ICARDA
Annual Report
1982

International Center for Agricultural Research in the Dry Areas

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Contents

Statement of Objectives

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

The Center has five principal objectives:

- To conduct research into and develop improved cropping, livestock, and cropping-livestock systems.
- To serve as an international center for the improvement of barley, lentils, and faba beans.
- To serve as a regional center, in cooperation with other appropriate international agricultural research centers, for the improvement of other major crops in the region, such as wheat and chickpeas.
- To collaborate with and foster cooperation and communications among other national, regional, and international institutions in the development of, adaptation, testing and demonstration of improved crops, farming, and livestock systems.
- To provide and foster training in research and other activities to further its objectives.

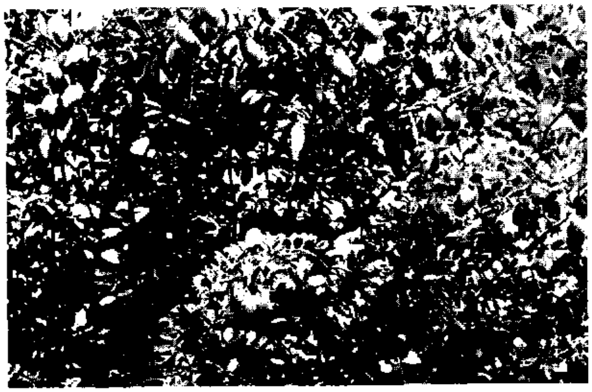
The ICARDA region extends from Morocco in the west to Pakistan in the east, and from Turkey in the north to Sudan in the south. It comprises 22 countries with a total population of more than 300 million. ICARDA's principal involvement in its region is with rainfed agricultural systems.

Latin *Hordeum* (spp.)
English Barley
Arabic Shai'r شعير

Lens culinaris
Lentil
Adas عدس

Vicia faba
Faba bean
Ful فول

Latin *Triticum* (spp.)
English Wheat
Arabic Qamh قمح



Cicer arietinum
Chickpea
Hummus حمص

Livestock

Foreword

As early as 1930, Depois, a French agricultural scientist working in North Africa, advised plant breeders that the variability of climate was such that testing under rainfed agriculture, without irrigation, was an arduous task, if not an outright impossibility, in the Maghreb countries. Extrapolating between sites within the zone, let alone between countries, was rather fruitless because results were seldom repeated. If you cannot irrigate, do not experiment, he warned. If you can, then you will need results from five years before you can make valid conclusions.

In 1961, Holme analyzed the available yield data for cereals in Tunisia over several years. She found that a crude frequency distribution for production over a five year cycle was one good, two fair and two poor crops.

This climatic variability is characteristic of not only North Africa, but of the rest of the ICARDA region as well. Farmers in this area know only too well about the uncertainty of, for example, rainfall, and they have adapted their agricultural practices and even their life styles in order to survive. Mixed crop-livestock systems, cropping patterns, land preparation, planting dates, etc., are all chosen as part of farmers' efforts to stabilize their incomes in such risky agricultural environments.

The message of Depois and Holme is that agricultural researchers must also consider this extreme climatic variability and take care when analyzing results, setting research priorities and developing recommendations for new technologies for dissemination in these areas.

At ICARDA, we realize the importance of climate to agricultural research and are resisting the temptation to claim successful findings prematurely. A look at the climatic variation during our short tenure in Aleppo, Syria reinforces this perspective.

First, consider annual rainfall: at Tel Hadya, our main experiment station, 338 mm of precipitation were received in the 1981-82 cropping season. This is close to the long term seasonal average, but it must be considered in the light of a wide range of seasonal precipitation experienced in the previous 25 years from 153 to 465 mm. We now have had five seasons at Tel Hadya with annual precipitation levels varying from 244 mm in 1978-79, to 425 mm in 1979-80; the annual average for Tel hadya being 350 mm. Our results have not yet been tested in a real dry year. The timing of the precipitation is also important. For example, the first rains, effective for crop germination at Tel Hadya in 1981-82, occurred over a month earlier than in the previous season.

Other short term meteorological events, such as frost, can also be important and are capable of a large variation in intensity, duration and timing in Northern Syria. In 1981-82, medium intensity and extended duration of frost severely influenced yields of a wide range in crops at Tel Hadya. This contrasts with a highly productive season in 1979-80 in which extremely low temperatures were recorded (close to -20°C) early in the growth season, yet without any apparent effect on crop yields.

We are certainly aware that extreme care must be taken in assessing the generality of research findings, and several years' research is required in this particular environment to produce results. Nevertheless, ICARDA has made progress this year in spite of two other uncertainties we faced: political (particularly the war in Lebanon) and financial (particularly the shortfall in CGIAR funding). We have pulled through and the Center has even experienced a period of dynamic and healthy growth.

The year began with the transfer of most ICARDA staff and facilities from four offices in Aleppo to the experimental station at Tel Hadya, about 30 km south of Aleppo. This consolidation has given staff a remarkable sense of cohesion which is amply reflected in performance and morale.

The year ended with another exciting step in the new era of development at Tel Hadya. On October 21, at a gathering of distinguished guests, the Governor of Aleppo, on behalf of the President of Syria, inaugurated the construction program for our permanent buildings. OPEC Fund and IFAD have generously donated more than 6.5 million dollars for the development of two buildings: one is a complex of scientific laboratories; the second is to accommodate the Training, Communications and Administration departments, as well as the Computer center.

The year has been marked by a number of other developments and accomplishments:

A. The Training and Communications program has changed: Training has become an integral part of the 4 research programs; and Communications, Documentation and the Library have been grouped as an independent activity. This reorganization should lead to better training and more effective communication.

B. The scientific support services were re-organized and the various disciplines are now located in the major research programs. Each commodity program now has its own plant pathology research; microbiology and weed control became part of the Farming Systems Program, and the entomology team joined the Food Legume Improvement Program.

C. In February, the United Nations University, ICARDA and the University of Aleppo sponsored a workshop on the interfaces between agriculture, food science and human nutrition. It was a stimulating discussion by a multidisciplinary group of regional and international scientists on agricultural development and research priorities.

D. The Government of the Netherlands sponsored a workshop and seed production training course in April which was attended by trainees from 10 countries in the region. The aim was to assist in overcoming the inadequate seed production situation that exists at the national level.

E. Faba beans and lentils were the focus of an ICARDA/IBPGR workshop held at ICARDA in May.

F. Like other centers in the CGIAR system, ICARDA experienced a most difficult and trying financial period from March to May. Intense activity and constant adjustment by the administration, as well as the cooperation and patience of the staff, enabled ICARDA to survive this period of great anxiety. The financial situation is still difficult, but not as difficult as at the begining of 1982.

G. New frontiers were opened for ICARDA when six ICARDA staff visited China in May. There is great potential for collaboration in faba bean and barley research. Farming systems research and training can play a positive role in developing contacts with Chinese scientists.

H. In the latter part of the year, ICARDA was engaged in the preparation of a medium-long term plan for its research. This is a timely undertaking as it also represents a necessary part of our preparation for the first Quinquennial Review of ICARDA, scheduled for April 1983.

I. Finally, a most valued development in 1982 was the intensification of ICARDA's cooperation with the Syrian Ministry of Agriculture and Agrarian Reform and other organizations engaged in scientific research in Syria. Collaborative research is now under way on the improvement of cereals, food legumes, and forage crops.

The growth and progress reported in this document would not have been possible without the sustained, and often increased, support of our donors. Neither would it have been possible without the healthy growing relationships between ICARDA and the research institutions in most countries of the region, and in the developed countries of the world. Finally, our growth owes much to the collaborative work we have conducted with other sister international agricultural research centers.

ICARDA looks forward to the future with confidence and anticipates significant progress in all of its activities; the goal being to improve the agricultural production and thus the economic and social wellbeing of people who live in the ICARDA region. We hope that this annual report shows the nature and scope of our research activities, and also highlights some of our accomplishments. We also hope it attests to ICARDA's awareness of the difficulty of improving food production in a harsh and uncertain environment.

Mohamed A. Nour
Director General

ICARDA Donors

Core Operations

US $ 000's

Unrestricted Funds

Australia	415
Belgium	107
Canada	503
Denmark	84
Ford Foundation	200
France	32
Germany	896
IDA/IBRD	3,690
Italy	420
Mexico	50
Netherlands	315
Norway	291
OPEC/IFAD	600
Spain	100
United Kingdom	559
USAID	3,650

Restricted Funds

Arab Fund	243
IDRC	419
IFAD	550
OPEC	650
Sweden	419
UNDP	850

Special Projects

Ford Foundation - Cereals	82
Ford Foundation - Farming Systems	78
IDRC - LENS	12
IDRC - FABIS	122
IFAD	1,110
Netherlands	31

Under the auspices of President Hafiz Al-Asad of Syria, ICARDA's ambitious building scheme was launched on 21 October 1982. A memorial plaque was unveiled by the Governor of Aleppo representing the Syrian President. The complete scheme will cost US $ 30 million, extending over a span of 5 years. It is hoped that the first three phases will be completed within 2 years. They will comprise the Training and Communications building and two laboratory blocks at a cost of US $ 11 million. The main spur to the start of the building operations came from two generous donations for which ICARDA is most grateful: US $ 3.5 million from the International Fund for Agricultural Development (IFAD) and US $ 3.165 million from the Organization of Petroleum Exporting Countries (OPEC) Fund. Another fund-raising campaign will be launched in the spring of 1983 to obtain the additional funds required.

The two-storey Training and Communications building will include several lecture rooms, an auditorium, the library, the computer services, offices for editorial staff, and the Director General's office. It will also accomodate the printing shop and the photographic and art units.

The two laboratory blocks will comprise laboratory modules and offices for scientists and technicians. One distinctive feature of the design is the easy adaptation of the modules to meet the various requirements as for area and function.

The consulting architects are Giffels and Associates of Toronto, Canada; and the contractor, Milihousing, the Syrian state-owned construction company.

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Dr. Richard Smith, Agro-Climatologist (Australia)

Dr. Mahmoud Solh, Plant Breeder (Terbol)

Dr. Hisham Talas, Medical Consultant (Aleppo)

Mr. Declan Walton, Planning Strategist (Ireland)

Prof. W.B. Ward, Science Writer/Editor (USA)

Dr. Philip Williams, Analytical Services (Canada).

* Left ICARDA during 1982.

Acronyms and Abbreviations

AOAD	Arab Organization for Agricultural Development
BNF	Biological Nitrogen Fixation
CAB	Commonwealth Agricultural Bureaux
CGIAR	Consultative Group on International Agricultural Research
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo
CP	Crude Protein
DDM	Digestible Dry Matter
DM	Dry Matter
FSP	Farming Systems Program
FSR	Farming Systems Research
GDP	Gross Domestic Product
GTZ	Deutsche Gesellschaft fur Technische Zusammenarbeit
IBPGR	International Board for Plant Genetic Resources
IBRD	International Bank for Reconstruction and Development
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IDA	International Development Association
IDRC	International Development Research Centre
IFAD	International Fund for Agricultural Development
IFDC	International Fertilizer Development Center
IITA	International Institute of Tropical Agriculture
INRA	Institut National de la Recherche Agronomique (Rabat)
INRAT	Institut National de la Recherche Agronomique de Tunisie
MOFC	Margin Over Supplementary Feed Costs
MPN	Most Probable Number
NAK	Netherlands Certifying Agency
NPC	Nominal Protection Coefficient
ODA	Overseas Development Administration, UK
OPEC	Organization of Petroleum Exporting Countries
RPVZ	Netherlands Government Seed Testing Station
SL	Syrian Lira
TDDM	Total Digestible Dry Matter
t/ha	Tonne (1000 kg)/hectare
TSP	Triple Superphosphate
UNDP	United Nations Development Programme
UNU	United Nations University
USAID	United States Agency for International Development
WUE	Water-Use Efficiency

Meteorological Data 1981-82

The physical environmental conditions in northern Syria at the beginning of the cropping season were generally favorable (Table 1). Rainfall was well distributed in time and the first rains capable of causing germination were recorded in early November, approximately 5 weeks earlier than in 1980-81. Seasonally low

Table 1. Summary of meteorological data, ICARDA Research Station, Tel Hadya, 1981-82 season. Latitude 35°55′ N, Longitude 36°55′ E, Altitude 362 m.

Weekly period	Daily air temperature			RH	SR	E_0	Rain	Wind run
	Max. (°C)	Min. (°C)	Mean (°C)	(%)	MJ (m²/d)	(mm/d)	(mm)	(km/d)
1981								
1-7 Oct	33.0	15.1	24.1	46.6	16.7	9.2		266.0
8-14 Oct	29.3	12.9	21.1	42.0	14.5	7.8		201.7
15-21 Oct	27.7	9.8	18.8	42.0	13.7	5.5	4.6	155.4
22-28 Oct	28.5	11.1	19.8	41.4	13.1	6.6		156.9
29 Oct-4 Nov	25.2	11.3	18.3	51.6	9.4	4.7	3.6	194.8
5-11 Nov	18.7	3.8	11.3	52.0	11.3	4.6	43.2	240.1
12-18 Nov	15.5	6.4	11.0	66.4	8.3	2.5	13.6	226.3
19-25 Nov	14.4	2.4	8.4	71.5	8.0	1.4	9.0	165.2
26 Nov-2 Dec	15.3	5.0	10.2	76.1	7.7	1.5	2.7	186.1
3-9 Dec	14.8	5.6	10.2	78.1	7.2	1.6	15.0	159.2
10-16 Dec	14.8	4.1	9.5	76.5	6.5	1.4	3.1	171.8
17-23 Dec	14.9	4.6	9.8	71.7	7.6	1.9	5.9	259.7
24-31 Dec	13.3	6.4	9.8	82.8	4.7	0.7	28.9	161.7
1982								
1-7 Jan	10.9	6.1	8.5	88.5	3.7	0.8	15.1	234.3
8-14 Jan	11.4	5.4	8.4	76.4	5.3	1.5	6.0	241.6
15-21 Jan	12.0	-3.3	4.3	56.9	11.1	3.0		179.0
22-28 Jan	11.3	0.2	5.8	64.6	7.9	2.3	23.4	275.3
29 Jan-4 Feb	11.2	3.9	7.6	76.9	6.7	1.3	39.1	228.1
5-11 Feb	9.6	-1.9	3.8	67.2	9.7	1.8	3.7	229.5
12-18 Feb	10.7	-4.1	3.3	53.6	13.2	2.6		172.1
19-25 Feb	12.5	0.1	6.3	64.0	11.4	2.6	11.8	331.7
26 Feb-4 Mar	15.2	3.6	9.4	68.8	10.5	3.0	10.4	261.7
5-11 Mar	15.7	3.1	9.5	68.9	13.0	3.0	6.9	228.8

Cont.

TABLE 1 Cont.

Weekly period	Daily air temperature Max. (°C)	Min. (°C)	Mean (°C)	RH (%)	SR MJ (m²/d)	E_0 (mm/d)	Rain (mm)	Wind run (km/d)
12-18 Mar	15.7	4.2	9.9	63.9	13.9	3.8	10.0	248.6
19-25 Mar	17.9	1.8	9.9	61.1	17.6	4.3	4.1	210.7
26 Mar-1 Apr	19.1	0	9.6	51.8	18.9	5.7		177.6
2-8 Apr	20.3	8.6	14.5	66.0	13.7	4.5	9.2	270.4
9-15 Apr	24.1	9.8	17.0	65.7	16.8	5.9	2.0	232.3
16-22 Apr	27.7	10.5	19.1	56.6	20.5	9.3		261.9
23-29 Apr	23.1	10.2	16.7	66.1	15.2	5.7	7.7	272.7
30 Apr-6 May	24.1	8.9	16.5	70.1	17.9	5.5	40.8	217.3
7-13 May	29.6	12.0	20.8	57.1	19.2	7.6	9.4	193.5
14-20 May	28.0	13.3	20.7	61.8	20.5	8.8	6.2	308.2
21-27 May	29.3	13.3	21.3	55.6	21.2	10.5	0.2	288.1
28 May-3 June	29.9	13.1	21.5	56.0	22.3	11.4		352.5
4-10 June	30.1	13.4	21.8	57.5	22.3	11.4	2.0	326.3
11-17 June	33.7	17.3	25.5	43.5	23.7	17.0		499.0
18-24 June	35.7	17.2	26.5	37.8	24.9	15.7		300.3
25 June-1 July	38.1	17.9	28.0	32.7	23.3	17.8		362.8

RH = relative humidity (%); SR = solar radiation (megajoules); E_0 evaporative demand.

temperatures with some frost occurred in December and January (Table 2). However, in February anticyclones resulted in minimum temperatures that were consistently below zero for a 3 week period.Lack of rain added to the early damaging effect of low temperatures. Most crops showed some damage ranging in extent from minor loss in leaf area to the more rare extreme of complete crop loss at certain sites. However, growth was retarded badly at all sites for most of February and thus the development of an adequate yield bearing structure was affected, particularly in early maturing cultivars.

Later maturing cultivars were favored this season by the highly atypical temporal rainfall distribution. Large amounts of rain were recorded in the late April to mid-May period, especially at drier sites. These occured in the mid-late grain filling period for early cereal cultivars and considerably reduced moisture stress effects.

The seasonal rainfall totals given in Table 3 show the odd situation in which the wetter areas (zones 1a and 1b in Table 4)had a drier-than-average season; intermediate areas (zone 2) had a normal season, and dry areas (zones 3 and 4) had a wetter-than-average season.

Figure 1 shows that in the previous three seasons, ICARDA's research center at Tel Hadya received average or better-than-average rainfall. The impact of very dry years in Aleppo such as 1958-59, 1959-60, and 1972-73 has not yet been encountered by the Center.

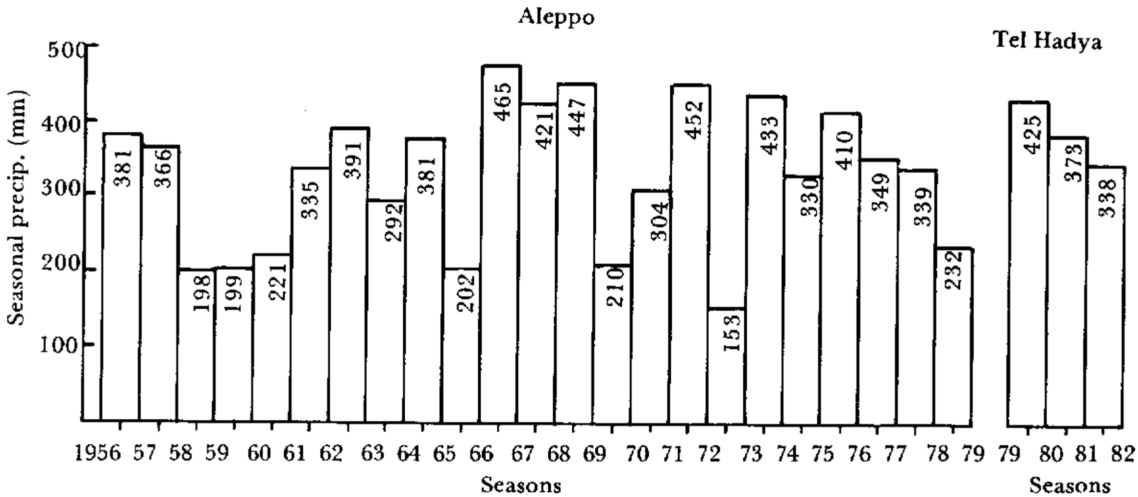


Figure 1. Seasonal variation in precipitation at Aleppo during 1956-79, and at ICARDA's research station at Tel Hadya during 1979-82.

Table 2. Number of frost days in 1980-81 and 1981-82 seasons.

	JINDIRESS[a]		KAFR ANTOON		TEL HADYA		BREDA		KHANASSER	
	No. of frost days	Min T°C	No. of frost days	Min T°C	No. of frost days	Min T°C	No. of frost days	Min T°C	No. of frost days	Min T°C
OCTOBER										
1980									2	-3.0
1981										
NOVEMBER										
1980	3	-2.5	10	-5.5	2	-4.0	8	-6.5	8	-7.5
1981	4	-2.8	10	-4.0	4	-4.2	4	-3.0	5	-6.0
DECEMBER										
1980	7	-4.0	15	-7.0	6	-3.6	14	-4.5	17	-5.0
1981			1	0.0						
JANUARY										
1981	2	-2.5	11	-7.0	3	-2.4	6	-5.0	7	-3.0
1982	9	-5.0	13	-6.0	11	-6.0	9	-6.0	8	-4.0
FEBRUARY										
1981	6	-2.0	13	-4.0	7	-3.0	6	-2.0	10	-3.0
1982	16	-7.0	21	-11.0	17	-7.8	17	-8.0	18	-6.0
MARCH										
1981			2	-3.0	2	-0.4			1	0.0
1982	10	-5.0	18	-7.0	7	-4.2	9	-4.8	16	-7.0
APRIL										
1981	1	-1.5	5	-3.1	3	-2.5	3	-2.2	2	-2.0
1982							1	-1.2		
SEASONAL TOTAL										
1980-81	19	-4.0	56	- 7.0	23	-4.0	37	-6.5	47	-7.5
1981-82	39	-7.0	63	-11.0	39	-7.8	40	-8.0	47	-7.0

a. For site locations see Table 3.

Table 3. Seasonal rainfall (mm) in northern Syria in 1980-81 and 1981-82.

	Latitude	Longitude	1980-81	1981-82	Long-term average
Lattakia	35°30'N	37°47'E	895	517	784
Kamishly	37°03'N	41°13'E	566	384	480
Jindiress	36°23'N	36°41'E	472	350	477
Kafr Antoon	36°32'N	37°02'E	467	397	436
Tel Hadya	35°55'N	36°55'E	373	338	379
Salamieh	35°00'N	37°02'E	311	264	309
Hassakeh	36°30'N	40°43'E	331	284	279
Breda	35°55'N	37°10'E	292	324	261
Khanasser	35°47'N	37°30'E	246	263	219

Table 4. Agroecological zonation of Syria.

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

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

FARMING SYSTEMS PROGRAM

Contents

(Photo on previous page: Mannual threshing and winnowing of grain is still widely practiced in the region)

FARMING SYSTEMS RESEARCH

Introduction

ICARDA's research was designed to include a farming systems orientation. The major aim was to develop appropriate technologies that can be easily integrated into the existing farming systems in the region. This should increase the quality and quantity of food, and in turn, improve the well-being of the population, particularly the small-holder and resource-poor farmers.

Initially, the Farming Systems Program (FSP) was expected to help set research priorities for the Center and assure that research findings of the commodity programs were suitable for and acceptable to these farmers. At first, the Program was hesitant to accept this responsibility; there was no theoretical basis on which to build, and there were few staff trained in Farming Systems Research (FSR). In the past five years, progress has been made in clarifying the Program's focus, developing an approach to FSR, gaining experience in the region, and conducting systems research. The benefits of this research structure are becoming clear and this is illustrated by research findings and results from the 1981-82 cropping season. The approach being taken to FSR is described in this Introduction; the results of recent research activities are then presented by projects in the subsequent sections.

Farming Systems Research

As it is perceived within the Program, FSR is a process that identifies problems limiting agricultural productivity and then searches for solutions to these problems. FSR is comprehensive in that an effort is made to evaluate new technologies in the light of all the components of the systems, including the complex interdependencies of these components. This process recognizes the resources and constraints of the farming families (who are both producers and consumers), and seeks solutions that are relevant, useful, and acceptable to these families. Research is undertaken by multidisciplinary teams of scientists that interact continually with the farmers for whom the research is intended. This approach should ensure that the research produces appropriate technologies and, therefore, will be more easily and quickly adopted.

The FSP sees its research as a process that passes through four stages: (1) diagnostic, (2) design or experimental, (3) testing, and (4) extension. FSR is problem oriented; a clear diagnosis and definition of the problem are of paramount importance if the effort to find appropriate solutions is to succeed. This will determine the composition of the team and the allocation of research effort to the various stages. Indeed, problem-oriented research acts to keep the team together, the effort focused, and on-schedule.

This process is dynamic and iterative because there is a frequent return to previous stages to clarify points as knowledge is gained, problems are confronted and research alternatives considered. In addition, the distribution between stages is not sharply defined as there is much overlap, and several stages are tackled simultaneously. Finally, the process is flexible and adaptable to many circumstances and different problems. By visualizing the research process this way, the Program's work is kept in perspective vis-à-vis other scientists and the farmer as well.

Program Goal and Long Range Objectives

The Program seeks to find strategies that will add stability and improve the farming systems in the region by increasing the technical and economic efficiency of limited resources. Particular emphasis is placed on soil and water resources, combined with improvements in crop and livestock husbandry. To achieve this goal, the Program has two over-riding objectives that allow the design of strategies for increasing agricultural production.

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

The second objective is to promote the use of FSR as an efficient approach to solving agricultural problems. FSR is a new approach to agricultural research, and few people are familiar with it. Thus, exposing scientists in the region to FSR, and training them to use it, is a high priority and will take a long time to achieve satisfactorily. A first step is to test the efficacy of the approach outside of Syria (Tunisia has been chosen for this test) and then adopt a training strategy to broaden the geographical base to include other countries. It is believed that a creative approach will have to be taken towards FSR training. Developing a regional FSR network is an idea that merits consideration.

Research Projects, 1981-82

The FSP has a number of immediate objectives that guide specific research activities. The main thrust in 1981-82 was concentrated on basic research (at the design stage) in search of an understanding of the simple as well as complex interrelations between plants, animals, and human beings. Thus, it was important to assess the potential for increases in productivity and find the means by which these can be achieved.

The research was conducted in the following five project areas:

Project I

Productivity of Rainfed Cereal Crops in Mediterranean Environments.

Project II

Nitrogen Fixation, Productivity, and Water Use of Grain and Forage Legumes.

Project III

Crop Productivity and Profitability within Rotation Systems.

Project IV

Livestock in the Farming Systems.

Project V

Environmental Zoning.

A large effort was allocated to research on cereals (Project I). In the last three cropping years a range of environmental conditions has been experienced and there is a considerable quantity of research findings that cover a diverse number of topics relating to this commodity group. While this research is not yet complete, there is now a good understanding of the factors affecting crop growth, and recommendations to farmers as agronomic practices are now possible. This research has lead the FSP directly into other activities such as (a) on-farm joint-managed (farmer and scientist) trials, (b) complementary research on legumes and crop rotations, (c) studies on grain and straw use for animal feed and (d) research on economic problems related to the availability of purchased inputs.

A major effort on the subject of biological nitrogen fixation (BNF) (Project II) indicates that a large potential exists for legumes to produce nitrogen, particularly when good management practices are used. This potential decreases as the availability of water decreases but even in the dry areas significant amounts of BNF have been measured. The research on crop rotations (Project III) is concentrating on the barley/fallow rotation in search of a forage and cereal-forage mixture that would replace the fallow; results are promising.

The livestock research (Project IV) has shown that sheep performance can be increased through improved feeding using home grown feeds and pasture/forage crops. The Program now has a better measure of how the presence of animals influence the cropping decisions of farmers. Finally, the recognition of environmental zones (Project V) has been useful in planning outreach activities. While agro-climatic zones overlap with economic zones, this research shows that basic research allocation decisions solely on agro-climatic zones will not be very effective.

Project I. Productivity of Rainfed Cereal Crops in Mediterranean Environments

In extensive areas of West Asia and North Africa, where winter rainfall is both limited and erratic, barley, and to a lesser extent wheat, are the principal crops Crop yields are affected by environmental, management, and socioeconomic factors. Within the framework of established crop rotations, the FSP scientists study the traditional and new management practices to determine their effects on (a) the underlying process and rates of crop growth as they are regulated by the physical and nutritional environment, and (b) cereal productivity within the limits of economic profitability and social acceptability.

Greater understanding of these areas will be helpful as agronomic recommendations are developed for cereal production. They must circumvent or alleviate the constraints inherent to agricultural production in the ICARDA region, and thereby, help to improve the living standards of the rural population.
Project I has the following four components:

1. Socioeconomic management. The principal activity is a survey of barley production in Syria to gather information about current practices and farming conditions with a view to determining the constraints of increasing production.

2. Cereal agronomy. This component aims to identify and analyze limitations to cereal productivity in environments that are typical of the ICARDA region. The effects of seed rates, nitrogen, and phosphorus fertilizers on various yield parameters for wheat and barley varieties have been studied for 3 years.

3. Physical environment. This component focuses on the interactions between the physical environment and factors under the farmers control and the consequent effects on plant growth and productivity of wheat and barley.

4. Nutritional environment. This component emphasises factors influencing soil fertility, with particular focus on nitrogen.

Each component comprises one or more studies, and their main findings are presented below.

Component 1. Socioeconomic Management: Barley Survey, Syria, 1981-82.

Our research on barley has shown that it is possible for farmers to increase barley yields and profitability by growing improved cultivars for grain production, growing improved dual-purpose types, applying phosphorus fertilizer, and sowing with a seed drill. The relevance and viability of these findings need to be analyzed and assessed at the farm level. Consequently, a survey was initiated in Syria to better understand the environment and the way in which barley is produced.

In the barley survey in the 1981-82 season, 168 barley producers were each visited three times. The first visit was in November-December 1981, at sowing time, when socioeconomic information and data on production practices were collected.

The second visit was in April 1982 to make field observations on agronomy, plant physiology, pathology, entomology, collect plant and soil samples, and obtain information on socioeconomic variables and production practices.

The third visit was in October 1982 to gather information on yields, production, utilization, storage, and marketing of barley.

These visits were conducted by multidisciplinary teams of social and biological scientists.

Preliminary Results

1. The differences in farming practices between western (Aleppo, Idlib, Hama, and Homs Provinces) and northeastern (Hassakeh, Raqqa, and Deir-ez-Zor Provinces) Syria were found to be greater and more complex than expected (Table 1).

Table 1. Some practices in barley production (percent of farmers) in Syria, 1981-82.

Practice	West	Northeast
Planting by broadcasting	80	7
Planting by drills[a]	20	93
Fertilizer use: P_2O_5	28	1
Nitrogen	26	0
Barley grazed during the year[b] (1980-81) (prior to anthesis)	13	64
Crop grazed instead of harvested (1980-81)	51	17

a. Some of these 'drills' are essential sophisticated mechanical means of broadcasting, e.g., a drill box plus disc, without shoes, or, a fertilizer hopper and spinner for distributing seed on the soil, which is subsequently disced to cover the seeds.

b. The nature of grazing during the year is different between the west and the northeast. In the northeast most grazing is completed between emergence and mid-February. In the west grazing takes place later in the year and in good years to prevent lodging.

(a) Even though the northeast appears more mechanized, the level of technology is substantially lower than in the west because of differences in prevailing tenure arrangements in the two regions. In the west, land is typically owned or rented from other farmers and in the northeast, it is predominantly rented from the State. When the tenant is a resource-poor peasant, he often re-rents his land to large and mechanized share cropping operators, who usually live in towns. Legally, the share cropping contracts cannot be longer than a year; thus there are no incentives to employ anything more than a minimum technology. The result is that the land is being "mined".

(b) Another significant difference is that in the west, fallow is more often used in barley rotations whereas in the northeast, barley is grown more continuously (Table 2). This situation in the northeast may be due to two interrelated reasons: first, at low levels of rainfall, fallowing and expensive land preparation to conserve moisture may not be worthwhile from a technical viewpoint; and second, the resource-poor peasant may not be able to afford to give up a year's crop and the contractor farmer has no interest in fallowing land that he can share-crop with annual contracts.

Table 2. Usual crop rotations on the largest barley plot (% of a farms in each region × zone) in Syria, 1981-82.

	Zone[a] 2		Zone 3		Zone 4	
	West	NE	West	NE	West	NE
Barley-fallow	67	33	50	19	63	8
Barley-barley	13	29	29	41	20	83
Barley-barley-fallow		19		33		8
Barley-legume-fallow	10					
Other	10	19	21	7	17	

a. See Meteorological Data 1981-82 in this report for characteristics of zones.

Situations (a) and (b) result in the predominance of continuous barley "mining" the land.

(c) In the northeast there are important interactions between the cultivated areas, livestock, and the steppe. In some areas, there are no qualitative environmental differences between the steppe and cultivated areas, which are contiguous with an arbitrary border separating them.

Barley planted in cultivated areas is grazed after plant emergence in January and the beginning of February. This is not part of the contractual arrangement between the peasant and the contract farmer-share-cropper. However, the absentee contractor farmer tolerates this, because he cannot control it, and because he does not want to jeopardize the tenurial relationship. About the beginning of February, by law and with the enforcement of the security authorities, flocks are removed from cultivated areas and sent to the steppe for grazing. Shepherds whose flocks remain in cultivated areas face the penalty of having their sheep confiscated.

Therefore, in the northeastern provinces, not only is there "mining" or over-exploitation of the cultivated areas, but also increased pressure on the remaining marginal lands in the steppe.

2. Some technical observations from the barley survey are given in Table 3. Analyses indicate that the soils are deficient in phosphorus and nitrogen.

3. Barley production in Syria is particularly influenced by climatic variables. Our studies indicate that rainfall is the primary constraint limiting barley yields. Yields in 1981-82 were low due to the severe adverse weather, parti-

Table 3. Some summary physical information from the second visit of the barley survey in Syria, 1981-82.

	Zone 2		Zone 3		Zone 4	
	West	NE	West	NE	West	NE
Average P-Olsen (ppm)	6.4 (60)[a]	4.9 (69)	7.3 (78)	4.3 (29)	7.5 (76)	5.3 (51)
Average plant N (%)	1.56	1.45	1.56	1.7	2.1	1.6
Average plant population per m^2	431 (43)	349 (29)	242 (48)	320 (35)	217 (50)	331 (31)
Average plant height (cm)	36 (28)	41 (25)	26 (27)	34 (23)	21 (34)	32 (16)

a. Figures in parentheses are the CV(%).

cularly repeated frosts. Farmer's expected yields in the long term and expectations for a poor year like 1981-82 are given in Tables 4

Table 4. Expectations by Syrian farmers of long-term barley yields.

	Zone 2		Zone 3		Zone 4	
	West	NE	West	NE	West	NE
Average yield (kg/ha)	867	997	967	778	573	557
CV(%)	81	40	52	33	55	42

and 5. Two conclusions can be drawn from this information.

- Yield expectations seem low; however they appear to be realistic when compared with actual performance within the region. Under these circumstances there is great potential for technical development, provided it is gradual and recognizes the constraints of the farmer. Neither the system (infrastructure, markets, policies, etc) nor the farmers appear to be ready for changes which may produce yields of 4000 to 6000 kg/ha. Research geared to more realistic targets will have a higher chance of success.
- Farmers expect "poor" years to occur in at least one year in 5 years. The expected gross returns from a "poor" year, e.g., 1981-82, are very low (Table 5). A 20% probability of a year with such low gross returns imparts a significant degree of risk to barley production. Therefore, farmers are reluctant to invest in costly technologies. If research is focused on increasing the stability of yields, as well as increasing yields, it is probable that the perceived risks of poor years will become less significant. This will increase the chances of adoption and diffusion of technology.

Table 5. Expected barley yields and gross returns for 1981-82[a] in Syria.

	Zone 2		Zone 3		Zone 4	
	West	NE	West	NE	West	NE
Expected yields (kg/ha)	687	289	298	180	272	254
Expected gross returns (SL[b]/ha) based on expected market prices	756	312	355	189	313	274
Expected gross returns (SL[b]/ha) based on expected government prices	632	243	277	153	253	216

a. These are based on products of averages and relate solely to grain yields. When gross returns fall below a threshold level, the fields will be grazed.
b. SL = Syrian Lira, 1 US $ 5.7 SL approximately.

Component 2. Agronomic Management

Seed Rate, Nitrogen, Phosphorus (SNP) Trial

This research component was designed to investigate the interaction between crop management and environment (principally rainfall). Field trials were established at five sites spanning the steep rainfall gradient (200-600 mm p.a.) found in Aleppo Province. At these sites a range of agronomic management practices was examined to estimate responses associated with environmental variations. This work aims to determine the most suitable agronomic management packages for specific environmental conditions.

A full analysis of the results should be available in 1983; however some general comments can be made now on specific results (Table 6).

Table 6. Effects of seed rates, nitrogen, and phosphate on grain yields of Beecher barley, tonnes/ha (1 tonne = 1000 kg), 1981-82.

Regression Coeffts.	Individual sites				
	Jindiress	Kafr Antoon	Tel Hadya	Breda	Khanasser
	Beecher barley				
Adj. Mean	3.09	3.68	3.34	1.74	0.95
S	0.02	0.02	-0.15***	0.04***	0.25***
N	0.42***	0.25***	-0.06***	0.08**	0.04***
P	0.15***	0.10***	0.01	0.09***	0.13***
SN	-0.02	0.03	0.00	0.00	0.12***
SP	-0.00	0.08*	-0.08*	0.01	0.05*
NP	-0.01	-0.15	0.08*	0.02	0.04*
S^2	0.00	-0.10	-0.07*	-0.01	0.01
N^2	-0.14***	-0.02	-0.21	0.01	0.03*
P^2	-0.04	-0.09	-0.12	-0.01	0.04**

*** significantly different from zero at $p \leq 0.01$.
** significantly different from zero at $p \leq 0.05$.
* significantly different from zero at $p \leq 0.10$.

Regression equation: $Y = a + b_1S + b_2N + b_3P + b_4SN + b_5SP + b_6NP + b_7S^2 + b_8N^2 + b_9P^2$

where S = seed rate,
P = P_2O_5, and
N = Nitrogen.

For these regressions the data were transformed for each input according to the following schedule:

		Independent variables				
		-2	-1	0	1	2
Level	S	30	60	90	120	150
of	N	0	30	60	90	120
input	P	0	30	60	90	120

1. In 1981-82 Beecher barley again yielded well at all sites and surpassed durum wheat Sahl and bread wheat S311 × Norteno at the wetter sites (Jindiress, Kafr Antoon, and Tel Hadya) by a good margin. In the dry areas, it yielded more than the local Arabi Aswad and Martin barleys. At the driest site, Khanasser, it yielded nearly 1000 kg/ha, whereas Martin virtually failed, and the farmers' crops in the surrounding area were also very poor. Thus, an improved variety appears to be a valuable agronomic input, particularly in drier areas.

2. Seed rates for Beecher barley had no effect on yields at the wetter sites, which implies that the high seed rates normally applied in areas with more than 350 mm annual rainfall in Syria could be reduced (providing weed control is not a problem). At the drier sites, a high seed rate seems to be more effective.

3. At the two wettest sites, Jindiress and Kafr Antoon, nitrogen application increased yields for the third successive year. At the two driest sites, Breda and Khanasser, the responses to N in 1981-82, although small, were generally positive, whereas in the previous 2 years they were mainly negative.

The positive responses to phosphorus were similar to those in previous years at the two wettest sites. At the two driest sites they were also positive, but due to the poorer growing conditions in the early part of the season, were not so large as the previous 2 years. The positive response to P is particularly noticeable in a barley crop after a fallow season. The responses of grain at Tel Hadya to N and P were generally negative which is the reverse of the general trends at the other sites. However, this site is probably a special case as it possesses a high level of natural fertility.

Table 7. Partial budget for Beecher barley at Breda, Syria, 1981-82.

	Nil P_2O_5	60 KG P_2O_5/ha
INCOME		
Grain yield (kg)	1520	1740
Grain revenue (SL)	1444	1653
Straw yield (kg)	1070	2810
Straw revenue (SL)	588	1545
GROSS REVENUE (SL)	2032	3198
INCREASE IN EXPENSES		
Fertilizer:		
P_2O_5 × price (SL)		144
Labor for application (SL)		10
Credit (SL)		15
Harvesting:		
Labor, equipment, transport, bags, etc. (SL)		38
TOTAL CHANGE IN EXPENSE (SL)		*207*
NET BENEFIT (SL)	2032	2991

Cost of P_2O_5 = SL 2.4 per kg.
Price of barley grain = SL 0.95 per kg.
Price of barley straw = SL 0.55 per kg.
Labor for broadcasting fertilizer. = SL 10.00 per 120 kg of TSP
Both trials received 60 kg of N/ha, at a seed rate of 90 kg/ha.

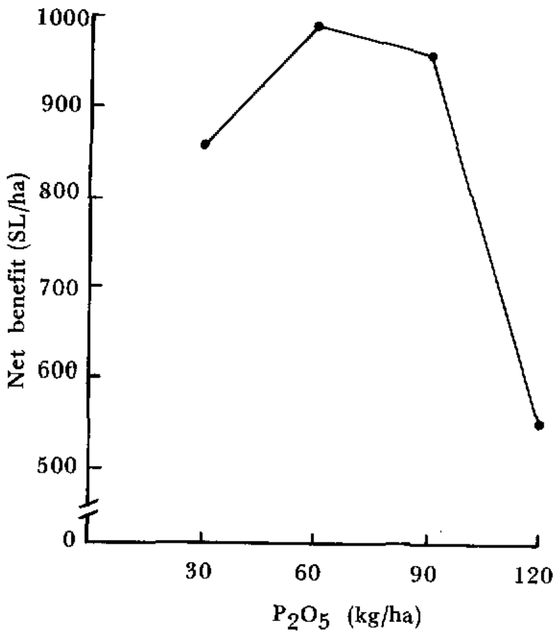


Figure 1. Increase in net benefit (Syrian lira, SL) from P_2O_5 applied to Beecher barley at Breda, 1981-82.

Economic Implications of the SNP Trial Results

The increased economic return from fertilizer application, particularly P, makes it very profitable to use. In Table 7, a partial budget is shown that compares two barley plots at Breda: one with no phospate and another with an application of 60 kg P_2O_5/ha. The increase in the net benefit, derived from adding this amount of fertilizer, is SL 959. Thus, the benefit-cost ratio is more than 4.5, i.e., for every Syrian lira spent, four-and-a-half Syrian liras were earned, which makes this an attractive economic investment.

Figure 1 illustrates the increase in net benefits at Breda at different levels of P application. The most profitable level was 60 kg P_2O_5/ha. The increases in net benefits at all five different levels of P_2O_5 are given in Table 8. At three sites 60 kg P_2O_5/ha was the optimum rate. At Kafr Antoon and Khanasser, the farmer would probably also apply 60 kg/ha; he would increase his net revenue by a

Table 8. Increases in net benefit in Syrian Lira (SL) from using P_2O_5 on Beecher barley in 1981-82.

Site	P_2O_5 (kg/ha)			
	30	60	90	120
Jindiress	689	1005[a]	935	482
Kafr Antoon[b]	293	359	405	418
Tel Hadya	557	757[a]	591	53
Breda	851	996[a]	951	548
Khanasser[b]	284	567	569	657

These calculations follow the same procedure as used for Table 7. The level of nitrogen was held at 60 kg/ha and the seeding rate was 90 kg/ha for all calculations. Since both straw and grain were included, the computations tend to refute the previous statement that there was no response to fertilizer application at same sites.

a. Highest increase in net benefit at that site.

b. No clear, best choice as net benefits from applications of 90 and 120 kg/ha of P_2O_5 are only slightly above the net benefit of 60 kg/ha.

very small amount if he used higher levels of P, and it is unlikely that he would accept the greater risks involved.

Residual Effects of Phosphate

At the two drier experimental sites, Khanasser and Breda, the rotation is two crops of barley after the year in which barley experiments are grown. Therefore, it is possible to measure the residual effects of P in the 2 years after application. At the two wetter sites, Jindiress and Kafr Antoon, there is one barley crop after the cereal experiments, hence 1 year's residual effect can be measured (Table 9).

Table 9. The direct and residual effects of 60 kg P_2O_5/ha on Beecher barley yields, t/ha (1 tonne - 1000 kg), 1981-82.

Site	Years when P was applied	Year when response was measured: 1st year		2nd year		3rd year		Total response over (n) years
		x	P.A.	x	P.1.	x	P.2.	
Khanasser	1979-80	1.88	0.84***	0.51	0.44**	0.16	0.16***	1.44 (3)
	1980-81	1.28	0.44***	0.45	0.06*			0.50 (2)
	1981-82	0.88	0.26***					0.26 (1)
Breda	1979-80	1.76	0.32***	0.64	0.24**	0.15	0.21***	0.77 (3)
	1980-81	2.03	0.54***	0.42	0.23***			0.77 (2)
	1981-82	1.52	0.18***					0.18 (1)
Kafr Antoon	1979-80	3.31	0.32**	2.18	0.30*			0.62 (2)
	1980-81	3.77	0.32**	1.66	-0.10			0.22 (2)
	1981-82	2.51	0.20***					0.20 (1)
Jindiress	1979-80	2.78	0.20	1.65	0.28**			0.48 (2)
	1980-81	3.08	0.30***	1.50	-0.04			0.26 (2)
	1981-82	1.90	0.30***					0.30 (1)

x is the mean yield obtained without phosphate, and with 20 kg N/Na.

P.A. is the direct yield increase over x obtained by applying 60 kg P_2O_5/ha at planting.

P.1. is the residual response to 60 kg P_2O_5/ha 1 year after application.

P.2. is the residual response to 60 kg P_2O_5/ha 2 years after application.

*** significantly different from zero at $p \leq 0.01$.

** significantly different from zero at $p \leq 0.05$.

* significantly different from zero at $p \leq 0.10$.

There was a steep decline in barley yields after a barley crop the previous year.

The yields of the second barley crop were generally about half of those obtained from the first crop (after fallow in the dry areas, and after a summer crop of sesame at the two wetter sites). The yield of the third successive barley crop, at Breda and Khanasser, was extremely poor.

In the 1981-82 season significant positive responses to residual P were again obtained at the two drier sites, but not at the two wetter sites. In previous seasons, responses have been found at all sites, except Tel Hadya. The effects of residual P are generally observable and add significantly to potential profitability of phosphate application over the range of environments.

Further Research

Based on our research into important farmer-controlled management practices, it is now possible to make "best bet" recommendations on management factors for specific environmental zones. Many years of cereal breeding (at ICARDA and elsewhere) have made improved wheat and barley varieties available. These have been extensively tested (under high levels of management), and as a result the breeders are in a position to recommend improved varieties for different zones.

However, because a vast majority of farmers in the region have limited resources, it is extremely unlikely that many could afford to adopt a complete "improved cereal farming package". ICARDA and the concerned national programs should, therefore, be in a position to recommend a clear order of economic priorities to farmers in different zones. Work planned in 1983 is designed to provide the information needed.

Component 3. Physical Environment

This study, initiated in the 1979-80 season in order to complement the agronomic trials reported in Component 2, was designed to examine the influence of physical and nutritional environment on the growth and productivity of barley and wheat. Particular attention is paid to five overlapping areas, namely: (a) the effect of environmental factors on crop phenology and the development of a yield structure; (b) the crops' ability to maximize their interception of incident radiant energy and the subsequent efficiency of its conversion to dry matter; (c) the crops' response to the rapid onset and the severity of drought stress in Mediterranean environments; (d) the interactive effects of nutrition and environment on phenology and crop productivity; and (e) quantification of the findings of items (a)-(d) for developing a crop model driven by meteorological parameters to predict crop maturity date and potential productivity.

Research highlights from two sub components of this study (c and d) are reported in the following sections.

Barley: Effects of Physical Environment and Nutritional Factors on Growth, Phenology, and Productivity

Key fertilizer treatments were selected form the SNP agronomic trial that would produce different patterns of growth and yield in barley (cv Beecher). In the 1981-82 season three levels of fertilizer were studied at Jindiress, Breda, and Khanasser. The treatments were: (1) zero fertilizer, (2) P at 60 kg P_2O_5/ha, and (3) P at 60 kg P_2O_5/ha plus 60 kg N/ha.

Some aspects of the data from the 1980-81 and 1981-82 seasons that are based on comparisons between unfertilized and fertilized crops are:

1. The large yield responses to fertilizer application, observed across all rainfall zones, were associated with large increases in water-use efficiency (Table 10). Similar trends were observed in the 1979-80 season.

2. Fertilizer application, principally P, had the effect of advancing phenological development; the effect began at early stages of growth. This has important implications for the analysis of crop growth and water use for different crop development phases.

3. Increased grain yield from fertilizer application was associated with increased total drymatter yield. The differences in drymatter production between fertilized and unfertilized barley occurred during the early stages of growth; thereafter crops had generally similar relative growth rates.

4. Fertilizer application resulted in increased levels of drymatter production at anthesis, but this did not result in an increase in the fraction of the total water supply used by anthesis. This suggests that further increases in early growth could lead to further field increases.

5. In the results of the two seasons reported here, yield increases were obtained, in many cases, *with no additional crop-water* use (Table 10). The depth of water extraction was not affected by fertilizer application and generally it coincided with the depth of the wetting front. Increased growth of fertilized crops appears to be associated with a greater proportion of the total water supply passing through the crop in transpiration, i.e., water that would otherwise be lost by evaporation from soil surface.

Wheat: Plant-Water Status Studies

In previous seasons we observed that management practices, particularly the application of N and P fertilizer, could change the pattern of crop moisture use. This is caused by an increase in, and earlier development of, crop green area in response to improved fertility. As a result, significant levels of moisture stress can be experienced in the later growth stages, particularly at grainfilling. Such

Table 10. Grain yield and crop-water-use efficiencies[a] (WUE) of barley, 1980-81 and 1981-82 seasons.

Site	Treatment	Crop yield (kg/ha)	Cumulative crop-water use (mm)	WUE in grain production (kg/ha/mm)	WUE in total DM production (kg/ha/mm)
1980-81					
Jindiress	No F[b]	2200	311	7	16
	N + P[c]	5000	352	14	34
Breda	No F	1600	224	7	16
	N + P	2600	214	12	33
Khanasser	No F	1400	226	6	14
	N + P	2200	220	10	25
1981-82					
Jindiress	No F	1400	323	4	14
	N + P	2900	315	9	28
Breda	No F	1300	218	6	18
	N + P	2200	218	10	28
Khanasser	No F	0400	210	2	6
	N + P	0900	210	4	12

a. Water-use efficiencies are based on crop-water use (evapotranspiration) from germination until maturity. Yields are expressed on a dry weight basis.

b. No fertilizer was applied.

c. 60 KG of P_2O_5 and 60 kg N/ha.

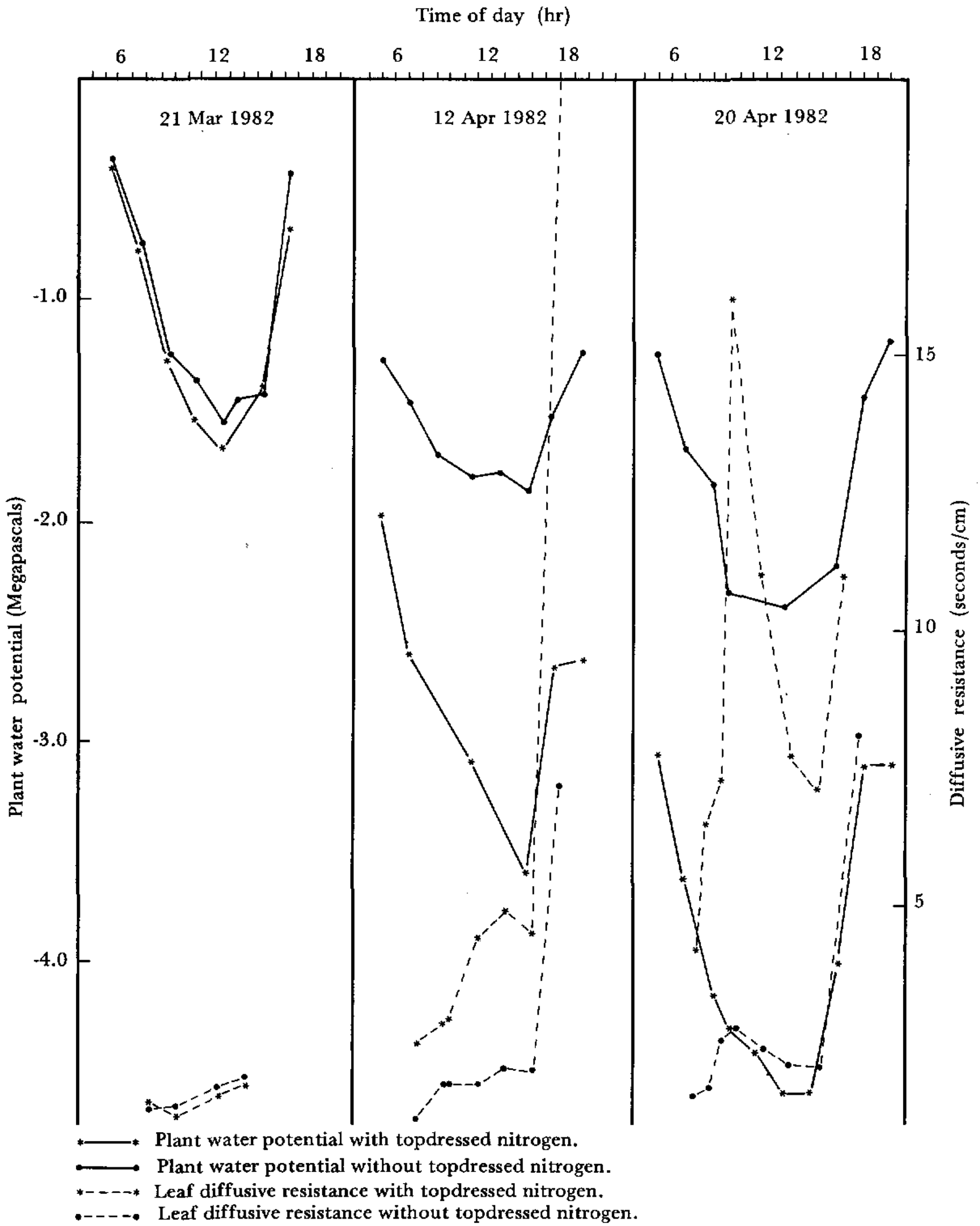


Figure 2. Diurnal variation in plant-water potential and leaf diffusive resistance on three dates for Mexipak wheat.

stresses were recorded in the 1980-81 season and 1000 grain weights of fertilized crops were significantly reduced.

In the current season this problem was studied in greater detail. Plant-water potential and diffusive resistance profiles were measured on a wheat crop with variable fertility treatments. These measurements were made every 2 hours from before dawn (3:30 hr) to late evening (22:00 hr) at weekly intervals from just before anthesis to maturity, at Tel Hadya.

The wheat treatments at Tel Hadya, which received additional N (90 kg/ha) as a top-dressing, suffered severe decrease in their plant-water potentials (more negative) (Fig. 2), from preanthesis (5 April 1982) to early grain filling (20 April 1982). The plant-water stress was sufficiently severe by 20 April 1982 to cause a considerable increase in diffusive resistance by mid-morning and this in turn would decrease the current production of photosynthate. Had this situation continued until harvest, it is likely that 1000-grain weights in the treatment with additional nitrogen would have been significantly reduced. However, in the next week there was 41 mm rainfall and this was followed by an additional 24 mm in the subsequent 2 weeks. The amount is atypical and was sufficient to relieve the moisture stress on the crop: hence, no reduction in 1000-grain weight in the high N treatment was recorded.

This experiment indicates that the higher yields obtained from improved nutrition in the seasons to 1980 are not achieved without a consequent increase in the risk of a reduced kernel size at harvest or ultimately severely reduced grain yields.

Component 4. Nutritional Environment

Nitrogen Dynamics in Soils in Aleppo Province

During the 1980-81 growing season the mineral nitrogen status of soils was monitored at five sites in Aleppo Province: Khanasser, Breda, Tel Hadya, Kafr Antoon, and Jindiress.

Mineral nitrogen is defined as the sum of ammonium- and nitrate-nitrogen. The ratio of ammonium-nitrogen to nitrate-nitrogen in soils at all sites tends to increase with increasing annual rainfall. At harvest time, fallow plots at all sites contained more mineral N (mainly in the form of nitrates), i.e., 50-80 kg more N/ha, than plots cropped with cereals. The nitrate contents of soils in fallow plots at all sites tend to fluctuate less during the season than the ammonium contents. At most sites, in particularly Breda and Tel Hadya, the onset of rains is followed by an increase in ammonium-nitrogen, presumably as a result of mineralization of easily decomposable organic

Using an atomic absorption spectrophotometer to identify micro nutrients in soil samples.

matter.This is illustrated in Fig.3 for Tel Hadya. The decrease in ammonium-nitrogen in February and March is not accompanied by an increase in nitrate-nitrogen, probably due to *immobilization of ammonium-nitrogen* in the biomass of the soil rather than to nitrification.

Nitrogen Fertilization

Because soils at most sites (with the notable exception of Khanasser) are low to medium in plant-available N, cereal crops at most sites responded to the application of N fertilizer. The N uptake efficiency (defined as the difference in nitrogen-uptake between a fertilized and an unfertilized crop divided by the amount of N applied) tends to increase with increasing annual rainfall, i.e., from 30 to 40% at the drier sites (Khanasser and Breda) to 70 to 80% at the wetter sites (Kafr Antoon and Jindiress) (Fig.4). A similar trend was observed at Tel Hadya, where the N uptake efficiency increased from 59% under rainfed conditions to 72% (157 mm) and 84% (236 mm) with irrigation.

Nitrogen Balance

In a number of experiments at Breda and Tel Hadya, ^{15}N-labeled nitrogen fertilizers were used to make up a mass balance for N in soils and to investigate whether losses of N occurred from the soil-plant system at these sites. At Tel Hadya, ^{15}N-recoveries were high: about 95% of the labeled material was recovered in the crop (Mexipak wheat) and the soil at harvest. This suggests that no significant losses occurred at Tel Hadya during the growing season. At Breda about 80% of the applied ^{15}N-enriched material was recovered in the crop (Beecher barley) and in the soil at harvest, which suggests that losses may have

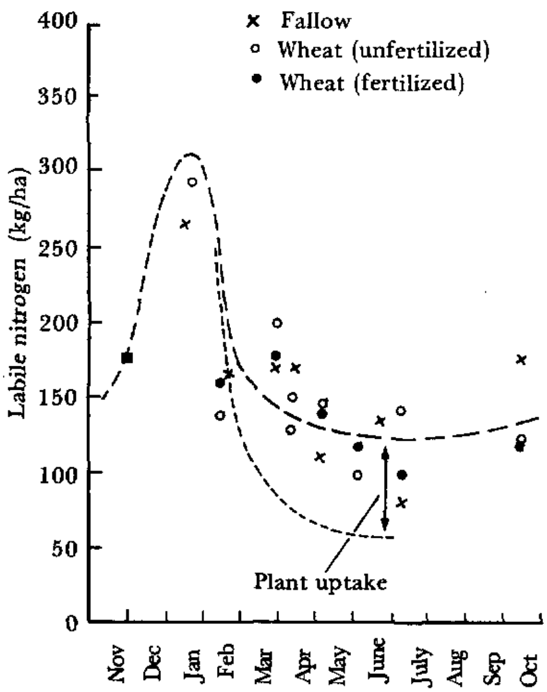


Figure 3. Dynamics of labile nitrogen in fallowed and cropped plots at Tel Hadya. *(Labile nitrogen is defined as the sum of mineral N in the soil (0-120 cm depth) and total N in the plant (cropped plots only).* Applied N fertilizer is not included in the labile N. At planting a composited soil sample representative for the whole field was analyzed (solid square). The broken line visualizes the dynamics of labile N, and the dotted line the dynamics of mineral N in soils in cropped plots. Thus, distance between the two lines is a measure of plant uptake of N.).

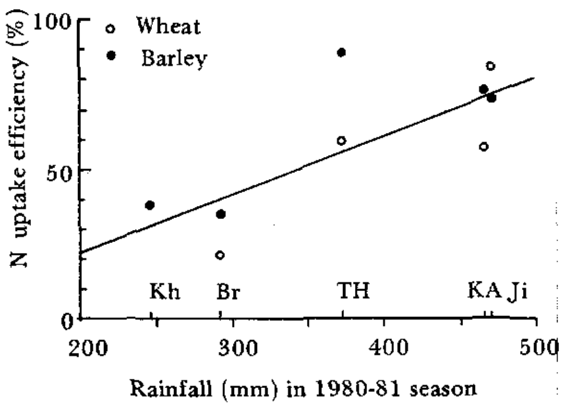


Figure 4. Relation between nitrogen uptake efficiency of barley and wheat, and rainfall during the 80-81 growing season at Khanasser (Kh), Breda (Br), Tel Hadya (TH), Kafr Antoon (KA), and Jindiress (Ji). The simple correlation coefficient of r = 0.75 is significant at 1% level.

occurred at Breda during the growing season. At both sites about equal amounts of ^{15}N-enriched material were recovered in soil and plant materials. Most of the ^{15}N-enriched material in the soil (60 to 70%) was recovered in the top 20 cm of soils at both sites (Fig. 5). Nitrogen losses may occur as a result of ammonia volatilization (the conversion of NH_4 into NH_3) or denitrification (conversion of NO_3 into N_2 or N_2O). Information available to date suggests that ammonia volatilization is the more likely loss mechanism. Immobilization of mineral N in the biomass of the soil at both sites occurred mainly during February and March.

Conclusion

In Project I, components 1 and 2 are efforts to understand and analyze socioeconomic and *biological constraints that face farmers* in the region. It is hoped that adaptable research based on these results will allow the formula*tion of viable and effective recommendations* for improved cereal production. Components 3 and 4 examine more deeply the dynamics of crop growth and seek an understanding of the complex interactions between nutrients, physical environment, and other factors that can be manipulated. Interaction between the four components is expected to improve ICARDA's research efforts.

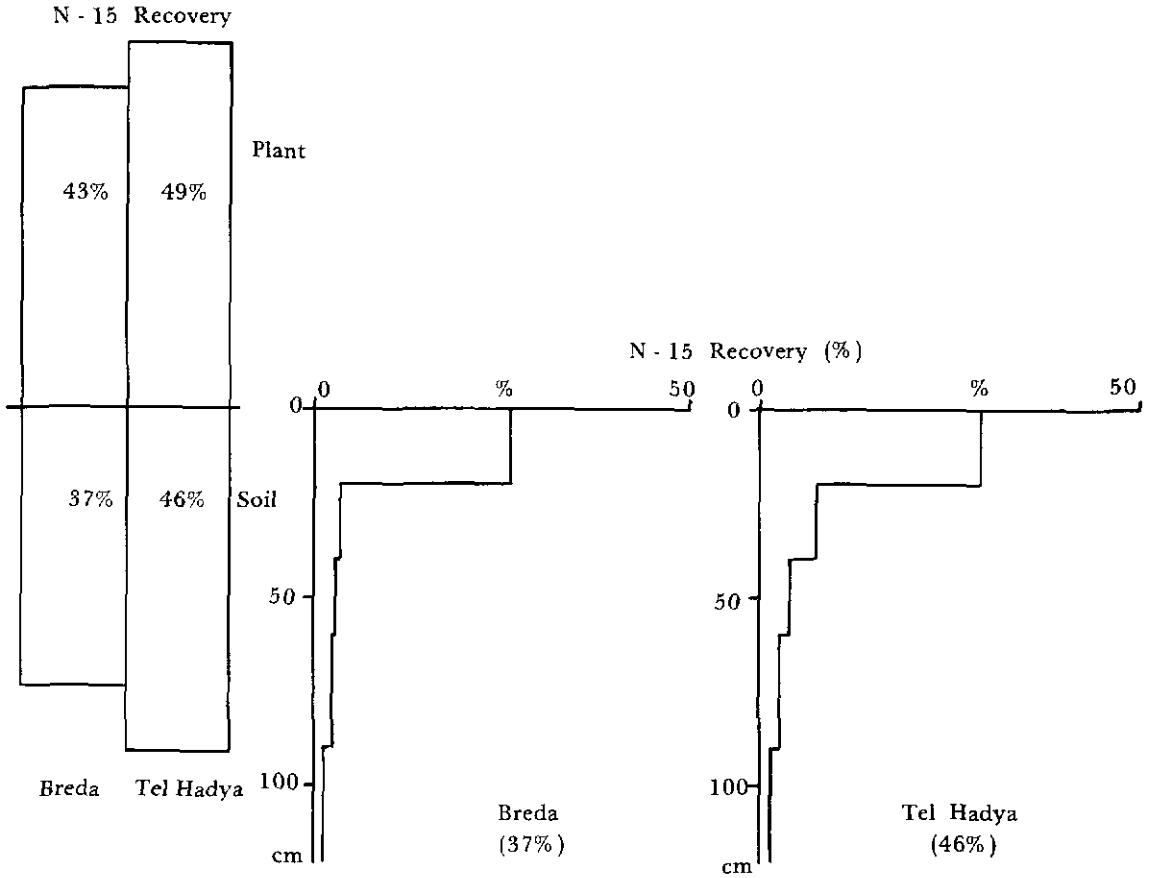


Figure 5. Schematic presentation of ^{15}N recoveries in soil and plant materials, and the depth distribution of ^{15}N-enriched nitrogen soils at Breda and Tel Hadya.

Table 11. Selected crops and levels of management (H - optimum, L - farmer) for three rainfall zones in Aleppo Province, 1981-82.

Zone <350 mm	350-450 mm	> 450 mm
Lentil (L)	Lentil (L)	Faba bean (L)
Lentil (H)	Lentil (H)	Faba bean (H)
Chickpea (H)	Chickpea (L)	Chickpea (L)
Vicia (H)	Chickpea (H)	Chickpea (H)
Pisum (H)	*Pisum* (H)	*Pisum* (H)
Fallow plot	Fallow	Fallow
Non-nod.[a] (barley)	Non-nod. (wheat)	Non-nod. (wheat)
Sites Nasrieh	Tel Hadjar	Jindiress
Breda	Hayyan	Segeraz
Ghrerite	Tel Hadya.	

a. Non-nod. = non-nodulating plant.

Project II. Nitrogen Fixation, Productivity, and Water Use of Grain and Forage Legumes

Research conducted by national programs and ICARDA has indicated that nitrogen deficiency is widespread within the region, and large responses to nitrogen fertilizer have been obtained by both farmers and researchers on a variety of crops, However, many farmers can ill afford the ever increasing cost of fertilizer, and thus the importance of nitrogen biologically fixed in the soil in association with the grain and forage legume components of the cropping system is very apparent.

There is considerable scope for the improvement of nitrogen fixation by manipulation of the two partners of symbiosis, i.e., the crop and *Rhizobium,* and by appropriate crop management practices. In order to obtain more information on the potential for increased nitrogen fixation within cropping systems,

Table 12. Management of grain and forage legumes at eight sites in Aleppo province, 1981-82.

Crop	Management	Seeding date	Seeding rate	Row width (cm)	kg/ha P-fertilizer	kg/ha N-fertilizer[a]	Inoc.	Sitona control	Weeding[b] (2)
Lentil	(L)	Late winter	100 kg/ha	45		20			(a)
Lentil	(H)	Early winter	100 kg/ha	22.5	50	20	+	+	(b) + (a)
Chickpea	(L)	Spring	10 plants/m row length	45		20			(a)
Chickpea	(H)	Early winter	10 plants/m row length	22.5	50	20	+		(b) + (a)
Faba bean	(L)	Early winter	10 plants/m row length	45		20			(a)
Faba bean	(H)	Early winter	10 plants/m row length	45	50	20	+		(b) + (a)
Vicia/Barley	(H)	Early winter	90/20 kg/ha	22.5	50	20	+	+	(b) + (a)
Pisum	(H)	Early winter	10 plants/m	22.5	50	20	+	+	(b) + (c)
Barley		Early winter	80 kg/ha	22.5	50	20			(c)
Wheat		Early winter	80 kg/ha	22.5	50	20			(c)

L = Farmer's management; H = Optimum management.

a. Fertilizer will be placed with the seed. All treatments hand planted.

b. (a) = hand weedings; (b) = preemergence spray; (c) = postemergence spray.

a collaborative project between the Farming Systems Program and the Food Legumes Improvement Program was conducted during the 1981-82 growing season. The main focus of this project was nitrogen fixation by grain and forage legumes at eight locations spanning the 250-550 mm/annum rainfall transect in Aleppo Province. Crops were selected for each location depending on their agronomic suitability (Table 11) and were grown at two levels of management to represent (a) *farmer's current practice and* (b) what at present is thought to be optimum management (Table 12).

The results obtained are interesting and will guide the continuation of this research. They are presented and discussed in the following six, separate but interrelated, sections.

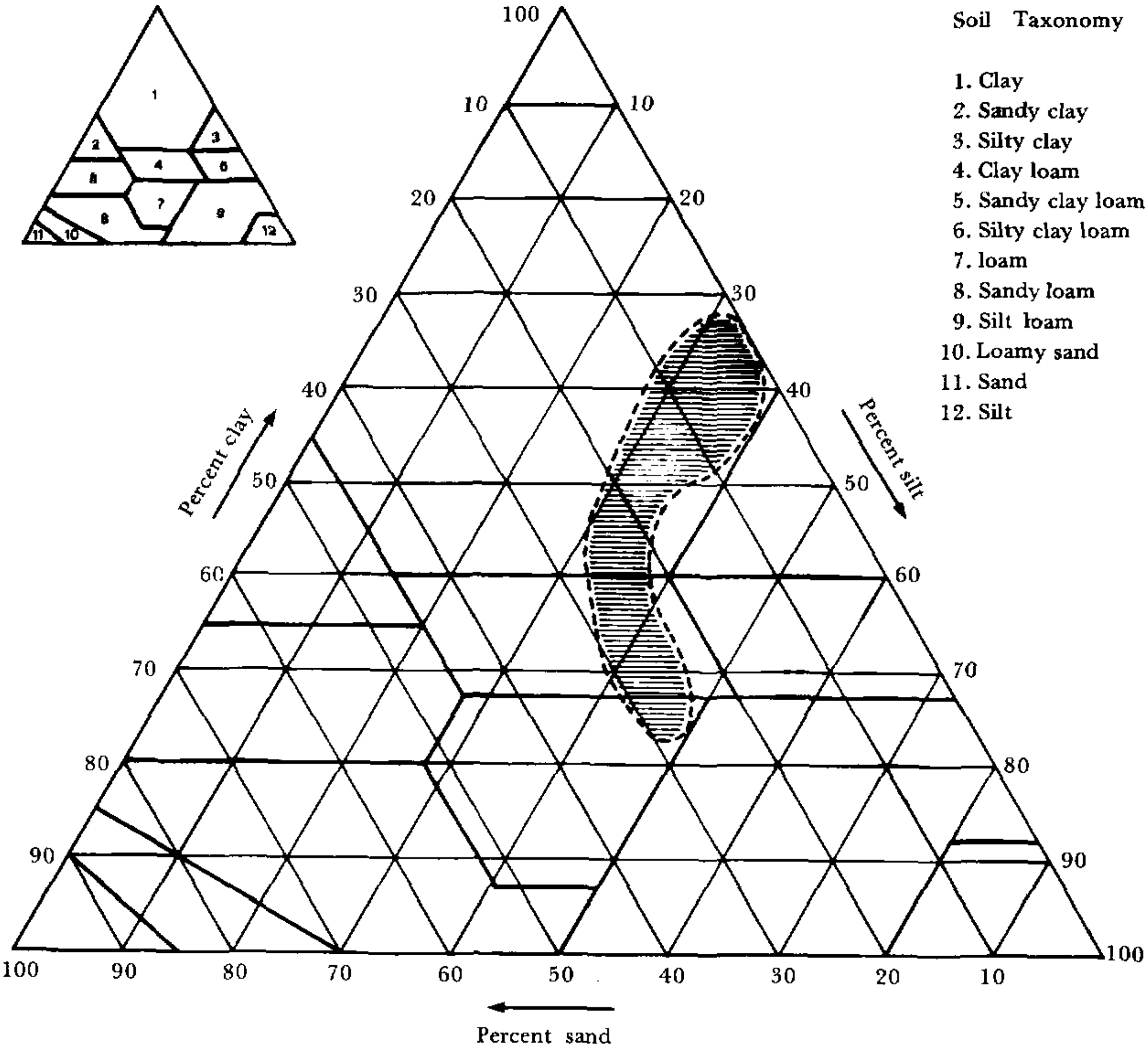


Figure 6. Texture of surface horizons (0-20 cm depth) of soils at BNF sites. All soils are in the shaded area. Textures range from clay to clay loam and loam.

Component 1. Soil and Soil Fertility at Biological Nitrogen Fixation (BNF) Experimental Sites

Soil Texture

The texture of the soils at the BNF sites (plus Khanasser and Kafr Antoon) is indicated in Figure 6. Soils at Breda and Khanasser are loam to clay loams in the surface horizon, merging into silty clay and silty clay loam at depth. The texture at Ghrerife and the wetter sites is clay throughout the profile. Soils at Kafr Antoon merge into the calcareous substratum below 120 cm depth. Soils at Tel Hadya have a heavy layer at 90-120 cm depth, possibly kaolinitic clay, which probably impedes root development.

The clay contents (averaged over the top 90 cm) at the different sites tend to increase with increasing annual rainfall ($r = 0.78$ significantly different from zero at $p = 0.05$, Fig.7). Soils at Hayyan, Jindiress, and Kafr Antoon are deep-cracking, heavy clays (Vertisols).

Lime Content

Soils at all sites are calcareous; lime contents range from 10% (Hayyan) to more than 40% (Breda and Khanasser). At most sites, lime contents are quite constant with depth. Only at Breda and Khanasser are there clear clacic horizons. At higher-rainfall sites there are no horizons with lime accumulation, although there is redistribution of lime in the profile (soft *lime spots*).

The lime contents (top 20 cm) at different sites tend to increase with decreasing annual rainfall ($r = 0.79^{**}$) (Fig.7).

Organic Matter

Organic matter contents at all sites are low, ranging from 1.6% (Segeraz) to 0.5% (Nasrieh). Organic-carbon contents in soils at Breda and Khanasser decrease more steeply with depth than at other sites. Carbon to

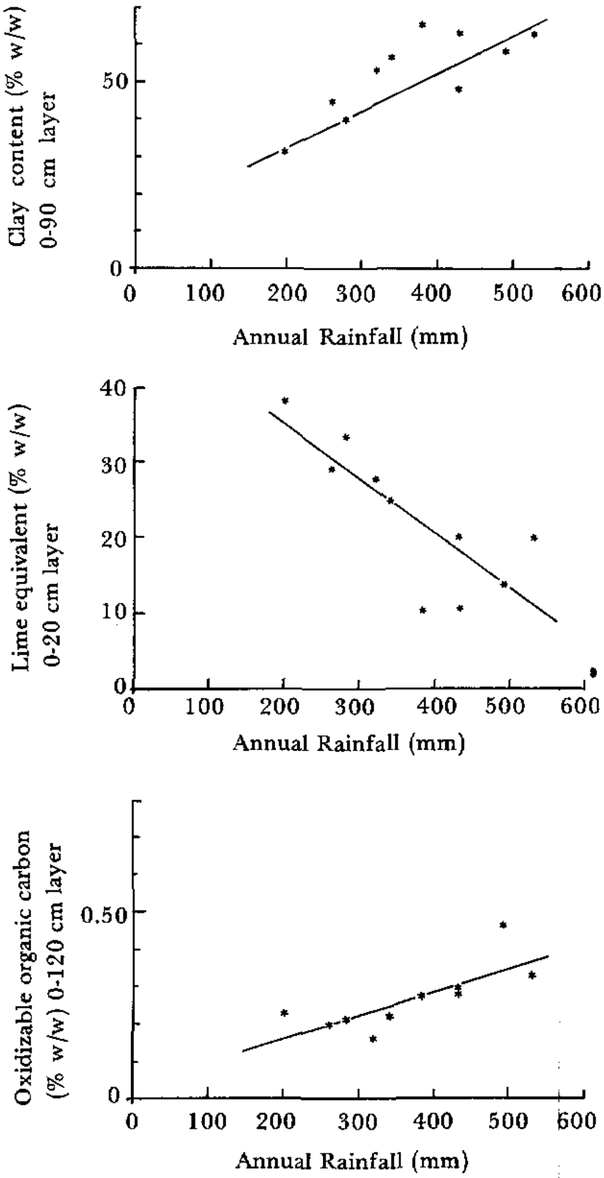


Figure 7. Relation between soil characteristics and estimated annual rainfall at BNF sites.

nitrogen ratios at all sites are around 9, i.e., rather low.

Organic-carbon contents (0-20 cm) of the soils tend to increase with increasing rainfall (r = 0.32, not significant). The correlation between organic-carbon and annual rainfall becomes highly significant (r = 0.75**) if the average contents of the top 120 cm are taken as the basis for comparison between sites (Fig. 7).

pH and EC

Soils at all sites have quite similar pH values (1:1 soil-water suspension), ranging from 8.0 (Jindiress, Segeraz, and Kafr Antoon) to 8.4 (Nasrieh).

Electrical conductivity of 1:1 soil-water extracts are low at Tel Hadya and wetter sites and are quite constant with depth. At the drier sites, EC_1 increases with depth due to the presence of soluble salts such as gypsum. Salinity is not expected to impede plant growth at any of the sites, because of low values of EC_{sat} in the rooting zone.

Available Phosphorus

Available phosphorus contents (extraction with sodium bicarbonate) are medium to high in the top 20 cm of soils at Segeraz and Tel Hadjar and low at all other sites. The higher contents at Segeraz and Tel Hadjar may be due to the use of phosphorus fertilizers in previous years. Available phosphorus contents of soils are low in horizons below the top layer (0-20 cm) at all sites (Fig.8).

Mineral Nitrogen

Mineral nitrogen contents of soils at planting are in the low range, except at Segeraz, which seems to be quite high. However, without knowledge of the nitrogen dynamics in these soils throughout the growing season, it is difficult to predict the availability of nitrogen to the crop.

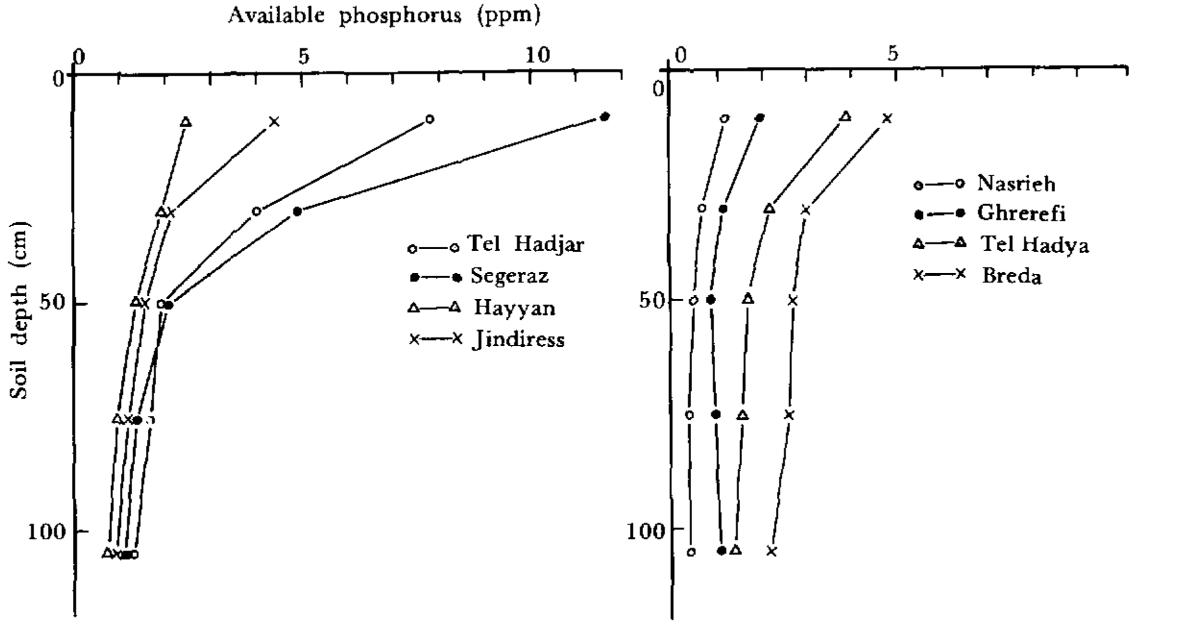


Figure 8. Distribution of available phosphorus (P-Olsen) with depth in soils at BNF sites. (Hay - Hayyan; Ji - Jindiress; T.Hjr - Tel Hadjar; Seg - Segeras; Nas - Nasrieh; Ghr - Ghrerife; TH - Tel Hadya; Br - Breda).

Component 2. Nitrogen Fixation and Microbiological Studies

Native *Rhizobium* Population

Composite soil samples were collected from the sites before planting the trials. Estimations of the Most Probable Number (MPN) of *rhizobia* present in those soils were made with a plant infection technique using a specific host crop, which was inoculated with a series of soil dilutions. As lentil, faba bean, and *Pisum* sp. are all nodulated by *Rhizobium leguminosarum,* counts were made on lentil alone for convenience.

The same method was used for vetch and chickpeas. Unfortunately, none of the soil dilutions resulted in nodulation on chickpeas, which may have been due to an inadequate environment in the growth room. Thus nodulation of the uninoculated plants during early vegetative growth was used to provide a measure of the native chickpea *Rhizobium* population.

Table 13 gives the MPN of rhizobia present at the locations of the crops being investigated. There was a native *Rhizobium* population for vetch, lentil, faba bean, and *Pisum* sp. present at all sites, but population numbers were quite variable. Only two (Jindiress and Tel Hadya) of the eight sites had a native *Rhizobium* population compatible with chickpeas. Plants from Jindiress had more nodules than those from Tel Hadya.

Nodulation and Nitrogenase Activity

Nodulation assays were made at the early vegetative and early pod filling stages. Nitrogenase activity of nodules was measured by acetylene reduction at early pod filling. In the early vegetative stage there were few differences between treatments in nodule status; however, by early pod filling differences were apparent (Table 14), which are discussed below on a crop by crop basis.

In all locations, faba beans with improved

Identifying new *rhizobium* strains for biological nitrogen fixation.

Table 13. Most probable number (MPN) of *Rhizobia* present (per gram dry soil) at different locations in Syria 1981-82.

Location	Lentil/ faba bean/ *Pisum*	Vicia	Chickpea
Jindiress	1.7 × 10^3	5.9 × 10^3	0.0(16.4)
Segeraz	NA	1.8 × 10^4	0.0(0.0)
Tel Hadjar	1.0 × 10^5	NE	0.0(0.0)
Hayyan	5.5 × 10^3	3.1 × 10^4	0.0(0.0)
Tel Hadya	1.0 × 10^5	NE	0.0(6.0)
Nasrieh	1.7 × 10^4	3.4 × 10^4	0.0(0.0)
Ghrerife	5.5 × 10^3	1.1 × 10^4	0.0(0.0)

Figures in parentheses represent the number of nodules/plant formed during the vegetative stage in the uninoculated treatment.
NE = Not estimated.

Table 14. Nodule mass, nitrogenase activity, and total drymatter production of five legume crops in different locations in Syria under farmer (low) and optimum (high) levels of crop managment, 1981-82.

Crop	Location	Nodule dry wt. (mg/plant)		MC_2H_4/plant/hr		MC_2H_4/g. nod/hr		Total dry wt. (g/plant)	
		Low	High	Low	High	Low	High	Low	High
Faba bean	Jindiress	141.0	486.0	0.30	3.24	2.08	6.47	10.42	23.74
	Segeraz	396	550.9	0.77	1.74	2.04	3.14	16.02	23.21
	Tel Hadya	209.2	280.1	0.77	1.01	2.80	4.10	12.11	14.23
Lentil	Tel Hadjar	5.8	10.8	0.013	0.004	2.64	0.39	0.34	1.47
	Hayyan	1.9	6.6	0.005	0.005	2.38	0.82	0.22	1.15
	Nasrieh	1.3	3.8	0.004	0.004	3.17	1.11	0.14	1.00
	Breda	1.3	2.8	0.002	0.003	2.25	1.07	0.24	1.07
	Ghrerife	1.0	4.2	0.003	0.017	1.68	4.41	0.22	0.80
Chickpea	Jindiress	21.2	145.2	0.09	0.65	4.11	4.53	0.32	4.44
	Segeraz	8.5	73.1	0.001	0.10	0.12	1.40	0.19	0.72
	Tel Hadjar	11.0	287.6	0.002	0.99	0.16	3.36	0.29	2.89
	Hayyan	13.8	12.2	0.012	0.014	0.91	1.13	0.25	0.24
	Nasrieh		319.3		0.313		0.97		2.67
	Breda		54.4		0.35		0.63		1.26
	Ghrerife		38.9		0.061		1.65		0 95
Pisum	Jindiress		30.6		0.07		2.07		11.66
	Segeraz		35.1		0.02		0.86		7.84
	Tel Hadjar		78.1		0.26		3.29		10.93
	Hayyan		23.0		0.02		0.94		3.64
	Nasrieh		12.9		0.010		0.82		5.28
	Breda		13.7		0.010		0.69		4.77
	Ghrerife		9.2		0.51		5.60		1.82
Vetch	Nasrieh		3.7		0.10		2.81		2.47
	Breda		5.6		0.003		0.61		1.12
	Ghrerife		2.4		0.006		1.30		0.70

management had a greater nodule mass than those in the low management treatment. The difference between these management treatments was much greater at Jindiress than at Segeraz and Tel Hadya. This suggests that the introduced strains performed better in the presence of even a small native *Rhizobium* population. The plants grown with improved management had higher nitrogenase activities, both in terms of ethylene production and of nodule efficiencies, than grown with unimproved management. This was reflected in their drymatter productivity.

With improved management, lentil crops had a greater nodule mass and produced more drymatter than with unimproved management. The greatest nodule mass was produced at Tel Hadjar whether the crops were inoculated or not. This reflects the large native *Rhizobium* population. Nitrogenase assays were made at the pod filling stage, but as this was rather late for lentils, there was very little difference in ethylene production between the two levels of management. Nodules produced at the lower level of management were more efficient at this stage possibly because nodule formation was delayed and the nodules were younger. In most locations, chickpea crops fixed more nitrogen with the improved management practices.

This difference was greater where the native *Rhizobium* population required for chickpeas was absent. *Pisum* crops were well nodulated at all locations although the degree of nodulation varied between sites. The highest nodule mass was obtained at Tel Hadjar and the lowest at Ghrerife. Nodules showed their maximum activity at Tel Hadjar. In contrast, nodules were the most efficient at Ghrerife. This may have been the result of significant rainfall at this site two days before the assay was made. For vetch, nodule weights were greatest at Breda but fixation efficiencies were greater at Nasrieh. The greater efficiency may have contributed to the larger drymatter production obtained at Nasrieh.

Nitrogen Fixation

The total drymatter production, seed yields, and estimated nitrogen fixation of the grain and forage legumes studied are presented in Table 15. Since the ^{15}N analyses have not been completed, computation of nitrogen fixation is still to be done. Nevertheless, at all locations the trial followed a cereal crop in 1980-81, and the growth and N-uptake of the non-nodulating crop indicated severe N deficiency. An exception was at Segeraz where the farmer had applied a heavy dressing of N fertilizer to his wheat in the preceding season. Because these sites were so N deficient, a reasonable estimate can be made of N-fixation by simply calculating the difference in N-uptake between the nodulating and non-nodulating crop.

As expected, there is a close relationship between the total drymatter produced and nitrogen fixation; it follows that a relationship also exists between levels of nitrogen fixation and potential productivity at different sites, depending on the availability of moisture. Figure 9 illustrates that nitrogen fixation by three legume crops under optimum management was related to rainfall. However, when the low level of management data is considered, it would appear that other constraints such as phosphate deficiency, weeds, and inefficient root nodulation combine to reduce the overriding effect of moisture availability.

The results (Table 15) also indicate a big variation in the potential increase in nitrogen fixation resulting from improved management in all the grain legume crops. In faba beans, the potential increase ranged from 54 kg/ha at Jindiress to 0 kg/ha at Segeraz. In chickpeas, the largest increase in N-fixation of 85 kg/ha was found at Jindiress, but only 16 kg/ha at Tel Hadya. In lentils, a 58 kg/ha increase occurred at Nasrieh compared with 12 kg/ha at

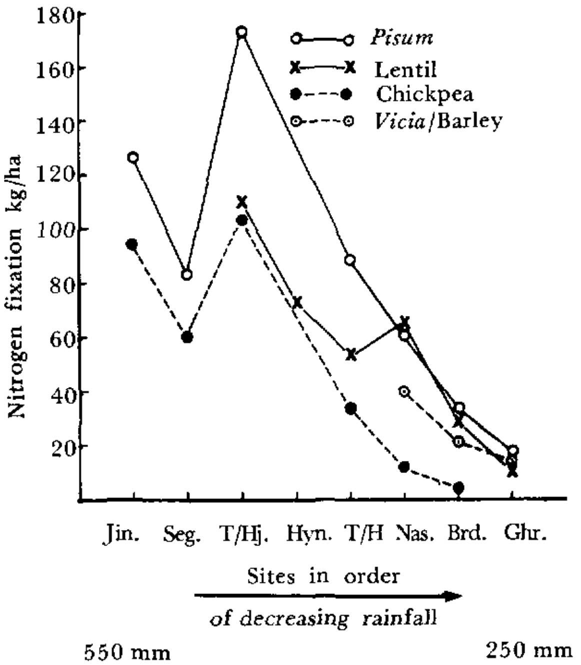


Figure 9. Nitrogen fixation by *Pisum*, Lentil, *Vicia*/barley and chickpea under optimum management as related to rainfall. (Jin – Jindiress; Seg – Segeraz; T/Hjr – Tel Hadjar; Hyn – Hayyan; T/H – Tel Hadya; Nas – Nasrieh; Brd – Breda; Ghr – Ghrerife.

Ghrerife. This large variation in the response of nitrogen fixation to improved management is due to a whole range of soil and environmental factors, not all of which were investigated in this trial. Nevertheless, when all the recorded data have been more fully analyzed, a clearer picture may emerge.

While any conclusion is still tentative, the data from the first year of this trial show that in spite of differences between crops and between sites there is considerable potential for improving biological nitrogen fixation. In general, this potential decreases from the wetter to the drier zones. In 1982-83 potential fixation rates will be measured in greater detail at three sites representative of wet (475 mm p.a.), intermediate (350 mm p.a.), and dry (275 mm p.a.) conditions, and on additional treatments particularly forage legume crops and forage legume/cereal mixtures.

Table 15. Dry matter, seed yield, and nitrogen fixation of grain and forage legumes at eight locations in Aleppo Province 1981-82.

Site/Crops	Manage-ment	Total dry matter (kg/ha)	Seed yield (kg/ha)	N-Fixation[a] (kg/ha)	
Jindiress					
Faba bean	H	4980	2380	108	(3)[b]
	L	3040	1540	54	(19)
Chickpea	H	6510	3440	94	(12)
	L	1740	990	9	(3)
Pisum	H	5380		127	(15)
Segeraz					
Faba bean	H	6590	3420	146	(13)
	L	7090	3270	168	(11)
Chickpea	H	4480	2920	60	(21)
	L	3590	2150	26	(11)
Pisum	H	4470		83	(33)
Tel Hadjar					
Chickpea	H	6330	3230	114	(5)
	L	2880	1640	31	(11)
Lentil	H	6440	1900	110	(17)
	L	4110	1230	79	(7)
Pisum	H	5720		175	(8)

Cont.

Cont. TABLE 15

Site/Crops	Manage-ment	Total dry matter (kg/ha)	Seed yield (kg/ha)	N-Fixation[a] (kg/ha)	
Hayyan[c]					
Lentil	H	4280	1570	72	(6)
	L	2210	880	25	(8)
Tel Hadya					
Chickpea	H[d]	2940	1170	32	(10)
	L	1850	960	16	(3)
Lentil	H	3450	1280	54	(12)
	L	2920	1260	43	(5)
Pisum	H	4430		89	(15)
Nasrieh					
Lentil	H	4130	1590	66	(4)
	L	1400	540	8	(6)
Chickpea	H[d]	2000	880	12	(2)
Barley/Vicia	H	2580		40	(11)
Breda					
Lentil	H	2140	720	29	(2)
	L	1000	390	4	(2)
Chickpea	H[d]	790	450	4	(5)
Barley/*Vicia*	H	2080		21	(8)
Pisum	H	2120		34	(14)
Ghrerife					
Lentil	H	1230	340	12	(8)
	L	790	190	0	(1)
Chickpea	H[d]	850	100	1	(1)
Barley/*Vicia*	H	1500		15	(5)
Pisum	H	1200		17	(8)

a. ^{15}N analyses not yet completed at IAEA. N-fixation estimated as difference between N-uptake of nodulating and non-nodulating crops. (See text for further explanatation).
b. Figures in parentheses are standard errors.
c. All crops except lentils destroyed by children or frost.
d. Severe ***Aschocyta*** blight during pod filling.
H = Optimum management; L = farmer management.

Component 3. Soil Moisture Studies

Trials were conducted at locations that cover a wide range of average annual rainfall in order to investigate the interaction between moisture supply and production of a grain legume (chickpea) and forage legume *(Pisum)*. In both crops, the improved management treatment was selected to minimize variation among sites of factors other than moisture supply. In addition to these two crops, fallow plots were included at each location, and moisture storage under fallow was investigated. These results are reported in Project III.

Results

The total drymatter production, total water use, estimated nitrogen fixation, and water use efficiency data for *Pisum* are presented in Table 16. In general, drymatter production and water use declined with delining seasonal rainfall. At the four wettest locations a substantial water-use efficiency value of around 20 kg/ha/mm was measured. However, this value decreased considerably at the three driest sites. Water-use efficiency (WUE) values are derived from evapotranspiration data that include both soil evaporation and crop transpiration. Large variations in WUE's (Table 16) are mainly due to variation in the percentage of radiant energy intercepted by the crop canopy and its resultant effect on the variable partitioning of evapotranspiration into its two components. Thus, at locations such as Jindiress (where the maximum green area index of *Pisum* is 6.0), much less radiant energy reaches the soil surface than, for example, at Breda (where the maximum green area index is 1.7). Therefore, at Jindiress a greater proportion of evapotranspiration is being actively used by the crop as transpiration rather than evaporation from the soil. This is reflected in the higher WUE value obtained at this site.

WUE can also be considered in terms of nitrogen fixed (Table 16). It is apparent that, because of a general relationship between total drymatter and nitrogen fixation, the same trends are observed. However, there is a much greater variation in the WUE for nitrogen fixation than for drymatter production at the wetter locations. The small value obtained at Segeraz may be associated with the high soil nitrogen status. (see Component 1.)

Extractable soil moisture is the difference between the maximum moisture observed in a discrete soil depth interval and that at harvest. These measurements are presented in Table 17. Because *Pisum* followed a cereal crop in 1980-81, there was no extractable soil moisture at the start of the season. Thus only depth intervals recharged by the rainfall in the current season contained moisture available for the *Pisum* crop. The extractable soil moisture data in Table 17 reflect both the depth of penetration of the current season rainfall, and the depth of extraction of moisture by the crop. These data emphasize the very restricted rooting depth of the crop at the drier locations.

There is, at present, much interest in the role that a forage legume could play in replacing the fallow year in the barley/fallow rotation practiced by many farmers. There is strong evidence to suggest that a barley/forage rotation will be much more productive and will maintain greater yield stability over long term (Project III). These forage crops are harvested for hay in mid- to late April before all the soil extractable moisture has been fully utilized. Thus, besides fixing appreciable nitrogen,

Table 16. Total dry matter (TDM), water use, nitrogen fixation, and water-use efficiency (WUE) of forage Pisum at seven locations in Aleppo Province, 1981-82.

Site	Rainfall-germ. to harvest (mm)	TDM kg/ha	Water use (mm)	N-fixation (kg/ha)	WUE (1)	WUE (2)
Jindiress	308	5380	252	127	21.3	0.50
Segeraz	322	4470	228	83	19.6	0.36
Tel Hadjar	285	5720	250	175	22.9	0.70
Tel Hadya	263	4430	214	89	20.7	0.41
Nasrieh	250	2700	210	61	12.9	0.29
Breda	245	2120	185	34	11.4	0.18
Ghrerife	217	1200	151	17	7.9	0.11

WUE (1) = kg TDM/ha/mm; WUE (2) = kg N fixed/ha/mm

Depth interval (cm)	Jindiress	Seregaz	Tel Hadjar	Tel Hadya	Nasrieh	Breda	Ghrerife
15-30	1.7	1.7	2.3	2.4	2.1	1.5	1.4
30-45	1.3	1.3	2.1	2.1	2.0	1.3	0.8
45-60	1.2	1.3	1.8	2.0	1.7	1.0	0.1
60-75	1.1	1.2	1.4	1.0	1.5	0.4	
75-90	1.0	1.0	0.8	0.1	0.9		
90-105	0.7	0.3	0.3				
105-120	0.4		0.2				
120-135	0.1						
135-150							
Total	7.5	6.8	8.9	7.6	8.2	4.2	2.3

Table 17. Extractable soil moisture (cm/15 cm depth interval) under forage Pisum at seven locations in Aleppo Province, 1981-82

a. For rainfall averages for these sites see chapter on Meteorological Data in this report.

Pisum crop also leaves some residual soil moisture from the current seasons rainfall which, with timely postharvest cultivation, can be stored. This is illustrated in Fig. 10, where the moisture distribution under *Pisum* at three dates is presented for two locations. The dotted line represents the distribution at the start of the season, and the other two dates represent the distribution at maximum profile recharge and at harvest. The shaded area in Figure 10 represents the moisture potentially available for next year's barley crop. Research in Project III indicated that similar results are obtained with a vetch forage crop in long-term rotation trials at Breda and Khanasser.

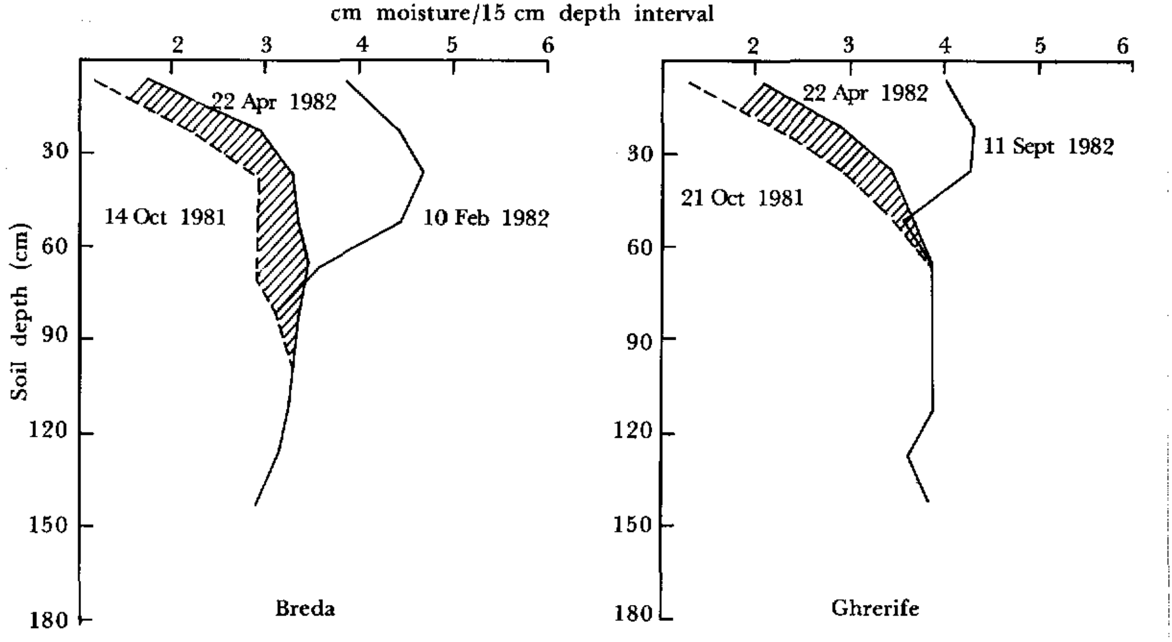


Figure 10. Moisture distribution under *Pisum* at two locations (≤ 275 mm) in northern Syria.

Component 4. Crop Physiology

This study was begun in the 1980-81 season to consider problems arising from the introduction of winter sowing of chickpeas as a potentially more productive management practice than the tradional practice of sowing in the spring. Cultivars for winter sowing must possess enhanced resistance to *Ascochyta* blight. If they do not, there is a risk of complete loss in cool humid winter conditions. The resistant cultivars that are currently available can be separated into erect, and spreading types. The interaction between environment and plant type is a further major consideration in this study as the erect forms, though they are more disease resistant, appear to be inherently less productive than the spreading types. Both aspects of this study are intimately linked to Component 3 of this Project, which investigates the growth behavior and moisture relations of legume crops.

Results

In the 1981-82 season, unlike the 1980-81 season, winter plantings of the spreading type ILC 482 showed no advantage in seed yield over the erect types ILC 202 and ILC 72 (Table 18). This resulted from a combination of circumstances, the principal factors of which were: (1) the heavy incidence of *Ascochyta* blight on the pods of ILC 482, particularly at Tel Hadya, which may have been due to atypical late rain, and (2) the effect of extensive frosts in February which seem to have had more impact on the productivity of the earlier maturing and less densely planted cultivar ILC 482.

The unusually late but abundant rains and some diseases incidence at Tel Hadya and Breda also served to eliminate the expected advantage of winter over spring planted ILC 482. However, an increase in yield was measured at Jindiress where there was little or no disease. The advantage of winter sowings was clearly evident in the performance of the resistant erect types.

Further data for detailed growth analysis on the improved management plots of chickpea and forage pea was collected from all eight

Table 18. Chickpea productivity in Aleppo Province 1981-82.

Site	Cultivar & planting time	Seed yield (t/ha)[a] 1982 (1981)	Drymatter production t/ha[a]	Harvest index	100-seed weight (g)
Jindiress	ILC 482 (W)	3.44 (4.20)[b]	6.51	0.53	22.3
	ILC 202 (W)	3.14	7.38	0.43	24.5
	ILC 72 (W)	3.84 (3.24)	8.32	0.42	24.9
	ILC 482 (S)	1.37 (1.88)	2.41	0.57	25.8
Tel Hadya	ILC 482 (W)	1.17 (2.09)	2.94	0.40	20.5
	ILC 202 (W)	2.21	4.50	0.49	25.3
	ILC 72 (W)	1.92 (1.38)	4.30	0.45	26.5
	ILC 482 (S)	1.43 (0.80)	2.65	0.54	24.7
Breda	ILC 482 (W)	0.45 (0.99)	0.79	0.57	25.5
	ILC 202 (W)	0.63	1.40	0.45	23.3
	ILC 72 (W)	0.51 (0.28)	1.05	0.49	26.0
	ILC 482 (S)	0.36 (0.74)	0.85	0.42	20.2

W = winter planted, S = spring planted.
a. 1 tonne = 1000 kg.
b. 1980–81 results.

BNF trial sites. The analysis of these data is in progress.

In the 1980-81 season the total moisture used by chickpeas planted in the winter and spring was similar at any one site and largely depended on the amount of the current season's rainfall. In both winter and spring planted crops, a marked cut-off point was observed in the relationship between the fraction of extractable moisture remaining in the soil profile and the crop's ability to increase transpiration loss in response to increasing atmospheric demand (Fig.11). Moreover, significant differences were observed in the patterns of crop-moisture use between winter and spring plantings.

As a result of these findings, the relationship between moisture supply and plant-water status was considered in greater detail in 1981-82. This was examined at weekly intervals from preflowering to maturity at Tel Hadya. Plant-water potential measurements

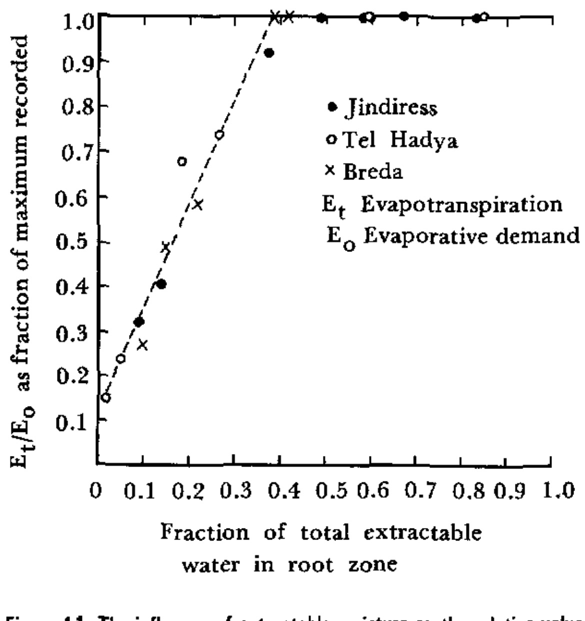


Figure 11. The influence of extractable moisture on the relative value of the E_t/E_o ratio of winter and spring-sown chickpea at three locations.

were taken at intervals of 2 hours from before dawn (3:30 hr) to late evening (22:30 hr) on winter-planted ILC 482 (spreading type) and ILC 72 (erect type) and the spring-planted ILC 482. The diurnal plant-water potential profiles (Fig.12) indicate that in winter-planted ILC 72 overall stress increased throughout the period from 21 March to 20 April 1982 (Fig. 12 A, B, and C). By 18 May 1982 plants were unable to recover high (less negative) potential values during the night. In contrast, spring-planted ILC 482 showed no change in plant-water potential profile during the same period mainly because the canopy was still small; water use increased later in the season. However, in the period close to maturity (3 weeks later) the diurnal plant-water profile of ILC 482 was similar to that of ILC 72 at a corresponding stage of development (dotted line, Fig. 12 C). This suggests that the soil moisture reserves are depleted to comparable levels. The similarity between plant-water potential profiles in ILC 482 and ILC 72 as both near maturity, indicates that the development of pre-dawn potentials in the region of −1.0 to −1.5 MPa and/or minimum (most negative) values of −2.0 to −2.5 MPa may cause the onset of maturity.

In the 1982-83 season we will continue our studies on the effect of physical environmental factors on the growth of legume crops in association with a proposed root development study.

Component 5. Survey of Lentil Production in Syria

At an early stage in its development, ICARDA recognized that there was little available information on legume crops, especially on production practices of lentils by farmers in the region and the role that lentils play vis-a-vis the other productive enterprises of the lentil farmer. Therefore, a survey was conducted in Syria during the growing season of 1978-79 and 1979-80 to collect this information. The Project was conducted jointly by the Food Legumes Improvement Program and the Farming Systems Program. One hundred and fifteen lentil farmers in 52 villages in Syria were interviewed on their farms; each farmer was visited four times. Now that the Computer Center is operational, the information on this crop is being re-analyzed in order to understand better the relationship among variables that were found to be important.

A summary of the findings is given below to illustrate the value of this kind of research. Incidence of weeds and limited use of fertilizer are two factors that may be suppressing lentil yields.

Summary of Results

1. Yields vary greatly (Table 19). Major yield constraints as seen by the farmers are: irregular rainfall; insufficient phosphate fertilizer; weed infestation (especially *Orobanche); lack* of mechanical implements, especially tillage and harvesting machinery; pests, particularly pod borers; and temperature fluctuation during flowering.

2. The use of phosphorus and nitrogen on

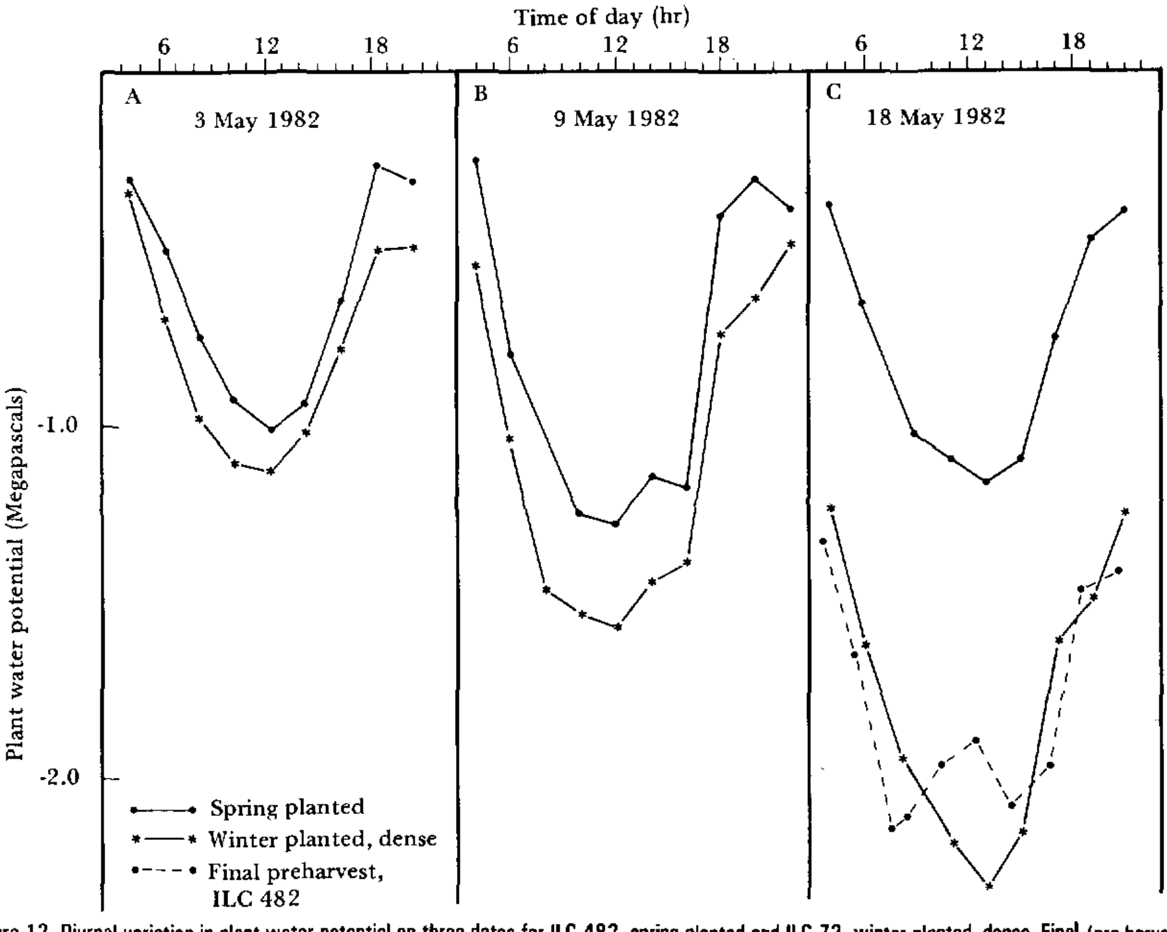


Figure 12. Diurnal variation in plant-water potential on three dates for ILC 482, spring planted and ILC 72, winter planted, dense. Final (pre-harvest) readings for ILC 482 (as on 7 June 1982) also shown.

Table 19. Yields (kg/ha) of lentils in Syria, 1977-78 to 1979-80.

	1977-78	1978-79	1979-80	Normal year: farmer's estimate
Average grain yield	1080	610	1020	1070
SD[a]	430	650	440	340
Range	0-2000	50-1750	0-2000	300-2000
Average straw yield	1250	930	1270	1220
SD[a]	500	530	530	450
Range	150-2800	200-3000	0-3000	250-2800

a. SD = Standard Deviation.

lentil production was found to be so variable among the farmers in the sample that provision of fertilizer recommendations by ICARDA would be beneficial to the farming community. At present, many do not use chemical fertilizer nor manure and those who do use fertilizer show considerable variation in the quantity applied. For example, phosphorus application was found to vary from 50-250 kg TSP/ha. Although ICARDA at present has general agronomic recommendations on fertilizer application in lentil production, an economic analysis of the benefits from applying fertilizer would currently be of value in guiding farmers to determine their most profitable fertilizer management practice (Table 20).

3. Weeds can be a serious problem. More than 46% of plots in the sample were heavily infested and 29% were moderately infested by different species of weeds. Only 2% of plots were weed free. Overall, weeds comprised more than 20% of total vegetation; in Hama Province, the figure was 33%. Farmers estimate that weeds cause, on average, a

Table 20 Distribution of fertilizer use in Syria, 1979-80.

	Large holders	Small holders	Zone 1	Zone 2	Overall sample
PHOSPHORUS			percent		
TSP kg/ha					
0	31	67	55	37	50
50-60	8	0	2	7	3
90-120	27	16	18	30	21
130-170	21	8	17	7	14
200	9	6	5	16	8
250	4	3	3	3	4
Total	100	100	100	100	100
NITROGEN					
Urea kg/ha					
0	75	78	78	73	77
50	11	3	6	10	7
100-120	10	9	9	10	10
130-160	4	8	7	3	6
350	0	2	0	4	1
Total	100	100	100	100	100

20% yield loss (Table 21).

Weed infestation was greater in Zone 2 than in Zone 1, which could be due to more frequent cultivations performed in Zone 1.

The timing of cultivations before sowing and soil tilth condition are recognized by 71% of farmers as the most important factors affecting weed populations. Seed rate (49%), rainfall (30%), frequency of cultivations (22%), fertilizer application (16%), and rotation (9%) were also mentioned as factors influencing weed populations.

Due to the increasing shortage and cost of farm labor, manual weeding is becoming less frequent (33% of farmers weeded once, 5% twice, and 1% three times). Manual weeding is carried out by the family when possible or sometimes by neighbors.

4. Straw is an important component of total revenue in the production of lentils (Component 6). Lentil grain yields vary more than straw yields. Straw acts to stabilize income over time, makes up a higher proportion of total biological yield in dry years, and also commands a higher price in such years.

5. Lentils play an important role in summer crop rotation with cereals in northern Syria. The fact that lentils benefit soil is recognized by farmers. However, few understand the biological nitrogen fixation capability of a legume plant.

6. Lentil production is sensitive to the economic environment, and the area sown in the recent years has decreased due to a fall in the price of lentils relative to other crops, and to a rise in the cost of manual labor. Lentil production currently uses more manual labor than cereal crops.

Processing of the survey data by computer will substantially improve the usefulness of

Table 21. Weed infestation in lentil crop in Syria, 1979-80.

	Zone 1	Zone 2	Combined
		percent of plots	
I. Level of infestation			
Nil	2.3	0.0	1.7
Low	27.6	10.0	23.0
Moderate	26.4	36.7	29.0
High	43.7	53.3	46.3
Total	100.0	100.0	100.0
II. Dominant type			
1. Broad leaf weeds	43.5	73.5	51.3
2. Grassy weeds	20.0	0.0	14.8
3. Both 1 and 2 weeds	23.5	16.7	21.7
4. *Orobanche*	3.5	0.0	2.6
5. Both 1 and 4 weeds	9.5	10.0	9.6
Total	100.0	100.0	100.0
	Plant/m^2	Plant/m^2	Plant/m^2
III. Plant population			
Broad leaf weed	43	78	52
Grassy weeds	17	7	14
Orobanche	5	2	4
Total	65	87	70
Lentils plants	259	311	272
Total	324	398	342
Weeds as percent of total plants	20%	22%	21%

the survey. The Farming Systems Program intends to proceed with multiple regression analysis, mapping of production practices and problems, and prepare a more refined classification of farmers and farm characteristics. A report will be submitted in the spring of 1983 to complete the study.

Component 6. On-Farm Trials

Most farmers cooperating in the on-farm lentil trials gave two main reasons for not sowing lentils earlier in the year, i.e., weed infestation and increased risk of frost damage. The trials on early vs late sowing over the past 3 years have given some evidence that, on average, greater yields may outweigh these disadvantages (Table 22).

Increased yields of grain and straw obtained from early sowing generally produce more gross revenues. An average of SL 142 more revenue per hectare was gained from early sowing, after subtracting the cost of an extra weeding. However, variations in yield between years were substantial due to the effect of time of sowing treatments (Table 22).

In the first year of the on-farm trials, 1979-80, an advantage of SL 775 per hectare was achieved from early sowing of lentils. In 1980-81, the comparable revenues of the early and late sowing were nearly identical, differing by only SL 19 per hectare. In 1981-82, the late-sown trials showed greater average revenues, i.e., SL 367 per hectare, which is a considerable economic disadvantage of early sowing. The range of year-to-year variation in comparable revenues was greater for the late-sown trials than for the early sowings; if it is established that early sowing stabilizes and increases the profits of lentil production, the practice will interest many Syrian farmers.

Trial sites were selected partly to avoid areas with notorious weed problems, e.g., *Orobanche*-infested areas. Thus, the above

Table 22. Summary of on-farm trials for early vs late sowing of lentils: average partial budgets for three growing seasons.

Seasons and locations	Item	Early sowing: Yield (kg/ha)	Early sowing: Revenues[a] and cost[b] (SL/ha)	Late sowing: Yield (kg/ha)	Late sowing: Revenues[a] (SL/ha)	Difference in comparable revenues (Early-Late) (SL/ha)
1979-80	Grain	1223	1223[a]	640	640	
9 locations in	Straw	2642	1057[a]	1601	640[a]	
Aleppo and Idleb Provinces	Cost of extra weeding		-225[b]			
	Comparable Revenue		2055		1280	775
1980-81	Grain	1150	1150[a]	990	990[a]	
13 locations in	Straw	3160	1264[a]	2950	1180[a]	
Aleppo and Idleb Provinces	Cost of extra weeding		-225[b]			
	Comparable Revenue		2189		2170	19
1981-82	Grain	967	967[a]	1174	1174[a]	
8 locations in	Straw	2298	919[a]	2135	854[a]	
Idleb Province	Cost of extra weeding		-225[b]			
	Comparable Revenue		1661		2028	-367
Average (Early-Late) difference in Comparable Revenues for three years						142

a. Revenues based on assumed prices of SL 1.0/kg for lentil grain and SL 0.4/kg for lentil straw for all years.
b. Cost of extra weeding based on 15 labor days per ha at SL 15 per day.

results may not apply to lentil farms in general. Even with two weedings, the early-sown lentils may suffer serious yield declines relative to the normal sowing on sites where weed populations are heavy. Thus, further trials are justified to define, more precisely, the conditions (especially weed environments) under which early sowing is more successful than late sowing.

Project III. Crop Productivity and Profitability within Rotation Systems

Improvements in crop productivity can be achieved by introducing new technologies within traditional cropping rotations or by changing the rotations. The interaction of the many factors involved needs to be understood from an economic as well as agronomic viewpoint before any changes can be promoted within the region. Project III is designed to test new techniques and crop varieties in proper rotational sequence and to refine future research.

Component 1. Socioeconomic Perspectives

Twenty years ago, the agricultural sector in Syria began a process of modernization, the speed and scope of which was in sharp contrast to the long period before 1960, when agricultural techniques were primitive and agricultural development was stagnant. Since 1960 rapid and wide ranging changes have taken place; the Syrian peasant has switched from the animal-drawn feddan plough to tractor-drawn tillage implements, and from hand harvesting and threshing to a combine harvester.

Although these changes were profound, others, equally important, can be observed today. Land reform, improved transportation

Interviewing farmers about crop rotations.

facilities, and changes in communications have contributed to completely modifying the agricultural environment. As a result, people living in these areas are having to adjust to new circumstances and incentives. The adjustment process is just beginning and is slow; the system is no longer in equilibrium. This has created problems, some of which are severe and deserve immediate attention.

In the past 20 years, tremendous disparities in potential have developed between agricultural regions, and all regions have not equally benefited from new techniques. For example, in the marginal areas, modernization has been restricted to partial mechanization. These areas are located in the drier zones of sedentary agriculture, and production per unit area is stagnant or even declining. The neighboring areas have increased their productivity, and the relative importance of the marginal villages has been dramatically reduced. Due to their lower potential, compared with higher rainfall and irrigated areas, the marginal villages are neglected by government agricultural policy; yet, the plight of marginal villages goes beyond development policies.

Compared with areas that have increased their productivity through modernization, the cost of sheep production in the marginal areas is higher and thus less profitable. In some cases the returns are negative, and this raises questions about the future prospects of sheep production in these areas.

The situation becomes even more critical when the resource base is examined. Villages that were recently settled are suffering from a decline in soil fertility, which can be very acute. If the degradation process continues during the coming years, which it is likely to do, it would surely jeopardize the system's future. Declining production and profitability have caused other changes in the villages. In general, agriculture in this area has become either a soil 'mining' activity or a secondary activity depending on the availability of off-farm employment; the latter is becoming more common as off-farm income increases.

The future prospects of the marginal villages are critical not only for the area, but also for the country as a whole, and there is an urgent need to improve them. The plight of these villages is highly related to the modernization process at the national level. If it is to succeed, an approach aiming to provide suitable improvements will have to take into account the on-going evolutionary process and the forces affecting it. Instead of simple technical changes, the area requires a strategy that combines technical and socioeconomic improvements.

Therefore, a need exists to develop a specific research effort that focuses on these villages and integrates the technical and socioeconomic components of the problem. Such an effort will use and provide feedback to the more technically oriented research discussed in the following sections, with particular reference to the drier areas, i.e., 350 mm rainfall or less.

Component 2. Rotation Trials at Breda and Khanasser

Two-Course Rotation Trial

This season is the second year of a two-course rotation trial at Breda (275 mm rainfall) and Khanasser (220 mm). The objective of this research is to compare, from technical and economic perspectives, existing and alternative rotational systems that could make the use of land resources more profitable and provide a more stable source of food and income, while maintaining or improving soil fertility.

Traditional rotations under study are barley/fallow and barley/barley, and alternative rotations are barley/vetch with and without fertilizer, barley/chickpeas and barley/lentils with fertilizer.

Results. Yield data obtained in 1981-82 are given in Table 23. There was a marked difference in barley yields in response to the applied treatments, particularly at Breda (from 490 kg/ha in Bo/Bo to 1710 kg/ha in B_{np}/F). Seed yields of barley grown after fallow at Breda were the highest of the rotations studied. Barley yields following chickpeas (the latter yielding 790 kg/ha in 1980-81) and lentils (yielding 615 kg/ha in 1980-81) were also promising. Barley/chickpeas and barley/lentils were the two most productive rotations after the barley/fallow rotation. Unfortunately, the chickpea yields in 1981-82 were infested by *Ascochyta* blight and were very low. This may affect the results of this rotation next year as well. Yields of vetch plots where fertilizer was applied were about 2000 kg/ha. Given the high cost of animal feed these yields are likely to be highly profitable.

Table 23. Yields and yield components of barley, vetch, chickpea, and lentils in two-course rotation at Breda and Khanasser, 1981-82.

	Breda[a]		*Khanasser*[b]
Treatment	Total DM (kg/ha)	Grain yield (kg/ha)	Grain yield (kg/ha)
Bo/F	3700	1470	940
Bnp/F	5250	1710	1120
Bo/Bo	1300	490	640
Bnp/Bnp	2790	920	780
Bo/Vo	2380	870	850
Bo/Vp	2500	870	960
Bnp/Vo	2890	1020	830
Bnp/Vp	3220	1120	1020
Bnp/Lent. p		1250	690
Bnp/Ch.P. p		1320	1010
LSD (0.05) for barley yields	740	150	217
Vo/Bo	1200		
Vo/Bnp	1830		
Vp/Bo	1900		
Vp/Bnp	2010		
LSD (0.05) for vetch	260		
Ch.P./Bnp	980	160	
Lent./Bnp	2580	860	

a. Breda results given here are from combined yields. Combining was done after severe storm. Hand harvesting of 1 m^2 quadrats before the storm gave higher yields. An estimate of grain loss due to storm was established and used to correct combined yields. (Mean value of estimated grain loss = 290 kg/ha).
b. No vetch, lentil or chickpea yields are available from Khanasser, as these crops were completely destroyed in late winter by birds and frost.
B = Barley; F = Forage; V = Vetch; Lent. = Lentil; Ch.P. = Chickpea.
o = No fertilizer; n = Nitrogen added; p = Phosphate added.

At Khanasser, the yields were generally about 25% lower than at Breda and the treatment effects were less.

The effect of rotation on yields is highlighted when unfertilized treatments are compared. At both locations, the highest yields were obtained in the barley/fallow rotation; yields from continuous barley were the least. At Breda, the barley grain yield of the barley/vetch rotation was 78% more (380 kg/ha increase) than continuous barley; at Khanasser it was 33% more (210 kg/ha increase). The increase in barley yields after a fallow are even more dramatic when compared with continuous barley. This increase was 200% (a gain of 980 kg/ha) at Breda and 47% (a gain of 300 kg/ha) at Khanasser. These yields, at Breda at least, were greater than expected. The cropping history of the plot always plagues rotation trials. In this case, the plot was in fallow for 2 years prior to the barley crop, and this may explain part of the 200% increase. In the third year of these trials, this problem should be less important.

Yields of barley after vetch at Khanasser were not significantly different from barley after fallow; at Breda, barley/vetch yielded less barley grain than barley/fallow. The barley yields in the barley/vetch rotation were about the same at both Breda and Khanasser (870 and 850 kg/ha, respectively), which was less than expected at Breda. A possible explanation is that vetch was mixed with barley in 1980-81 (at Breda barley comprised 69% of the total drymatter produced, and 57% at Khanasser), which resulted in poor nitrogen fixation by the vetch crop and decreased yields in the second year. This effect was less important at Khanasser due to the high nitrogen levels in the soils at this site. During the 1981-82 season, the vetch treatment was a pure vetch stand, and next year's results will reflect more accurately those of a barley/vetch rotation.

There was a large barley yield response to fertilizer application only at Breda, in contrast to the previous season where a significant fertilizer effect was observed at both locations. Phosphorus increased vetch yields even when applied to the barley phase of the barley/vetch rotation. However, residual phosphorus did not appear to affect barley yields in this same rotation when applied to the vetch crop. This year's results suggest that the most efficient way to apply phosphorus is in the barley phase of the barley/vetch rotation and in combination with nitrogen. In this way, barley production is increased and vetch is still able to benefit from the residual phosphorus.

Fertilizer application failed to increase grain yields significantly at Khanasser this season, contrary to 1980-81, even though the total amounts of annual rainfall were similar (246 mm in 1980-81 vs 250 mm in 1981-82). Temperature and rainfall distribution, however, were different this season. Frost damage was more severe than in 1980-81, and rainfall distribution was characterized by a dry period from mid-February to the end of April when most growth normally occurs (34 mm in 1981-82 vs 69 mm in 1980-81). By increasing vegetative growth and thus moisture use in the beginning of the season, fertilizer may add to the water stress during dry periods and at the end of the season during grain filling, thus reducing grain yield.

Moisture Studies

This season, soil moisture was monitored in the unfertilized barley plots at both locations and on vetch in Breda. A vetch crop was not obtained at Khanasser due to frost and bird damage.

Results. Profile recharge occurred from the start of rainfall until mid-February, when maximum recharge occurred at both locations (Figs. 13 a,b and c). Less recharge occurred at Khanasser than at Breda and in general, did not extend beyond 105 cm depth in the fallow plots and 75-90 cm in the other treatments at either site. Rapid profile discharge, due to increased plant growth combined with a dry period, occurred at both sites from mid-February until the end of April, when late rains slightly recharged the soil.

Studies conducted this year on fallow management at Breda and Khanasser indicated that water storage is possible under a well-managed fallow. This is confirmed by the results of 1981-82 Bo/F moisture use(Fig.13) where 12 mm available moisture at Breda and 6 mm at Khanasser were stored in the fallow. Although very small, these amounts were used very efficiently; 1 mm of stored water yielded approximately 30-40 kg/ha of grain.

In the continuous barley rotation at Breda, growth was so poor that the crop could not extract all the available moisture in the soil profile. This is in contrast to barley following vetch and indicates that a nutrient deficiency is a major limiting factor in continuous barley.

The vetch crop did not use all available water stored from the current season rainfall (Fig. 13 b). The reason is not poor growth, but early harvesting of the crop for hay (mid-April). This moisture can be saved for next season's crop, if cultivations can provide a good mulch layer shortly after harvest.

At Breda, water-use efficiency (WUE) was greatly increased by fallowing, which produced 6.8 kg grain/ha/mm and 17.2 kg drymatter/ha/mm, compared with 2.6 and

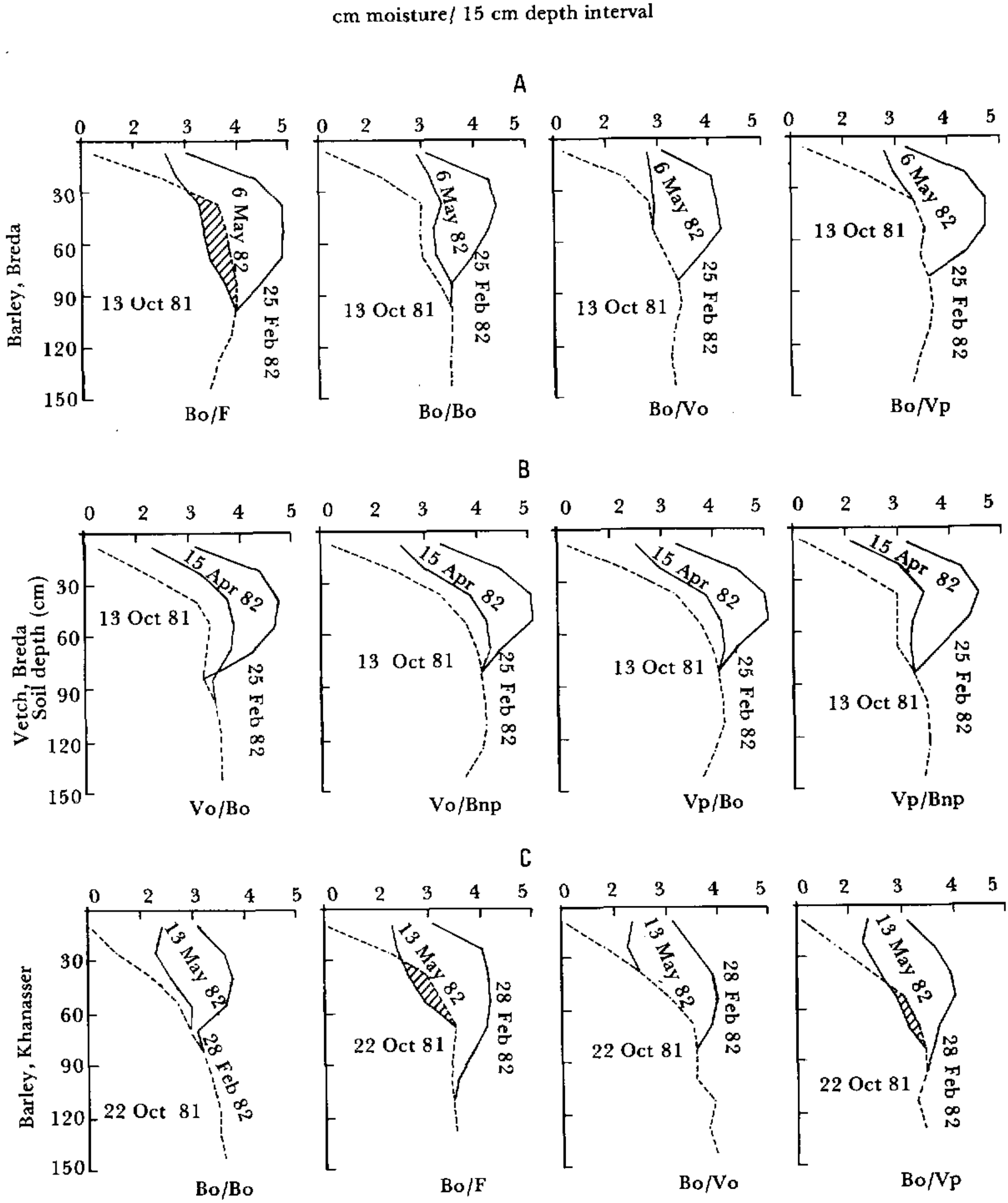


Figure 13. Moisture distribution on three selected dates under barley and vetch at Breda and Khanasser, 1981-82. Shaded areas represent available water stored from the previous season. (See Table 23 for explanation of abbreviations).

7.0, respectively, in continuous barley (Table 24). At Khanasser there was little difference in water-use efficiency between treatments, except in continuous barley which was less efficient in using water.

The inefficient use of water from germination to anthesis in all treatments at Breda (Table 24) was caused by the very low proportion of the evapotranspiration that was accounted for by transpiration from the crop. In addition, the accumulation of drymatter in the roots is not included in drymatter production measurements. From anthesis to maturity, however, WUE was greater in the Bo/F treatment and approached Fisher's predicted value of transpiration efficiency of 45 kg/ha/mm for April and May in Aleppo. This greater rate of WUE in Bo/F between anthesis and maturity was due to the development of a much greater ground cover by the crop (about 75%). Transpiration constitutes a larger proportion of the measured E_t. Root growth in cereals effectively ceases at anthesis, and drymatter production is then more accurately reflected by measuring the above-ground part of the plant.

In 1982-83 more intensive research will be conducted to obtain data from the rotation trials, aiming to develop a better understanding of soil nutrient and moisture dynamics of the different rotations and the climatic constraints on crop growth.

Component 3. Moisture Conservation in Fallow

Fallow Moisture Studies

Much work has been done on the role of fallow in the cereal/fallow rotation system in the Mediterranean environment. Invariably barley after fallow outyields barley after barley, and this has been confirmed by farmers and scientists in the ICARDA region. The major factors involved in this difference appear to be water conservation, available nutrient accumulation (principally nitrogen), weed control, ease of seed-bed preparation, and control of diseases.

Table 24. Barley and vetch yields and water-use efficiencies (WUE) in the two-course rotation trial at Breda, 1981-82.

Treatment	DM anth. (15/4) (kg/ha)	DM matur. (6/5) (kg/ha)	Seed yield (kg/ha)	E_t Germ. anth. (mm)	E_t Anth. matur. (mm)	Total E_t (mm)	WUE[a] (kg/ha/mm)	WUE[b] (kg/ha/mm)	WUE[c] (kg/ha/mm)	WUE[d] (kg/ha/mm)
Bo/F	2486	3700	1470	178	37	215	14.0	32.8	17.2	6.8
Bo/Bo	1609	1300	490	158	29	187	10.2	32.8	7.0	2.6
Bo/Vo	1935	2380	870	178	31	209	11.4	14.8	12.0	4.4
Bo/Vp	2203	2500	870	178	31	209	12.4	9.6	12.0	4.2
		Harv. (15/4)								
Vo/Bo		1200				159			7.5	
Vo/Bnp		1830				171			10.7	
Vp/Bo		1900				164			11.6	
Vp/Bnp		2010				170			11.8	

a. Germination-anthesis.
b. Anthesis-maturity.
c. Total WUE.
d. WUE of seed yield.
e. Higher yields obtained at anthesis than at maturity.
See Table 23 for treatment details.

It has been established that little moisture conservation is achieved by current levels of farmer-managed fallow in areas receiving less than 300 mm rainfall. However, there is potential for increased moisture conservation when fallow land is well managed. Moisture conservation studies were continued at several locations in Aleppo Province in 1981-82 (Fig. 14).

Results. The moisture distribution on three dates during the season is shown in Figure 13:(a) start of the season, (b) maximum profile recharge, and (c) at 2 months prior to seeding the following season's crop. The shaded area represents moisture stored from the current season. It is expected that between 6-12 mm of further evaporative loss will occur before the profile recharge starts in the 1982-83 season.

Optimum fallow management was achieved by rotavating to a depth of 25 cm in late spring. The deep, uniform tillage used in this treatment would be difficult for farmers to duplicate using local implements. From 2 years data there appears to be a general relationship between rainfall andmoisture storage. Even under optimum

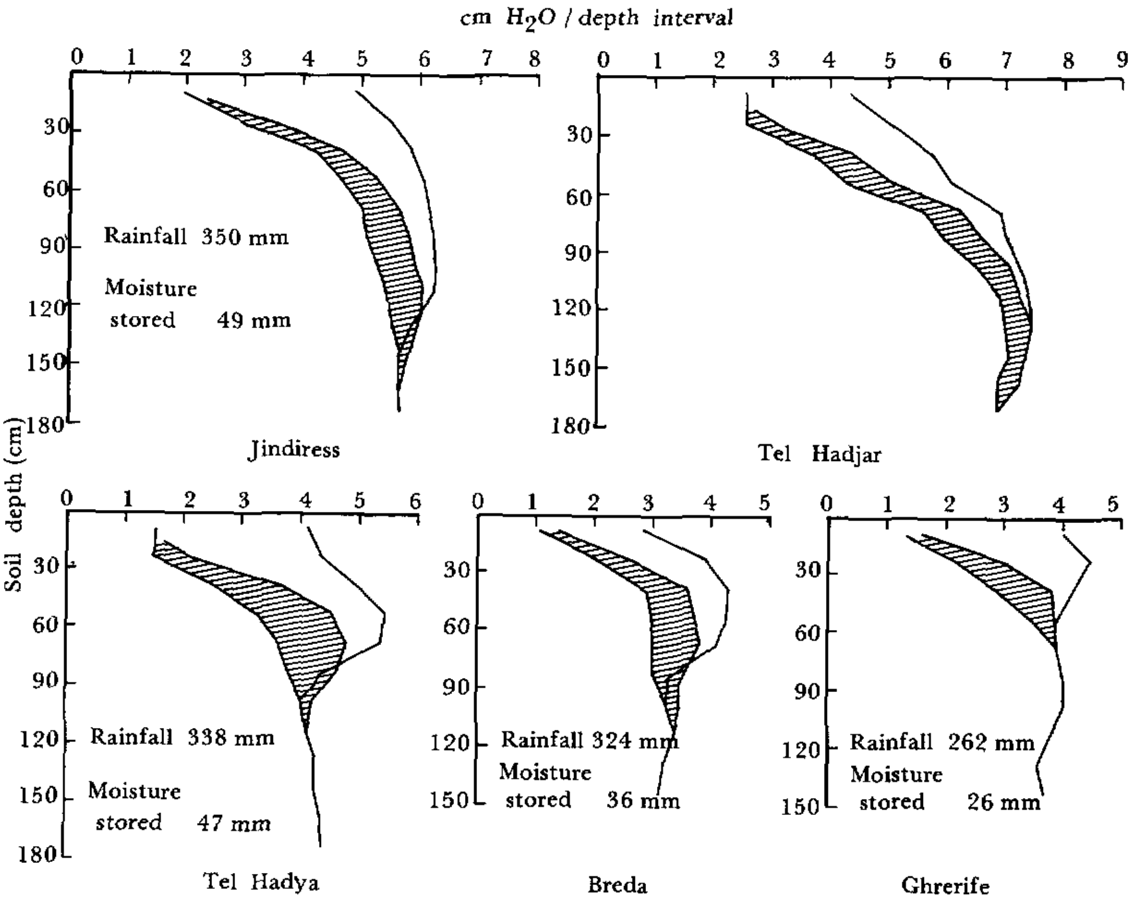


Figure 14. Moisture loss under fallow managed at optimum levels during summer months, 1982, at 5 locations in N. Syria.

fallow management it seems that no moisture can be expected to be stored in areas receiving less than 260 mm of annual rainfall, and this may be true for even wetter areas where local management practices are used.

To investigate whether moisture can be stored with these practices, a very simple trial was carried out in the 1981-82 season. A simple comparison was made at Breda (275 mm rainfall p.a.) on fallow management using a farmer's duckfoot cultivator. The cultivator was set up by the farmer with a single bank of tynes at a 45-cm row width. In one treatment the land was cultivated by one pass of the implement, and in the second treatment the land was cross cultivated a second time on the same day.

This cultivation followed the last heavy rainfall at the end of April.The moisture loss was monitored by use of a neutron probe with four access tubes per treatment. Initial results from this trial clearly show that the deeper, more even soil mulch achieved with the cross cultivation has significantly reduced the rate of soil evaporation during the summer months. Because of these interesting results, a more detailed fallow management trial is planned for the 1982-83 season.

Component 4. Cropping Systems and Crop Rotation Experiments at Tel Hadya

Long-term, large-scale trials were established at Tel Hadya in 1978 to examine typical two-and three-course rotations. The management of these rotations was varied to compare an improved agronomic package and the traditional farmer practice. Treatment details are summarized in Table 25.

Data from two seasons (1980-81 and 1981-82) are reported in Tables 26 and 27. These results are currently inadequate to arrive at any specific, long-term trends, but some generalized comments can be made. Owing to the large size of these trials (currently occupying 50 ha), agronomic management in the improved practice rotation proved to be a problem given the available resources. This, coupled with seasonal climatic variation, is reflected in inconsistent and variable yields. In general, however, improved management increased cereal yields in all rotations; yet, there was no clear indication that the management practice affected lentil yields. Data on summer crops were severely affected by the very low sesame yields in 1980-81 as a result of a severe disease infestation.

The yield of cereal crops, following either forage or fallow, showed no differences in 1980-81 but yields were reduced in 1981-82 in the plot following forage. More time is needed, and an economic evaluation of all components in these trials will be necessary to determine whether a forage/barley rotation can effectively replace the commonly prac-

Table 25. Cropping sequences in Two-and three-course rotational trials at Tel Hadya, 1978-79 to 1980-81.

	Two-Course Rotations			
Rotations	Deep soil		Shallow soil[a]	
years	1978-79	1979-80	1978-79	1979-80
1	SC	W	F	B
2	SC+	W+	F+	B+
3	Fo+	W+	Fo+	B

	Three-Course Rotations		
	1978-79	1979-80	1980-81
1	L	SC	W
2	L+	SC+	W+
3	SC	L	W
4	Fo+	SC	W

F = Fallow; B = Barley; Fo = Forage; W = Wheat; L = Lentils.
\+ = Improved management; SC = Summer crop: Water melon or sesame.
a. A soil survey showed that only a small proportion of the soil is shallow.

ticed fallow/barley rotation. It is clear that replicating farmers' practices on an experimental station is difficult and perhaps not a valid exercise. Research on crop rotations will change focus next year and more alternatives to a two-or three-course rotation will be considered.

Conclusion

Results obtained from this Project suggest that it is possible to increase crop productivity in marginal, low rainfall areas, by the introduction of new technologies and by changes in the traditional crop rotations.

Project IV. Livestock in the Farming Systems

Animal production accounts for 30 to 40% of the value of agricultural output in the countries of North Africa and West Asia. Demand for meat and milk products in particular is expanding rapidly due to human population growth and rising incomes, and it is necessary to increase production to satisfy this demand. However, the producers of these products are as important as the consumers; they are often resource-poor farmers with small areas of cultivated land and a few sheep and goats.

Table 26. Crop productivity from two-course rotations at Tel Hadya in the 1980-81 and 1981-82 seasons.

Treatment	Cropping season	
	1980-81	1981-82
Shallow soil		
1. Barley (grain kg/ha)		
Barley after fallow		
Traditional management	2388	2654
Barley after fallow		
Improved management	4728[a]	2555
Barley after forage		
Improved management	2256	1613
2. Vetch (Total drymatter kg/ha)		
Vetch/barley mixture after barley		
Improved management	2282	3611
Vetch/wheat mixture after wheat		
Improved management	1877	3131
Vetch/wheat mixture after water melon		
Improved management	2530	2301
Deep soil		
1. Wheat (grain kg/ha)		
Wheat after sesame		
Traditional management	2264	1321
Wheat after sesame		
Improved management	4048[a]	2522[a]
Wheat after forage		
Improved management	1986	1092
2. Sesame (grain kg/ha)		
Sesame after wheat		
Traditional management	69	160
Sesame after wheat		
Improved management	17	150

a. Significant effect of management.

Table 27. Crop productivity from three-course rotations at Tel Hadya in the 1980-81 and 1981-82 seasons.

	Cropping season	
	1980-81	1981-82
Wheat		
Wheat after lentil		
Traditional management	2440	1299
Wheat after water melon		
Traditional management	2366	1648
Wheat after water melon		
Improved management	4140[a]	3346[a]
Wheat after water melon	2342	1706
Lentil		
Lentils after wheat		
Traditional management	1149	897
Lentils after water melon		
Traditional management	1552	737
Lentils after wheat		
Improved management	932[b]	1559
Sesame		
Summer crop[c] after lentil		
Traditional management	81	4156
Summer crop after wheat		
Traditional management	54	3717
Summer crop after lentil		
Improved management	44	3097
Summer crop after forage		
Improved management	22	4162

a. Significant effect of management.
b. *Sowing was delayed.*
c. In 1980-81 the summer crop was sesame and in 1981-82 it was water melon.

In this region, livestock are so completely integrated into the farming systems that research aimed at increasing animal production must take into account that it complements crop production. The aim of livestock research in this context is to find ways of increasing farm income while raising the supply of animal products for consumers and enhancing ecosystem stability.

In the following section, some highlights of the livestock research are presented to demonstrate the approach being used. The research is organized into three components: crop-livestock systems, animal production from forage crops, and performance of Awassi sheep.

Component 1. Crop-Livestock Systems

Forage and Grain Values of a Barley Crop

Few crop management decisions in the drier areas are taken without considering the feed demands by livestock, and few livestock management decisions are taken without regard to the availability and prices of these feeds. One very close relationship between sheep and barley management is illustrated by the farmers' decision to harvest a crop for grain or use it for direct grazing by sheep.

The relationships between harvest costs and the economic values of barley grain and straw when harvested and the standing crop when grazed directly, are presented graphically in Figure 15. Some simplifying assumptions are:

1. Prices are constant through time and across locations.

2. The frequency distribution of grain yields is stable through time for a given cultivar and location, but differs between locations (as between Khanasser and Breda, Fig. 15c).

3. Harvest costs, grain, and straw values all increase as grain yield increases (Fig. 15a).

4. The direct grazing value of a standing crop (line dg in Fig. 15b) also increases with grain yield and is positive even at the lowest grain yields.

The shaded area in Figure 15b represents the contributions of forage to the total value of the crop. Grain yields are so low at Khanasser that farmers would have little interest in barley cultivation if there were no demand for forage. At Breda, average grain yields are nearly double those at Khanasser, and are rarely low enough for farmers to decide to graze rather than harvest. Nevertheless, forage values at Breda add substantially to the total value of the crop.

A farmer may be indifferent when choosing two cultivars if one exhibits lower grain but higher forage values than the other. Such an ambiguous case is illustrated in Figure 16. What cultivar A lacks in grain yields, relative to cultivar B, is compensated by its superior grazing and straw values. Another cultivar with the same yield distribution as cultivar B could be considered superior to both cultivars A and B, if its forage value were only slightly higher than that of cultivar B.

Barley is Syria's number one forage crop with most of its above-ground biomass being used in one way or another by livestock. More research is needed to develop cultivars superior to the local ones with respect to mature forage quality and quantity, and grain yields.

Livestock-Crop Survey Results

An important objective of the livestock studies has been to identify economic and husbandry constraints that limit animal productivity. Information on husbandry systems and sheep performance was collected in a 3 years survey conducted in the steppe area of Aleppo and Raqqa Provinces receiving about 200 mm annual rainfall. Results have been compiled on

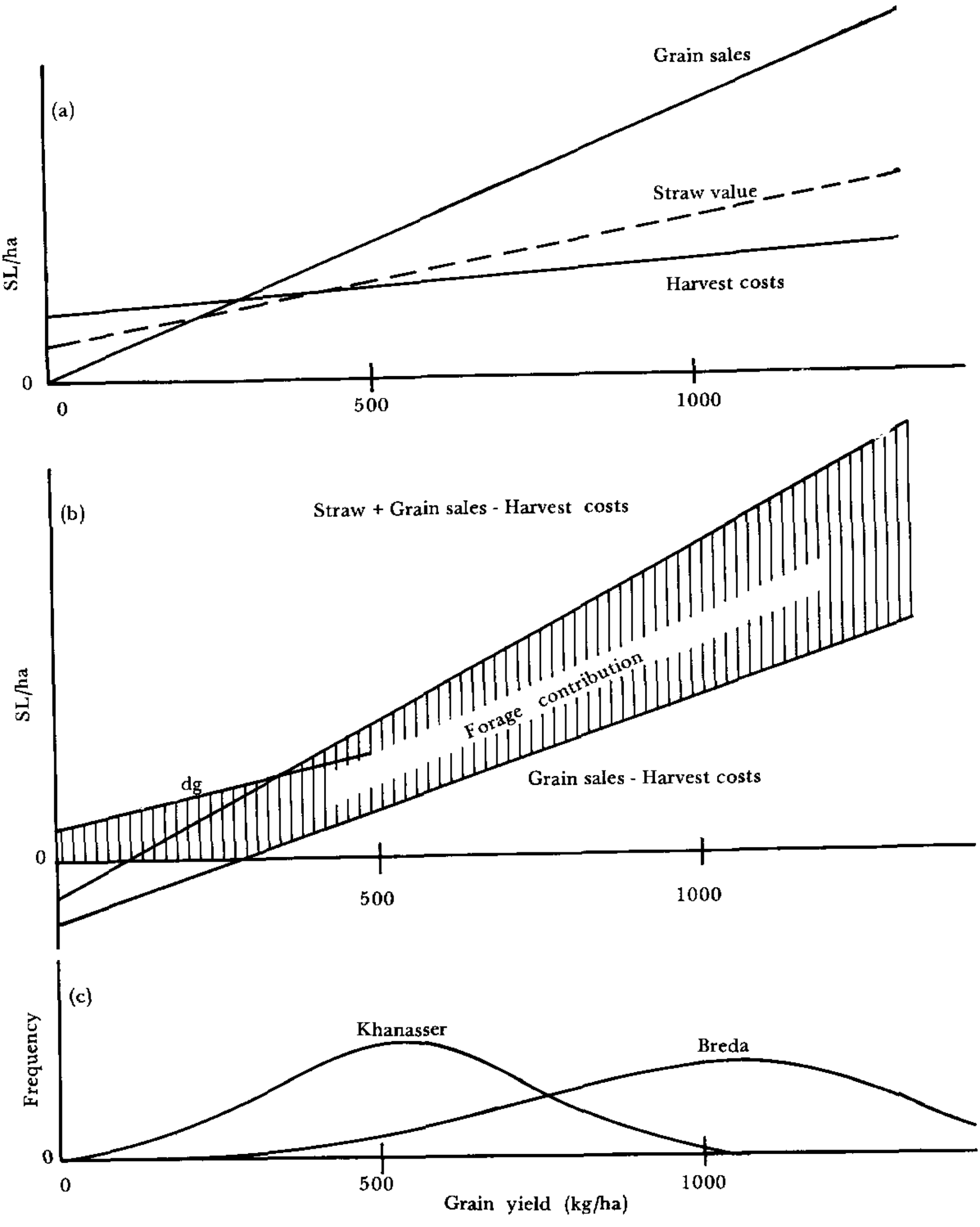


Figure 15. Forage contributions to barley crop value.

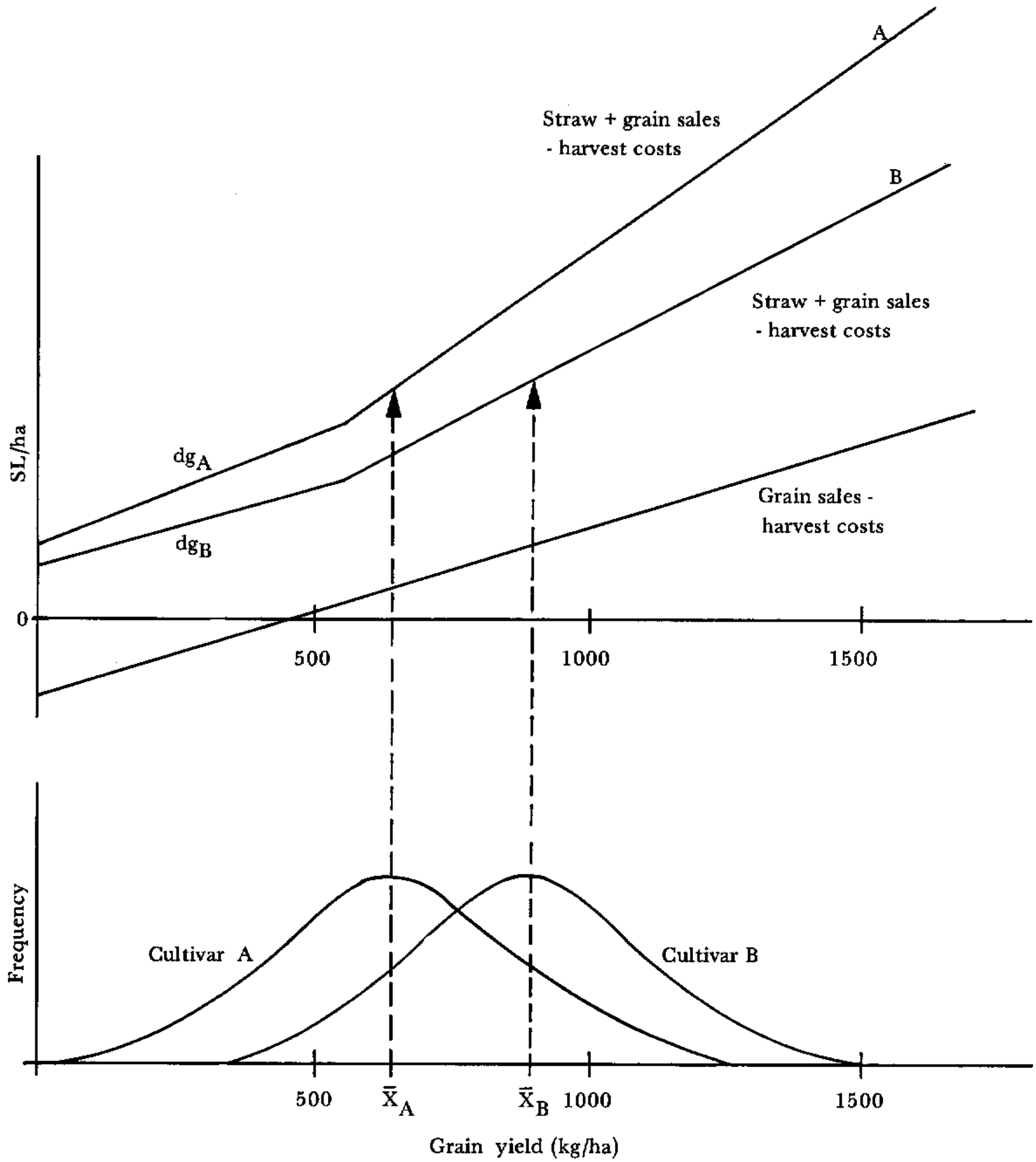


Figure 16. Counterbalanced forage and grain values of two cultivars A and B.

the flock structure, reproductive rate, and mortality levels of 18 flocks (Table 28).

During the survey, sheep numbers expanded on average by 3 to 4% per annum even though sheep numbers decreased due to a dry year in 1978-79. The flocks ranged in size from 30 to over 1000 head. Additions to the ewe flocks averaged 31%, of which 2% were purchased. Attrition from the flock totalled about 30%. After deducting transfers, which represent ewes given to other members of the family, the culling rate was 23%. This culling rate suggests that the average ewe bears four or five lambs and is culled at an age of 6 to 7 years. Increasing the culling rate would have little impact on ewe productivity since farmers are already removing ewes from the flock that are found to be barren following the mating season.

Lambing percentage is defined as the number of lambs born per 100 ewes mated. The average lambing percentage of 84% for the flocks in the survey is well below the 97% achieved across the three Tel Hadya flocks in 1981-82. However, large variations across flocks were evident, the range being from 69 to 102%. The 84% lambing rate is the same as that estimated in the earlier FSP studies of six villages in Aleppo Province. Low lambing percentages are a major factor limiting the biological and economic efficiency of the system. Increasing the lambing performance from 84 to 100% and holding mortality constant at 10% would increase lamb sales by 30%. *The causes of low lambing percentages* in village flocks warrant further study.

Mortality levels for ewes, yearlings, and lambs in the sample were less than expected. *These values may be slightly higher* since some sick animals are sold. Again the mean values are associated with large variations. There were cases where losses exceeded 30% in localized epidemics. The pathogens responsible for these epidemics need to be identified. They often attack healthy lambs that have passed through the critical neo-natal period. Good husbandry practices, particularly nutrition of ewes in late pregnancy, can reduce neo-natal deaths. But good nutritional practices can do little to reduce mortality of older lambs when virulent pathogens are involved. Instead, routine vaccination may be the only effective control.

Component 2. Animal Production from Forage Crops

The unit farms at Tel Hadya have shown increasing value as testing grounds for prototype crop rotations and sheep husbandry practices in the context of a complete system. Particular emphasis is being placed on the

Table 28. Summary of inventory balance sheet of survey flocks, 1978 to 1981[a]

	Ewes (per 100 ewes in opening inventory)	Yearlings (per 100 yearlings in opening inventory)	Lambs (per 100 lambs born)
Transfers (In)	29 ± 6.9	101 ± 49.7	
Purchases	2 ± 2.4	1 ± 3.2	
Sales	15 ± 10.7	5 ± 5.1	40 ± 7.3
Deaths	7 ± 6.7	2 ± 2.5	11 ± 9.5
Consumption	1 ± 0.6	2 ± 1.7	6 ± 3.0
Transfers (Out)	7 ± 7.3	90 ± 9.3[b]	43 ± 9.1[c]

a. Average flock size was 176 ± 110 ewes and 58 ± 39 yearlings. Over 3 years these numbers expanded at an annual rate of 3 and 4%, respectively.
b. To ewes.
c. *Female lambs to yearlings.*

replacement of fallow by a pasture crop, and the impact of improved nutritional regimes on the reproductive rates and milk production of ewes (as measured by the growth performance of their lambs).

The unit farms consist of one medium-input and one high-input farm of 14.1 and 10.9 hectares, respectively. Each has an area of stony-shallow soil and an area of deep soil. On the medium-input farm a barley/fallow rotation is practiced on the stony-shallow soil and a wheat/lentil/watermelon rotation on the deep soil. On the high-input farm a vetch pasture replaces fallow on the shallow soil and a vetch/wheat hay mixture replaces the lentil crop on the deep soil. In addition, improved crop varieties, higher fertilizer levels, seed drills, and herbicides are used on the high-input farm.

Flocks of 36 and 42 Awassi sheep are assigned to the medium-and high-input farms, respectively. The medium-input flock is managed in a manner similar to that by farmers in the Tel Hadya area. The high-input flock receives additional supplementary feed during the mating season, during late pregnancy, and early lactation. They are also vaccinated against diseases such as foot-and-mouth and enterotoxaemia.

Each flock is allocated a separate 11.5 hectare area of marginal rangeland for grazing. The stocking rates on the medium-and high-input farms are 2.6 and 3.9 ewes per cultivated hectare, respectively.

A third, low-input flock (named the sacrifice flock), serves as a control. It is subjected to a poor level of husbandry: limited supplementary feed in winter and over-stocking on marginal land are examples. The management of this flock is below that practiced by most farmers in the area. The three levels of husbandry, i.e., low, medium, and high, provide a useful framework for studies that aim to determine the most economical levels of inputs.

The performance of lambs grazing the vetch pasture, which replaces fallow, is shown in Table 29. A grazing season of 70 days was achieved in the 1981-82 crop year, which is close to the maximum that can be achieved with vetch. The daily lamb liveweight gains were less than those recorded in two previous years because of the higher stocking rate. However, there was an increase in liveweight gain per hectare to 260 kg, which is also considered to be near the maximum possible for vetch pasture.

It appears from these results that increasing animal production beyond 260 kg/ha will be possible only if drymatter yields can be increased or the length of the grazing season extended. It is unlikely that vetch can fulfil the first condition, so it will be necessary to identify a species with a longer grazing season;

Table 29. Lamb growth rates on vetch pasture, Tel Hadya 1979-80 to 1981-82.

	1979-80[a]	1980-81	1981-82
Number of lambs	30	24	38
Start of grazing	22 April	1 April	8 March
End of grazing	19 May	1 June	17 May
Grazing days/ha	18	41	47
Stocking rate lambs/ha	20	16	25
Initial liveweight (kg)	27.2	28.8	23.2
Final liveweight (kg)	34.1	43.3	33.7
Liveweight gains:			
per hectare (kg)	139	232	260
per lamb (g/day)	255	238	151

a. Crop resown in January.

such a species has not yet been identified. Alternative strategies could include using a sequence of a species or a mixture of species that combine early and late maturity. The Pasture and Forage Program has already identified barley cultivars that can provide early grazing in February.

The animal production potential of a pasture species that replaces fallow has been defined. A goal over the next 5 years is to reach a liveweight gain of 500 kg/ha in a 4 month grazing season in the 350 mm rainfall zone. Studies that aim to define the animal production potential of pastures in zones receiving below 350 mm are in progress and will receive increased emphasis in the future.

An assessment of the economic returns associated with replacing a fallow with a pasture crop is the most important criterion for judging the viability of this change in rotation. This has been studied in the case of the unit farms, and the results are presented in Table 30. Net benefits are defined as the difference between the gross revenue of a rotation minus the variable (direct) costs of carrying out the rotation. Introducing the pasture crop accounted for nearly 40% of the increase in net benefits of the barley/pasture over the barley/fallow rotation. The remaining increase was due to using an improved barley variety (Beecher), more nitrogen, and a seed drill.

Pastures are not yet able to supply sheep with feed from November until March, a period when the nutritional needs of the ewe are considerable. In Syria this deficit is corrected by using supplementary feeds. However, these are usually expensive and some are currently imported. Thus, hay production is being given considerable attention by researchers. There are numerous obstacles to the introduction of haymaking technologies. For example, vetch-wheat mixtures for hay following a wheat crop on the unit farm have not given satisfactory yield, partly because wheat follows wheat in 2 years of the rotation. It may be necessary to resort to pure stands of legume forage. Other difficulties include problems of mechanical harvesting on stony soils, loss of highly nutritious leaf material during the haymaking process, and the making of hay before the end of the rainy season. These problems should be given special attention by researchers, and some are already under study.

Table 30. Comparison of net benefits for medium-and high-input 2 years rotations at Tel Hadya[a]

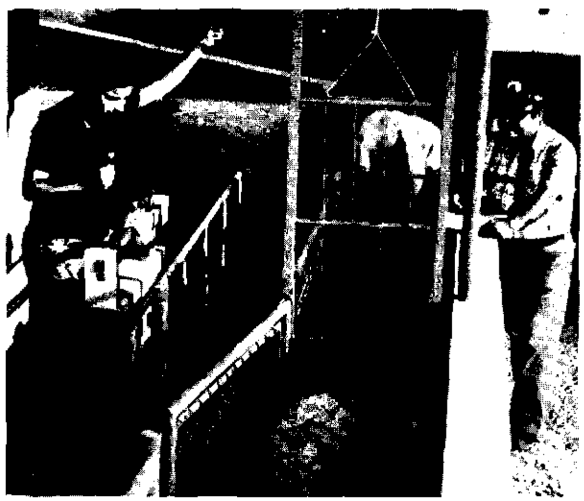
	Net benefit (SL/ha)[b]	
	Medium input	High input
Year 1	1097 (barley)	2369 (barley)
Year 2	(fallow)	1497 (pasture)[c]
Two-year sum	1097	3866

a. 1979-82 average performance.
b. Based on constant 1982 prices.
c. Gross revenue based on lamb liveweight gains when fattened on vetch pasture.

Component 3. Performance of Awassi Sheep

Lamb Growth Rates

Part of the 1981-82 survey of 13 flocks,



Weighing sheep for comparing various food regimes.

which was spread across the rainfall transect of Aleppo Province, involved the monthly weighing of about 250 ewes and their lambs. The actual growth performance of lambs in farmers' flocks was compared with those obtained in the three experimental flocks at Tel Hadya (Table 31). Such information on the actual and potential performance of a breed makes it possible to define the yield gap that exists in the system. With this information, research priorities can be established.

Results of the survey showed that growth performance of lambs in farmers' flocks could be increased by 59% if management of ewes in late pregnancy and early lactation were given more attention. This aspect, therefore, is given special emphasis in the study reported in the next section.

Supplementary Feeding of Ewes

The level of feeding of ewes during late pregnancy and early lactation can have a marked effect on the growth rate of lambs and on milk production for yoghurt and cheese making. A trial was conducted to study the effect of three levels of supplementary feed during the last 49 days of pregnancy and the first 56 days of lactation on lamb growth rates. The aim was to determine the economically optimal levels of supplemental feeds under various price and cost situations.

The low-, medium-, and high-input flocks received three levels of supplementary feed based on barley, cottonseed cake, wheat bran and a basal diet of vetch/ wheat-hay or lentil straw. Ewes were weighed weekly and supplements were fed on an individual basis. The metabolizable energy intakes, mean liveweights, and liveweight changes are presented in Table 32.

Supplementary feed had a marked effect on liveweight changes of the ewes during late pregnancy. During lactation the daily liveweight change of the low-input flocks was -96 g, but that of the other two flocks was about -200 g. The high level of nutrients supplied from the supplements together with the energy derived from body tissue reserves were the two major factors that lead to the highest liveweight gains in lambs of the high-input flock (Table 32). The total weight of lambs in the medium- and high-input flocks were, respectively, 25 and 45% higher than the low-input flocks.

Table 31. Daily liveweight gain (lambs to weaning[a]) in farmers' and three experimental flocks at Tel Hadya, 1981-82.

	Daily liveweight gain (g)	
	Males	Females
Farmers' flocks	185±32.2(75)[b]	158±28.3(71)
Three experimental flocks	246±49.7(41)	222±49.2(47)
High in-put flock only	299±16.4(13)	247±37.2(18)

a. 60 days.
b. Numbers of animals weighed.

A preliminary analysis of profitability was made on data from the three experimental flocks. Nutritional management of ewes had a clear effect on lamb weaning weights, but less impact on milk and wool production. This is significant since about 70% of earnings from breeding flocks are derived from the sale of lambs. These animal products are expressed as gross revenues in the budgets presented in Table 33, together with the cost of supplements. A measure of the returns for comparing the three flocks is given by the *Margin-Over-Supplementary-Feed-Costs* (MOFC).

Whereas gross revenues increased by 51% from the low- to high-input flocks, the increase in supplementary feed costs was 348%. Hence the MOFC was lowest for the high-input flock. Expressing the MOFC per hectare altered the picture because the stocking rate on the high-input farm was higher than on the medium-input farm. The MOFC of the high-input flock, however, was still less than that for the medium-input flock.

The major reason for the poor economic performance of the high-input flock was the heavy cost of supplementary feed during the

Table 32. Intake of supplementary feed, mean liveweight, and liveweight changes of ewes and growth rate of lambs (Tel Hadya flocks), 1981-82.

	Level supplementary feed		
	Low	Medium	High
Pregnancy (last 49 days)			
Dry matter intake (kg)	0.4	0.68	1.09
Metabolizable energy intake[a] (MJ)	3.49	5.43	11.44
Liveweight[b] (kg)	45.5	52.3	58.8
Liveweight change (g)	1.0	61.0	122.0
Lactation (first 56 days)			
Drymatter intake (kg)	0.45	0.8	1.04
Metabolizable energy intake (MJ)	3.89	6.4	10.97
Liveweight[c] (kg)	34.9	40.3	48.3
Liveweight change (g)	-96.0	-202.0	-206.0
Growth Rate			
Male Lambs			
Number of lambs	13.0	15.0	13.0
Birth liveweight (kg)	4.30	5.10	5.20
Weaning liveweight (kg)	16.60	19.10	23.20
Liveweight gain (g)	206.0	238.0	299.0
Female Lambs			
Number of lambs	13.0	16.0	18.0
Birth liveweight (kg)	4.1	4.5	4.7
Weaning liveweight (kg)	16.0	17.2	18.6
Liveweight gain (g)	200.0	212.0	247.0

a. Estimated from drymatter intake x digestibility of organic matter in drymatter x 0.15.
b. 24 days before lambing.
c. 28 days after lambing.

Table 33. Level of supplementary feeding and margin over supplementary feed costs in three experimental flocks, 1981-82.

	Level of input		
	Low	Medium	High
Unit farm size (ha)		14.1	10.9 (10.9)[a]
Unit farm flock size[b]	32	32	32 (32)
Supplementary period (day)	140	140	231 (140)
Flock gross revenue (SL)	6541	8853	9904 (9904)
Total suppl. feed cost (SL)	1875	2938	6433 (4925)
MOFC[c] per ewe (SL)	146	185	105 (156)
MOFC per hectare (SL)		419	309 (457)

a. Supplementary feed during mating period shown in parentheses.
b. Includes barren ewes and one ram.
c. Margin over feed costs.

mating period and the absence of an effect of this on reproductive rates. In future studies, emphasis will be placed on designing husbandry practices that will assure maximum reproductive rates and on controlling costs.

Conclusion

Livestock enable farmers to extract an economic value from resources that would, otherwise, be unusable. In the drier farming areas as at Khanasser, for example, sheep constitute an insurance policy against poor grain production, which is risky and unprofitable. Research will be continued to clarify these and other crop-livestock interactions and to estimate the parameters of those interactions already identified.

Project V. Environmental Zoning

There is a need to classify the ICARDA region into zones to provide realistic targets for agronomic or breeding programs, and this project seeks to fill this need. It has two principal objectives that comprise the initial data collection phase: (a) to collect and collate agroclimatic data for use in agroecological zoning and (b) to collect information on agricultural policies with the purpose of analyzing their effects on agricultural production.

Component 1. The Collection, Collation, Distribution, and Use of Agroclimatic Data

A comprehensive collection of a full range of daily records of meteorological variables was made in the 1981-82 cropping season at the five principal FSP research sites in Syria (Jindiress, Kafr Antoon, Tel Hadya, Breda, and Khanasser). This information has been widely circulated on a weekly basis within ICARDA. These data serve as the basic information required to assess the effects of climate on experiments in all FSP projects. They are of particular value in crop physiological and soil-moisture studies. The value of these data has been further enhanced by the increased use of the FSP research sites by the ICARDA commodity programs in the 1981-82 cropping season. Additional data (usually only rainfall) have been collected from a wide range of on-farm trial sites, to act as the minimum data required for site assessments. A summary of data from all sites for the 1981-82 season is presented in the chapter "Meteorological Data 1981-82" in this report.

Important additions to the ICARDA data bank in the current season include all available daily rainfall values for up to 25 years from the six Syrian Meteorological Service recording stations nearest to the principal FSP research sites. These include Jindiress, Azaz (for Kafr Antoon), Aleppo and Saraqeb (for Tel Hadya), Breda, and Khanasser. Long term seasonal rainfall values for these sites were generally calculated from daily data over 20 years.

This year, the ICARDA climatic data bank was tranferred from the University of New England, Australia, to ICARDA's computer. This comprehensive collection of data will act in the future as the core information for ICARDA's data collation effort.

Initial Zoning

The long term rainfall data acquired from the Syrian Meteorological Service for the six sites were given to the Agricultural Meteorology Research Group at the University of Reading for analysis and for quantifying the probability of a rainfall event and its likely intensity. Differences in the probabilities of rainfall occurrence between sites are evident and as a result of these differences it is hoped that the descriptive constants of the probability equations may act as initial building blocks for developing a zoning scheme.

The University of New England/ICARDA wheat maturity modeling project has been further developed in the 1981-82 season. This model, which is driven by meteorological variables, has considerable potential for zoning. The model is near completion and preliminary results are expected by mid-1983.

Intensive data collection at the principal FSP research sites will continue in the 1982-83 *cropping season*. Further sites will be added to the current on-farm trial network including the majority of cereal agronomy trial sites in Syria and Jordan (Project I).

Component 2. Socioeconomic Environments: The Perspective of Agricultural Policies

The basic premise for this component is that socioeconomic constraints, especially those emanating from government policies, are being increasingly recognized as important. Technical research aimed at a physically homogeneous zone may have variable results if the zone is further divided into several different socioeconomic environments. From an awareness of such policies, and without getting involved in value judgements, it is expected that the effectiveness of the FSP agricultural research will be increased. This project was initiated in 1982 with a literature survey and insights obtained have allowed the research effort to be economized by emphasizing summary measures or indicators of policy rather than by extensively enumerating specific policies.

The FSP is particularly interested in policies influencing ICARDA crops in the Middle East and North Africa. It is likely that, despite vast differences in political regimes, agricultural policies within the region will have substantial similarities. These similarities will be clearer in policy objectives whereas policy instruments will show a high degree of variation. These objectives and instruments are mentioned below followed by a brief discussion of summary measures.

Policy Objectives

Agricultural policies have various objectives of which the most important are:

1. Change income distribution among classes of producers, among classes of con-

A typical Syrian village in the drier zones.

sumers, between consumers and producers, and between the urban and the rural populace.

2. Increase production in general, or for a particular commodity.

3. Stabilize incomes, prices, or production.

4. Increase government incomes by taxing the agricultural sector.

5. Accelerate economic development as it is now recognized that economic development is impossible without agricultural development.

Policy Instruments

There are six classes of instruments with which these policy objectives can be achieved:

1. Price policies are the most widely used policy instruments. These include fiscal policies and foreign trade policies that directly influence the prices of agricultural products and inputs. Examples of these are subsidies, preferential credits, export taxes, subsidized sales from imports, etc. The variation in price policies is substantial; support prices, guaranteed prices, minimum prices, input subsidies all reflect on the costs and prices of agricultural products.

2. Fiscal and monetary policies, for example, taxes, subsidies, and credit policies usually impinge on the prices and profitability of the crops. Credit has a particularly important role in agriculture because of the seasonality of production.

3. Foreign trade policies generally involve controls, export and import taxes, tariffs and quotas on imports etc. Exchange rate policies even though aimed at foreign trade, have interesting implications for agricultural production. Overvalued or undervalued exchange rates essentially imply tariffs or export subsidies for domestic production, respectively.

4. Physical controls involve hectarage and area controls, delivery quotas to government purchasing agencies, restrictions on the movement of products, etc.

5. Structural change involves a discreet change or transformation with wide spatial and temporal effects. Examples of this sort of policy are land reform, agrarian reform, or implementation of irrigation schemes.

6. Agricultural research involving both pure and applied research and covering extension efforts as well, is usually not considered to be a policy instrument. However, the results of and returns from agricultural research and technological developments have indicated them to be most effective instruments, especially in achieving targets of production.

The multiplicity of policy targets and instruments makes analysis quite difficult: what is needed is a summary measure. The initial effort in this project is directed to those cases that are amenable to analysis within the frame of agricultural price policies.

Effects of Agricultural Price Policies

They can be summarized under four headings:

1. Production. It has been demonstrated fairly extensively in the literature that agricultural producers in developing countries are responsive to prices.

2. Costs of the purchasing agency and the state. Effective price policies require efficient management in purchasing, storage, etc.

3. Income distribution. Price policies targeted at given commodities (or inputs used intensively in the production of some commodities) benefit the producers of those commodities relative to other producers. Even for a given commodity, larger producers or those who market a larger amount benefit more. Price policies aimed at consumers are in essence income transfers.

4. Resource allocation. Changes in the absolute price of a given commodity implies a change in relative prices. These changes alter the relative profitability of producing different commodities. Consequently, resources will be drawn out of the production of less profitable

commodities, and transferred to more profitable uses.

Summary Measures

Only an example of a summary measure is given here to indicate the direction that this research is taking and its value. The Nominal Protection Coefficient (NPC) is the ratio of domestic prices to border prices, i.e.,

$$NPC = P_d/rP_b$$

where P_d = domestic price, P_b = border price, and r = official exchange rate.

NPCs provide simple measures that can be calculated easily. Furthermore, they provide a good idea about the extent to which a commodity is being subjected to interventions and whether these are in the form of incentives or disincentives. Following on the discussion above, a NPC less than 1 implies that the domestic producers are discriminated against, whereas a NPC more than 1 indicates policies that support local producers by protecting them from the effects of the international market.

For example, the NPC's for collection center purchases from farmers in a country in the ICARDA region are given in Table 34 for wheat and barley for 1972-73 to 1979-80. The general indication from these data is that there is a significant bias against agricultural production. Even when there are periods of preferential treatment of certain commodities, this treatment lacks continuity. The bias which exists in national policies against ICARDA crops will be a serious impediment to the effective dissemination of the new technologies that ICARDA is developing.

In 1982-83 work will continue in this project with a shift to data collection for detailed studies of the region and for ICARDA crops. Preliminary emphasis will be on claculating NPC.

Table 34. NPC ratios for a country in the ICARDA region for wheat and barley, 1972-73 to 1979-80.

	Durum Wheat	Bread Wheat	Barley
1972-1973	0.65	0.65	0.53
1973-1974	0.47	0.45	0.41
1974-1975	0.68	0.70	0.63
1975-1976	0.91	0.94	0.78
1976-1977	1.24	1.26	0.93
1977-1978	1.10	1.20	0.88
1978-1979	0.93	0.95	1.00
1979-1980	1.02	1.08	0.97


CEREAL IMPROVEMENT PROGRAM

Contents

(Photo on previous page: A newly developed, high yielding durum wheat at Tel Hadya).

CEREAL IMPROVEMENT PROGRAM

Introduction

The Cereal Improvement Program seeks to assist national research institutions in the region to increase barley and wheat production through the development and/or introduction of improved genotypes with high yield potential under rainfed conditions, stable performance, better resistance to diseases and insects, together with the development of improved management practices for their cultivation. It further aims at breaking the traditional yield limits of the less favorable cereal growing environments where resources and management are limited.

Barley ranks second to wheat as the most important winter cereal crop in North Africa and West Asia. It covers an area of about 10 million hectares and produces slightly less than 10 million tonnes of grain. A large percentage of the barley crop is grown in environments where other cereal crops are not dependable. Low prices of barley in relation to wheat and the absence of any significant research on the crop in the region are responsible for the dramatically low yields; however, the superior water-use efficiency of barley compared with other winter cereals makes it a suitable choice for many environments of the region. Very often in North African and West Asian countries, barley is grazed by sheep during the winter months, particularly in drier areas where barley fields are the only source of feed during the period December-February. Therefore the development and identification of varieties that produce good drymatter yields when grazed at the tillering stage and then recover well to produce large grain yields is a means of improving the productivity of one of the poorest farming sectors in the region.

Durum wheat occupies the largest cereal area in many countries in North Africa and the Middle East, e.g., Morocco, Tunisia, Algeria, Syria, Turkey, and Jordan. About 31% of the total wheat production in the region is durum wheat. In particular it is in the drier areas where it has proved to be better adapted than bread wheat. However, little work has been done in durum wheat improvement. Local unimproved varieties and traditional agriculture still prevail in much of the region. There is therefore ample opportunity for ICARDA to make an impact on durum production. One of the main objectives is to develop durum wheat varieties that possess the genetic potential to perform satisfactorily on limited soil moisture, with the capacity also to respond well when water and nutrition become less limiting. Selection for nutrient and moisture-use efficiency are also important.

Bread wheat ranks first among food crops in the ICARDA region and provides the principal food for the majority of the population, which on average consume more than 150 kg wheat/capita/annum. Although the region as a whole produces approximately 44 million tonnes/year, it is a substantial net importer. Over 90% of bread wheat is grown on 250-650 mm of rainfall; half of the area receives less than 400 mm annual precipitation. Because many modern high yielding varieties are more suitable for irrigated and high fertility conditions, ICARDA bears a special responsibility with CIMMYT to develop varieties and production technologies suitable for the low-rainfall zones. The goal of the ICARDA/CIMMYT bread wheat cooperative project is to develop and distribute within the region, superior germplasm that is tolerant to drought, cold, diseases, and insects.

ICARDA aims to breed triticales for specific, adverse environments. Development of triticales with high and stable yields, for these conditions, is a major goal. There is interest in triticale for the poultry industry. In Tunisia, it may replace imported maize grain for poultry food. ICARDA plans to do less work on triticale in future and devote more of its resources to barley and durum.

Agronomy research in the Cereal Program is conducted in support of breeding. The main aim is to develop genotypes adapted to less favorable environments, where resources are limited and the return from the use of fertilizer is uncertain

Because losses caused by diseases and insects are substantial the identification and

Hybridization, i.e., crossing, is the first step in the breeding program. It aims at bringing together desired characteristics. Here, barley lines are being crossed at Tel Hadya.

utilization of sources of broad-based genetic resistance is a major thrust in the Program.

ICARDA plans a different approach to research for high elevation environments (1000-3000 meters) than was proposed when the Center was established. Instead of centralized research at a major high elevation research station, efforts are now being directed towards the development of a network of smaller projects covering the diverse range of high elevation environments in the ICARDA region. Here, the high and medium elevation arable areas account for 50% of the total wheat areas in addition to eight million hectares of barley. These areas are mainly in Turkey, Iran, Afghanistan, Pakistan, and North Africa where more than 100 million people live, and of whom 60% are engaged in agriculture. Because the technologies evolved for lowland agriculture in various ecological zones of the region are not always applicable to the dryland farming communities of these areas, the development of suitable production technologies is of great importance. A research project at two locations (Quetta, Pakistan; Annaceur, Morocco) has been initiated to address the problems of these areas.

Where the Program is not able to conduct research needed in the ICARDA region, because of lack of expertise or facilities, it has developed contacts with centers of excellence in order to acquire and accumulate the scientific information needed.

Barley Improvement

In previous years barley improvement concentrated on assembling a large germplasm pool, which has since been used in crosses. The resultant improved germplasm is now being distributed to national programs to meet an urgent need for fixed lines in many countries in the region.

Barley Breeding

1. Improved Barley Varieties and Production Technology for Low Rainfall Areas
The main objective of this project is to develop disease-resistant barley genotypes with greater yield potential, yield stability, and adaptation to the lower rainfall areas in the region. There, barley is the dominant cereal crop, and with sheep constitutes the main farming activity. Information on breeding material tested in this project is presented in Table 1. The decrease in screening activities begun during the 1980-81 season continues while selection in generations F_2-F_8 and testing have increased. The effort devoted to international nurseries and yield trials remains more or less constant.

Many lines have now been selected by

Table 1. Evolution of germplasm material in the barley program: number of lines tested.

	Season				
Material	1978-79	79-80	80-81	81-82	82-83
Tel Hadya nurseries	13412	13496	3310	1404	900
International nurseries	448	349	374	674[a]	674
Seg. populations	13316	14412	22976	20030	16000
Yield trials	1078	1177	1188	1386	968

a. Different sets of material from one type of nursery are sent to different environments.

Table 2. Number of lines selected by national programs from international nurseries.

Country	Barley Yield Trial					Barley Observation Nursery					Total
	1977-78	78-79	79-80	80-81	81-82	1977-78	78-79	79-80	80-81	81-82	
Morocco		16	3		5		23		38		85
Algeria	4	0		3			47		40		94
Tunisia			15	20	18	20		51	116	57	297[a]
Egypt	13	19	7		0	29	10			0	78
Syria	23	15	13	6	14	38	117	16	63	51	356[a]
Lebanon	11	21	20	2	5	16	25	9	41	30	180[a]
Jordan	17	21	19	6	11	53	45	101	29	113	415
Cyprus	4	9	8	6	3	16	28	60	6	20	160
Iraq	16	11				b		37	50		114
Saudi Arabia		9	16	1							26
Iran	c	11		1		71			14		97
Afghanistan		1	14						38		53

a. ICARDA input.
b. Data returned but selected lines were not indicated
c. Data received too late to be included.

Table 3. Yields of the most promising genotypes in the ICARDA region during the past five seasons.

Mean yields[a]	Season				
	1977-78	78-79	79-80	80-81	81-82
National check	3117	2613	3039	4521	4261
Long term check	3464	3175	3320	4228	4150
Two checks	3290	2894	3179	4374	4255
Best 5 lines	3458	3024	3775	4783	4757
Best lines	3556	3150	4155	4931	5144
LSD (5%)	262.6[b]	144.5	152.8	127.3	181.5

a. Means are over 24, 20, 23, 18, and 13 locations, for the years 1977-78 to 1981-82, respectively.
b. LSD Calculated on the basis of 21 locations only.

national programs (Table 2). The table shows a better exploitation of the international nurseries in those countries where ICARDA has had a direct input. The yields of the most advanced genotypes distributed in the region have increased. This confirms the superiority of new genotypes (Table 3), which are now being used as national checks at research stations in the region e.g., Kantara (Roho) in Cyprus, ER/Apam in Tunisia, Orge 905 in Morocco, etc.

The main achievement in Syria has been the identification of ER/Apam, Badia, and Beecher for zones B (250-350 mm rainfall) and C ($<$250 mm). ER/Apam and Badia in

This recently developed barley variety, Badia, has shown wide adaptability in trials in the region. Badia is to be released to farmers in Syria.

Table 4. Highest yielding entries in the advanced yield trials in four growing seasons at Tel Hadya, 1978-82.

Year	Cross/pedigree	Yield (kg/ha)	% check[a]	CV%	LSD (5%)
1978-79	Comp. Cr. 89	4486	156.70		
	Arizona 5908/Aths CYBB-16A-1A-2A-2A-0A	4255	140.90		
	Esp./1808-4L	4137	136.60		
	Esp./1808-2L	4046	115.80		
	9120/CI 13280	3868	121.70		
1979-80	Impala	5234	168.24		
	Impala/11012.2	5023	161.45		
	DL69/Sultan	4478	143.94		
	H252	4651	129.77		
	CI 13871	4203	140.61		
1980-81	Mari/CM67 CMB 72-140-8Y-1B-3Y-1B-IY-0B	5963	150.12	7.9	600.5
	Rihane[b]	5670	143.07	13.5	1006.1
	Harmal'S'[b]	5361	159.36	18.7	966
	Matnan[b]	5346	134.90	13.5	1006.4
	Rihane'S'[b]	4923	127.80	7.8	564.5
1981-82	Rihane'S'[b] Sel, 2L-1AP-3AP-0AP	6533	130.50	9.0	700.9
	As46/Pro AP, Sel.	6366	127.00	12.7	1096.4
	Rihane'S'[b] Sel, 12L-2AP-0AP	6294	125.60	7.3	618.5
	Mzq/Aths. AP, Sel.	6300	125.00	6.8	513.8
	Matnan'S'[b]	6030	120.00	5.6	471.5

a. The long-term check Beecher had an average yield of 3238, 3570, 4206, and 4220 kg/ha for the years 1978-79 to 81-82 respectively.
b. ICARDA-developed germplasm.

particular had a greater yield than Arabi Abied in both zones.

The varieties Roho and Rihane will be increased for possible release to growers in southern Tunisia. ER/Apam has been found suitable for northern Tunisia.

The improvement in yields among the highest performing entries in the advanced yield trials at Tel Hadya since the 1978-79 season can be seen in Table 4. The yields varied from 3868 to 4486 kg/ha in 1978-79, from 4923 to 5963 kg/ha in 1980-81, and from 6030 to 6533 kg/ha in the 1981-82 season. The trend shown for the previous seasons has been maintained despite excessive cold weather and erratic distribution of the rainfall. Such results illustrate the gap that exists between yields obtained in farmers' fields from local cultivars and those from the newly developed genotypes. Table 4 shows the increased frequency of ICARDA-developed lines among the elite germplasm.

Wide genetic diversity has been incorporated into the new, high yielding genotypes. This is shown in Table 5 (Tel Hadya and Terbol data). Lines are selected on the basis of disease resistance — mainly powdery mildew and scald. Agronomic performance is scored on a scale of 1 to 5 for head type and plant type, where 1 is the best and 5 the poorest. At Tel Hadya and

Table 5. Yield and agronomic performance of promising lines in advanced yield trials, 1981-82.

	Tel Hadya		Terbol		Agronomic performance							
Line name/pedigree	Yield (kg/ha)	% check	Yield (kg/ha)	% check	Pl.Ht	DH	DM	HS	PS	PM	SC	Pro
Mzq/Aths	6300	125	6472	131	88	129	176	2	2	3	2	8.8
Mezquite	6175	123	7072	143	90	143	178	2+	1-	3	1	8.6
Matnan[a]	6030	120	7306	148	85	149	ML	2	2-	1	1	8.5
Rihane'S'	6533	131	6483	146	109	144	178	2-	2			8.9
Sel, 2L-1AP-3AP-0AP[a]												
As 46/Pro[a]	6366	127	6706	151	105	143	ML	2-	3	3	1	10.5
Rihane'S'	6294	126	6883	155	100	143	178	3+	3		2	8.9
Sel, 12L-2AP-0AP[a]												
Rihane'S'	6047	121	6158	139	90	143	3+	3	3	3	3	9.6
Sel, 7L-4AP-0AP[a]												
Matnan'S'	5622	125	6941	141	91	143	177	2+	2	0	3	7.8
Clipper/CR 115/Por	5700	126	6600	128	85	146	ML	2-	2	3	2	9.2
Rihane'S'	5688	123	6917	134	105	143	117	2-	2-		2	8.7
Sel, 2L-1AP-0AP												
Alger/Ceres[a]	5955	121	6278	112	75	151	Late	2	2+			8.4
ER/Apam[a] (Check)	5755	114	6694	136	85	138	184	2+	2+	2	2	9.2
Badia[a] (Check)	5160	120	6038	123	105	142	184	2+	3	2	2	3.6
Beecher (Check)	5229	122	6126	124	100	141	180	3	3	4	1	9.6
A. Abied (Check)	4302	100	4924	100	87	142	179	3	4	4	3	7.9

a. ICARDA-developed lines.

Pl.Ht = Plant height; DH = days to heading; DM = days to maturity; HS = head score; PS = total plant score (both scores are on a scale of 1 to 5 where 1 is the best and 5 the poorest); PM = powdery mildew; SC = scald; Pro = protein.

Table 6. Highest yielding lines in preliminary yield trials, Tel Hadya, 1981-82.

Name/predigree	Source	Yield (kg/ha)	% check	LSD (5%)	CV (%)
Comp. 29/Mzq//Gva CMB 771-1340-3AP-0SH-4AP-0AP	1120	8216.67	133.85	- 944	9.3
ER/Apam[a] (Check)	2101	8188.89	159.17	- 988	9.5
Matnan'S'[a]	1313	7777.78	126.22	- 842	8.5
Avt/2763[a] 2L-0AP	3302	7766.67	128.72	- 648	6.1
Aths/3/Api/Kristina//M66.85 CMB 77A-16-1AP-0SH-1AP-0AP	1114	7661.11	126.87	- 994	9.3
Vanguard/Coho Oregon S x W-86-3403-1AP-0AP	910	7622.22	137.48	- 973	9.8
Gerbel (C)	3322	7561.11	125.32	- 648	6.1
Manker/4/Bal.16/Pro//Apm/Dwarf 11-1Y/3/Api/CM67 CMB 77A-110-4AP-0SH-4AP-0SH-4AP-0AP	1116	7527.78	124.66	- 994	9.3
Gizeh 134/Apm//2196.68 CMSWB 77A-60-5AP-0AP	3320	7405.56	122.74	- 648	6.1
Manker/4/Bal.16/Pro//Apm//Dwarf 11-1Y/3/Api/CM67 CMB 77A-110-4AP-0SH-1AP-0AP	1115	7377.78	122.17	- 994	9.3
Cerise	2122	7233.33	140.61	- 988	9.5
Apm/HC 1905//Robur CMSWB 771-115-1AP-0AP	1020	7183.33	132.89	-1688	17.2
CR 115/Por//6-1Y-103C/3/Giza 121[a] ICB 78-77-3AP-0AP	813	6827.78	132.71	- 912	9.2
Leb 71/CB.937//Leb 71/CB.829	2107	6811.11	132.40	- 988	9.5

a. ICARDA-developed germplasm.

Terbol, days to heading of the most promising lines have varied from 129 to 151, while days to maturity varied from 176 to more than 185 days. On a regional basis many lines were promising at 5-9 sites in the 13 test locations. The most frequently selected lines in the 1981-82 Barley Observation Nursery (BON) were Vetulio; WI 2197/CI 13520, ICB 77-14-3AP-OAP; and Soufara'S'.

Preliminary yield trials indicate even higher yields (Table 6). Several lines yielded 7000 kg/ha or more, and showed a substantial improvement over Beecher and Badia. ER/Apam, ICARDA's new 2-row check, yielded nearly 8200 kg/ha.

To assist selection for drought resistance in advanced genotypes, promising lines are sown in yield trials 3 months later (i.e., around February 15) than the normal sowing date for barley. The objective of late planting is to subject promising lines, including early genotypes being developed for low rainfall areas, to heat and drought stress late in the season, i.e., during kernel filling, and to assess them for their tolerance to these stresses.

Kernel weight seems to be the yield component most affected by the environment during the last phases of plant development. Tiller number gives an indication of the plant's ability to adjust to an adverse environment in the early part of the plant life cycle. Kernel number, mainly in 2-rowed barley genotypes, does not seem to be sufficiently variable to play a similar role. These observations appear to be confirmed by agronomic work at ICARDA, which indicates that tiller number and kernel weight are closely correlated with yield, while kernel number per spike is not. The results indicate that genotypes with a

Table 7. Lines which performed best when late planted and their performance when sown at the normal time at Tel Hadya, 1981-82.

Name/pedigree		Yield (kg/ha)		Heading days		Protein (%)		1000 KW[a] (g)	
		Early	Late	Early	Late	Early	Late	Early	Late
Matnan'S'		5333	5622	143	86	7.8	10.9	30.4	36.5
Tokak/Magnif 102		5386	5469	142	86	7.9	11.7	32.6	38.0
Avt/Aths		5697	5933	141	81	9.3	10.8	39.5	39.2
Pro/Avt		5619	5338	137	87	9.1	11.7	36.0	41.3
Fold Foil (CI 6363)		5302	5216	144	99	8.2	11.7	43.0	43.6
Zoapila/CI 3087		5083	5777	141	84	9.0	12.4	34.9	38.4
TH.U. 23		5541	5333	137	88	10.0	11.1	31.4	39.7
Jha 33/M66-85		5305	5397	142	86	11.2	11.7	45.7	47.1
Steptoe		6100	5458	158	98	7.6	10.9	45.7	41.7
H.Odesskji 17/DL 71		5152	5233	144	90	9.4	11.6	37.5	39.4
CN100/DC23//Fun/2*Fun/3/ RM 1508		5180	5200	141	90	10.2	10.8	37.8	47.9
ER/Apam	(Check)	5757	4610	140	82	9.2		39.8	
Badia	(Check)	5160	4760	141	84	7.9		49.6	
Beecher	(Check)	5229	4412	141	85	9.5		47.9	
Arabi Abied	(Check)	4302	4405	140	85	10.3		41.9	

a. KW - Kernel weight.

Table 8. Lines which performed best when sown at normal time and their performance when sown late at Tel Hadya, 1981-82.

Name/pedigree		Yield (kg/ha)		Heading days		Protein (%)		1000 KW[a] (g)	
		Early	Late	Early	Late	Early	Late	Early	Late
Mzq/Aths		6300	4950	139	83	8.8	11.2	34.3	37.2
Mezquite		6175	4450	193	88	8.6	10.6	28.6	37.7
Matnan		6030	5022	149	88	8.5	11.4	33.3	39.9
Rihane'S' Sel, 2L-1AP-3AP-0AP		6533	4269	194	84	9.9	11.1	46.1	48.5
As46/Pro		6366	4683	143	88	10.5	10.5	39.0	40.1
Rihane'S' Sel, 12L-2AP-0AP		6294	4994	143	85	9.9	10.9	43.9	45.5
Rihane'S' Sel, 7L-4AP-0AP		6047	4308	143	86	9.6	10.6	40.7	42.9
H251		5772	4241	145	87	8.4	10.3	39.9	42.3
Clipper//CR115/Por		5700	4458	146	87	9.2	11.4	36.4	40.9
Rihane'S' Sel, 2L-1AP-4AP-0AP		5688	5013	143	86	8.7	11.4	45.5	48.9
Alger/Ceres		5955	4683	151	L	9.4	10.6	35.8	38.1
ER/Apam	(Check)	5757	4610	140	82	9.2		39.8	
Badia	(Check)	5160	4670	141	84	7.9		49.6	
Beecher	(Check)	5229	4412	141	85	9.5		47.9	
Arabi Abied	(Check)	4302	4405	140	86	10.3		41.9	

a. KW - Kernel weight.

high yield had large grains (Tables 7 and 8). Kernel weight generally increased with late sowing, indicating that nutrients were translocated to the seed in spite of stress, but tiller production decreased. The increase in kernel size with late planting might be due to a higher rate of translocation in some genotypes when under stress. High yielding lines with a short life cycle generally increased their yield under stress (Table 7), while lines that are high yielding under favorable conditions, decreased yield under stress (Table 8), although their kernel weight increased. For both groups, days to heading and days to maturity were significantly decreased and protein content of the seed was significantly increased.

2. Development of Dual-purpose Barleys (Grain and Grazing)

Barleys in the North African and West Asian regions are often grazed in the early stages of their growth, during the winter months. Barley genotypes respond differently to this practice. A quick procedure has been developed to assess barley genotypes for their grain, forage, or dual-purpose potential. To breed barley varieties that can be grazed during the

Barley workers evaluating performance of different dual-purpose barley lines.

winter months and then be left to produce a grain crop, requires good adaptability, good regrowth after grazing, and the potential to produce both a high drymatter yield for grazing and a high grain yield after grazing. It is therefore important (a) to assess the effect of grazing intensity on barleys newly developed at ICARDA, (b) to identify the plant characteristics associated with recovery from grazing, and (c) to characterize the germplasm for its grain, forage, and dual-purpose capacity.

During the 1981-82 season, 210 genotypes were studied. C-63, an improved barley selection was used as check. Genotypes were grouped in yield trials in which a randomized complete block design with four replications was used. There were three checks and 21 genotypes in each trial.

Parameters Measured

The parameters measured were drymatter yield for grazing (grazing simulated by mowing at 5 cm above-ground level in mid-February), tiller number (per m^2 prior to heading) head number (number of spikes/m^2), tiller mortality (tiller number minus head number), recovery from grazing, and final drymatter.

Recovery from grazing was scored visually prior to maturity using the following 1-5 scoring scale:

1 = More than 80% of the visual grain and drymatter yield, as judged by height and ground cover compared with the ungrazed treatments.
2 = 60-80% of the potential grain and drymatter yield of the ungrazed checks.
3 = 40-60% of the grain and drymatter yield of the ungrazed checks.
4 = 20-40% of the potential grain and drymatter yield of the ungrazed checks.
5 = Less than 20% of the ungrazed grain and drymatter yield.

There was a reduction in grain and drymatter yields following late cutting, which was much smaller for dual-purpose genotypes than for forage types. There was also a clear trade-off between grazing and grain yields (Table 9). The relationship between dry matter for grazing and grain yield may be used to separate forage, grain, and dual-purpose barleys and to assess dual-purpose genotypes for their grain and forage potential.

At ICARDA two indices are used to evaluate dual-purpose barleys; one for grain yield and one for drymatter yield. An index of 1.0 for either character is equal to the overall mean yield of all genotypes in all environments (Fig. 1). Genotypes with larger grain yield but smaller drymatter yield than the index are grain types; those with a larger grain and drymatter yield than the index are dual-purpose types; those with a larger drymatter yield than the index and a grain yield less than the index are forage types. The genotypes below the index for both characters are discarded.

Collaborative Projects

Collaboration with National Programs

In Tunisia, a large collection of barley germplasm was screened in the 1981-82 season. High yielding cultivars were selected from yield trials (Table 10), while from the Barley Observation Nursery, Vetulio, Rihane (CI 13871), and Rihane 'S'lines were selected over three widely differing environments, namely, Beja (high rainfall, high soil fertility); Le Kef (400 mm annual rainfall, medium soil fertility); and Hendi Zitoun in central Tunisia (180 mm *annual rainfall, poor soil fertility*).

Collaboration with Centers in Developed Countries.

A root study and also photoperiod /temperature studies on barley are being conducted at the University of Reading with the support of a grant from the U.K. Overseas Development Administration (ODA). Barley germplasm is being screened for drought and salt tolerance at the University of Saskat-

Table 9. Classification of barley genotypes into grain, forage, and dual-purpose types.

Entry	Name/pedigree	Grain yield[a] (kg/ha)	Drymatter yield (kg/ha)	Tiller No./m^2	Tiller mortality /m^2	Regrowth score	Grain index	Drymatter index	Grain Yield[b] (kg/ha)
	Grain types								
314	Europa	5172	1454	712	55	1-	1.14	0.89	4183
518	Vanguard/Julia//Zephyr	5272	1482	608	48	2	1.16	0.91	3458
522	Irania	5064	1421	692	61	3	1.12	0.87	3300
604	Piccolo	5308	1566	969	251	2	1.17	0.96	4358
703	Rihane"S"	5688	1394	573	279	3	1.26	0.86	3750
722	7028/Avt//Introduction	5758	1360			3	1.27	0.83	4750
	Dual-purpose types								
108	Lignee 527	4806	1955	485	60	1-	10.60	1.20	4167
220	Rabat 013	4689	2296	613	130	2-	1.04	1.41	3300
308	Antares	5271	1975	671	236	2+	1.16	1.21	4258
323	Matnan	5239	1731	632	81	2+	1.16	1.06	4350
422	Matnan"S"	5314	1828	833	133	2	1.17	1.12	3942
423	CM67/3/Apro//SV.012109/Mari	5378	1878	537	123	3+	1.19	1.15	3467
	Forage types								
207	M73-129	3608	2219	494	99	3+	0.80	1.36	2225
207	M75-12	3603	2021	380	112	3-	0.80	1.24	2358
215	Manker/Aths	3928	2208	429	88	3	0.87	1.36	2925
419	Ghar	3958	2092	428	84	3	0.87	1.28	2433
713	Canilla	4231	1972	1012	440	3	0.93	1.21	3008
217	BFK/Magnelone 1604	4338	1818	622	322	3	0.96	1.12	2958

a. Grain yield ungrazed.
b. Grain yield grazed.

Table 10. The best genotypes selected from advanced yield trials, Tunisia, 1981-82 crop season.

Cross/pedigree	Beja Yield (kg/ha)	Beja Rank	Beja Check (%)	Kef Yield (kg/ha)	Kef Rank	Kef Check (%)
Rihane	4116	5	136.65	5987	1	145.13
Lignee 527	4041	7	134.16	5658	2	137.16
ER/Apam	4016	8	133.33	5600	3	135.75
Matnan	4079	6	135.42	5195	4	125.93
Rihane'S' Sel, 6L-1AP-0AP	3833	11	127.25	5183	5	125.64

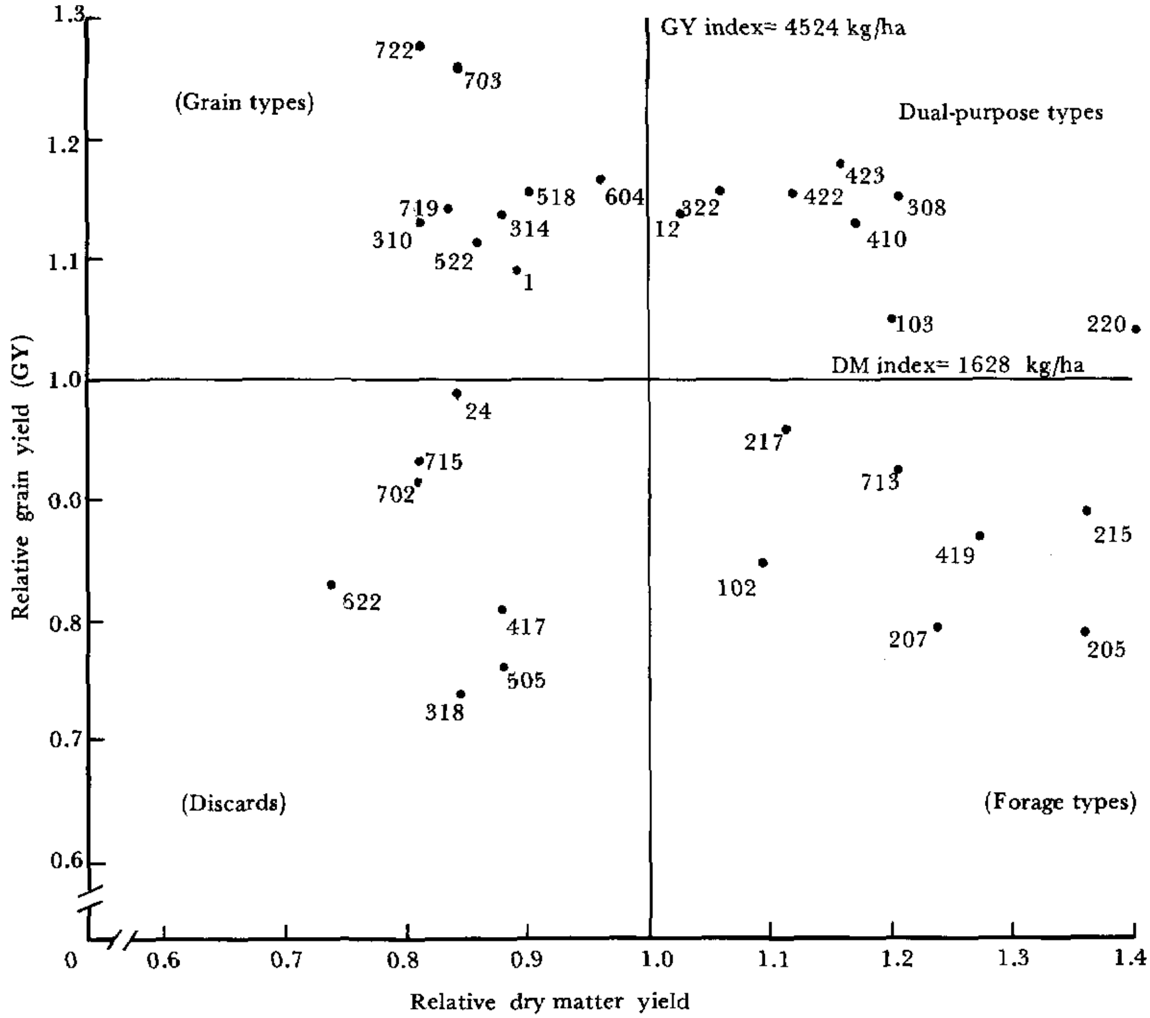


Figure 1. Identified grain, dual-purpose, and forage types, 1981-82. Numbers 1, 12, and 24 are checks; in the three-digit numbers, the first digit indicates the trial number, and the second and third digits indicate the entry number.

chewan in Canada. A grant from GTZ (German Association for Technical Cooperation) provides for varieties to be examined at Munich University for salinity tolerance. Screening, selection, and testing of Male Sterile Facilitated Recurrent Selection Populations (MSFRSP) is being conducted in cooperation with Montana State University, USA.

Agronomy/Physiology

Barley is the main crop in the low rainfall zone of the region, i.e., zone C, which has less than 250 mm annual rainfall, poor soil fertility, and low levels of crop production inputs. However, agronomic research has shown that improvements in yields are possible and economic, provided that recommendations take account of the risk aversion of farmers and the variability of responses in their fields compared with those in controlled experiments on research stations.

The variation in fertilizer responses in farmers' fields is due to differences in cropping history, soil type, and previous fertilizer use. Before fertilizer recommendations can be made to farmers, experiments must be conducted in selected fields and the range of responses ascertained. ICARDA began such studies in 1979-80 and continued them in the barley growing areas of northern Syria in 1981-82. The results are shown in Table 11.

In general, larger responses to fertilizer are obtained in the more favorable seasons and after fallow.

Other production inputs also play an important role in barley production in zone C. The results from experiments conducted over 3 years comparing farmers' and improved production practices are presented in Table 12. Sowing method (drilling) and fertilizer application increased yields most in zone C. Farmers tend initially to choose the least cost or most profitable practice and introduce later the more expensive or risky changes. The best sequence in which to change practices can be

Table 11. Responses of cereals to N and P_2O_5 in northern Syria in the *1979-80* to *1981-82* seasons.

Zone/crop[a]	No. of sites	Range of N (kg/ha) required for max. grain yield	Mean (kg/ha)	Range of P_2O_5 (kg/ha) required for max. grain yield	Mean (kg/ha)
Zone C (barley)	6	0 to > 80	30	0 to > 80	20
Zone B (durum)	7	0 to 140	65	0 To 60	10
Zone A (bread wheat)	8	0 to 240	95	0 to 120	25

a. Annual rainfall received in zones: A -> 350 mm; B = 250-350 mm; C -< 250 mm.

Table 12. Difference in yield between improved and farmers' production practices, 1979-80 to 1981-82.

Production practice practice	Mean yield difference (%)		
	Zone C (barley)	Zone B (durum)	Zone A (bread wheat)
1979-80			
Sowing method[a]	47	47	4
Fertilizer[b]	22	20	-12
Weed Control[c]	2	3	- 6
Variety[d]	7	5	7
1980-81			
Fertilizer[b]	11	21	- 2
Weed Control[c]	10	17	1
Variety[d]	2	0	4
1981-82			
Nitrogen[b]	- 1	22	0
Phosphate[b]	5	5	- 8
Weed Control[c]	4	15	5
Variety[d]	-41	3	8

a. Broadcast vs drilled-all zones.
b. Fertilizer rates (kg/ha): Zone C = 0 vs 20 N, 30 P_2O_5; Zone B = 0 vs 60 N, 30 P_2O_5; Zone A = 180 N, 100 P_2O_5 vs 120 N, 80 P_2O_5
c. Unsprayed vs post emergence sprayed with brominil (all zones).
d. Arabi Abied vs Beecher (Zone C), Haurani vs Sahl (Zone B), and Mexipak vs S311 × Norteno (Zone A).

determined by economic analysis from data such as that shown in Table 12.

Although barley is grazed under a variety of conditions and forms a vital part in the diet of sheep, management practices to achieve the best combination of grazing and grain production have not been extensively researched. To obtain the information needed, experiments were conducted in 1981-82 on nitrogen rates, seeding rates, and varieties of cereals for grazing. The results are shown in Table 13.

Nitrogen Fertilizer Rates

Five rates were tested on both grazed and ungrazed barley using one forage-type barley (Saida), one local grain-type (Arabi Abied), and one dual-purpose type (C-63). Half of each plot was grazed with sheep at the tillering stage. The optimum N rate for drymatter production at tillering was found to be about 50 kg/ha for all three varieties although C-63 may have required slightly more, which is a similar result to the 1980-81 experiment.

Grain yields after grazing were significantly smaller than in the ungrazed treatments. The best grain yields in the ungrazed plots were achieved with N rates of 50-100 kg/ha for Arabi Abied and Saida, but for C-63, rates exceeding 100 kg/ha were the best. After grazing, the best grain yields were obtained from N fertilizer rates of more than 100 kg/ha for Arabi Abied, 150 kg/ha for Saida, and 200 kg/ha for C-63 (Table 13). Arabi Abied significantly outyielded C-63 in both the grazed and ungrazed treatments at zero N, but the reverse was true at N rates above 100 kg/ha. This confirms our last year's result and indicates that for rainfall and soil conditions similar to those at Tel Hadya for these two seasons, the N rate required for grazing and grain production is about double that required for grain production alone. Thus the value of grazing has to be balanced against the cost of the extra N and the loss in grain yield.

Seed Rates

Five seed rates were tested on both grazed and ungrazed barley, using the same three varieties as in the previous experiment. Half of each plot was grazed at tillering. The varieties were not significantly different in drymatter production at any seed rate, however, drymatter production increased significantly up to a seed rate of 240 kg/ha.

The best grain yield was achieved at a seed rate of 30 kg/ha for all varieties in both the grazed and ungrazed condition, except for ungrazed Arabi Abied, which yielded significantly more at 60 kg/ha (Table 14). Again, the value of the extra grazing at a seed rate of 240 kg/ha will have to be balanced against the extra seed cost, compared with 30 or 60 kg/ha, and the reduction in grain yield.

Varieties

Thirty varieties previously selected by the

Table 13. Influence of variety, nitrogen, and grazing on grain yield at Tel Hadya, 1981-82.

	Ungrazed (kg N/ha)					Grazed (kg N/ha)				
Variety	0 N	50 N	100 N	150 N	200N	0 N	50 N	100 N	150 N	200 N
	Grain yield (kg/ha)					Grain yield (kg/ha)				
Arabi Abied	3321	3869	4095	4011	3590	2614	3035	3539	3595	3767
C-63	2896	3454	4303	4503	4815	2177	2897	3536	4052	4506
Saida	3052	3454	3817	4186	3936	2357	3126	3567	4185	4331

LSD (5%)
Variety means for the same N rate 374 kg/ha.
N means for the same variety 390 kg/ha.
Grazing means for the same N rate 420 kg/ha.

Table 14. Influence of variety, seed rate, and grazing on grain yield of barley at Tel Hadya, 1981-82.

Variety	Ungrazed (seed rates - kg/ha)					Grazed (seed rates - kg/ha)				
	30	60	120	240	480	30	60	120	240	480
	Grain yield (kg/ha)					Grain yield (kg/ha)				
Arabi Abied	3243	4062	3396	3798	3568	3420	3767	3211	2934	2653
C-63	4600	4427	3946	3738	3550	4096	3785	3211	3108	3054
Saida	3563	3894	3869	3243	3286	4018	3860	3192	2907	3006

LSD (5%)
Variety means for the same seed rate 639 kg/ha.
Seed rate means for the same variety 652 kg/ha.
Grazing means for the same seed rate 439 kg/ha.

barley breeder and the Pasture and Forage Program as either forage or dual-purpose types were tested for drymatter yield at tillering and grain yield after grazing. Significant differences (P > 95%) were found between varieties for drymatter yield at tillering with yields ranging from 1200 to 1800 kg/ha. After grazing, the grain yield differences were also significant (P > 95%) with several varieties exceeding 3500 kg/ha.

New Barley Lines

Three lines are under consideration for possible release to farmers in Syria in the next few years. Because little is known about the yield response to seed rates of these varieties, which may differ from the local variety Arabi Abied, an experiment was conducted with five seed rates under rainfed conditions.

The yields were affected by frost damage when the crop was at a critical development stage. The results refer to a single season only, so few conclusions can be drawn. The newer barley varieties Beecher and ER/Apam had a lower optimum seed rate than the standard variety Arabi Abied or the new variety Rihane.

Varietal Response to N and P

Soils in the growing areas in zone C are low in fertility. Farmers use only small amounts of nitrogen fertilizer, or none at all, because of the cost and the risk when using it where rainfall is limited and variable. Under these circumstances varieties that utilize nitrogen more efficiently for grain production could prove useful.

Forty-five genotypes of barley were grown following an irrigated, unfertilized maize crop at Tel Hadya. Eight rates of N were applied (0-210 kg/ha). The experiment was irrigated once in the spring. Grain and straw yield, and total nitrogen uptake were measured. Selected preliminary data (Table 15) can now be used to determine the heritability of such differences. In future, crosses made for improved nutrient efficiency can be screened in the field using this technique. This work could eventually provide the possibility of breeding varieties with greater efficiency of fertilizer

Table 15. Response of some barley genotypes to N fertilizer at Tel Hadya, 1981-82.

Variety/line	Yield at zero N (g/m^2)	Max. yield (g/m^2)	Optimum N rate (g/m^2)	Yield[a]/N applied (g/g)
CI 8887/CI 5761	60	325	6.0	44
Lignee 640	60	525	15.0	31
Ky63-1294	40	400	11.5	31

a. Maximum yield minus yield at zero N.

utilization for specific fertility conditions in farmers' fields in zone C.

The above responses, whilst encouraging, may be changed when factors other than nitrogen become limiting. To investigate this possibility, four varieties (two barleys and two wheats), previously found to have contrasting responses to applied N fertilizer, were grown at Breda where rainfall (250 mm) and soil phosphate are limiting.

There were no significant yield responses to nitrogen for either barley variety in the absence of applied phosphate fertilizer (Table 16). Similarly there was no significant response to 90 kg P_2O_5/ha in the absence of nitrogen fertilizer. This indicates that where another nutrient is extremely limiting the characteristic varietal N response was not manifested. When phosphate was added, both varieties responded significantly to N fertilizer (Table 16). Arabi Abied yielded significantly more than Martin when no nitrogen was applied, with or without phosphate, which confirms our results previously obtained under conditions of more favorable water supply. The yield of both varieties was similar at the optimum level of about 60 kg N/ha. This implied that the average response to N (kg grain/kg applied N) for Martin, which had a lower yield at zero N, was greater than for Arabi Abied, which had a higher yield at zero N. This result also confirms our earlier findings under more favorable conditions and shows that even under low yielding conditions, varietal differences in fertilizer response could be important for resource-poor farmers.

Pathology

Barley diseases play an important role in yield loss wherever barley is grown. In low rainfall areas powdery mildew (PM), stripe disease (SD), covered smut (CS) and the root rot complex are the major diseases. In cooler areas, scald (SC) and yellow rust (YR) are predominant while in Mediterranean type climates leaf rust (LR), net blotch (NB), and other *Helminthosporium* leaf spots are of major importance. Viral diseases, mainly barley yellow dwarf (BYDV) and barley stripe mosaic (BSMV), are also important in some areas. BYDV, being aphid transmitted, and BSMV-

Table 16. Yield response of two barley varieties (Arabi Abied and Martin) and two wheat varieties (Arvand bread wheat and Sahl durum wheat), to nitrogen, with and without phosphate, at Breda, Syria, 1981-82.

N applied (kg/ha)	Arabi Abied (kg/ha)	Martin (kg/ha)	Arvand (kg/ha)	Sahl (kg/ha)
		Zero applied phosphate/ha		
0	649	473	674	133
30	606	425	649	180
60	740	406	676	94
90	690	374	578	131
120	697	475	536	96
		90 kg applied phosphate/ha		
0	588	385	533	77
30	849	789	773	354
60	886	848	880	501
90	1057	726	912	422
120	867	1038	1026	562

LSD (5%) N means for the same variety 158 kg/ha.
Variety means at the same N rate 144 kg/ha.

being seed transmitted, represent a threat to barley production in some areas.

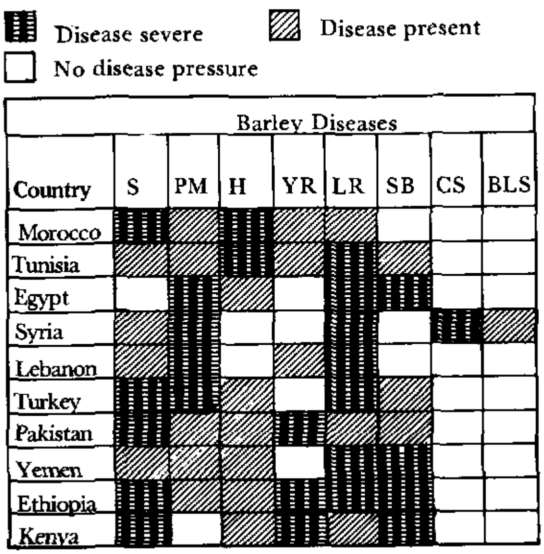
Resistance to diseases in barley is generally low compared with bread wheats, mainly because there has been less selection for resistance. Thus, improving the level of resistance to the major diseases in the region is the main thrust of the pathology work.

Germplasm developed by the breeding program is tested for major diseases in five different locations in Syria and Lebanon. Lines showing adequate level of disease resistance and good yield potential are promoted to the preliminary stage of yield tests and later to the advanced stage of yield testing. All genotypes that are yield tested at both stages are also included in the Key Location Disease Nursery (KLDN) and evaluated for diseases in 15-18 locations in the region where epidemics for different diseases prevail (Fig. 2). This gives a good coverage for the most important diseases. The aim is to select disease-resistant genotypes, which are already well adapted.

Lines with good resistance to diseases and others with different types of resistance are identified and crossed to bring the genes together. Varieties with multiple disease resistance are also identified and after repeated testing, are made available to the national programs in the region through international nurseries (Table 17). The pattern of disease reactions observed in the international nurseries is analyzed.

The KLDN was examined during the 1981-82 season in Morocco (Guich, Merchouch, Sidi Kassem), Tunisia (Mateur), Egypt (Gemmiza, Sakha), Pakistan (Islamabad, Quetta), Yemen (Taiz), Syria (El Ghab, Gebla, Kamishly, Tel Hadya), and Lebanon (Terbol). In general, good screening was possible for yellow rust, leaf rust, scald, powdery mildew, and covered smut.

Potential parents were screened for BYDV resistance in collaboration with Dr. A. Comeau



S= scald, PM= powdery mildew,
H= *Helminthosporium* spp., YR= yellow rust,
LR= leaf rust, SB= stem blight, CS= covered smut,
BLS= bacterial leaf streak.

Figure 2. Key Location Disease Nursery (KLDN) sites and diseases.

Table 17. Genotypes identified with multiple disease resistance in ICARDA region, 1981-82.

Cross and pedigree	Resistant to							
	YR	LR	SR	PM	SC	NB	SD	BYDV
Apm/Aths//Gva CMB 72A-118-H-3B-IY-500B-500Y-0B	+	+	+					
Hexa	+	+	+	+				
WI 2291	+	+			+			
CI 8887/CI 5761 SEA 13-24S-3S-0S	+	+		+	+		+	
CI 8887/CI 5761 SEA 13-16S-3S-0S	+	+	+	+				
Asse	+	+	+	+				
Aramir	+	+	+	+				
Sonja	+	+			+			
CI 13606	+				+	+		
Celaya					+		+	
Prato 68					+			+

\+ = Resistant.
YR = yellow rust; LR = leaf rust; SR = stem rust; PM = powdery mildew
SC = scald; NB = net blotch; SD = stripe disease; BYDV = barley yellow dwarf virus.

(Agriculture Canada), and some varieties showed resistance, e.g., G-481, Remal, Seed Source-72 Sel, GUS, Weeah, UC 566, and Asse.

Genotypes with genes for resistance to priority-ranked diseases have been identified through multilocation testing. They are being crossed to combine different sources of genes and build germplasm with multiple disease resistance (Table 18).

Entomology

The objectives of ICARDA's entomological research in the improvement of barley and other winter cereals are: surveying and identification of insect pests; determination of their economic importance; screening for host-plant resistance and incorporation of resistance into commercial varieties; and development of alternative methods of control for inclusion in a pest management system in which host-plant resistance is the foundation.

Little research has been previously conducted to determine the economic impact of insect pests on cereals in the Middle East.

Wheat Stem Sawfly on Barley

A screening of 108 lines in the 1981-82 BON was conducted with three replications in two locations to determine the level of resistance of barley to wheat stem sawfly (*Cephus* sp). The material was grown at Suran (Hama) where a heavy natural infestation occurs annually, and at Tel Hadya under artificial infestation. The results are summarized in Table 19.

The varieties with the best resistance were Kataja, with an average infestation percentage of 3.3 and 3.9 at Suran and Tel Hadya, respectively, and Hexa with 6.7 and 0%, respectively.

Grain Quality

Most of the barley grown in the ICARDA region is used as animal and poultry feed. Yield

Table 18. Examples of crosses made at Tel Hadya to build germplasm with different types of resistance genes, and others with multiple disease resistance.

Cross and pedigree	Resistant to
Emir/Br. Villa	YR, LR, SR, SC, NB
ICB 81.389	PM
Alger/Ceres//Martin	YR, LR, SC
ICB 81.776	Cyst Nematode
Alger/Ceres//Gerbel	YR, LR, SC
ICB 81.781	YR, LR, PM
Praeco × mass selection/Menuet	LR, SR
ICB 81-803	PM
Praeco × mass selection//Alger/Ceres	LR, SR
ICB 81.802	YR, LR, SC
Menuet/Br. Villa	PM
ICB 81.810	PM
Menuet/Emir	PM
ICB 81.808	YR, LR, SR, SC, NB
Cebada Capa/Ase	LR, YR
ICB 81.835	LR
Steptoe/Gerbel	SC, YR
ICB 81.975	YR, LR, PM
Steptoe/Asse	SC, YR
ICB 81.984	LR

a. Resistances in the upper line in each cross originate from the female parent, and those in the lower line, from the male parent.
See Table 17 for legend.

Table 19. Number of promising barley lines with least damage from wheat stem sawfly, 1982.

Location	No. of lines and range of % infestation	Check	No. of promising lines and range of % infestation
Suran	108 (3.3-53.5)	Arabi Abied (38.8)	6 (3.3-8.3)
Tel Hadya	108 (0-38.3)	MP-112 (B.W.)(20.4)	6 (0-5)

and protein content are the most important quality parameters. Recently it was considered likely that some lines may be satisfactory for the small, but significant malting industry. Malting quality requires plump kernels, low protein (10.5-12.5%, N x 6.25, dry basis), and high diastatic power, which is the capacity of the enzyme systems in the grain to convert starch to the sugars necessary for fermentation.

A testing sequence was determined during the year, based on European malt quality standards. Plump kernels and kernel size distribution are measured on a glasblaserei normal sorting sieve shaker, using screens of 2.8, 2.5, and 2.2 mm slotted holes. Protein content is determined by near-infrared reflectance, and diastatic power by the European Brewing Council Method. A total of 274 lines were tested for plump kernel count and protein. Of these, 20% were selected for diastatic power testing, and several lines emerged with a potential for malting, which were passed to a commercial malt company for full-scale industrial testing. One line was selected for inclusion in national trials.

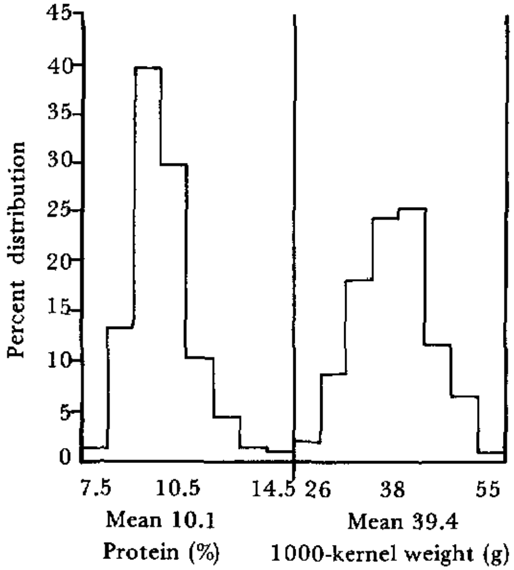


Figure 3. Distribution of protein and 1000-kernel weight, barley, 1981-82 season.

Statistical analysis showed that for lines with a particular parentage a high negative correlation (-0.7 to -0.97) existed between kernel size and diastatic potential, whereas in other series the correlations were not significant (-0.3 to -0.5). These series offer the potential for selecting barleys that combine good kernel characteristics and diastatic potential. High correlations (0.7 to 0.9) were computed between 1000 kernel weight and plump kernel count, which simplifies the screening. These and the above relationships are being further tested to determine the influence of the environment in which the grain is grown.

The percentage distribution results from testing 698 lines from the 1981-82 barley crop for protein and 1000 kernel weight are shown in Figure 3.

Weed Control

An experiment was conducted to select competitive barley varieties that can suppress weeds in areas where other methods of weed control are not applicable. The results (Table 20) were based on the total dry weight of weeds. Four good competing varieties were identified.

In a herbicide trial for control of broadleaf weeds under low rainfall conditions several

Table 20. Barley entries identified as able to compete with weeds at Tel Hadya, 1981-82 season.

Entry		TDW[a] (kg/ha)	Yield (kg/ha)
ABYT 1-23	Numar/Mz	195	3317.7
ABYT 3-16	Tanekase/Baitori//Aths	200	3343.8
ABYT 11-5	Harmal "S"	163	3664.1
RBYT 7	Fun/H45//PI3604/Fun/3/Avt/Nor//Bz/Winn/4/2xPro.-6L	250	3479.2
Control[b]		3800	

a. TDW = total dry weight of weeds.
b. The control consisted of an equal area of weeds and no crop was grown.

herbicide gave good results (Table 21).

Four experiments were conducted to select the most efficient and best tolerated herbicides on barley under low rainfall conditions. Certrol H and Brominal Plus at the rate of 1.0 kg a.i./ha gave as good weed control as the hand weeding treatment, while Certrol D and Dosamix were poorer than the non-weeded control.

Durum Wheat Improvement

Durum wheat is an important crop in North African and West Asian countries where its grain is consumed mainly in the form of bread, pasta, couscous, and bourghoul. Areas sown to durum wheat by the major producers, expressed in millions of hectares, are Turkey (2.7), Morocco (1.5), Algeria (1.5), Syria (1.1) and Tunisia (0.8).

ICARDA's durum wheat improvement program is aimed at developing germplasm with high yield potential, tolerance to environmental stresses (frost and drought), disease and insect resistance, and good technological and nutritional qualities. Also, the development of improved agronomic practices for different agroclimatic conditions is an integral part of the research.

Breeding

Efforts are being made to develop genotypes that will perform well in difficult environments with few inputs, and will also respond to good growing conditions.

Yield Trials

Entries have been identified that are high yielding when given supplementary irrigation, and also perform well when rainfed. The performance of one such line is shown in Table 22. With only limited water and low fertility, the local check Haurani performs well but many lines outyield it in both Preliminary (PDYT) and Advanced Durum Yield Trials (ADYT). Under good growing conditions Sahl is a better check than Haurani; 19% of PDYT lines and 6% of ADYT lines had significantly higher yields than Sahl.

In the PDYT and ADYT, whether rainfed or given supplementary irrigation, the average yields of superior ICARDA lines exceeded

Table 21. Effects of broad spectrum weed control in barley at Tel Hadya, 1981-82.

Herbicides	Rate (kg a.i./ha)	Grain Yield (kg/ha)	% control	Rank
Methabenz. + bromoxynil	1.5 + 0.25	3250	92.7	8
Cyanazine + MCPA	0.25 + 0.5	3590	102.4	4
Certrol D	1.0	3027	86.3	10
Certrol H	1.0	3898	111.2	2
Dosamix	1.0	3113	88.8	9
Dosamix	1.5	3245	92.8	7
Brominal Plus	1.0	3867	110.3	3
Brominal Plus	1.5	3315	94.5	6
Hand weeded		3906	111.4	1
Control		3506	100.0	5

LSD (5%) 405.40
(1%) 551.77

Table 22. Yield at Tel Hadya of an advanced durum wheat line with good yield stability compared with two check varieties, Stork and Haurani.

Variety or cross	Yield trial	Season	Relative yield as a % of Haurani	
			Rainfed	Suppl. irrigation
Br'S'/ZB/Gta'S'/Fg'S'	PDYT[a]	1980-81	126	159
ICD 77.141-3AP-OSH-OAP	ADYT[b]	1981-82	126	122
Stork (Check)	PDYT	1980-81	111	124
	ADYT	1981-82	104	118
Haurani (Check)	PDYT	1980-81	100	100
	ADYT	1981-82	100	100

a. PDYT = Preliminary Durum Yield Trial.
b. ADYT = Advanced Durum Yield Trial.

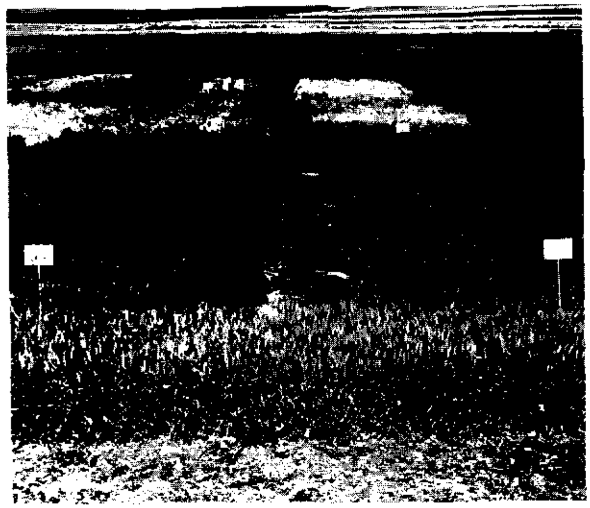
other lines, including Haurani,the local check, and Stork,the improved check (Fig. 4).

Haurani has good grain quality but it has a poor yield potential. A number of lines have been identified that combine good grain quality and high yield potential (Table 23).

Field Verification Trials

Valuable information to compare the performance of new durum lines with national varieties is provided by field verification trials on farms throughout Syria. In the 1981-82 season, these trials were conducted in:

(1) Irrigated areas.
(2) In zone A (where rainfall exceeds 350 mm per annum)
(3) In zone B, which receives 250-350 mm



Field verification trials in Syria in collaboration with the Directorate of Agriculture provide valuable information on the performance of cereals. Varieties for possible release in Syria have been identified.

Table 23. Advanced durum wheat lines that combine a good grain quality with a high yield potential compared with the local check Haurani at Tel Hadya, 1981-82.

Entry ADYT	Cross and pedigree	Location	Relative yield (%)	Vitreous kernels (%)	Protein (%)	1000-kernel weight (g)
	BYE/TC*T/5//Gdovz 512/Gdovz 512	TH-RF[a]	109	91	13.6	46
611	ICD 77.123-6AP-OSH-OAP	TH-Irr[b]	116	98	14.1	52
	Scar'S'/Gdovz 579	TH-RF	106	90	14.1	47
423	CD 9885-5M-2Y-1M-3Y-1M-OY	TH-Irr	152	97	14.6	48
	Ovi65/Cp//Fg'S'/3/Ruff'S'/Fg'S'	TH-RF	114	97	14.5	42
921	CD 16696-E-1M-2Y-1M-OY	TH-Irr	126	95	13.5	49
Check	Haurani	TH-RF	100	89	14.8	41
		TH-Irr	100	94	14.7	43

a. TH-RF = Tel Hadya rainfed.
b. TH-Irr = Tel Hadya supplementary irrigation.

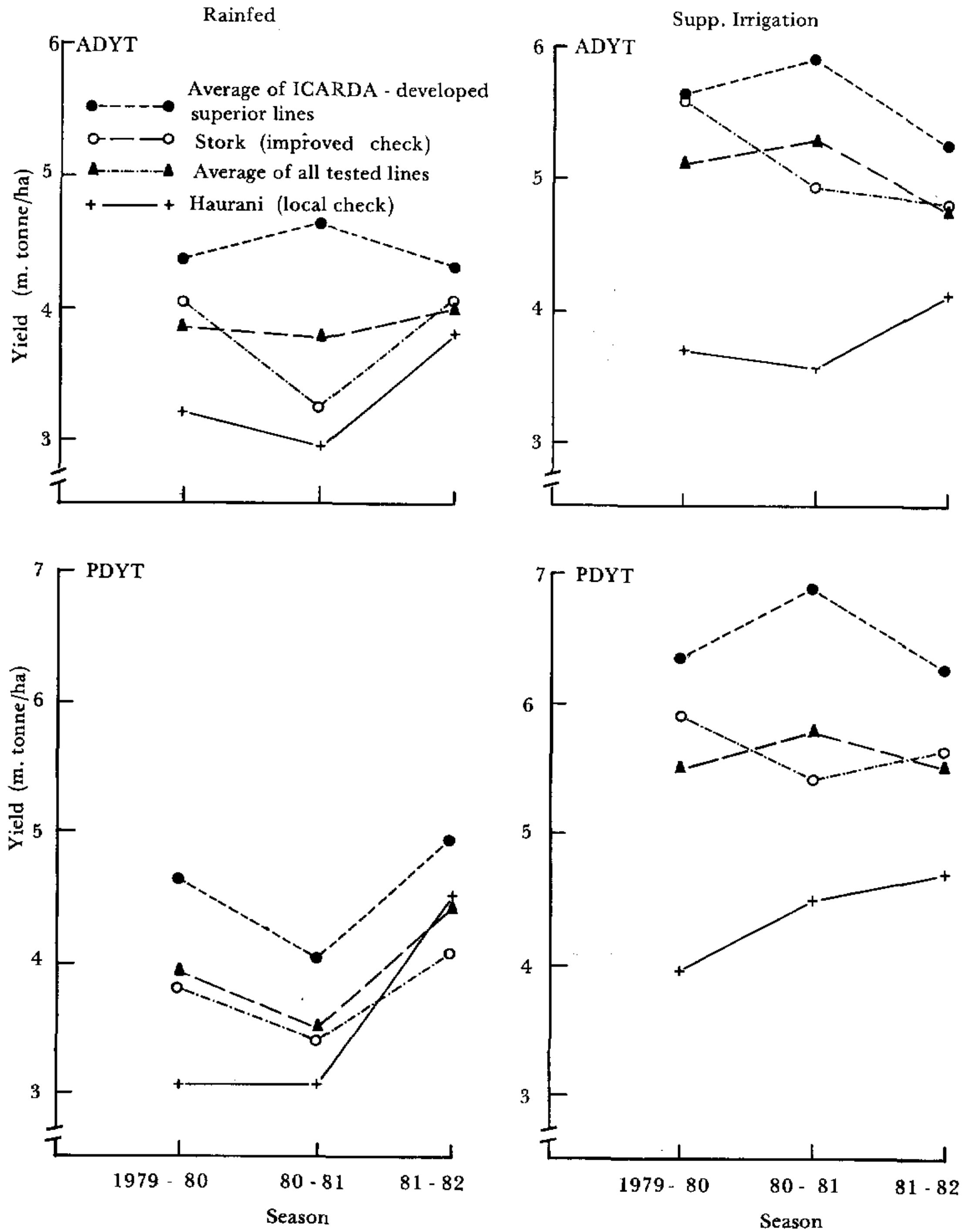


Figure 4. Comparison of breeding material in the Preliminary Durum Yield Trial (PDYT) and the Advanced Durum Yield Trial (ADYT) with the two checks, Haurani and Stork, in three seasons, 1979-80 to 1981-82.

rainfall, and where only moderate fertilizer applications, i.e., 40 kg N/ha and 40 kg P_2O_5/ha, are made.

In the irrigated areas at Hama, Raqqa, Deir Ezzor, and Ras El Ain, the lines Waha, Sahl, Forat, and Alsin all significantly outyielded the two local checks, Gezira 17 and Jori C69 (Table 24).

Table 24. Performance of lines in field verification trials in Syria, 1981-82.

	Yield (kg/ha)		
New varieties	Irrigated[a]	Zone A[b]	Zone B[c]
Waha	4115.9	3193.0	2195.8
Sahl	4052.6	3143.0	2175.0
Furat	4005.1		
Alsin	3864.8		
Checks			
Gezira 17	3545.5	3181.0	
Jori C69	2586.0	2869.0	
Haurani			2031.7
LSD (5%)	190.8	45.2	68.8

a. Means over four locations.
b. Means over eight locations.
c. Means over six locations.

In zone A, there were no significant yield differences between the new lines and the national check variety at Homs, Afrin, Khan Chekhon, Alkrem, Hialen, Kahtaneh, Al Heneweah, and Tel Hadya.

In zone B, the two new lines Waha and Sahl significantly outyielded Haurani, the check variety in trials at Al Hassaka, Raqqa, Hama, Idleb, Aleppo, and Tel Hadya. These results confirm the excellent performance of these lines in earlier years.

Preliminary Observation Nurseries

Data on the Preliminary Observation Nursery-Durum (PON-D) and Rainfed (PON-Rf) 1980-81 have been received from 34 and 29 locations, respectively, most of which are in North Africa and West Asia. Some of the entries in these nurseries were selected for further use by the national programs at over 50% of the locations. This indicates that several of the tested lines adapt well to various environmental conditions.

Regional Wheat Yield Trials (RWYT)

Since 1975-76, Mexipak, a high yielding bread wheat, has been used as a long-term check in Regional Yield Trials composed of both durum and bread wheats. For most of the last six seasons, the two best durum wheat lines have had a higher average yield than Mexipak in RWYT. Also, in the Rainfed Wheat Yield Trial (RfWYT), which is usually planted under less favorable conditions than the RWYT, durum lines have outyielded the national checks. Steadily the yield of durum wheat is achieving the yield of the best bread wheat lines, which have received a more intensive research input over a longer period at national and international levels, than durum wheat.

Agronomy/Physiology

Since the agroclimatic conditions, especially rainfall, crop rotation, and soil fertility in the main durum production zone (zone B, 250-350 mm rainfall) are different from those in the barley zone (zone C), it is important to investigate the range of responses to N and P_2O_5 fertilizers for durum wheat. The results from three seasons' experiments in farmers' fields are shown in Table 11.

The higher responses to N generally found in this zone are probably because there is more rainfall than in the barley areas of zone C (< 250 mm). However, smaller responses to phosphate were found, since some P_2O_5 is commonly used in this zone on durum and there is residual phosphate in the soil.

Improved sowing method, fertilizer application (especially nitrogen), and weed control have all given increases in yield (see Barley Agronomy, Table 12).

Two new varieties of durum wheat, i.e., Sahl and Waha, are under consideration for release to farmers in Syria. Their response to seed rate was compared with that of two varieties currently in use by farmers. The best seed rate for these two varieties was about the same as for the older variety Haurani. However, the optimum seed rate for the local variety Gezira 17 was slightly higher.

When farmers apply nitrogen to cereals in risky environments it is common for them to use a small amount, or even none, at sowing but to apply more later in the spring if the seasonal prospects look good. This avoids some of the risks involved and spreads the farmers' cash requirement more evenly over the crop period. Because previous experiments in similar environments have shown that grain yield increases seldom result from this practice, an experiment was conducted to obtain information that could help refine farmers' decisions about (a) the safe amount to apply at sowing and (b) the optimum amount to apply in the spring i.e., at tillering. Five rates of nitrogen were applied to durum wheat (variety Sahl) with five methods (ratios) of dividing the total N between the sowing and tillering applications.

The results (Table 25) show that there was no significant increase in grain yield above 30 kg N/ha when all the N was applied at tillering. However, when the N application was split in any of the ratios tested, there was a significant yield increase up to about 60 kg N/ha. When all the N was applied at sowing, grain yield increased significantly up to about 90 kg N/ha.

Clearly the lowest risk strategy was to apply no N at sowing and 30 kg/ha at tillering. The work will be extended to other environments in future to sample more climatic and soil variability.

Whilst durum wheat is grown under moderate soil fertility conditions varieties that could produce more grain using less N or respond more efficiently to applied N could be advantageous. Forty-five durum genotypes were tested for their N responses under conditions where soil moisture was not limiting (for details see Barley Agronomy section). Some selected, contrasting responses are shown in Table 26. These results confirm our previous year's findings and show that they are reproducible under field conditions.

Validation of such results under conditions where rainfall and soil phosphate were also limiting was attempted using one improved durum variety (Sahl) and one older bread wheat variety (Arvand). Neither variety

Table 26. Response characteristics of some durum genotypes to N fertilizer at Tel Hadya, 1981-82.

Variety/line	Yield at Zero N (g/m^2)	Maximum yield (g/m^2)	Optimum N rate (g/m^2)	Yield[a]/N applied (g/g)
Valgerardo	30	300	5.0	54
Faisca	30	425	11.0	36
Medjerda	120	375	14.5	18

a. Maximum yield minus yield at zero N.

Table 25. Effect of N rate and ratio of splitting on grain yield of durum wheat, at Tel Hadya, 1981-82.

N Ratio (% at sowing/% at tillering)	Nitrogen rate (kg/ha) 0	30	60	90	100
0-100	2481	3367	3322	3446	3671
25-75	2481	2878	3393	3342	4146
50-50	2481	2825	3596	3167	3821
75-25	2481	3159	3549	3967	4321
100-0	2481	2674	3003	3246	3862
LSD (5%) 774 kg/ha					

responded significantly to N in the absence of P_2O_5 (see Barley Agronomy, Table 16).

However, Arvand yielded significantly more than Sahl when no nitrogen was applied, with or without phosphate. Sahl durum, on the other hand, was relatively more responsive than Arvand to applied N in the presence of phosphate. This result indicates that characteristic varietal responses to applied N can be manifested even under low rainfall conditions provided that soil phosphate is not seriously limiting.

Pathology

Durum wheats lack resistance to many important diseases in the region and this has resulted in a shift towards growing bread wheat in areas where durum wheat is the traditional crop, e.g., North Africa.

The three rusts, i.e., yellow rust (YR), leaf rust (LR), and stem rust (SR), and *Septoria* leaf blotch (ST), tan spot (*Pyrenophora trichostoma*), and common bunt, (CB) are the major durum wheat diseases. In North Africa, *Septoria*, tan spot (TS), and rusts are predominant and in the Near East, common bunt, rusts, and tan spot are important. Bacterial leaf streak (BLS) caused by *Xanthomonas translucens*, has recently caused considerable losses in some areas in Turkey and Syria where yield losses of 50-80% were not uncommon. Barley yellow dwarf (BYDV) and barley stripe mosaic virus (BSMV) also cause losses in some areas of the region.

With durum wheat, the same approach as for barley is being used to improve the level of resistance to the major diseases in the region, i.e., identification and utilization of sources of genes for resistance to these diseases.

Analysis of disease data showed that multilocation testing for disease resistance is of utmost importance. Environmental conditions and virulence in the pathogen populations vary considerably throughout the region. In Taiz (Yemen) a heavy leaf and stem rust disease pressure prevailed, which was the same as in Debre Zeit (Ethiopia). In the latter location few genotypes survived the heavy rust infection (Table 27), however some entries were among the most resistant in Taiz (Yemen).

Table 27. Genotypes resistant to leaf and stem rusts in Debre Zeit (Ethiopia) at 1981-82.

Cross and Pedigree	Additional resistances
Jorro	BYDV
Boohai	Cereal aphids
Egypt local 8	
Stellata'S' A-4090-17P-2P-1P-1B	
Chichicuilote'S' CD 1314-A-1Y-2Y	
Stw 63/G11'S'//RD119 D 31759-1M-2Y-1M-0Y	BYDV
Gdo 512/Cit'S'/Ruff'S'//Fg'S' CD 10549-H-5M-2Y-5M-0Y	

Tan spot was severe at Quich (Morocco) in addition to other leaf spot diseases, and BYDV. At Mateur (Tunis) both *Septoria* leaf blotch and tan spot were severe and this enabled sources of resistance to these diseases to be identified. Varieties combining resistance to *Septoria* leaf blotch and tan spot, and with good agronomic type were selected for further use.

A clear difference between the virulence pattern of the *Septoria tritici* pathogen population of Tunisia and Syria was evident. In Syria, the widely grown variety Haurani, was severely attacked while it was only slightly attacked in Tunisia. Therefore, Tunisian isolates of the pathogen were brought to the laboratory to evaluate the sources of resistance identified from the region. These isolates are being used along with others to identify sources of broad-based resistance.

Screening of advanced germplasm using a composite collection of common bunt showed for the third consecutive season that durum wheats are generally more resistant than bread wheats. Lines that showed resistance in the last three crop seasons have been selected and are being used in the breeding program.

Late rains in the 1981-82 season favored rapid development of bacterial leaf streak at both Tel Hadya and El Ghab (Syria), and this enabled screening of all the germplasm for this disease. These tests are invaluable since very few sources of resistance to this disease have been identified in the world.

Screening of potentially resistant lines to BYDV was made in collaboration with Agriculture Canada and good levels of resistance were identified in lines such as Dickson JG 426, Jorro, Melianopus 69, Yamuna, Quake, Meltegue, Jaboul, and Boohai.

Sources of resistance to different diseases, and genotypes with multiple disease resistance have been identified. Some are being used in ICARDA's breeding program and have also been made available to the national programs in the region through specialized international nurseries. Some lines with multiple resistance are shown in Table 28.

Crosses have been made to combine different types of resistance to the major diseases in the region, and to build germplasm with multiple disease resistance.

Entomology

Tests for resistance to wheat stem sawfly and suni bug were made on 288 and 351 durum lines, respectively.

The two durum lines least attacked by wheat stem sawfly when exposed to heavy natural infestation at Suran (Syria) and artificial infestation at Tel Hadya are listed in Table 29. Several durum lines have now been found to be resistant over the last 5 years

Table 29. Durum lines with least damage from wheat stem sawfly attack, 1981-82.

Lines	Suran[a]	Tel Hadya[b]
Ureyik 126/61-130/Kohak 2916/Lds/3/Alle		
ICD 77.186-5AP-0SH-0AP	1.1	0.6
Loon'S'		
CM 14528	0	1.1

a. Heavy natural infestation.
b. Artificial infestation.

Table 28. Examples of lines of durum wheat with multiple disease resistance in ICARDA region, 1981-82.

Cross and pedigree	Resistant to							
	YR	LR	SR	PM	ST	CB	BYDV	TS
Stw 63/G11'S'//RD119								
D 31759-1M-2Y-1M-0Y	+	+	+					
Ruff'S'//Jo'S'/Cr'S'								
CM 18537-1Y-0L-0AP	+	+	+	+				
Cfn/Lan F4 Lan//Jo'S'/Cr'S'								
ICD 77.167-2AP-0SH-0AP		+	+		+	+		
Waha'S'//D.dwarf S15/Cr'S'								
CD 10448-9SK-0SK	+	+	+					
Tunisian Durum 7	+	+	+			+		
Ruff'S'/Fg'S'								
CM 9880-25M-3Y-1M-0Y						+	+	
Lobeiro				+	+	+	+	

\+ - Resistant
YR - Yellow rust, LR - leaf rust, SR - stem rust, PM - powdery mildew,
ST - Septoria leaf blotch, CB - common bunt, BYDV - barley yellow dwarf virus.
TS - tan spot.

Table 30. Number of durum lines tested for several years to wheat stem sawfly attack, 1978 to 1982.

Location	No. of lines and range of % infestation	Check	No. of promising lines and range of % infestation
Suran	63 (0 - 5.9)	Hammari (5.9)	13 (0 -0.6)
Tel Hadya	63 (0.2-17.4)	Hammari (17.4)	13 (0.2-1)

The following lines were the most resistant in different years:

	% infestation					
	1978	79	80	81	82	Years Av.
Cr'S' (21563/61-130×Lds) CM 225-21M-1Y-0M-0Y	11.35	0.46	4.07	0.34	1.20	3.48
Corm'S'/Ruff'S' CD 7476-4Y-3Y-0Y		1.02	3.09	0.21	0.5	1.21
CI 15258 Gerardo 517			0.71	0.54	0.2	0.48
PI 191227 Verdeal Rijo			0.65	1.11	0.7	0.82
Parana 66/270			0.66	1.60	0.7	0.99

(Table 30). This indicates that there are reliable durum sources of resistance to the wheat stem sawfly that can be used as donor parents.

A preliminary screening with artificial infestation to determine the resistance to suni bug (*Eurygaster* sp) has shown that there is genetic variability for resistance. In the 351 lines tested, 24 showed very little infestation and there was excellent agreement between replicates. The value of these lines as sources of resistance is yet to be confirmed.

Grain Quality

Over 2300 durum lines were tested at Tel Hadya from the 1981-82 crop. The quality data for irrigated and rainfed trials are presented in Table 31. The overall high protein content, despite irrigation, largely masked differences between vitreous kernel counts and affected all other tests.

Table 31. Mean protein content, kernel weight, and vitreous kernel count of durum lines grown at Tel Hadya, 1981-82.

	Rainfed	Suppl. irrigation
Protein (%)	15.2	14.7
1000 Kernel weight (%)	48.5	44.2
Vitreous kernel (%)	93.8	90.7

Screening for protein and vitreous kernel counts would be more effective with irrigation and the application of "normal" or no fertilizer. At present the quality measures of all cereals do not represent the fertility level of farmers' land, which makes quality screening and evaluation difficult.

Weed Control

The effect of herbicides on broadleaf weeds and durum yield were studiedat Tel Hadya in 1981-82 (Table 32). Hand weeding gave the best control of weeds and resulted in the largest yield but with bentazone the yields were as good. In contrast with herbicide applications in barley, none of the herbicides caused a yield reduction compared with the unweeded check. Durum wheat appears to be less affected by herbicides than barley.

Twenty durum entries were tested for their ability to compete with weeds. The results in terms of Total Dry Weight of Weeds (TDW) indicated differences between the tested lines; the most competitive lines allowed the weeds to produce only 475 kg/ha TDW, and the least competitive line allowed 1188 kg/ha TDW. The potential weed population was

Table 32. Results of broadleaf weed control in durum wheat at Tel Hadya, 1981-82.

Herbicide	Rate (kg a.i./ha)	Yield (kg/ha)	Control (%)	Ranking
Bentazone	1.5	3183	139	2
Metoxuron	2.5	2804	122	4
Metoxuron	3.0	2383	104	7
Dinoseb-acetate	2.0	2646	115	5
Cyanazine	0.4	2427	106	6
Bromoxynil	0.5	2950	129	3
Hand weeded		3329	145	1
Control		2296	100	8
LSD (5%) 354				

determined by measuring the TDW from an equal area that was not planted with a crop. The TDW of such an area was 3175 kg/ha.

Bread Wheat Improvement

Wheat, both bread wheat and durum wheat, is the major source of protein and energy in the human diet in the ICARDA region. Population has increased faster than the production of wheat, and in some countries the production is stagnant. Although good, high yielding bread wheat varieties have been developed and released in the area, improved agronomic practices have not been widely adopted. This serious problem can be solved only by a combined effort by the national governments within the region to improve wheat production practices and to breed high yielding, disease- and insect-resistant varieties.

The joint ICARDA/CIMMYT bread wheat program uses the facilities at both centers to generate adapted germplasm for the ICARDA region. CIMMYT's main contribution is on the winter x spring crosses, rust and *Septoria* resistance, and germplasm with high yield and wide adaptability. The ICARDA contribution is increased adaptation of the germplasm to withstand specific environmental stresses, insects, and diseases encountered in the region.

Breeding

The aims of the bread wheat improvement program are to produce genotypes for the ICARDA region with the following characteristics: stable and high yield under varied amounts and distributions of rainfall; tolerance to cold, heat, and drought;resistance to the three rusts, and to *Septoria*, bunt, and loose smut; resistance to sawfly, Hessian fly, suni bug, and aphids; and improved nutritional and grain quality.

Parental material is available and is used to improve resistance to the diseases and sawfly. Both natural and artificial epidemics are used to select for resistance. The selection for high and stable yield in stress environments as part of aims 1 and 2 are much more complex. There are no easy ways to identify these characteristics in the segregating populations. Selection in segregating populations, in as many stress environments as possible, will help isolate the better material. Selected material is recycled into the breeding program for further improvement.

Quality improvement will continue to receive attention to meet the needs of the region. Quantity with usable quality is the first priority as quantity is the most pressing need.

To date there has not been sufficient screening for resistance to suni bug, Hessian fly, and aphid species or biotypes in the region. These problems will require much more input of time, personnel, and facilities than is available now to identify resistance and develop selection techniques before genetic improvement is possible.

About 500 single and top crosses have been made during the past 2 years for bunt and sawfly resistance. The best resistance for bunt is in the winter types. The best sawfly resistance is in photoperiod-sensitive spring wheats. Top and double crosses are made on the best F_1 to improve the photoperiod-insensitivity and spring habit in these crosses. Selection will begin in the F_2 next season.

There were 40 days when the temperature was below 0°C in 1982; leaf injury from frost in some lines was severe during January and February. On March 26 the temperature dropped to -5°C causing severe damage at the early boot stage. Drought stress in April was followed by good rainfall and mild temperature in May. Without any significant disease development, selection for cold tolerance was the main factor this season.

In Table 33 the mean yields of the two highest yielding lines in each yield trial are compared with the check varieties Mexipak and Golan. The check varieties showed good resistance to early cold damage. They are medium-late varieties and escaped heavy damage from the March 26 frost and gave very good yields this season. The yield expression this year was strongly influenced by the late frost at Tel Hadya. Many of the early to mid-maturing lines gave poor yields due to their advanced development when the late frost occurred.

There were 21 and 6 lines that yielded significantly higher than Mexipak and Golan, respectively, in eight AWYT experiments. In 27 experiments in the PWYT, 16 and 13 lines were significantly higher yielding than Mexipak and Golan, respectively, when compared in each experiment of 24 lines.

Mexipak and Golan averaged 5.2 in rank in the AWYT. In the PWYT the average rank was 4.5 and 3.6 for Mexipak and Golan, respectively. Since the yield comparison was made against check varieties near the top of the yield distribution, lines showing yield above the 5% level of significance would be less likely to occur by chance alone than if the check varieties were near the mean yield.

In the unreplicated yield trial where a comparison was made between the mean yield of Mexipak and Golan in each block of 12, 36 lines yielded more than 20% above the checks and 19 were more than 30% higher.

The regional yield and observation nurseries distributed by ICARDA have been very useful in the region. The first yield trials were harvested at Tel Hadya in 1978. The first regional yield trials that reflect the results of these trials were distributed in 1979-80. The results of the last three years for RWYT are

Table 33. Grain yields (kg/ha) of the two highest yielding lines in the AWYT[a] and PWYT[b] at Tel Hadya and Terbol compared with Mexipak and Golan, 1981-82.

	Tel Hadya				Terbol (Lebanon)
	Rainfed (350 mm)		Irrigation (400 mm)		Irrigated
	AWYT	PWYT	AWYT	PWYT	AWYT
Golan	3270	3318	3472	5182	7217
Mexipak	3094	3254	3444	4876	7201
1st Line	3385	3452	3998	5337	7879
2nd Line	3201	3249	3807	4939	7681

a. Advanced Wheat Yield Trial, 176 lines, 8 experiments.
b. Preliminary Wheat Yield Trial, 594 lines, 27 experiments.

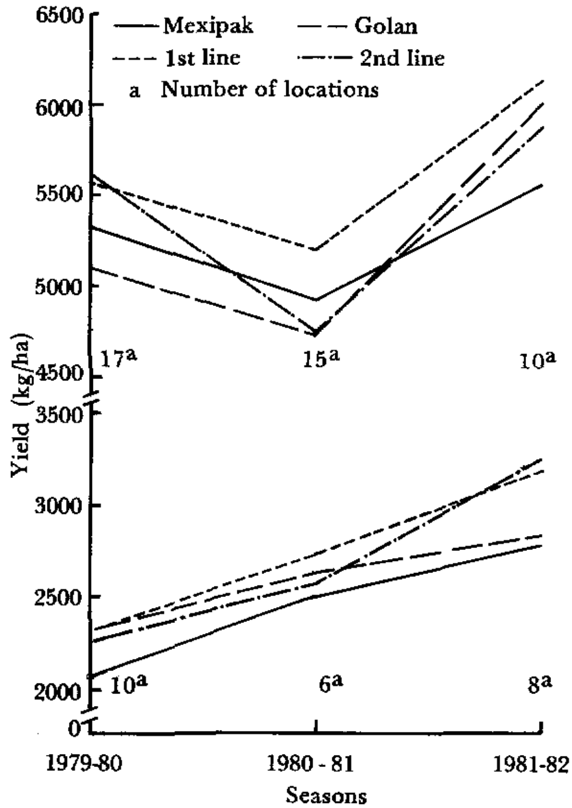


Figure 5. Comparison of two top yielding bread wheat lines for 3 years in the Regional Wheat Yield Trial (RWYT) with Mexipak and the national check in poor and favorable environments (mean location yield below or above 3500 kg/ha).

shown in Figure 5. The two top yielding lines show a consistent advantage over Mexipak and the top line over the national check.

In the 1981-82 Bread Wheat Observation Nursery (WON) 20 lines were selected at six or more of the locations from which data were received. The lines that were selected at seven or more locations are shown in Table 34.

The first six lines listed in Table 34 were spring x winter single or top crosses back to spring wheat. Of the 20 lines selected at six or more locations, 12 were crosses involving winter wheat. Ten of these lines have one common parent, which has one chromosome arm replaced by a rye chromosome arm. This translocation originally came from Weique. Of

Table 34. Lines selected at seven of the 18 locations in the Wheat Observation Nursery, 1981-82.

Frequency	Pedigree
9	Au//Kal/Bb/3/Bon CM 33203-E-1M-2Y-0M
9	Kvz/4/Bb/Cno'S'//Jar/3/Cno/7C/CC/Tob SWM 2903-4L-6AP-0AP
8	Kal/Bb//Ald'S' CM 37217-16Y-1M-0Y-1Mn-0AP
8	WRM//Kal/Bb SWM 1445-BY-2M-500Y-502M-500Y-506M-502Y-0M
7	Vee'S' CM 33027-F-9M-1Y-4M-500Y-500M-502Y-0M
7	RBS/Hork'S' SWM 2923-5L-1AP-0AP
7	2*MB//Inia'S'/Napo/5/N066/Bb/3/Cno//Nad/Chr'S'/4/7C CM 32973-2AP-3AP-0AP-1K-0AP

the eight spring x spring crosses five had one selection for disease in Kenya. Only 30 of 117 lines in the WON were spring x winter single or top crosses. It appears that the winter wheat parents are giving adaptability to the region. This gene pool needs further exploitation.

The bread wheat breeding program will be successful only if the germplasm generated is widely adopted. Agronomic practices must also be improved and applied to realize the high production potential already in the bread wheat varieties. Breeding is a continuous process that builds on the previous developments to improve yield, adaptation, and disease and insect resistance.

Agronomy/Physiology

Bread wheat is mainly grown in zone A (>350 mm rainfall) and with irrigation. In the 1980-81 season, experiments were continued to test the response of bread wheat to N and P_2O_5 fertilizers in farmers' fields. Negative responses to N fertilizer have now been observed for three successive seasons (see Barley Agronomy, Table 12). It is likely that there was a substantial amount of residual N at these sites from the previous heavy use of fertilizer. There were also some sites at which no response to P_2O_5 was measured. Thus it is likely that some farmers in zone A could increase crop returns from a reduction in fertilizer use.

When improved and farmers' levels of various production practices were compared in farmers' fields over three seasons, the response to the improved variety was consistent. Small responses to weed control were also recorded. Differences in fertilizer responses were not statistically significant ($P > 95\%$).

The response of three new bread wheats under consideration for release in Syria, to seed rates was also tested and compared with the local variety. Above 30 kg/ha increasing seed rate did not increase grain yield of any of the varieties tested. Frost damage at heading in the two new varieties, Veery and HD 2172, was severe.

For the second year, eight bread wheat varieties chosen to provide contrasts of tillering, kernel weight, numbers of fertile spikelets per head, and size of head, were sown at 50, 100, 200, 400, and 800 viable seeds/m^2. The aim was to determine which yield components are most closely related to yield in the Aleppo environment and how variation in components determines optimum plant density.

Only in the case of the variety Condor was there any significant increase in yield ($P > 95\%$) at populations higher than 50 plant/m^2. The optimum population of Condor, the highest tillering and yielding line, was 150 plants/m^2. The grain yield of several varieties was significantly smaller at 300 plants/m^2 than at 50 plants/m^2.Data from several more seasons are required before conclusions can be drawn from this type of experiment.

The varietal response of 45 bread wheat genotypes to eight rates of N was tested at Tel Hadya when water was not limiting.However the results were possibly affected by severe frost damage to some lines during flowering. The results will therefore require verification next season. Some selected data are given in Table 35. Whilst tolerance to low soil fertility is less likely to be important in zone A, an efficient response to applied N could improve production efficiency.

Pathology

In general the level of disease resistance in bread wheat is better than in durum wheat and barley. This is mainly because bread wheat has received greater attention of researchers over a longer period. However, in ICARDA region, breeding bread wheat for resistance to *Septoria* leaf blotch, common bunt, and tan spot is a continuing task, in addition to maintaining an adequate level of resistance to rusts. The approach followed to identify and utilize sources of resistance is the same as for barley and durum wheat.

In 1981-82 at Guich (Morocco) there was a severe infection of tan spot, other leaf spot diseases, and barley yellow dwarf (BYDV). In Mateur (Tunisia), *Septoria* leaf spot and tan spot infections were adequate for making reliable selection, while in Gemmiza (Egypt)

Table 35. Response of some bread wheats to N fertilizer at Tel Hadya, 1981-82.

Variety/line	Yield at zero N (g/m^2)	Max. yield (g/m^2)	Optimum N rate (g/m^2)	Yield[a]/N applied (g/g)
Trakia	75	375	8.0	38
Sannine - Ald'S'	125	375	18.0	14
Kavco	105	275	17.0	10

a. Maximum yield minus yield at zero N.

and Quetta (Pakistan) yellow, leaf, and stem rusts were severe. Genotypes with a good level of resistance to all of these diseases have been selected (Table 36). In Faisalabad (Pakistan) tan spot, a leaf spot complex, and rusts were severe.

Table 36. Examples of lines with good resistance to different diseases in Morocco, Tunisia, Egypt, and Pakistan, 1981-82.

Source (KLDN No.)	Cross and pedigree
26	Blo'S'-Emu'S' CM 29946-2AP-2AP-0AP-2AP-0AP
157	Sannine -Ald'S' L 932-4L-5AP-0AP-1K-0AP
167	Snb'S' CM 34630-D-3M-3Y-1M-1Y-0M
314	Bb × Tob-Cno/Huac'S' CM 32763-1L-1AP-0AP-1K-0AP
406	Sprw'S'-Pvn'S' CM 35210-48M-1Y-0M
468	Bg-Hork'S' × Aldan'S' CM 48016-P-2M-1Y-1M-0Y
476	Chrc'S'-Hork'S' CM 39812-8M-5Y-0M
510	K4500.2-BJY'S' CM 40480-23M-1Y-4M-1Y-2M-1Y-0B
586	{Son-SS2 [Cc-Kal(AZ × Nad-LR/BB)]}Maya'S-Jar'S' × Sjm'S' CM 43790-F-1Y-2M-1Y-1M-1Y-0B
733	R37-Gh1S121/Cno-Inia'S' × HD 832-0N SWM 4585-74M-1Y-3M-0Y
738	Rbs-Ti Resel SWM 4781

From the analysis of disease data collected from the international nurseries, which are grown in a wide range of environments, it was possible to identify (a) sources of resistance to different diseases, (b) lines with different sources of resistance genes, and (c) genotypes with multiple disease resistance. Some lines were used in the breeding program this season and were also made available to national programs in the region through specialized international nurseries (Table 37).

Continuous efforts in breeding for resistance to *Septoria tritici* in bread wheat have resulted, in general, in a better level of resistance than in durum wheat. This is shown by the results from Tunisia. The level of resistance in the bread wheats in the advanced and preliminary stages of yield tests was higher than that of durum wheat.

The level of resistance to common bunt in bread wheat is generally poor. Special efforts have therefore been taken to identify and utilize sources of broad-based resistance to this disease. All improved lines have been evaluated for resistance to a composite collection of common bunt collected from Syria. The average percentage of infection was high. 70% in the KLDN (1284 entries) and 68% in the Initial Disease Nursery, IDN (631 entries). This made it possible to select genotypes with good resistance to this pathogen. Resistant selections from the 1980-81 screening were retested in the 1981-82 season and in general this confirmed the results of the previous tests.

Forty-eight wheat genotypes have been evaluated against 10 collections and/or isolates of common bunt. Some of the varieties carry known genes for resistance while others were selected on the basis of their resistance to the Syrian collections in previous tests. The collections and/or isolates consisted of four races of common bunt with known genes for virulence and six collections from different countries in the region. These are as follows: Collection (1) from Syria; (2) from Turkey (spring wheat area); (3) from Turkey (winter wheat area); (4) from Lebanon; (5) from Tunisia; (6) from Iran; (7) race T-19 virulent to genes for resistance *Bt1, 2, 3, 7;* (8) race T-30 virulent to *Bt1, 2, 4, 6, 7, 9, 10;* (9) a race virulent to *Bt2, 5, 7, 8;* and (10) a race virulent to resistance genes *Bt1, 2, 3, 5, 7.*

Examples of the varieties with known genes for resistance are Nugaines, Hyslop, and Paha, which all carry the resistance genes *Bt1, Bt3,* and *Bt4* and Luke with genes *Bt9, Bt10,* and one more unidentified gene.

Table 37. Examples of lines with multiple disease resistance made available to national programs in the region, 1981-82.

Cross and pedigree	Resistant to							
	YR	LR	SR	PM	ST	CB	BYDV	TS
Au//Kal/Bb/3/Bon								
CM 33202-E-1M-2Y-0M		+		+	+			
WRM//Kal/Bb								
SWM 1445-8Y-2M-500Y-518M-501Y-503M-500Y-0M		+					+	
Snb'S'								
CM 34630-D-5M-2Y-3M-3Y-0M	+	+				+		
S277/FAO 215.1.2//Cut 75								
SE 1858-31S-1S-0S			+			+	+	
Mrs/MO//P10								
CM 43533-M-1Y-2M-1Y-1M-0Y	+	+						
NS 2699	+	+						
CI 8155/2*Nar 59								
Code 170 - 133	+	+					+	
Ti 71/Pci'S'								
CM 27712-1L-2AP-1AP-1AP-0K	+	+	+					+
Bb/CC/2*Cno/3/Tob/8156	+	+	+					
Peg'S'								
SWM 1368-500Y-1B-501Y-503M-0M	+	+		+	+			

\+ = *Resistant.*
YR = yellow rust, LR = leaf rust, SR = stem rust, PM = powdery mildew.
ST = Septoria leaf blotch, CB = common bunt, BYDV = barley yellow dwarf virus, TS = tan spot.

The aim of this study has been to identify genotypes with broad-based resistance to the common bunt fungus population.

The results showed that some varieties confer good resistance to all virulences used (Table 38). It also shows that some varieties have a differential reaction to these virulences and that the collection and/or isolates differ significantly in their virulence on some of the varieties used.

Entomology

Resistance to Wheat Stem Sawfly

The 288 lines of the WON, AWYT, and PWYT 1981-82, plus nine promising bread wheats which had been tested previously over several years for resistance to wheat stem sawfly, were screened at two locations in three replications. The material was grown at Suran (Syria) where a heavy natural infestation occurs annually, and at Tel Hadya with artificial infestation. Results of these tests are summarized in Tables 39 and 40.

The major source of sawfly resistance for bread wheat is in the cultivar Fortuna, a solid-stem bread wheat. This resistance has been incorporated in some short-strawed photoperiod-insensitive cultivars by CIMMYT and this parental material as well as the lines that have shown resistance over 5 years (Table 40) will be used in the sawfly resistance breeding program.

Grain Quality

Test procedures for bread wheat were con-

Table 38. Bread wheat lines with good resistance to common bunt at Tel Hadya, 1981-82.

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

Table 39. Number of bread wheat lines with least damage from wheat stem sawfly, 1982.

Location	No. of lines and range of % infestation	Check	No. of promising lines and range of % infestation
Suran	288 (1.1-22.8)	MP-112 (9.6)	6 (1.1-2.2)
Tel Hadya	288 (1.1-23.6)	MP-112 (23.6)	6 (1.7-4.4)

Table 40. Number of bread wheat lines tested that showed least damage from wheat stem sawfly over the period 1978 to 1982.

Location	No. of lines and range of % infestation	Check	No. of promising lines and range of % infestation
Suran	9 (0 - 7.2)	MP-112 (7.2)	7 (0 -1.1)
Tel Hadya	9 (0.5-23.3)	MP-112 (23.3)	7 (0.5-3.8)

Bread wheat lines that have shown resistance to wheat stem sawfly over several years:

	% infestation 1978	79	80	81	82	Years Av.
MT-777 CI 9294/Fortuna	1.02	0.71	4.60	0.61	0.5	(1.49)
MT-773 CI 9294/Fortuna	1.14	0.51	4.66	1.63	3.8	(2.35)
Fortuna	5.09	0.42	5.04	3.45	2.1	(3.22)
Sawtana	4.24	0.26	6.16	4.67	3.1	(3.69)
MT-778 CI 11490/Fortuna	5.18	0	7.06	3.60	3.3	(3.83)

solidated during 1981-82 by the installation of a Buhler Laboratory Flour Mill, a bran finisher, a *khobz fourn* (kiln-type baking oven), and commercial type sheeting rolls for *khobz* baking. A standard procedure was developed for baking *khobz.* The technique was based on commercial baker's methods. Judging the baked *khobz* is based on color, texture of crumb, thickness and uniformity of the two layers, smell, taste, "bitability", and keeping quality. A comprehensive operations manual describes the baking and judging. The building of the oven is described in a separate ICARDA publication.

The Buhler Mill was modified by changing the clothing of the reduction sieves, and changing the reduction roll settings to give flours that conform more closely to local commercial flours in terms of extraction and ash. Individual lines have been milled with extractions of up to 84%. A wide range in milling quality has been revealed.

At the request of the Aleppo milling department the ICARDA cereal laboratory investigated the reasons underlying the poor baking quality of some commercial flours. The chief reasons appeared to be low protein content (7.2-9.2%), inherent weakness of the flour, and above-normal proteolytic activity in the flour. Low protein is the result of a combination of high yields and low soil fertility. The poor protein strength is the result of growing varieties that have been selected on the basis of yield parameters alone, with no regard for quality. Proteolytic activity is caused by the suni bug (*Eurygaster* sp), which is known to infest certain areas of Syria , Turkey, and Lebanon.

Baking studies at Tel Hadya revealed that dough strength and *khobz* quality could be improved by addition of 3% dried wheat gluten, small amounts of lactic or citric acids, and 50-75 ppm of ascorbic acid. The results of the investigations were reported to the Aleppo office of the Syrian Milling Directorate and samples of *khobz* were submitted. The assistance of Mr. Ali Kamel Suleiman, Technical Director of Cereal Quality, from Damascus is appreciated.

The survey of the ways in which cereals are used was extended by a visit to Egypt and by a study of the making of *frekeh* in several villages in Syria. Stages in the making of *frekeh* where application of simple technology can make the process easier, to give a product that is free of foreign material and therefore more valuable, were identified.

Cereal Quality Nursery (CQN)

The CQN is a series of advanced lines of bread and durum wheats, and barley, which are grown in several locations throughout the ICARDA region. The 1981 CQN provided material from Terbol, Kfardan, and Tel Hadya irrigated and rainfed. The objectives of the CQN are chiefly to determine the stability of ranking in grain quality parameters under different conditions and the extent to which environment rather than genotype determines individual quality factors. Close correlations between quality parameters for individual lines grown under different conditions indicate that the environment has less effect on quality than the genotype. The most significant correlations between locations were obtained for kernel hardness in bread wheat, which is a highly heritable and important characteristic. Kernel weight and wheatmeal fermentation time (WMFT) are also affected more by genotype than by any other factor. Results for bread wheat are summarized in Table 41.

Table 41. Correlation across locations for hardness, kernel weight, and wheat meal fermentation time (WMFT) in bread wheat, 1981-82.

Parameter of grain quality	Coefficient of correlation		
	Low	High	Mean
Hardness	0.89	0.98	0.94
Kernel weight	0.71	0.85	0.81
WMFT	0.54	0.78	0.69

In the case of rainfed durum wheat the closest correlations between locations were for protein content and kernel weight (+ 0.93), vitreous kernel count (+ 0.79) and WFMT (+ 0.76). The CQN has been extended to include barley and five extra locations.

Weed Control

Herbicides were studied to determine the most effective control for broadleaf weeds and for broad spectrum control of all weeds at Tel Hadya, 1981-82. The results are given in Tables 42 and 43. Bromoxynil alone and in combination with other herbicides gave the best control. This confirms our results from previous years.

In another trial, different population densities of *Sinapis arvensis* (wild mustard) and *Avena sterilis* (wild oats) were studied to determine effects on the yields of wheat. The natural infestation of wild mustard depressed yield by 18%. Increasing mustard seeds to 60 and 70 kg/ha depressed yield by 25 and 26%; but increasing the mustard seed rate still more, did not reduce the yield further. The natural infestation of wild oats reduced yield by 27%. Increasing the wild oats by an additional 40 and 60 kg/ha resulted in 34 and 40% yield reductions, respectively. Further increases in wild oat density did not increase yield loss.

Table 42. Results of herbicides tested for broad leaf control in bread wheat at Tel Hadya, 1981-82.

Herbicide	Rate (kg a.i./ha)	Yield (kg/ha)	(%) Control	Rank
Bentazone	1.5	2896	125.6	4
Metoxuron	2.5	2954	128.1	2
Metoxuron	3.0	2579	111.8	7
Dinoseb-acetate	2.0	2952	123.0	3
Cyanazine	0.4	2604	112.9	6
Bromoxynil	0.5	3179	137.9	1
Hand weeded		2871	124.5	5
Control		2306	100.0	8
LSD (5%) 532.78				
(1%) 725.14				

Table 43. Results of broad spectrum weed control in bread wheat at Tel Hadya, 1981-82.

Herbicide	Rate (kg a.i./ha)	Yield (kg/ha)	(%) Control	Rank
Methabenz. + bromox.	1.5 +0.25	2873	112.9	5
Cyanazine + MCPA	0.25+0.5	3217	126.9	2
Certrol D	1.0	2398	94.3	9
Certrol H	1.0	3058	120.2	4
Dosamix	1.0	2740	107.7	6
Dosamix	1.5	2365	93.0	10
Brominal Plus	1.0	3235	127.2	1
Brominal Plus	1.5	2715	106.7	7
Hand-weeded		3188	125.3	3
Control		2544	100.0	8
LSD (5%) 414.30				
(1%) 559.47				

Weeds can severely reduce yield in cereal crops. At Tel Hadya, weed control experiments are conducted to evaluate the effectiveness of new herbicides.

Triticale Improvement

The objective in triticale improvement is to develop genotypes with greater yield potential, disease and insect resistance, and good nutritional and technological qualities, for the environments of North Africa and West Asia.

Uncertain weather, diseases, and insect pests are major constraints to cereal production in countries in North Africa and West Asia. New varieties with high yield potential that will tolerate these conditions will improve grain yield and stabilize production in the region. Triticale, a cross between wheat and rye, has been developed with the aim of combining the tolerance of rye to frost, drought, and diseases, and the nutritional quality of its grain with the yield potential and milling and baking quality of wheat.

The hardiness of triticale in adverse environments and its resistance to diseases make it of interest to ICARDA. The improvement in the yield of triticale in the last decade

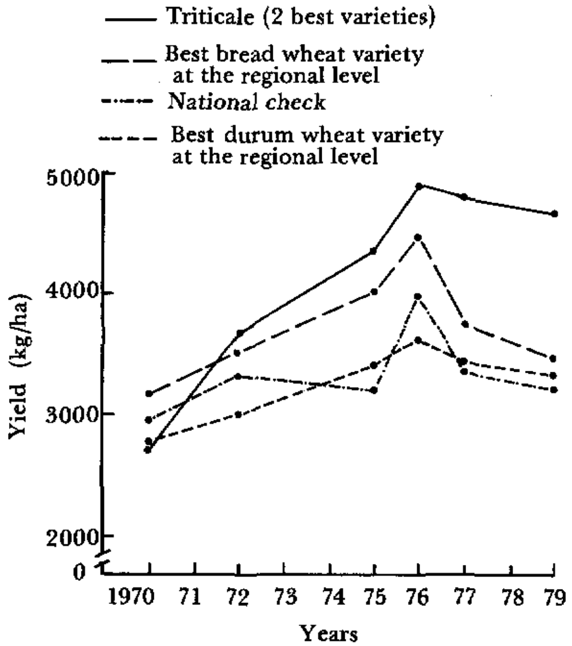


Figure 6. Evolution of triticale yield-International Triticale Yield Nurseries 1969-70 to 1979-80, Regional Wheat Yield Trials 1976-80, and Rainfed Wheat Yield Trials, 1976-80.

in North Africa and West Asia confirms this potential (Fig. 6).

In the 1981-82 season, triticale line Drira Outcross (DO) was again high yielding in trials at Tel Hadya. In 18 yield trials, it ranked first in five trials, second in four trials, and third in four other trials. In the 1981-82 Rainfed Wheat Yield Trial (RfWYT), DO outyielded the national checks at all locations (Table 44).

Selection for wide adaptation and disease resistance is conducted in collaboration with national programs.

Different planting dates are used at Tel Hadya to create differences in the environment during growth in screening nurseries and yield trials. Early planting exposes the test lines to early drought, frost in the susceptible stages of plant development, and serves to evaluate seedling vigor. Early planting exposes the seedlings to a moisture stress that affects seedling vigor. This technique permits selection of genotypes that suffer less from early moisture stress. Only 27% of triticale lines showed good vigor in early planting, but 72% had good vigor when planted at the normal time. The early planting was damaged more by frost than planting at the normal time. Only 10% of the lines showed tolerance to frost when sown early, but 52% were found tolerant when sown at the normal time.

Late planting exposes the material to frost at a different stage of development and to warm temperatures and drought during grain filling. Tiller number per unit area was affected drastically by late planting. Genotypes that tolerated late planting and had acceptable grain yield were selected and will be used as parents in the crossing program.

Wheat supplies more than 50% of the daily intake of calories and protein to people in North Africa and West Asia. Therefore improving the nutritive value of cereals can have an important effect on the quality of the diet in this region. ICARDA aims to improve the industrial quality of triticale so that it can be used in the same way as wheat. Triticale lines that combine good yield with large seed and

Table 44. Yield (kg/ha) of the triticale line DO[a] in comparison with the national check (NC), 1981-82.

Variety	Laxia/Cyp	Tel Hadya/Sy	Tajoura/Lib	Islamabad/Pak	Kfardan/Leb	Izraa/Sy
DO	3778	6400	2283	3533	1904	3288
NC	2633	5183	1342	3467	1583	3142
CV (%)	10.2	8.2	27.7	14.1	20.2	22.8
LSD	495.7	637.0	535.0	434.2	458.9	896.2

a. DO - Drira outcross.
b. Cyp - Cyprus, Sy - Syria, Lib - Libya, Pak - Pakistan, Leb - Lebanon.

Table 45. Triticale lines with good yield potential, large seed, and high and stable protein content in grain at Tel Hadya, 1981-82.

Entry	Yield as % of Golan[a]	Test weight as % of Golan	Protein content (%)
TA 1001-Tej/Bgl'S'/Nv'S'	167	96	16.0
TA 314-CIN/Pi//Pto/3/Bgl	111	97	13.3
TA 401 D010	133	95	14.9
TA 408 Selfert/Cinuem//Bgl	132	99	13.1
TA 516 DLF76	100	95	14.1
TA 617 1A/SPY//CIN/3/PTR'S'	124	97	15.2
TA 509 H507.71A/Bg12	111	97	13.7

a. Golan = a bread wheat.

high protein content have been identified (Table 45).

Advanced triticale lines that were analyzed for lysine content and other amino acids essential for human growth and development, showed a range of 3.5 to 4.4% lysine in the total protein content. This compares with Opaque-2 maize (3.8%), normal maize (2.5%), Atlas 66 bread wheat (2.8%), Naphall bread wheat (3.1%), and Hiproly barley (4.0%).

Agronomy/Physiology

Triticale is not yet a major crop in the region, however there are signs that it could eventually serve an important role, especially for animal feed and in areas where low temperatures adversely affect wheat yield. Three new triticale lines were compared at Tel Hadya in 1981-82 with an older line (Beagle) for their response to seed rate. Two of these new lines, M_2A/Bgl and M_2A/Up 301//Bgl cross, did not yield significantly more at seed rates above 50 kg/ha. However grain yield of Beagle and one other new line, Drira/M_2A, increased up to 100 kg/ha (Table 46). The results for Beagle confirm those of the previous 2 years. It is likely that triticale varieties, such as Beagle, have a higher optimum plant population and seed rate than most other cereal varieties grown under similar conditions.

Since triticale can be grown on soils of low fertility a range of genotypes were tested for their response to N fertilizer under such conditions at Tel Hadya. Selected data are presented in Table 47 to demonstrate the range of responses found where water was not limiting.

Entomology

A total of 108 triticale lines were screened at two locations (Suran and Tel Hadya) in three replications to determine the level of resistance to the wheat stem sawfly (*Cephus*

Table 46. Influence of seed rate and variety on grain yield of triticale at Tel Hadya, 1981-82.

	Seed rate (kg/ha)				
Variety	50	100	150	200	250
Beagle	3297	3799	3781	3835	3762
M_2A/Bgl	3189	3324	3352	3305	3256
Drira M_2A	3803	4370	4401	4011	4136
M_21/UP 301//Bgl.	2692	2922	3008	2936	3008

LSD (5%) Variety means for the same rate 453 kg/ha.
Seed rate means for the same variety 465kg/ha.

Table 47. Response of some triticale genotypes to N fertilizer at Tel Hadya, 1981-82.

Variety/line	Yield at zero N (g/m²)	Maximum yield (g/m²)	Optimum N rate (g/m²)	Yield[a]/N applied (g/g)
CML Pato × Bgl B-113	35	425	9.5	41
Juanillo 92 × - 21295	90	475	17.0	23
Selfert Cineum × Bgl B-52	160	375	11.0	20

a. Maximum yield minus yield at zero N.

sp). The two entries with the lowest infestation are shown in Table 48.

A preliminary test for suni bug resistance suggested there is resistance to this economically very important insect in the triticale germplasm.

Table 48. Two triticale lines resistant to stem sawfly and the degree of infestation compared with 108 lines and the check, 1981-82.

Triticale line	Range of % infestation by stem sawfly	
	Suran	Tel Hadya
M2A/Sar 702/Jup 73 CM 75A-1261-0AP	1.7	1.7
Abn'R'/M1A//M2A	1.7	3.9
MP112 (check)	12.9	17.1
Range of 108 lines	1.7-25	1.7-18.9

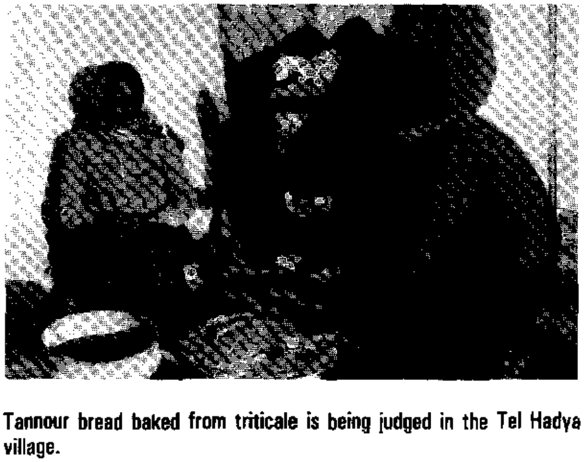
Grain Quality

Nearly 2500 lines of triticale were tested for protein and 1075 lines for kernel weight, from the 1981-82 crop. Mean protein content was 13.6% (10.1 to 16.6%) and mean kernel weight was 38 g/1000 kernels (27-56 g).

Tannour and *saaj* breads were baked in three villages in the Aleppo area by experienced local women. Blends of bread and durum wheats with triticale and triticale alone were baked, using subsamples of 100 wholemeals milled on the stone mill in Tel Hadya village. The triticale baked very good bread alone, or in blends, as judged by dough-handling, taste, and bread texture. Color was judged too dark, but could be improved by selection for bright colored seed and by crossing with white rye. It is felt that *tannours, saajs,* and similar village breads could become a good means of introducing triticale into suitable areas. For socioeconomic reasons the baking of village breads is decreasing in Syria.

Weed Control

Tests of the effects of application of herbicides to control broadleaf weeds in triticale at Tel Hadya in 1981-82 revealed that all treatments gave a slight yield increase over the unweeded check, but even in the hand-weeded treatment the yield increase was not significant at the 5% level (Table 49). This suggests that triticale is a relatively good competitor with weeds, and possesses a fair resistance to the herbicide treatment. In some instances, the application of broad spectrum herbicides resulted in yield increases nearly equal to hand weeding. Hand weeding, Brominal Plus (1.0 kg a.i./ha), Certrol H, and Cyanazine + MCPA gave significant yield increases over the unweeded control.



Tannour bread baked from triticale is being judged in the Tel Hadya village.

Table 49. Results of broadleaf weed control in triticale at Tel Hadya, 1981-82.

Herbicide	Rate (kg a.i./ha)	Yield (kg/ha)	Relative yield	Rank
Bentazone	1.5	3185	105	4
Metoxuron	2.5	3213	106	3
Metoxuron	3.0	3098	102	7
Dinoseb-acetate	2.0	3229	107	2
Cyanazine	0.4	3160	104	5
Bromoxynil	0.5	3119	103	6
Hand weeded		3569	118	1
Control		3031	100	8

a. LSD (5%) 607

High Elevation Cereals Research

Poor yields in high elevation environments are a consequence of the varieties grown and the production practices used.

To improve varieties for these environments ICARDA tests special genotypes that have been assembled and developed at Tel Hadya, at several locations. Adapted landrace varieties are crossed with modern elite lines of winter and spring types at Tel Hadya. The segregating populations obtained are channelled back to highland environments to identify specific plant ideotypes.

Production practices are more location specific. Production problems are identified in collaboration with national program scientists, and simple agronomic experiments, designed jointly, are mainly conducted by the local researchers.

The Cereal Program has begun research on a limited scale at six high elevation sites, i.e., three in Quetta in Pakistan, two in Morocco, and one in Syria.

Varietal Improvement

1. Quetta, Pakistan

Fixed lines from the Winter Bread Wheat Observation Nursery (WBWON), Winter Barley Observation Nursery (WBON) etc., as well as segregating populations were planted in and near Quetta (Table 50). These nurseries help to identify lines that can be used directly or channelled into the breeding program. A small number of lines were selected, which suggests that because of the specific adaptation needed for this area there is no short cut to developing better varieties, except from segregating populations. The material should have a short grain-filling period. The time for planting on the Kakir plateau is September, because the temperature starts to fall rapidly thereafter.

2. Annaceur, Morocco

A few nurseries comprising bread wheat, durum wheat, and triticale were grown in the Atlas mountains at Annaceur (Table 50) and at Oulmes. Rigorous selection was imposed to identify genotypes with resistance to diseases. The material required for these areas should be cold-tolerant spring or facultative types with a short maturity period.

3. Sarghaya and Tel Hadya, Syria

Observation nurseries were planted to observe cold damage, plant development, reaction to diseases, and to explore the possibility of us-

Table 50. Evaluation of winter cereal nurseries at high elevation sites and Tel Hadya, 1981-82.

Nursery	Total No. of entries	Selected entries: Quetta	Annaceur	Sarghaya	T.Hadya
WBWON	260	5	32	88	83
WBON	102	12	23		57
Durum (USDA)	247			36	90
DON	55				46
Winter barley	440	52		66	
D & BW (BARI)	2028				107
HPHL (Nebraska)	97	0	0	25	25
Cold Tol. Barley	23			8	
Cold Tol. Durum	12	0		4	2
BW (California)	139		13		
TEN	366		130		
F_1WBW	1017				816
F_1WD	490				413
F_1B	79				74
F_2WBW	303	96			90
F_2Triticale	280		29		
F_3WBW	486	114			46
F_3WD	156				22
F_4-F_7	176				53
Bulk lines (Durum)	284				103
F_1 wide crosses	104				53

B - Barley
BW - Bread Wheat.
D&BW - Durum and Bread Wheat.
DON - Durum Observation.
HPHL - High Protein High Lysine.
TEN - Triticale Evaluation Nursery
WBON - Winter Barley Observation Nursery.
WBW - Winter Bread Wheat.
WBWON - Winter Bread Wheat Observation Nursery.
WD - Winter Durum.

ing the sites for making the first selections (Table 50). However, it appears that the frost or cold damage is not severe because temperatures fall and rise gradually, which coupled with high rainfall, conditions the plants.

A set of nurseries was also planted at Tel Hadya so that information gathered from other sites could be used in developing new genotypes (Table 50). Selections were made on the basis of disease development, frost damage, and agronomic score. Some F_1 material was discarded as agronomically inferior, but for F_2 populations information on discarded material was conveyed to cooperating scientists in Quetta for their use.

Winter Wheat Yield Trial

The results from Quetta and Tel Hadya are presented in Table 51. At Tel Hadya two entries, i.e., Cleo/Pch//7C/3/At166/Au and Jar/6720//Ytk 406/ No. 67 gave higher yields than the best spring check and Bezostaya and Kavkaz winter checks. There were 18 entries better than the Bezostaya check and only four exceeded Kavkaz.

However, at Quetta all entries outyielded the local unimproved check variety (local white), 12 outyielded Bezostaya, and 17 were better than Kavkaz. Entry No. 18 (Cleo/Pch//7C/3/At166/Au) was among the top yielding five lines. These results suggest

Table 51. Winter Wheat Yield Trials, 1981-82.

Entry No.	Variety/line	Yield (kg/ha)
A. Quetta site (Irrigated)		
23	Zargoon 79 (Local improved)	7222
11	Cambord/5133//Mt/KKC/3/Lfn/NDP101	7089
18	Cleo/Pch//7C/3/At 166/AU	6667
2	Kanred/Funo//11 9933-3B	6611
9	Zincirli/4/KKZ/Nai 60//N10B/3/Staring/Cnn	6500
24	Local White (Check)	4556
21	Bezostaya	6167
22	Kavkaz	5667
B. Tel Hadya site		
18	Cleo/Pch//7C/3/At166/AU	3600
5	Jar/6720//Ytk406/No57	3594
23	S 311 × Norteno (Improved check)	3522
22	Kavkaz	3378
15	NS 2630-1	3256
21	Bezostaya (Check)	2322

SE ± 311.19

the possibility of identifying genotypes of wider adaptability with high yield potential for the high elevation areas.

Package of Production Practices

Agronomic experiments were conducted with and without irrigation in Baluchistan to develop a package of production practices.

1. Performance of Dual-purpose Barley under Irrigated and Rainfed Conditions at Quetta

Among the varieties tested with irrigation, the local variety gave the largest fodder yield at tillering. However, its grain yield was small. The variety Martin gave a reasonable grain yield in both cut and uncut treatments with irrigation. The variety Ahor gave the best overall result for both fodder and grain after cutting, when rainfed. Its performance with irrigation was also fair. When rainfed only, the local variety was poor as a dual-purpose crop.

2. Varietal Response to N and P Fertilizers at Quetta

Trial results indicated clearcut differences between three genotypes in their response to various doses of N and P fertilizers. At the lowest level of fertility the yield differences suggest a greater genetic potential in the new lines. The maximum yield of the local variety was 593 kg/ha with 100 kg N + 60 kg P_2O_5/ha. With variety Zamindar yield increased from 498 to 3125 kg at the 100 kg N and 60 kg P_2O_5/ha level after which the yield declined with increased fertility. However, in S311 x Norteno the yield increased linearly to the highest fertilizer dose of 150 kg N + 60 kg P_2O_5/ha.

3. Seed Rate

The best seed rate for the local variety and Zamindar was 100 kg/ha and with S311 x Norteno, an 80 kg/ha seed rate produced the maximum yield (3275 kg/ha).

4. Seed Treatment

Genotypic differences to various chemical treatments were observed for controlling seed-borne diseases such as bunt. The local variety, Local White, and Haramoun gave the *highest yields with a Vitavax treatment;* however with variety Zamindar, a Benlate treatment produced the highest yield, i.e., 2329 kg/ha.

Collaborative Projects

Jordan

The Jordan Cooperative Winter Cereals Improvement Project, funded largely by the Ford Foundation and the Government of the Netherlands, entered its fourth year in 1981-82. Responsibility for field operations was taken over from ICARDA by the University of Jordan and the Jordanian Ministry of Agriculture. Scientists from ICARDA continue to provide advice and support through regular visits to Jordan.

A series of experiments were conducted at 16 sites in farmers' fields in order to refine earlier findings on production practices for Jordanian cereal farmers. The season commenced unusually late and there was severe seedling drought in most areas. When the rains came, the weather was too cold to support *rapid plant growth; as a consequence* yields were very low. Despite this, good responses to drill sowing (compared with broadcast sowing) and herbicide application were found in all rainfall zones.

From the 1981-82 experiments and 3 previous years results, a set of "best bet" production practices for the three rainfall zones (Table 52) were established. It is anticipated that when present funding ceases in 1983, additional funds will be sought to continue the project into a demonstration and extension phase. If this effort is successful, a

Table 52. "Best bet" production practices for cereals in Jordan.

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

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

significant rise in cereal production in Jordan is possible.

Tunisia

A senior ICARDA scientist is located in Tunisia to cooperate with Tunisian scientists. The principal cooperating agency is L'Institut National de la Recherche Agronomique de Tunisie (INRAT). The 1981-82 season was the first full season of a collaborative project on barley breeding and cereal pathology with the research effort mainly directed to northern and central Tunisia. Due to the poor yields, disease susceptibility, and lodging susceptibility of local varieties, the need for new varieties is urgent.

Barley genotypes were intensively screened for local adaptation and disease resistance at several locations. Many lines were identified as sources of genes for resistance to the major barley diseases in Tunisia and North Africa. A small crossing program was begun. Yield data (Table 53) from three trial sites with widely different average rainfall indicate the advances achieved over the local check.

Syria

In the 1981-82 season an extensive collaborative project with the Ministry of Agriculture and Agrarian Reform in Syria was started. Yield trials, segregating populations, crossing blocks, and disease nurseries of all the winter cereals were prepared by ICARDA. They were sown and harvested by the Syrian Ministry. The project also included a continuation of on-farm variety testing across the major cereal areas of the country and a limited program of agronomic trials. The work was coordinated by ICARDA. Joint visits were made to the sites by ICARDA and Ministry scientists.

Selections were made for high yield, disease resistance, and agronomic traits and a small number of crosses were made to combine desirable features.

This project is by far the most comprehensive of all the collaborative projects. It involves most of the cereal research workers in Syria; over 150 trials were grown at 14 research stations. Training, which ranged from short-term, intensive courses on specific topics to informal instruction, was a feature of the project in 1981-82.

Morocco and Pakistan

Collaborative projects involving breeding cold-tolerant cereal varieties and agronomic research were started in Morocco and Pakistan in high elevation areas. The results of this work are described in the High Elevation Cereals Research section of this report.

Table 53. Yields (kg/ha) of promising barley lines in the 12th RBYT at three sites in Tunisia in 1981-82.

Variety/line	Site		
	Hindi Zeitoun (230 mm)	El Kef (350 mm)	Beja (610 mm)
ER/Apam[a]	1230	6720	4820
WI 2198[a]		5925	
Ky 63-1234		5295	5070
As54/Tra//2* (Cer/Toll)	1250	5875	
Avt/Ki/4/Avt/3/Toll		6235	4895
Martin (local check)	930	4950	3615
LSD (5%)	117	316	342

a. These lines plus Roho are being multiplied by the Tunisians for possible release to farmers.

Cyprus

Collaboration consists of reciprocal testing of barley and durum wheat breeding material from ICARDA and the national program. Cyprus provides a suitable environment for screening lines that perform well in warmer winter conditions than those at Tel Hadya. Such lines have been found to be suitable for those large areas of North Africa that have mild winters. In Cyprus, the work is conducted entirely by national scientists with the aid of a small grant from ICARDA.

Lebanon

Collaboration with Lebanese scientists is carried out mainly at ICARDA's station at Terbol, where a range of diverse breeding lines are routinely tested. Selected lines are tested in on-farm trials.

International Nurseries and Data Feedback System

International nurseries play a key role in the dissemination of germplasm. These nurseries are organized in such a way as to enable every national program to utilize the germplasm developed, according to its capacity. About 700 sets of international nurseries were sent in September 1982 to 87 cooperators in 45 countries. They represent about 80% of the total requests made by national program scientists and amount to about three tonnes of small packages of elite germplasm. They include different types of segregating populations, observation nurseries, yield trials, and crossing blocks of barley, durum wheat, and bread wheat. The Key Location Disease Nursery was also dispatched to 20 "hot spot" locations for disease evaluation.

A gradual shift in emphasis is envisaged towards tailoring international nurseries to specific conditions. This year three different sets of segregating barley populations have been prepared for dry, cool, and humid environments.

The crossing blocks of barley, durum wheat, and bread wheat consist of different groups of material and are essentially for use by national programs as parents in their crossing programs. They include groups of commercial varieties and local cultivars, high yielding advanced lines in the region, lines adapted to moisture stress and low fertility, genotypes characterized by tolerance to different stresses, i.e., drought, cold, salinity, in addition to a group of genotypes with resistance to different diseases and insects.

Triticale nurseries have not been sent this year, except in response to very special requests and only to potential areas.

For seed increases Jordan, Lebanon, Pakistan, Saudi Arabia, Syria, and Tunisia requested larger quantities of nucleus seed of some of the barley, durum wheat, and bread wheat germplasm, which were developed and/or introduced through the international nursery system. These seeds were provided; some lines may become commercial varieties in these countries.

The feedback received from national programs indicates that the material generated provides considerable variability to meet the local requirements for plant type, specific and wide adaptability, disease resistance etc.

CRISP, ICRISAT's computer statistical package, is used for analyzing international nursery data together with custom designed programs in preparation for the computerization of data entry, analysis, and reporting.

Training, Workshops, and Conferences

Residential Training Course

This cereal course in which 12 trainees from eight countries participated, lasted 6 months from February-July, 1982. The countries represented were Afghanistan, Cyprus, Egypt, Iran, Morocco, Sudan, Syria, and Tunisia. The course was mainly field oriented with 60% of the time spent in field activities and 40% in class lectures. Special research projects were assigned to each trainee and reports on these projects were presented at the end of the season. The trainees also gave seminars on wheat and barley production and constraints in their countries. Books, training manuals, handouts, class notes, and teaching aids were provided and visits were made to the Syrian Agricultural Research Center at Damascus and to some of the major research stations in the country. The visits resulted in a good interaction with national program scientists and an appreciation of the wheat and barley experiments being conducted. Also, farmers' field verification trials in several locations representing the different agroecological zones in Syria were inspected.

ICARDA's barley breeder discusses seed characteristics of barley lines with trainees from many countries in the region.

National Training Courses

During 1982, in-country training courses were held in Morocco and Syria. They were organized by the respective national program scientists and were conducted jointly with ICARDA staff.

In Morocco about 20 wheat and barley research workers received training in many aspects of cereal improvement. The trainees were selected from all the research stations involved in cereal improvement in Morocco. The training was mainly field oriented and 80% of the time was spent in field activities. The course dealt with breeding, agronomy, pathology, and entomology and considerable emphasis was given to field scoring. Visits were made to the five major research stations.

In Syria, 16 people were trained at Kamishly over a 2-week period, in April, in breeding, pathology, and machinery.

A 2-day comprehensive training course was also conducted at the Hama research station in Syria during the crossing season. It concentrated on emasculation and pollination methodology in wheat and barley.

Workshops

The lack of a functional infrastructure for seed production at the national level in the ICARDA region has always hampered the spread of new varieties. The Government of the Netherlands has continued to assist ICARDA improve this situation by sponsoring a workshop and seed production training course at Aleppo in April 1982, which was attended by 17 trainees from 10 countries in the region.

Research Fellows and Visiting Scientists

Many research fellows and scientists visited the Program, which resulted in a better understanding of the needs of the national programs and in fostering research links with other institutes.

Visiting scientists from Egypt and Tunisia spent varying amounts of time at ICARDA. The Egyptian group was mainly involved in making selections from the World Collection of Durum Wheat and from the improved material, which has different characteristics. More than 500 entries were selected. Also, selections were made in the bread wheat and barley plots. Tunisian scientists were mainly interested in the durum wheats and barleys.

FOOD LEGUME CROPS IMPROVEMENT

Contents

(Photo on previous page: Trainees at Tel Hadya taking faba bean samples for growth analysis).

FOOD LEGUME CROPS IMPROVEMENT

Introduction

The most important food legumes commonly grown and consumed in the Near East and North Africa are faba beans (*Vicia faba*), chickpeas (*Cicer arietinum*), and lentils (*Lens culinaris*). They are a valuable source of comparatively cheap yet good quality protein in the diets of the people in the region and are also an important component of rotations with cereals in farming systems.

Faba beans are grown either as a rainfed winter crop in the low elevation coastal Mediterranean region with high rainfall ($\geq$ 500 mm), or as an irrigated crop in the low rainfall areas, inland. Chickpeas are mainly grown on conserved moisture as a spring-sown crop in areas receiving about 400 mm seasonal rainfall. Cultivation of lentils is restricted to relatively drier areas, which receive about 300 mm seasonal rainfall. In high elevation areas of the region all three food legumes are grown as spring-sown crops.

ICARDA serves as an international center for the improvement of faba beans and lentils, and has a joint responsibility with ICRISAT for research on kabuli-type chickpeas. The major constraints to higher production of these legumes are the inherently low yield potential of the existing landraces; high instability in yield because of susceptibility to a number of diseases, pests, and parasitic weed species of *Orabanche*; poor production techniques; high cost of hand harvesting; and the lack of suitable mechanized harvesting methods. The major research thrust of the program during the 1981-82 season was towards overcoming these constraints. Improved genotypes and production techniques developed in the program are transferred to national programs by way of international nurseries and trials so that national scientists can test and adapt them to their local needs.

The emphasis in faba bean improvement research has been on (a) the identification of sources of resistance to the most common diseases, namely, chocolate spot (*Botrytis fabae*), ascochyta blight (*Ascochyta fabae*), and rust (*Uromyces fabae*), and on stem nematode (*Ditylenchus dipsaci*) and the parasitic weed *Orobanche*, and (b) the utilization of such sources in the development of high-yielding genotypes with appropriate phenology for different environmental conditions. Screening was conducted mainly at the ICARDA subsite in Lattakia, where environmental conditions favor the development of epiphytotics. Other improvement work was carried out at Tel Hadya and Kafr Antoon in Syria, and at Terbol in Lebanon.

Chickpea improvement work has concentrated on developing genotypes and production technology suitable for winter and early spring sowing in contrast to conventional spring sowing. A major requirement for this is the incorporation of tolerance or resistance in genotypes to ascochyta blight (*Ascochyta rabiei*), and to frost. Weather conditions at Tel Hadya in 1981-82 proved ideal for this work.

The thrust in lentil improvement work was the development of genetic material with more yield and reasonably wide adaptability for the low-land conditions of West Asia, tolerance to *Orobanche* and drought, and attributes permitting mechanized harvest. The work was conducted at Tel Hadya, Terbol, and the drier subsites at Breda (northern Syria) and Kfardan (Lebanon).

In collaboration with the Farming Systems Program, research was continued on the evaluation of symbiotic nitrogen fixation by food legumes, and on the significance of food legumes affecting productivity of rainfed cereals in a two-course rotation.

Faba Bean Improvement

Improved Faba Bean Cultivars and Production Practices for West Asia

The aim of this project is to develop cultivars for production under higher rainfall /supplementary irrigation in Syria, Lebanon, Jordan, Iraq, Turkey, and Cyprus. Emphasis is placed on cultivars with high and stable yield, resistance to *Ascochyta fabae, Botrytis fabae, Orobanche crenata*, large seed size and long pods suitable for both green and dry consumption, and acceptable nutritional quality. In addition, resistance to aphids, stem borers, and stem nematodes is being studied and appropriate production practices are being developed for existing and new cultivars.

Germplasm

In a joint IBPGR/ICARDA meeting to decide a minimum list of descriptors it was agreed that Brazil, China, India, Morocco, Pakistan, and USSR are priority areas for future exploration for faba beans.

The base (ILB) collection of faba bean populations stands at 2758 accessions. A total of 363 new accessions from China, Cyprus, Morocco, Spain, and Sudan were multiplied in the screen house. From the pureline collection (BPL), 1384 accessions were multiplied in the screen house, and 692 were evaluated in the open for a wide range of morphological and agronomic characters. The range for plant height was 30-85 cm, and for time to flowering and maturity, 105-127 days and 155-185 days, respectively. A total of 677 germplasm accessions from both the ILB and

BPL collections, were distributed to 11 countries including Australia, France, Germany, Mauritius, Morocco, Sudan, Tunisia, U.K., and USA.

In a collaborative project with the University of Reading we are examining the crossability of *Vicia faba* with wild species of genus *Vicia.*

Development of Cultivars and Genetic Stocks

Sources with high yield potential and resistance to *Ascochyta, Botrytis,* and *Orobanche* have been identified in germplasm evaluation. These are now being used in an expanded crossing program. The total number of crosses made in 1981-82 season was 628 and this large volume of crosses will increase the probability of obtaining desired recombinations in the future.

Yield Potential

Replicated yield trials of 199 lines were conducted under irrigated conditions during the 1981-82 season at Tel Hadya (Table 1). The highest yield achieved was 5528 kg/ha in an advanced yield trial. A total of 103 entries exceeded the yield of checks.

At Terbol in Lebanon, 225 lines were tested in replicated trials, and 175 of these lines were common to Tel Hadya. There were 107 lines yielding more than the checks in Lebanon. Of these, 58 yielded more than the check in both locations.

Table 1. Summary of results from faba bean yield trials (irrigated) at Tel Hadya in Syria and Terbol in Lebanon, 1981-82.

Trial	No. of trials	No. of test entries	Terbol		Tel Hadya	
			Highest yield (kg/ha)	No. of entries exeeding check	Highest yield (kg/ha)	No. of entries exceeding check
Preliminary yield trial, large seeds	3	34	3505	17[a]	3685	6[a]
Advanced yield trial, large seeds	1	14	2284	14[b]	5528	11[a]
Advanced yield trial, (Terbol) large seeds	1	19	3097	11[b]		
Advanced yield trial, small seeds	3	72	2590	46[c]	2958	65[c]
Advanced yield trial, (Terbol) small seeds	1	19	1671	9[d]		
Regional yield trial large seeds	1	24	Not harvested		2963	2[e]
International yield trial, large seeds	1	15	3574	3[a]	2648	1[a]
International yield trial, small seeds	1	15	3769	1[d]	3093	15[c]
Commercial varieties	1	25	2454	2[a]	2759	3[a]

Check:
a. Syrian local large (ILB 1814);
b. Lebanese local large (ILB 1817);
c. Syrian local small (ILB 1811);
d. Lebanese local small (ILB 1812);
e. *Cyprus local (ILB 1562).*

Disease Resistance

The major disease resistance work was carried out at Lattakia, where the environment is conducive to the natural development of epiphytotics. However, in order to ensure proper screening, artificial inoculations were also developed.

Ascochyta blight. Of the 620 lines tested in 1979-80 and 1980-81, 14 were rated resistant. Resistant selections (14434-1 and 14986-3) from this study were also resistant to isolates X and Y in Canada. Line BPL-2485 from ICARDA was resistant to all three isolates (A, X, and Y) in Canada and thus should have broad-based resistance. These resistant sources are now being used in crosses. The F_1 seeds of 58 crosses made during 1982 are being increased in the off-season nursery at Bab-Janneh near Lattakia. Screening the F_3 progenies of 2252 selections during 1981-82 yielded 4 highly resistant lines and 92 with a resistance reaction, whereas all the spreader rows were highly susceptible. In this nursery, 855 selections were made.

Chocolate spot. By adopting a two-cycle screening technique, considerable progress was made in identifying promising sources of resistance to *Botrytis fabae*. In the first cycle, 1730 lines were tested and 529 rated 1 (highly resistant) or 3 (resistant) on a 1-9 rating scale.

In the second screening cycle, 16 of the 529 selections tested rated 1 and 148 rated 3. When 326 entries were retested in 1981-82, 11 rated 1 and 104 rated 3 as against an average score of 7.4 for the local check. Highly resistant selections found in this study, i.e., BPL 710 and BPL 1179, also rated highly resistant in Egypt and U.K. This is of considerable importance because such a multilocational resistance was lacking in the past.

Of the 178 F_3 progenies tested in 1981-82, 16 rated 1 and 95 rated 3. Sixty crosses were made for *Botrytis* resistance.

Stem nematodes. A total of 2100 germplasm lines were screened for stem nematode (*Ditylenchus dipsaci*) resistance using the standard technique developed during the last season. Twenty-two lines rated 1 (highly resistant), 30 rated 3 (resistant), and the remaining lines rated 5 or above. The local check was susceptible. Entries BPL 27 and BPL 40 seemed highly resistant.

Orobanche. Screening for resistance to *Orobanche* was carried out at the Kafr Antoon subsite. Of the 504 new BPL accessions screened with the checks, i.e., Family-402 (resistant) and ILB-1814 (susceptible), 13 accessions appeared promising. They had a maximum of 3 spikes of *Orobanche* per plant as against 7.2 spikes in ILB 1814 and 2.3 spikes in F-402. Thirteen of the 84 accessions rescreened this season had a maximum of 2 spikes/plant. Accessions BPL 1517, 1983, 2038, 2138, and 2270 were very promising.

Sixty-two crosses were made for *Orobanche* tolerance and a total of 235 single plants in F_2 progenies were selected based on a high

Protein content of food legumes is evaluated using the Near Infra-red Reflectance Analyzer in the Quality Laboratory, Tel Hadya.

resistance or good tolerance to *Orobanche*, and more yield.

Quality

Faba bean pure lines from the germplasm collection were screened during the 1981-82 season for percent seed protein. The range in 1400 BPL lines was from 18% to over 37% (N x 6.25, dry basis). The standard deviation for the lines was 2.4 and relatively low. About 90% of the lines had protein contents that differed by only 2-3% from the overall mean of 28%.

Diseases and their Control

The highlights of our research on identification of sources of resistance and incorporation of resistance into improved cultivars have been discussed above. A summary of the resistance sources that have been identified is given in Table 2. Aspects of epidemiology and alternate control measures are reported below.

Table 2. Sources of resistance identified from ICARDA's germplasm collection for major faba bean diseases.

Disease	Sources of resistance
Chocolate spot *(Botrytis fabae)*	BPL 266[a], 710[a], 1179[a], 1196, 274 1278, 1390, 1821, 678
Ascochyta blight (Ascochyta fabae)	Sel. 80-Lat.-14435[b], 14422[b], 14434[b] 14986[b], 14998[b], 15035[b], 70015[b] 14200, 14336, 14339, 14398, 14399, 14427, 15025[b]; BPL 2485[b]
Rust *(Uromyces fabae)*	Sel. 80-Lat.-15563-3[b]
Rust and *Ascochyta blight*	F_6, F_{17}, Sel. 15563-3
Stem nematode *(Ditylenchus dipsaci)*	BPL 1, 7, 10, 11, 12 21, 23, 27, 40, 48, 57, 63, 75, 76, 88, 110, 121, 127, 183, 185, 210, 211.

a. Resistance reconfirmed in Egypt and U.K.
b. Resistance reconfirmed in Canada.

Chocolate Spot

Knowledge concerning physiological variations in *B. fabae* is essential to establish sound breeding strategies for resistance. In a cooperative study with the national program of Egypt and the American University of Beirut (Lebanon) to determine pathogenic variabilities and morphological characteristics of certain isolates of *B. fabae* from different geographical regions in Egypt, Syria, and Lebanon, five chocolate spot resistant genotypes, selected in the previous year, were cross-inoculated separately in moist chambers with eight different isolates of *B. fabae* from Egypt and Syria.

The Nubaria isolate from Egypt looked the most virulent, followed by the Ismailia isolate, whereas in Syria the Homs isolate was signficantly more virulent than those obtained from Doha (Lebanon) and Lattakia (Syria). In Syria, physiological variations in *B. fabae* were associated with distinct cultural and morphological characteristics. The more virulent Homs isolate produced less conidia and formed larger sclerotia than the less virulent Lattakia and Doha isolates. Homs and Doha isolates were significantly faster growing ($P \leq 0.01$) than the Lattakia isolate (Fig. 1).

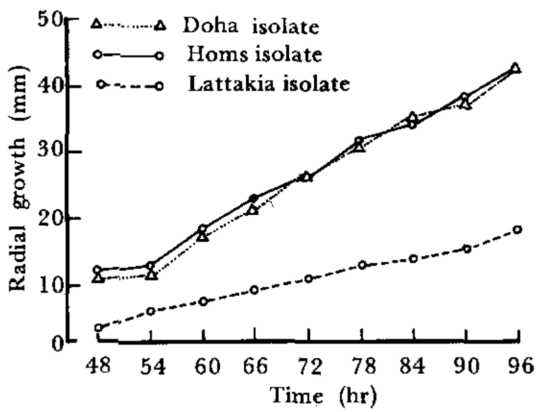


Figure 1. Growth rate of three isolates of Botrytis fabae.

Ascochyta Blight

To develop a host differential set, a number of selfed faba bean genotypes, selected for diversity of disease reaction, were cross-inoculated separately with four isolates of *Ascochyta fabae*, obtained from Lattakia, Homs, Hama, and Aleppo. Based on disease readings (made on a 1-9 rating scale) the host status of the genotypes in this test was classified into five significantly different categories (Table 3). In this study, the Lattakia isolate obtained from resistant faba bean genotype ILB 37 was significantly more virulent than other isolates. Seed from these differentials has been increased for distribution and further testing in different geographical regions during 1983.

In an attempt to develop an alternate control measure, the combined effects of seed and foliar chemical treatments on the severity of ascochyta blight in certain faba bean cultivars were studied in field conditions under artificial inoculation with *A. fabae.* Seeds were treated with Benlate (50 WP) at the rate of 5 g/kg of seeds. Dithane-M45 was used for foliar applications at the rate of 2.5 g/1 employing 500-600l of water per hectare. The initial application was when the disease was first observed, and the second at either the early flowering or early podding stage. The combination of Benlate seed treatment with the early flowering application of Dithane-M45 provided the best protection in all faba bean genotypes.

Stem nematodes.

The population density/yield relationships of *Ditylenchus dipsaci* in faba beans was studied in the field, with three replications. Disease readings were made on a 1-9 rating scale. The decrease in nematode population density in Temik (aldicarb)-treated plots was associated with less disease and a larger yield. Seeds obtained from plants grown in Temik-treated soils were nematode-free, except for seeds obtained from plots with the largest population of nematodes at the start. Seed from plants grown in untreated soils was infested with nematodes.

Phoma Blight

A new blight was observed for the first time in 1980 on faba bean plants at Lattakia. The symptoms were irregular brown lesions with tiny black pycnidia randomly buried in infected stem tissues. The fungus isolated from diseased tissues was identified by the Commonwealth Mycological Institute as *Phoma medicaginis* Malbr. under CMI Herb. No. 254776, and was found to be pathogenic.

Root-Knot

A root-knot injury was observed for the first time in 1980 on faba bean roots at Jub-Hasan near Lattakia. The symptoms were stunting, yellowing, and irregular galls on the roots.

Table 3. Ascochyta blight host differential set in faba bean.

Entries	Disease reaction* for isolates from				Host status
	Lattakia	Homs	Hama	Aleppo	
A - 1	3.0a	1.0e	1.6j	1.6p	Highly resistant
A - 4	4.3b	2.3 f	3.0 k	3.6q	Resistant
A - 5	7.0c	5.0g	5.6 l	5.0r	Moderately resistant
A - 7	7.6c	6.3h	7.0m	7.0s	Susceptible
A - 9	9.0d	8.3 i	9.0 n	9.0t	Highly susceptible

* Means followed by different letters are significantly different ($P \geq 0.01$) according to Duncan's Multiple Range Test.

Adult female nematodes identified as *Meloidogyne incognita* were found in these galls. Artificial inoculation confirmed that this root-knot nematode will attack faba beans.

Insects and their Control

As in previous seasons, surveys were conducted throughout Syria, which showed that *Sitona, Apion,* and bruchids were the most prevalent insects. *Lixus* was important in Tartous and Lattakia, and for the first time was detected in Homs.

In a trial designed to estimate losses due to insects, a soil application of carbofuran increased yields by 7.1% (Table 4). Deltamethrin -treated plots yielded less than the check, suggesting a phytotoxic effect. Total insect control, i.e., soil and foliage treatments failed to increase yields, possibly due to the adverse effect of deltamethrin.

Lixus algirus is regarded as a major pest in northern Africa and the coastal areas of Lebanon, Syria, and Turkey. However, its economic importance is yet to be evaluated. In a study of its biology, it was found that the oviposition period extends from late January to early April and reaches a definite peak between mid-February and early March. This is the time when adult female activity is greatest and any attempt to control the borer will have to coincide with this period.

In rating for *Lixus* resistance, it was found that counting the number of holes opened by the ovipositing female tends to overestimate the damage (Table 5). Better separation of materials was obtained by counting the number of insects per stem. Out of 168 BPL accessions tested, only 14 (8.3%) showed less than average infestation. The value of these lines as sources of resistance has to be reconfirmed.

Table 5. Rating of 168 faba bean lines for *Lixus* resistance according to different evaluation parameters.

Parameter	% of lines rated as[a]		
	Resistant	Intermediate	Susceptible
No. of holes/stem	5.9	60.1	33.9
No. of insects/stem	8.3	49.9	41.7
Index for holes and insects	25.0	43.5	31.5

a. Calculated for each parameter as a fraction of the check.

Cultural practices, especially planting dates, might be the key to stem borer control. Planting densities did not affect *Lixus* infestation levels, whereas an important effect of planting dates was found in an agronomy trial in Terbol, i.e., infestation percentage and number of insects/10 stems were significantly greater in early plantings. A similar trend was observed in Lattakia when infestation levels of crops planted early and late were compared.

Planting date was not as important to control *Bruchus dentipes.* No major differences in infestation were found among early plantings; only in late plantings was the infestation significantly smaller. Planting densities did not play a significant role. More important was the timing of insecticide application. A trial in-

Table 4. Effect of soil (carbofuran) and foliar (deltamethrin) insecticidal applications on faba bean insect populations and yields at Tel Hadya 1981-82.

Treatment	% nodules infested by *Sitona* larvae	% leaflets damaged by *Sitona*	% leaflets damaged by *Apion*	No. of thrips/ 20 flowers	% seeds infested by bruchids	Yield (kg/ha)
Soil	3.1b*	3.2b	11.3a	29.7a	41.2b	3276.1a
Foliar	8.2a	31.6a	17.9a	37.0a	38.7b	2986.8a
Soil + foliar	2.7b	7.2b	14.8a	23.7a	40.1b	3112.1a
Check	11.7a	33.3a	18.6a	40.7a	50.9a	3024.3a

* The numbers followed by the same letter are not significantly different at $P \leq 0.05$.
CV (%) for yields 16.3

dicated that applications in late March or early May were less effective than those in mid-April. This is important for efficient, economic control.

Production Practices

Planting Date

Results presented in Table 6 show that planting delayed beyond mid-December reduced both the total biological and seed yields at all three locations (Lattakia, Tel Hadya, and Terbol). *Though advancing the planting date into* November reduced growth and yield at Terbol and Tel Hadya, the effect was very slight at Lattakia. This was because of frequent sub-zero temperatures at Tel Hadya and Terbol during the early stages of crop growth and development. Reproductive growth was more sensitive to frost.

Plant Populations

A variation in plant population from 16.7 to 33.3 plants/m^2 caused no significant yield difference at Lattakia and Terbol, whereas at Tel Hadya a population of 33.3 plants/m^2 gave the highest seed yield, particularly in the early dates of planting.

Fertilizer Application

There was no response in seed yield of faba beans (ILB 1815 at Lattakia and ILB 1814 at Tel Hadya) to the application of phosphate and potash, singly and in combination, and with or without inoculation with *Rhizobium leguminosarum,* at either Lattakia or Tel Hadya, where the available soil phosphorus in the top 15 cm of soil was 5.5 and 13 ppm, respectively, and the available potassium was *very high.*

A foliar application of small doses of N, P, and micronutrient formulations (containing Fe, Zn, and Mn) at the time of early pod filling had no beneficial effect on ILB 1814.

Rhizobial inoculation and N_2-fixation

Three *Rhizobium* strains (BB 48a, BB 54b, and BB 85b) were evaluated for their N_2-fixation ability with ILB 1814 faba bean, with and without the application of the herbicide Tribunil. Nitrogenase assay using the acetylene reduction technique revealed that in the presence of Tribunil, inoculation with BB

Table 6. Effect of date of planting on the total recoverable biological yield (TBY, t/ha), seed yield (SY, t/ha), and harvest index (HI) of local large faba beans at Lattakia (ILB 1815), Tel Hadya (ILB 1814), and Terbol (ILB 1817), 1981-82.

Location	Particulars	Date 1	Date 2	Date 3	Date 4	CV (%)	LSD (5%)
Lattakia	Dates	Nov.6	Dec11	Jan.18	Feb.9		
	TBY	5.96	4.81	2.34	1.99	36.0	1.08
	SY	1.61	1.74	0.63	0.44	48.0	0.42
	HI	0.27	0.36	0.27	0.22		
Tel Hadya	Dates	Nov.6	Nov.16	Dec.6	Jan.4		
	TBY	5.67	5.87	5.31	3.86	13.3	0.55
	SY	2.96	3.28	3.44	2.66	15.6	0.38
	HI	0.52	0.55	0.65	0.69		
Terbol	Dates	Nov.3	Nov.11	Dec.8	Jan.1		
	TBY	4.53	5.20	5.03	4.02	20.0	0.75
	SY	1.82	2.19	2.71	2.20	29.6	0.53
	HI	0.40	0.42	0.53	0.55		

1 tonne (t) - 1000 kg.

48a strain of *Rhizobium* gave more N_2-fixation than the other two strains, whereas without Tribunil, no difference was observed amongst the strains.

Studies on seed treatment with Calixin-M, Benlate, Actellic, and a mixture of these chemicals at recommended rates revealed that they had no deleterious effects on nodulation.

A mixture of ground faba bean straw and faba bean seed, in equal proportions, appears to serve as an effective carrier for *Rhizobium leguminosarum* and may substitute for irradiated peat, both from the point of view of shelf-life and quality of freshly prepared inoculum.

Environmental Constraints to Production

In a cooperative study "Growth and development of faba beans in relation to specific environmental conditions" with the faba bean group of the European Economic Community, the effect of soil moisture and mineral nutrient supply was investigated with a set of diverse genotypes of Mediterranean and European origin. The data generated from this study along with that from other centers may lead to a better understanding of the physiology of adaptation of faba bean genotypes to some components of the aerial environment.

A maximum yield plot of faba bean at Tel Hadya to study the interaction between genotypes and environment.

The results of the crop performance (Fig. 2) show that at Tel Hadya limited soil moisture supply is the major constraint to the realization of high yields of faba beans. Soil nutrient supply can become a second constraint to the productivity of faba beans. Once these two constraints are removed, total biological yields could exceed 11000 kg/ha and seed yield 6000 kg/ha with a well adapted genotype, e.g., Aquadulce (Table 7). The water-use efficiency also improved with an increased moisture and moisture + nutrient supply. The Mediterranean genotypes, Aquadulce and Giza-3, showed a better overall performance than the two European types (Minica and Herz-freya) in all three soil environments. They were also less sensitive to severe moisture deficits, to which the crop was exposed in treatment C, than the European genotypes. The number of seeds per plant and 100-seed weight increased with improved moisture supply, and both contributed to increased seed yield per hectare.

Weed Control

Crop loss from weeds was assessed at Hama and Tel Hadya where the weedy check yielded only 62% and 74%, respectively, of the weed-free treatment. The trials also tested the preemergence herbicides chlorbromuron, methabenze, and terbutryne, all of which gave effective broadleaf weed control at both sites (Table 8). The availability and cost of these chemicals will determine their role in controlling weeds on farms.

Glyphosate, pronamide, and trifluralin were compared to control *Orobanche* in high and

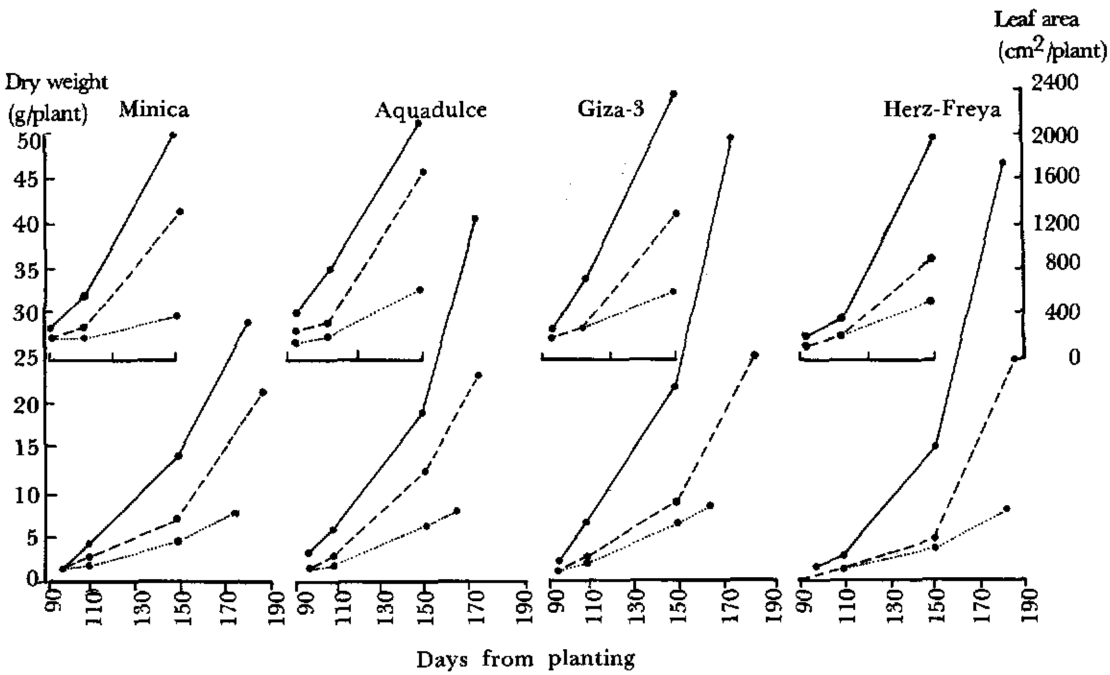


Figure 2. Total biological yield (g) and leaf area (cm²) per plant in four faba bean genotypes as affected by water supply and fertilizer application. A – artifical rooting medium + liquid fertilizer + irrigation; B – Irrigation + standard fertilizer; C – rainfed + standard fertilizer. (See table 7 for more details of treatments.)

Table 7. Yields and water-use efficiency of four faba bean genotypes as affected by soil moisture and soil fertility treatments at Tel Hadya, 1981-82.

Genotype	Soil environment	YIELD TBY (kg/ha)	YIELD Seed (kg/ha)	Harvest index	Seasonal water supply (mm)	WUE (kg/ha/mm) TBY	WUE (kg/ha/mm) Seed yield
Minica	A	9414	4578	0.49	515	18.28	8.89
	B	6263	3131	0.50	515	12.16	6.08
	C	2061	970	0.47	335	6.15	2.89
	Mean	5913	2893	0.49			
Aquadulce	A	11345	6008	0.53	500	22.70	12.02
	B	8121	4909	0.60	500	16.24	9.80
	C	2909	1620	0.56	335	8.68	4.83
	Mean	7461	4179	0.56			
Giza-3	A	9818	5689	0.58	500	19.64	11.38
	B	7333	4101	0.56	500	14.67	8.20
	C	2828	1479	0.52	335	8.44	4.41
	Mean	6660	3756	0.56			
Herz-freya	A	7636	3317	0.43	515	14.82	6.44
	B	6909	2812	0.41	515	13.41	5.46
	C	1495	578	0.39	335	4.46	1.72
	Mean	5347	2236	0.41			

A = Artificial rooting medium + four times 100 kg N + 33kg P + 33kg K per ha as a liquid feed + irrigation.
B = As for (C) + irrigation (12 trickle irrigations of 15 mm each).
C = Control (indigenous soil, 100 kg TSP/ha, no irrigation).
TBY = Total Biological Yield; WUE = Water-Use Efficiency; TSP = Triple Superphosphate.

Table 8. Results of the International Faba Bean Weed Control Trial from Tel Hadya (with rainfed ILB-1814), and Hama (with irrigated Cyprus local faba bean), 1981-82.

Treatment[a]	Tel Hadya SY[b]	Tel Hadya Ph[c]	Hama SY	Hama Ph
Weedy check	1290		3196	
Weed-free check	1754		5163	
Weeding 2 times	1628		4450	
Chlorbromuron 1.0 kg a.i./ha	1628	2	4597	1
Chlorbromuron 1.5 kg a.i./ha	1510	2	4898	1
Chlorbromuron 2.5 kg a.i./ha	1489	4	4574	1
Methabenzthiazuron 2.5 kg a.i./ha	1419	1	4821	1
Methabenzthiazuron 3.0 kg a.i./ha	1610	1	4391	1
Methabenzthiazuron 3.5 kg a.i./ha	1510	2	5127	1
Terbutryne 2.0 kg a.i./ha	1374	2	5074	2
Terbutryne 2.5 kg a.i./ha	1406	5	4608	2
Terbutryne 3.0 kg a.i./ha	1469	5	4657	4
CV (%)	12.0		10.2	
LSD (5%)	348.4		669.7	

a. Herbicides applied as preemergence sprays.
b. Seed yield (kg/ha).
c. Crop phytotoxicity scale: 1 = no toxicity; 9 = complete kill.

low rainfall environments (Lattakia 500 mm, and Tel Hadya 373 mm precipitation). There were dramatic differences between locations with glyphosate, which caused phytotoxicity symptoms and reduced yield at Lattakia, but increased yield at Tel Hadya (Table 9). In a separate time of application trial at Lattakia, i.e., in a high rainfall environment, glyphosate gave the best yields when applied at 50% flowering. Both pronamide, as a postemergence herbicide, and trifluralin, presowing incorporated, were used successfully at Lattakia, but were ineffective at Tel Hadya.

Faba Bean Genetic Stocks for Regions Other than West Asia

The objective of this project is to develop and distribute genetic stocks (early generation and/or random-mating populations) with adaptation to a specific country or subregion; resistance to one or more of the common parasites and pests; and acceptable seed size and nutritional quality. The need for this project arose when international trial results in previous years showed that selections made in Syria and Lebanon were of little value as direct introductions into the markedly different environments of irrigation in the Nile Valley and rainfed cultivation in North Africa.

There is clearly a need to recombine identified sources of resistance with local adaptation. For example BPL 938, a selection from Colombia germplasm, has been found resistant to *Botrytis fabae* in Egypt, Syria, and the U.K. However, it is poorly adapted to each location and must therefore be used in recombination before the source of resistance can be exploited. It is anticipated that this recombination can be made by the national program in Egypt and the ICARDA regional

Table 9. *Orobanche* control in faba bean (ILB 1814) with herbicides in low and high rainfall sites during 1981-82.

Treatment	Low rainfall site Tel Hadya				High rainfall site Lattakia			
	Faba seed Yield		Dry weight of *Orobanche*		Faba seed yield		Dry weight of *Orobanche*	
	kg/ha	%	g/m^2	%	kg/ha	%	g/m^2	%
Glyphosate 0.08 kg a.i./ha, 3 times, starting early flowering	703	858	4.3	42	527	126	2.5	2
Pronamide 4.0 kg a.i./ha early post-emergence	70	86	7.7	60	1393	429	15.50	10
Trifluralin 0.5 kg a.i./ha, preplanting incorporation	95	116	72.3	75	1370	414	0.75	0.5
Pronamide 2.0 kg a.i./ha+glyphosate 0.12 kg a.i./ha, at flowering	53	64	31.3	33	538	129	61.00	38
Control	82	100	96.3	100	417	100	160.25	100
LSD (5%)	289		18.9		565		28.9	
CV (%)	108		28.3		42		39.2	

program for North Africa that is located in Tunis. The headquarters program at ICARDA *will concentrate on building trait-specific gene* pools, using identified and confirmed sources of resistance, and on selecting for multiple resistance.

For yield potential, results of the international large-seeded yield trial indicate a wider adaptation than has been found previously. The line 5 MCI Elegante (ILB 1805), a selection made at Douma by the Syrian Agriculture Research Directorate, yielded more than the local check in 8 of 11 locations in the 1980-81 season. Its yield advantage at these locations is shown in Figure 3. This entry will be used extensively in the crossing block next season.

National programs in 28 countries have been provided with 212 sets of 10 different nurseries and trials for the 1982-83 season. They include screening nurseries, F_3 trials, and yield trials. A limited number of sets of broad-based sources of resistance to common diseases have also been distributed.

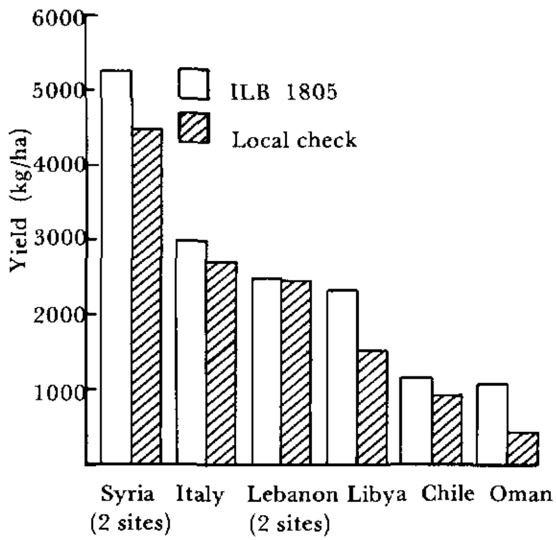


Figure 3. Seed yield of 5 MCI Elegante (ILB 1805) and the best check in the International Faba Bean Yield Trial-Large Seeded in six countries, 1981-82

Cultivars and Agronomic Practices for Low Rainfall Environments

Farmers in areas with 300-400 mm annual rainfall have a limited choice of crops. The development of high, stable yielding faba bean cultivars, and agronomy capable of producing an economic dry seed yield will be important because this may provide another option and lead to diversified cropping.

Development of Cultivars

Breeding of faba bean for low rainfall situations was conducted at Tel Hadya, where the season's total rainfall was 373 mm in 1981-82. Faba beans are normally grown only with supplementary irrigation at that level of rainfall. A total of 42 crosses were made with lines selected in low rainfall environments. Also, 44 single plants were selected from F_2 and 22 plants from F_3 generations of segregating material developed and grown on *limited rainfall.*

In rainfed yield trials, 129 lines were assessed. A total of 47 entries (or 36%) yielded more than the check (Table 10). It is clear that there is a response to selection for yield, in a rainfed crop. Confirmation of this response was evident in the results from the Regional Rainfed Yield Trial conducted in cooperation with the Syrian Ministry of Agriculture in Douma. Entry 78S 49048 (ILB 29), a selection from Iraqi germplasm, consistently outyielded the check at three sites in Syria under rainfed conditions (Table 11). The overall yield advantage of this entry over the check was 14%.

Drought Tolerance Studies

A number of faba bean genotypes were evaluated for their relative drought tolerance in

Table 10. Summary of rainfed faba bean yield trials at Tel Hadya, 1981-82 season.

Trial	No. of entries	Highest yield (*kg/ha*)	No. of entries *exceeding* check	CV (%)
Advanced yield trial (Terbol), large seeds	19	1865	4[a]	13.5
Advanced yield trial, small seeds-rainfed	24	1986	21[b]	16.4
Advanced yield trial (Terbol), small seeds	19	2417	4[a]	15.3
Regional yield trial, large seeds-rainfed	12	1833	2[a]	15.8
International yield trial, large seeds	15	2037	2[a]	15.3
International yield trial, small seeds	15	1759	13[b]	17.9
Commercial varieties trial	25	1296	1[a]	39.3

a. Check entry SLL (ILB-1814).
b. Check entry SLS (ILB-1811).

Table 11. Performance of faba bean 78S 49048 (ILB 29) and the local check at three locations in Syria under rainfed conditions, 1981-82 season.

Selection	Acc. No. ILB	Seed yield (kg/ha) Gellin	Izra'a	Tel Hadya	Mean	Advantage over check (%)
78 S 49048	29	863	697	1815	1125	14
Syria local	1814	735	422	1796	984	
SE±		73.3	57.7	124.0		

1980-81 season using two methods, i.e., (a) growing them at locations with different amounts of rainfall (Jindiress, Tel Hadya, and Breda), and (b) varying the moisture supply at Tel Hadya by supplementing rainfall with irrigation. The yield of some genotypes was less affected than others by a limited supply of water.

The trial was repeated in 1981-82 season at the same locations. At Tel Hadya, supplementary irrigation was applied again. Yield, growth, and water-use efficiency were measured at Tel Hadya. Total biological yield and seed yield corresponded closely with total seasonal moisture supply (Table 12). As in the previous season ILB 10, 277, 605,1814, and 1816 were less sensitive than others to a limited moisture supply.

Differences in extractable soil moisture, total evapotranspiration, and water-use efficiency for selected genotypes are shown in Table 13. Extractable moisture is the difference between the maximum recharge value and the lowest value to which it is reduced. The largest extractable moisture value was recorded for ILB 10, followed by ILB 1819 and ILB 1814. The depth of extraction of moisture by ILB 10, 227, and 1814 was greater than for the other genotypes. These genotypes, and also ILB 605 and ILB 1816 had a greater water-use efficiency than the others. Thus, based upon all these parameters, genotypes

ILB 10, 277, 605, which were selected from the rainfed nursery in the 1978-79 season, and the local large-seeded landrace (ILB 1814) appear promising genetic material for rainfed cultivation in northern Syria.

Development of Alternative Plant Types in Faba Bean

The aim of the project is to develop and evaluate alternative plant types for their yield potential in different environments, investigate the relationship between different morphological characters and yield development, and to study the pollinating system in faba beans.

Determinate Faba Beans

The determinate habit of mutants from Sweden is of potential importance in faba bean production areas that are either irrigated or are highly fertile. Its use will help to avoid excessive vegetative growth, which is common in favorable environments, and should therefore increase harvest index.

The "topless" mutant from North Europe is poorly adapted to Mediterranean environments, and efforts are being made to

Table 12. Total recoverable biological yield (TBY, kg/ha) and seed yield, (SY, kg/ha) of some selected genotypes of faba beans at different locations in northern Syria during the 1981-82 season.

		Breda		Tel Hadya				Jindiress	
	ILB	Rainfed	(275 mm)	Rainfed	(335 mm)	Irrigated	(385 mm)	Rainfed	(350 mm)
Genotype	No.	TBY	SY	TBY	SY	TBY	SY	TBY	SY
Syrian large	1814	1256	318	4154	2701	5407	3495	3301	1567
78-S-48428	277	825	250	3590	2363	4056	2597	3075	1545
Seville Giant	1933	1019	261	2940	1941	4225	2595	2694	1162
Giza - 3	1819	342	94	2979	1966	3053	2186	2476	1175
Aquadulce	1266	694	150	3363	2063	3775	2685	2179	996
78-S-49907	10	706	207	3200	2257	4625	2958	2863	1389
Lebanese small	1816	819	270	3712	2367	4466	3012	2981	1459
78-S49694	605	763	247	3584	2402	4531	2978	2719	1324
Mean		803	224	3440	2254	4267	2813	2788	1327
CV (%)		18.8	26.3	13.7	13.7	13.7	13.7	15.9	18.8
LSD (5%)		222.5	87.2	534	350.8	534	350.8	652	366.6

a. Figures in parentheses represent total seasonal moisture supply through rain, or rain plus irrigation.

Table 13. The total extractable moisture (EM), evapotranspiration (E_t), water use efficiency (WUE, kg/ha/mm) for total recoverable biological yield (TBY) and seed yield (SY) for some selected genotypes of faba beans under rainfed conditions at Tel Hadya, 1981-82.

		EM	Total E_t	Yield (kg/ha)		WUE	
Genotype	ILB	(mm)	(mm)	TBY	SY	TBY	SY
Syrian large	1814	103.1	278.4	4153	2701	14.6	9.47
78-S-48428	277	97.1	279.3	3711	2363	12.7	8.06
Seville Giant	1933	97.1	270.4	3200	1941	11.7	7.10
Giza-3	1819	105.5	265.7	3096	1966	11.2	7.12
Aquadulce	1266	91.0	270.5	3363	2036	12.0	7.29
78-S-49907	10	129.7	271.2	3454	2257	12.4	8.12
Lebanese small	1816	86.9	269.2	3712	2367	13.5	8.59
78-S-49694	605	97.0	269.3	3584	2402	12.9	8.62

transfer the character into an adapted background. To this end, 46 crosses with at least one determinate parent were made this season. Single-plant selections of determinate material were made in the F_2, F_4, and F_5 generations of crosses made earlier with "topless" parents. These selections are in an off-season seed increase in Jordan, so that a yield test of 257 lines will be possible next season. Interest in the determinate habit is also being shown in Egypt, where 55 determinate lines from ICARDA were tested during the last season at two locations; 23 lines were selected for further evaluation.

Out-crossing Studies

The genetics of esterase isoenzymes in bean leaf tissue were investigated by electrophoresis. The inheritance of 10 of the bands in the polyacrylamide gel was found to be controlled by five major genes. Experiments were performed using these genes as markers to monitor the level of out-crossing. In screen cages with enclosed beehives, low bean density (8 plants/m²) gave a higher rate of out-crossing (53%) than 16 plants/m². Under field conditions there was 36% out-crossing between plots with bean guard rows, 18% in plots separated by a triticale border, and only 7% in plots separated by a 2 m high cotton mesh. There was a consistent reduction in out-crossing at the base of the plant (47% at node number 2) upwards to 15.8% at node number 14. This information will greatly assist in the manipulation of out-crossing rates in the breeding program.

Plant Population x Plant Type

The hypothesis that, given an adequate plant population, a small structured plant (monoculm model, determinate model, etc.) may outyield a branched, indeterminate plant, typical of landraces, was tested in an experiment with supplementary irrigation at Tel Hadya. The monoculm and determinate plant models were simulated by removing branches and the apex of the main stem, respectively, above the 12th flowering node in ILB 1814. A determinate bulk line was also included. These were evaluated in a fan-type design (Nedler Design).

Results (Fig. 4) showed that yield increased with an increase in plant population, but it increased most in the monoculm model. Yield from the determinate bulk line was small because of its high susceptibility to frost, but the determinate model of ILB 1814 gave the largest yield, indicating that in a well adapted genetic background such a plant type has high yield potential.

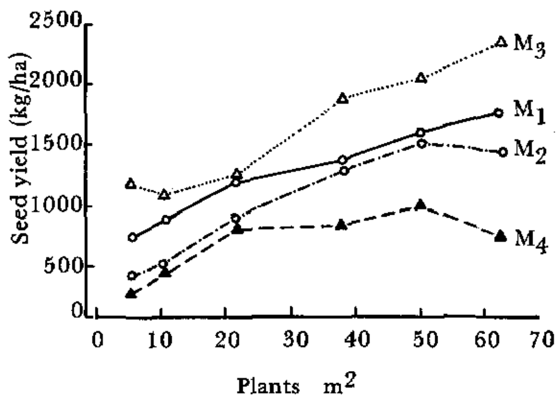


Figure 4. Yield of faba bean plant type models as affected by plant population.
M_1 – control; M_2 – main stem only;
M_3 – detopped to simulate determinate habit; M_4 – determinate mutant bulk.

Lentil Improvement

Improved Cultivars and Production Technology for Different Environments

The aim of this project is to develop cultivars or genetic stocks with appropriate phenology, high and stable yields for each of the three major agroecological production regions, maintained or wherever possible improved, cooking and nutritional qualities, and better nitrogen-fixing ability. Other specific traits required for the different regions are:

1. High altitude environments: Cold tolerance for winter planting, attributes to facilitate harvesting (i.e., tall, nonlodging growth habit, and pod retention and indehiscence).

2. Middle to low elevation areas in the Mediterranean region: Maintained biological yield, tolerance to broomrape (*Orobanche* sp), resistance to the root rot/wilt complex, attributes to facilitate harvesting, tolerance to drought during the reproductive period of growth.

3. More southerly latitudes (including Egypt, Sudan, Ethiopia, India, Pakistan): Earliness through insensitivity/reduced sensitivity to photoperiod and temperature, resistance to the root rot/wilt complex and rust.

The project also aims to develop appropriate agronomic practices for existing and improved cultivars.

Germplasm Development

A joint ICARDA/IBPGR meeting in May 1982 in Aleppo prepared a minimum list of descriptors for lentils and faba beans and identified Algeria, India (Madhya Pradesh), Morocco, and parts of Turkey as priority areas for further collections of lentils. A need was expressed to supplement the current ICARDA lentil germplasm holding (5420 accessions) with material from collections now held in Bangladesh, Iraq, and Pakistan.

The passport information on all 5420 accessions has been entered into the computer, together with evaluation data for 16 characters in 3500 accessions. A further 500 accessions were evaluated during the year. The data bank will be distributed as a germplasm catalog during 1983 and will be available for information searches.

Improved Lentil Cultivars for Different Agroecological Situations

During the evaluation of germplasm, many genotypes with a desirable expression of important traits were identified and these have been included in the crossing program for recombination.

A total of 362 single crosses were made in the 1981-82 season. The target areas and criteria for crosses are shown in Table 14. Sixty three percent of crosses were made for the low to middle elevation region around the Mediterranean, 29% for more southerly latitudes, and only 8% for high altitude areas. These proportions show the relative degree of emphasis given to the three main agroecological lentil production regions.

There were 67 entries in the crossing block from 22 different countries, which indicates the width of the genetic base being used for lentil improvement. This is of particular importance because of the paucity of breeding efforts elsewhere in the region.

During the 1981-82 season, 567 lines were tested in replicated yield trials at Tel Hadya, Syria and 291 of these lines were also tested at Terbol in Lebanon (Table 15). A total of 81 entries or 14.2% of the lines tested at Tel Hadya yielded more than the best check. Eighty four percent of the lines under test were small seeded, and only 16% were large seeded (100-seed weight greater than 4.5 g). The growth habit of 22% of the test entries made it possible to harvest them with a cutter bar. These proportions reflect the relative emphasis within the breeding program.

At present no lentil cultivars have been released in Syria. However, in cooperative

Table 14. Lentil crossing program in 1982, showing target regions, aims of recombination, and the number of crosses made.

Region	Aims of recombination	No. of cross-combinations
High plateau	Cold tolerance × High yield (Turkey)	15
	Attributes for harvest × High yield (Turkey)	15
	Subtotal	30
Middle to low elevation (Mediterranean)	High yield (large seeds) × Wide adaptation (large seeds)	38
	High yield × Attributes for harvest	35
	High yield (small seeds) × Wide adaptation (small seeds)	34
	Orobanche tolerance × Local cultivars	24
	Crosses for Jordanian national program	22
	Orobanche diallel	21
	High yield × General combining ability	20
	High yield (small seeds) × High yield (large seeds)	18
	High yield (large seeds) × Red cotyledon (large seeds)	9
	High yield × Tendrilous habit	6
	Subtotal	227
Southern latitudes	High yield (India) × High yield (other origins)	91
	High yield (India) × High yield (Ethiopia)	14
	Subtotal	105
Grand total		362

Table 15. Summary of lentil yield trials in Syria and Lebanon, 1981-82.

Trial type and location	No. of test entries	Highest yield (kg/ha)	No. of lines exceeding best check[a]	Range in CV (%)
Tel Hadya, Syria				
Small seeds (17 trials)	374	2699	56	8 - 32
Small seeds, mechanical harvest (5 trials)	105	2683	13	10 - 17
Large seeds (3 trials)	66	2577	12	12 - 19
Large seeds, mechanical harvest (1 trial)	22	2540	0	11
Terbol, Lebanon				
Small seeds (5 trials)	110	2431	6	14 - 20
Small seeds, mechanical harvest (5 trials)	105	2503	14	12 - 32
Large seeds (3 trials)	56	2528	13	9 - 16
Large seeds, mechanical harvest (1 trial)	20	1778	4	18

a. Syrian local large (ILL 4400) and small (ILL 4401) were included as checks in all trials.

trials with the Syrian Ministry of Agriculture, selections from ICARDA have shown consistent yield increases over local cultivars. For example, 78S 26004 has yielded an average of 32% more than the best local check in six trials during the last two seasons (Table 16). As a consequence, four selections will be tested in large-scale multilocation trials in Syria during the next season.

Superior cultivars have been provided through national programs to lentil farmers in Egypt, India, Jordan, Lebanon, and Syria. In

Table 16. Mean seed yield (kg/ha) of 78S 26004, a promising lentil genotype, and its percent advantage (parentheses) over the local check in two seasons at different locations in Syria.

Selection	ILL	Origin	1981[a]	1982[b]
78S 26004	9	Jordan	1771 (33%)	1382 (32%)
Syrian local	4401	Syria	1330	1050
SE ±			54.6	42.4

a. Mean of two locations.
b. Mean of four locations.

1981-82, national programs in the following countries used ICARDA genotypes in either multilocation testing or on-farm trials — Egypt (ILL 4354), India (ILL 4605), and Lebanon (ILL 1880, ILL 4400).

Lentils are harvested laboriously by hand in the Middle East, where the high cost of labor is driving some farmers from cultivating them. Progress has been made in selecting lentil cultivars suited to mechanical harvesting. The selection 78S 26002 (ILL 8) showed improved resistance to lodging over local cultivars and increased seed yield in both Syria and Lebanon (Table 17). An international screening nursery of tall genotypes that can be harvested by cutter bar was sent to 14 countries.

Table 17. Mean values of lodging score, plant height (cm), and seed yield (kg/ha) of lentils at locations in Lebanon and Syria.

Selection	Lodging score[a]	Plant height	Yield in Lebanon[b]	Yield in Syria[c]
78S 26992 (ILL 8)	2.2	35	884	1361
Lebanese local (ILL 4399)	4.1	39	744	864
Syrian local (ILL 4401)	3.9	35	861	1143

a. Scale 1-5; 1 = unlodged, and 5 = all plants lodged.
b. Mean of two trials.
c. Mean of six trials.

The straw of the lentil crop is of great economic value in Jordan, Lebanon, and Syria. It enters into both national and international trade, and sometimes may give to farmers a greater return than seed. Although the breeding program has concentrated on breeding for increased seed yield, the relationship between seed and straw yields has also been studied.

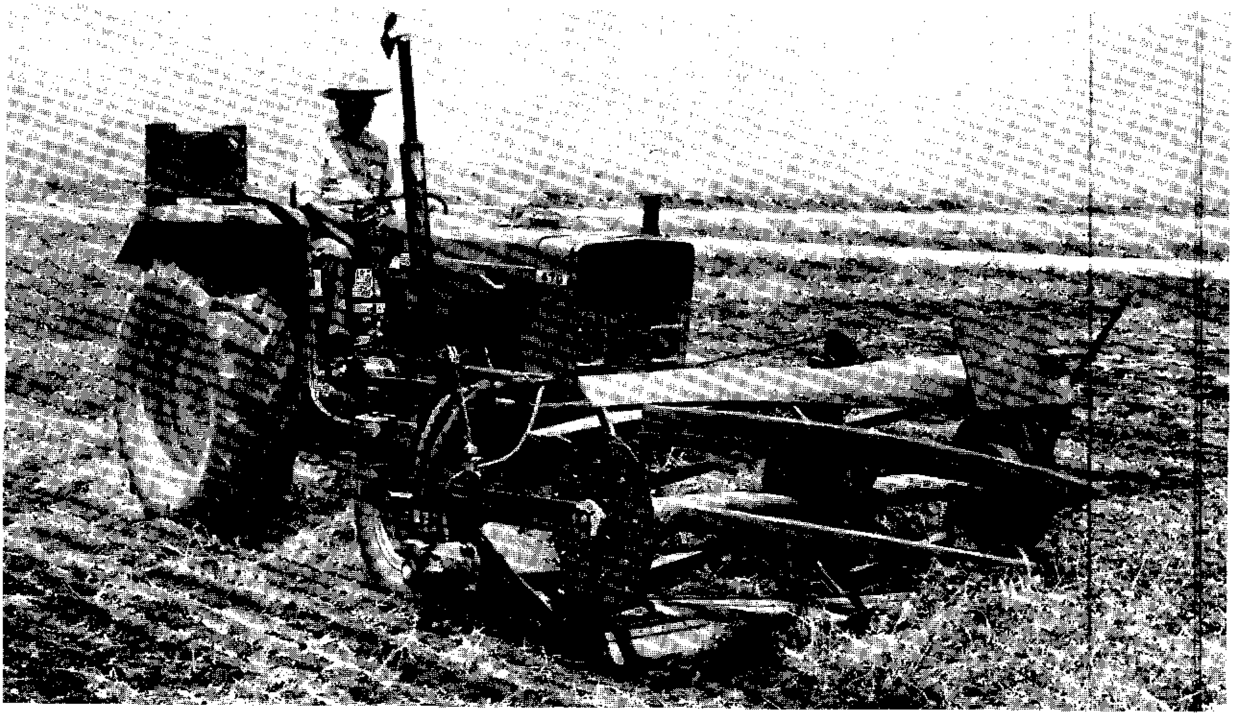
In a world germplasm collection of 3586 accessions grown at one location, mean yields of seed and straw were 1287 and 2932 kg/ha, respectively. The 20 best straw-producing accessions had an average biological yield of 9132 kg/ha. The phenotypic correlations between seed and straw yields were positive and significant at r = 0.526 and r = 0.239 for *microsperma* and *macrosperma* accessions, respectively. In another trial of 24 cultivars grown in three locations, the mean seed and straw yields were 1222 and 3166 kg/ha, respectively. The harvest index varied from 0.19 to 0.41 across locations. The genetic correlation between seed and straw yields was r = 0.755. It can therefore be concluded that continued selection for increased seed yield will not adversely affect straw production. Consequently, the current breeding strategy with emphasis on selection for an increased seed yield will remain.

In parts of North Africa and Syria, *Orobanche* sp, a parasitic weed, is a major problem in lentil production. Following the identification of lentil genotypes tolerant to *Orobanche crenata,* an international nursery with this material was sent to five countries. However in Syria this season, many of the tolerant genotypes from India were killed by low temperatures. This underlines their poor adaptation to the Mediterranean environment, and also the need to combine them with local cultivars to produce tolerant, adapted segregants. A total of 45 crosses were made with the tolerant genotypes (see Table 14).

Seed Quality

The time required to cook lentils is an important aspect of seed quality. A method to

Traditional hand harvesting of lentils is laborious, time consuming, and costly.



Mechanical harvesting of lentils is being investigated. A lentil puller prototype is subjected to rigorous field testing.

measure cooking time has been developed using a crude fibre digestion system. In a test of cooking time on 24 cultivars from three different locations, the coefficient of variation was 7.7%, which shows the high repeatability of the test. The corresponding coefficients of variation of seed weight and seed yield were 4.5 and 31.8%, respectively. The genetic correlation between seed size and cooking time across the locations was high at $r = +0.919$. The range in cooking time amongst the cultivars was from 29.5 to 45 m, which was greater than the variation of 29.7 to 35.5 m between locations. The broadsense heritability for cooking time was $h^2 = 0.82$, and it is clear that a response to selection for cooking time may be expected.

Production Technology

Date of planting and plant population studies with landraces in Syria (Tel Hadya) and Lebanon (Terbol) confirmed our previous results that sowing delayed after December reduces seed yield. Sowing in November was not superior to December sowing in 1981 because of frequent low temperatures. Reducing the plant population below 166.7 plants/m^2 resulted in a lower seed yield.

To study the genotype x environment interaction, six promising genotypes were evaluated for their response to dates of sowing at Tel Hadya. Early sowing benefited all genotypes. The maximum benefit occurred with ILL 4349 (Laird), which is a late-maturing cultivar adapted to North American conditions. The benefit from early planting was particularly evident in terms of total biological yield. The effect on seed yield was less because of frequent frosts during the early reproductive development of the crop in early dates of planting.

In farmer-managed trials that compared early and normal dates of sowing, there was no advantage from early sowing in 1981-82. Farmers stated that weed problems and fears of frost damage were the reasons for not planting early. However, on-farm trials comparing early vs late sowing over the past 3 years indicated that these disadvantages may be outweighed by higher yields on average, from early sowing. These increased yields translate into higher gross revenues, on average. Subtracting the cost of an extra weeding from the early-sowing revenues left an average net advantage of SL 142 per ha over 3 years. However, variations in sowing date effects between years were very substantial. The range of year-to-year variation in comparable revenues was much higher for the averages of the farmer-method, i.e., late sowing (SL 1280 to 2170) than for early sowing (SL 1661 to 2189). Thus, there is a strong indication that early sowing does stabilize and increase the profits of lentil production. More trials are planned for the coming season.

A comparison of improved management vs traditional management was made with ILL 4401 lentil in 50 m × 25 m plots in Tel Hadya during 1981-82. The improved package included drill seeding in rows 30 cm apart on December 9, phosphate application at 50 kg P_2O_5/ha, application of 1.5 kg a.i./ha of carbofuran, and early hand weeding. The traditional management included broadcast planting on January 12, no phosphate and carbofuran application, and late hand weeding. The seed yield with improved management was 1402 kg/ha compared with 952 kg/ha with traditional management. The corresponding values for total biological yield were 3719 and 2471 kg/ha, respectively.

Development of Wide Adaptation in Lentils

The project aims to develop high yielding, stable genetic stocks with wide adaptability for each of the following lentil growing environments: high altitude environments, middle to low elevation Mediterranean environments, and environments in southern latitudes (Africa/Asia). It also aims to study the physiological basis for wide adaptation.

Cultivars and Genetic Stocks with Wide Adaptation

The limited adaptation of most lentil cultivars has hindered their widespread use. However, a wider adaptation to environments within the middle to low elevation area around the Mediterranean has been found in some new selections. For example 78S 26013 (ILL 16), a selection from germplasm from Jordan, outyielded the best local check at seven out of nine locations around the Mediterranean. This yield advantage in four countries is shown in Figure 5.

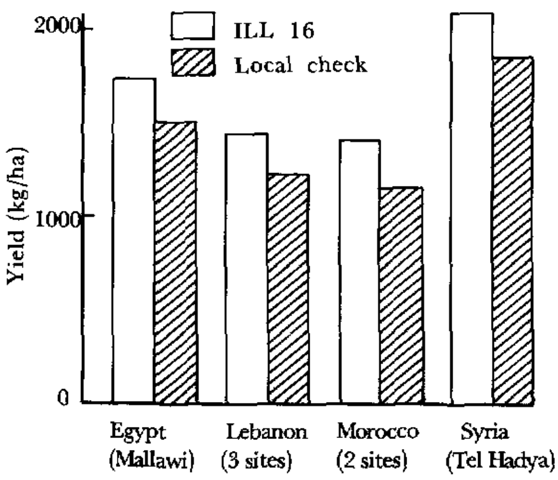


Figure 5. Mean seed yield (kg/ha) of 78S 26013 (ILL 16) and the best local check in the Lentil International Yield Trial-Small Seeded in four countries around the Mediterranean, 1981-82.

Physiological Basis for Wide Adaptation

Results from the Lentil Adaptation Trial grown internationally and from pot experiments in the greenhouse in Aleppo, Syria have indicated the profound importance of both temperature and photoperiod on the phenological development and hence adaptation of lentil. A collaborative project with the University of Reading, U.K., has been started to study the effect of these factors in controlled environments. As a prelude, a comparison is being made between the phenology and growth of three test genotypes in the field at Tel Hadya, and their performance in growth cabinets at Reading.

Cultivar Differences in Thermo-photoperiodic Response

The effect of daylength and temperature on the reproductive growth of a diverse set of genotypes has been under investigation for the last two seasons in a greenhouse in Aleppo. The results show that although long days and warm temperatures hasten the onset of reproductive growth, genotypes ILL-784 (Egypt) and ILL 256 (India) are less sensitive than other genotypes to these factors. The 1980-81 trial was repeated in 1981-82 with one additional genotype, i.e., Precoz, ILL-4605 (Ex-Argentina) and the results (Table 18) confirm the 1980-81 findings. They also show that Precoz is the least sensitive to temperature and daylength changes.

Development of Drought Tolerance in Lentils

The aim of this project is to develop cultivars and genetic stocks capable of producing an economic and stable yield on limited rainfall, through tolerance to drought and heat stress during the reproductive period of growth. It also aims at developing appropriate agronomic practices for increasing the water-use effi-

Table 18. Effects of long day (LD) of 16 hr vs normal day (ND) conditions on the days to flower-bud appearance of 10 genotypes of lentil under low and high ambient temperature conditions.

Genotype	Origin	Days from planting to first flower bud			
		High temperature		Low temperature	
		LD	ND	LD	ND
ILL					
58	Iraq	63.0	85.9	92.1	160.1
92	USSR	68.0	119.4	109.7	154.0
183	Turkey	66.5	109.0	98.9	158.7
204	Ethiopia	64.6	104.3	95.5	147.0
784	Egypt	58.9	71.9	95.6	98.4
4401	Syria	53.6	77.6	96.2	143.6
4349	USSR	64.1	110.9	102.0	161.0
2526	India	61.5	67.0	93.6	92.1
854	Algeria	63.6	118.9	88.7	147.0
4605	Argentina	64.5	67.3	84.5	91.0

ciency of promising cultivars under low rainfall conditions.

Development of Cultivars and Genetic Stocks

The first step taken in screening for drought tolerance was a search for high yield combined with early maturity and hence, for drought avoidance. A total of 1899 accessions were grown in Syria at Breda, a low rainfall site, which received about 275 mm rainfall during the growing season. From the screening, 750 accessions (39.5%) were selected for earliness and yield, and they will be retested next season.

A trial to evaluate the response of 12 geographically diverse genotypes to total seasonal moisture supply, i.e., rainfed and irrigated, was conducted in 1980-81 at Tel Hadya. The results showed that reducing the total moisture supply had little effect on genotypes ILL 101, 470, 793, 4354, and 4401. The trial was repeated at Tel Hadya in 1981-82. The 12 genotypes were also grown on drier subsites at Breda and Khanasser. Intensive soil moisture studies were carried out on eight selected genotypes using the neutron scattering technique to assess the suitability of this field method for evaluating drought tolerance in lentils.

Compared with the rainfed situation at Tel Hadya, an assured moisture supply (484 mm) from irrigation increased the total biological yield of all the genotypes, but ILL 470, 4349, 4354, 4400, and 4401 were affected less than the others (Table 19). Assured moisture increased the seed yields of most genotypes, but it tended to reduce those of ILL 793, 1877, and 4349.

Yields of all 12 genotypes declined sharply when they were grown in the drier locations (Table 19). However, ILL 470, ILL 4354, and ILL 4401 were affected less drastically than the others. These same genotypes were affected less by increasing the seasonal moisture supply, this season and last at Tel Hadya.

The seasonal water use and water-use efficiency of the eight selected genotypes grown at Tel Hadya without irrigation are given in Table 20. Genotype ILL 4349 used the most water, and ILL 223 the least. Water-use efficiency in terms of seed yield was higher in ILL 101, 223, 470, 4400, and 4401 than in the others. Genotypes ILL 101,223, and 4401

Table 19. Effect of total seasonal moisture supply on the seed and total biological yield of some diverse genotypes of lentils in North Syria during the 1981-82 season.

		Seed yield (kg/ha)				Total biological yield (kg/ha)			
		Khanasser	Breda	Tel Hadya				Tel Hadya	
Genotype	Origin	Rainfed (230 mm)	Rainfed (275 mm)	Rainfed (335 mm)	Irrigated (484 mm)	Khanasser (230 mm)	Breda (275 mm)	Rainfed (335 mm)	Irrigated (484 mm)
ILL									
4401	Syria	208	524	1391	1680	487	1429	4380	5909
793	Egypt	84	164	1363	950	406	1018	3970	8164
1861	Sudan	100	304	1193	1484	339	946	3315	5643
2501	India	128	396	1458	1798	342	1015	3488	5645
1877	Turkey	155	161	1223	816	537	869	3824	6080
4349	Russia	195	109	1147	843	1006	1015	4606	6561
101	Morocco	333	74	1721	2003	969	699	4703	7470
4400	Syria	290	137	1644	1691	747	821	4082	6085
1744	Ethiopia	71	257	1028	1721	154	923	2500	4158
470	Syria	210	496	1566	1952	499	1429	3818	5224
223	Iran	118	481	1847	2978	385	1467	4676	8033
4354	Jordan	77	643	1733	2260	278	1726	4370	6842
Mean		164	312	1433	1681	512	1113	3978	6318
CV (%)		72.1	15.4	16.5		52	11.9	13.21	
LSD 5%		NS	69.1	364.9		386	190.7	958.5	

NS = Not significant.

Table 20. Total extractable moisture (EM, mm), evapotranspiration (E_t, mm) and water-use efficiency, (WUE, kg/ha/mm) for total biological yield (TBY) and seed yield (SY) for different lentil genotypes under rainfed conditions at Tel Hadya, 1981-82 season. Evaporation (E_0) was about 680 mm for the same duration.

Genotypes	Date of maturity	EM (mm)	E_t (mm)	Yield (kg/ha) TBY	Yield (kg/ha) SY	WUE TBY	WUE SY
ILL 4401	May 25	105.8	288.9	4380	1391	15.2	4.8
ILL 793	June 8	136.6	329.9	3970	1363	12.0	4.1
ILL 1877	June 8	134.1	322.7	3824	1223	11.8	3.8
ILL 4349	June 8	151.9	335.5	4606	1147	13.7	3.4
ILL 101	June 1	131.7	312.5	4703	1721	15.0	5.4
ILL 4400	June 1	130.3	316.8	4082	1644	12.8	5.2
ILL 470	May 25	110.8	293.7	3818	1566	13.0	5.3
ILL 223	May 25	107.8	285.7	4676	1847	16.4	6.4

also gave the highest water-use efficiency in terms of total biological yield. Thus, these genotypes may be of use in breeding for improved water-use efficiency.

Agronomic Management

Advancing the sowing date of Syrian local large-seeded landrace (ILL 4400) from early January to late November resulted in increased seed and total biological yield, and in improved water-use efficiency (Table 21). The daily and the accumulated total evaporation and evapotranspiration (E_t) for the two sowing dates are shown in Fig. 6. The peak in daily E_t was reached earlier with the November sowing than with the January sowing. Soil moisture extraction data (Fig. 7) reveal that with the earlier sowing date the crop is able to extract more moisture than with the later sowing date. The early-sown crop, therefore,

Table 21. Effect of date of planting on the productivity and water-use efficiency (WUE) of Syrian Local Large (ILL 4400) lentil with a population density of 222 plants/m² at Tel Hadya, 1981-82.

Particulars	Planting date: Date-1 (D_1) (Nov. 23)	Planting date: Date-3 (D_3) (Jan. 10)	Relative $\frac{D_3}{D_1}$
Date of maturity	May 20	June 3	
Total E_t (cm)	32.0	29.5	
Total E_o (cm)	64.5	79.6	
Seed yield (kg/ha)	1785	1251	0.70
Recoverable biological yield (kg/ha)	5249	3034	0.57
Harvest Index	0.33	0.41	
WUE1 (kg seed yield/ha/cm E_t)	55.7	42.4	0.76
WUE2 (kg Rec. biol. yield/ha/cm E_t)	163.8	102.8	0.62

E_t = Evapotranspiration; E_o = Evaporation; WUE = Water-use Efficiency.

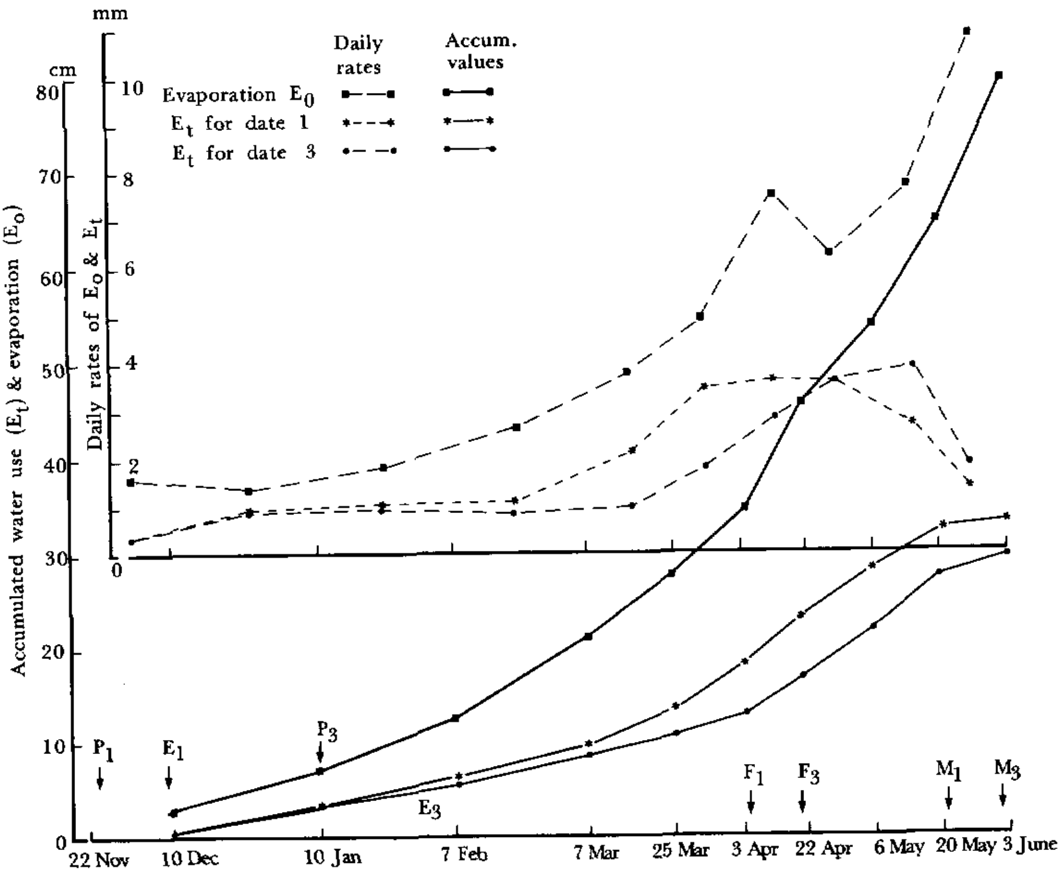


Figure 6. Effect of date of sowing on the daily and accumulated evapotranspiration in Syrian local large-seeded landrace (ILL 4400) at Tel Hadya, 1981-82. P, E, F, and M refer to the dates of planting, emergence, flowering, and physiological maturity, respectively. The subscript indicates the treatment date.

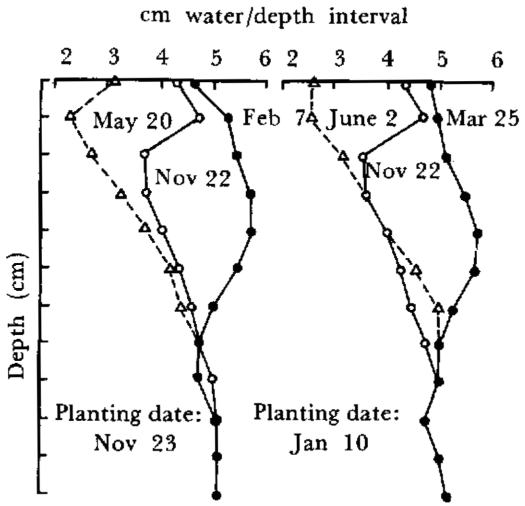


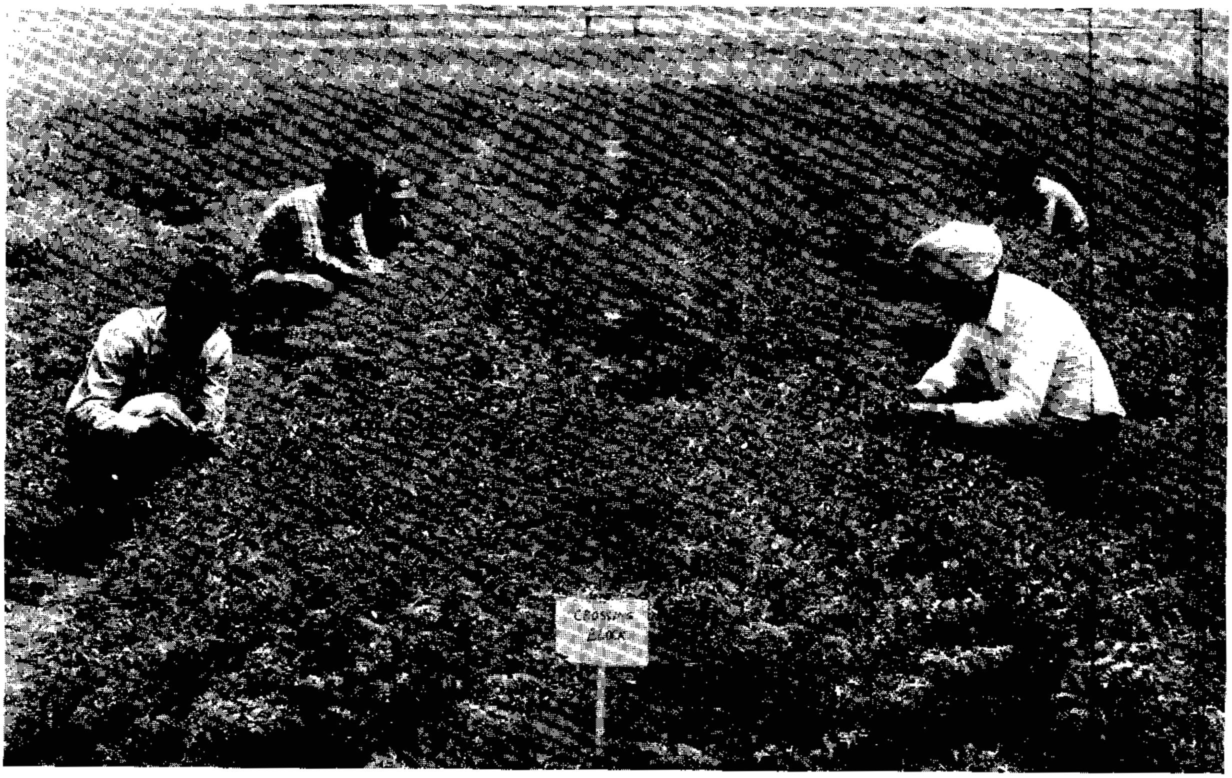
Figure 7. Recharge/discharge curves for soil moisture in different layers under two different dates of planting of lentil (ILL 4400) at Tel Hadya, 1981–82.

makes better use of seasonal rainfall than the crop from a later sowing.

Chickpea Improvement

Improved Kabuli Chickpea Cultivars and Production Technology

The project aims to develop cultivars and genetic stock with a range of maturities to suit different agroecological situations, high and stable yield, resistance to ascochyta blight, and suitability for earlier sowing. It also aims to develop appropriate agronomic practices for early and conventional spring sowing of existing and improved cultivars.



Plant breeders in the chickpea crossing block at Tel Hadya cross chickpeas to combine disease resistance and high yield.

Germplasm

About 3300 kabuli-type accessions have been evaluated for 27 characters. Evaluation details and passport information have been stored on the computer and a germplasm catalog is to be printed. Over 1000 germplasm accessions have been sent to national programs in Bulgaria, Chile, India, Italy, Jordan, Morocco, Pakistan, Tunisia, USA and USSR. Also, 183 lines were supplied to ICRISAT.

Development of Cultivars and Genetic Stocks

Crossing

A total of 385 crosses were made to generate tall, large-seeded material for spring and winter sowing. Of these, 319 were two-way crosses, 32 three-way, and 34 backcrosses. A few crosses were also made at the request of the national programs, including Jordan, Pakistan, and Syria. Crosses were made for the first time to generate desi segregating material for Ethiopia, India, Iran, and Pakistan.

Segregating Populations

Since one of our major objectives is to incorporate ascochyta blight resistance in to the types suitable for conventional spring sowing, segregating generations from F_2 through F_4 are sown in winter and evaluated for their reaction to ascochyta blight. Information on breeding material grown during winter and spring is presented in Table 22. During the season, 266 F_5 and 1162 F_6 progeny rows were grown at Tel Hadya and Terbol and a number of plants were selected. A total of 23 F_5 and 36 F_6 promising and uniform progenies were bulked.

Yield Trials

Two Advanced Yield Trials (AYT) and 11

Table 22. Chickpea breeding materials grown for winter (W) and spring (S) sowing: large (L) and tall (T) plant types selected; and progenies bulked during 1981-82 main season (Tel Hadya and Terbol) and 1981-82 off-season (Terbol).

Generation	No. of segregating materials grown			No. of plants selected			No. of. progenies bulked		
	Main season	Off-season	Total	Main season	Off-season	Total	Main season	Off-seaon	Total
F_1	45	349	394						
F_2 Populations	269	9	278	2940		2940			
F_3 Bulks	51		51						
Progenies	351	1595	1946	1091	910	2001			
F_4 S + W	1282	653	1935	1355	450	1805	18	23	41
L	1	16	17	6	69	75	1		1
T	9		9	33		33	6		6
F_5 W	1987	1765	3752	2945		2945	148	170	318
S	532		532				23		23
L	122	1	123	61	4	65	18	1	19
T	17	2	19	24		24	7	2	9
F_6 W	2484	4	2888	2232		2232	132	1	133
S	2324		2324				36		36
L	4		4						
T	12	7	19	24		24	6	7	13

Preliminary Yield Trials (PYT) were conducted at Tel Hadya and Kfardan. Results from Tel Hadya only are presented (Table 23), as trials in Kfardan could not be harvested for various reasons. Two local checks, viz., ILC 1929 (ex-Syria) and ILC 1930 (ex-Lebanon), and an improved check (ILC 263) were used in all trials. In AYTs, entries 12, 8, and 11 yielded more than ILC 263, ILC 1930/ILC 482, and ILC 1929, respectively.

Two hundred and thirty-one lines developed through hybridization were evaluated in 11 PYTs. Fifty-four, 156, and 97 entries yielded more than ILC 263, ILC 1930/ILC 482, and ILC 1929, respectively. The yield differences were as much as 74% (Table 23), which suggests that considerable improvement is being achieved.

Large-Seeded Types

In many countries, especially in southern Europe and North and South America, very large seeds (40g/100 seeds) are preferred. Hence there is an effort to develop these types with good agronomic characters. An International Yield Trial-Large Seeded (IYT-LS) and a Preliminary Yield Trial-Large Seeded (PYT-LS) were conducted during the spring season, 1982. The performance of the five best yielding entries is presented in Table 24.

Table 23. The number of chickpea test entries exceeding the yield (kg/ha) of checks in Advanced (AYT) and Preliminary (PYT) Yield Trials in spring, 1982, season, Tel Hadya.

Trial	No. of test entries exceeding checks			Highest yield of test entry	Percent of check			CV%
	ILC 263	ILC 482	ILC 1929		ILC 263	ILC 482	ILC 1929	
AYT-W_1-S	1	3	3	1674	102	108	111	12
	ILC 262	ILC 1930	ILC 1929		ILC 263	ILC 1930	ILC 1929	
AYT-S	11	5	8	1690	110	103	107	11
PYT-S_1	7	7	18	1992	122	123	148	15
PYT-S_2	3	7	8	2192	108	119	123	20
PYT-S_3	15	15	2	2200	134	133	108	22
PYT-S_4	1	18	5	2119	106	149	113	18
PYT-S_5	0	18	18	1919	93	143	146	22
PYT-S_6	3	18	18	2022	105	173	171	20
PYT-S_7	3	15	7	2194	111	143	119	15
PYT-S_8	6	21	20	2214	122	174	163	19
	ILC 263	ILC 482	ILC 1929		ILC 263	ILC 482	ILC 1929	
PYT-W-S_1(S)	3	13	1	2300	106	119	98	16
PYT-W-S_2(S)	6	5	1	2375	127	122	106	16
PYT-W-S_3(S)	7	19	0	2039	120	148	97	17

Table 24. Performance of the five highest yielding chickpea entries in the International Yield Trial-Large Seeded (IYT-LS) and Preliminary Yield Trial Large Seeded (PYT-LS) at Tel Hadya, 1981-82 season.

Rank	IYT-LS Entry	IYT-LS Yield (kg/ha)	IYT-LS 100-seed weight	PYT-LS Entry	PYT-LS Yield (kg/ha)	PYT-LS 100-seed weight
1	ILC 35	2048	42	ILC 1795	2342	48
2	ILC 116	1973	45	FLIP 81-181	2272	43
3	ILC 134	1960	47	FLIP 81-176	2253	41
4	ILC 132	1824	46	ILC 76	2176	45
5	ILC 596	1758	47	FLIP 81-178	2164	41
	Check	1456	36		2056	35
	CV (%)	13.5			17.2	
	LSD (5%)	311			574	

A total of 17 F_4, 123 F_5, and 4 F_6 progeny rows were grown in the ascochyta blight nursery to identify large-seeded, blight-resistant lines. A total of 140 individual plants were selected from F_4 and F_5 generations, and 20 promising uniform progenies were bulked for evaluation in replicated trials next year.

Quality

In West Asia, chickpeas are used to make *Hommos Bi-Tehineh.* In Experiment 1, six samples each of kabuli, desi, and intermediate seed type were used to prepare *Hommos Bi-Tehineh.* Two organoleptic tests were carried out to measure the acceptability of the product. Fifteen judges tasted and scored the samples using a 1-5 scale, where 5 = excellent, 4 = good, 3 = fair, 2 = poor, and 1 = unacceptable. Preparations from the kabuli and intermediate seed types were acceptable; that from the desi type were unacceptable (Table 25). It seems that because of the colored testa in the desi type, *Hommos Bi-Tehineh* prepared from it had a poor appearance. Therefore in Experiment 2, *Hommos Bi-Tehineh* was prepared from decorticated desi types and compared with that of kabuli types. Eighteen judges scored the samples three times. The results indicated a better scoring for *Hommos Bi-Tehineh* made from decorticated desi types (Table 25).

The cooking quality of kabuli chickpeas is being evaluated using the Labconco Crude Fibre Digestion System.

Insects and Their Control

Surveys conducted in southern Syria indicated that *Heliothis* is a potential major pest in that region. Mean percentages of pod infestation in Dara'a and Sweeda were 13.1% and 19.5% and in some areas, 32%.

Leafminer infestation was severe in 1982. Repeated applications of endosulfan increased yields by 45%, but as in previous years, it was impossible to separate leafminer damage from pod borer damage. However, in another trial in which *Heliothis* infestation was very low, an 18% yield loss due to the leafminer was estimated.

In more than 2700 chickpea lines screened for leafminer resistance (Table 26), 14 were selected as being the least susceptible. They

Table 25. Organoleptic evaluation of Hommos Bi-Tehineh prepared from six chickpea samples each of kabuli, desi, and intermediate type in Experiment 1, and from kabuli and decorticated desi in Experiment 2.

Quality factor	Experiment 1 Score[a]			Experiment 2 Score	
	Kabuli	Desi	Intermediate	Kabuli	Decorticated desi
Color	3.74	1.20	3.84	3.52	4.16
Odor	3.76	2.57	3.47	3.65	3.92
Texture	3.57	1.50	3.40	2.94	4.44
Taste	3.54	2.27	3.77	3.59	3.83

a. Scored on 1-5 scale; 1 - unacceptable, 2 - poor, 3 - fair, 4 - good, 5 - excellent.

Table 26. Frequency distribution of chickpea materials rated for resistance to the chickpea leafminer in the Chickpea International Yield Trials (CIYT) and germplasm at Tel Hayda, 1981-82.

Nursery	Total materials rated	Percent materials classified as:		
		Resistant	Intermediate	Susceptible
Winter germplasm	1142	2.2	10.1	87.7
CIYT winter	14	0	21.4	78.6
CIYT winter/spring	16	12.5	25.0	62.5
CIYT spring	24	0	50.0	50.0
Spring germplasm	1504	0.9	5.3	93.8

will be included in yield trials next season to test for leafminer resistance.

Significant progress was made in developing a reliable screening method to study bruchid resistance.

Production Agronomy

The responses of ILC 482 (a conventional plant type) and ILC 202 (a tall, late-maturing plant type) to five levels of plant population ranging from 16.6 to 50 plants/m^2 were studied in rainfed conditions at four ICARDA subsites with different seasonal rainfall. Seed yield increased with an increase in plant population up to 50 plants/m^2 at all locations, except at Lattakia where highest yields were obtained with 33.3 plants/m^2.

Strain IC-26 of *Cicer Rhizobium* was the best of five strains used for inoculating winter and spring sown chickpeas. It gave the greatest nitrogenase activity and the best seed yield. Seed treatments with the fungicides Benlate and Calixin-M, and the insecticide Actyllic, singly or in combination, had no adverse effect on nodulation.

Photoperiod Studies

Decreasing daylength in late summer and autumn prevents advance of late-maturing chickpea types by a generation during the off-season. Preliminary studies in 1980 showed that artificial light at night to extend daylength hastened reproductive development of most genotypes and ensured early and uniform maturity. Genotypes from Egypt, India, and Sudan showed the least response to change in photoperiods whereas the genotypes from Russia showed a large response.

During the 1981 summer a photoperiod experiment was conducted using 16 contrasting chickpea genotypes grown in different photoperiods (Fig. 8). One treatment was natural daylength, which ranged from 14.0 hr at the beginning of crop growth to about 12.0 hr towards the end. The results (Table 27) show that genotypes ILC 1919 (ex-India) and ILC 1933 (ex-Sudan) responded less than genotypes ILC 72 (ex-Spain) and ILC 3279 (ex-USSR). Continuous light greatly hastened flowering in the latter genotypes. Night break (P2) shortened the time to flowering of the latest genotypes only. A 14 hr photoperiod was adequate to shorten the time to maturity of most genotypes, but was inadequate to do so for the late maturing types from Russia. Supplementary light was used successfully at Terbol in 1981, and is in use at Sarghaya in 1982.

Improved Kabuli Chickpea Cultivars and Production Technology for Winter Sowing

The objective of this project is to develop high and stable yielding, cold-tolerant, ascochyta

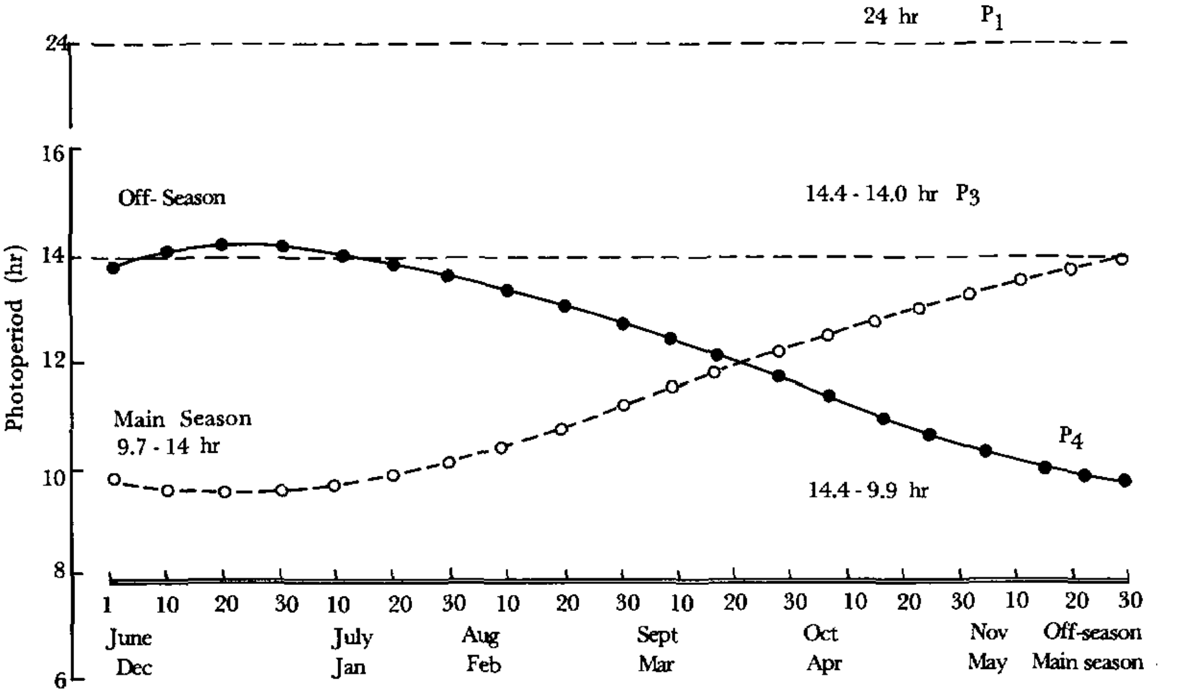


Figure 8. Change in photoperiod during the off-season and main season cropping period of chickpeas at Terbol (33° 52′ N) P_1, P_3, and P_4 are the photoperiodic treatments. (See Table 27 for details).

Table 27. Effect of photoperiodic treatments on flowering and maturity of some diverse chickpea genotypes during the off-season planting at Terbol, 1981 summer.

	Days to first open flower				Days to physiological maturity			
	Photoperiodic treatments				Photoperiodic treatments			
Genotypes	Continuous light (P1)	Night break 00-1a.m. (P2)	14 hr of light 4a.m.-6p.m. (P3)	Natural day length (P4)	Continuous light (P1)	Night break (P2)	14 hr light (P3)	Natural day length (P4)
July 2, 1981 planting:								
ILC 482 (Turkey)	43.6	50.5	49.4	49.4	72.0	74.2	77.3	80.8
ILC 1919 (India)	34.1	38.9	41.5	39.4	55.0	62.0	63.8	62.0
ILC 1929 (Syria)	35.8	39.7	39.6	40.6	62.0	66.0	66.5	62.0
ILC 1933 (Sudan)	31.1	34.2	34.1	34.7	55.7	62.0	62.0	62.0
ILC 72 (Spain)	49.0	65.3	73.4	79.0	67.5	85.5	103.5	104.0
ILC 3279 (USSR)	48.5	58.0	74.4	76.9	72.0	81.5	104.0	-
July 16, 1981 planting:								
ILC 482	30.3	45.7	52.8	58.9	58.6	71.7	84.5	82.9
ILC 1919	29.2	43.4	44.0	43.2	60.0	68.8	69.1	69.1
ILC 1929	29.7	40.7	42.8	47.7	58.0	66.0	67.9	76.2
ILC 1933	28.8	33.1	38.8	38.3	58.0	64.5	61.8	65.0
ILC 72	31.4	69.2	63.0	NF	58.2	93.5	86.0	-
ILC 3279	31.9	62.7	63.5	NF	59.0	88.5	90.0	-

blight resistant cultivars and genetic stocks adapted to winter sowing in areas of the Mediterranean region where the crop is presently spring sown, although the climatic conditions would permit winter sowing. Appropriate agronomic practices for winter sowing have to be developed.

Development of Genetic Stocks and Cultivars

Germplasm

During the 1981-82 season, 1000 germplasm accessions were evaluated in winter for phenological characters, for the first time. Since a prerequisite for success with winter chickpeas is cold tolerance, screening for cold tolerance was given high priority.

Screening for Cold Tolerance

Conditions for screening were excellent at Tel Hadya during the 1981-82 season. There were 31 nights with subzero temperatures, which killed susceptible plants. In previous years, only partial damage occurred.

A total of 10,800 lines, including 5484 desi and 1286 kabuli types, 387 entries in yield trials, and 3643 lines in advance breeding generations were screened for cold tolerance at Tel Hadya. Among the pure lines, 1808 remained free from any cold damage and another 1806 showed a substantial tolerance. However, 294 lines were killed and another 943 were severely damaged and gave a susceptible reaction (7 to 8 rating). Among the germplasm accessions, desi types were generally more cold-tolerant than kabuli types (Table 28).

Since field screening is not reliable mainly because it is not possible to rely on a repeat of ideal weather conditions, attempts have been made to develop a laboratory screening technique. Potted plants at the 5 to 7 leaf stage were exposed to-5°C temperatures for different periods. Resistant and susceptible lines from the field screening were used. Preliminary observations indicated a close similarity between field and laboratory screening if plants were exposed to -5°C for 18 hours continously.

Winter Types

Sixty-three promising winter-type lines developed from hybridization were tested at Tel Hadya, Lattakia, and Terbol, and 15 lines

Table 28. Screening of chickpea germplasm accessions, cultivars, and advanced breeding lines for cold tolerance at Tel Hadya, 1981-82.

Scale	Germplasm accessions [a]				Yield nurseries[b]		Total of	% of	Breeding lines	
	Desi	% of total	Kabuli	% of total	Kabuli	% of total	(a)&(b)	total	Number	% of total
1	1778	32.4	30	2.3	0	0.0	1808	25.3	0	0.0
2	691	12.6	78	6.1	1	0.3	770	10.7	4	0.1
3	737	13.4	287	22.3	12	3.1	1036	14.5	110	3.0
4	398	7.3	311	24.2	91	23.5	800	11.2	1126	30.9
5	527	9.6	247	19.2	76	19.6	850	11.9	1348	37.0
6	474	8.6	129	10.0	53	13.7	656	9.2	614	16.9
7	384	7.0	116	9.0	58	15.0	558	7.8	274	7.5
8	240	4.4	82	6.4	63	16.3	385	5.4	136	3.7
9	255	4.6	6	0.5	33	8.5	294	4.1	31	0.9
	5848	*99.0*	*1286*	*100.0*	*387*	*100.0*	*7157*	*100.0*	*3643*	*100.0*

Scale: 1 = no visible symptom of damage; 2 = up to 5% leaflets show yellowing or withering but no apparent damage to plant; 3 = 5-10 % leaflets in most plants show yellowing but no damage to stem; 4 = 10-15 % leaflets affected and up to 5 % stems show withering; 5 = 15-25 % leaflets show damage and up to 10% stem breakage; 6 = 25-50 % leaflets damaged and up to 25% plants killed above ground level, but later most plants recover; 7 = 50-75 % leaflets and stems damaged and 25-50 % plants killed above ground level but later most recover; 8 = all leaflets and stem damaged, most plants killed and only a few recover; 9 = all leaflets and stem damaged and 100 % plants die.

at Tel Hadya in Advanced Yield Trials during the 1981-82 winter season. The five best yielding entries and their ratings for ascochyta blight and cold are shown in Table 29. Very high yields were obtained, which suggests a high yield potential in winter-sown chickpeas. These lines have an adequate resistance to ascochyta blight and cold, and some of them have been made available to national programs, through international nurseries.

One hundred and twenty-six entries developed from crosses were evaluated at Tel Hadya and Kfardan in six Preliminary Yield Trials, each consisting of 21 test entries with three checks, namely, ILC 3279, ILC 482, and ILC 1929. The results from Kfardan could not be obtained due to circumstances beyond ICARDA's control. Entry ILC 1929, which is ascochyta blight susceptible, was killed in all trials. The yields from 10 and 74 entries ex-

Table 29. Five highest yielding entries of chickpea in Advanced Yield Trial-Winter at Tel Hadya (TH), Lattakia (L), and Terbol (T), 1981-82.

Trial/Entries	Yield (kg/ha)					Evaluation at Tel Hadya		
	TH	L	T	Mean	R[a]	AB[b]		Cold
						Veg.	Pod	Tol.[c]
AYT-W1								
FLIP 81-10W	2267	3648	2431	2782	1	3.3	5.3	4.3
FLIP 81- 3W	2298	3311	2804	2771	2	3.8	6.0	4.3
FLIP 81-11W	1709	3494	2852	2685	3	4.5	6.8	5.0
FLIP 81-12W	1239	3819	2796	2618	4	4.3	7.3	5.5
FLIP 81-15W	1628	3976	2188	2597	5	4.0	6.0	6.0
AYT-W2								
FLIP 81-41W	2184	4519	2788	3164	1	3.0	3.3	4.8
FLIP 81-37W	1723	4907	2158	2929	2	3.5	5.8	5.3
FLIP 81-27W	1687	4233	2625	2848	3	3.3	4.0	6.3
FLIP 81-35W	1553	4448	2481	2827	4	4.0	6.3	5.8
FLIP 81-24W	1311	4611	2494	2805	5	5.3	7.0	6.3
AYT-W3								
FLIP 81-60W	1358	5882	2819	3353	1	4.5	7.0	4.8
ILC 3279	2427	4539	2671	3212	2	2.0	2.0	4.5
FLIP 81-56W	2691	4129	2810	3210	3	3.0	4.3	4.5
FLIP 81-43W	1489	5179	2546	3071	4	4.0	7.0	6.3
FLIP 81-57W	1897	4954	2278	3043	5	3.0	4.8	5.5
AYT-W4								
FLIP 81-67W	2556				1	2.5	3.0	4.3
FLIP 81-63W	2239				2	3.3	4.3	4.8
ILC 3279	2066				3	2.0	2.0	4.5
FLIP 81-74	1739				4	3.5	4.5	5.0
FLIP 81-71	1735				5	3.8	5.0	5.0

The underlined figures were in the top significant group

a. R = Yield ranking.

b. AB = Ascochyta blight rating on 1-9 scale, where 1 is free and 9, dead.

c. Cold tolerance evaluated on 1-9 scale, where 1 is free and 9, dead.

ceeded ILC 3279 and ILC 482, respectively (Table 30). Despite severe cold and a heavy pod infection of ascochyta blight at Tel Hadya, FLIP 80-347 remained resistant and yielded 3539 kg/ha, the highest yield ever recorded at Tel Hadya.

Table 22 shows segregating material grown, individual plants selected, and promising uniform lines bulked. A total of 11,923 individual plants were selected in different segregating generations for growing in progeny rows next season. Four hundred and seventy-three promising, ascochyta blight resistant, cold tolerant, and photo-insensitive uniform lines were bulked for evaluation in yield trials.

Tall Types

An Advanced Yield Trial comprising 24 lines was conducted at Tel Hadya and three lines, namely, ILC 72, ILC 202, and ILC 3279, which were among the best yielders, also had a high level of resistance to ascochyta blight and cold. In a replicated row trial with 32 entries, some promising lines were identified.

Fifty-eight progenies in advanced generations were planted and 81 individual plants were selected. Thirty-nine promising, uniform, tall, and ascochyta blight resistant lines were bulked for further evaluation.

Screening for Resistance to Ascochyta Blight

Screening of new germplasm lines was continued to identify additional sources of resistance. The same technique was used as reported in ICARDA Annual Report, 1980-81.

Disease development in the nursery in the early stages of crop growth, i.e., until the end of March was comparatively slow because of low temperatures. By late April, disease development reached very high proportions (the susceptible checks were killed) and because of continuing favorable weather for blight development, a heavy pod infection also developed.

Kabuli types. Four hundred and sixty-eight new kabuli germplasm lines were screened (Table 31). Judged on vegetative infection, there were 10 lines, namely, ILC 3803, 3856, 3862, 3863, 3864, 3866, 3868,

Table 31. Summary of the results of kabuli and desi chickpea germplasm screening for resistance to Ascochyta blight at Tel Hadya, 1981-82.

Blight reaction category	Kabuli lines: No. of lines	Kabuli lines: Percent of total	Desi lines: No. of entries	Desi lines: Percent of total
1	0	0.00	0	0.00
1	0	0.00	5	0.14
3	4	0.86	17	0.48
4	6	1.28	80	2.23
5	0	0.00	66	1.84
6	3	0.64	93	2.62
7	17	3.63	65	1.81
8	3	0.64	60	1.70
9	435	92.95	3184	89.18
Total	468		3570	

Table 30. Number of entries of chickpea exceeding the yield (kg/ha) of checks in Preliminary Yield Trials-Winter(PYTs-W)at Tel Hadya, 1981-82.

Trial	No. of entries exceeding checks		Highest yield of test entry	Percent of check		CV (%)
	ILC 3279	ILC 482		ILC 3279	ILC 482	
PYT-W_1	0	12	3181	92	338	25.0
PYT-W_2	3	14	3036	110	310	14.9
PYT-W_3	1	10	2703	101	224	26.9
PYT-W_4	4	17	3539	131	436	17.7
PYT-W_5	1	16	3050	117	429	28.6
PYT-W_5	1	5	2413	110	193	40.3

3870, 3871, and Obraztsov Chiflic 1 that were rated resistant. However, judged on both vegetative and pod infections, only three of these, namely ILC-3856, 3863, and 3864, were considered resistant.

Desi types. A total of 3570 additional lines provided by ICRISAT were screened (Table 31). Judged on vegetative infection, 102 lines were rated resistant; when judged on both vegetative and pod infections, only 11 lines were considered resistant. These were ICC-7550, 7580, 7584, 7591, 7592, 7321, 7367, 7376, 7514, 8204, and 11232.

Advanced screening of germplasm for resistance. Two hundred and eighty five lines, including desi and kabuli types identified as resistant during the 1980-81 season at Tel Hadya, were screened at three locations (Tel Hadya, Lattakia and Terbol) for confirmation. At all locations, disease development was very severe and at Tel Hadya, severe pod infection also developed. Most of the lines maintained their resistance to vegetative infection. Only 10 lines, i.e., ILC 2506, 3274, ICC-3634, 4200, 4248, 4368, 5124, 5313, 6262, and 6981, showed a resistant/tolerant reaction for both vegetative and pod infection (40% or less) at all three locations.

Multilocational testing. Through the Chickpea International Ascochyta Blight Nursery (CIABN-82), 60 lines, including desi and kabuli types identified as resistant in Syria and Lebanon during previous years, were tested at different locations in the region. Some lines were included that showed a differential reaction in previous years. Results from 15 locations in Syria, Lebanon, Pakistan, India, Turkey, Tunisia, and Morocco showed that a few to several lines were resistant in each country. One line, ILC-3346, showed resistance at all locations, except at Beja in Tunisia, where it was tolerant.

Genetics of resistance to Ascochyta blight. The genetics of resistance to blight (*Ascochyta rabiei* (Pass.) Lab.) in chickpea was studied in lines ILC 72, ILC 183, ILC 191, ILC 200, and ICC 4935. A single dominant gene controlled resistance in four parents (ILC 72, ILC 183, ILC 200, and ICC 4935) whereas resistance in ILC 191 was conferred by a single recessive gene. This is the first report on the identification of a recessive gene governing resistance to blight. The information will be important in planning an effective breeding strategy.

Resistance to *Orobanche crenata*

Chickpea grown during the spring is highly resistant to *Orobanche crenata.* When sown in winter, less infestation has been found. Therefore a total of 504 kabuli accessions were screened in a winter-sown nursery at Kafr Antoon in 1981-82. Most were found to be resistant, including 72 that were totally free from infestation in all three replications.

International Nurseries

A gradual increase in demand for international nurseries suggests that our nurseries have been useful to cooperators. A total of 315 sets of eight different nurseries have been supplied to cooperators in 42 countries for the 1982-83 season. Results from the 1981-82 season are being received at ICARDA for detailed analysis.

Results from the 1980-81 season nurseries have been analyzed and the salient features of the yield nurseries are reported here. In the Chickpea International Yield Trial (CIYT) conducted at 20 locations, ILC 576 was the best yielding and appeared in the first five entries at six locations. In the Chickpea International Yield Trial-Winter (CIYT-W) conducted at 18 locations, ILC 484 and ILC 482 were the best with ILC 482 appearing in the five highest ranking entries in 9 out of 12 countries. In the Chickpea International Yield Trial-Large Seeded (CIYT-L), conducted at 17 locations, ILC 484 ranked first and ILC 604 second, but ILC 604 appeared in the five top ranking entries in 7 out of 17 locations.

Material from these international nurseries has been found useful by national programs in many countries and some entries are being tested in multilocation or in on-farm trials (Table 32).

Table 32. Promising chickpea lines included in multilocation or on-farm trials by national programs.

Country	Cultivar
Syria	ILC 195, 202, 3279
Jordan	ILC 72, 202, 484
Lebanon	ILC 482, 484
Egypt	ILC 249, 484, 1407, 2912
Tunisia	ILC 482, 484
Morocco	ILC 482, 484
Pakistan	ILC 192, 195, 482
USA	ILC 90, 102, 171, 232, 517, 650
Canada	ILC 451, 464, 604

Winter Sowing and On-Farm Trials

In the past 2 years, chickpea winter sowing has been compared with spring sowing in on-farm trials, jointly conducted with the Directorate of Scientific Agricultural Research, Syria. During the 1981-82 season on-farm trials were conducted using ILC 482 sown during winter, and ILC 482 and Syrian local sown during spring. The results showed that the yield of ILC 482 when winter sown exceeded by 100% that of Syrian local sown in spring. Line ILC 482 when spring sown exceeded Syrian local by 40%. Since the plants were weakened by cold, and late rains favored the development and spread of ascochyta blight, ILC 482 showed only a moderate level of resistance to the disease. It maintained its yield superiority over Syrian local in three consecutive seasons, whether spring or winter sown (Table 33).

The results of the on-farm trials for the past 3 years were reviewed at a joint meeting between the Ministry of Agriculture and Agrarian Reform, Damascus, Syria and ICARDA in September 1982. In view of the consistently superior performance of ILC 482, the Ministry of Agriculture approved this cultivar for general cultivation in zones B (250-350 mm rainfall) and C (<250 mm rainfall) in Syria.

Production Agronomy

Planting Date.

The response of five new chickpea genotypes (ILC 202, 464,484, and 3279) was evaluated without irrigation at Tel Hadya by planting them at monthly intervals from November 23 to February 22. All genotypes produced more than twice as much seed and total biological yield when sown in December or November than when sown in February.

Table 33. Mean results of the on-farm chickpea trials conducted in Syria from 1979-80 to 1981-82.[a]

	Seed yield (kg/ha)				Percent increase of ILC 482 over Syr. Loc. in	
	ILC 482		Syrian Local			
Year	Winter	Spring	Winter	Spring	Winter	Spring
1979-80	1839		988	973	89	
1980-81	1685	962	500	646	161	49
1981-82	1255	875		626	100	40
Mean	1593	919	744	748	114	23

a. There were 18, 24, and 20 locations in 1979-80, 1980-81, and 1981-82, respectively.

The large-seeded genotype ILC 464 gave the largest yield. Growth analysis of the two earliest sowings showed that this genotype surpassed all others in its leaf area and total drymatter accumulation (Fig. 9).

Plant Population

Winter-sown ILC 482 and ILC 202 genotypes responded to an increase in plant population above 20 plants per m² at all four locations

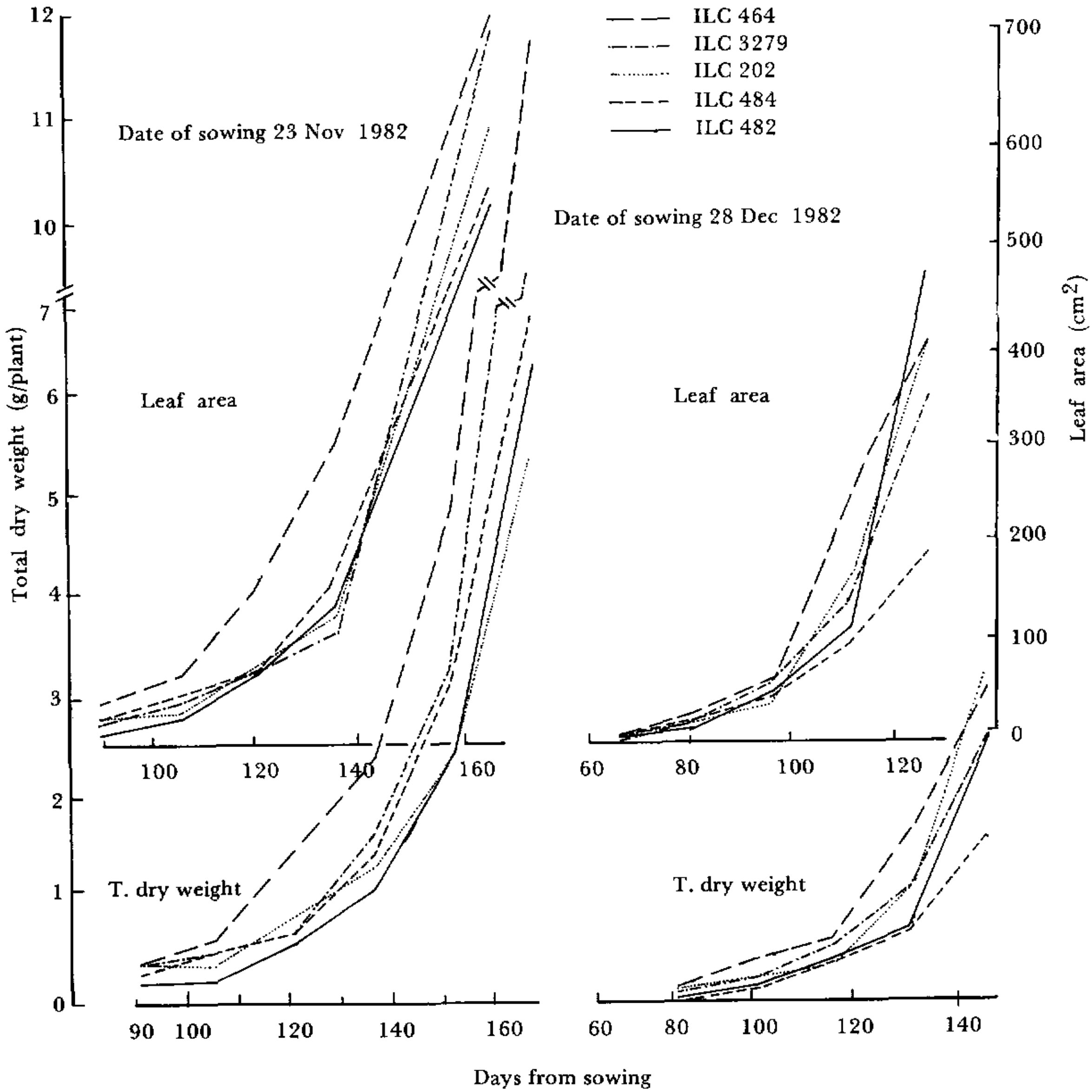


Figure 9. Effect of date of sowing on total dry weight (g/plant) production and leaf area at the 100% flowering stage of five promising winter chickpeas at Tel Hadya, 1981-82.

(Breda, Tel Hadya, Jindiress, and Lattakia), except for ILC 482 at Lattakia. Studies on plant population and planting geometry with the same two genotypes at Tel Hadya confirmed the positive effect of increasing plant population up to 60 plants/m^2.

There was a tendency for square spacing (1:1) to be better than rectangular spacing (1:2 or 1:3), particularly at the highest plant population.

Fertilizer Application

An International Fertility-cum-Inoculation Trial was conducted at four ICARDA subsites in North Syria. No response was obtained to the application of phosphate and potash at any of the locations because the supply of these nutrients in the soil was adequate, as shown by soil analysis. Drilling 50 kg P_2O_5/ha (as triple superphosphate) with the seed had no adverse effect on crop emergence.

Weed Control.

Winter-sown chickpeas require more weed control than the spring-sown ones. At Terbol the yield of winter-sown ILC 482 without weeding was only 25% of the weed-free treatment. The yield of the weedy check was 399 kg/ha compared with 1575 kg/ha for the weed-free treatment. Weeding twice proved satisfactory, and a preemergence application of cyanazine at 1.0 kg a.i./ha mixed with pronamide at 0.5 kg a.i./ha also proved very effective. Chlorbromuron at 1.5 kg a.i./ha as a preemergence treatment appeared promising.

Diseases and their Control

The emphasis in the kabuli chickpea pathology program continued to be in the area of (1) utilizing host-plant resistance for the control of ascochyta blight, and (2) obtaining essential information on disease epidemiology, and integrated control.

Disease Problems in Winter Chickpea

Winter chickpea has shown great yield potential in the Mediterranean region provided ascochyta blight is controlled. Observations in the winter-sown crop at experimental stations and on-farm trial sites in the region were made for the occurrence of any new potential disease problem that may arise with the change in planting date. During the past three seasons, no major diseases were encountered in the region as a whole, other than ascochyta blight. Traces of *Sclerotinia* stem rot and *Fusarium* and *Rhizoctonia* root rots were observed. Although incidence of these diseases is expected in the crop planted in the wet season, the low temperatures that prevail then seem to limit their development.

Some other problems, e.g., the incidence of viruses, were found to be specific to certain areas. During the 1981-82 season, a serious incidence of viruses (possibly a complex of pea streak and bean yellow mosaic viruses) was observed at Beja in Tunisia. Build up of root-knot nematode and *Orobanche* was observed in some experimental plots in Syria.

Fungicides and Ascochyta Blight Control

The role of fungicides in controlling blight is mainly confined to seed treatment. The combined use of foliar sprays and resistant/tolerant cultivars is also being explored.

Seed dressings with Calixin M (11% Tridemorph + 36% Maneb) alone or in combination with Benlate (0.3%) were found to eradicate the blight pathogen completely from seed of a susceptible and a tolerant cultivar with deeply infected lesions. The fungicide was more effective at higher doses (6 g/kg) but it induced minor phytotoxic effects, i.e., slightly delayed germination, malformed leaves, and reduced growth initially, but the symptoms disappeared within 2 weeks.

Intensive sprays with Bravo 500 alone, or alternated with Calixin M (17 sprays at 7-10 days interval, at 3 g/l) gave nearly complete protection to a highly susceptible cultivar planted in the winter season with severe artificial inoculation. This result indicates the potential of the fungicide to control blight. Spraying with Calixin M alone also gave satisfactory control.

Spraying a tolerant cultivar, (ILC-482) planted in winter and artificially inoculated with Bravo 500 at the early podding stage resulted in almost four times more yield than the control, which indicates the potentiality for using fungicides in combination with tolerant cultivars (Table 34). The effect of the fungicide seems to be mainly to control pod infection. The spray did not have a significant effect in the resistant cultivar (ILC-195). Without protection the susceptible cultivar was killed.

Epidemiology of Ascochyta Blight

Infected seed and diseased plant debris are the known sources of inoculum of *Ascochyta rabiei*. However, serious outbreaks have been noticed in places where these sources of inoculum do not seem to be present. Preliminary studies on other means of survival of the fungus have given some understanding of the epidemiology of the disease. With artificial inoculation, the fungus was found to infect *Pisum sativum, Phaseolus vulgaris,* and *Vigna sinensis*. In cultures held for a prolonged period at room temperature (18-28 °C) some chlamydospore-like structures were observed. The fungus was found to be saprophytic on the straw of many food and forage legumes, including faba beans and lentils. The extent to which these factors are important in the epidemiology of blight requires further research.

Variability in *Ascochyta rabiei*

Sampling the blight pathogen population present in the screening nursery at Tel Hadya revealed the presence of at least three isolates that varied considerably in pathogenicity. When screening was begun at Tel Hadya in the 1978-79 season, lines ILC-194, 215,

Table 34. Effect of foliar sprays of Bravo 500 (5 g/litre) on *Ascochyta* blight development; and yield of a resistant (ILC 195), a tolerant (ILC 482), and a susceptible (ILC 1929) cultivar of chickpea, with (+SD) and without (-SD)[a] seed dressing with Benlate.

		Blight score on				Seed yield (kg/ha)	
	Spray of	Vegetative parts		Pods			
Genotype	Bravo at	+SD	-SD	+SD	-SD	+SD	-SD
ILC	Flowering	3.0	3.0	3.5	3.3	737	909
	Early podding	3.0	3.0	2.8	2.8	1170	1657
	Late podding	3.0	3.5	3.0	4.0	925	1124
	None	3.0	3.0	2.8	3.3	1157	1370
ILC 482	Flowering	5.3	5.0	8.0	8.0	489	717
	Early podding	4.8	5.0	5.0	5.3	1391	1603
	Late podding	5.5	5.8	8.0	7.8	493	504
	None	5.8	5.8	8.0	8.0	315	287
ILC 1929	Flowering	9.0	9.0			0	0
	Early podding	9.0	9.0			0	0
	Late podding	9.0	9.0			0	0
	None	9.0	9.0			0	0
CV (%)						51.8	
LSD 5%						451.7	

482, and 3279 were among those found resistant, indicating that isolate TH-1 was then the most prevalent isolate. In 1979-80, while ILC-249 showed susceptibility, ILC-482 showed a tolerant reaction indicating the appearance of isolate TH-2 in that season. During the 1980-81 season these two lines, and ILC-3279 and most of the resistant lines were found susceptible to an isolate (TH-3) obtained from a patch infection in ILC-482. Against this isolate, ILC-194 showed a resistant to tolerant reaction and a desi line, ICC-3996, also showed resistance. The selection pressure on the pathogen, imposed by the method of screening (use of diseased debris collected from the previous seasons' nursery as inoculum), seems to be reponsible for such a rapid change in the pathogen population. Screening against such a mixture of pathogens is expected to result in the identification and development of durable resistant materials.

Preliminary studies on the reaction of 60 genotypes against these three isolates and two others from Syria and Lebanon indicated a differential reaction of certain genotypes with the isolates (Table 35). Line ILC-1929 was susceptible against all isolates, whereas ICC-4107 was resistant. All lines, except ILC-194 and ICC-4107, were susceptible to isolate TH-3. All lines, except ICC-1591 and ILC-1929, were resistant to isolate TH-1. The Lattakia isolate differed from TH-1 by its virulence on ILC-194 and 482. TH-2 differed from TH-1 by its virulence on ILC-249 and 482. The susceptibility of ILC-482 to the Lattakia isolate and its resistance to the Terbol isolate, differentiated them. Based on the reaction of these five isolates on the seven genotypes, they are considered as five distinct races of *A. rabiei*. More work on the physiological variation in *Ascochyta rabiei* is being done in a collaborative project at the University of Reading, U.K., where isolates from different chickpea growing regions are being examined.

Table 35. Differential interaction of some chickpea genotypes with five isolates of *Ascochyta rabiei* from Syria and Lebanon.

	Isolates				
Genotypes	TH-1	TH-2	TH-3	Lattakia	Terbol
ILC 72	R	R	S	R	R
ILC 194	R	R	R-T	S	S
ILC 249	R	S	S	R	R
ILC 482	R	T	S	S	R
ICC 4107	R	R	R	R	R
ICC 1591	S	R	S	S	T
ILC 1929	S	S	S	S	S

R = resistant, T = tolerant, S = susceptible reaction,
TH = Tel Hadya.

Search for Durable Resistance

As evidence for the existence of physiologic races in *Ascochyta rabiei* is accumulating there is need to identify lines with nonspecific race resistance. A search is therefore being made for characters such as low sporulation capacity, small lesions, and less leaf wettability, which are indicative of such resistance.

Sporulation capacity. The sporulation capacity of four isolates of *A. rabiei* on a set of 60 genotypes found resistant/tolerant to one isolate (TH-1) was studied. Significant differences in the sporulation capacity of the isolates on the various genotypes were observed. However, in many lines there was no correlation between the disease severity and the amount of sporulation. Lines that showed less sporulation (5 million spores/g) than the others were ILC-191, 194, 200, 202, 2506, 2548, 2956, 3279, 3340, 3342, 3346, 3400, ICC-3996, 4107, and 4475.

Lesion size. Stem lesions are the most destructive damage caused by ascochyta blight. The size of the lesions induced on 60 genotypes by four isolates was measured. Some lines showed resistance to the formation of lesions by some isolates: e.g., ILC-194 against TH-1 and ILC-482, ICC-1467, 3919, 4107, and 4192 against Terbol isolate.

Leaf wettability. The extent of leaf wettability at different stages of growth was measured in a set of 25 genotypes with different degrees of susceptibility. Significant genotypic differences were observed at some growth stages. Leaf wettability was not uniform among the resistant lines and thus may not be the sole factor in host-plant resistance.

Effect of humidity on resistance. The effect of near 100% humidity for periods ranging from 0-15 days was studied in a set of genotypes resistant to TH-1 isolate. None of the lines including the susceptible check developed infection in a dry environment. In general, disease severity increased with increase in the duration of the periods of humidity from 2-15 days, and with a 15-day period of exposure most lines became susceptible; only two lines, ILC-194 and 200, continued to show tolerance.

Effect of Cultural Practices on Ascochyta Blight

Even though the main emphasis in the control of ascochyta blight is on the use of host-plant resistance or tolerance, because of the very considerable variation shown by the blight pathogen, efforts are also being made to develop integrated control systems based on host-plant resistance, chemical protection, and cultural practices to prolong the useful life of the resistant cultivars that are developed.

Since the infected seed and debris of diseased plants are the main sources of inoculum, the effect of depth at which seed is sown and of burying diseased debris on the development of the disease was studied.

Sowing infected seed at a depth of 10 cm or more made seed-borne inoculum ineffective. Even though the infection developed on the plants from deep-sown seed, the symptoms were not severe. Similarly, burial of debris from diseased chickpeas to a depth of 10 cm or more, prevented it acting as a source of inoculum.

Role of Food Legumes in Dryland Agriculture

Food legumes provide a comparatively cheap, good quality protein in the diet of people in the region. They are also an important component of the cropping system. Their value in crop rotations is their ability to fix atmospheric nitrogen, and the residual benefit of this to the following cereal crop.

The results from 1980-81 studies to measure the potential of rainfed food legumes to fix atmospheric nitrogen, using an isotopic dilution technique and a non-nodulating crop, showed that more than 80% of the total nitrogen harvested in the shoots was derived from symbiosis (Fig. 10). Improvements in the production technique, e.g., the use of the insecticide Carbofuran in lentils, or the early sowing of chickpeas, also increased symbiotic nitrogen fixation.

The residual effect of cropping treatments in 1980-81 on the yield in 1981-82 of rainfed wheat grown with different rates of directly applied nitrogen fertilizer is presented in Table 36. The yield of wheat following legumes was much more than that following wheat. Wheat yield following fallow was more than wheat following wheat, however the effect of fallow was not as beneficial as that of lentils, peas, and faba beans. The effect of chickpeas equalled that of fallow. The results show that under rainfall of about 300 mm as at Tel Hadya, a crop rotation of food legume-wheat can be very productive.

Table 36. Effect of 1980-81 cropping treatments on the grain yield of rainfed Norteno × S311 wheat grown in 1981-82 at three levels of directly applied fertilizer nitrogen (N_0 = 0; N_1 = 30; N_2 = 60 kg/ha).

1980-81 Cropping treatments (C)	Grain yield of wheat (kg/ha)			
	N_0	N_1	N_2	Mean
Lentil (L)	1456	1929	2199	1834
L + carbofuran	1200	1837	1898	1645
L for green forage	1592	1847	2022	1821
Winter chickpea (WC)	875	1188	1566	1209
Spring chickpea	630	1350	1522	1167
Faba bean	1320	2072	2228	1873
Peas	1260	1755	1994	1680
WC + wheat intercropped	532	1288	1655	1158
WC + barley intercropped	264	1225	1820	1103
Wheat at 20 kg N/ha	533	1369	1539	1147
Wheat at 60 kg N/ha	394	1249	1371	1004
Fallow	824	1396	1572	1264
N rate means	907	1544	1775	
CV (%)	For C = 23.3. For N = 18.9			
LSD (5%)	For C = 274.3. For N = 108.3.			
	C × N = Nonsignificant.			

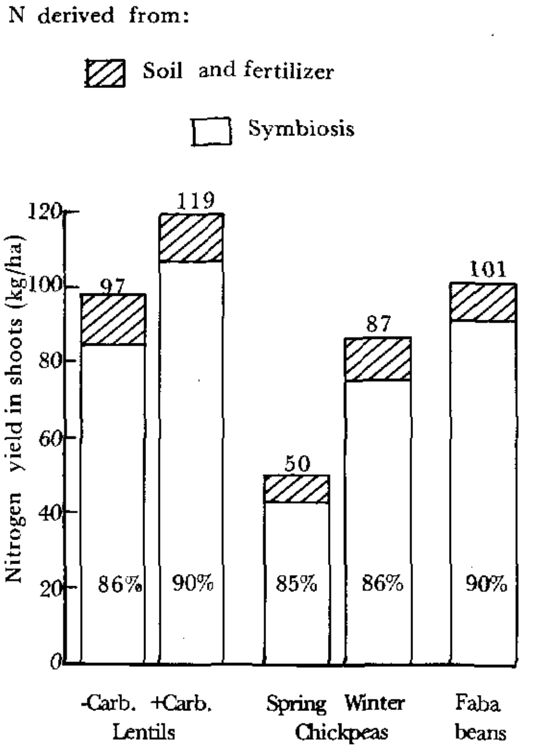


Figure 10. Total shoot nitrogen yield per hectare, and the contribution from symbiosis in lentils with and without carbofuran; spring- and winter-sown chickpeas; and faba beans under rainfed conditions (345 mm) at Tel Hadya, 1981-82 season.

Nile Valley Faba Bean Project

The objective of this applied research project is to test recommended cultivars of faba bean and cultural practices in farmers' fields in Egypt and Sudan, and to evaluate both the practicality and potential contribution of these factors at the farm level.

On-Farm Studies in Egypt

Studies to identify yield constraints were conducted on farms at 15 sites in each of Minia and Kafr El-Sheikh Provinces in the 1981-82 cropping season. Seed and straw yields were increased by 350 kg/ha (10.2%) and 700 kg/ha (14.4%), respectively, in Minia by the adoption of recommended plant populations. In Kafr El-Sheikh, the corresponding values were smaller, i.e., 160 kg/ha (6.1%) and 570 kg/ha (13.6%), respectively. Recommended population and fertilizer levels increased seed and straw yield by 16.3% and 22.1%, respectively, over the farmers' treatments in Minia. In Kafr El-Sheikh, the corresponding values were 9.8% and 14.4%, respectively.

At five of the 15 sites in Minia, an average increase over farmers' yields of 1410 kg/ha in seed yield (53.4%) and 1800 kg/ha in straw yield was obtained when the recommended level of irrigation (one additional watering than the farmers' practice) and of plant population and fertilizer were applied (Fig. 11). A smaller yield increase was obtained from improved water management when the other two factors (population and fertilizer) were kept at farmers' level.

Weeds are a major constraint to production of faba beans. In Minia, application of Igran and one hand-weeding increased yield by 310-690 kg/ha at three sites where weed infestation was high. In Kafr El-Sheikh, yield increase from weed control ranged from 190-720 kg/ha at eight sites.

In studies at Minia on the control of *Orobanche* in three infested sites, a tolerant line, Family 402, gave 18.4% more seed yield and 24.1% increase more straw yield than the susceptible Giza-2 when no glyphosate was applied. With Giza-2, two sprays of glyphosate gave a 24.1% increase in seed yield and 16.2% in straw yield over the unsprayed check (Fig.12).

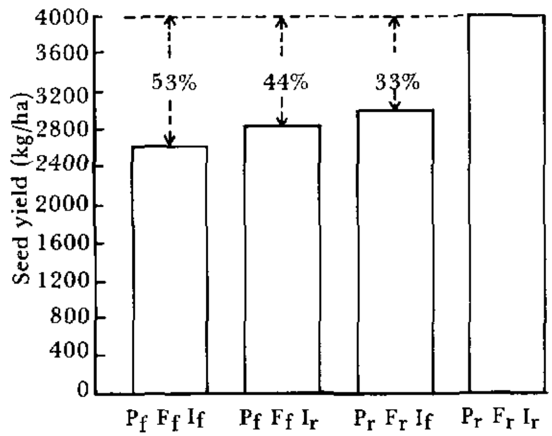


Figure 11. Faba bean yield gap assessment in on-farm trials at Minia in Egypt, 1981-82. (P - plant population; F - fertilizer; I - irrigation; r - recommended level; f - farmers' level).

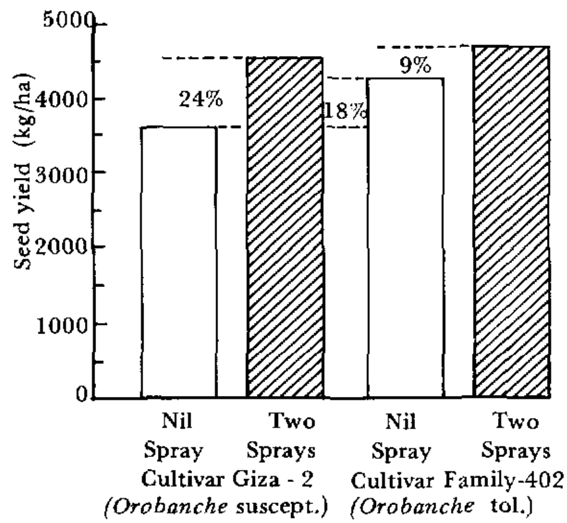


Figure 12. On-farm trials with and without glyphosate herbicide applications on *Orobanche* at Minia in Egypt, 1981-82.

On-Farm Studies in Sudan

Trials were conducted in three major faba bean producing areas in northern Sudan, namely, Zeidab, Aliab, and Selaim to examine the effect of various agronomic factors on potential farm yields and to assess the yield gap between farmers' practices and improved management.

At Aliab the recommended watering, method of planting, seed rate, and fertilizer application resulted in significant seed yield gains of 354,239,235, and 164 kg/ha, respectively. At Zeidab the most conspicuous effect was from improved irrigation which increased seed yield by 698 kg/ha over the farmers' practice. In

Selaim, recommended weeding and irrigation practices increased yield gains significantly by 746 and 451 kg/ha, respectively, over farmers' level. The yield gaps between farmer practices and recommended practices for the three areas are shown in Fig. 13.

Back-up Research in Egypt and Sudan

A total of 43 and 32 trials were conducted as a part of the back-up research in Egypt and Sudan, respectively. They included studies on agronomy, genetic improvement, water use, nodulation, diseases, pests, weed and *Orobanche* control, seed quality, and human nutrition in relation to anti-metabolites in faba beans. Economic analysis of the production factors evaluated in the on-farm trials, and a limited socioeconomic survey were also undertaken. Facilities for back-up research have been considerably augmented by the provision of glass houses, and laboratory and field equipment.

The results of all the trials and surveys conducted in 1981-82 and the consolidated results from the entire first phase period of the project were reviewed at the third annual coordination meeting at Sakha, Egypt, in September 1982.

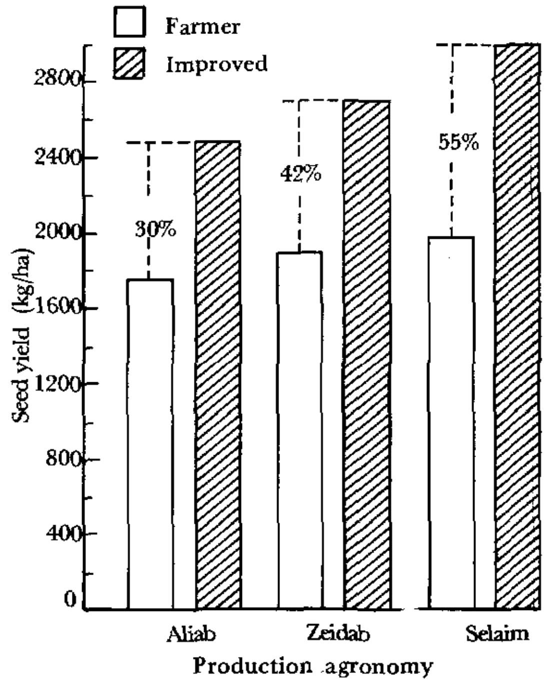


Figure 13. Faba Bean yield gap assessment in on-farm trials in the Sudan, 1981-82.

PASTURE AND FORAGE CROPS IMPROVEMENT

Contents

(Photo on previous page: Evaluation of annual medics in microplot trials at Tel Hadya)

Pasture and Forage Crops Improvement

Introduction

Livestock play an important role in the national economy of countries in the Middle East and North Africa. In some countries between 15 and 50% of the agricultural GDP is derived from livestock. Despite its economic importance animal production is not increasing sufficiently to meet population demand. One major reason for this is the shortage of livestock feed.

The objectives of the Pasture and Forage Improvement Program are to develop appropriate and low-input technology for increasing the utilization of fallow and marginal lands, to increase livestock production by ensuring a better distribution of feed throughout the year, to identify and improve pasture and forage species, and to develop economically sound pasture and animal management practices that will promote the integration of livestock into the farming systems.

Less emphasis was given in the 1981-82 season to broadening the genetic base of pasture and forage germplasm. Available material was multiplied and conserved. Evaluation of adapted pasture and forage species previously selected for improvement was continued and confident recommendations can now be made for selections of forage legumes and forage cereals for extensive use in farmers' fields. The number of accessions of pasture species under field evaluation in clipping or grazing trials was broadened considerably. In collaboration with the Farming System Program, some on-farm trials were started which examine the feasibility of introducing pasture crops into fallow areas in zones receiving less than 350 mm rainfall. A concerted effort was made to multiply seeds for multilocation trials that will generate important information on pasture establishment and utilization, and on sound livestock management practices.

The appointment of a full time agronomist enabled us to strengthen our agronomy research. Experiments were conducted with the objective of developing appropriate hay production technology. Studies were made on forage cereal-legume mixtures to define proper seed rates, legume-cereal seed ratios, and phosphate fertilizer requirements. The influence of harvesting stage on drymatter yield and forage quality was also investigated.

Trials were conducted to determine seed rates and fertilizer requirements for establishing and maximizing forage legume productivity. Provisional findings indicate that it may be possible to utilize forage mixtures for early grazing in spring, and then subsequently for hay production.

Pasture agronomy research also focused on the adaptation and productivity of Australian cultivars of annual *Medicago* (medics) in various climatic zones in Syria. The results of trials, some of which were in the third year, indicate that at least two Australian cultivars can be recommended for higher rainfall zones. Some of the pasture establishment and management problems have been identified. Experiments were conducted to study the relationship between pasture establishment and the build-up of soil fertility. On-farm trials were increased during the 1981-82 season to gain additional information from multilocation experiments and to expose farmers to pasture production technology.

The results of adaptation trials with annual and perennial grasses have confirmed that *Phalaris aquatica* is the most promising perennial grass. The commercially available cultivar Sirosa showed particularly good adaptation and persistence. *Agropyron* species have been identified that combine early summer and early winter growth. Studies on reseeding marginal land with small-seeded perennial legumes have indicated that investigations are required to solve problems of seedling establishment.

Surveys on the incidence of diseases and insect pests were conducted in Syria and Lebanon. Important diseases of forage and pasture crops were identified in the survey and by intensive screening of various trials conducted by the Program. This information will be useful to determine economic thresholds and to define priorities in developing integrated control programs for both diseases and insect pests.

Pasture and Forage Plant Introduction

A working germplasm collection is vital for establishing and conducting a crop research program. It is essential to manipulate and exploit broad-based genetic diversity in order to develop productive pasture and forage species with cold tolerance, disease and insect resistance, and other desirable characteristics. The main objectives of the plant introduction project are to broaden the genetic diversity of the pasture and forage species being improved, to multiply and maintain the present germplasm stock, and to conduct preliminary evaluation of germplasm.

Germplasm Collection and Multiplication

In 1981-82 a collecting trip was made to northern Syria where, in two districts in the 250-350 mm rainfall zone, 107 accessions were obtained from 40 different sites. A high percentage were annual *Medicago* species. In addition,61 new accessions of grasses were acquired from various research organizations and commercial sources. The total number of accessions in the germplasm collection is now 16513 accessions. The material multiplied for medium-and long-term storage totalled 3125 accessions.

Germplasm Evaluation

Observation rows replicated in a cubic lattice design were used for screening and appraising germplasm materials of annual *Medicago* species, *Vicia sativa*, and *Pisum sativum*. A total of 216 entries of annual medics, and 343 accessions each of *P. sativum* and *V. sativa* were evaluated in three replicates at Tel Hadya, and one replicate at Terbol in Lebanon where the materials were subjected to colder winter temperatures and more rainfall in the spring. Observations were made on establishment, winter and spring growth, vigor, leafiness, growth habit, height, spread, flowering date, and reactions to diseases and insects. Each accession was also scored on a visual estimation for drymatter yield and seed production.

Annual *Medicago* species were confirmed as very promising for pasture production. Thirteen different species were screened at Tel Hadya and *M. rigidula* was again found to be the most promising species for the Aleppo-type environment (Table 1). Selections were also made in species such as *M. truncatula, M. rotata,* and *M. noeana* because they could be as productive as *M. rigidula* in other countries of the Middle East and North Africa.

The *Vicia sativa* observation nurseries were severely affected by frost and later probably by nematodes. No selections were therefore made in this material.

From the 343 accessions of *Pisum sativum* planted, 161 promising lines were identified for evaluation of drymatter production and seed yield in microplot trials.

Annual Forage Crops to Replace Fallow

In the cropping zones in various countries in the Middle East and North Africa extensive areas are left as fallow, which could be used to grow hay crops. Hay can be of considerable importance to provide a continuous supply of feed throughout the year. Usually a very serious deficit in feed supply occurs during early winter and summer. Cereal-legume mixtures offer very good prospects for providing high quality hay.

Evaluation of Annual Forage Crops

Yield Trials

The objective is to develop screening methods, evaluate selected germplasm accessions, and identify productive forage plants for hay production in fields left fallow after a cereal crop. The forage plants earmarked for utilization after extensive testing include the three forage legumes, *Vicia sativa,*

Table 1. Evaluation of medic observation rows, Tel Hadya, 1981-82.

Medicago species	No. of accessions	No. of accessions selected	Selections as % of No. of accessions for each species	Selection as % of total accessions of all species	Range and mean selection score of selected accessions[a]
M.rigidula	87	43	49.4	19.9	3-4.7
M.aculeata	28	11	39.3	5.1	3-4.7
M.truncatula	42	6	14.3	2.8	3-4.0
M.littoralis	6	0			
M.truncatula & M.littoralis	3	0			
M.turbinata	23	11	47.8	5.1	3-4.3
M.rotata	11	4	36.4	1.9	3.7-3.7
M.noeana	3	2	66.7	0.9	3.3-5.0
M.polymorpha	3	0			
M.murex	2	0			
M.blanchiana	1	1	100.0	0.5	3.7[b]
M.constricta	6	0			
M.tornata	1	0			
Total	216	78		36.2	

Mean selection score of control 3.3 ***(M. rigidula).***
a. Selection score: 1 = poor; 5 = very good.
b. One accession selected.

Pisum sativum, and *Lathyrus* spp. and forage barley, forage triticale, and oats.

In the microplot trials, germplasm selections of both *V. sativa* and *P. sativum* were planted at Tel Hadya in 3.5 m^2 plots arranged in a triple lattice design. For both legumes, the seed rate was 80 kg/ha and the fertilizer application was 40 kg/ha. These replicated microplot trials were duplicated, and one trial was harvested for quantitative determination of drymatter and the other for seed yield.

In the advanced yield trials, potentially high performing lines of all three legumes were planted in larger plots (24 m^2) in a triple lattice design. Seed rate and fertilizer application were the same as for the microplot trials. The trial was duplicated, and one trial was harvested for seed yield and the other for drymatter production.

Vicia sativa. A total of 64 selections were tested in microplot trials and 20 lines, which combined both good seed yield and drymatter production, were identified for more critical evaluation in advanced yield trials (Table 2). Only one line (selection No. 2109) outyielded the control in drymatter production but its seed yield while satisfactory, was only 76% *of the control.*

In the advanced yield trial, 16 lines were tested and none outyielded the control in either seed yield or drymatter production.

Table 2. Drymatter (DM) and seed yield of selected lines of *Vicia sativa,* Microplots Trial, Tel Hadya, 1981-82.

Selection No.	DM yield			Seed yield		
	kg/ha	Rank	% control	kg/ha	Rank	% control
2109	3787.2	1	101	980.9	9	76
Control	3743.07	2	100	1283.8	1	100
2095	3391.19	5	91	1104.7	4	86
2063	3362.54	7	90	1160	3	90
2100	3184.78	10	85	1017	8	79
2057	2880.74	15	77	875.2	15	68
2025	2803.47	18	75	814.3	19	63
2021	2728.92	19	73	905.7	13	71
2038	3592.82	3	96	753.3	22	59
2106	3466.14	4	93	519.1	42	40
2037	3380.38	6	90	699	29	54
2044	3202.93	9	86	730.5	26	57
2108	3083.68	11	82	611.4	36	48
2017	3068.7	12	82	602.9	37	47
2024	2721.95	20	73	722.9	27	56
2024	2721.95	20	73	722.9	27	56
2020	2686.2	21	72	745.7	24	58
2062	2684.24	22	72	840	17	65
2065	2657.41	23	71	770.4	21	60
2022	2618.07	24	70	1026.7	7	80
2086	2603.73	26	70	1095.2	6	85
2068	2559.34	27	68	1096.2	5	85

Total No. lines = 64.
SE of a difference between DM crop means ± 491.4.
SE of a difference between seed yield crop means ± 132.5.

Table 3. Drymatter (DM) and seed yield of selected lines of *Vicia sativa*, Advanced Yield Trial, Tel Hadya, 1981-82.

Accession No.	DM yield kg/ha	Rank	% control	Seed yield kg/ha	Rank	% control
Contol	3423.22	1	100	1618.92	1	100
715	3245.15	2	94	1564.97	2	96
1350	2987.35	3	87	932.87	12	57
2	2848.55	4	83	933.80	11	57
709	2637.58	5	77	1135.13	7	70
7	2369.2	6	69	1255.34	5	77
716	2328.09	7	68	1402.94	3	86

Total No. lines = 16.
SE of a difference between crop DM means ± 406.
SE of a difference between crop seed yield crop means ± 118.

However, six lines were chosen for multilocation trials (Table 3).

The control used in both the microplot and advanced yield trials has been derived through mass selection procedure from the local *V. sativa* sold in the market. It has been consistently high-performing and following its multilocation testing in 1982-83, recommendations will be considered for its release to farmers.

Pisum sativum. Sixty-four lines of *Pisum sativum* were evaluated at Tel Hadya in microplots and 24 were selected for advanced testing (Table 4). Several lines combined good drymatter yield with good seed yield. All 24 lines outyielded the control in drymatter production, and 16 in seed yield.

Five selections were made from 25 accessions in the advanced yield trials on the basis of drymatter and seed yield (Table 5). Two selections (No. 325 and No. 330) are of particular interest because of their good ranking in relation to the control and their promising performance in the 1980-81 season. The five superior lines will be field tested in multilocation trials during the next cropping season.

The control in the *Pisum* trials was derived through mass selection from local material purchased in the market. It has performed satisfactorily in a number of tests and is being multiplied for use by farmers.

Lathyrus spp. In advanced yield trials at Tel Hadya, 16 accessions were evaluated and six were selected for off-station testing. One accession (No. 384), which was also high yielding during the 1980-81 season, is being multiplied, as is the control, for use by farmers (Table 6).

Forage cereals. Promising lines of forage cereals (barley, triticale, and oats) were evaluated in pure stand in preliminary and advanced yield trials at Tel Hadya in 1981-82. Barley and oat lines were also tested in mixtures with *Pisum* and vetch, respectively. In these mixtures drymatter yield was measured at two stages of maturity, i.e., the dough stage of the cereal component, and the beginning of pod formation of the legume component, respectively.

Barley lines that produce more drymatter than the control (local barley) when cut for hay have been identified in preliminary and advanced yield trials (Table 7), whereas none of the triticale lines tested in 1981-82 was more productive than the local barley.

Some of the best barley and oat lines identified in the advanced yield trials of the

Table 4. Drymatter (DM) and seed yield of selected lines of *Pisum sativum, Pisum* Microplots Trials, Tel Hadya, 1981-82.

Selection No.	DM yield kg/ha	Rank	% control	Seed yield kg/ha	Rank	% control
469	4567.85	1	141	1644.71	21	107
493	4520.53	2	139	1826.29	5	119
489	4171.79	3	128	1728.9	13	113
478	4094.48	4	126	1739.31	12	113
490	3882.37	5	119	1748.19	10	114
465	3875.94	6	119	1771.6	9	115
476	3824.75	7	118	1801.24	7	117
440	3721.98	10	114	1662.5	19	108
470	3644.94	12	112	1854.93	3	121
484	3586.38	14	110	1740.4	11	113
443	3489.13	18	107	1614.94	24	105
457	3463.56	20	106	1667.65	18	109
504	3362.12	21	103	1652.9	20	108
455	3322.51	22	102	1641.26	22	107
466	3788.11	8	116	1254.27	46	82
481	3773.78	9	116	1554.84	28	101
501	3657.57	11	112	943.14	56	61
438	3641.66	13	112	955.29	54	62
468	3504.03	15	108	1408.47	36	92
496	3492.07	16	107	1487.18	33	94
464	3491.23	17	107	1240.46	47	81
502	3469.59	19	107	864.93	58	56
485	3280.23	23	101	1985.01	2	129
445	3264.2	24	100	1395.83	38	91
Control	3238.44	25	100	1528.68	31	100

Total No. lines = 64.
SE of a difference between crop DM means ± 375.7.
SE of a difference between crop seed yield means ± 201.1.

Table 5. Drymatter (DM) and seed yield of selected lines of *Pisum sativum,* Advanced Yield Trial, Tel Hadya, 1981-82.

Selection No.	DM yield kg/ha	Rank	% control	Seed yield kg/ha	Rank	% control
325	3723.98	2	113	1486.38	1	131[a]
330	3625.49	3	110	1310.33	5	115[a]
257	3204.15	9	97	1340.15	4	118[a]
323	3198.37	10	97	1474.24	2	130[a]
319	3377.43	5	103	1107.11	12	97
Control	3273.63	7	100	1130.33	10	100

Total No. lines = 25.
a. Elite lines.
SE of a difference between crop DM means ± 294.3.
SE of a difference between crop seed yield means ± 174.6.

Table 6. Drymatter (DM) and seed yield of selected lines of *Lathyrus* species, Advanced Yield Trial, Tel Hadya, 1981-82.

Selection No.	DM yield kg/ha	DM yield Rank	DM yield % control	Seed yield kg/ha	Seed yield Rank	Seed yield % control
384	2845.47	1	100	748.52	4	110
104	2135.47	4	75	768.25	3	113
385	2393.18	3	84	680.79	6	100
471	1994.71	5	70	717.28	5	105
439	1952.51	6	69	851.35	2	125
185	1920.16	7	67	646.03	10	95
Control	2827.47	2	100	678.24	7	100

Total No. lines = 16.
SE of a difference between crop DM means ± 300
SE of a difference between crop seed yield ± 115.9.

Table 7. Drymatter yield (kg/ha) of five best lines of forage barley and forage triticale in preliminary and advanced yield trials at Tel Hadya, 1981-82.

Lines	Preliminary yield trials	Lines	Advanced yield trials
Barley		Barley	
1113	10,029	334	8,248
1061	9,798	191	7,917
1063	9,555	202	7,682
1038	9,162	109	7,611
1120	9,125	423	7,405
Triticale		Triticale	
1188	6,566	242	6,477
1204	6,442	804/838	6,321
1189	6,301	1023/406	6,318
1195	6,014	803/331	6,311
1210	5,761	332	6,157
Local barley	7,408	Local barley	5,716
SE ±	880	SE ±	720

1980-81 season maintained their superiority over the local barley when tested in mixtures with *Pisum* and vetch, respectively (Table 8). As a result of the different maturity time of the two cereals, barley-*Pisum* mixtures were more productive when cut at pod formation of the peas, whereas oats-vetch mixtures were generally more productive when cut at the dough stage of the oats.

Field evaluation studies of forage legumes will be considerably curtailed and will be restricted to advanced yield trials and multilocation testing of selected, high-performing lines. A limited number will be considered for varietal release. The evaluation of forage cereals will be discontinued and the Program will use existing materials and improved dual-purpose barleys emerging from the Cereal Improvement Program.

Pathology

Diseases of Forage Crops

The results of a field survey conducted in the 1980-81 cropping season on diseases of pasture and forage crops were incomplete. Another survey was therefore conducted in

Table 8. Effect of time of harvest on barley-*Pisum* and oats-vetch mixtures at Tel Hadya, 1981-82.

Lines	Drymatter yield	
	Dough stage	Pod formation
Barley		
222/91	5344	5688
208/83	4306	6482
49/30	4283	5440
46/28	4040	4364
47/29	3936	4638
Oats		
5	4972	4251
15	4823	3929
18	4726	5278
12	4543	4600
20	4526	3937
Local barley	4586	3358
SE ±	397	457

the 1981-82 season to provide additional information on the disease spectrum in different climatic zones in Syria and Lebanon in order to determine, on a priority basis, the economically important diseases for consideration in screening programs.

Diseases of forage crops were diagnosed in the field and confirmation of the causal agent/s was made in the laboratory. The prevalence of a disease in a location was determined by its incidence (percent attacked plants in a fixed population) and by its severity (percent coverage of plants by the disease). A 0-4 rating scale was used, where 0 = resistant and 4 = susceptible .

Diseases found on *Vicia* spp. were: *Ascochyta,* powdery mildew, downy mildew, rust, *Stemphylium* leaf spot, virus, *Ovularia* and *Ramularia* leaf spot, *Sclerotinia* blight. Root-knot nematodes, cyst nematodes, and the flowering parasitic plants *Orobanche* spp and *Cuscuta* spp. were also recorded. According to the frequency and prevalence of these diseases in the locations surveyed, downy mildew, *Ascochyta,* and powdery mildew can be considered as the major diseases of *Vicia* spp.

Diseases found on *Pisum* spp. were: *Ascochyta,* powdery mildew, downy mildew, bacterial blight, rust, *Stemphylium* leaf spot, virus, root-knot nematodes, cyst nematodes, and the flowering parasitic plant *Orobanche* spp. According to the frequency and prevalence of these diseases, *Ascochyta,* powdery mildew, and bacterial blight can be considered as the major diseases of *Pisum* spp.

Diseases found on *Lathyrus* spp. were: *Ascochyta,* downy mildew, and bacterial blight. Root-knot nematodes, cyst nematodes, and the flowering parasitic plant *Orobanche* spp. were also found. According to the frequency and prevalence of these diseases, the following can be considered as the major diseases of *Lathyrus* spp: *Ascochyta,* powdery mildew, and bacterial blight.

The results of the survey indicate that two different locations are of significant importance. The first, Jableh (Zone 1), in the coastal region where most, if not all, diseases of forages are endemic and severe. This location will be used for screening adapted ecotypes for disease resistance. In the second location, Al Tah, in the lower rainfall region (Zone 2), forage diseases are very rare and their occurrence is scattered. This location can be used for the production and multiplication of forage seed.

Future survey work on diseases of forage crops should determine the occurrence of the identified diseases and their importance in other countries in the ICARDA region.

Screening for Disease Resistance

Prior to the 1980-81 cropping season, the Program had been selecting forage species for desirable agronomic characteristics through screening and selection procedures, and a large number of accessions and potential cultivars of many species were evaluated. However, all these materials were not screened for disease resistance, since pathology work in the Program started only during the 1980-81 cropping season.

Therefore, in the 1981-82 cropping season, all selected lines in the successive stages of crop evaluation (observation rows, microplots, advanced yield trials) were screened to determine their susceptibility to the important diseases identified in Syria and Lebanon. Diseases of *Pisum* spp. in this evaluation were *Ascochyta*, powdery mildew, and downy mildew.

A total of 1817 entries (967 of *Pisum* spp. and 850 *Vicia* spp.) were evaluated at Tel Hadya during the 1981-82 season (Table 9). From the observation rows only highly susceptible entries (score 4) have been excluded from further testing. From the microplots and advanced yield trials, highly susceptible and susceptible (score 4 and 3) entries have been excluded; all entries showing resistance (score 0-2) at these stages will be reevaluated next year in the disease nurseries. A large number of entries were susceptible to more than one disease; these entries will be excluded from further evaluation except those possessing very good agronomic characteristics.

Screening was also done in two disease nurseries located in two different climatic zones. One nursery was established at Jableh, in the coastal region near Lattakia, and the other at Tel Hadya. The results from the 1980-81 survey indicated that the diseases spectrum and severity were different in these two locations. No artificial supplementary inoculation was used in either nursery.

A total of 189 genotypes (125 *Pisum* spp. and 64 *Vicia* spp.) were planted in the disease nursery at Jableh to duplicate the genotypes in the nursery at Tel Hadya. These lines originated from microplots and advanced yield trials of both forage crops. Susceptible genotypes for the most common forage

Table 9. Number of lines of *Pisum* spp. and *Vicia* spp. in the successive stages of selection, classed according to disease susceptibility, Tel Hadya, 1981-82.

Crop	Stage	No. of entries attacked by one disease Score 0	1-2	3-4	No. of entries attacked by more than one disease	Total
	Nursery	161	148	34	0	343
	Nursery (Terbol)	89	146	100	9	344
Pisum spp.	Microplots	6	19	16	23	64
	AYT	0	0	13	12	25
	Increase	31	53	86	21	191
						967
	Nursery	286	50	0	7	343
	Nursery (Terbol)	275	53	9	7	344
Vicia spp.	Microplots	14	29	16	5	64
	AYT	0	0	13	3	16
	Increase	29	15	21	18	83
						850
					Total	1817

Scoring scale: 0 = resistant; 4 = susceptible.
AYT = Advanced Yield Trial.

diseases were planted in the nurseries as susceptible indicator rows. These were selected from the breeding material grown in the previous season at Tel Hadya.

The *Pisum* material was screened for major diseases, which included bacterial blight, powdery mildew, and *Ascochyta*. The response of *Pisum* spp. to *Ascochyta* and bacterial blight was similar in both locations, but different to powdery mildew. At Tel Hadya, about 94% of entries showed resistance to this disease, whereas at Jableh only 10% were resistant.

The *Vicia* accessions were screened for *Ascochyta*, downy mildew, and powdery mildew. All entries were resistant to powdery mildew at Tel Hadya, but only 31% at Jableh.

The coastal region in Syria represents an ideal location to screen for disease resistance. Most, if not all, diseases of forage crops have occurred in this region during the last two cropping seasons and the incidence and severity of some diseases, e.g., powdery mildew, were very high.

Future screening work should be done at both locations, i.e., the coastal region and at Tel Hadya, for a critical evaluation of promising forage genotypes. At Tel Hadya screening under artificial supplementary inoculation should be started, whereas in the coastal region such inoculation is not required.

Entomology

A survey was conducted to evaluate and define the status and importance of insect pests and mites on the most promising forage species. At present, there is little information on the pests that damage forage crops in the Middle East and North Africa.

The survey was conducted in May and June 1982 in the trials conducted by the Program in Syria and Lebanon, and in August 1982 in farmers' fields. At each location, each crop was monitored by choosing 10 accessions at random diagonally to the field. In each accession five branches were checked for frequency (percent branches attacked); thus the results represent the attack on 50 branches of the respective crop in a particular location. A scale was developed (0 = no infestation; 1 = less than 5; 2 = 5 to 25 ; 3 = 25 to 50, and 4 = more than 50 specimens/branch) in order to allow quick and reliable estimates of the severity of the attack.

The insect pests observed on *Vicia* spp. and *Pisum* spp. are listed in Table 10. *Vicia* spp. were completely free from attack at Kamishly whereas at Tel Hadya and Terbol there were 100% infestations of *Aphis craccivora* and *Acyrthosiphum pisum*, respectively. At one site *Pisum* spp. were severely attacked by thrips (*Thysanopteroidea*), especially the pods. The pod borer (*Laspeyresia* spp.) was prevalent only at Tel Hadya. The larvae of this lepidopterous pest feed on seeds and this can be a serious problem in seed production fields. Leaf miners and aphids appear to be of minor importance.

This survey provides only an incomplete impression of insect damage on annual forage crops. There is a need to continue monitoring these pests in order to determine economic thresholds, define priorities and, if necessary, to develop an integrated pest control program on promising forage species.

Agronomy

Agronomy of Forage Crops

The objective of agronomy research in forage crops is to develop suitable technology for hay production and conservation. Adapted and high producing lines of forage legumes (*Vicia* spp., *Pisum* spp., *Lathyrus* spp.) and forage cereals (barley, triticale, and oats) have been identified by the Program. They are being further evaluated in agronomy trials for developing suitable cereal-legume mixtures for hay making.

Table 10. Frequency and severity of insect and mite attack on vetch (*Vicia* spp.) and *Pisum* sp. at different locations in Syria and Lebanon, 1982.

Crop	Location	Pest		Frequency (%)	Severity (0-4)
Vetch (*Vicia* spp.)	Terbol	***Acyrthosiphum pisum***	aphid	100	2
		Liriomyza sp.	leaf miner	44	1
		Sitona sp.	leaf weevil	82	1
	Jableh	***Acyrthosiphum pisum***	aphid	6	1
		Thysanopteriodea (not yet identified)	thrips	4	1
		Liriomyza sp.	leaf miner	2	1
		Collembola (not yet identified)	spring tail	28	1
	Fidio	***Acyrthosiphum pisum***	aphid	6	1
		Therioaphis trifolii	aphid	4	1
		Thysanopteroidea (not yet identified)	thrips	14	2
		Jassidae (not yet identified)	cicada	18	1
	Kamishly				
Peas (*Pisum* sp.)	Terbol	***Acyrthosiphum pisum***	aphid	18	1
		Thysanopteroidea (not yet identified)	thrips	2	1
		Liriomyza sp.	leaf miner	26	1
	Jableh	*Acyrthosiphum pisum*	aphid	10	1
		Thysanopteroidea) not yet identified)	thrips	82	2
	Kamishly	***Thysanopteroidea*** (not yet identified)	thrips	38	1
		Liriomyza sp.	leaf miner	14	2
	Tel Hadya	***Acyrthosiphum pisum***	aphid	28	2
		Thysanopteroidea (not yet identified)	thrips	100	2
		Liriomyza sp.	leaf miner	8	1
		Laspeyresia sp.	pod borer	26	1

Forage conservation studies include investigation of simple hay baling equipment. A simple one-man operated hay baler is demonstrated to interested farmers.

Seeding rate and nutritional requirements of forage cereal-legume mixtures. Data from our previous experiments have indicated that there are different levels of DM production in forage mixtures when compared with forage monocultures as different seed rates and different legume-cereal seed ratios are used.

In 1981-82 we investigated the effect of phosphate fertilization, seed rates, and seed ratios of legume-cereal components on DM production and forage quality. In these experiments the following mixtures were evaluated: *Vicia*-triticale, *Pisum*-triticale, *Vicia*-barley, *Vicia*-oats, and *Lathyrus*-triticale.

Each experiment was designed to study the effects of three fertilizer rates (0, 40, and 80 kg P_2O_5/ha), six seed rates (80, 100, 120, 140, 160, and 180 kg/ha) with six legume-cereal seed ratios (0:100, 20:80, 40:60, 60:40, 80:20, 100:0) in each seeding rate. The experiments were laid out in a split-plot design with three replicates, with fertilizer rates as main plots, seed rates as subplots, and seed ratios as the sub-subplot treatments. Areas for the main, sub, and sub-sub plot treatments were 75.6, 12.6 and 2.1 m^2, respectively. The experiments were sown at Tel Hadya in November 1981 and harvested for DM yield in April 1982 at 50% heading of the cereal component. Subsamples representing all treatment combinations were taken at time of harvest, oven dried, and analyzed for total nitrogen (N) using the Kjeldahl technique.

Phosphate application. The phosphate application resulted in a significant yield increase in drymatter production in most of the mixtures at Tel Hadya in 1981-82. Drymatter increase over the control was 21% and 36% for *Vicia*-triticale by using 40 and 80 kg P_2O_5/ha, respectively (Table 11). The highest DM production for *Pisum*-triticale was obtained with an application of 40 kg P_2O_5/ha, which was significantly higher ($P \leq 0.05$) than the control. A moderate response to phosphate application was found with *Lathyrus*-triticale, which amounted to 16% and 23% over the control when 40 and 80 kg P_2O_5/ha, respectively were applied. Corresponding values for *Vicia*-barley were 23% and 27%, and those for *Vicia*-oats were 7% and 15%.

Table 12 compares the response to phosphate application of legume-cereal mixtures with that of the individual components grown in pure stand. At 40 kg P_2O_5/ha, the response of *Vicia*-cereal mixtures was higher than that of both the individual components grown in pure stand, except for the *Vicia*-oats mixture. Mixtures of *Pisum*-triticale and *Lathyrus*-triticale also gave a higher response to phosphate than at least one of the individual components. At the high phosphate rate (80 kg P_2O_5/ha), response of the legume in pure stand was higher than *Vicia*-cereal mixtures.

Seed rate. Drymatter production was significantly increased by increasing the seed rate in all mixtures. However, some differences were observed among mixtures in the optimum seed rate required. Maximum forage yields were recorded at 180 kg/ha for *Vicia*-triticale, *Lathyrus*-triticale, and *Vicia*-oats, while lower seed rates of 160 and 140 kg/ha were required for *Pisum*-triticale and *Vicia*-barley, respectively (Table 13). *Vicia*-oats produced the highest DM yield of all mixtures regardless of seed rate.

Seed ratios. The highest DM yields were recorded when the cereal crop (oats, triticale, barley) was grown in pure stand. However, these yield levels were closely matched by

Table 11. Effects of phosphate fertilizer on DM yields (kg/ha) of some forage legume-cereal mixtures[a].

	Phosphate rate (kg P_2O_5/ha)			
	0	40	80	SE ±
Vicia-triticale	4591	5577	6280	112.9
Pisum-triticale	4329	5495	5090	397.0
Lathyrus-triticale	4213	4912	4775	305.5
Vicia-oats	7641	8225	8853	529.3
Vicia-barley	4479	5545	5693	449.6

a. Each value is an average of 6 seed rates × 6 seed ratios.

Table 12. Response to phosphate fertilization of legume-cereal mixtures and individual components at Tel Hadya in 1982.

Crop	Phosphate applied (kg P_2O_5/ha)	Mixture[a] DM yield (kg/ha)	Mixture[a] % increase over control	Legume component[b] grown in pure stand DM yield (kg/ha)	Legume component[b] grown in pure stand % increase over control	Cereal component[b] grown in pure stand DM yield (kg/ha)	Cereal component[b] grown in pure stand % increase over control
Vicia-triticale	0 (control)	4647		3408		5544	
	40	5822	25.3	3738	9.7	6436	16.1
	80	6244	34.3	5417	58.9	7287	31.4
Vicia-barley	0 (control)	4615		2448		5964	
	40	5836	26.5	2827	15.5	7095	19.0
	80	5902	27.9	3552	45.1	6999	17.4
Vicia-oats	0 (control)	8299		4211		8439	
	40	8456	1.9	4858	15.4	10666	26.4
	80	9095	9.6	5863	39.2	10874	28.9
Lathyrus-triticale	0 (control)	4461		2179		5253	
	40	5165	15.8	2338	7.3	6471	23.2
	80	5025	12.6	2094	-3.9	6451	22.8
Pisum-triticale	0 (control)	4287		3299		5525	
	40	5595	30.5	4309	30.6	6281	13.7
	80	5285	23.3	4042	22.5	5355	-3.1

a. Each value is an average of 6 seed rates × 4 seeding ratios.
b. Each value is an average of 6 seed rates.

Table 13. Drymatter production (kg/ha) of different forage legume/cereal mixtures as affected by seed rate[a] at Tel Hadya, 1981-82.

Forage mixture	Seed rate (kg /ha) 80	100	120	140	160	180	SE ±
Vicia-triticale	4595	5090	5617	5551	5809	6033	183.0
Pisum-triticale	4559	4421	4884	4896	5471	5596	310.3
Lathyrus-triticale	4161	3945	4365	4830	4923	5573	265.4
Vicia-oats	7446	8200	8304	8300	8451	8737	523.6
Vicia-barley	4317	5026	5037	5647	5807	5600	253.6

a. Each value is an average of 3 phosphate rates × 6 seed ratios.

those of mixtures containing 20 or 40% legume (Fig. 1). Sharp decreases in forage yields were generally recorded in the mixtures as the legume component was increased from 60 to 80%. *Vicia*-triticale and *Pisum*-triticale mixtures were exceptions. The level of reduction was 18% in *Vicia*-barley, 14% in *Vicia*-oats, and 18% in *Lathyrus*-triticale, while it was only 6% in both *Vicia*-triticale and *Pisum*-triticale. The differences in DM yield of *Vicia* in pure stand (Fig. 1) were the result of different harvesting dates of the trials, which were based on the 50% heading stage of the cereal component. The heading date for barley was approximately 1 month earlier than for oats.

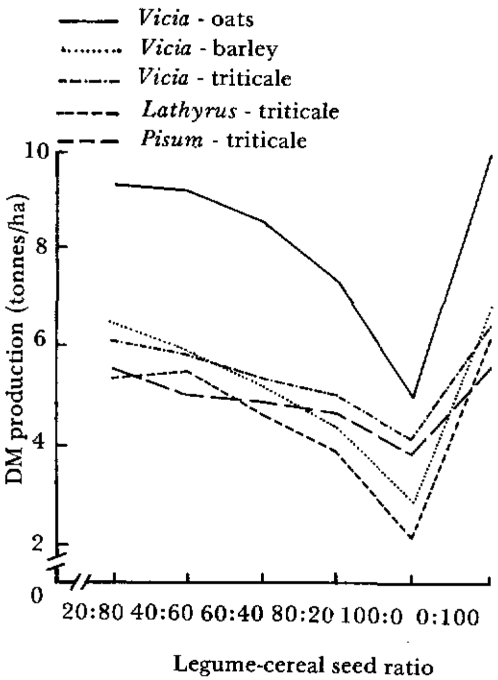


Figure 1. Total DM production of forage mixtures as affected by legume-cereal ratios.

Comparisons between *Vicia*-barley and *Vicia*-triticale with regard to the percent crude protein (CP) and total CP are presented in Figure 2. Percent CP in triticale in pure stand was 10% higher than that of barley in pure stand. Similarly, *Vicia*-triticale mixtures consistently had a higher percent of CP at all seed ratios used (Fig. 2). It was also found that *Vicia* in pure stand had a higher percent CP when harvesting was done early (*Vicia*-barley) as compared with the percent CP in the *Vicia*-triticale experiment. Differences in percent CP in the two forage mixtures were also reflected in their total CP content (Fig. 2). Total CP was higher in *Vicia*-triticale as compared with *Vicia*-barley at all seeding ratios. This difference was markedly higher at 80:20 (seed ratio) where *Vicia*-barley, as stated earlier, had demonstrated greater reduction in DM yield (18%) as compared with *Vicia*-triticale (6%). It would appear that *Vicia*-triticale and *Pisum*-triticale mixtures provide more flexibility for improving forage quality without sacrificing high DM production.

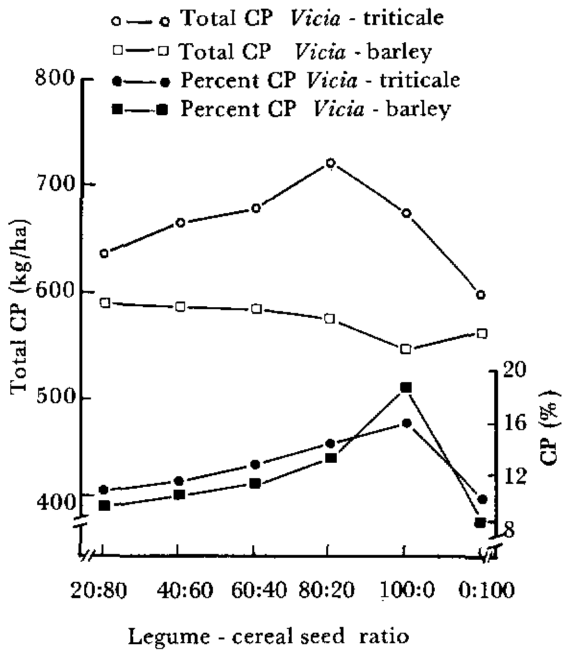


Figure 2. Total crude protein (CP) and percent CP in *Vicia*-barley and *Vicia*-triticale mixtures as affected by legume-cereal ratios.

Influence of harvesting stage on yield and nutritional value of cereal-legume mixtures. The effect of harvesting stage on yield and forage quality was studied using three legumes (*Vicia, Pisum,* and *Lathyrus*) grown in mixture with triticale. Three separate experiments were conducted, one for each legume. The treatments in each experiment consisted of six accessions of the legume grown in mixture with each of two accessions of triticale at the seed ratio of 33:66. Sowing was done in November 1981. In April 1982, and prior to harvest, each plot was divided into three (2 m^2) subplots, which were harvested at 10% flowering, 100% flowering, and full pod formation of the legume component. Harvested forage material was oven dried and subsamples were analyzed for nitrogen using the Kjeldahl technique.

Drymatter yield was significantly increased with delayed harvesting in all legume-cereal mixtures (Fig. 3). Increases in DM of 46% and 66% were obtained for *Pisum*-triticale harvested at 100% flowering and at full pod formation, respectively, as compared with 10% flowering. Similarly, yield of *Vicia*-triticale mixtures harvested at 100% flowering and at full pod formation increased, respectively, by 88% and 145%. Corresponding values for *Lathyrus*-triticale were 46% and 80%.

Percent CP was highest at 10% flowering and was significantly reduced ($P<1\%$) as harvesting was delayed (Table 14). However, this high percent CP at 10% flowering did not compensate for the lower DM yield when the results were expressed in terms of total CP (total DM x CP) as shown in Figure 3. Similarly

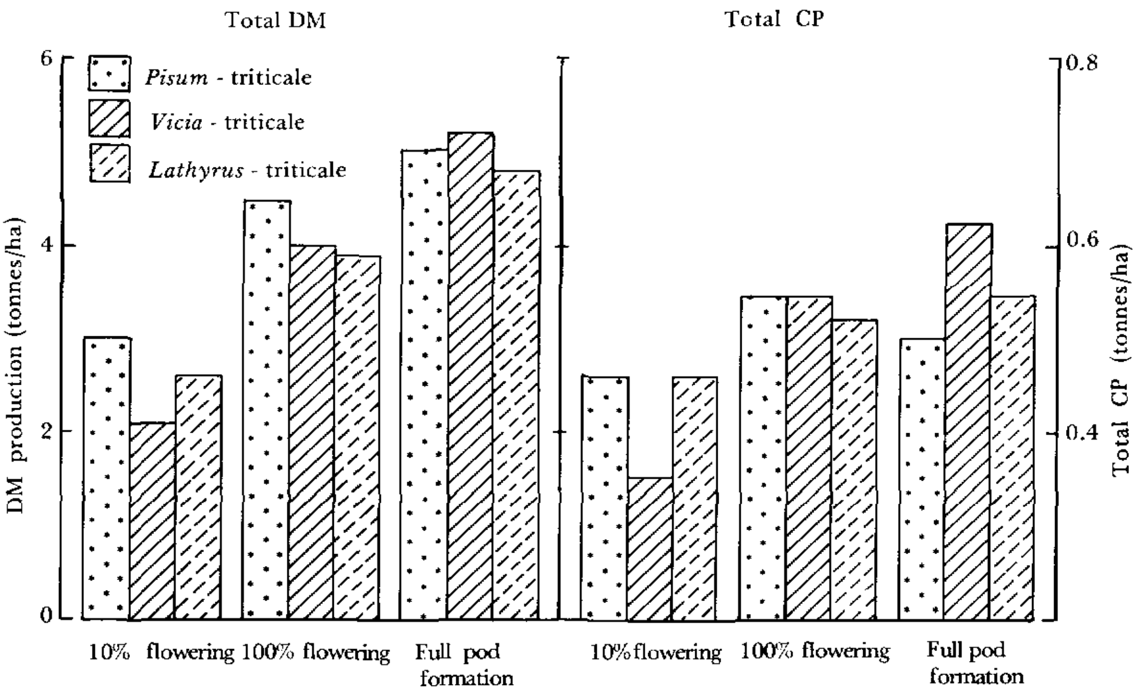


Figure 3. Total DM and Total CP as affected by harvesting stage of the legume component in forage mixtures of *Pisum*-triticale, *Vicia*-triticale, and *Lathyrus*-triticale.

Table 14. Percent crude protein[a] of different legumes in pure stand and in mixture with triticale as affected by the harvesting stage of the legume at Tel Hadya in 1981-82.

Legumes	Harvesting stage 10% flowering	100% flowering	Full pod Formation	Mean
Vicia sativa (V.s)	20.48	17.81	16.05	18.11
V.s + triticale	16.05	12.47	10.62	13.05
Mean	18.27	15.14	13.34	
Pisum sativum (P.s)	19.11	16.67	13.89	16.56
P.s + triticale	14.44	11.23	9.03	11.57
Mean	16.78	13.95	11.46	
Lathyrus spp. (L. spp.)	24.02	20.21	17.95	20.73
L. spp. + triticale	16.00	11.64	9.78	12.47
Mean	20.01	15.93	13.87	

a. Each value is an average of 6 legume accessions × 2 triticale accessions.
SE of a difference between two harvesting stage means for *Vicia* ± 0.29.
SE of a difference between two harvesting stage means for *Pisum* ± 0.36.
SE of a difference between two harvesting stage means for *Lathyrus* ± 0.24.

the total digestible dry matter yield (TDDM) was significantly higher with delayed harvest despite the higher percent digestible dry matter recorded at 10% flowering (Fig. 4).

Phosphate requirements for establishing forage legumes. Our earlier study indicated that different legumes have different nutritional requirements for establishment. Differences were also noticed between accessions of the same species. In 1981-82 we examined the phosphate requirement for *Vicia, Pisum,* and *Lathyrus* in an experiment at Tel Hadya. Six accessions for each legume were included in the trial and four levels of phosphate fertilizer (0, 40, 80, and 120 kg P_2O_5/ha) were used. The crops were sown in plots 1.4 m x 5.0 m and the experiment was laid out in a randomized complete block design with three replicates. In May 1982 the plots were harvested for DM whenever the legume had reached the 100% flowering stage. Subsamples representing two accessions in each legume (*Vicia*, *Pisum*, and *Lathyrus)* were used for phosphorus tissue analysis.

High phosphate levels (80 and 120 kg P_2O_5/ha) resulted in a significant DM increase

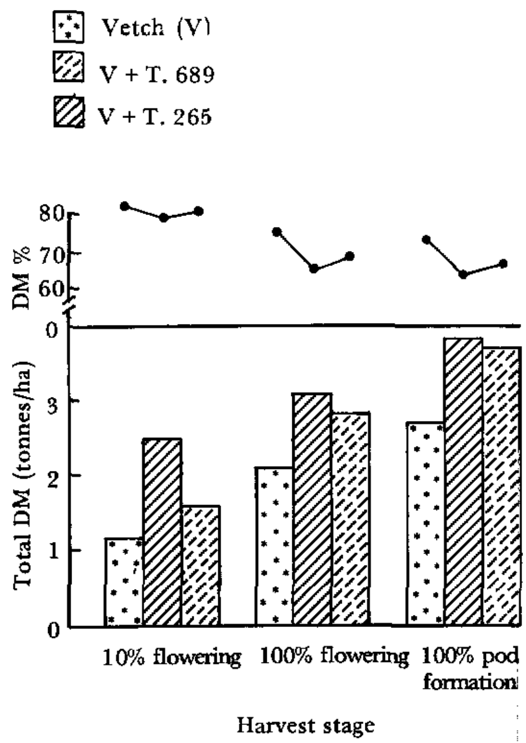


Figure 4. Total DDM and percent DDM as affected by harvesting stage of forage vetch in pure stand, vetch + triticale 689, and vetch + triticale 265.

over all other fertilizer treatments but the difference between these two fertilizer rates was not significant (Table 15). *Pisum* spp. showed the largest response to phosphate application, while *Lathyrus* spp. showed the smallest response.

Significant differences in response to phosphate application were observed among accessions (Fig. 5). For instance, with the 80 kg P_2O_5/ha rate, the range of DM increase over the control was between 3 and 29% in *Vicia* spp., 11 and 87% in *Pisum* spp., and between 3 and 143% in *Lathyrus spp.* Compared with other legumes, *Lathyrus* spp. had the highest phosphate concentration in plant tissues, especially at the highest level of phosphate application (Table 16). The *Pisum* spp. had the lowest tissue phosphorus concentration.

In summary, applications of 40 to 80 kg P_2O_5/ha resulted in a significant improvement in *Vicia* and *Pisum* DM production, with maximum yield being obtained at the 80 kg P_2O_5/ha rate in both legumes. However, *Lathyrus* showed the smallest response to phosphate application but had a high tissue phosphorus, suggesting a lower efficiency in the utilization of the applied fertilizer.

Large differences existed among the accessions tested for their response to phosphate application and this makes generalization on phosphate requirement difficult, especially for *Lathyrus.*

Table 15. Effect of phosphate level on DM yield (kg/ha) of three legumes (mean of six accessions) at Tel Hadya in 1981-82.

	Legumes			
Phosphate applied (kg P_2O_5/ha)	*Vicia*	*Pisum*	*Lathyrus*	Mean
0	4137	4120	2600	3619
40	4470	4510	2825	3935
80	4890	5630	2988	4502
120	4753	5828	3167	4582
Mean	4562	5022	2895	

SE of a difference between two phosphate means ± 148.4
SE of a difference between two legume means ± 128.5
SE of a difference between two phosphate at same legume and
SE of a difference between two legumes at same phosphate ± 257.1.

Table 16. Phosphate concentration in plant tissues in different legumes as affected by phosphate fertilizer at Tel Hadya, 1981-82.

		Phosphate level (kg P_2O_5/ha)	
Crop	0	120	Mean
L.ochrus 101	0.338	0.379	0.358
L.sativus 347	0.376	0.449	0.413
P.sativum 205	0.273	0.256	0.264
P.sativum 99	0.212	0.279	0.245
V.sativa 715	0.279	0.325	0.302
V.sativa 2541	0.308	0.302	0.305
Mean	0.298	0.331	

SE of a difference between crop means ± 0.017.
SE of a difference between phosphate level means ± 0.011.
SE of a difference between two means within species groups ± 0.028.

Effects of seed rate on DM yields and seed yields in forage legumes. The effect of seed rate on DM production and seed yield are considered basic information needed for growing any forage crop. Therefore DM production and seed yield were evaluated in relation to seed rate for different legumes (*Vicia, Pisum,* and *Lathyrus*). The experiment consisted of three *Vicia* species (*V. dasycarpa, V. ervilia,* and *V. sativa*); three accessions of *Pisum sativum;* two accessions of *L. sativus* and one accession of *L. ochrus.* Each legume was sown at seed rates of 20, 40, 60, 80, 100, and 120 kg/ha in plots 1.4 m x 3 m, in November 1981. The experiment was laid out as a split-plot design with three replicates. Half the area of each plot was harvested during April 1982 when the legume had reached 100% flowering stage to estimate DM production; the other half of the plot was harvested for grain at the end of May 1982.

Drymatter production was significantly im-

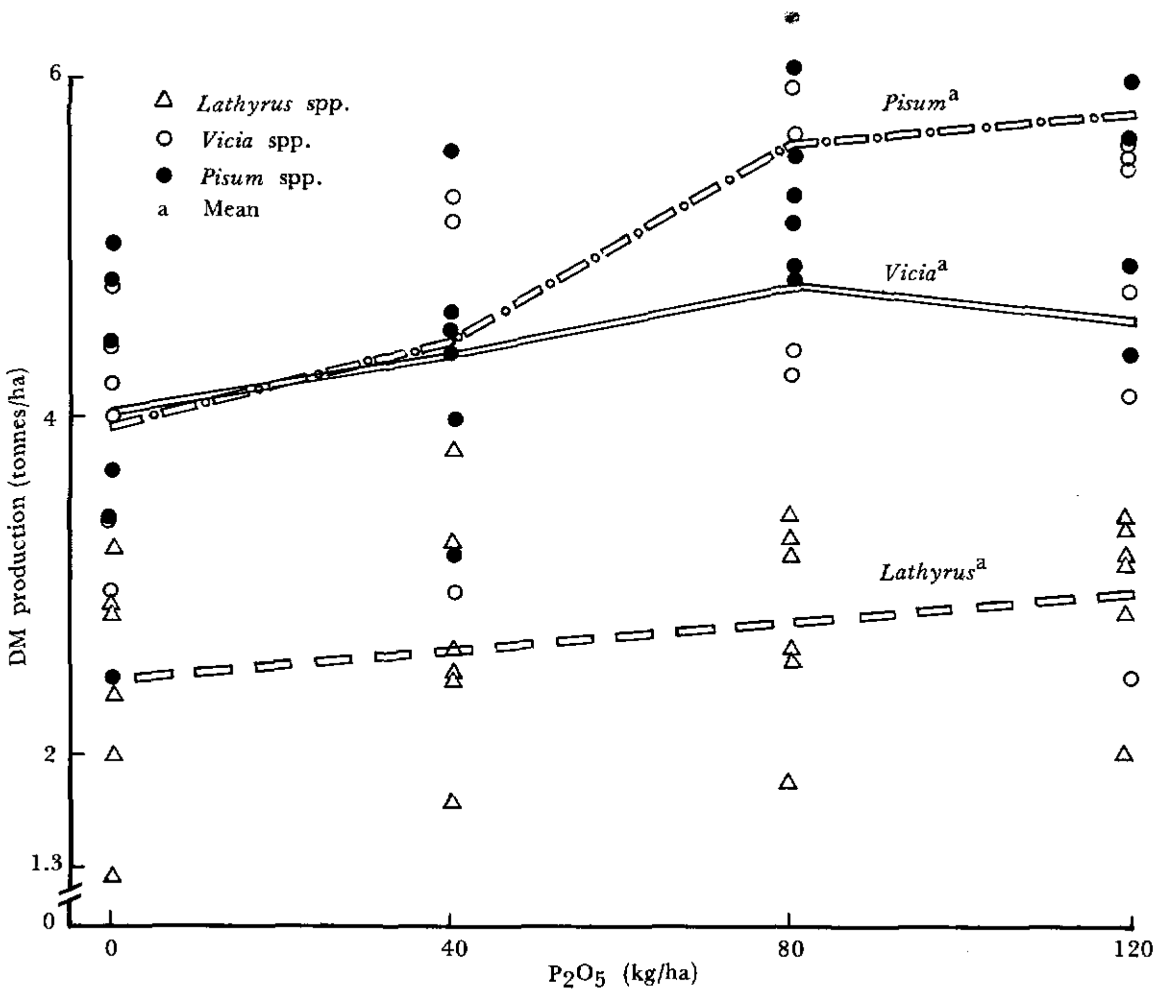


Figure 5. Response of different accessions of *Pisum, Vicia,* and *Lathyrus* species to phosphate applications, 1981-82.

proved with increasing seed rate up to the maximum of 120 kg/ha (Table 17). Differences existed within each legume with regard to the required seed rate. For example in *Vicia,* the optimum seed rate was 60 kg/ha for *V. dasycarpa,* whereas that for *V. ervilia* was almost double. Optimum seed rates for other legumes ranged between 60 and 100 kg/ha for DM production. The average seed rates for maximum seed yield were 80 kg/ha for *Vicia,* 100-120 kg/ha for *Pisum,* and 20-80 kg/ha for *Lathyrus* (Fig. 6).

In summary, *V. ervilia* seemed to require the highest seed rate (120 kg/ha) of all legumes for maximum DM production, whereas all other legumes required between 60 and 100 kg/ha. Optimum seed rates for seed yield were less variable among the same group of legumes except for *Lathyrus.* The values were 80 kg/ha for *Vicia* spp., 100-120 kg/ha for *Pisum* spp., and 20-80 kg/ha for *Lathyrus* spp.

Effect of early harvest on regrowth and yield of some promising lines of barley and triticale. The possibility of utilizing some forage crops for grazing early in the season and for hay production towards the end of the season is being investigated.

Promising barley and triticale lines previously screened for their ability to regrow after cutting were evaluated again this year in two different experiments. Thirteen lines were included in one experiment, and five lines of triticale in the second. In each experiment the forage cereals were subjected to three cutting regimes, i.e., one cut for hay, one early cut plus a final harvest for hay, and two early cuts plus a final harvest for hay. Seed rates were 100 kg/ha for barley and 125 kg/ha for triticale. Plot size was 1.4 m x 3.0 m and the lay-out of the experiment was a split-plot design with three replicates. The early harvests (to simulate grazing) were made using quadrats of 1 m^2 in the middle of the plots, whenever the plant height was close to 20 cm. The final cut for hay was taken at the 50% heading stage.

Five accessions of barley (250, 249, 264, 251, and 248) showed the highest overall DM yield. These were the same accessions that responded better to one early cut by producing a higher forage yield than

Table 17. Drymatter production (kg/ha) of different legumes as affected by seeding rate at Tel Hadya, 1981-82.

Legume		Seeding rate (kg/ha)						
		20	40	60	80	100	120	Mean
Vicia dasycarpa	Sel 683	2894	3665	4052[a]	4252	4336	4741	3990
V. ervilia	local	2215	3422	3933	4687	4698	5888[a]	4140
V. sativa	local	2368	3116	3963	4504[a]	4839	4424	3872
Pisum sativum	Sel 61	1987	3014	3933	3698	4089[a]	4670	3565
P. sativum	Sel 322	2995	4032	5258[a]	5417	5313	5731	4791
P. sativum	local	2547	3744	3301	4949[a]	5232	5666	4239
Lathyrus sativus	local	1521	2977	3126	3159	3504[a]	4161	3075
L. ochrus	Sel 384	956	2138	2625	3546[a]	3360	3353	2663
L. sativus	Sel 50	1041	1861	2474[a]	2173	2682	2945	2196
	Mean	2060	3108	3629	4043	4228	4620	

a. Optimum seed rate.
SE of a difference between two legume means ± 311.
SE of a difference between two seed rate means ± 144.
SE of a difference between two seed rates within legume ± 433.

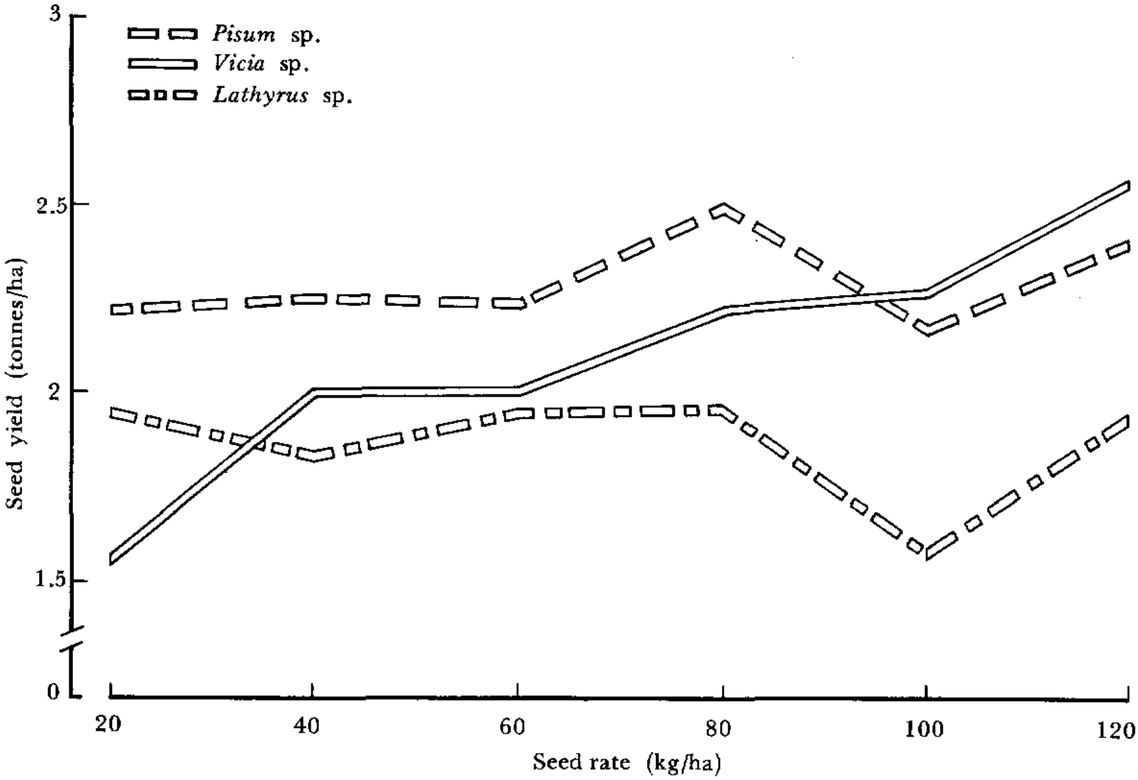


Figure 6. Seed yield of *Vicia, Pisum,* and *Lathyrus* species as influenced by seed rates, 1981-82.

Sheep grazing a barley-vetch mixture in a palatability trial at Tel Hadya.

when harvested only once at the end of the season. Three of these five accessions (250, 264, and 248) were still productive even with the two early cuts. All five lines were fast growing types and were ready for early grazing in January.

Accession 314 was the best triticale line in terms of yield and regrowth characteristics (Fig. 7). None of the five triticale accessions responded satisfactorily to two early cuts.

In summary, five accessions of barley and one accession of triticale were identified as high producing lines that responded well to early cuts. These lines will be utilized in mixtures with suitable legumes to provide forage for grazing early in the season (late January-early February) without sacrificing a high forage yield later in the season.

Forage Quality Research

The improvement and establishment of forage crops on arable land is of great importance to an area where meat imports increased by 55% between 1969-71 and 1981, and are projected to reach over a million tonnes by 1985. To get the maximum productivity from a crop-livestock production system, it is essential that the best genotypes of adapted pasture and forage species are selected. Selection of plants depends on a number of criteria : one is the digestible nutrients they supply. ICARDA's Forage Quality Laboratory has the principal responsibility of providing a measure of this.

During its first year, the laboratory has been largely engaged in exploratory work to modify and refine techniques. Forage quality is difficult to assess directly since the evaluation of a forage is basically its efficiency in terms of animal liveweight gain, and the nutritive and processing quality of the animal and its products. Nutritional efficiency can only be verified by feeding trials, which are expensive in terms of resources. Chemical analysis including digestibility provides useful guidelines as to the nutritive efficiency of a forage.

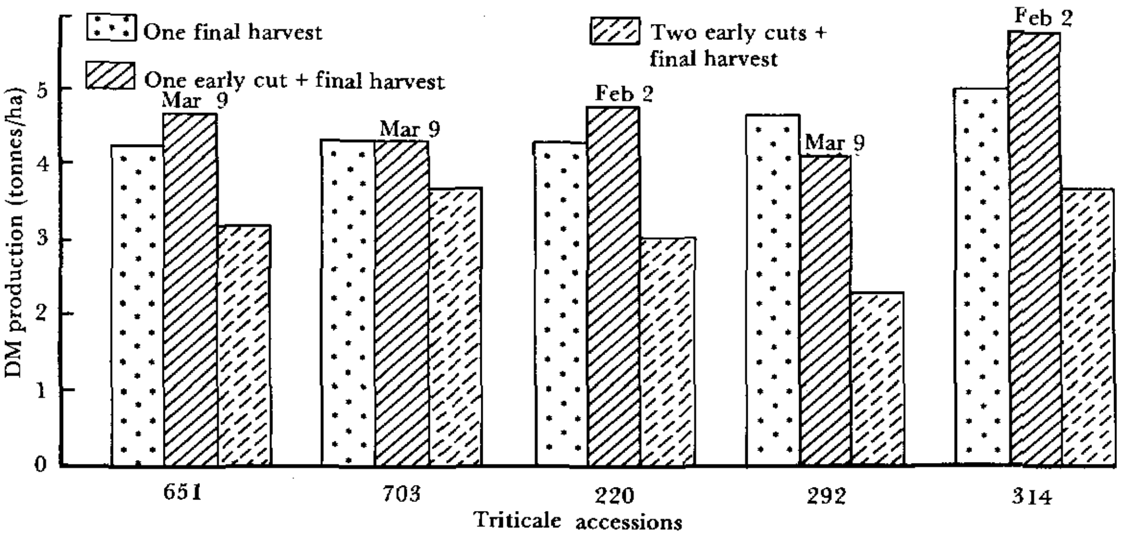


Figure 7. Drymatter production of five triticale lines under different cutting regimes.

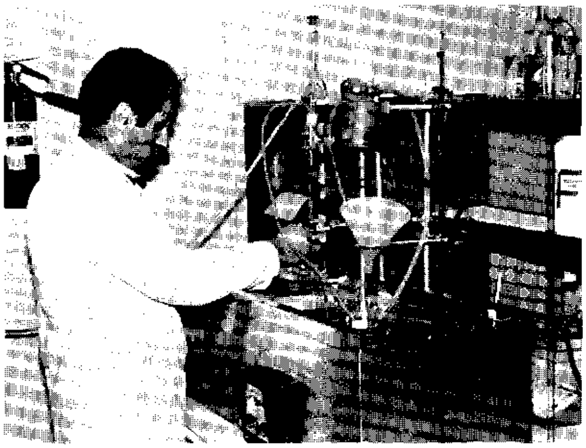
The laboratory facilities are now complemented by an animal feed unit which makes it possible to measure *in vivo* digestibility and voluntary feed intake. This will link the chemical and *in vitro* studies conducted by the Pasture and Forage Improvement Program with the *in vivo* studies conducted by the Farming System Program.

During 1981-82, projects completed in the Forage Quality Laboratory included:

Establishment of techniques for the determination of crude protein (CP), neutral and acid detergent fibre (NDF and ADF), lignin (LIG), hemicellulose (HEMI), cellulose (CELL), and *in vitro* dry matter digestibility (DMD).

Determination of chemical quality characteristics of the forage legume species of *Medicago, Lathyrus, Vicia,* and *Pisum;* the cereals *Avena, Hordeum,* and triticale; and the ryegrass *Lolium.*

Over 230 entries were examined. Correlations of CP, MDF, and DMD with drymatter production were generally low and of little practical significance. Entries were ranked according to drymatter production, CP, NDF, and digestible dry matter (DDM) and this indicated overall efficiency in terms of yield and quality (yield of digestible nutrients). Legume and cereal entries were identified that were significantly superior to local check varieties, especially barley. (Table 18)



An animal nutrition scientist determining *in vitro* digestibility of pasture herbage in the Quality Laboratory, Tel Hadya.

Lines 231 and 334 were clearly superior to line 1225. NDF is reported to be highly correlated to voluntary intake (r = 0.76). Large differences in voluntary intake are important, but it is unlikely that differences of less than 3-4% have great practical significance. On this basis a judgment decision would recommend selection of line 334 over lines 231 and 182 because of the greater yield of digestible nutrients at the stage of growth harvested. All of these were superior to the local check, Arabi Abied, on this basis. On the chemical evaluation basis of cereals, barley appeared to be the most useful forage and ryegrass (*Lolium*) the least.

Table 18. Overall efficiency and ranking of some barley forage lines at Tel Hadya, 1981-82.

Accessions	Protein (kg/ha)	Rank (kg/ha)	DDM[a] (%)	Rank	NDF[b] rank	Rank	Total	Overall
Local check[c]	466	84	2591	23	54.4	11	188	98
231	700	3	4459	3	53.1	4	10	1
182	668	6	4364	6	53.9	5	17	2
334	826	1	4678	1	55.6	23	25	3
1225	621	19	3428	58	53.0	3	80	12

a. DDM = Digestible Drymatter. b. NDF = Neutral Detergent Fibre. c. Local check = Arabi Abied.

Investigation of changes in chemical quality factors of forage legumes at different stages of maturity.

Chemical composition of *Vicia, Lathyrus, Medicago,* and *Pisum* was studied at five stages of maturity: incipient flowering, 10 and 100% flowering, 100% podding, and maturity. NDF increased from 25 to 54%, while CP and DMD fell, respectively, from means of 29% and 79% to 9% and 48%. The 100% flowering stage appeared the most suitable stage to cut for hay, in terms of overall nutritive efficiency. *Medicago* species were much higher in NDF at that stage, but were also 40% more productive in protein/ha.

Determination of nutrition potential of mature straws (low quality roughage).

Mature straws of several lines of oats, barley, wheat, and lentil were analyzed for DMD and protein. Barley was the highest in DMD (44%), followed by lentil (43%), oats (40%), durum wheat (38%), and bread wheat (29%). Barley DMD between seasons (1980 and 1981) had a correlation coefficient of 0.90, which suggests that straw digestibility may be a heritable characteristic.

In future the *in vivo* digestibility and voluntary feed intake aspects of some forages and straw will be given greater attention jointly with the Pasture and Forage Improvement Program and the Farming System Program.

Determination of relationship between fibre components, CP and DMD in forage legumes and cereals.

Fibre components were determined in about 100 samples of forage legumes and cereals. Data were analyzed using a simple linear regression matrix. The intercorrelations are summarized in Tables 19 and 20 for the relationships of fibre components to CP and DMD. The main conclusions were that (1) with all forage legumes an ADF determination is sufficient to enable the prediction of DMD, (2) with barley in its later stages of maturity, and triticale, a NDF test will enable the prediction of DMD, (3) this consideration is not applicable to oats at any stage, based on these data, and (4) most fibre components are highly negatively correlated with protein, particularly in legumes.

Establishment of techniques for determination of CP, fibre components and DMD by Near-Infrared Reflectance (NIR).

Table 19. Interrelationship between fibre components and protein for forage legumes and cereals. Protein correlation with:

Species	NDF[a]	ADF[a]	Hemicell.	Cellulose	Lignin	WSS[a]	DMD[a]
Medicago	-0.94	-0.93	-0.89	-0.87	-0.87	0.90	0.74
Lathyrus	-0.94	-0.87	-0.29	-0.87	-0.87	0.66	0.91
Vicia	-0.85	-0.92	-0.52	-0.93	-0.89	0.81	0.91
Pisum	-0.83	-0.82	-0.72	-0.81	-0.80	0.53	0.76
All legumes	-0.86	-0.88	-0.41	-0.89	-0.83	0.60	0.84
Avena I	b						-0.65
Avena II	-0.29	-0.76	-0.60	-0.78	-0.73	-0.50	0.01
Hordeum I	-0.78	-0.95	0.01	-0.92	-0.01	-0.89	0.80
Hordeum II	-0.91	-0.92	-0.32	-0.94	-0.49	0.68	0.86
Triticale	-0.75	-0.75	-0.72	-0.77	-0.06	0.47	0.85
All cereals	-0.68	-0.70	-0.34	-0.72	-0.40	-0.12	0.73
All forages	-0.72	-0.62	-0.40	-0.72	-0.10	-0.09	0.64

a. NDF = Neutral Detergent Fibre ; ADF = Acid Detergent Fibre
WSS = Water-soluble Sugars ; DMD = Drymatter Digestibility.

b. Correlation not reported if they were less than 0.01.

Table 20. Interrelationship between fibre components and Drymatter digestibility. DMD[a] correlations with:

Species	NDF[a]	ADF[a]	Hemicell.	Cellulose	Lignin	WSS[a]
Medicago	-0.91	-0.90	-0.87	-0.72	-0.93	0.83
Lathyrus	-0.92	-0.99	b	-0.99	-0.99	0.66
Vicia	-0.92	-0.98	-0.57	-0.98	-0.99	0.85
Pisum	-0.90	-0.94	-0.65	-0.93	-0.94	0.94
All legumes	-0.87	-0.94	-0.29	-0.92	-0.93	0.73
Avena II	-0.29	-0.13	-0.18	0.01	-0.52	0.58
Hordeum I	-0.60	-0.87	0.36	-0.91	0.18	-0.72
Hordeum II	-0.96	-0.91	-0.55	-0.91	-0.63	0.93
Triticale	-0.97	-0.96	-0.54	-0.96	-0.21	0.68
All cereals	-0.93	-0.92	-0.45	-0.91	-0.64	0.46
All forages	-0.73	-0.93	-0.06	-0.89	-0.63	0.57

a. See Table 19 footnotes.
b. Correlation not reported if they were less than 0.01.

The samples analyzed in project 5 were read on an interfaced computerized NIR Spectrophotometer (RCA6350) at the Grain Research Laboratory, Winnipeg, to select wavelengths for CP, fibre components, and DMD, in forage legumes and cereals. Wavelengths are reported as "pulse-points" and can be set directly into ICARDA's NIR analyzer. The presence of up to 10% cereal forage in a cereal-legume mixture and vice versa made no noticeable difference in the wavelengths selected. Pulse-points are reported in Table 21 for legumes, cereals, and combined legumes and cereal forages.

Weed Control

Weed control research in forage crops began in the 1980-81 season with herbicide screening experiments. In 1981-82 we continued these experiments with three leguminous forage species, i.e., *Vicia sativa, Pisum sativum,* and *Lathyrus sativus* to verify earlier results. Nine preemergence herbicides, and three postemergence herbicides were applied individually or in combination with preherbicides and postemergence to control both the early and the late winter weeds. Four grass killers, one preemergence and three

Table 21. Pulse-points[a] for forage analysis by Near Infra-Red Reflectance Spectroscopy, FOA51A.

Species		NDF[b]	ADF[b]	Hemicell.	Cell.	Lignin	WSS[b]	Protein	DMD[b]
All Leg.	1	487	539	651	540	50	54	405	174
	2	547	164	230	156	174	102	646	542
	3	680	680	102	434	83	228	545	678
	4					110	70		104
All Cer.	1	516	653	363	545	735	522	412	394
	2	193	607	254	230	287	26	210	516
	3	294	365	540	364	691	285	94	
	4		106	130	255	101	736		
All For.	1							383	487
	2							198	52
	3							409	510
	4								91

a. Wavelengths in nanometers.
b. See Table 19 footnotes.

postemergence, were applied individually or in combination with selected broadleaf herbicides (preemergence or postemergence) to enlarge the spectrum of weeds that can be controlled. The preemergence applications were made directly after sowing, and the postemergence herbicides were applied between mid-February and early March.

Vicia sativa

The grass killers pronamid and PP009 applied individually, had no phytotoxic effects on *Vicia* plants. Combinations of pronamid or PP009 with cyanazine or fluorodifen reduced the weeds significantly and increased the DM yield of *Vicia* between 11.4% and 34.1% (Table 22). This combination of grass killers will be recommended for use on the basis of these results. The three most promising herbicides, i.e., chlorbromuron, carbofluorfen and methabenzthiazuron increased the DM yield by 31.6%, 29.3%, and 29%, respectively (Table 23). Combinations of carbofluorfen or chlorbromuron with bentazone or dinoseb-acetate reduced the weeds significantly.

Pisum sativum

Fluorodifen applied individually on *Pisum sativum,* gave the highest DM yield (Table 23). The herbicides carbofluorfen, terbutryne, and methabenzthiazuron reduced weeds significantly and will be further used. The combinations of bentazone with terbutryne or carbofluorfen increased the DM yield by 28.9% and 11.4%. The grass killers pronamid, diclofop-methyl, difenzoquat, and PP009 had no phytotoxic effect on *Pisum.* Pronamid and PP009 satisfactorily controlled volunteer cereals, wild oats, and canary grass. Combinations of methabenzthiazuron with the grass killers pronamid, diclofop-methyl, difenzoquat, and PP009 reduced significantly the dry weight (DW) of weeds; this was accompanied by an increase in the DM yield of *Pisum* between 37.1% and 67.4%. Combinations of pronamid with dinoseb-acetate and bentazone increased the DM yield by 80.3% and 59.4%, respectively, and reduced weeds significantly. These promising combinations will be used to control weeds in evaluation plots and seed multiplication fields.

Lathyrus sativus

Three herbicides, terbutryne, carbofluorfen, and cyanazine applied individually reduced the dry weight of weeds in *Lathyrus sativus* significantly (Table 23). A combination of bentazone with cyanazine or with chlorbromuron reduced the weeds significantly and increased the DM yield by 21.9%. Combinations of dinoseb-acetate with fluorodifen, prometryne, terbutryne or chlorbromuron reduced the DW of weeds significantly. The grass killers pronamid and diclofop-methyl had no phytotoxic effect on *Lathyrus.* Applying terbutryne with pronamid, diclofop-methyl or difenzoquat reduced the weeds significantly and increased the DM yield of *Lathyrus sativus* between 18.3% and 39.2% (Table 22). The combination of cyanazine with pronamid, diclofop-methyl or difenzoquat also reduced the weeds significantly and increased the DM yield of the crop between 23.1% and 33.9%.

Microbiology

The major objective is to increase biological nitrogen fixation in the forage legumes that have been selected for improvement.

Research at Tel Hadya over the last 4 years has demonstrated that forage legume production can be increased by (1) inoculating with efficient strains of *Rhizobium* to improve symbiotic nitrogen fixation and (2) applying carbofuran to prevent damage by insect larvae to *Pisum sativum* and *Vicia sativa* nodules.

A replicated trial in a split-plot design was conducted to investigate the responses of each of four genotypes of *Vicia sativa* and

Table 22. Effects of different broadleaf herbicides and grass killers on drymatter yield of *Vicia sativa, Pisum sativum,* and *Lathyrus sativus,* and on dry weight (DW) of weeds at Tel Hadya, 1981-82.

Herbicide treatments	Application time	Rate (kg a.i./ha)	*Vicia sativa* DM yield (kg/ha)	*Vicia sativa* DW of weeds (kg/ha)	*Pisum sativum* DM yield (kg/ha)	*Pisum sativum* DW of weeds (kg/ha)	*Lathyrus sativus* DM yield (kg/ha)	*Lathyrus sativus* DW of weeds (kg/ha)
Hand weeding			3611.1	20.0	4066.7	17.0	3055.1	119.2
Control			2409.3	1858.7	1965.8	1794.8	2481.8	1661.5
Pronamid	Pre	0.5	3260.1	860.0	2014.5	653.8	3492.1	688.5
Diclofop-methyl	Post	1.0	2253.3	1975.3	1466.7	1901.2	3156.5	1196.0
Difenzoquat	Post	1.0	1689.4	2668.3	2122.2	1862.6	2637.0	1557.7
PP099	Post	1.5	2843.8	1578.7	2181.9	1571.8	1718.9	811.3
Pronamid + terbutryne	Pre	0.5 + 1.0					3323.7	174.2
Pronamid + cyanazine	Pre	0.5 + 1.0	3231.8	126.8	2924.2	388.4	3143.6	297.2
Pronamid + methabenz	Pre	0.5 + 2.0			3291.7	113.8		
Pronamid + fluorodifen	Pre	0.5 + 1.5	2683.0	191.3				
Pronamid + dinoseb-acetate	Pre + Post	0.5 + 1.0	3563.9	254.7	3544.3	383.8		
Pronamid + bentazone	Pre + Post	0.5 + 0.5			3133.4	756.0	2839.4	190.8
Diclofop-methyl + cyanazine	Post + Pre	1.0 + 1.0	1811.9	515.8	3103.0	576.4	3322.1	247.5
Diclofop-methyl + terbutryne	Post + Pre	1.0 + 1.0					3454.1	561.0
Diclofop-methyl + methabenz.	Post + Pre	1.0 + 2.0			3048.1	625.6		
Difenzoquat + cyanazine	Post + Pre	1.0 + 1.0	1779.8	545.2	2117.0	444.4	3056.2	428.7
Difenzoquat + terbutryne	Post + Pre	1.0 + 1.0					2932.5	566.8
Difenzoquat + methabenz.	Post + Pre	1.0 + 2.0			3148.1	501.2		
PP009 + cyanazine	Post + Pre	1.5 + 1.0	2751.2	211.8	2151.3	272.4	2407	143.0
PP009 + methabenz.	Post + Pre	1.5 + 2.0			2694.5	185.6		
PP009 + fluorodifen	Post + Pre	1.5 + 1.5	3050.2	291.2				
LSD (5%)			1077.7	585.2	1415.8	721.5	1044.3	348.4

Table 23. Effects of different herbicide treatments on drymatter yield of *Vicia sativa*, *Pisum sativum*, and *Lathyrus sativus*, and on dry weight (DW) of weeds at Tel Hadya, 1981-82.

Herbicide treatments	Application time	Rate (kg a.i./ha)	*Vicia sativa* DM yield (kg/ha)	*Vicia sativa* DW of weeds (kg/ha)	*Pisum sativum* DM yield (kg/ha)	*Pisum sativum* DW of weeds (kg/ha)	*Lathyrus sativus* DM yield (kg/ha)	*Lathyrus sativus* DW of weeds (kg/ha)
Hand weeding			3433.1	69.6	2882.7	12.8	2803.7	108.2
Control			2392.4	1375.7	2674.7	1249.8	2128.8	1412.6
Fluorodifen	Pre	1.5	2237.1	785.4	3276.8	766.8	1843.1	1002.8
Carbofluorfen	Pre	1.0	3094.5	474.9	2523.8	497.4	2528.3	525.2
Terbutryne	Pre	1.5	2806.5	149.5	2165.4	273.4	2546.3	425.0
Methabenthiazuron	Pre	2.0	3085.4	172.4	1791.3	211.0	1931.0	493.8
Chlorbromuron	Pre	1.0	3148.1	419.0	1616.9	282.8	1762.0	1352.6
Cyanazine	Pre	1.0	1713.8	196.8	1941.6	384.0	2501.6	672.4
Bentazone	Post	0.5	1576.5	1266.1	1764.3	1218.2	2106.8	984.6
Cyanazine + bentazone	Pre + Post	0.5 + 0.25	2315.7	237.1	1579.7	435.0	2595.6	760.8
Chlorbrom + bentazone	Pre + Post	0.5 + 0.25	2621.4	613.4	1911.1	320.4	2595.3	386.4
Terbutryne + bentazone	Pre + Post	1.0 + 0.25	2354.3	403.4	3448.6	392.4	1603.8	804.2
Carbofluorfen + bentazone	Pre + Post	0.5 + 0.25	3073.7	361.3	2980.4	768.8	2088.9	941.2
Terbutryne + dinoseb acetate	Pre + Pre	1.0 + 0.5	2478.7	503.8	2475.5	455.2	2540.6	456.6
Fluorodifen + dinoseb acetate	Pre + Pre	1.0 + 0.5	2278.0	1198.0	-	-	2491.7	887.8
Prometryne + dinoseb acetate	Pre + Post	1.0 + 0.5	1028.2	241.1	1617.1	381.8	2455.3	260.2
Chlorbrom. + dinoseb acetate	Pre + Post	0.5 + 0.5	2601.4	527.5	1308.0	865.8	2377.8	712.6
Carbofluorfen + dinoseb acetate	Pre + Post	0.5 + 0.5	2799.5	586.7	2691.6	827.2	2192.7	654.8
LSD (5%)			1007.5	482.4	1366.4	492.5	1098.4	475.5

Lathyrus ochrus and six genotypes of *Pisum sativum* to farmers' practice (where neither *Rhizobium* nor fertilizer was applied) and to improved practice (where *Rhizobium*, phosphate fertilizer, and carbofuran were applied).

A minimum of 40 plants were scored for nodulation from each treatment at the early flowering stage. Dried forage yield was recorded at complete physiological maturity. The results are summarized in Table 24. All genotypes of the three forage species responded positively to improved management practices, although the degree of response differed considerably between genotypes of the same species. Carbofuran treatment was particularly effective in preventing insect larvae damage in *Vicia sativa* and *Pisum sativum*. In *V. sativa* the nodule mass production doubled, on average, with improved practices. For some lines of *P. sativum* the drymatter production increased by over 100%. Although *Lathyrus ochrus* was severely affected by frost there was an increase in drymatter production of 12.9% to 55.8%.

In another study *Pisum sativum* and *Vicia sativa* were grown separately in a mixture with barley and with triticale at different seeding rates to determine whether the cereal crop had any detrimental effect on legume nodulation and nitrogen fixation. The cereal seeding rates were 0, 20, 40, 60, and 80 kg/ha.

The results are shown in Table 25. The number of nodules formed did not follow a particular trend. *Vicia* spp. when grown in pure stand had more nodule mass than when grown in mixture, either with barley or triticale. High seed rates of barley (60 and 80 kg/ha) tended to reduce nodule mass production in *Vicia*, but the seed rate of triticale had little effect on nodule mass. Nodule mass for *Pisum* remained more or less the same in the different mixtures with barley and triticale.

In general *Vicia* and *Pisum* produced more nodules and a greater weight of nodules in the barley and legume combinations than in the corresponding triticale-legume mixtures. The individual plant dry weight of the legumes gradually decreased with increasing populations of barley or triticale.

Mycorrhizal studies in the 1980-81 season indicated that forage legumes are associated with a large population of the native mycorrhizal fungi. Studies were conducted in the 1981-82 season to determine whether this association could influence the uptake of phosphorus from rock phosphate and triple superphosphate fertilizers.

Three forage legumes, *V. sativa, L. ochrus*, and *P. sativum* were grown at three levels of phosphate (0, 30, and 60 kg P_2O_5/ha) using triple superphosphate, Gasfa rock phosphate from Tunisia, and Jordan rock phosphate. The incidence of mycorrhiza in the roots was determined at the early vegetative and 50% pod filling stages. Dried forage yield was obtained at physiological maturity stage.

Table 24. Nodule, nodule mass, and forage drymatter production of three forage legume crops under farmers' (low) and improved (high) practices, Tel Hadya, 1981-82.

Crop	Nodule No./plant		Nodule dry wt. (mg/plant)		Dried forage yield (kg/ha)		% increase in yield
	Low	High	Low	High	Low	High	
Vicia sativa	13.9	19.4	3.0	7.6	2878	4771	65.8
Lathyrus ochrus	9.9	10.9	9.2	9.7	2639	3511	33.0
Pisum sativum	10.3	11.7	3.5	6.2	2406	3778	57.0

Table 25. Nodule, nodule mass, total drymatter and forage production by Vicia and Pisum separately, in combination with different barley and triticale populations at Tel Hadya, 1981-82.

Legume crop	Barley and triticale seed rate (kg/ha)	Mixed with barley: Nodule No./plant	Mixed with barley: Nodule dry wt. (mg/plant)	Mixed with barley: Total dry wt. (g/plant)	Mixed with barley: Dried forage yield (kg/ha)	Mixed with triticale: Nodule No./plant	Mixed with triticale: Nodule dry wt. (mg/plant)	Mixed with triticale: Total dry wt. (g/plant)	Mixed with triticale: Dried yield (kg/ha)
Vicia sativa	0	40.1	10.0	6.73	3406	36.5	12.2	6.73	3378
	20	41.1	8.6	3.29	8378	29.6	6.7	5.56	6278
	40	36.9	8.9	2.37	8850	20.0	7.9	3.50	6900
	60	40.5	5.5	1.73	9317	26.2	7.7	2.32	8889
	80	44.1	6.9	1.54	10084	30.4	7.0	2.26	8083
Pisum sativum	0	24.7	9.9	5.32	3739	22.7	7.7	4.90	3844
	20	25.2	8.8	4.43	7856	28.8	7.2	2.87	5267
	40	29.8	8.3	3.72	8084	21.0	8.6	3.44	6400
	60	29.5	9.1	3.47	9967	25.5	6.7	2.06	8695
	80	26.0	9.4	3.22	8095	19.7	7.7	2.09	8033

In all species more than 80% of the roots were infected by *Mycorrhizae*. Rock phosphate fertilizers, irrespective of their source and rates, stimulated more mycorrhizal infection than triple superphosphate.

Lathyrus and *Vicia* species produced similar or more drymatter as a result of rock phosphate addition compared with triple superphosphate at similar rates. *Pisum* spp. drymatter yield was higher with triple superphosphate treatment than with either Gasfa or Jordan rock. The results suggest that for *Vicia* spp. and *Lathyrus* spp., less expensive rock phosphates could provide enough phosphate for good crop growth.

Annual Pastures to Replace Fallow

Annual self regenerating *Medicago* species (medics) have much potential for pasture production in many countries of the Middle East and North Africa. In the low rainfall zone, i.e., 200-350 mm per annum, medic pastures can be effectively used to replace the fallow that currently succeeds a cereal crop. The Program is currently evaluating indigenous species and commercial cultivars. Trials are being conducted to determine the best establishment and grazing management practices, and the technology to integrate medic pastures in a cereal-pasture sequence that will ensure pasture regeneration in alternate years.

Evaluation of Annual Medics

Yield Trial

From preliminary screening in the 1980-81 season, some accessions were selected for the quantitative determination of drymatter yield and seed production in microplot trials. Also, high performing lines from 1980-81 microplot trials were promoted to advanced yield trials in the 1981-82 season.

A total of 124 accessions selected from nine different species were planted together with the control in microplots (3 m^2) arranged in a cubic lattice design. The trial had six replicates, of which three were harvested for drymatter determination and three for seed yield. For the advanced yield trial a triple lattice experiment was conducted to compare 36 high performing entries of three medic species, in six replicates. Three replicates were harvested for drymatter determination and three for seed yield. The seed rate for these trials was 15 kg/ha and fertilizer at 40 kg P_2O_5/ha was applied during seed bed preparations.

The results of the microplot trials indicated that some accessions of three species, *M. rigidula*, *M. aculeata*, and *M. noeana* were outstanding in their herbage and seed yield performance (Table 26). Three other species, *M. rotata, M. constricta,* and *M. blanchiana* ranked lower than the control in dry matter and seed yield. Although they might not be impressive at Tel Hadya, they may possibly be adapted to other countries of the region. *Medicago truncatula* and *M. scutellata,* from which some Australian cultivars have been developed, have continued to be relatively low performers. The outstanding accessions in this trial will be tested in advanced yield trials in the next season.

High yielding lines identified in the advanced yield trials are shown in Table 27. One *M. noeana* selection (No.1639), and *M. constricta* selection (No. 1620) were included with the group of *M. rigidula* selections. Six accessions* were selected for their performance both in the 1980-81 and 1981-82 seasons for future multilocation testing to validate the results obtained at Tel Hadya. Seeds of these selections were multiplied for pasture establishment trials in several locations in Syria next season.

Medic Regeneration Studies

The regeneration of medic pastures in alternate cropping years with cereals partly depends on the amount of hard seeds that do not absorb water readily. A high percentage of these hard seeds remain dormant for about a year and thus a good regenerated pasture is assured. Genotypes with a high percentage of hard seeds are therefore selected.

The objective of regeneration studies was to investigate the seed permeability of selected genotypes of *M. rigidula, M. aculeata, M. noeana,* and *M. constricta.*

Random samples of medic pods from 111 potentially high yielding accessions were collected from replicated experimental plots at

Table 26. Drymatter (DM) and seed yield of medic selections in microplot trials, Tel Hadya, 1981-82.

Species	Accessions (No.)	DM yield (kg/ha) Range of mean	Seed yield (kg/ha) Range of mean
M.rigidula	79	9714.76 - 3102.24	1913.61 - 549.17
M.aculeata	7	5306.82 - 1825.96	756.94 - 322.22
M.noeana	3	8181.88 - 4681.39	1495.93 - 962.78
M.rotata	18	6110.33 - 2137.74	2402.49 - 593.89
M.constricta	2	4572.95 - 4180.36	751.45 - 254.16
M.blanchiana	2	3562.22 - 3203.01	948.89 - 333.33
M.turbinata	6	3443.24 - 1637.41	714.17 - 184.17
M.truncatula	6	2760.09 - 802.79	290.28 - 159.17
M.scutellata	1	1271.00	173.05
Control ***(rigidula)***		6665.10	1123.05

Total No. Accessions in trials = 124 + 1 control.

Table 27. Drymatter (DM) yield and seed yield in high yielding lines of medics from advanced yield trials, Tel Hadya, 1981-82.

Medicago species	Sel. No.	DM yield kg/ha	DM yield Rank	DM yield % Control	Seed yield kg/ha	Seed yield Rank	Seed yield % Control
M.rigidula	Control	2768.49	29	100	641.95	14	100.0
M.rigidula	1534	4224.54	1	152.6	430.99	34	67.1
M.rigidula	953	4114.85	2	148.6	533.74	22	83.1
M.rigidula	1531	4060.63	3	146.7	630.81	15	98.3
M.rigidula	1557	4012.35	4	144.9	458.77	29	71.5
M.rigidula	716	3995.64	5	144.3	675.95	11	105.3
M.rigidula	734	3993.45	6	144.2	456.04	30	70.0
M.rigidula	1561	2713.02	7	134.1	676.93	10	105.4
M.rigidula	1310	3696.97	8	133.5	515.82	26	80.4
M.rigidula	1546	3651.83	9	131.9	718.95	5	112.0
M.rigidula	1569	3641.07	10	131.5	611.78	16	95.3
M.rigidula	960	3585.76	11	129.5	575.07	18	91.1
M.rigidula	1555	3525.39	12	127.3	644.66	13	100.4
M.rigidula	1295	3505.77	13	126.6	533.94	21	83.2
M.rigidula	1542	3491.33	14	126.1	704.62	6	109.8
M.rigidula	1562	3325.43	18	120.1	661.79	12	103.1
M.rigidula	1559	3307.4	19	119.5	727.97	4	113.4
M.rigidula	1524	3278.39	20	118.4	806.87	2	125.7
M.noeana	1639	3433.06	15	124.0	493.31	28	76.8
M.constricta	1620	2830.34	27	102.2	526.31	25	82.4

Total No. lines 15 trials = 35 + 1 control.
SE of a difference between DM crop means = ± 573.
SE of a difference between seed yield means = ± 94.

monthly intervals from early August 1981 to early December 1981. Pods on moistened filter paper in petri dishes were kept in a refrigerator for 5 days at 5°C. Subsequently, the dishes were transferred to a germinator at 20°C for 10 days when the percentage of seeds not germinated, i.e., hard seeds, was calculated.

The variability for hardseededness in *M. rigidula, M. aculeata, M. noeana,* and *M. constricta* is shown in Table 28. Genotypes with about 70% hard seed at the beginning of December are ideally suited for pasture rotation with cereal crops. Many genotypes of *M. rigidula* and the five selections of *M. constricta* can therefore be selected with some confidence.

Medicago aculeata exhibited a high percentage of soft seed; only one accession was in the 60-70% range. Many accessions of this species can be used advantageously for production of continous pastures that can be grazed from one year to the next. The relationship between percent seed permeability (soft seeds) and time of year is shown in Figure 8. The comparatively slow breakdown in seed permeability of *M. noeana* contrasts with the faster breakdown in seed permeability of several accessions of *M. aculeata.*

In another study, regeneration was observed in a randomized complete block design experiment with three replicates. A total of 49 high performing lines were planted in the 1980-81 cropping season and regeneration was scored during early spring (March) in 1982 (Table 29).

The accessions with a small percent seed permeability (large proportion of hard seed) had a low regeneration score, whereas accessions with a higher percent seed

This medic regeneration trial clearly shows the vigorous second year growth made by some accessions, which will be selected for rehabilitating marginal lands.

Table 28. Variability for hardseed character in four species of medics at Tel Hadya, 1981-82.

Hard seed	No. of entries			
(%)	*M. rigidula*	*M. aculeata*	*M. noeana*	*M. constricta*
0 - 10		1		
11 - 20		3		
21 - 20	1	7		
31 - 40		7		
41 - 50	1	3		
51 - 60	3	4		
61 - 70	7	1		2
71 - 80	16			2
81 - 90	33			1
91 - 100	8		11	
Total	69	26	11	5

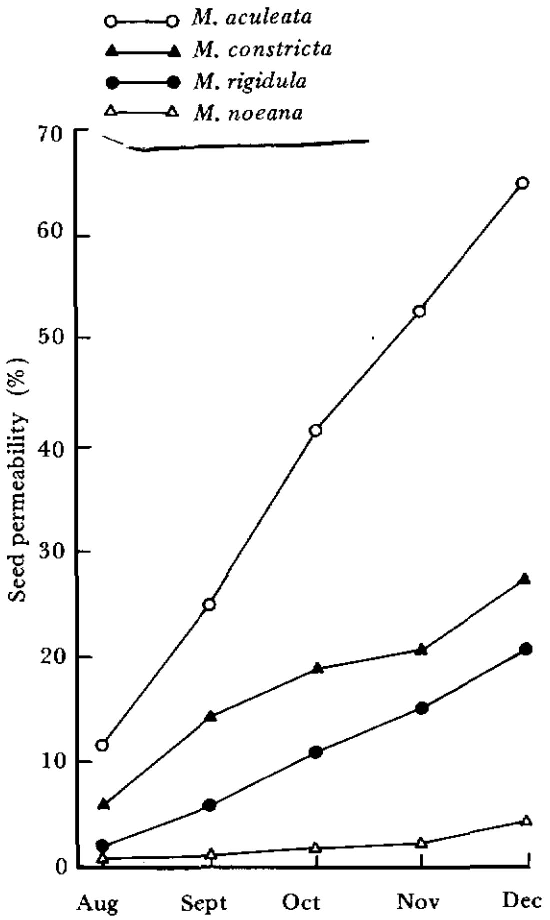


Figure 8. The relationship between seed permeability percentage (soft seeds) and time of year for *M. aculeata, M. rigidula, M. constricta,* and *M. noeana*.

Table 29. Relationship between seed permeability and regeneration of medics, Tel Hadya, 1981-82.

Accessions No.	Soft seed (%)	Regeneration score[a] (mean)
20	1.8 - 10.0	2.5
18	10.3 - 20	3.3
4	25.4 - 29.7	3.5
4	31.0 - 34.0	3.8
2	40.7 - 47.0	4.0
1	66.5	4.3

Total No. of accessions = 49.
a. Score 1 = Poor regeneration.
5 = Excellent regeneration.

permeability (soft seeds) had a relatively high regeneration. A score of 4.3 (out of 5) was given to one accession of *M. aculeata* with a large proportion (66.5%) of soft seeds. Seed size (1000 seed weight) and seed yield per m^2 are two other important parameters of a medic pasture. The interpretation of results of regeneration studies should take into account these two parameters.

Pasture Regrowth Study

The regrowth of 125 promising accessions of 11 medic species was studied in a grazing trial. Because of the unavailability of seeds, microplots (3.5 m^2) in a cubic lattice design with three replicates were used. The experiment was established in the 1980-81 season and allowed to regenerate in the 1981-82 season. Regeneration was scored just prior to grazing in mid-March 1982. The regrowth was scored at mid-May 1982; poor regrowth was scored 1 and excellent regrowth, 5. An accession scoring 5 would be 12-13 cm high and with individual plants spreading 25-30 cm.

Some accessions of *M. rigidula, M. aculeata, M. noeana,* and *M. constricta,* which were selected on the basis of drymatter and seed production, had good regeneration capacity and very satisfactory regrowth characteristics (Table 30). *M. rigidula* and *M. noeana,* two consistently high performing species, showed vigorous regrowth.

Pathology

Diseases of Annual Medics

Powdery mildew, downy mildew, rust, *Stemphylium* leaf spot, spring black stem and leaf spot, common leaf spot, wilt/root knot nematodes, cyst nematodes, and anthracnose were identified on annual medics in Syria and Lebanon. In addition, they were attacked by

Table 30. Regeneration and regrowth of medic accessions in a grazing trial at Tel Hadya, 1981-82.

Species	No. of Accessions	Regeneration (before grazing) 14 March 1982		Regrowth (after grazing) 17 May 1982	
		Range	Mean	Range	Mean
M.rigidula	64	1-5	2.0	1-4.7	2.6
M.aculeata	26	1-4	2.2	1-2.3	1.3
M.truncatula	3	1-1	1	1-1	1
M.rotata	1	3.3	3.3	1	1
M.noeana	11	1-2.3	1.6	2-4.7	3.6
M.polymorpha	4	1-2.3	1.9	1.3-3.3	2.2
M.murex	1	1	1	1.7	1.7
M.blanchiana	5	1-4.3	1.9	1-2.3	1.5
M.scutellata	2	1-1	1	1-2	1.5
M.littoralis	3	1.3-2	1.7	1.7-2.3	2.1
M.constricta	5	1-3.3	2.5	2.3-4.7	3.3
Total	125				

Mean regeneration score (before grazing) of the control 1.7.
Mean regrowth score (after grazing) of the control 3.3.
Regeneration and regrowth score (1-5):
1 = *Poor regeneration and regrowth.*
5 = Excellent regeneration and regrowth.

Table 31. Number of annual medic breeding materials, in the successive stages of selection, classed according to disease susceptibility.

Stage	No. of entries attacked by one disease with score[a]			No. of entries attacked by more than one disease	Total
	0	1-2	3-4		
Nursery	77	110	24	5	216
Nursery (Terbol)	32	19	164	2	217
Microplot	31	60	1	33	125
Microplot 2nd.	26	56	6	37	125
Microplot *(aculeata)*	34	2	0	0	36
AYT[b]	25	9	2	0	36
Increase	142	37	13	11	203
					958

a. Scoring scale: 0 = Resistant; 4 = Susceptible.
b. AYT = Advanced Yield Trial.

the parasitic plants *Orobanche* spp. and *Cuscuta* spp. Powdery mildew and spring black stem and leaf spot, are important diseases that merit special attention. They will be monitored carefully in trials in the 1982-83 season.

Evaluation of Disease Reactions

A total of 958 genotypes in the successive stages of selection were evaluated for susceptibility to powdery mildew, rust, spring black stem and leaf spot, and common leaf spot. A scoring scale of 0-4 was used (Table 31).

Only those entries not susceptible to any of these diseases and those resistant (score 1-2) to one of the diseases have been promoted to the next stage of selection. From the advanced yield trials, entries with a score of 0 and also those with a score of 1-2 will be retested in the disease nurseries at Jableh and Tel Hadya next season. Also, entries attacked by more than one disease and which have good agronomic characteristics will be retested next season.

Screening for Disease Resistance

A total of 125 promising genotypes from microplots and advanced yield trials were screened at Jableh and at Tel Hadya for powdery mildew and rust. Almost all entries (99%) were resistant to rust in both locations, but showed different responses to powdery mildew. At Tel Hadya only 26% were resistant to powdery mildew; at Jableh 99% were resistant.

Entomology

Several hundred annual medic accessions were grown in three different climatic zones (Jableh, Kamishly and Tel Hadya) in Syria, and at Terbol in Lebanon, and examined for insect pests. The results of this survey are summarized in Table 32.

The main insect pests observed were leaf miners and alfalfa weevil (*Hypera* spp.); the latter should be considered a potentially dangerous insect on annual medics.

Because it was not possible to conduct this survey throughout the crop-growing season it is likely that some important insects were not recorded. A more comprehensive survey is required to provide information on the economic importance of these pests.

Agronomy

The suitability of adapted species of annual medics for replacing fallow land with pasture in the existing cereal-fallow cropping system in the ICARDA region is being investigated. Promising lines already developed by the Program are being multiplied for use in a expanded agronomic research program.

The suitability of some Australian cultivars for different climatic zones and identification of constraints and problems in pasture establishment, management, and utilization are being examined.

The relationship between pasture establishment and buildup of soil fertility, which is expected to be carried over to the subsequent cereal in the rotation, is being studied at different locations. On-farm trials initiated in 1980-81, were expanded in 1981-82 to gain additional information on pasture production technology.

Performance of Australian Medic Cultivars in Syria

Four Australian medic cultivars (Snail, Jemalong, Cyrus, and Harbinger) were evaluated for establishment and drymatter

Table 32. Frequency and severity of insect and mite attack on annual medics *(Medicago spp.)* in Syria and Lebanon, 1981-82.

Location	Pest	Frequency (%)	Severity[c] (0-4)
Terbol[b]	***Acyrthosiphum pisum*** aphid	1	1
	Liriomyza sp. leaf miner	2	1
	Hypera sp. alfalfa weevil	2	1
Jableh[c]	***Hypera*** sp. alfalfa weevil	28	1
Kamishly[c]	***Liriomyza*** sp. leaf miner	74	2
Tel Hadya	***Liriomyza*** sp. leaf miner	48	1
	Hypera sp. alfalfa weevil	34	1

a. severity: 0 = no infection; 4 = $\geq$50 insects/branch.
b. Lebanon.
c. Syria.

production and seed yield at Kamishly, Hama, Lattakia, Idleb, and Homs in Syria. These locations had different amounts of rainfall and different rainfall distribution patterns. The cultivars were sown after a wheat crop, except at Idleb where sowing was between olive trees. Plots of 100 m^2 were used for each *cultivar and the experiments were laid out in a* randomized complete block design with three replicates. The trials were established in 1981-82 for all locations except Lattakia, where the trial was sown in 1979-80 and followed by a wheat crop in 1980-81, leaving the medic to regenerate in 1981-82.

Drymatter production was estimated by harvesting two quadrats of 1 m^2 each in May 1983. Similar quadrats were used to estimate seed yield in June 1982.

Snail and Jemalong were more productive than Cyprus and Harbinger at four out of five locations, with the differences in DM yield exceeding 100% at Kamishly and Hama (Table 33). At Idleb, yields from all four cultivars were low and this is attributed to late sowing (January). Pod yield and seed yield were high for Snail and Jemalong at all 5 locations. Dry matter yield from medic regeneration at Lattakia was high but slightly lower than that produced during the first year growth at Kamishly and Hama. The conditions for medic growth are very favorable at Lattakia where productivity was expected to exceed that at Kamishly and Hama.

However, it is suspected that deep plowing following the cereal crop resulted in deep burial of the medic seeds accumulated during the first year. The DM yield indicated here for the Australian cultivars Snail and Jemalong is *comparable with that of the promising lines of M. rigidula* medic now undergoing tests at Tel Hadya.

Table 33. Performance of Australian medic cultivars grown at different locations in Syria in 1981-82.

Location[a]	Cultivar	DM yield (kg/ha)	Pod yield (kg/ha)	Seed yield (kg/ha)
Kamishly	Snail	6631	3867	1150
	Jemalong	4534	2861	698
	Cyprus	2328	2344	450
	Harbinger	1163	541	107
Hama	Snail	5509	3612	1212
	Jemalong	6267	2803	606
	Cyprus	2660	2509	463
	Harbinger	2788	2448	594
Lattakia[b]	Snail	5289	2182	736
	Jemalong	4112	1264	274
	Cyprus	2266	1202	303
	Harbinger	3146	1122	304
Idleb	Snail	1552	941	230
	Jemalong	1392	1136	283
	Cyprus	1558	766	166
	Harbinger	1194	624	136
Homs-Arjoun	Snail	3451	2262	640
	Jemalong	3007	1906	396
	Cyprus	1982	1394	229
	Harbinger	1521	1190	273

a. Av. Rainfall at Kamishly, Hama, Lattakia, Idleb, and Homs to May 31, 1982 was 417, 406, 664, 447, and 306 mm, respectively.
b. Regeneration after cereal crop.

Yields of Cereals in Rotation with Annual Medics

Two trial areas of annual legumes, which were established in 1980-81 at Kamishly and Salamieh, were sown in 1981-82 with wheat (Kamishly) and barley (Salamieh). Generally the grain yields were equal to or higher than those of the same cereal crops grown after fallow (Table 34). Medic regeneration after the cereal crop will be studied during the 1982-83 season.

Table 34. Grain yield of wheat and barley grown after annual legume at two locations in Syria, 1981-82.

Treatments	Grain yield (kg/ha)	
medic cultivars	Wheat (Kamishly)	Barley (Salamieh)
Clare	3279	519
Cyprus	2975	539
Jemalong	2860	452
Snail	2507	508
Harbinger	2104	554
Fallow	2799	550
LSD	1194	75.9

Weed Control

To identify herbicides that can be used to control weeds in selection trials and seed production fields, nine preemergence herbicides, four grass killers and three postemergence herbicides were applied individually or in combination with selected broadleaf herbicides to medic (*Medicago rigidula*) plots.

The effect of preemergence herbicides in controlling weeds in medic plots was not assessed because of the long period necessary for medics to grow and produce a satisfactory vegetative stand during the cold winter months. The grass killers pronamid and PP009 showed no phytotoxic effects on medic plants. They resulted in a 20% DM yield increase and a significant reduction in the dry weight of weeds. The mixture of dinoseb acetate and PP009 resulted in a significant DM yield increase and significant reduction of weeds. These herbicides will be tested further to evaluate their usefulness.

Marginal Land Improvement

Although marginal lands, i.e., non-arable lands in the region are grossly mismanaged, they are potentially one of the main sources of animal feed. The widespread tendency of growing cereals as opportunity crops, which are mostly used as sheep forage, is a serious threat to the stability and future productivity of these important areas.

Pasture species that can be exploited as permanent pastures on these lands include annual reseeding grasses, annual self-regenerating legumes, and perennials (both grasses and legumes). The perennials could be imporant in the higher rainfall zones ($\geq$350mm), whereas the annuals could be utilized more advantageously in the drier areas.

Research was begun in 1979 to evaluate the adaptation of cultivars and ecotypes of annual and perennial grasses, and of perennial legumes, to the hot and dry summer and the cold and moist winter, which are characteristic of large areas in the region. Seasonal distribution of drymatter production was also studied to assess the potential of forage grasses to fill deficits in animal feed supplies.

Annual self-regenerating legumes were not included at this initial stage, as no seed of cultivars or ecotypes with satisfactory seed permeability were available.

Adaptation Trials of Annual and Perennial Grasses

More observations were made on the adaptation trials that were established in 1979, 1980, and 1981, with 144, 49, and 81 different accessions, respectively.

These pasture plots at Tel Hadya show striking differences in the spring growth made by annual and perennial grasses.

Two features of the methodology used in these trials were that (1) the plants were defoliated whenever herbage height reached 10-15 cm, and (2) the plants were transplanted in the field, a condition which does not permit evaluation of establishment. On the other hand, establishment cannot be properly evaluated on a large number of accessions, and in any case the amount of seed available was limited.

1979 Adaptation Trial Observations

Information collected on summer dormancy in 1980, and on winter regrowth in 1981 and 1982 are summarized in Table 35. These data show that 2 years after the establishment, *Phalaris aquatica* is the most productive perennial grass followed by *Dactylis glomerata* and *Festuca ovina*, which were the only two species capable of an early winter regrowth, as indicated by the drymatter yield on December 6, 1981.

A high variability was observed within many species for attributes of adaptive significance, such as summer dormancy and winter regrowth. This variability was analyzed in *Dactylis glomerata* because of the high number of cultivars and ecotypes available in this species.

The ecotypes collected in Syria and Jordan were more summer dormant and showed more vigorous winter growth than exotic cultivars, and ecotypes collected in Turkey (Table 36). The drymatter yield in the winter of 1981-82 suggests that the ecotypes collected in Syria and Jordan may possess a high degree of persistence under rainfed conditions.

Table 35. Summer dormancy in September 1980, winter regrowth in 1980-81, and drymatter yield on Dec. 6-1981 and in the period Dec. 81-March 82, in 12 species of perennial grasses, at Tel Hadya.

Species	No. of cultivars or ecotypes	Summer dormancy (0 - dormant 5 - green)	Winter regrowth (0 - min; 5 - max)		Drymatter yield (g/m²)		No. of cultivars 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	0.6±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±0.3	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±03	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±0.04	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	2

Table 36. Summer dormancy, winter regrowth in 1980-81, drymatter yield on December 6, 1981, and total drymatter yield in the period December 1981-March 1982 of 27 populations of *Dactylis* glomerata of different origin at Tel Hadya.

Origin	Number of populations	Summer dormancy (0 - dormant 5 - green) Sep.15,1980	Winter regrowth (0 - min; 5 - max)		Drymatter yield (g/m²)	
			Jan.12,81	Jan.28,81	Dec.6,81	Dec.81-March.82
Exotic cultivars	9	2.6b	1.2b	1.4b	0.0b	2.1b
Ecotype from Syria	12	1.1a	3.0a	4.1a	14.1a	141.7a
Ecotype from Jordan	3	0.5a	3.8a	4.3a	19.2a	186.5a
Ecotype from Turkey	2	2.5b	1.0b	3.0b	0.0b	5.7b

Means followed by the same letter are not significantly different ($P \leq 0.05$) based on t-test.

A similar variability that has been observed among the ecotypes collected in Syria is associated with the total annual rainfall of the collection site (Table 37).

1980 Adaptation Trial

Observations were also continued on this trial to determine the seasonal distribution of drymatter yield of the most productive cultivars and accessions of the perennial grasses established in November 1980 (Table 38). The growth patterns showed the maximum yield in spring and a second peak in winter, which is also a common feature of the less productive species. The most active growth period is when neither temperature nor moisture are limiting factors. In the other periods of the year the main climatic constraints appear to be low winter temperatures, and high temperatures and drought in summer and autumn.

In summer some additional growth is possible on residual moisture. This growth varies between and within species and is influenced by summer dormancy and rainfall distribution. The data in Table 38 validate the information generated in the 1979 adaptation trial. *Phalaris aquatica* is confirmed as the most productive perennial grass tested to date. It has a high spring productivity and a comparatively high winter production. The latter is a highly desirable attribute in view of the scarcity of animal feed in the winter. The cultivar Sirosa appears to be the most productive cultivar of *P. aquatica.*

Species such as *Festuca arundinacea, Agropyron varnense, Agropyron intermedium,* and *Agropyron cristatum* are capable of early summer growth; however, only *A. cristatum* combines summer growth with autumn regrowth, but its total productivity is low when compared with the best cultivars of *P. aquatica.* Two other perennial grasses with early regrowth after summer are *D. glomerata* (the ecotype collected in Syria) and *A. desertorum.* Because seedling growth of both these perennials is very slow they may be difficult to establish.

Festuca arundinacea made a very satisfactory growth in the establishment year, and one accession (U.S.S.R. n. 16) had a long growing season but its productivity decreased sharply in the second year due to its relatively high mortality (Table 39). Productivity is expected to decline further in the third year.

The second year productivity decline was a general feature of all species, and it varied greatly both between and within species. In *P. aquatica* it ranged from 3.8% (cv. Seedmaster) to 29% (cv. Sirocco), in *F. arundinacea* from 40.8% (U.S.S.R. n. 15) to 48.8% (cv. Demeter), and in *D. glomerata* from 16.0% (ecotype from Syria) to 92.3% (cv. Potomac). The low temperatures in March 1982 partly caused the productivity decline.

Data on summer dormancy and mortality after the first summer are given in Table 39. A high variability was observed both between and within species, for summer dormancy levels on September 22 and when a cultivar becomes dormant. In *P. aquatica,* for example, the cultivar Sirocco becomes dormant much earlier than the other cultivars, and has a higher percent of dormant plants on September 22 but these differences are not reflected in the levels of mortality.

The ecotype of *D. glomerata* collected in Syria has an earlier and higher level of summer dormancy than the three exotic cultivars. In this species there was a direct relationship between final level of summer dormancy and percent mortality in March 1982.

Table 39 also shows that similar levels of dormancy led to different percent mortality in different species. For example, *F. arundinacea* (U.S.S.R. n. 16) and *A. desertorum* had a percent dormancy on September 22, 1981 of 14.8% and 14.5%, whereas the mortality on

Table 37. Summer dormancy, winter regrowth in 1980-81, drymatter yield on December 6, 1981, and total drymatter yield in the period December 1981-March 1982 and drymatter yield on June 2, 1982 of 12 Syrian ecotypes of *D.glomerata* grouped according to rainfall of the collection site (evaluated at Tel Hadya).

Rainfall	Number of population	Summer dormancy (0 = dormant 5 = green) Sept.15, 1980	Winter regrowth (0 = min; 5 = max)			Dry matter yield (g/m²)	
			Jan.12,81	Jan.28,81	Dec.6,81	Dec.6,81-Mar.82	June 2,82
450 mm or less	7	0.6	3.9	4.6	22.6	178.9	4.5
700 mm or more	5	1.9	1.8	3.4	2.1	89.6	14.4
d		-1.3*	2.1*	1.2*	20.5**	89.3**	-9.9**

* $P < 0.05$; ** $P < 0.01$.

Table 38. Seasonal distribution of growth (g/m²) in 14 perennial grasses in two seasons under rainfed conditions at Tel Hadya.

Species	Cultivar or origin	Winter 80-82	Spring 81	Summer 81	Autumn 81	Winter 81-82	Spring 82	Summer 82	Total
Phalaris aquatica	Sirosa	46.0	605.2	0.0	0.0	158.1	310.2	3.3	1122.8
Phalaris aquatica	Australian	45.6	539.8	0.0	0.0	98.8	337.3	5.1	1026.7
Phalaris aquatica	Sirocco	76.8	484.9	0.0	0.0	175.6	221.2	2.0	960.6
Phalaris aquatica	Seedmaster	32.5	443.5	0.0	0.0	136.9	316.5	4.3	933.7
Festuca arundinacea	Demeter	38.1	470.5	0.0	0.0	65.8	177.1	17.3	768.8
Agropyron varnense	Unknown	0.0	426.4	24.3	0.0	90.9	190.4	9.0	740.9
Agropyron acutum	U.S.S.R.	0.0	389.2	0.0	0.0	91.9	248.7	8.3	738.2
Festuca arundinacea	U.S.S.R.(n.16)	35.4	356.1	29.9	0.0	37.2	175.8	21.3	655.7
Agropyron intermedium	Australia	0.0	363.0	22.0	0.0	61.7	164.7	10.4	621.8
Agropyron desertorum	U.S.A.	0.0	318.9	0.0	14.8	98.5	161.4	11.9	605.5
Festuca arundinacea	U.S.S.R.(n.15)	27.4	349.7	0.0	0.0	54.0	152.5	16.9	600.5
Dactylis glomerata	Syria	0.0	322.0	0.0	9.2	79.6	179.7	2.8	594.0
Dactylis glomerata	Porto	46.9	323.0	0.0	0.0	32.5	102.2	16.8	521.6
Agropyron cristatum	ind. tetraploid	0.0	279.9	15.0	5.5	56.7	108.0	5.5	470.7
SE		±6.3	±34.4	±3.1	±0.6	±7.6	±14.3	±1.8	±47.3

Table 39. Percent summer dormancy at six different dates in 1981, and percent mortality on March 23, 1982 in 16 perennial grasses at Tel Hadya.

Species	Cultivar or origin	% dormancy						% mortality
		July 4	July 21	August 9	August 18	September 1	September 22	March 23, 1982
Phalaris aquatica	Sirosa	8.0	11.8	19.3	28.1	32.7	63.0	6.9
Phalaris aquatica	Australian	5.3	9.4	13.0	19.7	28.1	63.1	7.5
Phalaris aquatica	Seedmaster	5.5	7.2	9.4	21.9	28.8	70.8	4.1
Phalaris aquatica	Sirocco	58.8	62.5	74.0	79.3	83.8	91.6	0.0
Dactylis glomerata	Syria	12.7	27.6	31.9	63.1	66.4	85.2	1.2
Dactylis glomerata	Phyllox	0.2	0.3	0.8	1.7	4.8	10.8	82.5
Dactylis glomerata	Porto	0.2	1.0	5.6	11.8	17.6	40.4	38.9
Dactylis glomerata	Potomac	0.0	0.0	0.3	1.6	1.9	11.7	86.0
Festuca arundinacea	Demeter	0.0	0.0	0.0	0.1	0.1	6.5	41.4
Festuca arundinacea	U.S.S.R.(n.15)	0.1	0.3	0.4	2.3	3.6	9.2	46.5
Festuca arundinacea	U.S.S.R.(n.16)	0.1	0.2	0.3	1.6	2.5	14.8	45.9
Agropyron varnense	Unknown	0.3	2.3	5.7	15.7	27.5	61.1	11.0
Agropyron acutum	U.S.S.R.	0.4	1.0	2.8	12.5	18.4	40.0	18.9
Agropyron intermedium	Australia	0.7	4.8	16.0	34.1	41.2	61.9	20.2
Agropyron desetorum	U.S.A.	0.5	0.7	0.7	2.1	5.2	14.5	5.8
Agropyron cristatum	ind.tetraploid	1.8	2.3	3.8	11.7	19.8	43.1	10.5
SE		±1.8	±2.1	±3.0	±3.5	±3.6	±4.2	±4.1

Table 40. Drymatter yield (g/plant) of 12 annual grasses established in November 1981 at Tel Hadya.

Species	Cultivar or country of *origin*	Date of cutting (1982)							Total DMY[a] *(g/plant)*
		March 21	*April 13*	*May 2*	*May 19*	*June 9*	*June 27*	*July 18*	
Lolium rigidum	Wimmera	1.30	0.03	3.54	1.30	1.45	0.15	0.00	10.77
Lolium rigidum	Merredin	1.18	2.61	2.54	0.81	0.52	0.08	0.00	7.75
Lolium rigidum	Cyprus	0.36	1.38	1.88	1.41	1.54	0.57	0.16	7.30
Lolium rigidum	Spain	0.99	2.90	3.40	1.34	0.99	0.09	0.00	9.71
Lolium rigidum	Afghanistan	0.35	1.18	1.78	1.63	1.07	0.21	0.13	6.35
Lolium multiflorum	Combita	1.17	2.86	4.39	2.45	2.74	0.33	0.13	14.07
Lolium multiflorum	Dilana	0.75	2.41	5.27	2.63	2.94	0.54	0.24	14.78
Lolium multiflorum	Hesa	1.25	3.01	2.80	2.51	2.34	0.46	0.19	12.56
Lolium multiflorum	Tetrone	0.96	2.91	4.48	1.94	2.26	0.40	0.14	13.09
Phalaris canriensis	Syria	0.00	0.51	0.80	0.64	0.53	0.19	0.00	2.67
Phalaris canariensis	Sweden	0.70	3.30	4.31	2.05	1.62	0.21	0.00	12.19
Phalaris canariensis	Iraq	1.16	3.51	4.74	2.28	1.21	0.23	0.00	13.13
SE		±0.06	±0.24	±0.33	±0.18	±0.18	±0.22	±0.02	±0.66

a. DMY = Drymatter yield.

March 23, 1982 was 45.9% and 5.8%, respectively. This suggests that although summer dormancy is important for survival, it is only one of the adaptive mechanisms that enable a plant to persist under dry conditions. For some perennial grass species a rapid decline in survival is expected only after the second summer.

1981 Adaptation Trial

Although only first year data are available for this trial, they were useful for comparing the initial growth between perennial and annual grasses.

The seasonal distribution of drymatter production of the 12 annual grasses included in the 1981 adaptation trial (Table 40) shows that *Lolium multiflorum* and one accession of *Phalaris canariensis* collected in Iraq were more productive than the cultivar Wimmera of *Lolium rigidum,* which was the most productive annual grass previously tested.

Similar data for the 13 most productive perennial grasses are given in Table 41, where the best annual grass (*Lolium multiflorum* cv. Dilana) is also included for comparison. Perennial grasses were less productive than the best annuals in the establishment year. The best perennial grass was an ecotype of *Lolium perenne* collected in Syria, followed by an ecotype of *P. aquatica,* also collected in Syria. The cultivar Sirosa of *P. aquatica* confirmed its excellent adaptation to the study area.

One of the problems associated with establishing annual and perennial pastures is weeds. A number of herbicides are available which control broadleaf weeds; their phytotoxicity was tested on four perennial grasses, i.e., *D. glomerata, A. elongatum, B. inermis,* and *P. aquatica,* and on *Lolium rigidum.*

The best preemergence herbicide was penoxaline, which did not have any phytotoxic effect.

The most promising postemergence herbicides, on the basis of phytotoxicity and weed control were bromofenoxim (1 kg a.i./ha), bromoxynil (1 kg a.i./ha), dinoseb acetate (1 kg a.i./ha), and bentazone (1 kg a.i./ha).

Responses to grass killers between species were diverse. Results indicate that the choice of the most suitable grass killer will depend on the dominant forage grass in the pasture.

In general the evaluation of annual and perennial grases has shown (1) the potential of annual grasses for rapid establishment and growth, and (2) the unique ability of some perennial grasses to produce some dry matter early in winter when there is a major nutritional gap due to the scarcity of animal feed, and (3) that for many of the more productive species a high level of summer dormancy is important for early regrowth in winter. However few species have been identified that combine early summer growth with early regrowth in winter.

Perennial Legumes

Alfalfa *(Medicago sativa)* and sainfoin (*Onobrychis* spp) have been tested in the past 3 years for their production potential under rainfed conditions. Initially a large number of accessions (460 *Medicago sativa* and 579 *Onobrychis* spp.) were evaluated in a nursery under rainfed conditions. Also, one agronomy trial was established in November 1979 to evaluate 22 alfalfa cultivars and ecotypes.

The experiment was conducted in a randomized block design with three replicates. One cut was taken in the establishment year (1980), four in 1981, and three in 1982. A number of cultivars developed in southwestern USA produced from 3.0 to 3.5 tonnes/ha of drymatter yield in 2 years (Table 42). Among the most productive cultivars, there were two ecotypes from Turkey and

Table 41. Drymatter yield (g/plant) of the 13 best perennial grasses and best annual grass in an adaptation trial established in November 1981 with 81 species and/or accessions at Tel Hadya.

Species	Cultivar or country of origin	Date of cutting (1982)								Total DMY[a] (g/plant)
		March 21	April 13	May 2	May 19	June 9	June 27	July 18	Aug. 9	
Lolium perenne	Syria	1.36	3.23	3.55	1.04	0.52	0.75	0.00	0.00	10.45
Phalaris aquatica	Syria	0.00	2.12	4.34	1.39	0.50	0.23	0.00	0.00	8.58
Lolium perenne	Tasdal	0.36	1.40	2.53	1.36	1.82	0.33	0.20	0.25	8.25
Lolium perenne	Iran (n.122)	0.51	1.52	2.29	1.06	1.93	0.32	0.20	0.21	8.04
Lolium perenne	Maprima	0.37	0.92	1.94	1.93	1.55	0.50	0.00	0.00	7.20
Lolium perenne	Victoria	0.50	1.52	2.21	1.04	1.21	0.31	0.14	0.00	6.93
Stipa tortilis	Turkey	0.00	0.70	0.95	0.96	2.17	0.76	0.26	0.00	5.80
Lolium perenne	Tasmanian	0.00	0.84	1.36	1.36	1.42	0.32	0.16	0.00	5.46
Phalaris aquatica	Sirosa	0.00	0.53	1.36	1.44	1.09	0.66	0.00	0.00	5.08
Lolium perenne	Iran(n.124)	0.36	0.74	1.41	1.00	0.97	0.24	0.18	0.00	4.87
Lolium perenne	Iran(n.123)	0.00	0.65	1.05	1.06	1.29	0.28	0.00	0.00	4.33
Phalaris aquatica	S.African(n.49)	0.00	0.36	0.99	1.41	1.16	0.39	0.00	0.00	4.32
Phalaris aquatica	Australia(n.54)	0.00	0.69	1.12	1.11	1.13	0.19	0.00	0.00	4.24
Lolium multiflorum	Dilana	0.75	2.41	5.27	2.63	2.94	0.54	0.24	0.00	14.78
SE		±0.06	±0.24	±0.33	±0.18	±0.18	±0.22	±0.02	±0.04	±0.66

a. DMY – Drymatter yield.

Table 42. Drymatter yield (kg/ha) of 22 cultivars and ecotypes of alfalfa under rainfed conditions in 1981 and 1982 at Tel Hadya.

Cultivar/ecotype	1981	1982	Total
Mesa Sirsa	2494	1037	3531
Arizona (n.646)	2450	974	3424
Sonora	2182	1091	3273
Turkey (n.619)	2267	951	3218
Iran (n.546)	2117	1077	3194
Moapa 69	2193	984	3177
Arizona (n.647)	2050	1077	3127
Hijazi	2083	1010	3093
Hunter River	1899	1112	3011
Sonora 70	1979	987	2966
Paravivo	1863	1087	2950
Hayden	2297	641	2938
Cargo	2129	787	2916
CUF 101 (n.55)	1962	938	2900
Salton	1938	945	2883
CUF 101 (n.670)	2101	779	2880
Cyprus	2143	577	2720
Iraq (n.484)	2073	633	2706
Syria (n.485)	1748	943	2691
El Unico	1867	687	2554
Yugoslavia (n.832)	1671	832	2503
Lebanon	1341	796	2137
SE	±233	±136	±329

Iran. Although the total productivity did not differ significantly, the distribution of drymatter yield showed two distinct patterns (Fig. 9), which are characteristic of winter active types, e.g., Mesa Sirsa, and of winter dormant types, e.g., the ecotype from Turkey. Winter active cultivars are expected to be adapted to areas with mild winters where they may produce an early winter forage supply, whereas winter dormant types are expected to be much more cold tolerant, and therefore adapted to high plateau and other cold winter areas.

In the 1982 survey of forage diseases and pests in Syria and Lebanon, alfalfa was found to be susceptible to wilt, common leaf spot, spring black stem and leaf spot, powdery mildew, *Leptosphaerulina* leaf spot, *Stemphylium* leaf spot, virus, downy mildew, yellow blotch, stem canker, anthracnose, and rust. Powdery mildew, rust, anthracnose, wilt, and *Ascochyta* were diseases in sainfoin.

Rainfed alfalfa was severely attacked by several aphid species and to a lesser extent by the alfalfa weevil *Hypera* spp. Sainfoin was lightly attacked by aphids and thrips.

In the Ghouta of Damascus, where alfalfa has been grown for a long period and is rapidly expanding, the major problem is the flowering parasitic plant *Cuscuta*. In 1978, 38% of the alfalfa fields in the eastern part of the Ghouta were infested. In 1982, 42 alfalfa fields were checked again and 64% contained *Cuscuta*.

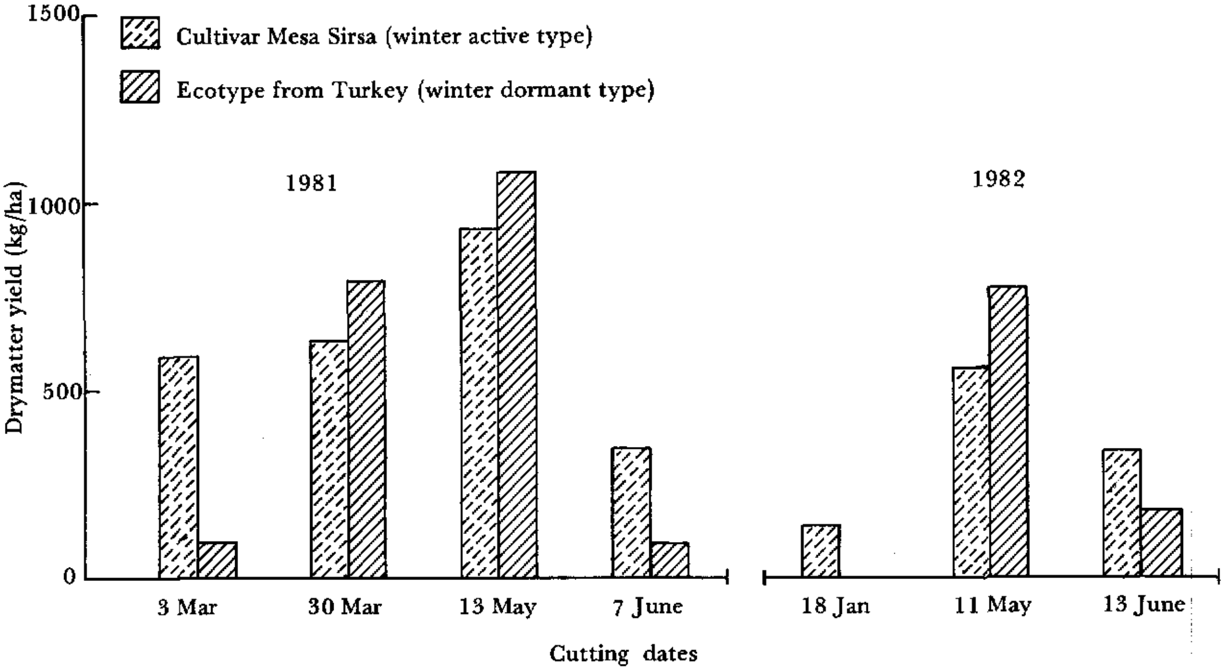


Figure 9. Drymatter yield of two contrasting alfalfa types under rainfed conditions, 1981-82.

As some of these fields are located in the western part of the Ghouta, and were only 1 or 2 years old, there is an alarming evidence that *Cuscuta* is rapidly expanding. Analysis of seed samples collected from seed merchants and farmers in Syria and Lebanon showed that 42% were contaminated with *Cuscuta* seeds.

Recommendations to deal with this problem have been submitted to the Syrian National Program (ARC-Douma).

COMMUNICATION AND TRAINING

Contents

(Photo on previous page: A plant pathologist shows disease symptoms in faba beans in a nursery at Lattakia, to trainees from the region)

Communications and Training

Communications

The communication activities at ICARDA are concerned with printing and publishing, and the provision of library and documentation services.

Publications

Some examples of the various types of publications that ICARDA produced in 1982 are listed below. Unfortunately the printing facilities are limited and overworked.

1. **Conference and Workshop Proceedings**

   Crop Production in Lebanon-Proceedings of a Research Conference

   Proceedings of Seed Production Symposium, sponsored by the Netherlands Government and ICARDA.

2. **Information Brochures in English and Arabic**

   ICARDA Brochure in Arabic
   Food Legumes Improvement Program in English and Arabic
   Pasture and Forage Improvement Program in English and Arabic

3. **Training Manuals in English and Arabic**

   Introduction to the Major Insect Pests of Wheat and Barley in the Middle East and North Africa
   Introduction to Seed Science and Technology
   Legume Crops Physiology
   Seed Production

4. **Abstracts**

   Nile Valley Faba Bean Abstracts (ICARDA/CAB)

5. **Special Publications**

   A series about ICARDA's activities in the countries of the region - the first in this series entitled "ICARDA in Syria".
   ICARDA Research Highlights 1981 in English and Arabic
   Nile Valley Project in English and Arabic
   Annual Report 1981
   FABIS Newsletter
   LENS Newsletter

ICARDA aims to translate most of its own publications into Arabic. The booklet entitled 'ICARDA in Syria' was originally written and published in Arabic, and is now being produced in English. Because Arabic is the language of more than 140 million people, an effort is being made to translate scientific publications into Arabic to assist agriculturists throughout the Middle East.

Documentation

This was the first year of the International Development Research Centre (IDRC) projects for the development of the FABIS (Faba Bean Information Service) and LENS (Lentil Experimental News Service). IDRC is supporting these legume information services because legumes were neglected during the "green revolution" period and because it wishes to contribute to improving the protein content of the diet in the Middle East and North Africa. The IDRC grant of CAN. $ 500,000 for 1982-84 is intended for building up the library and documentation services to make them a world information collecting and disseminating center for faba bean and lentils. The grant includes training, equipment, and publications components. It is hoped to arrange in-service training for library and documentation staff in 1983.

The main publications supported are the FABIS and LENS newsletters. The LENS Newsletter is the subject of a grant by IDRC jointly to the University of Saskatchewan to support editorial and other inputs, and to ICARDA to edit, publish, and distribute the newsletter. Other activities supported are document collection, storage, retrieval, and information dissemination in the form of photocopies, bibliographies, literature searches, a question-and-answer service, and critical reviews.

During the year, two issues of FABIS Newsletter (Nos. 4 and 5), one issue of LENS (No. 9), and the World Directory of Faba Bean Research (containing names of some 800 researchers with their addresses and specializations) were published. Another production was the Nile Valley Faba Bean Abstracts (containing over 500 abstracts), which was a collaborative venture with CAB. It involved the training of staff for writing and indexing 150 abstracts; the abstracts were

Some of ICARDA's Communications Unit staff at work

produced to assist the ICARDA/IFAD (International Fund for Agricultural Development) Nile Valley Project. CAB also published Faba Bean Abstracts Nos. 1 and 2 (1982) and Lentil Abstracts No. 2 and distributed them according to the mailing list supplied by ICARDA. An ICARDA staff member is a joint editor of a text book entitled "Faba Bean Improvement".

The Documentation Service assisted in the preparation of the first RACHIS Newsletter (the Barley, Wheat and Triticale Newsletter for the Near East and North Africa), which aims to disseminate research results, encourage communication between researchers, and assist in the overall development of cereals research in the region.

ICARDA has been designated as the AGRINDEX input center for ICARDA publications, and staff have been trained in the use of the AGRINDEX classification. In September, a senior staff officer attended an AGROVOC Training Course in Copenhagen which dealt with the change-over from AGRINDEX object codes to the index keywords of the AGROVOC Thesaurus. In October, he visited the University of Saskatchewan, IDRC, and FAO to discuss LENS, FABIS and LENS, and AGRINDEX.

Library

In March, the Library was transferred from an ICARDA office building in Aleppo to the Tel Hadya Experiment Station where most of ICARDA scientists are now located.

During the year, ICARDA established a new information bulletin, *Current Awareness,* in which library additions such as new textbooks, reprints, journal articles, and photocopies are systematically recorded. It is intended that *Current Awareness* will form the basis of ICARDA's information collection, recording, storage, and retrieval system and in due course be entered in the computer. By December, the eighth issue had been published and distributed. In particular, it is being sent to scientists in areas with inadequate information services. Readers there can either contact authors for reprints or obtain photocopies from the ICARDA library.

Agrindex and *Current Contents* have been regularly searched for journal data relevant to ICARDA's needs. Authors of journal articles have been contacted with special request cards for reprints. There has been a good response, and the library's collection of scientific papers has been substantially increased.

As a result of steps taken to increase the number of exchange publications, some 50 new journals will be received in the library to supplement the 125 journals now received on a subscription basis.

A special grant from IDRC for developing library services has enabled the acquisition of a new photocopier and a microfiche reader-printer.

Training

In keeping with its objective to increase food production, ICARDA believes that training is an important part of its activities, especially because in all countries in its region there is a shortage of trained personnel. The interest and response of national programs to the training that ICARDA has provided since 1978 has encouraged the Center to expand and diversify this program.

During 1982, the courses conducted by ICARDA were group training (both long and short term) and in-country training.

Long-Term Group Training

Two residential courses each of 6 months duration were given at ICARDA from February to July, and dealt with the improvement of cereals and food legumes, respectively.

Twenty trainees participated from Afghanistan, Egypt, Iran, Morocco, Pakistan, Sudan, and Syria.

Training focused on applied field activities, and was complemented by relevant theoretical courses. In the field, the trainees were instructed by program scientists, and worked alongside members of the staff.

Individual attention was also given to trainees to cater for specific training needs as requested by some national programs. This was done through assigning simple projects to these trainees. Projects were used to train the participants in simple field experimentation, analysis of data, and report writing.

Technical publications were supplied to trainees for use as reference material during the course and on return to their national programs. These publications ranged from technical manuals to specialized books. Training manuals were used in a self-teaching process.

Short-term Group Training

1. Seed Production Training - Course 1

The Netherlands Government Seed Testing Station (RPVZ), the Netherlands Certifying Agency (NAK), and ICARDA jointly sponsored Seed Production Training Course 1 from 20 April to 10 May, at ICARDA. The course aimed to bridge the trained manpower gap, which is a major constraint to the seed industry in West Asia and North Africa. It was directed at promoting the development of sound national seed industries via the trainees who attended this course. It is intended to provide a series of similar courses.

Twenty trainees from various countries in West Asia and North Africa participated in the course. Topics included laboratory procedures, field-oriented practicals, and theoretical backgrounds. Planning, organization, and management of seed production programs, including variety release, crop certification, and seed testing in self-pollinated crops (barley, wheat, lentils, chickpeas, forage peas) were covered. Seed testing problems in cross-pollinated crops (alfalfa and forage grasses) were explained. Training manuals and other literature on seed production were given to the trainees. The lecture notes in this course have been edited and prepared for publication as a technical manual that can be used as a reference source by seed production officers.

2. Food Legume Germplasm Training Course

The erosion of food legume genetic resources is severe in West Asia and North Africa. In order to create an awareness amongst the national food legume workers of the importance of genetic resources in food legume improvement, and to train them in the collection, conservation, and utilization of germplasm, a Food Legume Germplasm Training Course was conducted during May 2-11, at ICARDA. The course was sponsored by the International Board for Plant Genetic Resources (IBPGR) and ICARDA.

Twenty participants from 11 countries received training in the collection, conservation, documentation, evaluation, and utilization of germplasm of faba beans, chickpeas, and lentils in an improvement program. Relevant information was given on the taxonomy and evolution of these crops. Field trips were made in northern Syria to collect both wild and cultivated food legumes. Legume germplasm activities at ICARDA were also shown.

In addition to ICARDA program staff, food legume workers from ICRISAT (India), Jordan, and Spain lectured the trainees. The course lecture notes are being prepared as a technical manual for use in future food legume training courses.

In-Country Courses

In response to a request by the national program in Morocco, an in-country cereal training course, sponsored jointly by ICARDA and INRAT (l'Institut National de la Recherche Agronomique) was held at Rabat, Morocco during April 12-24. The objective of this course, which was attended by 24 Moroccan engineers and technicians, was to improve their technical skills, and interactions with Moroccan scientists.

The training covered practical aspects of cereal production and improvement. Field activities dominated the curriculum, with theoretical backgrounds to complement them. Topics included cereal morphology, wheat and barley diseases, breeding methods, crossing techniques, plot layout, agronomic practices, and the use of machinery for small plots.

The trainees were lectured by Moroccan and ICARDA scientists, and a CIMMYT scientist. In this course literature handouts and visual aids were used extensively. The national program and trainees evaluated the training as being very useful to their needs.

In Syria, two courses were conducted for Syrian scientists. At the Hama Agricultural Center, Kamishly, 16 trainees from 9 research centers in Syria received training from March 27 to April 7 in crop improvement, crop experimentation techniques, pathology, agronomy, and the use of farm machinery. The course was jointly conducted by ICARDA and ARC of Syria. In late April, ICARDA assisted the Homs Agricultural Research Center in the training of five Syrian trainees in cereal and food legume crossing techniques, and breeding methods for field crops.

Workshops and Conferences

To establish links among agricultural scientists, food scientists, and nutritionists, the United Nations University (UNU), ICARDA, and the University of Aleppo sponsored a workshop on the Interfaces between Agriculture, Food Science and Human Nutrition in the Middle East during February 21-25, at Aleppo University, Syria. It was attended by 50 participants from the national programs in the Middle East. Key papers were given by authorities in nutrition, food science, and agricultural sciences. Recommendations made by the workshop included many projects to link scientists in these three disciplines. It was proposed that a series of similar workshops be held in the national programs. A publication containing the workshop papers and discussions is in press.

An ICARDA/IBPGR sponsored workshop to develop minimum descriptor lists for *Vicia faba* and *Lens culinaris* was held at the Tel Hadya Experiment Station on May 11-12. Food legume germplasm staff from ICARDA, India, Jordan, Lebanon, and Spain participated. Priority areas for future explorations, and locations for the maintenance and duplication of the crops' base collections were also discussed.

COMPUTER SERVICES

Introduction

In introducing electronic computing methods at ICARDA, two main problem areas are identified: the first relates to the changes necessary in existing scientific research and administrative practices, and the second to operation in regions where electronic data processing has only recently been introduced. The latter is clearly manifested in the near-absence of specialists and skilled personnel.

The first ICARDA computer, a PDP-11/34A was installed in August, 1981. It came into immediate use with the initial version of Crop Research Integrated Statistical Package (CRISP). The main thrust of programming work was in administrative applications, principally the General Ledger.

Plans for 1982 were formulated early in October 1982, incorporating:

1. Intensive Programming Packages Development, and
2. User Training and Utilities Documentation, in addition to the tasks of installation and optimization of the computing systems.

Program Development

The tasks of program and package development may be conveniently divided into two main areas: scientific and administrative. Such a division does not entail strict boundaries in analysis, design, or programming. Indeed, the scientific applications benefited from the wealth of material made available through the administrative applications.

Scientific Applications

Up to 2000 experiments were analyzed in the 1981-1982 cropping season on ICARDA's version of CRISP. Certain research activities were entirely handled by the computer at the Aleppo Computer Centre. The figures for 1982 continuously reflected growing needs, with only a short pause in growth in the post-harvest period of 1982. Indeed, the production of Field Books for international nurseries, by itself, will treble the volume of experiments to be analyzed in 1983.

The Computer Services is planning to support over 6000 experiments in 1983, most of them from design stage to analysis of results, through randomization, fieldbook production, data entry and data summarization. The bulk of the work entailed will be handled by the VAX-11/780 at the Harry S. Darling Computer Center in Tel Hadya.

Work on CRISP 2, the VAX VMS version of CRISP, began in the second half of 1982, to enable rapid exploitation of the VAX-11/780 upon its commissioning. CRISP 2 uses the same file structure as CRISP, but exploits the advanced features of the VAX VMS Operating System permitting a more sophisticated programming structures and lighter user intervention.

It is clear that the current scientific computer needs lie (in addition to the experimental aids and statistical facilities) in the data storage and retreival utilities. From the figures of 1982 over 40% of computer usage has been linked to data management. Development on ICADET (ICARDA's Generalized Data Manager) continued throughout 1982. ICADET allows for varied data management facilities, in entry, verification, sorting, selecting, report generation, and data conversion.

In addition, work continues on completing the major modules, such as ICARDA's File Management System (ICAFIL); the Generalized Documentation Package (ICAREP); ICARDA's utilities (ICALIB) among other lesser packages and modules. Finished components of ICARDA's software are in active use in both scientific and administrative application.

Administrative Applications

Initially, such applications were centred around the PDP-11/34A, at the Aleppo Computer Center. The design of various packages and program modules took into consideration the need to maintain complete compatibility with the VAX-11/780 Operating System requirements, to avail ICARDA of reliable backup system in the event of system breakdown.

Early in October 1981, areas of possible computer intervention were identified and specific priorities were defined. These include:

1. General Ledger and Voucher System
2. Payroll subsystem
3. Stock Control and Order Entry Subsystems
4. Budget Development and Control Subsystem
5. Management Information System

These five areas constitute ICARDA's Management, Accounting and Information System (MAS). The General Ledger entered the parallel running stage early in September 1982. The Payroll Subsystem entered the parallel run stage in December 1982. These two components, as well as the Budget Subsystem will be commissioned for active usage on 1 January 1983.

The Stock Control and Order Entry Subsystems were, at the end of 1982, in the user-evaluation stage, and are expected to enter the parallel running stage in late January or early February of 1983.

In the meantime, elements of the Management Information System were accumulated during the stage of component development. Weekly management reports covering the operational parameters of finance and the purchasing and supplies activities will be available. Further, as other administrative areas are computerized, their contribution to the management information system will be made available.

Training

An important aspect of the introduction of computing methods is that of training. In the early stages of implementation individual training sessions were held with particular users. The Computer Services shouldered the main burden of data entry and analysis since the users' participation was not very encouraging. Therefore, CRISP Seminars were held in 1982, which attracted a good number of trainees from all programs. This was followed by individual training, covering specific problems of the users.

The growth of products developed by the Computer Services made it necessary, late in 1982, to appoint a person in charge of training in the Computer Services. This has proved very useful in areas like word processing, where more than 35 scientific and other staff, received instruction and are now active users of the facility.

In addition, training courses are organized in association with the programs. These courses are related to the specific needs of the programs.

Installation of the VAX-11/780

The Harry S. Darling Computer center was completed in May 1982. The VAX-11/780 was commissioned in August 1982. Initially, the system was used for instruction on the word processing facility, as well as for transportation of the systems and application programs that had been developed for the VAX-11/780 prior to its arrival and installation.

The VAX-11/780 at present serves 16 users in the locale of the Computer Center. In January 1983, terminals will be installed in strategic areas in Tel Hadya. It is hoped that by the end of 1983, 48 terminals would be located in scientists' offices and other areas for direct accessibility to the users.

Visitors' Services

Visitors at ICARDA are received by the Visitors' Section of the Center, which consists of an administrative supervisor with a scientific background, and support staff.

About 1000 visitors from Syria and other countries came to ICARDA in 1981-82. They included scientists, agricultural officials, members of the diplomatic corps,ICARDA's trustees, consultants, delegates to workshops and conferences, trainees, farmers, students, and the media. The visitors came from 50 countries, and from more than 35 universities and 120 national, international, and private institutions.

Among the foreign officials who visited ICARDA were the British Ambassador to the Syrian Arab Republic, the Netherlands Ambassador, the Australian Ambassador, the Pakistan Ambassador, the West German Ambassador, the Yugoslavian Ambassador, and the Tunisian Ambassador.

A special guest during the year was Dr. Dunstan Skilbeck, who in 1972 led the team commissioned by the CGIAR to review the agricultural research needs of the Near East and North Africa region, and consequently recommended the establishment of ICARDA.

During the year, 10 program events were held. ICARDA was honored by visits of the Syrian Minister of Agriculture, the Governor of Aleppo, and more than 100 officials.

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Collaborative Projects with Advanced Institutions, 1982

	Subject	Institution	Funding
1.	Replacement of fallow by forage crops	McGill University, Canada	CIDA
2.	Studies on rural labour	University of Western Canada, Canada	Population Council
3.	Root studies on barley and chickpeas	University of Reading, UK	ODA
4.	Phenology and productivity modeling in wheat	University of New England, Australia	UNDP
5.	Nitrogen fertilizer efficiency using ^{15}N	International Fertilizer Development Centre (IFDC), USA	IFDC/UNDP
6.	Establishment of an agrometeorological data bank	Academia dei Georgofili, Florence, Italy	National Research Council (CNR)
7.	Nitrogen fixation studies using ^{15}N	International Atomic Energy Agency, Austria	IAEA
8.	Studies on ***Rhizobium*** carrier systems	University of Manitoba, Canada	IDRC
9.	Photo-thermal relations in barley, faba beans and lentils	University of Reading, UK	ODA
10.	Collection and evaluation of barley and durum wheat germplasm.	University of Saskatchewan, Canada	NSERC
11.	Screening for salt tolerance in barley and durum wheat and development of cultural practices for salt affected areas.	University of Munich, West Germany	GTZ
12.	Cereal, food legume and forage quality evaluation.	Grain Research Laboratory, Winnipeg, Canada	Canadian Grain Commission.
13.	Interspecific hybridization in durum wheat	Plant Breeding Institute, Bari, Italy	CNR
14.	Genetic evaluation of virulence genes in cereal pathogen populations in the Mediterranean Basin.	Institute of Cereal Crops, Rome, Italy	CNR
15.	Data exchange on germplasm collections	Germplasm Institute, Bari, Italy	CNR
16.	Evaluation of forage shrubs ***(Medicago arborea)*** in the Mediterranean region.	Plant Breeding Institute, Bari, Italy	CNR
17.	Genetic improvement of forage peas	Institute of Agronomy, Naples, Italy	CNP
18.	Screening of Sulla ***(Hedysarum)*** under rainfed and irrigated conditions	Institute of Agronomy, Palermo, Italy	CNR
19.	Studies on nematodes affecting chickpeas, peas and forage legumes in the Mediterranean region.	Institue of Nematology, Bari, Italy	CNR
20.	Studies on ***Ascochyta*** blight of faba beans	University of Manitoba, Canada	IDRC
21.	Faba bean adaptation studies	EEC	-
22.	Phosphate and iron use efficiency in chickpeas and lentils	University of Hohenheim, West Germany	-
23.	Aphid resistance in faba beans	University of Bonn, West Germany	GTZ
24.	Stem nematode studies in faba beans	University of Bonn	GTZ
25.	Mechanisms of resistance to ***Ascochyta*** blight in chickpeas	University of Bonn	GTZ
26.	Agronomy studies on dry peas	University of Giessen, West Germany	GTZ
27.	Studies on resistance to ***Botrytis fabae*** in faba beans	Cambridge University, UK	-
28.	Interspecific crossing in ***Vicia***	University of Reading, UK	ODA
29.	Physiological variation in ***Ascochyta rabiei***	University of Reading, UKD	ODA
30.	Resistance to bruchids in faba beans	University of Reading, UK	Ford Foundation
31.	Faba bean breeding methodology studies	University of Manitoba, Canada	IFAD
32.	Nutritive value of food legume and cereal straws	Tropical Products Institute, London, UK	TPI
33.	Screening for cold tolerance in lentils	University of Perugia, Italy	CNR

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