruses, and stem blight (*Sclerotinia sclerotiorum*). Diseases of clover were common leaf spot and rust. The flowering parasitic plant, *Orobanche* spp., was found on peas, medics, rough pea, and vetch in the surveyed locations, *Cuscuta* spp. was found to attack alfalfa and medics.

Preliminary evaluation of the breeding material in germplasm nurseries, nurseries, and microplots was done at Tel Hadya. It was classified into three categories: disease-free genotypes, genotypes attacked by one disease, and genotypes atacked by several diseases (Table 33).

The 1980/81 survey helped to clarify the disease situation of legume forage crops in Syria. It will be continued for another growing season and in other countries of the ICARDA region to complete the picture of the disease situation and to identify locations with heavy disease pressure ("hot spot" locations) and areas which are relatively disease-free for future forage crop seed production.

Ranking the diseases according to their frequency of occurrence in the different locations does not highlight their economic importance. Some diseases occurring even in only one location may cause total damage to the crop. (For example, anthracnose and stem blight.)

Herbicide Screening and Weed Control

Weeds pose a serious problem for pasture establishment both on marginal lands and in cropping zones. The prolific weed growth in fields previously planted with fertilized cereal crops needs to be carefully managed to ensure the establishment of a productive medic pasture. Control of weeds is also a necessary requirement in pasture seed production fields.

Twenty-four chemicals were tested to study their selectivity on the establishment of five selected pasture and forage species: *Medicago truncatula, Pisum sativum, Vicia sativa, Lathyrus sativus,* and *Trifolium resupinatum.* Three of these chemicals were incorporated into the soil before planting (PPI), 14 were pre-emergence types (Pre.) and seven were used as post-emergence applications (Post). Visual observations were made to study the sensitivity of the five species to the herbicides and assess the effects on five important species of weeds.

Results of these studies are shown in Tables 34 and 35. The species tested were not affected by or were highly tolerant to many of the herbicides applied (Table 34). However, many of the herbicides which did not affect the legume crop did not control all the important weeds (Table 35).

The pasture or forage legume sown, the dominant weed species present, and certain edaphic and other environmental conditions are all factors which influence the choice of herbicide or combination of herbicides that should be used. Research is being continued to further determine the most suitable herbicide for a given situation.

***Table 34.* Summary of the effect of 26 herbicides on six species of forage crops.**

Hebicide	Rate (kg ai/ha)	Applic. date	*Pisum sativum*	*Lathyrus sativus*	*Medicago truncatula*	*Trifolium resupinatum*	*Vicia sativa*
Eprolam	3.0	PPi	+	–	+	–	+
Benfluralin	0.5	PPi	–	–	–	–	–
Trifluralin	0.25	PPi	–	–	–	–	–
Chlorbromuron	1.0	Pre	–	+	–	–	–
Methabenz	2.0	Pre	(+)	(+)	–	–	–
Pronamid	0.5	Pre	+	+	–	–	+
Pronamid	0.25	Pre	+	+	+	+	+
Metribuzin	0.2	Pre	(+)	+	(+)	(+)	+
Cyanazine	1.0	Pre	(+)	+	–	–	+
Dichlofop-M	1.0	Pre	(+)	+	+	(+)	+
Metolachlor	0.7	Pre	–	–	–	–	–
Carbofluorfen	1.0	Pre	(+)	(+)	+	–	–
Prometryne	1.5	Pre	(+)	(+)	–	–	(+)
Terbutryne	1.5	Pre	(+)	+	–	–	(+)
Fluorodifen	1.5	Pre	(+)	(+)	+	+	(+)
Metoxuron	0.5	Pre	–	+	+	+	+
Metoxuron	1.0	Pre	–	+	–	–	+
Penoxalin	0.5	Pre	–	–	–	–	–
Oxyfluorfen	0.5	Pre	–	–	–	–	–
Simazine	0.1	Post	–	+	+	–	–
MCPB	0.8	Post	–	–	–	–	–
Dinoseb-a	1.0	Post	+	(+)	+	+	(+)
Bentazon	0.5	Post	+	+	+	+	–
Barban	1.0	Post	–	+	+	+	+
Diclofop-M	2.0	Post	+	+	+	+	+
PP009	1.5	Post	+	+	+	+	+

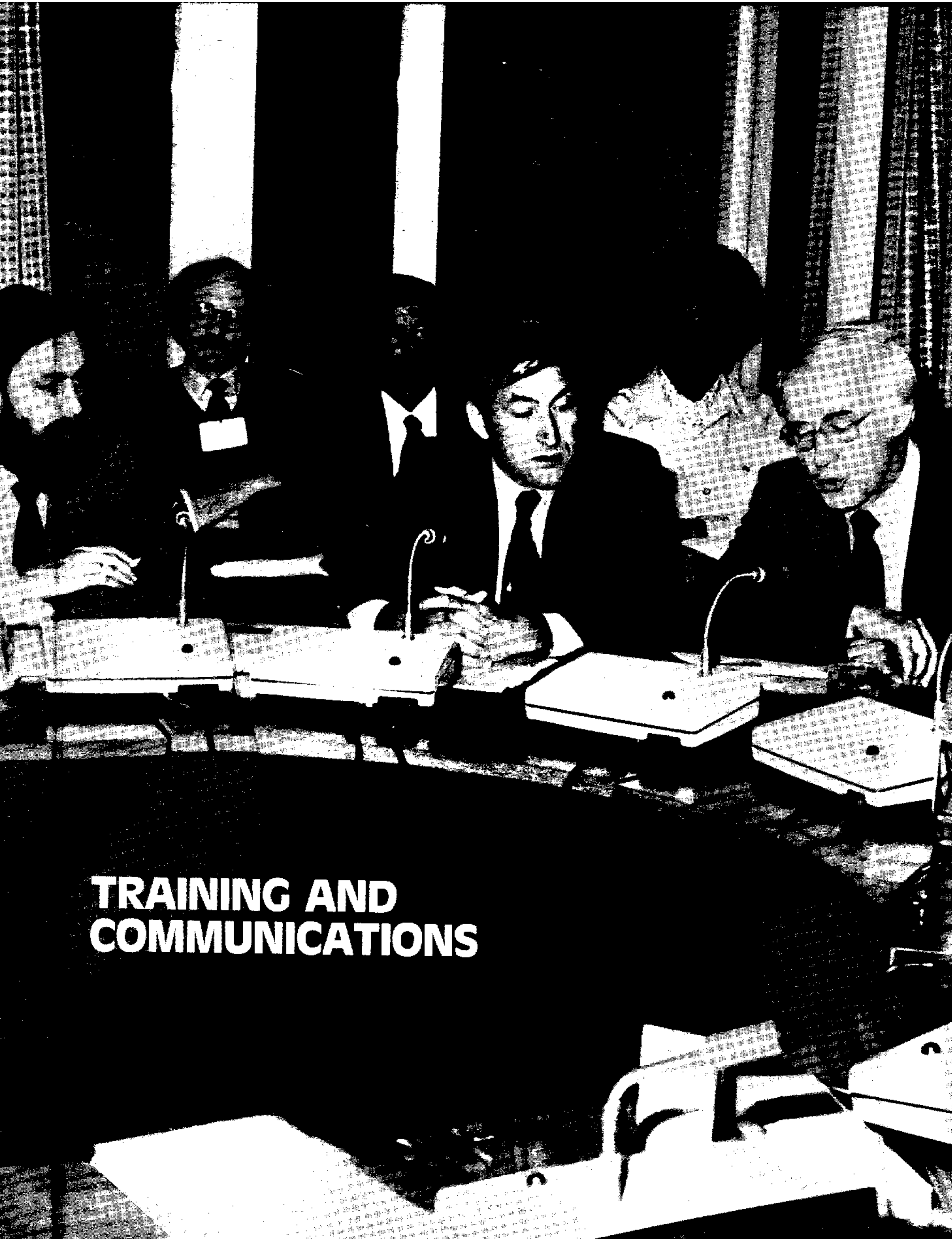
+ No damage on the crop.
(+) Slight damage (5–10%).
– Strong damage.

***Table 35.* Effect of 18 promising herbicides on five weed species estimated according to the EWRC[1] scoring system.**

			Weed Species				
Herbicide	Rate (kg ai/ha)	Field of[2] activity	*Sinapis arvensis*	*Phalaris* spp.	*Galium tricorne*	*Papaver* spp.	*Vaccaria pyramidata*
Eprolam	3.0	G	9	1	9	9	9
Chlorbromuron	1.0	B	1	9	5	—	—
Methabenz	2.0	B+G	1	9	9	—	—
Pronamid	0.5	G	9	1	9	9	9
Pronamid	0.25	G	9	1	9	9	9
Metribuzin	0.2	G+B	1	9	9	—	—
Cyanazyne	1.0	B	2	9	9	9	9
Diclofop-m	1.0	G	9	1	9	9	9
Carbofluorfen	1.0	B	1	4	5	9	9
Prometryne	1.5	B	4	9	9	6	—
Terbutryne	1.5	B	4	—	8	—	9
Fluorodifen	1.5	G+B	1	2	1	9	9
Metoxuron	0.5	G	9	9	9	9	9
Simazine	0.1	B+G	6	8	9	7	—
Dinoseb-a	1.0	B	1	9	1	1	9
Bentazon	0.5	B	2	9	1	9	—
Barban	1.0	B+G	8	5	9	—	9
PP009	1.5	G	9	1	9	9	—

[1]EWRC: European Weed Research Council; 1 = 100% control; 9 = 0% control.
[2]Field of activity: G = Grasses; B = Broadleaf weeks.

TRAINING AND COMMUNICATIONS



Contents

(Photo on previous page: The Ambassador of the Netherlands Government in Syria (right) speaks at the "Key Figures Symposium on Seed Production" at ICARDA.)

TRAINING AND COMMUNICATIONS

Training

During the year, 43 agricultural research workers from various national programs in developing countries completed training at ICARDA. Practical, as well as theoretical training, was provided in a wide range of subjects.

FOOD LEGUME. Training at Aleppo was given to six research fellows from Ethiopia, China, Syria, Chile, and India during 1981. They visited the center for periods ranging from three weeks to nine months, worked jointly with the legume scientists, conducted research, and became familiar with the various ICARDA activities. The training was aimed at improving the technical skills of these research workers and building links between them and the ICARDA scientists.

As part of the food legume training efforts, an in-country training course was held in January 1981 at the Hudeiba Research Station in northern Sudan. This was a part of the ICARDA/IFAD Nile Valley Faba Bean Project. The three-week course was attented by 14 technicians from the national food legume programs in Egypt and Sudan. Field oriented instruction, which dominated the course, was given by Egyptian and Sudanese scientists. This was complemented by background classroom lectures whenever required. ICARDA scientists and training staff

The Training Program involves practical field instruction as well as classroom lectures and laboratory work.

played only a catalytic role through the coordination of activities and the supply of educational materials. It was run with the close involvement

Trainees with an ICARDA cereals training officer (right) in an experimental field.

of training staff from the Agricultural Research Corporation in Sudan.

FORAGE. Three trainees from Syria and Morocco participated in forage training during 1981. These trainees worked with the forage scientists in conducting research with the aim of building links and improving technical skills.

CEREALS. The major training activity in cereals improvement was the six-month residental course which covered the period from February until the end of July. Trainees from seven countries in the ICARDA region participated in this course. It was mainly field-oriented, emphasizing breeding as well as agronomic research techniques. As part of the field training, each participant was assigned the responsibility of conducting a special research experiment. Projects involved simple field experimentation and included the planning, layout, note taking, and writing of reports. In addition to field training, theoretical lectures were given as background. Seminars and visits to on-farm research and farmers' fields were emphasized during the course.

RESEARCH FELLOWS AND SCHOLARS. Two research fellows from Pakistan and Tunisia visited the Tel Hadya research station and worked closely with the cereal improvement staff. They undertook research training in high altitude research and grain quality.

The relationship between ICARDA and many universities in the region and Europe was strengthened in 1981. Five research fellows (Ph.D. candidates) and two research scholars (M.Sc. candidates) joined the cereals, food legumes, and farming systems reseach programs. The relationship with the University of Aleppo remains unique among these activities.

A food legume research fellow from Chile crosses lentils.

A total of five M.Sc. students from this University undertook their thesis research at ICARDA during the year.

Library, Information, and Documentation

Documentation and library activities expanded during 1981 to meet scientists' needs within ICARDA and to act as a base for exchange and distribution of information within the region. This expansion was due in large measure to the provision of a special grant from IDRC to support a project on the development of library and information/documentation services, particularly FABIS (Faba Bean Information Service) and LENS (Lentil Experimental News Service). The latter was formerly published by the University of Saskatchewan which will continue to provide important inputs to the service. A senior information scientist was appointed to head the project.

Funds are also provided under this project for training, equipment, the production of bibliographies and other literature, and a reprint service. Production and distribution costs of the FABIS and LENS newsletters are also covered.

PUBLISHING RESEARCH REQUESTS IN FABIS. The aim of the FABIS service is to provide a medium (the FABIS Newsletter) for the fast publishing of research results and to foster contacts among researchers. It also encourages publishing activities by scientists from developing countries. FABIS Newsletter No. 3 was published and sent to 724 researchers at more than 300 institutes in 61 countries. A special FABIS publication, "Genetic Variation in *Vicia faba*," lists and indicates the origin of known genetic variation within the species. As part of FABIS, the Commonwealth Agricultural Bureau (CAB) in the United Kingdom has produced four issues of the journal, "Faba Bean Abstracts." They were distributed free of charge to the FABIS participants in the ICARDA region of West Asia and North Africa. The first issue of "Lentil Abstracts" was also published during the year.

EXCHANGE OF INFORMATION. Links were established with the International Information System for the Agricultural Sciences and Technology (AGRIS) in Vienna and Rome for ICARDA to become an input center for its publications. As part of an exchange of information with national programs, a documentalist from ICARDA visited Egypt in June 1981 to collect research papers and other documents dealing with faba beans. This was sponsored by ICARDA/IFAD Nile Valley Project on Faba Beans. The staff collected 191 documents for abstracting and publication by CAB as the Nile Valley Faba Bean Abstracts.

The Legumes Information meeting in Washington was attended by a senior staff member who presented a paper on ICARDA's information activities. At this meeting it was agreed that ICARDA would be responsible, among the International Centers, for collecting, storing and providing information on faba beans and lentils.

INCREASED LIBRARY USE. ICARDA's library added a substantial number of books and journals to its collection, and scientists made increased use of the facilities during the year. Participants in training courses also made regular use of the library. In response to a request by the Syrian national research program, a librarian was trained in book selection, classification, and cataloguing at Damascus. To keep the scientists within ICARDA well informed of the latest publications, photocopies of contents pages of all new journals and books received by the library were circulated.

Research information is published in a variety of publications for distribution in the ICARDA region and worldwide and for internal staff uses.

Conferences and Workshops

JOINT INTERNATIONAL CONFERENCE. The ICARDA/IFAD Nile Valley Project on Faba Beans and the Egyptian Government jointly sponsored "The International Faba Bean Conference" in Cairo, Egypt, from March 1 to March 11, 1981. The conference was attended by 136 scientists from 16 nations, as well as scientists from ICARDA and other international organizations. The primary objective of the conference was to focus on the problems of irrigated faba beans in the Nile valley of Egypt and northern Sudan. All presentations and discussions were geared to having practical relevance to research on increasing the productivity and food value of faba beans in the Nile Valley.

Participants at the conference made recommendations which stressed the need for increased international cooperation between all faba bean scientists. Other recommendations covered various aspects of faba beans improvement such as breeding, agronomy, weed control, pathology, nutrition, and pests.

FABA BEAN BOOK PUBLISHED. An authoritative reference book entitled, "Faba Bean Improvement," based on papers presented at the international conference, will be published by the Martinus Nijhoff Publishing Company in the Netherlands. This book focuses on genetic improvement, the development of cultural practices, control of pests, diseases and weeds, nitrogen fixation and the use of faba beans as a human food. The proceedings of the conference will be published by ICARDA to complement the "Faba Bean Improvement" book through compiling national program reports, Nile Valley Project reports, discussions on the research papers presented at the conference, and details of the recommendations adopted by the conference.

SEED SYMPOSIUM. The "Key Figures Symposium on Seed Production," sponsored by the

Government of the Netherlands, was held at Aleppo, Syria, from March 23 to March 25, 1981. It was attended by more than 30 participants, including specialists from 16 developing countries in the ICARDA region. This symposium was planned to appraise the local needs for seed industries, examine the technological constraints which limit the development of such industries and make recommendations to improve the situation.

Recommendations made by the participants covered various aspects of seed production such as cultivar testing and evaluation, production of breeder's and foundation seed, quality control, and crop certification. Proceedings of this symposium will be published by ICARDA.

CHICKPEA WORKSHOP. From May 4–7, a workshop was held at Aleppo to focus attention on the control of *Ascochyta* blight in chickpeas and the advantages of winter sowing the crop. Thirty-nine participants from 9 countries attended this workshop jointly sponsored by ICARDA and ICRISAT. Participants recommended that investigations should be intensified into the possible existence of physiologic races of *Ascochyta rabiei* (Pass) Lab, and into the epidemiology of the disease. Other recommendations included: establishment of screening facilities by ICARDA and ICRISAT at four to six key centers; investigation of agronomic variables in different agroclimatic situations; monitoring of disease and pest complexes; breeding for frost tolerance; and running of simple on-farm demonstrations which involve the farmer and extension services. Proceedings of the workshop are being prepared at ICARDA.

CROP PRODUCTION CONFERENCES. This conference, sponsored by ICARDA, was held in Chtaura, Lebanon, from December 10–12. Sixty participants from different Lebanese institutions, ICARDA, FAO, and national embassies attended. The aim of the conference was to identify production constraints and formulate collaborative research programs that could be implemented jointly by Lebanese and international institutions, especially ICARDA. Major recommendations made by the conference participants included: construction of a Genetic Resources Laboratory; survey of the socio-economic situation of Lebanese dryland farmers in the Bega's valley; research on soil fertility; on-farm trials; forage germplasm acquisition and development; mechanizaiton of the harvest of legumes; and the training of research workers.

LIST OF PUBLICATIONS

FARMING SYSTEMS

GENERAL

Jaubert, R. 1981. "Analysis of a traditional agricultural system-Salme in Nepal." *PhD Thesis, Institut National de la Recherche Agronomique,* (Fac. Sci. Econ. Gestion), 250 pp. (French).
Nygaard, D. 1981. "Socio-economic constraints to the future development of the dryland farming regions of the world." *Proceedings of the International Congress of Dryland Farming, Adelaide.*
Nygaard, D. & Allan, A. 1981. "A farming systems approach to agricultural research." *Crop Production in Lebanon. Research Conference at Chtaura, Lebanon, December.*
Nygaard, D. & Basheer, A.M. 1981. "How yield stability can influence farmers' decisions to adopt new technologies. The case of faba bean production in Egypt." *International Conference on Faba Bean, Cairo, March.*
Nygaard, D. & Hawtin, G.C. 1981. "Production, trade and uses." *Lentils.* Ed. by C. Webb and G. Hawtin. Published for ICARDA by CAB, pp. 7–14.

SOIL, WATER, AND NUTRIENTS

Cooper, P., Allan, A., Harmsen, K., Keatinge, D., Nygaard, D., Saxena, M., Islam, R. 1981. "Soil water and nutrient research, 1979-80, Farming Systems Program, ICARDA" *Project Report* No.3, 215 pp.
Cooper, P., Sabet, Y., Houdiard, P. 1981. "The effect of N supply on growth, water use and yield of barley at five locations in N. Syria." *Proceedings of the 2nd Symposium on Water Resources in Dry and Semi-Dry Areas, Rabat, Morocco, September.*
Harmsen, K. 1981. "Some data on soils and ferility at Tel-Hadya, Brida, and Khanasser." *ICARDA*, 36 pp.
Harmsen, K. 1981."Some data on the classification and the fertility of soils at Khanasser, Brida, Tel-Hadya, Kafr Antoon, and Jindiress," *ICARDA,* 85 pp.
Monteith, J. & Webb. C. (Editors) 1981. "Soil water and nitrogen in Mediterranean-type environments" (Review papers only). Martinus Nijhoff/Dr.W.Junk Publishers, 1981. The Hague., London, 338 pp. (Joint publication with ICARDA)
Monteith, J & Webb.C. (Editors) 1981. "Soil-water and nitrogen in Mediterranean-type environments." Review papers and technique papers). Published for ICARDA by Martinus Nijhoff, The Hague, Boston, London, 1981, 444 pp. Special issue of *Plant & Soil,* 1981, 58(1–3).

LIVESTOCK FARMING

Bahhady, F.A. 1981. "Recent changes in Bedouin systems of livestock production in the Syrian steppe." In: *The future of pastoral peoples. Proceedings of a Conference held in Nairobi, Kenya, August 1980.* IDRC, 1981, No. IDRC-175e, pp. 258–266.
Brooken, R.F., O'Connor, C.W. and Nordblom, T.L. 1981. "Costs of reducing grain feeding of beef cattle: Part 1." In: *Feedstuffs,* Vol.53, No.1, pp. 15, 19–20, 23–24.
Brooken, R.F., O'Connor, C.W. and Nordblom, T.L. 1981. "Costs of reducing grain feeding of beef cattle: Part 2." In: *Feedstuffs,* Vol.53, No.2, pp. 30–31.
Nordblom, T.L. 1981. "Simulation of cattle cycle demography: cohort analysis of recruitment and culling decisions in the national beef cow herd." *PhD Thesis (Dep. Agric. Resource Economics), Oregon State Univ.*, 277 pp.
Nygaard, D. Martin, A., Bahhady, F. 1981. "Range and sheep cooperative and fattening cooperatives in Syria. Supplemental feed purchases and credit requirements." *ICARDA Project Report* No.4, 141 pp.
Thomson, E.F. 1981. "The sheep husbandry project of the Farming Systems Program of ICARDA." *Report of the TCDC workshop on the improved utilization of feed resources for sheep fattening in the Near East, Amman, Jordan. Workshop Report AG: DG/INT/80/905, FAO, Rome,* 4 pp.

CEREALS

WHEAT, BARLEY, AND GENERAL

Ahmed, S. 1981. "Movement and management of the germplasm in the Cereals Program of ICARDA." *ICARDA Training Paper,* 19 pp.

Ahmed, S. 1981. "Practices in wheat and barley breeding." *ICARDA Training Paper,* 21 pp.

Ahmed, S. & Walker, P. 1981."Analysis of repeated experiments." (combined analysis). *ICARDA Training Paper,* 18 pp.

Anderson, W.K., Srivastava, J.P. and NAJI, I. 1981. "Some agronomic considerations to improve efficiency of dryland cereal production." *Fourth Arab Seminar on Improvement of Agricultural Practice under Dry Farming Conditions, Damascus, March, 1981.*

El-Ahmed, A. 1981. "Seedling reaction of the 7th International Barley Observation Nursery (IBON) to Rhynchosporium secalis in green-house and source of resistance." *Barley Diseases and Associated Breeding Methodology Workshop. Rabat, Morocco, April.*

El-Ahmed, A., Ghodbane, A., Laribi, A., El-Felah, M., 1981. "Barley diseases in Tunisia and sources of resistance." *Barley Diseases and Associated Breeding Methodology Workshop. Rabat, Morocco, April.*

Ghodbane, A., El-Ahmed- A., Laribi, F. and Ketata, H. 1981. "Barley Program in Tunisia for improving resistance to powdery mildew." *Reference as above.*

Kamel, A.H. 1981. "Barley diseases in the dry areas." *Reference as above.*

Kamel, A.H. 1981. "Useful genes for disease resistance from wild cereal species and native populations." *Wheat & Barley Germplasm Workshop, ICARDA, Aleppo, Syria, April.* Sponsored by ICARDA, & IBPGR.

Kamel, A.H. 1981. "Breeding wheat and barley for disease resistance in ICARDA." *Abstracts, 3d International Symposium on Plant Pathology, New Delhi, December,* p. 4.

Maalouf, G., Rubeiz, N., Russell, W.J. 1981. "On-farm demonstrations to introduce improved cereal production technology in Lebanon." *Crop Production in Lebanon. Research Conference, Chtaura, Lebanon, December.*

Mamlouk, O. 1981. "Review of scald of barley." *Barley Diseases and Associated Breeding Methodology Workshop, Rabat, Morocco, April.*

Mamlouk, O. 1981. "Review of smut diseases in Jordan." *Reference as above.*

Mekni, M.S., 1981. "Barley improvement at ICARDA: objectives and achievements." *Paper presented at the FAO/SIDA/SAREC Conference at Ankara, Turkey, May.*

Mekni, M.S. and Anderson, W.K. 1981. "Development of dual purpose barleys: grain & grazing." *Report of the EUCARPIA Meeting, Fodder Crops Section, Merelbeke, Belgium, September.*

Mekni, M.S. and Kamel, A.H. 1981. "The ICARDA barley program and efforts to breed for disease resistance." *Barley Diseases and Associated Breeding Methodology Workshop, Rabat, Morocco, April.*

Mekni, M.S. and Kamel, A.H. 1981. "Barley breeding at ICARDA for North Africa and West Asian regions." *4th International Barley Genetics Symposium, Edinburgh, Scotland, July.*

Niks, R.E. 1981."Appressorium formation of *Puccinia hordei* on partially resistant barley & two non-host species." *Netherlands Journal of Plant Pathology,* 1981, 87, pp. 201–207.

Srivastava, J.P. 1981. (Editor) "Seed Production Symposium" *ICARDA, Aleppo, Syria, March.*

Srivastava, J.P. 1981. "Status of seed production in the ICARDA region." *Proceedings of the Seed Production Symposium, ICARDA, Aleppo, Syria, March.*

Srivastava, J.P. 1981. "Wheat & barley germplasm at ICARDA." *Report presented in the Wheat Subcommittee Meeting of the IBPGR held at CIMMYT, Mexico, January.*

Srivastava, J.P. 1981. "Current status and constraints to barley production." *Barley Diseases & Associated Breeding Methodology Workshop, Rabat, Morocco, April.*

Srivastava, J.P., Anderson, W.L., NAJI, I. 1981. "Some agronomic considerations to improve efficiency of dry land cereal production." *4th Arab Seminar on Improvement of Agricultural Practice under Dry Farming Conditions, Damascus, Syria, March.*

Srivastava, J.P., Anderson, W.K., Kamel, A., Tahir, M., Nelson, W., Rashwani, A. 1981. "Cereals improvement program at ICARDA-objectives and achievements." *FAO/SIDA/SAREC Seminar at Ankara, May.*

Srivastava, J.P., Kamel, A.H., Mekni, M.E., Nachit, M. 1981. "Cereal research & production activities in Lebanon & their impact in West Asia & North Africa." *Crop Production in Lebanon. Research Conference, Chtaura, Lebanon, December.*

Weltzien, H.C. and Srivastava, J.P. 1981. "Stress factors and barley productivity implications in breeding strategies." *4th International Barley Genetics Symposium, Edinburgh, July.*
Williams, P.C., Thompson, B.N., Wetzel, D.L., McLay, G. and Loewen, D. 1981. "Application of Near-Infrared reflectance spectroscopy to flour mill quality control" *Cereal Foods World,* 26(5), pp. 234–237.
Williams, P.C. and Cordeiro, H.M. 1981. "Influence of variety and degrading factors on accuracy of measurement of protein in wheat by Near-Infrared reflectance spectroscopy." *Cereal Foods World,* 26(3), pp. 124-128.
Williams, P.C. and Maceachern, L.W. 1981. "A note on the use of titanium oxide catalyst in an automated Kjeldahl-type instrument." *Laboratory Practice,* 30(2), p. 125.
Williams, P.C. 1981. "A study of grinders for preparation of grain samples for analysis." *Milling Feed and Fertilizer,* Vol, CLXIV, 30–33.
Williams, P.C. 1981. "Analytical methods for grains." In: *Handbook Series in Agriculture, Marketing and Transportation* Vol. 1. E. Finney (Ed.) CRC, Cleveland, Ohio.
Murphy, P.J. and Witcombe, J.R. 1981. "Variation in Himalayan barley and the concept of centres of diversity." *IV International Barley Genetics Symposium, Edinburgh, Scotland, July.*
Murphy, P.J. and Whitcombe, J.R. 1981. "The analysis of plant genetic resources data by multivariate techniques." *FAO/UNFP/IBPGR Technical Conference, FAO, Rome, April.*
Gilani, M.M. and Whitcombe, J.R. 1981. "Ordination of wheat and barley on a Himalayan centre of diversity." *Pakistan Journal of Agricultural Research,* (2), pp. 92–96.
Rifaie, R., Bourgois, J.J. and Witcombe, J.R. 1981. "Aegilops and wild wheat in Syria." *Plant Genetic Resources Newsletter, FAO,* No. 45, pp. 2–7.

FOOD LEGUMES

GENERAL

Hariri, G. (Consultant), 1981. "Distribution and importance of bruchid attacks on different species of pulses consumed in the Near East." In: *The ecology of bruchids attacking legumes (pulses). Series Entomologica 19* Ed. by V. Labeyries, Dr. W. Junk Publishers, The Hague, pp. 215–221.
Hariri, G. 1981. "The problems and prospects of Heliothis management in S.W. Asia." *Paper presented at the Heliothis Management Workshop ICRISAT, Hyderabad, India, November.*
Islam, R. 1981. "Evaluation of different food legumes for their symbiotic nitrogen fixation in a two course rotation under the rainfed conditions of Northern Syria." *Paper presented at the 4th Coordination Meeting on the use of isotopes in studies on biological nitrogen fixation for the dual purpose of increasing crop production and deceasing fertilizer use to conserve the environment, held in Vienna, Jan. 25–29, 1982.*
Islam, R. 1981. "Improved nodulation in chickpeas, faba beans and lentils in the West Asia and North Africa region." *International Biological Nitrogen Fixation Meeting, CIAT, Colombia, March.*
Sandhu, T.S. and Malhotra, R.S. 1981. "New varieties of pulses." *Indian Farming,* August, 4 pp.
Watson, A.W. (Consultant). 1981. "Food legumes in North Africa and Iraq." ICARDA, Aleppo, Syria, pp. 180.

CHICKPEAS

Hanounik, S.B., Reddy, M.V. 1981."Role of fungicides on the management of Ascochyta blight of chickpeas." *Workshop on Ascochyta blight and winter sowing of chickpeas, Aleppo, Syria, May.*
Hawtin, G.C., Singh, K.B. 1981."Prospects and potential of winter sowing of chickpeas in the Mediterranean region." *Workship on Ascochyta blight and winter sowing of chickpeas, ICARDA, Aleppo, Syria, May.*
Islam, R. 1981, "Nodulation aspects of winter planted chickpeas." *Workshop on Ascochyta blight and winter sowing of chickpeas, ICARDA, Aleppo, Syria, May.*
Islam, R. 1981. "Responses of winter and spring planted chickpea to inoculation with Rhizobia in Syria." *International Chickpea Newsletter 4,* (June), pp. 24–25.
Islam, R. 1981. "Nodulation of chickpeas in West Asia and North Africa." *International Chickpea Newsletter 5,* December, p. 16.

Nene, Y.L., Haware, M.P. and Reddy, M.V. 1981. "Chickpea-diseases resistance/screening techniques." *ICRISAT Information Bulletin*, October, No. 10.
Reddy, M.V., Singh, K.B., Nene, Y.L. 1981. "Screening techniques for Ascochyta blight of chickpea." *Workshop on Ascochyta blight and winter sowing of chickpeas, ICARDA, Aleppo, Syria, May.*
Singh, K.B. 1981. "Yield potential of tall chickpeas at increased plant density. *International Chickpea Newsletter*, 4 (June) pp. 10–11.
Singh, K.B., Gridley, H.E., Hawtin, G.C. 1981. "Strategy for breeding Ascochyta blight resistant cultivars." *Workshop on Ascochyta blight and winter sowing of chickpeas, Aleppo, Syria, May.*
Singh, K.B., Hawtin, G.C., Nene, Y.L., Reddy, M.V. 1981."Resistance in chickpeas to *Ascochyta rabiei.*" *Plant Disease* 65(7), pp. 586–587.
Singh, K.B., Izgin, N., Tuwafe, S. 1981. "Screening Kabuli chickpea for cold tolerance." *International Chickpea Newsletter 4,* (June), pp. 11–12.
Singh, K.B., Reddy, M.V. 1981. "An international screening of chickpea for resistance to Ascochyta blight." *Workshop on Ascochyta blight and winter sowing of chickpeas, ICARDA, Aleppo, Syria, May.*
Singh, K.B., Reddy, M.V., Nene, Y.L. 1981. "Sources of resistance to Ascochyta blight of chickpea." *International Chickpea Newsletter 4,* (June), pp. 16–17.
Singh, K.B., Saxena, M.C., Gridley, H.E. 1981. "Screening chickpeas for cold tolerance and frost resistance." *Workshop on Ascochyta blight and winter sowing of chickpeas, ICARDA, Aleppo, Syria, May.*
Singh, K.B. and Tuwafe, S. 1981. "The collection, evaluation, and maintenance of Kabuli chickpea germplasm at ICARDA." *International Chickpea Newsletter,* 4(June), pp. 2–4.
Sithanantham, S., Tahhan, O., Hariri, G. and Reed, W. 1981. "The impact of winter sown chickpeas on insect pests and their management." *Workshop on Ascochyta blight and winter sowing of chickpeas, ICARDA, Aleppo, Syria, May.*
Sithanantham, S., Tahhan, O., Reed, W. 1981. "Chickpea entomology." *Annual Report for 1979–80,* (ICRISAT/ICARDA), ICRISAT, 73 pp.
Weltzien, H.C. and Kaak, H.J. 1981."Epidemiological aspects of chickpea Ascochyta blight." *Workshop on Ascochyta blight and winter sowing of chickpeas, ICARDA, Aleppo,Syria,* 5 pp.

FABA BEANS

Hawtin, G.C. and Colin Webb (Editors) 1981. "Faba Bean Improvement" *Proceedings of the International Faba Bean Conference, Cairo, March 1981. Martinus-Nijhoff (publisher) 1982, Netherlands.* 383 pp.
Hanounik, S.B. 1981. "Influence of Ronilan on the severity of chocolate spot and yield in faba beans." *FABIS Newsletter* (3): pp. 50–51.
Hanounik, S.B. and Hawtin, G.C. 1981, "Breeding for resistance to chocolate spot caused by *Botrytis fabae. International Conference on faba bean, Cairo, March.*
Hawtin, G.C. 1981. "An overview of breeding methods for the genetic improvement of faba beans." *International Conference on Faba Beans, Cairo, March.*
Hawtin, G.C. and Omar, M. 1981."Breeding faba beans for use as a green vegetable." *FABIS Newsletter* (3): pp. 60–62.
Hawtin, L. 1981. "Faba bean cook book." ICARDA, Aleppo, Syria.
Islam, R. 1981. "Screening of several strains of faba bean Rhizobium tolerant to moisture stress conditions." *FABIS Newsletter* (3): pp. 32–33.
Islam, R., Ghoulam, W. 1981. "Screening of several strains of faba bean Rhizobium for tolerance to salinity." *FABIS Newsletter* (3): pp. 34–35.
Islam, R. and Afandi, F. 1981. "Responses of several strains of faba bean Rhizobium to Tribunil and nitrogen fertilizer application." *FABIS Newsletter* (3): pp. 35–37.
Omar, M. and Hawtin, G.C. 1981. "Effect of plot to plot distance on the percentage of intercrossing between faba bean plots." *FABIS Newsletter* (3): pp. 27–28.
Omar, M., Walker, P. and Hawtin, G.C. 1981. "Increasing the efficiency of hand crossing on faba beans." *FABIS Newsletter* (3): pp. 29–30.
Osman, A.A. Ageeb 1981. "Faba bean agronomy in Sudan." *International Conference on Faba Beans, Cairo.*
Saxena, M.C. 1981. "Physiological aspects of adaptation." *International Conference on Faba beans, Cairo.*

Saxena, M.C., Hawtin, G.C., Ibrahim, H. 1981. "Aspects of faba bean ideotypes for drier conditions. *Vicia faba: physiology and breeding." Proceedings of the EEC Seminar organized by Centrum voor Agrobiologisch Onderzoek (CABO), Wageningen, Netherlands, June 1980.* Edited by T. Thompson.
Tahhan, O. and Hariri, G. 1981. "Screening of aphid resistance in faba bean lines." *FABIS Newsletter (3):* p. 57.
Tahhan, O. and Hariri, G. 1981. "Infestation of faba bean seeds by *Bruchus dentipes* Baudi (Coleoptera: Bruchidae)." *FABIS Newsletter* (3): pp. 58–59.
Tahhan, O. and Hariri, G. 1981."Feeding and oviposition and chemical control of *Sitona limosus* (Rossi) (Coleoptera: Curculionidae) on faba bean plants." *FABIS Newsletter* (3): pp. 59–60.
Tahhan, O. and Hariri, G. 1981. "A note on chemical control of faba bean insect pests." *FABIS Newsletter* (3): p. 60.
Watson, A.W. 1981. "Faba bean production in Egypt, a study of the economic and infrastructural context." *ICARDA/IFAD Nile Valley Project Consultancy Report,* pp. 107.
Watson, A.W. 1981."Faba bean production in Sudan, a study of the economic and infrastructural context." *ICARDA/IFAD Nile Valley Project Consultancy Report,* pp. 130.
Witcombe, J.R. 1981. "Genetic resources of faba beans." *Paper presented at the International Faba bean Conference, Cairo, March.*

LENTILS

Basler, F. 1981."Weeds and their control" *Lentils.* Ed. by C. Webb and G. Hawtin. Published for ICARDA by CAB, pp. 143–154.
Erskine, W. and Solh, M. 1981. "Border effects in isolated plots of lentils." *LENS* No. *8,* pp. 9–10.
Erskine, W., Meyveci, K., Izgin N. 1981. "Screening a world lentil collection for cold tolerance." *LENS* No. *8,* 1981, pp. 5–8.
Hariri, G. 1981."Insects and other pests." *Lentils.* Ed. by C. Webb and G. Hawtin. Published for ICARDA by CAB, pp. 173–189.
Islam, R. 1981."Improved nitrogen fixation in lentils." *Lentils.* Ed. by C. Webb and G. Hawtin. Published for ICARDA by CAB, pp. 155–162.
Nygaard, D.F. and Hawtin, G.C. 1981. "Production, trade and uses." *Lentils.* Ed. by C. Webb and G. Hawtin. Published for ICARDA by CAB, pp. 1–14.
Sandhu, T.S., Brar, J.S. and Malhotra, R.S. 1981."Combining ability for harvest index and grain yield in lentils (*Lens culinaris* Medik)." *Crop Improvement* (India) (in press).
Saxena, M.C. and Hawtin, G.C. 1981. "Morphology and growth patterns." *Lentils.* Ed. by C. Webb and G. Hawtin. Published for ICARDA by CAB, pp. 39–52.
Saxena, M.C. 1981."Agronomy of lentils." *Lentils.* Ed. by C. Webb and G. Hawtin. Published for ICARDA by CAB, *pp.111–130.*
Solh, M. and Erskine, W. 1981. "Genetic resources." *Lentils.* Ed. by C. Webb and G. Hawtin. Published for ICARDA by CAB, pp. 53–68.
Webb, C. and Hawtin, G.C. (Editors) 1981. "Lentils." *ICARDA/CAB publication,* 216 pp. *(Based on Proceedings of a seminar held at ICARDA.)*

PASTURE AND FORAGE

Ceccarelli, S. 1981. "Handling plant materials after release as varieties in cross pollinated crops: *Seed Production Symposium, ICARDA, Aleppo, Syria.*
Ceccarelli, S. & Somaroo, B.H. 1981. "Relationship between dry matter yield and seed yield in annual legumes under dry conditions." *Report of the EUCARPIA Meeting, Fodder Crops Section, Merelbeke, (Belgium), September.*
Diekmann, J. 1981."Investigation on forage production in Bahraini agriculture." *PhD (Agric), University of Bonn, GFR,* 125 pp (DE).
Mariotti, D., Arcioni, S. & Ceccarelli, S. 1981. "Molecular weight distribution of fructosan macromolecules in two differently adapted varieties of *Lolium perenne L." Genetica Agraria 35:* pp. 97–106

Ceccarelli, S. 1981. "Divergent selection for culm length in barley. III. Response to six cycles of within families selection." *Zeitschrift für Pflanzenzüchtung 86:* pp. 56–68. (Co-author with S. Grando.)
Ceccarelli, S. 1981. "Selection for seed yield in *Lolium perenne." Genetica Agraria,* 35: pp. 73–88. (Co-author with M. Falcinelli and F. Damiani.)
Gaul, H.P.K. 1981. "Handling plant materials after release as varieties in self pollinated crops." *Seed Production Symposium ICARDA, Aleppo, Syria.*
Somaroo, B.H. & Ceccarelli, S. 1981. "Seed multiplication of cross-pollinated forage crops at ICARDA." *Symposium on Seed regeneration in Cross-Pollinated Species, Copenhagen, July,* 10 pp.
Somaroo, B.H. 1981. "Variety testing and release." *Proceedings of the Seed Production Symposium, ICARDA, Aleppo, Syria.*

TRAINING AND COMMUNICATIONS

Ibrahim, M.H. 1981. "Developing skilled manpower for the seed industry." *Seed Production Symposium Sponsored by the Government of the Netherlands and ICARDA, March.*
Ibramim, M.H. 1981."Some agricultural training and communications activities in Lebanon." *Crop production in Lebanon. Research Conference, Chtaura, Lebanon, December.*

MISCELLANEOUS

Ahmed, S. 1981. "Introduction to principles of experimental designs in agriculture" (In Arabic.) *Forage and Pasture Training Course, ACSAD and UNESCO, Damascus, Oct.–Nov.,* 8 pp.
Ahmed, S. 1981. "Designs and analysis of common experiments used in forage and pasture crops." (In Arabic.) *Forage and Pasture Training Course, ACSAD and UNESCO, Damascus, Oct–Nov.,* 24 pp.
Ahmed, S. and Walker, P.T. 1981. "Analysis of repeated experiments (combined analysis)." *ICARDA Training Paper,* 18 pp.
Ceccarelli, S. and Walker, P.T. 1981. "Balanced incomplete block designs." *Discussion Paper* No. 7, ICARDA, 12 pp.
Erskine, W. and Khan, T.N. 1981. "Variation within and between land races of winged bean (*Psophocarpus tetragonolobus* (L.) DC.)." *Field Crops Research* 3, (1980/81) pp.359–364.
Erskine, W. 1981. "Heritability and combining ability of vegetative and phenological characters of winged beans (*Psophocarpus tetragonolobus* (L.) DC.)" *Journal of Agricultural Science,* UK, 96, pp. 503–508.
Hawkins, R.C., Cooper, P.J.M. 1981."Growth, development and grain yield of maize." *Experimental Agriculture,* 17, pp. 203–207.
Hawtin, G.C. 1981."The role of National and International Crops Research Programs in Seed Production." *Proceedings of the International Seed Symposium, ICARDA, Aleppo, Syria, March 23–26, 1981,* pp 32–33.
Ibrahim, M.H. and Buxton, D.R. 1981. "Early vegetative growth of cotton as influenced by leaf type." *Crop Science, 21*(5), pp. 639–643.
Hughes, G., Keatinge, J.D.H. and Scott, S.P. 1981. "Pigeon pea as a dry season crop in Trinidad, West Indies. (2) Interception and utilization of solar energy." *Tropical Agriculture 58,* pp. 191–199.
Hughes, G., Keatinge, J.D.H. and Scott. S.P. 1981. "Planting density effects on the dry season productivity of short pigeon pea in the West Indies. (1) Growth and development." *Proceedings of the ICRISAT/ICAR International Workshop on Pigeon Peas 2,* pp. 235–240.
Keatinge, J.D.H. and Hughes, G. 1981. "Pigeon pea as a dry season crop in Trinidad, West Indies (1) Yield and yield components." *Tropical Agriculture 58,* pp. 45–51.
Keatinge, J.D.H. and Hughes, G. 1981."Planting density effects on the dry season productivity of short pigeon pea in the West Indies. (2) Yield and moisture supply." *Proceedings of the ICRISAT/ICAR International Workshop on Pigeon Peas 2,* pp.241–248.
Kemp, P.J. 1981."Tropical Pest Management plant growth regulator index." (A list of chemical, coded, common and trade names and manufacturers). *Tropical Pest Management,* 27(4), pp. 539–550.

Maalouf, G., Kiwan, P., Russell, W.J. 1981. "On-farm demonstrations to introduce improved production technology in Lebanon." In: *Crop Production in Lebanon, Research Conference, Chtaura, Lebanon, December.*

Nour, M.A. 1981. *Presentation made by the Director General at Washington, D.C., on November 10 on the occasion of Centers Week. ICARDA,14 pp.*

Nene, Y.L., Kannaiyan, J. and Reddy, M.V. 1981. "Pigeon pea diseases: resistance screening techniques." *ICRISAT Information Bulletin* No. 10.

Nene, Y.L., Reddy, M.V. and Deena, E. 1981. "Modified infector row technique to screen pigeon pea for sterility-mosaic resistance" *International Pigeon pea Newsletter, 1:* p. 27.

Goldfield, Y.N., Reddy, M.V., Nene, Y.L. and Reed, W. 1981. "Preliminary studies of the Euphyid vector of sterility mosaic." *International Pigeon pea Newletter, 1:* pp. 25–27.

Gupta. S.C., Reddy, M.V. and Nene, Y.L. 1981. "Sterility mosaic resistant *lines in early-maturing pigeon pea* developed at ICRISAT." *International Pigeon pea Newsletter, 1:* p. 20.

Kannaiyan, J., Reddy, M.V., Nene, Y.L. and Reju, T.N. 1981. "Prevalence of pigeon pea wilt and sterility mosaic in India (1975–80)." *International Pigeon pea Newsletter, 1:* p. 25.

Somel, K. 1981."The Economics of Maize in Turkey, Ankara." (Assisted by Erol Cakmak). *CIMMYT, PK 120, Yenimahalle, Ankara, Turkey.* iv + 173 pp. Bibliography.

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