ICARDA
Annual Report
1984

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International Center for Agricultural Research in the Dry Areas

Published by
The International Center for Agricultural Research in the Dry Areas
ICARDA
P.O.Box 5466, Aleppo, Syria
Telex: 331206 SY 331208 SY 331263 SY

ICARDA/GUEST HOUSE
Hamed Sultan Bldg., First Floor
Abdul Kader Ghazali Str.,
Abu Roummaneh (Next to Al-Malki Circle)
P.O.Box 5908,
Damascus/Syria
Tlx 412924 SY

ICARDA CAIRO OFFICE
15 G. Radwan Ibn El-Tabib Str.,
11th Floor, Giza,
P.O.Box 2416
Cairo/Egypt
Tlx 091-21741 ICARD UN

ICARDA BEIRUT OFFICE
Dalia Bldg., 2nd Floor,
Rue Bashir El-Kassar
P.O.Box 114/5055,
Beirut/Lebanon
Tlx 22509 LE

ICARDA TUNIS OFFICE
Immeuble Saadi, Route de l'Ariana
El-Menzah, Tour C-D, 7th Floor,
Appartment No. 25, Tunis
P.O.Box 84, 2049
Ariana/Tunisia
Tlx 14066 DEFRA TN

ICARDA AMMAN OFFICE
Jordan University, Faculty of
Agriculture,
P.O.Box 5008,
Amman/Jordan
Tlx 21629 UNVJ JO

ISSN 0254-8313

Correct citation: ICARDA (International Center for Agricultural Research in the Dry Areas). 1985. Annual Report 1984. Aleppo, Syria.

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Statement of Objectives

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

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

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

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

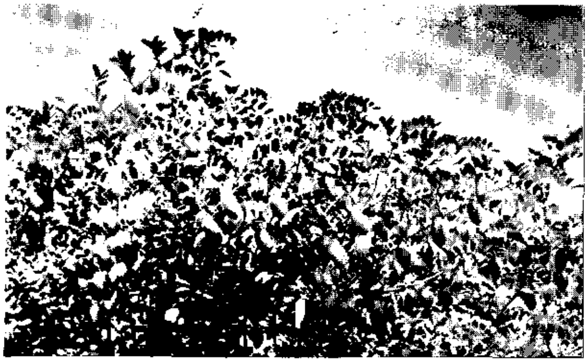
c. To conduct research into and develop, promote, and demonstrate improved systems of cropping, farming, and livestock husbandry.

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

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

ICARDA's Principal Research Areas

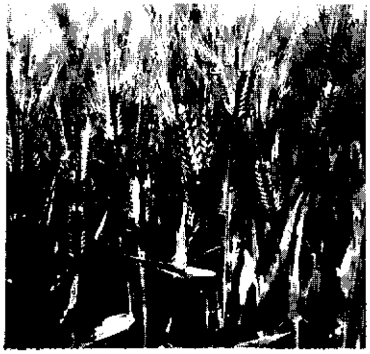
Lens culinaris
Lentil
Adas عدس



Cicer arietinum لاتيني
Chickpea انكليزي
Hummus حمص عربي

Vicia faba
Faba bean
Ful فول

Farming Systems
النظم الزراعية



Hordeum (spp.)
Barley
Shai'r شعير

Triticum (spp.)
Wheat
Qamh قمح

Pasture and Forage Crops and Livestock
المراعي والاعلاف والمواشي

ICARDA Donors

Currency: US $ (x 000)

Core Operations

Unrestricted Funds

Australia	446
Canada	579
China	50
Denmark	129
Ford Foundation	175
Germany	709
IBRD	5,370
Italy	368
The Netherlands	306
Norway	224
Saudi Arabia	600
Spain	50
Sweden	368
United Kingdom	500
USAID	5,300

Restricted and Capital

Arab Fund	230
France	38
IDRC - Farming Systems	111
- FABIS	115
- LENS	13
IFAD - Cereals/North Africa and West Asia	270
Buildings	1,700
Italy - Building (GRU)	840
- Forage	250
OPEC - Barley and SWAN	233
- Buildings	1,570
UNDP - SWAN	400

Special Projects

Ford Foundation - Farming Systems 83/85	75
IBPGR - Barley	15
IDRC - Arabic Dimension	21
IFAD - Nile Valley Special Project	1,250
The Netherlands - Virologist	63
- Training	48

Board of Trustees

Acronyms and Abbreviations

ABR	Ascochyta Blight Rating
ACSAD	Arab Center for Studies of the Arid Zones and Dry Lands
ADF	Acid Detergent Fiber
ADYT	Advanced Durum Yield Trial
ARA	Acetylene Reduction Activity
ARC	Agricultural Research Center of the Syrian Ministry of Agriculture and Agrarian Reform
ATYT	Advanced Triticale Yield Trial
AUB	American University of Beirut
BCB	Barley Crossing Block
BNF	Biological Nitrogen Fixation
BON	Barley Observation Nursery
BYDN	Barley Yellow Dwarf Virus
CERINT	Cereal Internacional Nurseries Data Processor
CILMN	Chickpea International Leaf Miner Nursery
CIMMYT	Centro International de Mejoramiento de Maiz y Trigo
CIYT	Chickpea International Yield Trial
CP	Cereal Improvement Program
CRISP	Crop Research Integrated Statistical Package
DCB	Durum Crossing Block
DDM	Digestible Dry Matter
DMB	Determinate Mutant Bulk
DON	Durum Observation Nursery
DON-Rf	Durum Observation Nursery-Rainfed
DSP	Durum Segregating Populations
DST	Durum Septoria Trial
EDYT	Early Durum Yield Trial
EM	Total Extractable Moisture
EPR	External Program Review
EPS	Early Podding Stage
ESWYT	Early Spring Wheat Yield Trial
E_T	Evapotranspiration
FAO	Food and Agriculture Organization
FABIS	Faba Bean Information Service
FBIABN	Faba Bean International Ascochyta Blight Nursery
FBICSN	Faba Bean International Chocolate Spot Nursery
FBIRN	Faba Bean International Rust Nursery
FBISN	Faba Bean International Screening Nursery
FBISN-L	Faba Bean International Screening Nursery—Large-Seeded
FBISN-S	Faba Bean International Screening Nursery-Small-Seeded
FBOCCT	Faba Bean Orobanche Chemical Control Trial
FBRYT-I	Faba Bean Regional Yield Trial-Irrigated
FBRYT-R	Faba Bean Regional Yield Trial-Rainfed
FMT	Farmer-Managed Trial
FLIP	Food Legume Improvement Program
FSP	Farming Systems Program
GRU	Genetic Resources Unit
GTZ	German Agency for Technical Cooperation
HI	Harvest Index
IBPGR	International Board for Plant Genetic Resources
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IDRC	International Development Research Center
IFAD	International Fund for Agricultural Development
INAT	Institut National Agronomique de Tunisie
INRA	Institut National de Recherche Agronomique
INRAT	Institut National de la Recherche Agronomique de Tunisie
ITSN	Initial Triticale Screening Nursery
ITYN	Initial Triticale Yield Nursery
IPSPRG	International Parasitic Seed Plant Research Group
IYT	International Yield Trial
IVCD	*In vitro* Cellulose Digestibility
IVD	*In Vitro* Dry Matter

KLDN	*Key Location Disease Nursery*
LAI	Leaf Area Index
LENS	Lentil Experimental News Service
LIF_3T	Lentil International F_3 Trial
LIF_3T-E	Lentil International F_3 Trial-Early
LISN	Lentil International Screening Nursery
LISN-TE	Lentil International Screening Nursery-Tall Erect
LPS	Late Podding Stage
LSWYN	Late Spring Wheat Yield Nursery
LTA	Long-Term Average
MOFC	Margin-Over-Feed-Costs
MRR	Marginal Rate of Return
MS-MS Trial	Multiple Site-Multiple Season Trial
NARC	National Agricultural Research Council
NARP	North African Regional Project
NDF	Neutral Detergent Fiber
NRA	Nitrate Reductase Activity
NVP	Nile Valley Project
ODA	Overseas Development Administration of the UK
PARC	Pakistan Agricultural Research Council
PDYT	Preliminary Durum Yield Trial
PFIP	Pasture and Forage Improvement Program
PFLP	Pasture, Forage, and Livestock Improvement program
PTYT	Preliminary Triticale Yield Trial
RACHIS	Barley, Wheat, and Triticale Newsletter
RBYT	Regional Barley Yield Trial
RBWYT	Regional Bread Wheat Yield Trial
RD	Recommendation Domain
RDYT	Regional Durum Yield Trial
RFDYT	Regional Rainfed Durum Yield Trial
RMT	On-Farm Researcher-Managed Trial
RWYT	Regional Wheat Yield Trial
SIMTAG	Simulation of *Triticum aestivum* Genotypes
SL	*Syrian Lira*
SPB-HAA	Barley Segregating Populations for High-Altitude Areas
SPB-HRA	Barley Segregating Populations for High-Rainfall Areas
SPB-LRA	Barley Segregating Populations for Low-Rainfall Areas
TAT	Training and Agrotechnology Transfer
TBY	Total Biological Yield
TDRI	Tropical Development and Research Institute
TON	Triticale Observation Nursery
TSM	Total Seasonal Moisture Supply
UNDP	United Nations Development Programme
WBON	Winter Barley Observation Nursery
WBWON	Winter Bread Wheat Observation Nursery
WCB	Bread Wheat Crossing Block
WDON	Winter Durum Observation Nursery
WMFT	Wheat Meal Fermentation Time
WON	Bread Wheat Observation Nursery
WUE	Water-Use Efficiency

Introduction

Throughout most of the ICARDA region, farmers as well as researchers were daunted by the extreme drought which afflicted the 1983/84 crop. This season was the driest so far experienced by ICARDA over the last seven years, with the total precipitation at Tel Hadya of 230 mm, against the long-term average of 350 mm. For Syria, the season was the driest since 1972/73. The rainfall distribution in 1983/84 was also poor. About 35% of the rain fell by the end of November, leaving the main growing season miserably dry. In the previous drought year of 1978/79, the total rainfall was 246.8 mm, but only 8% came by the end of November while the rest fell during the main growing season.

In my Introduction to the 1982 Annual Report, I quoted Depois (1930), a French agricultural scientist who, while working in North Africa, advised plant breeders there 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, you will need results from five years before you can make valid conclusions.» From the 1983/84 season results it became amply evident that even five years of dryland agricultural research is not sufficient to extrapolate results when such an exceptionally dry season hits the research trials as well as the farmers' fields. This exceptionally dry season, however, provided the opportunity to test our seven years of research material under very harsh conditions, and to collect germplasm which fought and survived the drought, as well as discard that which succumbed to it. Breeding for stress tolerance would thus become an increasingly important objective in our research strategies.

Some of our newly developed genotypes of cereals and food legumes did successfully face the challenge of the dry season. In barley, the Rihane sister lines, ER/Apam, and the varieties Harmal and Soufara deserve a special mention since they performed well both at

Tel Hadya and elsewhere in the regional nurseries. Durum wheat varieties Sebou and Korifla significantly outyielded the locally adapted Haurani for the second consecutive season in Syria. Two advanced bread wheat lines, Flk 'S' / Hork 'S' and HD 2206/Hork 'S' were *selected for intensive multilocation national- level testing* by 17 countries in the region. A number of other lines were identified that performed well in the drought conditions at Tel Hadya.

Faba beans suffered a severe drop in yields, about half of that obtained last season. Lentil yields also suffered, yet yield increases of over 25% from ICARDA- selected lentil genotypes were obtained over the local cultivars in the on- farm trials conducted jointly with the Agricultural Research Center (ARC) of Syria. The dry season also highlighted the role of lentil straw in stabilizing farm incomes, as the low yields in farmers' fields were compensated for by the high price of *lentil* straw, *since no other livestock feed was available.*

Effects of the dry season were felt most severely in the barley/ livestock producing areas of the region with less than 300 mm long-term average rainfall. The marginal grazing areas were unproductive, and farmers experienced acute feed shortages for their sheep. As a result, barley fields in Syria were grazed off in February and, by March, the feed supply in the villages was exhausted. The farmers were forced to sell a large number of sheep for slaughter and move others to wetter areas.

In contrast to this, our experimental plots in these areas that received nitrogen and, particularly, phosphate fertilizer produced substantial yields (1.5 t/ha grain at locations receiving only 200 mm of rainfall), revealing yet again the enormous potential of fertilizer use under these dry conditions. In spite of the somewhat lower yields than obtained in a «normal» year, economic returns from the judicious use of fertilizer were still very attractive because barley feed ran short and prices shot up substantially. The drought reduced the seed set of pasture legumes in the long- term rotation trial and thus gave us the opportunity to measure the livestock productivity from pastures in a poor year.

Agriculture in ICARDA region faces diverse problems of serious magnitude. But the pool of knowledge generated by ICARDA has set the stage for more sharply focused research in areas of immediate relevance to the farmers. The improved germplasm lines provided by ICARDA to national programs are giving handsome dividends. In cereals, five new varieties of barley, six of durum wheat, and four of bread wheat were identified for release to farmers by the national programs of Cyprus, Egypt, Iran, Libya, Morocco, Pakistan, Peoples Democratic republic of Yemen, Portugal, Qatar, Sudan, and Syria. The impact of new varieties released last year was evident from the requests received from Syria for the supply of the seed of two new varieties, namely, Sham 1 of durum wheat and Sham 2 of bread wheat; and from Morocco, Jordan, Lebanon, Turkey, and Pakistan for other promising genotypes of wheat and barley. In food legumes, Cyprus released ILC 3279 chickpea, a tall genotype suitable for mechanical harvesting, and the Ethiopian national program launched a large-scale multiplication of NEL (ILL) 358 lentil for release to farmers.

In 1983/84, cooperation between the national programs and ICARDA reached new heights, indicating the increasing credibility and the potential impact of ICARDA. Our collaborative research with our host country, the Syrian Arab Republic, was further strengthened during the year. Collaborative research programs made tangible headway with Tunisia and Morocco, and a formal Agreement is expected to be signed with Morocco soon. So far ICARDA has signed formal Collaborative Program Agreements with the Governments of Syria, Lebanon, Cyprus, Sudan, Egypt, Tunisia, and Pakistan. The successes recently made in the Nile Valley Project (NVP) in Egypt and Sudan, which is supported by the International Fund for Agricultural Development (IFAD), attracted Ethiopia to join the project. The NVP activities were reviewed by IFAD in 1984 and plans were drawn up for the second phase of the project, to commence from mid-1985, with Ethiopia as the third participating country. This is indeed a most positive development.

In the 1983/84 season, a Pilot Production Demonstration Program was organized under the auspices of the Nile Valley Project in the Zeidab Irrigation Scheme in the Sudan. The Program covered 77 farmers with 21 production plots spread over 140 hectares. The mean seed yield increase from the test plots was 85% over that obtained by neighboring farmers not using the recommended package. Prizes were distributed at an official ceremony to farmers who obtained such high yields. The ceremony was attended by over 100 farmers, the Minister of Agriculture and other high-ranking officials, and farmers union representatives, as well as researchers from Sudan, Egypt, and ICARDA. Farmers interviewed at the ceremony expressed eagerness to adopt the recommended package and the Government promised to make the necessary inputs available.

Active collaborative research continued in Pakistan with the Arid Zone Research Institute, Quetta, and the Provincial Agricultural Research Institute, Sariab. The objective of this research is to develop germplasm and production technology for the high- elevation areas of Baluchistan. On- farm trials were conducted in Baluchistan with FAO support to evaluate and demonstrate the improved cereal cultivars and production parctices.

The agreement on the Management of Agricultural Reséarch and Technology project (MART) was signed between the Government of Pakistan/Pakistan Agricultural Research Council and USAID. Subsequently, the Arid Zone Research Institute Strengthening Component, one of the five sub-projects of MART, was approved by the parties involved and ICARDA was invited to be the Implementing Agency. In December 1984 ICARDA received the Statement of Work for this component and, following a review of this document by ICARDA management and the scientific staff, we are currently preparing a program of work and budget to establish this collaborative research in Pakistan.

Active collaboration has been established with Turkey and Iran, and useful contacts are being developed with Iraq and the Yemen Arab Republic.

The training activities of the Center received a greater impetus during 1983/84 as a result of the increased interest of national programs in ICARDA as well as the strengthening of our Training Coordination Unit. In this Annual Report, the training activities are presented under each section dealing with the respective research programs to provide a better perspective of the training objectives in different areas of work.

A major effort was made in 1984 to strengthen our Arabic publications. Arabic versions of the 1983 Annual Report and 1983 Research Highlights have been produced and distributed, and other important publications, including RACHIS (the barley and wheat newsletter), are lined up for translation. In 1985 a greater number of ICARDA publications will be issued in Arabic for researchers, extension workers, and policy makers in the region and elsewhere.

Construction of our building complex at Tel Hadya is progressing at a satisfactory pace. Laboratories 1 and 2 and the Training and Communications building should be ready for occupation toward the end of 1985 or beginning of 1986.

We have introduced a new feature beginning with this year's Annual report: At the end of each project report the names of the scientists concerned are given. It is hoped that this will help readers who want more information on a particular topic to contact the appropriate researchers at ICARDA. The work reported here, however, would not have been possible without the painstaking efforts of a large number of support staff in each program, who are not named here but whose valuable contributions are gratefully acknowledged.

In conclusion, I would like to express our deep sense of gratitude to all the donors on whose support ICARDA depends. I wish to thank all the ICARDA staff who continue to work with dedication and enthusiasm even with the limited physical resources and other facilities. I also wish to acknowledge the enthusiastic cooperation from national programs and research institutions in the region, as well as many institutions in developed countries, and our sister international centers. ICARDA owes a special word of thanks to its host country, the Syrian Arab Republic, for its continuing whole-hearted support and cooperation.

I sincerely hope that this report will prove useful to all those concerned with improving food production in the region and elsewhere.

Mohamed A. Nour
Director General

The Weather During the 1983/84 Season

The 1983/84 season in northwestern Syria was characterized by rainfall far below the long-term average (Table 1). Seasons as dry as this occur only once in approximately 10 years.

At Tel Hadya, Jindiress, and Breda, however, the season started off very favorably. November rainfall was well distributed and well above the long-term average. This, together with temperatures almost 2° C warmer than usual, ensured rapid germination and emergence at these three sites. Conversely, at Khanasser, November rainfall was slightly below normal and not sufficient to induce germination.

December was extremely dry at all four sites. Similar or lesser amounts of rainfall in December are not likely to occur more frequently than once in about 30 years. Each of the sites received 40-50 mm rainfall in January (Tables 2 to 5), which finally enabled crops to germinate and emerge at Khanasser.

In February, rainfall again was way below average. By the end of the month crops were under extreme moisture stress at all sites except Jindiress. This resulted in a severe depression of yield, even though rainfall throughout March and April was favorable. At Jindiress, the overall seasonal rainfall was comparable to that received at Tel Hadya during a normal season. The last rain of the season fell unusually early in the last week of April.

Temperatures were slightly warmer than usual until March and there was only an average number of frost days (Table 7), in contrast with the previous two seasons, which were markedly cooler.

Table 1. Monthly precipitation during the 1983/84 season as percentages of the long-term averages.

	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Season
Tel Hadya	169	33	234	26	84	25	64	101	0	0	0	0	69
Jindiress	82	86	255	22	58	52	99	142	0	0	0	0	82
Breda	0	61	138	24	93	40	119	98	0	0	0	0	72
Khanasser	0	5	83	15	112	55	128	66	0	0	0	0	68

Table 2. Tel Hadya 1983/84: Monthly meteorological data.

Month	Max temp (°C)[1]	Min temp (°C)[2]	Avr temp (°C)	Rel hum (%)[3]	Rain (mm)[4]	Evap (mm/d)	Sol rad[5]	Wind run (km/d)
September								
Mean or total	33.5	16.2	24.9	46.3	2.2	10.4	16.3	374
(Abs.) Max	38.1	21.0	28.7	62.0	2.2	15.1	18.1	735
(Abs.) Min	29.0	9.2	20.4	27.0	0.0	3.7	13.3	133
October								
Mean or total	26.9	9.9	18.4	46.0	6.4	5.8	13.2	230
(Abs.) Max	32.8	17.0	23.0	66.0	3.4	10.2	15.8	556
(Abs.) Min	20.8	4.8	13.9	18.5	0.0	1.6	5.3	109
November								
Mean or total	19.5	8.7	14.1	73.5	71.5	2.1	8.9	146
(Abs.) Max	26.7	14.6	18.1	95.0	17.6	5.1	14.0	244
(Abs.) Min	13.8	4.5	10.4	49.5	0.0	0.5	3.0	63
December								
Mean or total	14.3	3.0	8.6	73.4	18.0	1.7	8.6	221
(Abs.) Max	19.4	9.8	13.2	91.0	5.6	3.9	11.4	750
(Abs.) Min	7.2	-3.9	4.1	61.0	0.0	0.4	1.6	61
January								
Mean or total	12.3	3.3	7.8	78.1	49.3	1.2	7.1	159
(Abs.) Max	17.0	7.2	9.8	94.0	11.7	3.0	14.2	460
(Abs.) Min	9.2	-2.4	5.3	61.0	0.0	0.2	2.0	30
February								
Mean or total	15.2	1.7	8.5	66.1	11.8	2.4	13.6	194
(Abs.) Max	17.5	8.5	12.5	93.5	4.8	4.3	19.1	536
(Abs.) Min	8.5	-4.1	6.1	45.5	0.0	0.6	3.4	100
March								
Mean or total	18.2	5.4	11.8	65.8	31.1	3.6	16.5	223
(Abs.) Max	24.6	11.2	15.0	78.5	7.4	6.3	23.2	502
(Abs.) Min	12.4	-0.5	7.9	47.5	0.0	1.6	5.9	117
April								
Mean or total	21.0	6.7	13.9	67.5	38.8	5.0	20.0	215
(Abs.) Max	29.0	13.8	19.2	81.0	13.8	8.3	26.8	436
(Abs.) Min	15.0	2.2	10.2	50.5	0.0	1.8	9.9	101
May								
Mean or total	30.1	12.8	21.4	46.5	0.0	10.8	26.6	292
(Abs.) Max	35.4	17.0	25.4	66.5	0.0	17.4	29.3	613
(Abs.) Min	23.8	4.7	14.3	25.0	0.0	5.7	15.4	114
June								
Mean or total	33.3	17.5	25.4	44.3	0.0	14.7	29.2	452
(Abs.) Max	38.0	20.2	28.8	60.0	0.0	17.7	30.8	696
(Abs.) Min	28.6	13.1	21.5	28.5	0.0	10.9	19.2	209
July								
Mean or total	35.8	19.9	27.8	44.6	0.0	15.5	28.3	504
(Abs.) Max	40.0	24.0	30.7	58.0	0.0	19.2	30.2	748
(Abs.) Min	31.6	16.0	24.2	21.5	0.0	11.1	26.4	244
August								
Mean or total	34.0	19.7	26.9	47.4	0.0	14.8	26.0	551
(Abs.) Max	37.2	23.0	28.4	60.5	0.0	17.0	28.6	785
(Abs.) Min	31.8	16.8	24.3	23.0	0.0	11.6	23.4	310
Mean or total	24.5	10.4	17.5	58.3	229	7.4	17.9	297
(Abs.) Max	40.0	24.0	30.7	95.0	17.6	19.2	30.8	785
(Abs.) Min	7.2	-4.1	4.1	18.5	0.0	0.2	1.6	30

Footnotes for Tables 2 to 5.

1. (Abs). Max = Absolute maximum temperature.
2. (Abs). Min = Absolute minimum temperature.
3. (Abs). Max = Day with highest average relative humidity.
   (Abs.) Min = Day with lowest average relative humidity.
4. Mean or total = Total monthly or seasonal rainfall.
   (Abs.) Max = Day with highest rainfall.
5. in $MJ \cdot m^{-2} \cdot d^{-1}$.

Table 3. Jindiress 1983/84: Monthly meteorological data.

Month	Max temp (°C)[1]	Min temp (°C)[2]	Avr temp (°C)	Rel hum (%)[3]	Rain (mm)[4]	Evap (mm/d)	Sol rad[5]	Wind run (km/d)
September								
Mean or total	32.8	16.7	24.8	54.5	1.4	9.9	17.7	286
(Abs.) Max	37.8	20.7	28.0	64.9	1.4	16.4	22.9	676
(Abs.) Min	27.2	9.3	19.6	27.6	0.0*	4.0	11.2	115
October								
Mean or total	26.5	10.3	18.4	55.9	21.6	5.4	16.2	184
(Abs.) Max	31.3	17.7	23.2	75.1	8.2	9.6	25.1	495
(Abs.) Min	20.5	5.0	13.6	28.8	0.0	2.2	4.2	101
November								
Mean or total	19.5	9.7	14.6	73.7	127	2.5	8.7	143
(Abs.) Max	27.7	13.6	19.1	91.0	30.4	8.4	14.1	292
(Abs.) Min	15.0	3.5	9.9	43.4	0.0	0.2	2.7	77
December								
Mean or total	14.1	3.8	8.9	73.8	22.6	1.9	8.1	195
(Abs.) Max	18.7	12.8	14.2	90.0	8.4	5.4	11.3	516
(Abs.) Min	7.6	-2.2	4.3	53.3	0.0	0.3	1.0	78
January								
Mean or total	12.4	3.8	8.1	78.8	51.3	2.5	6.6	176
(Abs.) Max	16.5	9.0	11.2	91.4	21.6	5.3	14.1	423
(Abs.) Min	9.4	-1.8	5.9	61.8	0.0	0.3	1.9	73
February								
Mean or total	15.6	3.2	9.4	65.3	39.2	3.1	13.3	198
(Abs.) Max	18.3	7.4	12.8	95.6	22.6	8.0	18.9	569
(Abs.) Min	8.4	-2.3	7.3	43.2	0.0	0.1	2.7	100
March								
Mean or total	17.9	6.5	12.2	69.4	60.4	4.1	15.2	218
(Abs.) Max	25.4	11.0	16.0	84.5	17.0	8.8	25.0	487
(Abs.) Min	11.8	-0.4	6.7	50.4	0.0	0.6	5.5	103
April								
Mean or total	21.2	8.8	15.0	72.1	68.8	4.7	20.3	214
(Abs.) Max	29.0	12.5	20.8	87.1	17.2	10.6	29.7	428
(Abs.) Min	15.0	5.5	11.9	54.0	0.0	0.4	5.6	127
May								
Mean or total	29.9	12.8	21.3	54.0	0.0	8.4	27.3	240
(Abs.) Max	35.0	18.5	25.0	71.0	0.0	13.7	30.9	487
(Abs.) Min	23.5	6.0	14.8	34.0	0.0	1.8	14.7	118
June								
Mean or total	33.2	17.2	25.2	51.8	0.0	12.0	29.7	343
(Abs.) Max	37.0	24.8	30.4	68.8	0.0	20.3	32.9	523
(Abs.) Min	27.7	12.4	22.0	31.3	0.0	8.0	19.3	147
July								
Mean or total	34.2	21.2	27.7	50.8	0.0	14.4	28.9	444
(Abs.) Max	38.2	24.3	29.6	61.5	0.0	21.2	35.0	701
(Abs.) Min	28.1	18.7	23.8	37.8	0.0	8.4	24.4	257
August								
Mean or total	34.1	20.2	27.1	49.2	0.0	12.7	26.6	419
(Abs.) Max	37.5	22.8	28.4	60.4	0.0	16.4	31.4	628
(Abs.) Min	31.5	16.0	25.6	17.3	0.0	7.9	19.8	128
Mean or total	24.3	11.2	17.8	62.4	392	6.8	18.2	255
(Abs.) Max	38.2	24.8	30.4	95.6	30.4	21.2	35.0	701
(Abs.) Min	7.6	-2.3	4.3	17.3	0.0	0.1	1.0	73

Table 4. Breda 1983/84: Monthly meteorological data.

Month	Max temp (°C)[1]	Min temp (°C)[2]	Avr temp (°C)	Rel hum (%)[3]	Rain *(mm)*[4]	Evap *(mm/d)*	Sol *rad*[5]	Wind *run* (km/d)
September								
Mean or total	33.4	14.6	24.0	45.2	0.0	10.0	23.3	265
(Abs.) Max	38.0	20.3	28.6	59.8	0.0	15.0	25.3	486
(Abs.) Min	29.0	9.8	21.6	22.6	0.0	6.2	19.1	116
October								
Mean or total	27.2	9.4	18.3	42.7	8.0	5.8	17.6	186
(Abs.) Max	32.7	15.0	22.5	64.4	6.0	9.3	21.8	377
(Abs.) Min	20.2	5.7	13.6	16.9	0.0	2.7	6.8	109
November								
Mean or total	20.2	8.9	14.5	72.0	45.0	2.9	10.0	162
(Abs.) Max	27.3	14.9	18.3	91.2	11.2	6.6	15.9	276
(Abs.) Min	15.0	4.8	11.1	33.8	0.0	0.4	3.2	68
December								
Mean or total	14.4	2.0	8.2	77.7	14.4	1.8	9.4	230
(Abs.) Max	19.5	10.6	14.4	99.0	5.4	4.9	11.8	632
(Abs.) Min	7.7	-5.0	3.4	60.3	0.0	0.9	3.0	83
January								
Mean or total	12.1	2.2	7.1	82.7	43.6	1.5	8.1	174
(Abs.) Max	15.7	7.8	10.3	100	16.0	7.1	15.0	570
(Abs.) Min	8.2	-3.2	4.4	64.6	0.0	0.2	1.9	53
February								
Mean or total	15.3	1.1	8.2	65.2	14.8	2.7	14.9	203
(Abs.) Max	18.4	6.6	12.1	96.0	5.6	6.9	21.2	724
(Abs.) Min	9.6	-5.5	5.2	44.7	0.0	1.1	4.3	87
March								
Mean or total	18.4	4.7	11.5	66.6	42.8	4.2	18.1	228
(Abs.) Max	25.2	11.7	18.1	79.8	11.0	8.4	26.1	665
(Abs.) Min	12.0	-1.0	6.0	49.9	0.0	1.6	6.9	106
April								
Mean or total	21.9	7.1	14.5	55.0	35.4	4.7	22.5	219
(Abs.) Max	29.6	11.0	20.3	77.0	17.0	8.4	30.3	395
(Abs.) Min	14.8	3.5	10.9	43.5	0.0	1.8	9.0	109
May								
Mean or total	30.7	14.5	22.6	40.8	0.0	10.6	29.4	283
(Abs.) Max	37.2	21.5	27.3	59.0	0.0	18.6	35.4	589
(Abs.) Min	20.6	6.0	13.3	25.5	0.0	4.0	17.4	114
June								
Mean or total	34.0	15.9	25.0	49.8	0.0	15.3	32.2	382
(Abs.) Max	39.0	20.0	28.7	66.8	0.0	19.0	34.0	568
(Abs.) Min	29.4	11.7	21.4	37.0	0.0	10.2	23.8	213
July								
Mean or total	36.7	19.0	27.8	42.3	0.0	17.2	30.9	382
(Abs.) Max	41.0	24.4	30.7	55.1	0.0	23.0	32.9	638
(Abs.) Min	32.7	14.2	23.6	24.6	0.0	13.3	27.4	228
August								
Mean or total	35.7	18.6	27.1	39.9	0.0	16.0	28.5	381
(Abs.) Max	39.0	21.5	28.6	49.9	0.0	20.3	38.3	619
(Abs.) Min	33.0	15.3	24.6	22.1	0.0	12.4	25.4	264
Mean or total	25.0	9.8	17.4	56.6	204	7.8	20.4	256
(Abs.) Max	41.0	24.4	30.7	100	17.0	23.0	38.3	724
(Abs.) Min	7.7	-5.5	3.4	16.9	0.0	0.2	1.9	53

Table 5. Khanasser 1983/84: Monthly meteorological data.

Month	Max temp (°C)[1]	Min temp (°C)[2]	Avr temp (°C)	Rel hum (%)[3]	Rain (mm)[4]	Evap (mm/d)	Sol rad[5]	Wind run (km/d)
September								
Mean or total	*33.7*	*14.6*	*24.2*	*36.5*	*0.0*	*14.2*	*22.6*	*329*
(Abs.) Max	39.8	19.8	28.4	50.2	0.0	20.8	24.5	573
(Abs.) Min	28.8	5.4	17.1	19.4	0.0	9.3	19.2	96
October								
Mean or total	27.1	8.6	17.8	39.4	0.2	8.4	17.1	223
(Abs.) Max	32.8	13.6	22.4	59.6	0.2	13.7	28.7	478
(Abs.) Min	19.8	3.6	13.3	16.3	0.0	4.9	9.9	89
November								
Mean or total	20.6	7.2	13.9	66.7	18.8	3.3	10.4	189
(Abs.) Max	27.3	15.0	18.2	79.8	6.0	6.6	15.0	329
(Abs.) Min	16.1	1.6	9.1	40.8	0.0	0.8	6.4	79
December								
Mean or total	14.6	0.6	7.6	70.9	5.8	2.4	9.5	248
(Abs.) Max	20.0	7.6	13.8	88.0	2.6	7.1	11.6	498
(Abs.) Min	8.0	-7.0	2.0	59.5	0.0	0.7	2.5	82
January								
Mean or total	12.2	1.9	7.0	79.3	42.4	1.4	8.3	199
(Abs.) Max	16.0	7.0	10.6	97.5	13.8	3.1	13.6	423
(Abs.) Min	9.2	-3.9	3.9	60.8	0.0	0.3	2.8	103
February								
Mean or total	14.8	0.9	7.8	65.5	21.2	3.5	13.7	230
(Abs.) Max	17.9	6.4	11.5	97.5	10.6	7.5	18.5	597
(Abs.) Min	*9.2*	-4.3	5.4	*40.7*	*0.0*	*0.4*	*3.8*	*90*
March								
Mean or total	19.3	5.4	12.3	64.1	43.6	5.4	16.2	270
(Abs.) Max	26.7	12.0	18.5	79.2	19.8	10.2	23.3	591
(Abs.) Min	12.0	-0.6	7.1	46.4	0.0	1.1	6.3	136
April								
Mean or total	22.4	7.2	14.8	57.1	19.6	7.7	21.1	276
(Abs.) Max	29.7	11.0	19.0	69.3	6.2	11.9	26.8	461
(Abs.) Min	17.2	3.5	11.4	40.8	0.0	3.7	9.9	99
May								
Mean or total	30.8	13.3	22.0	35.8	0.0	15.6	26.1	336
(Abs.) Max	*37.2*	*18.7*	*27.0*	*60.3*	*0.0*	22.5	29.2	*649*
(Abs.) Min	23.4	5.8	14.6	22.5	0.0	8.8	15.9	135
June								
Mean or total	35.1	16.9	26.0	36.5	0.0	21.0	31.1	457
(Abs.) Max	39.6	20.2	29.1	51.3	0.0	27.4	36.0	705
(Abs.) Min	30.5	12.5	21.6	25.5	0.0	15.0	22.6	297
July								
Mean or total	37.8	19.3	28.6	34.2	0.0	21.4	32.9	460
(Abs.) Max	41.5	25.8	32.7	47.4	0.0	29.2	35.9	637
(Abs.) Min	32.5	14.8	24.5	17.4	0.0	15.9	29.4	330
August								
Mean or total	35.1	17.3	*26.2*	*33.7*	*0.0*	19.0	30.1	456
(Abs.) Max	38.5	21.4	29.4	44.8	0.0	24.8	32.6	604
(Abs.) Min	32.2	13.2	22.7	18.0	0.0	15.9	26.9	342
Mean or total	25.3	9.5	17.4	51.6	152	10.3	19.9	306
(Abs.) Max	41.5	25.8	32.7	97.5	19.8	29.2	36.0	705
(Abs.) Min	8.0	-7.0	2.0	16.3	0.0	0.3	2.5	79

Table 6. Seasonal rainfall at ICARDA research sites in Syria, 1983/84.

Site	Latitude	Longitude	Altitude (m)	Long-term average rainfall (mm)	1983/84 seasonal rainfall (mm)
Breda	35°55'N	37°10'E	350	283	204
Hama	35°08'N	36°45'E	316	325	223
Hassake	36°30'N	40°45°'E	300	279	146
Homs	34°45'N	36°43'E	487	480	320
Idleb	35°56'°N	36°39'E	446	479	391
Jindiress	36°23'N	36°41'E	231	476	392
Khanasser	35°47'N	37°30'E	350	225	152
Lattakia	35°30'N	35°47'E	7	784	713
Qamishly	37°03'N	41°13'E	467	480	240
Raqqa	35°57'N	39°00'E	251	207	93
Salamieh	35°00'N	37°02'E	480	309	202
Sweida	32°42'N	36°35'E	997	364	295
Tel Hadya	35°55'N	36°55'E	362	342	229

Table 7. Frost events at the FSP research sites (1980-1984).

	1980/81 season	1981/82 season	1982/83 season	1983/84 season	Mean
Khanasser					
Number of frost days	47	47	66	31	48
Absol. min. temp. (°C)	-7.5	-7.0	-9.3	-7.0	
Breda					
Number of frost days	37	40	62	32	43
Absol. min. temp. (°C)	-6.5	-8.0	-9.8	-5.0	
Tel Hadya					
Number of frost days	23	39	52	25	35
Absol. min. temp. (°C)	-4.0	-7.8	-9.8	-3.9	
Jindiress					
Number of frost days	19	39	51	20	32
Absol. min. temp. (°C)	-4.0	-7.0	-8.5	-2.3	

Table 8. Agroecological zonation of Syria

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

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

Farming Systems

Contents

Cover: On-farm trials, following farmers' management, are used to test the responses and economics of fertilizer use on barley. Farmers' opinions on such trials are of great value in directing our research.

Farming Systems

Since ICARDA's foundation in 1977, the development of the Farming Systems Program (FSP) has been guided by two major factors: a need to develop methodologies of research and training most suited to serving ICARDA's objectives, and a continuing realignment and refining of both short and long-term objectives as both our knowledge of current constraints to agricultural production and our experience in evaluating potential solutions increase. The 1983/84 season was typified by this process of development and proved to be both exciting and challenging for the Program.

Staff Changes

Several staff changes took place in 1983/84. After 3 years as FSP Leader, and 5 years at ICARDA as an agroeconomist, Dr. David Nygaard left to join the Agricultural Development Council and was succeeded by Dr. Peter Cooper who for the previous 5 years had been responsible for crop agronomy/soil moisture research. This work will now be continued and expanded by Dr. Hazel Harris, recruited from University of New England, Australia. Dr. Karl Harmsen also left ICARDA to join IFDC after 4 years of soil fertility research and has been replaced by Dr. Abdulla Matar from Tishreen University, Syria. Dr. Eugene Perrier, from ICRISAT, has also joined the Program as a Water Management Specialist to develop and lead our new field of research into the role and impact of small-scale supplementary irrigation in rainfed agricultural systems. Dr. Fares Asfary, Postdoctoral Fellow Agronomist, left the Program on completion of his 2-year appointment, and was replaced by Mr. Wolfgang Goebel who previously had worked as an agroclimatologist in Ethiopia. Mr. Goebel will be developing ICARDA's agroecological zonation work. Dr. Dennis Tully joined as a Postdoctoral Fellow, and in his role as an Anthropologist has brought a new and welcome discipline of research to the Program.

Two Postdoctoral Fellows, Dr. Habib Amamou (Economist) and Dr. Aida Kawouk (Sociologist), and three postgraduate students — Miss Eglal Rashed (Agronomist), Miss Mirella Mokbel (Nutritionist), and Mr. Mahmoud Wahoud (Agronomist) — also left the Program, but we were rejoined by Miss Andree Rassam who completed her M.Sc. in Canada on Women's Labor and Impact of Technologies, and by Mr. Yousef Sabet who completed 6 months training in France and is now working for a Ph. D. in Rainfall Intensity/Soil Erosion Studies. Mr. Mohamed Abdel Moneim also joined the Program to work for a Ph. D. in Nitrogen Dynamics of Urea Fertilizer. Lastly, we were joined by two colleagues from the Sudan, Dr. Awad el Karim Ahmed and Mr. Salah Abdel Magid. Dr. Awad is with us for 1 year as a Postdoctoral Fellow engaged in Livestock Economic Research and Mr. Magid for 6 months studying for his M.Sc. in Forage and Livestock Surveys. In Tunis, our Farming Systems Project officially started in January 1984, and Dr. Tom Stilwell joined as agronomist.

New Project Structure

As well as these changes in personnel, changes also took place in our project structure. Our 1983/84 research results are reported under a new project structure for the first time. In previous years we reported our results under six project headings, namely:

(1) Productivity of Cereals
(2) Nitrogen Fixation and Productivity of Legumes
(3) Crop Rotations and Cropping Systems
(4) Livestock (transferred to PFLP)
(5) Environmental Zoning
(6) Farming Systems Research in Tunisia

But the above project structure allowed presentation of results only within a "component" framework. It did not provide a means whereby research relevant to a particular farming system could be reported in an integrated fashion within one project. For instance, much of our current research is focused in areas where a barley/livestock farming system predominates and yet to assess this work a reader would need to extract information from four projects. As such, we felt the need to present our results in a way which reflected the multidisciplinary and systems-orientated approach which is the essence of Farming Systems Research.

Our new project structure is based on the rationale that there are clearly distinguishable farming systems in ICARDA region. Each system has its unique characteristics and problems, and requires specific research objectives and methodologies. Therefore, beginning with this annual report, our core research program, based in Syria, will be reported under the following three major project headings:

Project 1: Barley/Livestock Systems Research
Project 2: Wheat-Based Systems Research
Project 3: Inter-Systems Research

Project 3, although of direct relevance to both Projects 1 and 2, in fact spans across all farming systems. Such research is conducted within, or is related to, the complete range of environmental and socioeconomic conditions within ICARDA region, and is thus most logically and clearly reported within this context. Ultimately, of course, the results of such work will be integrated into defined farming systems. In this first year of reporting within this new structure, Project 1 results are reported in some detail since it is in this project that much of our effort is focused. In Project 3, some different, but complementary approaches to the problem of extension of results through agroecological zonation are presented. Project 2 is not reported this year, but the results will be made available separately.

Other projects will be developed as our research progresses. This year we also report initial results of our joint work with the Tunisian National Program in Project 4, Cereal/Livestock Systems in Tunisia. Next year we hope to report progress in Project 5, High-Elevation Farming Systems in Baluchistan, and Project 6, Barley/Livestock Farming Systems in Northwest Egypt.

1983/84 Meteorological Summary

Meteorological data for our four principal research locations in Syria are shown in Figs 1 and 2, and Table 1. The season at all locations was characterized by unusually low seasonal rainfall totals. Totals as low as these are likely to occur about once in 10 years. However, even more striking was the distribution of rainfall. At the three wettest locations, Jindiress, Tel Hadya, and Breda, the early rains in November were above the long-term average (LTA), and good crop establishment was observed, both in our trials and in farmers' fields. However, rainfall in December and February was well below average, and monthly totals as low as these are very unusual, occurring about once in 30 years. At Khanasser, the November and December rains were insufficient for crop germination, which was delayed until January.

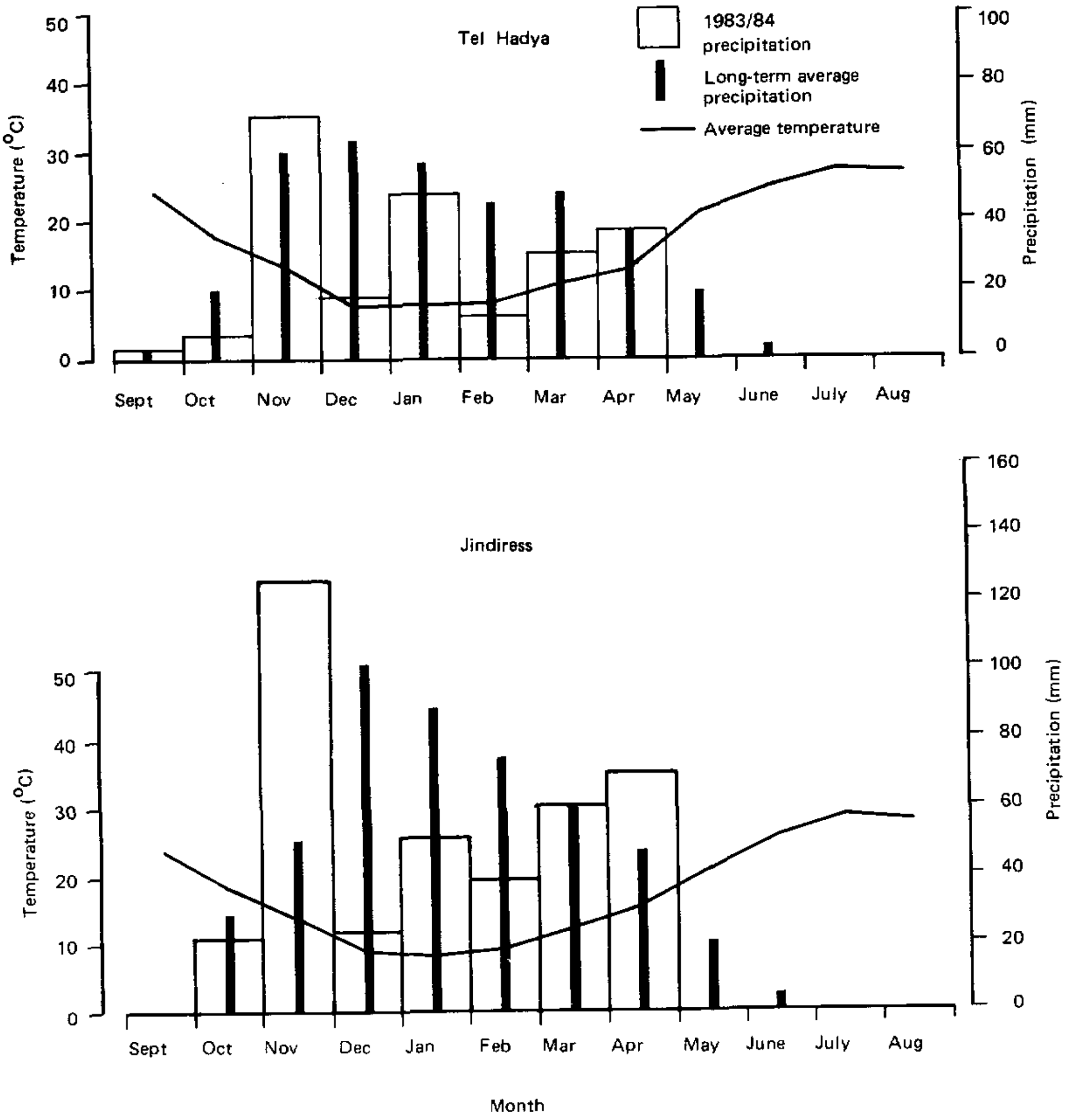


Fig. 1. Monthly precipitation and average temperature at Tel Hadya and Jindiress, 1983/84 season.

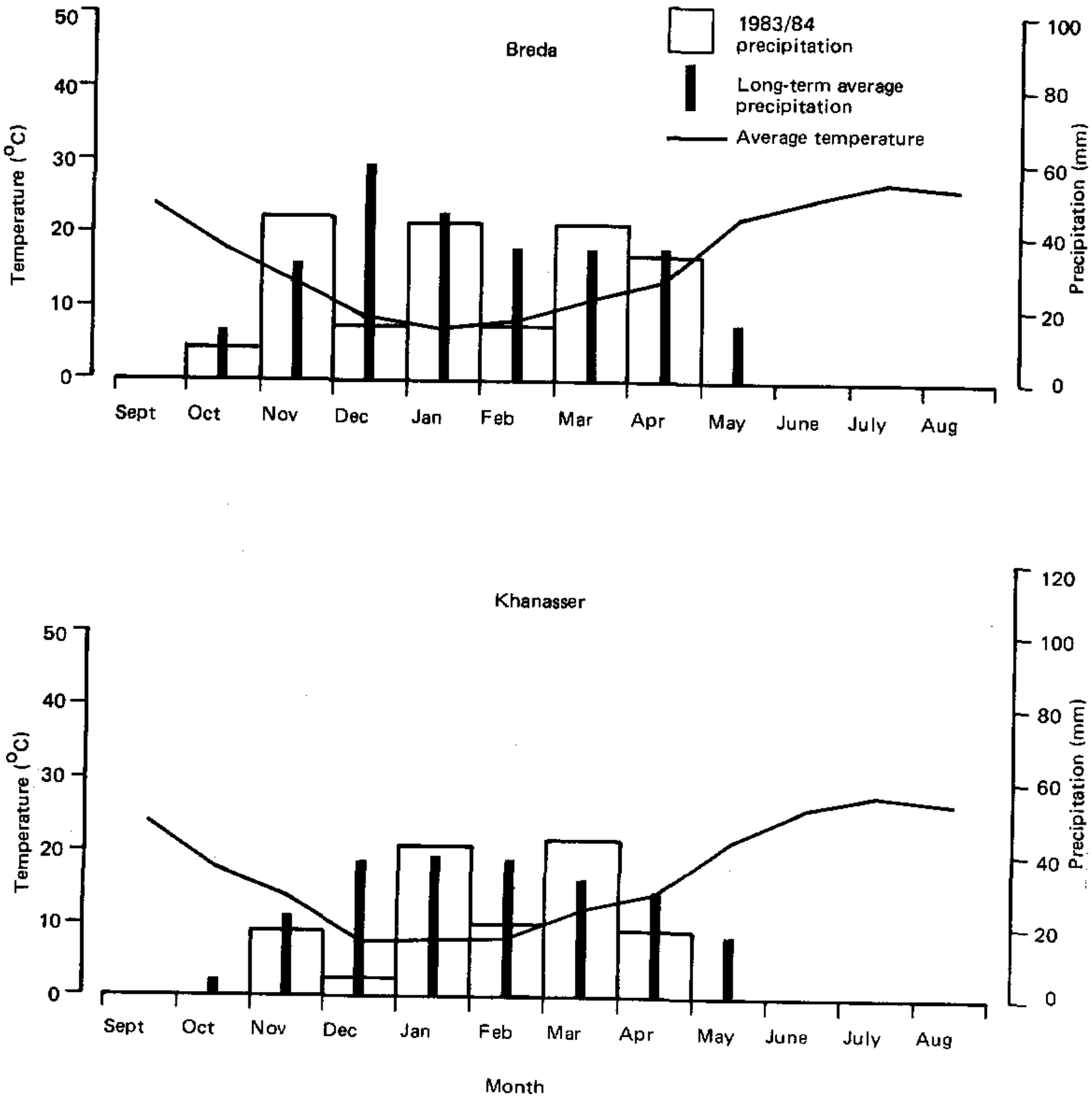


Fig. 2. Monthly precipitation and average temperature at Breda and Khanasser, 1983/84 season.

Table 1. Frost events at the FSP research sites (1980-1984).

Site	1980/81	1981/82	1982/83	1983/84	Mean
KHANASSER					
Number of frost days	47	47	66	31	48
Absol. min. temp. (°C)	−7.5	−7.0	−9.3	−7.0	
BREDA					
Number of frost days	37	40	62	32	43
Absol. min. temp. (°C)	−6.5	−8.0	−9.8	−5.0	
TEL HADYA					
Number of frost days	23	39	52	25	35
Absol. min. temp. (°C)	−4.0	−7.8	−9.8	−3.9	
JINDIRESS					
Number of frost days	19	39	51	20	32
Absol. min. temp. (°C)	−4.0	−7.0	−8.5	−2.3	

Table 1 indicates that the 1983/84 winter season was somewhat warmer than the immediately preceding seasons, with fewer frost days and higher absolute minimum temperatures. However, comparison of these results with long-term data suggests that temperature in 1983/84 was closer to the LTA, and that the preceding winter seasons were colder than would normally be expected. The implications of these weather patterns on our research results are discussed more fully in the following text.

Research Highlights

The unusually dry season experienced in Syria during 1983/84 had pronounced effects on crop performance, both in farmers' fields and in our research plots. Nevertheless, such years are a salient feature of the Mediterranean environment, and any potential improvement in farming practice will have to stand the test of such years. In this respect, the 1983/84 season provided invaluable information in many of our research projects. Some of the most striking results are highlighted below:

1. Substantial responses of barley to phosphate were again observed at locations which this year received less than 200mm of rainfall. Yields up to 1.7 t/ha of grain were obtained at Breda in contrast to adjacent farmers' crops which largely failed or were grazed. (see Project 1, Agronomy within Fallow/Barley Rotations, and Effect of Crop Rotation on Fertilizer Responses.)

2. A joint Syrian Soils Bureau/ICARDA Workshop was held, which examined, in depth, the potential for fertilizer use in dry areas. As a result, a collaborative program of research throughout the barley growing areas of Syria was established to reevaluate existing fertilizer policy which *does not, at present, encourage fertilizer* use in such areas.

3. The introduction of forage legumes into current dryland rotations continued to show promise (Project 1, Alternative Crop Rotations), and even in this dry year, crop

rotations containing these legumes performed well. The greatly reduced supply of barley feed for sheep resulted in a pronounced increase in the price of barley and forage legumes at harvest time. Thus, inspite of the lower than usual yields obtained in our trials this year, economical analyses indicated that many of the rotations showed increased profitability.

4. *Further survey work (Project 1, Feasibility of Annual-Sown Forage Legumes in Barley/Livestock Systems)* continued to examine the feasibility of introducing forage legumes and confirmed that high production costs could be a constraint to adoption unless yields can be raised.

5. Studies of Biological Nitrogen Fixation (BNF) (Project 1, Agronomic Studies of BNF by Forage Legumes, and Microbiological Studies of BNF by Forage Legumes) of forage legumes showed that an improved management package had a significant effect on increasing BNF. In addition, studies again indicated that damage to root nodules by the larvae of sitona weevil may be causing large losses of BNF potential in many farmers' fields.

Another important aspect of the 1983/84 season was the rapid progress achieved in the first full season of our FSR project in Tunisia (Project 4). This has been entirely due to the enthusiasm and cooperative spirit which has evolved between the Tunisian national program and ICARDA. It is an encouraging sign for the future, and with the appointment of an agronomist in Tunisia, we expect this rate of progress to be maintained.

Our outreach activities increased this year with program staff travelling to Tunisia, Morocco, Cyprus, Jordan, Egypt, Sudan, Pakistan, Lebanon, and Turkey. Many of these trips have strengthened old contacts, but in Pakistan and Morocco new contacts were established.

Project 1: Barley/Livestock Systems

Barley is the second most widely grown cereal crop in West Asia and North Africa, and is predominant in environments receiving between 200 and 350mm of rainfall. In most countries, both the barley grain and straw are almost entirely utilized as feed for sheep, and thus crop and livestock management are closely interlinked. In these systems, rainfall is low and variable, so seasonal distribution of rainfall is of major importance. Because of the uncertainty of crop performance, farmers appear hesitant to make substantial investments in agriculture, and in many countries national policies also reflect this attitude since they place more emphasis on higher potential areas.

Because these systems are prevalent in those areas of ICARDA region where the poorest farmers live, FSP has allocated much of its resources to examining the potential for improvements in such systems. Currently, our work is focused within Syria where barley/livestock systems occupy a large proportion of the cultivated area. Nevertheless, many of the problems we have identified and the potential solutions which we are researching and testing are relevant to similar environments in other countries.

Several diagnostic surveys of these systems in Syria have been undertaken and reported. The trends observed are summarized. During the last 30-50 years important changes have occurred which have led to a decline in productivity. The introduction of mechanization and an increase in population have resulted in more intensive cultivation of the land and the expansion of production into more marginal areas. Land used to be fallowed for one or more years, but in many areas this is being replaced by continuous cereal cropping. But the increased exploitation of the land has not been matched by increased inputs, resulting in poor soil fertility and therefore low yields. Although economic responses to fertilizer have been demonstrated in research fields, very few farmers currently use fertilizer. Lack of investment in inputs is further exacerbated by land tenure systems in northeast Syria where large custom operators sharecrop the land of smaller farmers, an arrangement which does not provide an incentive for investment to either party.

Associated with the low levels of productivity, severe seasonal shortages of sheep feed occur. Winter and early spring are critical, and during these periods the sheep rely on supplementary feed (both produced on farm and purchased) and native grazing obtained either on local communal marginal grazing areas or by moving the sheep to the steppe. Currently, the productivity of these grazing areas is very low and is likely to become worse.

Another important aspect of these systems is that many farmers are now seeking off-farm employment. This probably reflects both increased opportunity for such activities and a decline in profitability of farming. Whatever the reason, the relative scarcity of labor, particularly in critical seasons, may well have implications for the introduction of new farming practices.

Many of these issues are discussed in more detail later. It seems probable that unless substantial and economically feasible improvements can be made available to the farmers in these areas, both through research and changes in policies, the process of declining productivity will threaten to continue to a level at which farming will no longer be a viable proposition. Faced with the issues of low productivity, low rural incomes, and the need to conserve the natural resource base of these systems, our research is focused within three main topic areas: (a) increased productivity of currently practiced crop rotations, (b) alternative crop rotations, and (c) the on-farm testing and evaluation of potential changes. Much of this work is conducted in close collaboration with the Pasture, Forage, and Livestock Program since changes in crop husbandry techniques can only be fully evaluated when integrated with livestock management research.

Improvements in Current Cropping Rotations

Our results over the last five seasons have consistently shown that substantial economic increases in barley yields can be obtained through improved crop management, largely through the correct use of phosophate and, to a lesser extent, nitrogen fertilizers. Detailed studies on the effect of phosphate fertilizer on crop water use have consistently shown that the large production increases obtained do not depend on increased water use. In many instances, water use is reduced in crops receiving phosphate, largely due to a faster rate of development resulting in a shorter growing season and earlier maturity. Although total crop evapotranspiration is largely unaffected, the increased crop canopy, and thus greater soil shading, radically changes the ratio of crop transpiration to soil evaporation. This important finding has been discussed in detail in ICARDA Annual Report (1982). These results, however, were observed in barley grown in a fallow/barley rotation. Results from long-term rotation trials have shown that fertilizer responses are considerably modified within a continuous barley rotation. The results for the 1983/84 season, the driest in our experience, support those from previous seasons, and also examine in more detail the effect of crop rotation on fertilizer response. The potential role of improved varieties was also assessed for the second year.

Agronomy within Fallow/Barley Rotation

The main effects and interactions of important management factors were again studied in a 2^5 factorial design giving 32 combinations of five factors (phosphate fertilizer, nitrogen fertilizer, variety, weed control, and sowing method) at two levels. The trial was conducted at four locations spanning the 200-350 mm rainfall gra-

Table 2. Main effects and interactions of five management practices on barley grain and straw yields (kg/ha) at three sites in northern Syria, 1983/84.

Main Effect		Tel Hadya (230 mm)		Breda (204 mm)		Khanasser (152 mm)	
		Grain	Straw	Grain	Straw	Grain	Straw
Nitrogen	+	1590**	2190**	751	633*	269	260
	−	1320	1720	775	596	271	262
Phosphorus	+	1520*	2130**	874**	722**	331**	309**
	−	1390	1780	652	506	209	213
Variety	Improved	1630**	2180**	738	652	238*	242
	Local	1280	1730	788	576	302	280
Weed Control	+	1570*	2080*	755	607	260	256
	−	1350	1830	771	621	280	266
Sowing Method:	Drill	1540*	2110**	949**	765**	311**	295**
	Broadcast	1370	1800	577	463	230	227
	SE ±	189	208	120	113	59	48
Interactions:							
	N− N+						
P−	X X		1680 1880**				
P+	X X		1760 2500				
Treatments							
1) N (kg/ha) (Urea)	+	60		20		20	
	−	0		0		0	
2) P_2O_5 (kg/ha) (TSP)	+	60		60		60	
	−	0		0		0	
3) Variety:	Local	A/Aswad		A/Aswad		A/Aswad	
	Improved	Harmel		Harmel		Harmel	
4) Weed Control	+	Brominal		Brominal		Brominal	
	−	n/a		n/a		n/a	
5) Sowing Method:							
	Drill	17.5 cm		17.5 cm		17.5 cm	
	Broadcast	45 cm ridge & tabban		45 cm ridge & tabban		45 cm ridge & tabban	

* *Significant at* $P<0.05$; ** *Significant at* $P<0.01$.

dient. The treatment details and results for three of the locations are given in Table 2. The fourth location, Ghrerife, was lost due to severe drought preceded by poor rains during the germination period. Barley was sown at a seed rate of 100 kg/ha, with the phosphate and 20 kg N/ha applied with the seed at sowing, where applicable. At Tel Hadya, an additional 40 kg N/ha was top-dressed at the start of stem elongation. Weed control treatments were also applied at this time.

The following points are of interest. In spite of the drought year, reasonable yields were obtained, in contrast to farmers' crops in adjacent fields which were largely grazed off in February/March, and consistent responses to phosphate fertilizer were again observed at all sites. Nitrogen responses occurred at Tel Hadya (230 mm rainfall), but were not observed at the two drier locations (Breda 204 mm, Khanasser 152 mm). This confirms our earlier results that nitrogen response decreases with decreasing rainfall. Pooled regression analyses of barley

Even in the dry 1983/84 season, phosphate application enhanced early growth rates and grain yields of barley in northwest Syria.

yields from five locations over 3 years with environmental variables (seed rate, nitrogen and phosphate fertilizer, soil nitrogen and phosphorus, and rainfall) indicated a significant ($P < 0.02$) positive rainfall x nitrogen fertilizer interaction. This interaction is so strong that it cannot be eliminated by other interactions of rainfall, nitrogen, and other variables. (For more details, see Project 3 in this report).

The improved barley variety, Harmel, outyielded the local variety at the wettest location (Tel Hadya), was not different at the intermediate site (Breda), and was significantly worse at the driest site (Khanasser). This supports our previous results that in dry and harsh environments, it will be hard to improve on the local landraces. A more detailed examination of the potential for improved varieties is reported in the next section.

Weed control effects decreased with rainfall which is again consistent with results reported in the 1983 Annual Report. This reflects the inherently lower levels of weed infestation at dry locations. Drilling the seed gave a yield advantage over broadcasting across ridges at all locations. Since the seed and phosphate fertilizer are applied together, this yield advantage probably reflects both better crop geometry and better phosphate placement (very important in calcareous soils) in the drilled treatments, but no phosphate x sowing method interactions were observed.

In conclusion, the results obtained this year support those of previous seasons, and clearly indicate that, even in very dry years, there is considerable potential for improvement in barley yields, particularly through phosphate fertilizer application. — *P. J. M. Cooper.*

The Potential of Improved Varieties

Syrian landraces of barley show considerable variation from location to location, but can be broadly grouped into Arabi Abiad (white) and Arabi Aswad (black). Farmers currently favor these types for their general adaptability and good grain and straw quality. ICARDA has the global responsibility for barley improvement, and therefore has a strong barley breeding project within the Cereal Crops Improvement Program (CP). FSP has been cooperating with CP in evaluating the performance of some of the most promising lines in dry and harsh environments, and PFLP has undertaken considerable research on their straw quality. In 1982/83, 10 improved varieties were grown at two locations in northern Syria, Ghrerife, (240 mm in 1982/83) and Khanasser (290 mm in 1982/83), typical representatives of the drier barley growing areas. At both locations, in the absence of nitrogen and phosphate fertilizer, the local Arabi Aswad significantly outyielded the improved cultivars. However, its superiority was far less pronounced when fertilizer (20 kg N/ha, 60 Kg P_2O_5/ha) was added.

This trial was repeated in 1983/84 at four locations spanning the 200-350 mm rainfall range, namely, Tel Hadya, Breda, Ghrerife, and Khanasser. Varieties were grown with and without N and P fertilizer at the same rates as in 1982/83. Both N and P were applied at planting, and seed was drilled at a rate of 100 kg/ha. Herbicide Brominal Plus (bromoxynil + MCPA) was applied uniformly at stem elongation. A randomized block design with three replicates was used. Only the grain yield results are presented in Table 3, but the main points discussed also apply to straw yields. Varieties are ranked on their overall performance (plus and minus fertilizer) for each location.

Highly significant responses (at $P < 0.01$) to fertilizer were obtained at all three locations, although the responses were not economical at Khanasser where yields were very small. There were no variety x fertilizer interactions. Of the improved varieties, ER/Apam and Rihane performed consistently well at all locations, but at only Tel Hadya did an improved variety (ER/Apam) significantly outyield the local check, and this was only significant when fertilizer was applied.

In general, the improved varieties performed better at the wettest location, Tel Hadya. However, it is interesting to note that the rainfall at Tel Hadya this year (230 mm) was considerably less than that received at Khanasser in 1982/83 (290 mm) where the improved varieties performed so poorly in comparison to Arabi Aswad. This indicates that moisture supply is not the only environmental variable affecting the relative performance of varieties. Soil type, soil fertility, temperature, evaporative demand, and distribution of rainfall, for example, are all important factors and need to be considered when identifying zones for which varieties can be recommended. Evaluation of long-term weather data in terms of probability of amounts and distribution of rainfall, coupled with the use of crop-growth simulation models, will play an important role in this context. This is dicussed further under Project 3.

The results this year support those obtained by both FSP and CP in previous years. It is clear that in the drier barley growing areas where yield expectations are low, the breeding and selection of improved barley varieties will continue to be a difficult and challenging task. To meet this challenge, the CP has started to carry out much of its selection work in drier environments than afforded at Tel Hadya. — *P. J. M. Cooper.*

Effect of Crop Rotation on Fertilizer Response

As already said, most of our research on fertilizer responses in barley has been conducted within the fallow/barley rotation which still predominates in northwest Syria. However, there is evidence

Table 3. Grain yields (kg/ha) in barley variety trials at Tel Hadya, Breda, and Khanasser, 1983/84.

Location: Seasonal Rainfall:	Tel Hadya 230 mm		Breda 204 mm			Khanasser 152 mm		
Variety	N_0P_0	$N_{20}P_{60}$	Variety	N_0P_0	$N_{20}P_{60}$	Variety	N_0P_0	$N_{20}P_{60}$
ER/APM	1610	2450ab	Rihane	850	1300b	Rihane	230	540b
Rihane	1620	2230b	A/Aswad (Control)	800	1330b	ER/Apam	310	410
WI	1590	2220b	Badia	930	1150b	Harmel	220	450b
Harmel	1550	2140b	ER/Apam	830	1180b	A/Aswad (Control)	210	430b
Aurore	1550	2040	WI	860	1090ab	WI	240	380
Badia	1570	1990	Aurore	760	1070ab	Aurore	170	370b
C 63	1520	2020b	Arar	770	1060ab	Badia	180	350b
Arar	1490	1820	C 63	730	990ab	Matnam	100	260a
A/Aswad (Control)	1370	1820	Harmel	700	990ab	Arar	70	200a
Matnam	1330	1290a	Antares	580a	710a	C 63	70	200a
Antares	710a	1220ab	Matnam	580a	610a	Antares	(Failed)	
LSD (0.05) for comparison of any two means is 500 kg/ha			LSD (0.05) is 210 kg/ha			LSD (0.05) is 170 kg/ha		

a. Indicates variety significantly better or worse than control.
b. Indicates significant fertilizer response within variety.

*that these responses are modified by crop rota*tion, and since continuous barley is becoming increasingly common, a trial was designed to examine the contrasting effect of a fallow/barley and barley/barley rotation on responses to nitrogen and phosphate fertilizer.

A 5 x 5 factorial design was used (N 0, 30, 60, 90, 120 kg/ha; P_2O_5 0, 60, 120, 180, 240 kg/ha). The 25 N × P combinations were replicated three times within each rotation.

Barley (Arabi Aswad) seed was drill-sown at 100 kg/ha *with phosphate fertilizer at the re*quired level. Where applicable, 20 kg N/ha was applied at sowing, with the remainder being top-dressed at stem elongation. Uniform control of weeds was achieved by a single spray of Brominal Plus (bromoxynil + MCPA) at stem elongation. Three treatment combinations (N_2P_0, $N_{30}P_{60}$ and $N_{90}P_{180}$), were selected for *detailed comparative crop growth and soil-*moisture studies. Root dry matter and root length density distribution were also determined.

The results of this trial are extensive, so only highlights are reported here. The work is being repeated in 1984/85, after which a more detailed report will be presented.

Table 4 shows the available nitrogen (ammonia plus nitrate) and the moisture distribution in the soil profile at the start of the season under the two rotations. The amount of available *nitrogen and moisture was greater under land* preceded by fallow, which agrees with results obtained from previous studies in our long-term rotation trials.

Dry-matter production data within the three selected treatments in each rotation are presented in Table 5. Differences in growth rates, due to the effects of fertilizer and rotation

Table 4. Initial available nitrogen and moisture distribution under fallow/barley and barley/barley rotations at Breda, 1983/84.

Available nitrogen (ppm)			Soil moisture (cm H_2O/ depth interval)		
Depth (cm)	Fallow/barley	Barley/barley	Depth (cm)	Fallow/barley	Barley/barley
0-20	13.1	5.2	0-15	1.46	1.23
20-40	13.7	3.6	15-30	2.49	2.11
40-60	6.5	3.2	30-45	3.48	2.73
60-90	6.5	5.7	45-60	3.95	3.21
			60-75	4.05	3.52
			75-90	3.94	3.60

Table 5. Total dry-matter production (kg/ha) in three selected treatments in two barley rotations, Breda, 1983/84.

Days post-germination (12/11/83)	Barley/barley N_0P_0	Barley/barley $N_{30}P_{60}$	Barley/barley $N_{90}P_{180}$	Mean for rotation	Fallow/barley N_0P_0	Fallow/barley $N_{30}P_{60}$	Fallow/barley $N_{90}P_{180}$	Mean for rotation
75	90	130	170	130	130	160	210	170
96	160	350	530	350	170	410	750	440
118	350	570	880	600	380	740	960	690
139	730	1620	1880	1410	900	1510	2680	1700
154	1050	1730	2400	1730	1170	1970	3300	2150
166	1010	1630	2270	1640	1540	2200	2970	2400
Harvest	860	1580	2250	1560	1340	2090	2880	2100

Table 6. Components of barley yield (Arabi Aswad) in selected treatments in 5 × 5 (NP) trial in two rotations at Breda, 1983/84.

Rotation/Treatment		Grain yield (kg/ha)	1000-grain weight (g)	Straw yield (kg/ha)	TDM (kg/ha)	E_T (G-M) (mm)	WUE[1] (kg/ha/mm)	
	N_0P_0	740	38.6	600	1340	171	7.84	
Fallow/Barley	$N_{30}P_{60}$	1160	40.7	930	2090	174	12.00	(53%)
	$N_{90}P_{180}$	1540	38.3	1340	2880	176	16.36	(109%)
	N_0P_0	470	34.4	390	860	160	5.40	
Barley/Barley	$N_{30}P_{60}$	770	34.7	810	1580	161	9.81	(82%)
	$N_{90}P_{180}$	1100	32.8	1150	2250	162	13.89	(157%)

1. WUE of TDM. Figures in parentheses indicate % increase over N_0P_0 treatment for each rotation.

became apparent at an early stage of growth. The effect of rotation was evident even in the presence of high levels of fertilizer application ($N_{90}P_{180}$) and started to show during the winter months when the soil profile was recharging with water and no moisture stress was occurring. Thus the improved fertility and moisture status of land following a fallow do not alone account for the observed differences in growth and subsequent yield.

Components of yield, water use, and water-use efficiency data for the selected treatments are presented in Table 6. In both rotations fertilizer application resulted in large increases in grain and straw yields, but yields for a given fertilizer treatment were consistently smaller in the barley/barley rotation.

Evapotranspiration (E_T) between germination and maturity was only marginally affected by fertilizer application, largely because of the very dry season which imposed severe stress on all treatments. Nevertheless, the initial wetter profile following fallow (Table 4) provided additional available moisture, and this is evident in the greater seasonal E_T totals of crops following fallow. The extra moisture was stored between 30 and 75 cm, below the depth of wetting by the current season's rainfall (Fig. 3) and was

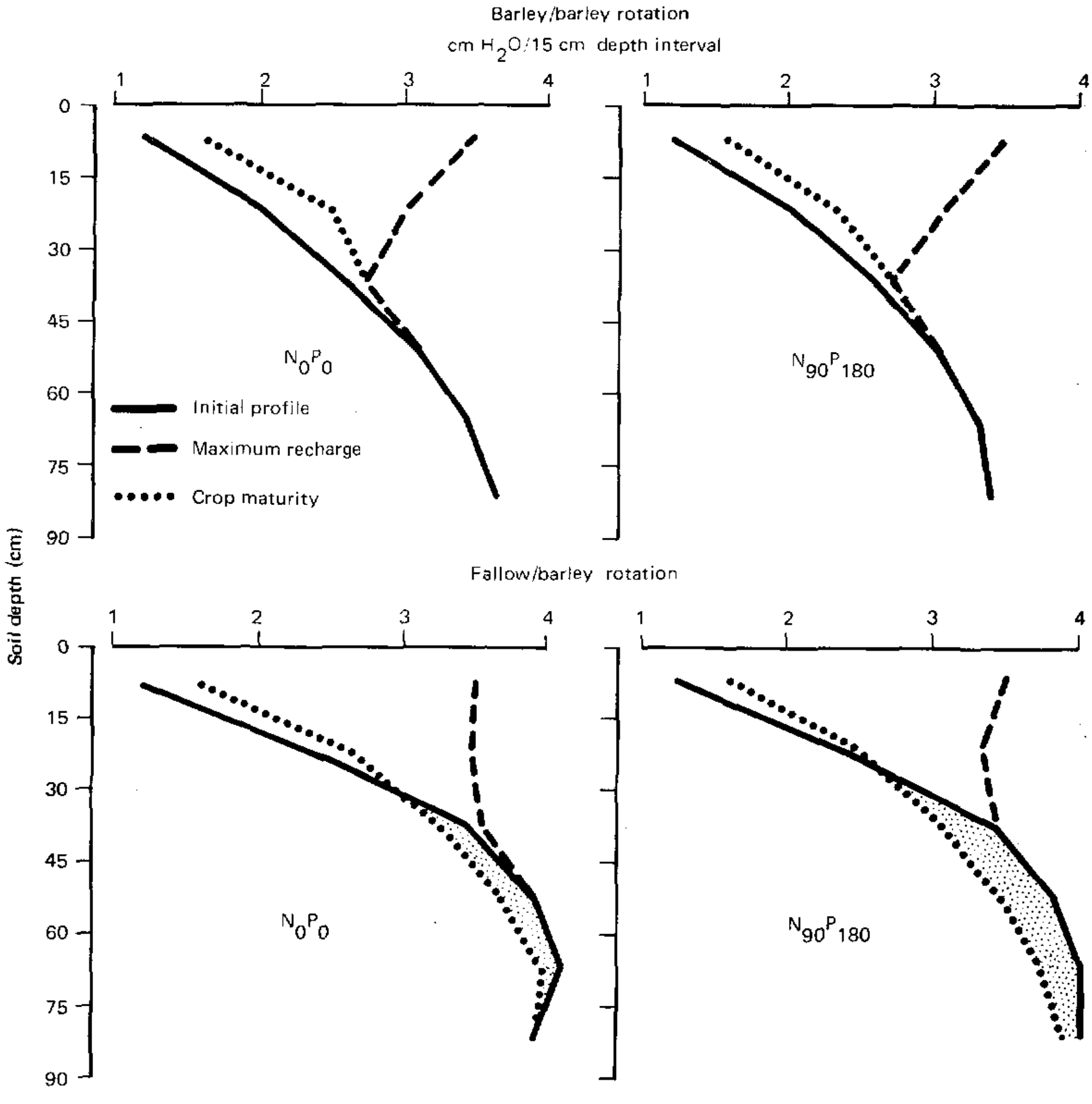


Fig. 3. Moisture distribution under two contrasting crop rotations on the selected days (1) initial profile, (2) maximum recharge, and (3) crop maturity. (Shaded area represents utilization of moisture stored from previous season).

utilized by the crop during the grain-filling period. This additional supply of moisture, and hence reduced stress, resulted in larger 1000-grain weight of barley following fallow (Table 6). As in previous seasons, fertilizer application resulted in a dramatic increase in water-use efficiency (WUE) in both rotations, but WUE was consistently less in the barley/barley rotation for a given fertilizer treatment.

Extractable moisture, defined as the difference between the maximum observed within a given depth interval and that recorded at maturity, is determined by both the available moisture supply in the soil and the ability of the crop to take up that moisture. These values are presented in Table 7, and indicate both the effect of fallowing

Table 7. Extractable moisture (cm H_2O/15 cm depth interval) in selected treatments under two barley rotations at Breda, 1983/84.

Depth interval (cm)	Barley/Barley			Fallow/Barley		
	N_0P_0	$N_{30}P_{60}$	$N_{90}P_{180}$	N_0P_0	$N_{30}P_{60}$	$N_{90}P_{180}$
0-15	1.99	1.99	1.99	1.99	1.99	1.99
15-30	0.49	0.59	0.73	0.81	0.92	0.92
30-45		0.04	0.05	0.26	0.38	0.39
45-60				0.18	0.35	0.39
60-75				0.04	0.16	0.26
75-90					0.05	0.13
Total	2.48	2.62	2.77	3.28	3.85	4.08

on available moisture, and the effect of fertilizer on the crop's ability to extract that moisture. Our studies have clearly shown that improved nutrition of a barley crop results in more prolific rooting, and that the amount of extractable moisture within a given soil depth interval is closely related to the root length density within that horizon (Fig. 4).

At harvest, data on yield components were obtained for all treatment combinations. Full analyses of these data have not yet been completed, but the main effects of nitrogen and

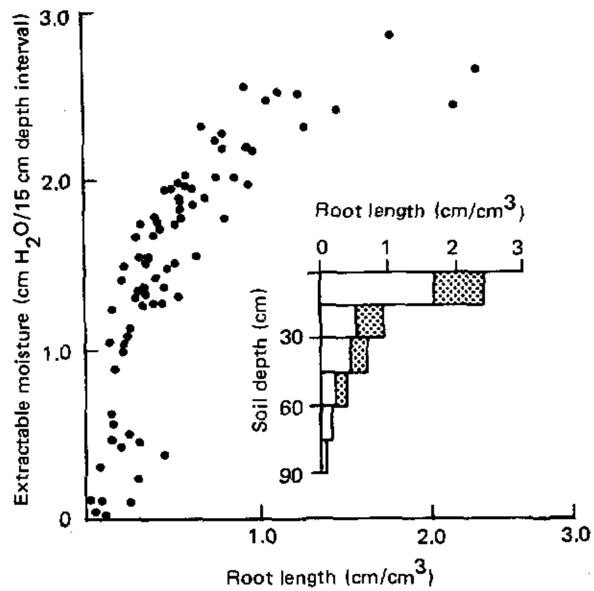


Fig. 4. Relationship between root length density of barley and extractable moisture. The inset shows the effect of fertilizer (shaded area) on root distribution of barley with depth at Breda, 1982/83.

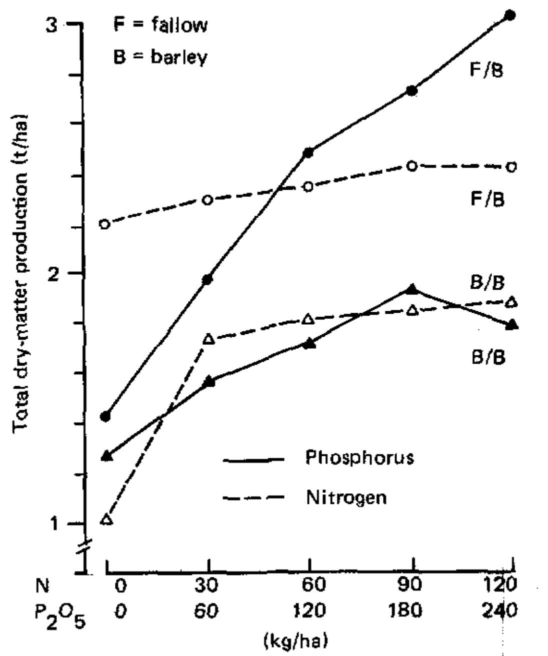


Fig. 5. The main effects of nitrogen and phosphorus fertilizers on total dry-matter production of barley in two contrasting rotations (F/B, B/B), 1983/84.

Table 8. Regression equations for barley grain and straw yields (kg/ha) in two rotations at Breda, 1983/84.

	Constant	N	P	N x P	N^2	P^2
Fallow/Barley						
Grain yield	760	−0.39	5.6	0.96×10^{-2}	-0.10×10^{-2}	-0.10×10^{-1}
Sig. level		NS	***	*	NS	**
Straw yield	590	0.18	4.4	-0.10×10^{-2}	-0.63×10^{-3}	-0.58×10^{-2}
Sig. level		NS	***	NS	NS	**
Barley/Barley						
Grain yield	390	11.0	3.1	-0.27×10^{-2}	-0.57×10^{-1}	-0.74×10^{-2}
Sig. level		***	**	NS	***	*
Straw yield	370	8.3	2.3	0.10×10^{-1}	-0.48×10^{-1}	-0.78×10^{-2}
Sig. level		***	**	*	***	**

1. Sig. levels (*, 5%); (**, 1%); (*** *sig. at 0.0005% or higher*).
2. The Null hypothesis that there were no significant differences between the two response surfaces in F/B and B/B was subjected to an F-test according to the equation:

$$F = \frac{(RSS_p - \Sigma RSS_i)/k + 1}{\Sigma RSS_i/n + m - 2k - 2}$$

where RSS_p = residual sum of squares of pooled regression.
RSS_i = residual sum of squares for individual rotations.
k = number of variables in regression equation.
n and m = number of observations in fallow/barley and barley/barley regression equation.

Highly significant F-values (52.2 for grain; 34.8 for straw) were obtained and the Null hypothesis was rejected. (F 6, 138 at 1% = 2.80).

phosphorus fertilizer on total dry matter (grain plus straw) are presented for both rotations in Fig. 5, and the regression equations relating grain and straw yields to fertilizer levels are given in Table 8. There were substantial and highly significant differences between the fertilizer response levels in the two rotations. There was no significant response to nitrogen fertilizer in the fallow/barley rotation, but there was in the barley/barley rotation. The response in the latter case was associated with the first 30 kg N/ha and above that the response was very small and similar to those in the fallow/barley rotation. Significant phosphate responses were observed in both rotations, but the response per kg P_2O_5 applied was much less in the barley/barley rotation, and this is reflected in the linear terms of the regression equations. The economic implications of these results have still to be assessed.

This experiment will be repeated during the 1984/85 season, and the results can then be more fully evaluated. However, it is clear that even in this very dry year, substantial responses to fertilizer occurred in both rotations. Differences observed in nitrogen responses can be largely accounted for by the different initial nitrogen status of the soils, but the differences in response to phosphorus are not so easy to explain. It seems likely that the less efficient uptake of phosphorus is associated with a less efficient and prolific root system. In this context, the probability of root diseases or changes in microflora leading to accumulation of toxic root exudates within the continuous barley rotation cannot be ignored and should be examined in more detail.
— *P.J.M. Cooper and K. Somel.*

Research in Alternative Crop Rotations

Research has shown that there is considerable scope for the introduction of annually-sown forage legumes into dryland barley rotations, either to replace fallow, or to break the cycle of continuous barley. Forage legumes such as vetch, peas, or lathyrus can provide a supply of high quality feed for sheep as a grazing crop in late winter/early spring, or as a hay crop harvested in late spring, or as a mature crop harvested for grain and straw.

Barley yields are increased by fallowing, as indicated in this and previous studies. This appears largely due to an increase in available nitrogen, and, to a lesser extent, greater available moisture. It also appears that breaking continuous barley with a fallow year has a less clearly defined beneficial effect which could be associated with the prevention of a build up of pests and diseases. Thus, if fallow is to be replaced by a forage legume without reducing subsequent barley yields, it is important that biological nitrogen fixation (BNF) by the forage crop is sufficient to meet all or most of its needs. Our research is therefore focused on maximizing forage production and BNF while also investigating the effects of these forage legumes (compared with both fallow and continuous barley) on subsequent barley production. This latter research involves long-term phased-entry rotation trials, and includes studies of the management of fertilizer (principally phosphate) and its residual effects.

Agronomic Studies of BNF by Forage Legumes

This experiment began in the 1982/83 season. Forage crops were grown at Jindiress, Tel Hadya, and Breda, both as pure stands and as 80:20 legume/cereal mixtures. At all three locations, forages followed a uniform unfertilized cereal crop. Two levels of management, «traditional» and «improved», were employed (Table 9). A nonnodulating ceral crop (barley) was also planted. BNF was estimated both by the ^{15}N dilution technique using low levels of ^{15}N-enriched ammonium sulphate (20 kg N/ha), and by examining the difference in total nitrogen uptake between the nodulating and nonnodulating crops. In 1983/84, a uniform barley crop was sown on all plots to assess the residual effects of the forage legumes on barley productivity and nitrogen uptake. Phosphate fertilizer (90 kg P_2O_5/ha) was placed with the barley seed to mask the differential residual effect of phosphate applied to the forages. The results from both years of this trial are reported.

Table 10 presents the dry-matter production of the forages in the 1982/83 season. There were significant responses to improved management at all locations, but vetch, both in pure stands and as a mixture, responded less than peas. The inclusion of barley as a mixture with the forage produced no consistent effects across locations, but overall it resulted in a small increase in dry-matter production. In the «improved» practice treatments, where environmental constraints other than moisture supply had been minimized, there was a clear positive relationship between production and rainfall. This relationship was not apparent in the «traditional» management treatments.

Total crop nitrogen uptake data for the forages are presented in Table 11. Improved management consistently increased crop nitrogen uptake but there was a significant crop x management interaction in which peas appeared to respond better to improved management than vetch. Nitrogen uptake in the legume crops was significantly greater than in continuous cereal under improved management but was no better when traditional management was employed. There appeared to be no effective difference between pure stand legume crops and 80:20 mixtures with barley in terms of nitrogen uptake.

Table 9. Treatment details of "improved" and "traditional" management of forage legumes.[1]

Treatment	Traditional	Improved
Time of sowing	Late winter	Early winter
Row spacing (cm)	45	22.5
Inoculation	*No*	*Yes*
Phosphate (kg P_2O_5/ha)	0	60

1. Seed rate and hand weeding were uniform across management.

In a comparison between environments there was a significant site x crop interaction. Nitrogen uptake was lowest at the driest site, Breda, and differences in N uptake between the legume crops and barley were not significant (Table 11). At Tel Hadya (intermediate rainfall), N uptake was higher than at Jindiress (the wettest site) and N uptake in the legume crops was consistenly greater than in barley. At Jindiress, where soil N levels were higher, as indicated by

Table 10. Dry-matter production (kg/ha) of forage legumes at three locations, 1982/83.

Forage	*Management*	Jindiress *(417 mm)*	Tel Hadya (340 mm)	Breda (285 mm)	Mean across sites
Peas	(Trad.)	580*	2060*	510*	1050*
	(Imp.)	5700	4650	2220	4190
Pea/Barley	(Trad.)	780*	3260*	900*	1650*
	(Imp.)	5920	5390	2430	4580
Vetch	(Trad.)	1270*	2850NS	660NS	1590*
	(Imp.)	4100	3560	1070	2910
Vetch/Barley	(Trad.)	1530*	3730NS	930*	2060*
	(Imp.)	5220	4440	1470	3710
LSD (0.05)		764	812	485	668

* Significant at $P<0.05$.

Table 11. Total crop nitrogen uptake (kg/ha) by forage legumes in a legume/barley rotation, 1982/83.

(a) Interaction: management x crop

Management		Crop:	Peas	Vetch	Peas mix.[1]	Vetch mix.	Barley
Improved			78.3	57.0	80.3	61.3	34.8
Traditional			25.0	32.9	29.2	36.5	34.8
SE ±	= 3.6						
LSD (0.05)	= 8.4						

(b) Interaction: site x crop

Site	Seasonal Rainfall (mm)	Crop:	Peas	Vetch	Peas mix.[1]	Vetch mix.	Barley
Breda	285		27.4	21.1	28.7	24.8	32.6
Tel Hadya	340		76.9	66.2	76.3	65.7	28.0
Jindiress	417		50.8	39.9	59.2	56.4	44.0
SE ±	= 4.4						
LSD (0.05)	= 10.3						

1. Mixture with barley as an 80:20 proportion.

the uptake of the barley crop, only the legume/barley mixtures took up significantly more N than barley. At this location traditionally-manged legume crops grew very unsatisfactorily (Table 10) and were much poorer in N uptake than those crops with improved management. This remains unexplained but may have been associated with ineffective inoculation by local *rhizobia strains or inadequate phosphate* availability.

The residual nitrogen uptake data of the uniform barley crop planted in 1983/84 are presented in Table 12. In all barley plots preceded by forage legumes, nitrogen uptake was significantly greater than those preceded by barley, but were not different from those preceded by fallow. It must be noted that the fallow plots did not receive the 20 kg/ha of labelled nitrogen in 1982/83.

Table 12. Total crop nitrogen uptake (kg/ha) by barley in a legume/barley rotation, 1983/84.

(a) Crop main effect following:		
Vetch	38.1	
Fallow	37.2	
Peas	36.8	
Vetch mix.[1]	35.9	
Peas mix.	35.2	
Barley	25.7	
SE ±	= 2.9	
LSD (0.05)	= 6.8	
(b) Site main effect:		
	Seasonal rainfall (mm)	
Breda	204	22.5
Tel Hadya	230	17.1
Jindiress	392	58.6
SE ±	= 1.67	
LSD (0.05)	= 4.00	

1. Mixture with barley as an 80:20 proportion.

There were no significant differences in residual N uptake by barley following pure stands or mixtures, nor was there any significant effect of improved or traditional management of the forage crop. This latter result was unexpected, but does not necessarily imply that the contribution of residual symbiotic N in crops under improved management was similar to that under traditionally managed crops. The expected higher levels of residual symbiotic N under improved management conditions may have been offset by available residual soil N in the traditional management plot because less nitrogen was used by legume crops due to poor management, thus mimicing a partial fallow. There were obvious differences between sites with Jindiress showing an exceptionally large uptake of residual nitrogen.

The total amounts of nitrogen fixed *per se* in each treatment are not presented. However, the results of a comparison between the two methods of estimating BNF are discussed. This *comparison of the* ^{15}N *dilution technique for* estimating BNF with that of the substantially cheaper and less complex method of measuring the difference in crop N uptake between a non-fixing crop (barley) and legume crop showed that over two experimental years and at eight sites there was a close relationship between the two *methods of measurement. The methods of* measurement were linearly related as described by the equation:

N by difference method = -13.22 + 1.097 N by ^{15}N method (r_2 = 0.904)

The slope of this line is approximately equivalent to a 1:1 relationship. However, there is a substantial negative intercept because negative values do not occur in the ^{15}N method, and there were occasional instances in which legume crops in traditionally managed systems *grew so poorly that they did not even manage* to use the limited N available to a barley crop following barley.

The closeness of the results of the two methods of measurement indicates that, in the physical environment experienced by crops grown in northern Syria, the difference method is likely to give a satisfactory estimate of BNF with a correction factor of + 13.22 kg N/ha.

In conclusion, it is clear that an appropriate package of improved management practices for forage legumes can contribute substantially to the nitrogen budget of two-course rotations. However, it is important to determine an order of priority of the components of this package to arrive at practical and economic recommendations. This work was started in 1983/84 at Tel Hadya and Breda. Four management factors (phosphate fertilizer, inoculation, row spacing, and weed control) were investigated on three crop species, lentils, vetch, and peas. These crops will be followed by a uniform cereal crop in 1984/85 to assess the residual effects and the results will be reported when the 2 years' data are available. — *D. Keatinge.*

Monitoring seasonal changes of acetylene reduction activity (ARA) of the root systems of food and forage legumes helps us identify constraints to improved biological nitrogen fixation.

Microbiological Studies of BNF by Forage Legumes

Studies reported in the 1983 Annual Report indicated that most legume crops (faba been, chickpea, lentils, vetch, and pisum) produced the bulk of their dry matter after nitrogenase enzyme activity, as reflected by acetylene reduction activity (ARA), had declined to low and sometimes undetectable levels. This was of some concern since it indicated that in most instances a large proportion of the dry-matter production occurred at the expense of soil-nitrogen uptake.

The benefit of replacing fallow by forage legumes in barley growing areas will depend on a large proportion of the crops' nitrogen requirement being obtained through BNF. If the forage crop depletes the native soil nitrogen reserves, it is probable that the subsequent barley crop will suffer from nitrogen deficiency.

Because of the importance of these observations, seasonal monitoring of ARA values of both vetch and peas was continued in the 1983/84 season at Breda. Two trials were monitored, the first being a long-term rotation trial in which several two-course rotations are being compared (see Project 1, Long-Term Rotation Trials). Four barley/vetch rotations were selected. The four treatments were Bo/Vo, Bnp/Vo, Bo/Vp, and Bnp/Vp, where o indicates no fertilizer, n indicates 20 kg N/ha applied to the barley and p indicates 60 kg P_2O_5/ha applied to either barley or vetch, or both phases of the rotation. All vetch crops were inoculated. This trial was started in 1980/81 using a phased-entry design, and thus by the 1983/84 season, the four rotations had received 0, 120, 120, and 240 kg P_2O_5/ha, respectively.

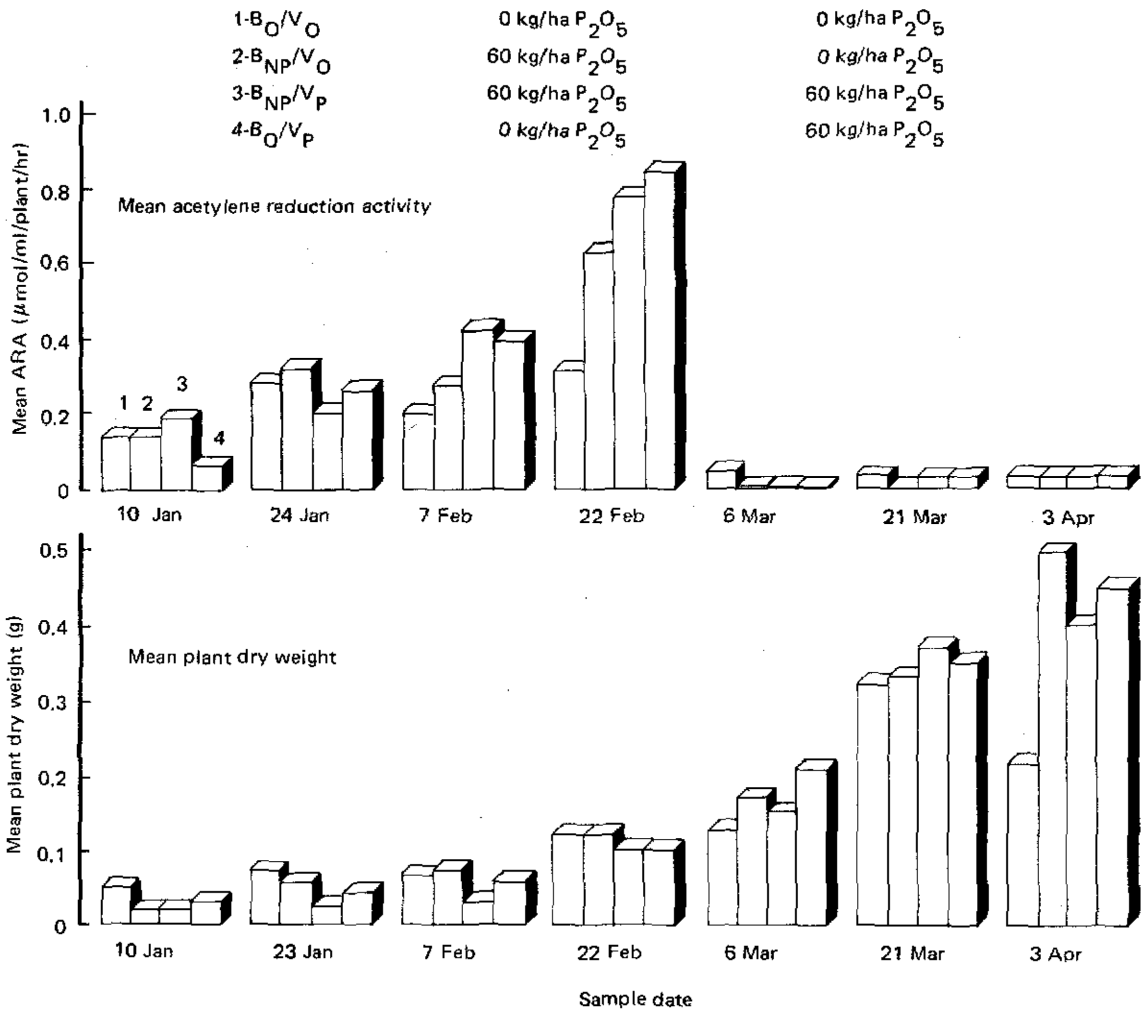


Fig. 6. Histograms of acetylene reduction activity (C_2H_4 production) and mean plant dry weight (g) with time for vetch grown under differing P_2O_5 regimes at Breda, 1983/84.

The results (Fig. 6) showed a pattern similar to that found in 1982/83. ARA values increased during the winter months, but between 22 Feb and 6 Mar, these values dropped dramatically to very low levels. It was around this time that dry-matter production of vetch began to increase rapidly, again indicating that soil nitrogen reserves were being utilized. A comparison of seasonal mean ARA values for the four treatments showed that all rotations receiving phosphate fertilizer had significantly larger ($P<0.01$) seasonal mean ARA values than the rotation receiving none, and that rotations in which phosphate was applied to the vetch phase (Bo/Vp and Bnp/Vp) had larger values than when the phosphate was applied to the previous barley crop. These trends are clearly reflected in the results obtained on 22 Feb when ARA values reached a maximum, and also in the final yield data (Table 13) obtained from a large sample

Table 13. Final yield data and ARA values recorded for forage vetch at Breda, 1983/84.

Treatment	Final yield (kg/ha)	Max. ARA[1] value 22 Feb	Seasonal mean[1] ARA value	Ratio of yield to mean ARA
Bo/Vo	576	0.33	0.139	4.14×10^3
Bp/Vo	850	0.66	0.208	4.09×10^3
Bo/Vp	1048	0.80	0.234	4.47×10^3
Bp/Vp	1007	0.85	0.228	4.42×10^3
LSD (0.05)	106			

1. µ mol /ml/ plant/hr.

taken at harvest (5 m^2/plot). The mean seasonal ARA values appeared closely related to the final yield, which supports the hypothesis that the main causal effect of increased ARA due to the application of phosphate fertilizer results from increased plant vigor, and its associated effect on *Rhizobium* spp. activity.

The dramatic decline in ARA, now observed over two seasons for many legume crops, has important implications both for the nitrogen supply to the legume crop itself, and for the subsequent barley crop. There is evidence that this pattern of ARA is associated with sitona weevil larvae damage to the nodules. The sitona weevil is endemic in ICARDA region and economic control of either the adult or larval stages may have striking effects on the BNF of legume crops, soil nitrogen dynamics, and nitrogen uptake and yield of subsequent cereal crops. This will be more fully investigated for forage legumes in the 1984/85 season.

The second trial monitored at Breda was a 2^5 design which examined the main effects and interactions of five factors: phosphate fertilizer (0.60 kg P_2O_5/ha), weed control (with and without), inoculation (with and without), row spacing (17.5 and 35 cm), and species (vetch, pisum). BNF was measured by the ^{15}N dilution technique in all 32 treatment combinations, and ARA was monitored in selected plots. The residual effect of these treatments on the nitrogen uptake and yield of a following crop of barley will be monitored in 1984/85. The full results of this trial will be reported after the 2-year cycle, and will allow a comparison of seasonal variation in ARA with BNF as assessed by the ^{15}N dilution technique. A summary of the results obtained in the seasonal monitoring of ARA is presented.

Sixteen treatment combinations all at the 17.5 cm row spacing were monitored for seasonal ARA. Mean sesonal ARA was analyzed according to the usual ANOVA technique, and the results are presented in Table 14.

Table 14. Main effects and interactions of four management factors on the seasonal mean ARA values (µ mol /ml/ plant/hr) of forage legumes, Breda, 1984/85.

Main Effects		Seasonal mean ARA
Peas		0.404**
Vetch		0.261
Inoc. +		0.404**
Inoc. −		0.261
$P_2O_5^+$		0.355
$P_2O_5^-$		0.310
WC +		0.427**
WC −		0.238
SE ±		0.033
Interactions		
	$P_2O_5^+$	$P_2O_5^-$
Inoc. +	0.489	0.320*
Inoc. −	0.222	0.299
	WC +	WC −
Inoc. +	0.549	0.261*
Inoc. −	0.305	0.214
	WC +	WC −
Peas	0.560	0.246*
Vetch	0.294	0.230

** $P<0.01$; * $P<0.05$.

Main effect responses to crop species, inoculation, and weed control were found to be significant. However, all four factors were involved in significant first-order interactions, and these are discussed. A phosphate x inoculation interaction indicated a much enhanced phosphate effect on ARA in the presence of seed inoculation. These results can be related to the responses observed to phosphate in inoculated vetch treatments reported earlier in this section.

An inoculation x weed control interaction indicated that inoculation had a greater effect on ARA where weeds were controlled and the interaction of crop species x weed control indicated that peas only supported higher ARA values than vetch when weeds were controlled.

This is the first year that such studies in factorial trials have been conducted, and further supporting data are required before firm conclusions can be drawn. Nevertheless, the results indicate the complexity of interactions of management factors on mean seasonal ARA values, and should caution against overly simplified investigations. It is clear that investigations of the effect of single factors, whilst all other management factors are kept constant, could mask important interactions. Farmers growing legumes employ a range of husbandry practices, and will seldom adopt an improved package of recommendations, but they will adopt components of the package. Thus the interaction of these components on ARA, and hence the implications for BNF, are very important. These studies will be continued during the 1984/85 season. — *J.H. Stephens*.

Long-Term Rotation Trials

Improved management of existing rotations and evaluation of alternative rotations can only be realistically assessed through long-term rotation trials. We have initiated two sets of such trials to compare fallow/barley, barley/barley, and forage legume/barley rotations. The first trial was established in 1980/81 in two typical barley growing areas, Breda and Khanasser. A phased-entry design was used with three replicates. This trial compared three rotations, fallow/barley, barley/barley, and vetch/barley under different fertilizer management regimes. Rotations and treatments are given in Table 15.

Table 15. Rotations and treatments of rotation trials at Breda and Khanasser, NW Syria.

Treatment notation	Phase I[1]	Phase II[1]
Bo/F	Barley (0, 0)	Fallow (0, 0)
Bnp/F	Barley (20, 60)	Fallow (0, 0)
Bo/Bo	Barley (0, 0)	Barley (0, 0)
Bnp/Bnp	Barley (20, 60)	Barley (20, 60)
Bo/Vo	Barley (0, 0)	Vetch (0, 0)
Bnp/Vo	Barley (20, 60)	Vetch (0, 0)
Bo/Vp	Barley (0, 0)	Vetch (0, 60)
Bnp/Vp	Barley (20, 60)	Vetch (0, 60)

1. Figures in parentheses indicate levels of N and P_2O_5 applied (kg/ha).

The trial at Khanasser had to be abandoned due to consistent and severe bird damage to forage legume seedlings, but the site will be used in the next two seasons to evaluate the residual effects of different levels of phosphate application. The trial at Breda has been monitored in great detail for the past three seasons. Soil nutrient, soil moisture and crop dynamics were studied, and these results will be submitted for a Ph.D. thesis. Results obtained during the 1982/83 and 1983/84 seasons are presented in a summary form.

The second set of rotation trials, established at Tel Hadya and Breda in 1982/83, considers more rotations (Table 16), including both peas and vetch as forage legumes, in pure stands and in 80:20 seed-weight ratio mixtures with barley. Different fertilizer-use strategies are examined in the six basic crop rotations.

Table 16. Rotations and treatments of rotation trials at Tel Hadya and Breda.

Treatment notation	Phase I	Phase II[1]
Bo/F	Barley (0, 0)	Fallow (0, 0)
Bnp/F	Barley (20, 60)	Fallow (0, 0)
Bo/Bo	Barley (0, 0)	Barley (0, 0)
Bo/Bnp	Barley (0, 0)	Barley (20, 60)
Bnp/Bo	Barley (20, 60)	Barley (0, 0)
Bnp/Bnp	Barley (20, 60)	Barley (20, 60)
Bo/Vo	Barley (0, 0)	Vetch (0, 0)
Bnp/Vo	Barley (20, 60)	Vetch (0, 0)
B/Vp	Barley (20, 0)	Vetch (0, 60)
Bnp/Vp	Barley (20, 30)	Vetch (0, 30)
Bo/V:Bo	Barley (0, 0)	Vetch/Barley (0, 0)
Bnp/V:Bo	Barley (20, 60)	Vetch/Barley (0, 0)
Bn/V:Bp	Barley (20, 0)	Vetch/Barley (0, 60)
Bnp/V:Bp	Barley (20, 30)	Vetch/Barley (0, 30)
Bo/Po	Barley (0, 0)	Peas (0, 0)
Bnp/Po	Barley (20, 60)	Peas (0, 0)
Bn/Pp	Barley (20, 0)	Peas (0, 60)
Bnp/Pp	Barley (20, 30)	Peas (0, 30)
Bo/P:Bo	Barley (0, 0)	Peas/Barley (0, 0)
Bnp/P:Bo	Barley (20, 60)	Peas/Barley (0, 60)
Bn/P:Bp	Barley (20, 0)	Peas/Barley (0, 60)
Bnp/P:Bp	*Barley (20, 30)*	*Peas/Barley (0, 30)*

1 Figures in parentheses indicate levels of N and P_2O_5 applied (kg/ha).
At Tel Hadya, 40 kg N/ha was applied.

Barley yield and water-use data for 2 years from the first trial (established 1980/81) are presented in Table 17. In both barley/fallow and barley/barley rotations, phosphate and nitrogen application have produced substantial responses in barley production, but fallow/barley rotations outyielded continuous barley in 1983/84. The results mirror those found in the rotation x fertilizer response trial at Breda, discussed earlier. In general, barley yields following vetch are intermediate between those following fallow and those following barley. There was no difference in yield between the phosphate management strategies in barley/vetch rotations, but all barley/vetch rotations receiving phosphate produced significantly higher barley yields than the Bo/Vo rotation. Crop water use was largely unaffected by rotation due to the overall moisture stress conditions, but the Bnp/F rotation clearly utilized more moisture. This reflects some storage of moisture under fallow from the previous year, and an increased ability (due to greater root production) to extract this moisture compared with the Bo/F rotation (see also *Effect of Crop Rotation on Fertilizer Response*). As observed before, both rotation and fertilizer use have dramatic effects on water-use efficiency, with values ranging from 4.8 to 17.1 kg/ha per mm. Vetch hay yields are also presented. These have been discussed in some detail in the previous section.

This trial has now completed two cycles, and the rotational effects are well established. The 1982/83 season (287 mm) and the 1983/84 season (204 mm) provide an interesting contrast of years wetter and drier than normal for this location.

These results were subjected to economic analysis using the cost and price assumptions given in Table 18. Since each of the rotations requires two years to complete a cycle, revenues and costs were computed on the basis of two hectares per season, with each phase of the rotation accounting for one hectare. This corresponds to the situtation of a farmer with half of his land each year in one phase of the rotation and his remaining land in the other phase. The results for two seasons are shown in Fig.7, with arrows in each case indicating the direction of change from the first season to the second. These data and the calculated ratios of net (after cost) revenue to cost for the eight rotations are summarized in Table 19.

Crop yields in the 1982/83 season were greater than those in the drier season of 1983/84 for all of the tested rotations. This was also generally true for much of the nonirrigated

Table 17. Yield and water-use data for treatments (see Table 15) in the rotation trial at Breda, 1982/83 and 1983/84[a]

	Grain yield (kg/ha)		Straw yield (kg/ha)		Water use (mm)		WUE[1] (kg/ha/mm)	
Treatment	**1982/83**	**83/84**	**1982/83**	**83/84**	**1982/83**	**83/84**	**1982/83**	**83/84**
Barley yields								
Bo/F	810	660	1220	1190	218	191	9.2	9.7
Bnp/F	2080	1290	2980	2140	229	201	22.3	17.1
Bo/Bo	450	260	920	620	201	185	7.0	4.8
Bnp/Bnp	1440	720	2240	1440	207	186	17.9	11.6
Bo/Vo	700	510	1120	970	211	188	8.5	7.9
Bo/Vp	1300	910	1540	1440		187		12.6
Bnp/Vo	1880	800	2470	1670	208	189	21.2	13.1
Bnp/Vp	2060	920	3010	1720		191		13.8
LSD (0.05)		230		322				
Vetch hay yields								
Vo/Bo			1460	580				
Vp/Bo			2170	1050				
Vo/Bnp			2270	850				
Vp/Bnp			3000	1010				
LSD (0.05)				106				

a. This work was conducted by Miss Eglal Rashed as part of her Ph.D. research.
1. WUE of total dry matter.

Table 18. Cost and price assumptions of crop rotation budgets for two seasons at Breda, Aleppo province. All values are in Syrian lira.

	1982/83 season		1983/84 season	
Item	**Seeding time**	**Harvest time**	**Seeding time**	**Harvest time**
Tractor cultivation (each)	44/ha		50/ha	
Hand broadcasting (each material)	17/ha		20/ha	
Barley grain	0.95/kg	0.92/kg	1.0/kg	1.5/kg
Barley straw		0.33/kg		0.7/kg
Vetch seed	2.0/kg		2.5/kg	
Vetch hay dry matter (DM)		0.55/kg		1.0/kg
Urea (45% N)	2.0/kg N		2.0/kg N	
Triple Superphosphate (46% P_2O_5)	2.7/kg P_2O_5		2.7/kg P_2O_5	
Barley harvest, transport, threshing, *winnowing and bagging*	120/ha + 0.32/kg grain/ha		138/ha + 0.37/kg grain/ha	
Vetch hay harvest, transport, chopping and bagging	174/ha + 0.29/kg DM/ha		200/ha + 0.33/kg DM/ha	

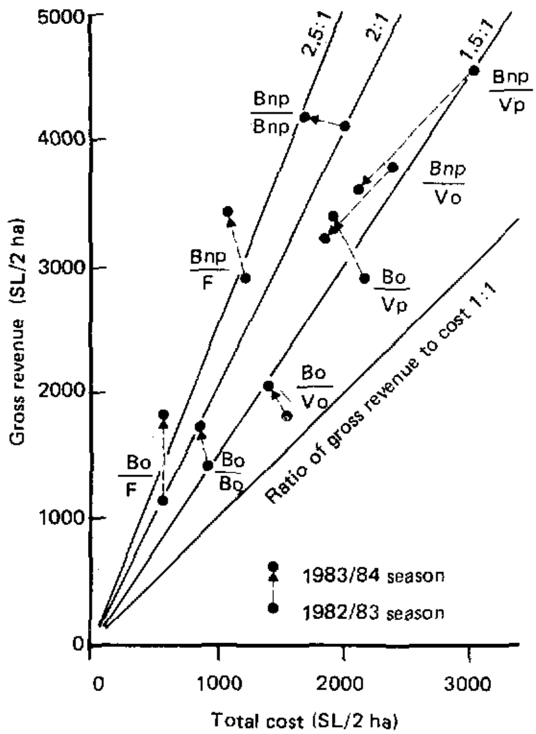


Fig. 7. Gross revenues and costs for eight rotations in two seasons at Breda, Aleppo Province.

farmland and grazing land in Syria, and caused a large increase in sheep feed prices by harvest time in 1984. This increased net revenues of all but two of the eight rotations in 1984, in spite of the lower yields.

All rotations in both years appeared to have covered their costs, some by small margins and others by interestingly large margins. Two groups of rotations are evident: the low-yielding group, Bo/F, Bo/Bo, and Bo/Vo, which received no fertilizer, in contrast to the higher yielding group of fertilized rotations. Another criterion to define groups of rotations is the ratio of gross revenues to costs. The most profitable rotations by this measure are Bo/F, Bnp/F, and Bnp/Bnp, each giving gross revenues more than double their respective costs. Fallow and/or fertilizers are inexpensive ways of boosting crop yields and revenues.

Rotations including vetch hay production had relatively high costs per unit of revenue. Vetch hay has the double economic disadvantage of high seed cost and high harvest and handling cost. Harvested as hay, the vetch crop is too immature to yield seed. If mature vetch is harvested the seed which may be collected from

Table 19. Summary of gross revenue, total costs, net revenues, and simple rates of return for eight rotations in two seasons at Breda, Aleppo province.

	Bo/F	Bnp/F	Bo/Bo	Bnp/Bnp	Bo/Vo	Bnp/Vo	Bo/Vp	Bnp/Vp
1982/83 season								
Gross revenue (SL/2 ha)	1148	2897	1436	4128	1817	3794	2898	4538
Total costs (SL/2 ha)	570	1213	910	2016	1537	2386	2144	2834
Net revenue (SL/ha)	289	842	263	1056	140	704	392	852
Rate of return = (Net revenue/ha / Total Cost/ha)	1.01	1.39	0.58	1.05	0.18	0.59	0.37	0.60
1983/84 season								
Gross revenue (SL/2 ha)	1823	3433	1648	4176	2024	3219	3423	3594
Total costs (SL/2 ha)	592	1067	888	1712	1423	1862	1909	2140
Net revenue (SL/ha)	616	1183	380	1232	301	679	757	727
Rate of return = (Net revenue/ha / Total Cost/ha)	2.08	2.22	0.86	1.44	0.42	0.73	0.79	0.68
Average rate of return for two seasons	1.55	1.81	0.72	1.25	0.30	0.66	0.58	0.64

Nitrogen deficiency is widespread in the soils of ICARDA region. Analysis of seasonal changes in available nitrogen in the soil profile is important in the evaluation of current and alternative cropping systems.

it will have an opportunity value approximately as high as the market price of seed. Thus, the problem of high crop establishment costs would persist. Direct grazing of vetch would have the advantage of avoiding the costly harvest operations, but could reduce the crop's value due to lower total biological yield and the availability of other grazing resources in the spring. A question remains on whether the cost advantages available from the direct grazing of vetch pasture would be sufficient to encourage adoption of the practice.

Some caution is required in the economic interpretations given above, since these trials were conducted in small replicated plots at a single location. Little can yet be said about the performance of these rotations on other soil types in neighboring areas or in farmers' management practice. However, it is encouraging that on-farm forage trials (see below) gave very similar yields to those obtained at Breda station.

Results from the expanded rotation trial at Tel Hadya and Breda (see Table 16) will provide additional detailed results as the effects become established. The results of the second year of the trial on the effect of forage species and pure forage versus mixtures on subsequent barley yields for both locations are given in Tables 20a, and 20b. There was no difference in barley yields following vetch or peas at either location, and at

Table 20a. Comparison of grain yields (t/ha) of barley in peas/barley and vetch/barley rotations at Breda and Tel Hadya, 1983/84.

(a) Breda Rotation	Grain yield	(b) Tel Hadya Rotation	Grain yield
Peas/barley	0.83	Peas/barley	1.73
Vetch/barley	0.84	Vetch/barley	1.68
F_{sig}	= NS	F_{sig}	= NS
SE ±	= 0.108	SE ±	= 0.267

Table 20b. Comparison of grain yields (t/ha) of barley following pure stands and 80:20 mixtures (forage legume/barley) in forage legume/barley rotations in 1983/84 at Breda and Tel Hadya.

(a) Breda Rotation	Grain yield	(b) Tel Hadya Rotation	Grain yield
Pure stand/barley	0.89	Pure stand/barley	1.76
80:20 mixture/barley	0.78	80:20 mixture/barley	1.64
F_{sig}	= 94 %	F_{sig}	= NS
SE ±	= 0.104	SE ±	= 0.266

Tel Hadya there was no effect of pure forage versus a forage/barley mixture. However, at Breda, barley following a pure forage stand outyielded barley following a mixture, although the effect was small. Other effects of fertilizer and rotation on barley yields mirror those reported in Table 17, and these will be reported in more detail next year when 2 years data of established rotational effects are available.

On-farm trials with cooperating farmers in the Breda and al-Bab are under way to answer some of the questions raised above. The preliminary results of this work are summarized in the following text. — *D. Keatinge, E. Rashed, P. Cooper, and T. Nordblom.*

On-Farm Evaluation of Potential Improvements

This section reports on the survey and agronomic and livestock research conducted at the farm level to assess the implications and impact of potential improvements to the system discussed above. This research is conducted in close collaboration with PFLP, which has research projects on improvement of communal marginal grazing areas and livestock management, both integral components of the system. These are reported in the PFLP section of this annual report. This «testing» phase of Farming Systems Research is vital if we are to identify solutions to problems which are acceptable and profitable. The feedback from such work is proving invaluable, and keeps our research focused on the problems facing the farming community.

The very dry season in 1983/84 resulted in very poor crop performance and poor growth of native pastures, and farmers were forced to graze their barley crops. Communal marginal grazing areas were even less productive than usual and critical shortages of feed for village- and steppe-based flocks occurred. As a result substantial sales of ewes and lambs started in February to raise money for feed purchases and flocks were moved to grazing areas in higher rainfall wheat-production zones.

Although years as dry as 1983/84 are not common, their implications for farming practices are important not only for the subsequent year when winter feed shortages for sheep are likely, but also for the years it will take farmers to recover from the economic hardship and reductions of flock size.

As a result of the decisions made by farmers, much of the crop and sheep monitoring which was planned had to be abandoned. Nevertheless, some important results obtained are reported here.

The first section, «Sheep Feeding Strategies at Bueda» examines the current strategy adopted by farmers. The study is being conducted in an area where communal marginal grazing areas are an important feature. The second section, «The Feasibility of Annual-Sown Forage Legumes in Barley/Livestock Systems» reports on a village survey conducted in the al-Bab area of NW Syria where farming systems are similar to Bueda, but there is a lack of communal marginal grazing areas. This has important effects on the sheep feeding cycle.

Sheep production is the central feature of the systems, and all potential improvements must eventually be evaluated in this context. On-farm evaluation of improved practices is reported under «On-Farm Forage Trials» and «On-Farm Barley Trials», below.

Sheep Feeding Strategies at Bueda, NW Syria

Bueda, which is a group of four villages, was selected as a «management unit» for detailed study in 1983/84, as it is representative of 20 villages which had been surveyed during the 1982/83 season. The full details of that preliminary survey are not reported here, but the following important points can be noted.

Farmers report that during the last 20 years yields have declined substantially. As a result of this, and the introduction of mechanization in the early 1960s, fallow areas have decreased from 60 to 30% of the cultivated area. Wheat used to be the principal crop (80% of cropped area), but this has fallen to about 30%, largely being replaced by barley. Lathyrus was also grown for forage (10-15% of cropped area), but has almost entirely gone out of production due to low yield expectation and increased manual harvesting costs.

Sheep numbers have declined, and the large transhumant flocks which traditionally moved to the steppe for spring grazing have become fragmented, although they still account for a large proportion of the sheep population.

The 1982/83 survey indicated that currently, 20-30% of the land cannot be cultivated and is used as communal grazing areas. Of the remaining cultivated land, 6% is irrigated and the rest rainfed. The land-use pattern of the cultivated area is presented in Table 21 which compares the mean results of the 20 villages surveyed with the land-use pattern of the 19 farmers selected for study in 1983/84 in the Bueda area.

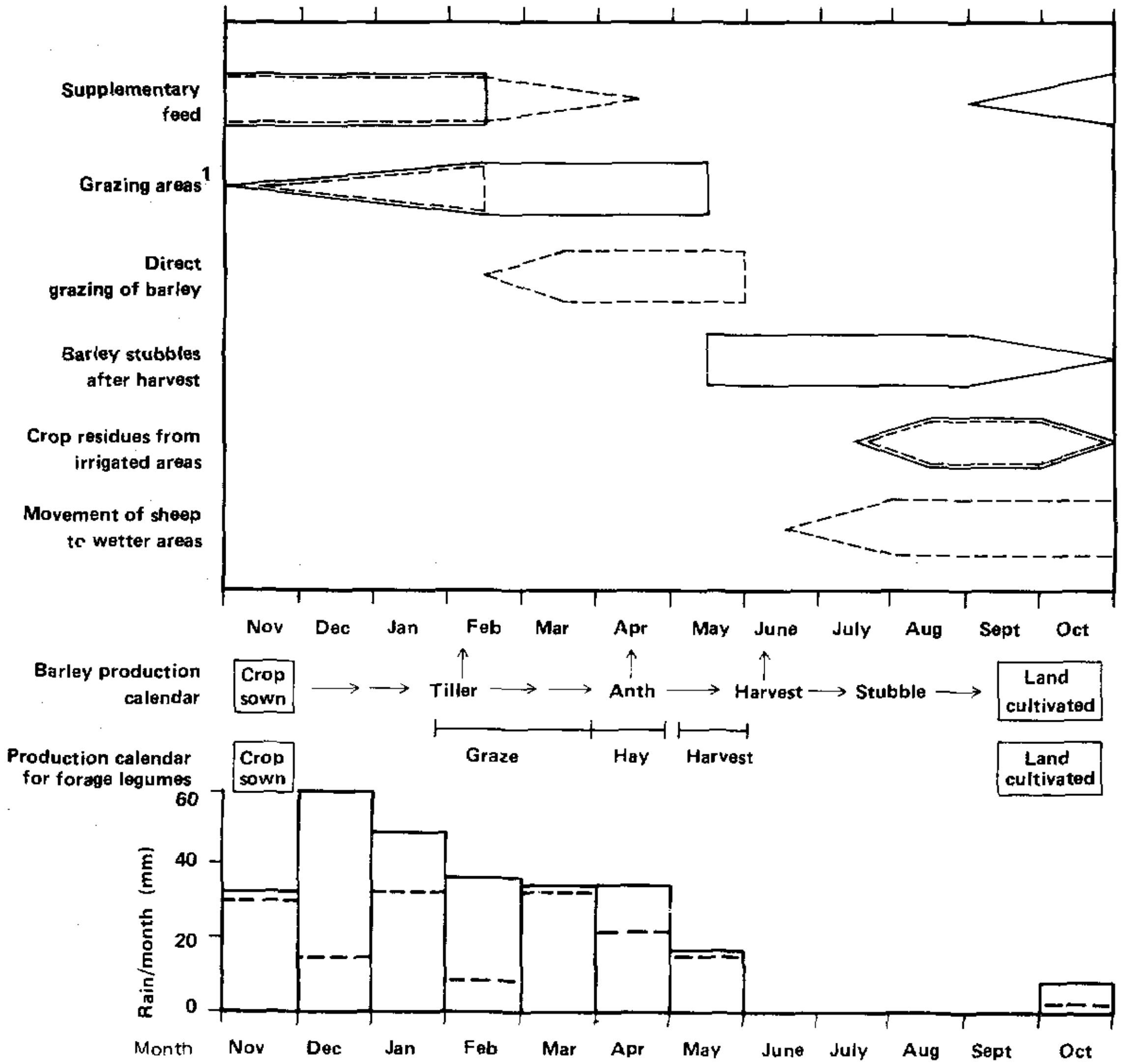
Flock sizes in the 1982/83 survey varied from 3 to 600 head, with an average of 46 head. Over 80% of the farmers in this survey had a flock. These flocks fall into two broad categories: large transhumant flocks of over 100 head which move to the steppe in spring, and smaller flocks averaging only 20-25 head, which remain in the village throughout the year. The transhumant flocks currently represent only 38% of the flocks, but account for 78% of the sheep population.

Cereal stubble grazing is an important component of the sheep feeding cycle in much of ICARDA region.

The study conducted in the Bueda area in 1983/84 was designed to monitor all components of the farming system which related to livestock production, and focused its attention on the village-based flocks. Based on previous survey work, a schematic representation of the contribution of the various components of the

Table 21. Mean land-use patterns of 20 villages in the 250-300 mm rainfall zone compared with mean land-use pattern of 19 selected farmers in Bueda area.

	% of rainfed cultivated area				
	Barley	Wheat	Legumes	Summer crop	Fallow
Mean of 20 villages	45	19.5	2	1.5	32
Mean of 19 Bueda farmers	42	12.0	6	1.5	38



[1] Village based flocks utilize local marginal grazing areas. Transhumant flocks move to steppe land in spring for grazing.

Fig. 8. Feed cycle of flocks at Bueda.

system to the sheep feed cycle is given in Fig. 8. The solid lines represent normal feeding practice as determined during the 1982/83 survey, and the dotted lines represent the patterns observed in the drought year of 1983/84.

From November to mid-February, supplementary feed constitutes the major source of feed. This is either produced on farm (barley grain and straw) or is purchased from outside (cottonseed cake). The actual levels of supplementary feed recorded in the sample flocks are given in Table 22. The amount of feed given to sheep in Bueda

Table 22. Levels of supplementary feed recorded for sample flocks in Bueda, 1983/84.

	DM	ME	CP	Size of sample	% of ewes receiving supplementary feed
November-December	1.9 (0.39)[a]	17	163	602	100
January	1.9 (0.47)	19	190	580	100
February	1.5 (0.61)	19	182	414	100
March	0.8 (0.54)	9	96	416	57
April	0.2 (0.10)	3	55	401	23

a. SD.
DM = Dry matter kg/day/ewe.
ME = Metabolizable energy MJ/day/ewe.
CP = Crude protein g/day/ewe.

is very high (average 1.9 kg/ewe per day) compared with the economically optimum value of 1.1 kg/ewe per day determined at Tel Hadya Unit Farm. In spite of this, the liveweight gain of lambs at Bueda, at 157 g./lamb per day SD± 42), was not higher than those achieved at Tel Hadya which ranged between 161 and 234g/lamb per day over a 3-year period. All these values are below the breed potential of about 300g and 250g per day for male and female lambs, respectively.

In more normal years, supplementary feeding is stopped in February, and sheep become entirely dependent on the communal marginal grazing areas. However, in 1983/84 these areas at Bueda were so unproductive that supplementary feeding was continued into April (Table 22). The flock sample size started to decrease in January due to the farmers' decision to sell off part of their flocks to raise money for purchasing additional feed.

Sheep usually start to move onto the communal marginal grazing areas following the early rains in October/November to take advantage of the first flush of growth. However, these areas are becoming so degraded that it is doubtful whether the daily energy intake during the winter months compensates for the energy required to trek there and back. This is supported by the data that the flocks which trekked to the marginal grazing areas in November, December, and January received a higher level of supplementary feed than the non-grazing flocks (Table 23). Animals usually stay on these grazing areas until

Table 23. Seasonal movement of sheep onto marginal grazing areas as related to supplementary feed supply, Bueda, 1983/84.

	% of sheep on communal grazing areas	Grazing duration (hr/day)		DM intake (kg/ewe/day)		Total sample size
		Grazing flock	Non-grazing flock	Grazing flock	Non-grazing flock	
November	64	4	0	2.2	1.7	602
December	64	4	0	2.2	1.7	602
January	68	5	0	2.2	1.4	580
February	100	7	7	1.7		414

mid-May before being moved onto the barley stubble after harvest, where they remain throughout the summer. However, in 1983/84, production was so low on these grazing areas that the animals were removed at the end of February, and started grazing the immature barley crop, a practice which is seldom used in a normal year. By the end of May the immature barley crops had been grazed off and the supply of feed in Bueda was almost entirely exhausted. Many of the animals were moved out of the village to the wetter wheat-growing areas, again, a practice which is not followed in more normal years. Some of the animals remained in the village and were fed on the residues from the irrigated areas, a common practice even in good years. The irrigated area is relatively small, but the stability of production is an important factor in the sheep feeding cycle, particularly in years when the production of the rainfed areas is low.

Because of the movement of the sheep to wetter areas, the flock monitoring ended in June, and since all barley crops in the study area had been grazed, the planned monitoring of crop production could not take place. This was unfortunate since within the Bueda area, a variety of barley growing practices had been identified and fields had been selected which would have allowed a comparison of phosphate fertilized versus unfertilized fields, manured versus unmanured fields, and fallow/barley versus continuous barley cultivation. Productivity and economic studies on these fields would have provided further valuable information. However, the study will continue during the 1984/85 season.

Fig. 8 indicates the crop calendar for various options of annual forage production. An integral part of this study involved the testing of various annual forages in farmers' fields in the Bueda area. The results of this study are reported below in conjunction with other on-farm forage trials in nearby Breda village, and the potential impact of these options on the sheep feeding cycle are discussed. — *R. Jaubert and E. Thomson (PFLP).*

The Feasibility of Annual-Sown Forage Legumes in Barley/Livestock Systems

As discussed earlier in this report, the possibility of substituting annual forages for fallow has interested ICARDA's Pasture, Forage, and Livestock Program as well as the Farming Systems Program for some time (FSP 1982a, 1982b, 1983; PFIP 1982). The principle is simple. A legume crop uses land which would otherwise be fallow or breaks continuous barley cultivation. The forage legume produced is valuable either for sale or as a nutritious feed for the farmers' livestock. As shown in this report, legumes appear to be almost as beneficial as fallow with respect to a subsequent cereal crop, partly because they fix a proportion of the nitrogen they use, and partly because moisture conservation in fallow years is minimal in these dry areas. Finally, if the farmer is applying phosphate fertilizer to the cereals, the legume takes advantage of residual phosphate which might otherwise become unavailable during the fallow year. Thus, phosphate and a legume crop in combination make a potentially more economic package than either by itself.

On-station and on-farm trials with cereal-forage rotation have been promising. However, a number of potential problems have been raised by farmers participating in on-farm trials and other research at Breda and Bueda (ICARDA 1984; Jaubert 1984). These include labor problems, high costs, and risks involved in growing legumes in dry areas. Therefore, a survey was undertaken to evaluate the feasibility of introducing legume crops, and the circumstances under which they would be attractive to farmers.

Al-Bab *mantika* of Aleppo Province was chosen because it has a great potential for forage introduction, and also because it presents some interesting contrasts to the Breda/Bueda area where most of our other forage work is based (Fig. 9). Al-Bab has a large area of fallow in the 200-350 mm rainfall range where we hope forages can be introduced. Although small, al-

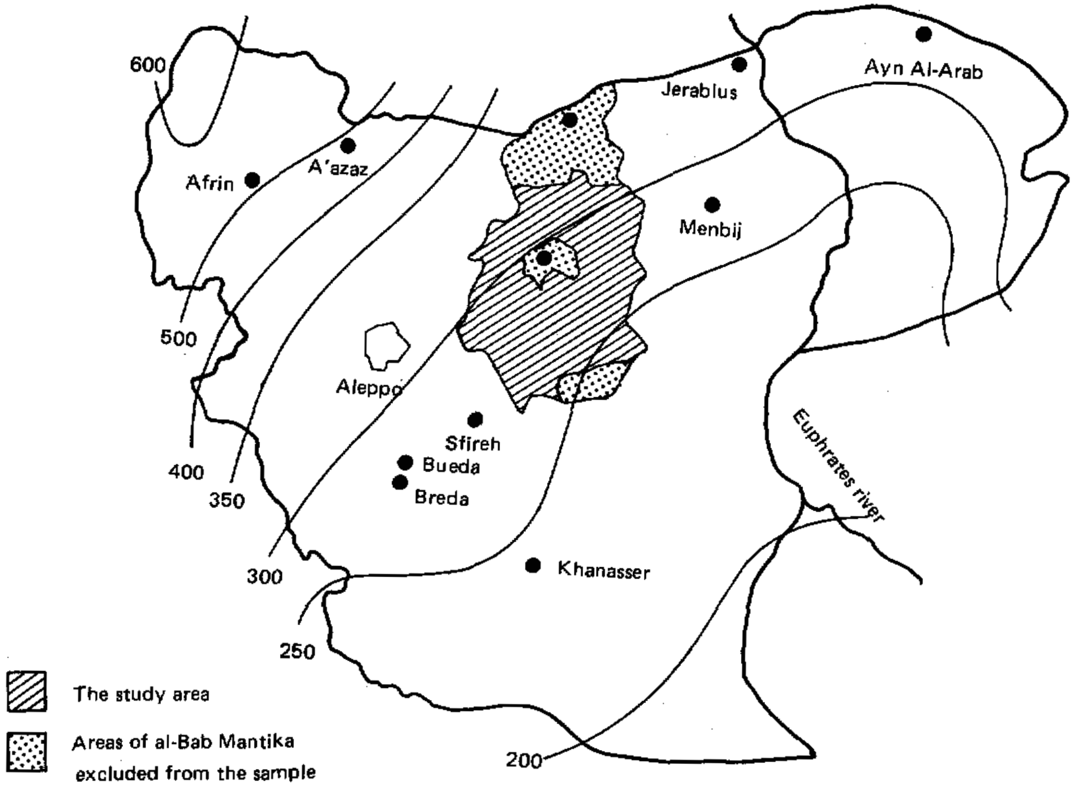


Fig. 9. Location of the study area in Aleppo Province.

Bab makes up a large part of the cultivable dry area of Aleppo Province, particulary in Agricultural Stability Zones 2 and 3. In terms of farm size and land per caput, it is fairly typical of the province. However, it has relatively little communal marginal grazing land, which affects farmer adoption of forages in the Breda/Bueda area (Table 24).

Table 24. Grazing lands by *mantika* in Aleppo province.

Mantika	Total area (ha)	% communal marginal grazing areas
A'azaz	155625	26.9
'Afrin	203375	23.5
Al-Bab	195287	4.7
Menbij	276409	6.4
Jerablus	64253	12.5
'Ayn al-Arab	273000	26.1
Jebel Sam'aan	277724	23.3
Sfireh	404327	66.7
Total	1850000	28.7

To assess the feasibility of adoption of annual-sown forage legumes, a random sample of 24 villages, stratified by position on the rainfall gradient, was surveyed. Information was collected concerning the current and previous usage of land, cultivation practices, hiring of labor, relative costs and benefits of legumes and cereals, and other issues related to legume cultivation. Considerable attention was given to livestock feeding practices, because the demand by farmers to grow forages for their own use will depend upon the ability of forage legumes to meet the deficits in the feeding cycles.

Table 25. Percentages of land planted to each crop by soil depth[1] and analysis group.

Group	Crop	Deep soil	Medium soil	Shallow soil	Total[2]
A					
(Upper Zone 2)	Wheat	27	29	11	22
	Barley	19	17	36	25
	Legumes	17	8	0	9
	Summer crop	37	3	0	18
	Fallow	0	43	53	27
B					
(Middle Zone 2)	Wheat	9	15	21	19
	Barley	32	22	27	27
	Legumes	0	15	0	1
	Summer crop	0	0	0	0
	Fallow	59	47	52	52
C					
(Lower Zone 2)	Wheat	28	30	25	26
	Barley	22	20	25	24
	Legumes	1	0	0	0
	Summer crop	0	0	0	0
	Fallow	49	50	50	50
D					
(Zone 3)	Wheat	16	27	17	20
	Barley	34	23	33	30
	Legumes	0	0	0	0
	Summer crop	0	0	0	0
	Fallow	50	50	50	50
Total	Wheat	24	27	20	22
	Barley	23	20	29	26
	Legumes	11	4	0	3
	Summer crop	23	1	0	5
	Fallow	19	48	51	44

1. Deep = over 80 cm; medium = 40-80 cm; shallow = less than 40 cm. Summer crop figures are those reported for an average year.
2. Some totals do not add up to 100% due to rounding off the decimal places.

A total of 443 ha or 3% of rainfed land is sown to legumes in the 24 villages. Areas of lentils and lathyrus are equal, while the vetch area is about 25% smaller. Almost all of the legumes (407 ha) are grown in the six wettest villages, where they take up 9% of rainfed land (Table 25). They are usually grown in place of fallow in rotation with cereals. However, legumes were grown in rotation with fallow, i.e., in place of cereals, in two villages, making up 25% of the total legume area.

Legumes are usually planted on the deeper soils; about 78% (346 ha)were planted on soils over 80 cm deep, while none were planted on soils less than 40 cm deep. Unfortunately, most rainfed land in the sample area is quite shallow

Table 26. Depth of rainfed soils under annual crops in sample villages.

Soil depth	Area (ha)	Percentage
Deep (>80 cm)	3124	21
Medium (40 - 80 cm)	2425	16
Shallow (<40 cm)	9323	63
Total	14872	100

and stony. Of the total, 63% is reported to be less than 40 cm deep, while only 21% is more than 80 cm deep (Table 26). On the better soils of the wetter villages, legume crops compete with summer crops, which occupy twice as much area of deep soils. To expand legume areas substantially, they will have to be grown on poorer soils and in drier areas than is currently the case.

In spite of the small areas planted to forage legumes, farmers were familiar with them. Many farmers said that food and forage legume areas had formerly been greater. Areas are limited by two closely related factors: yields and profitability. Farmers did not plant legumes in the drier areas or on shallower soils because they expected yields to be low. Furthermore, costs of planting and harvesting are high and profitability is low. Based on estimated costs and returns to crops currently grown, legumes are less profitable than cereals grown on deep soils (Fig. 10). Any expansion of legume cultivation into drier areas and poorer soils will almost certainly face even lower profitability, unless productivity can be improved.

The legumes also have relatively high initial costs compared with cereals (Fig. 10). This is due to high rates of costly seed, especially for lathyrus (Table 27). Tillage practices or seed treatment, which make more efficient use of seed, would certainly improve the economics of legume cultivation. Germination rates and plant density should be monitored in future trials to assess the potential of this approach.

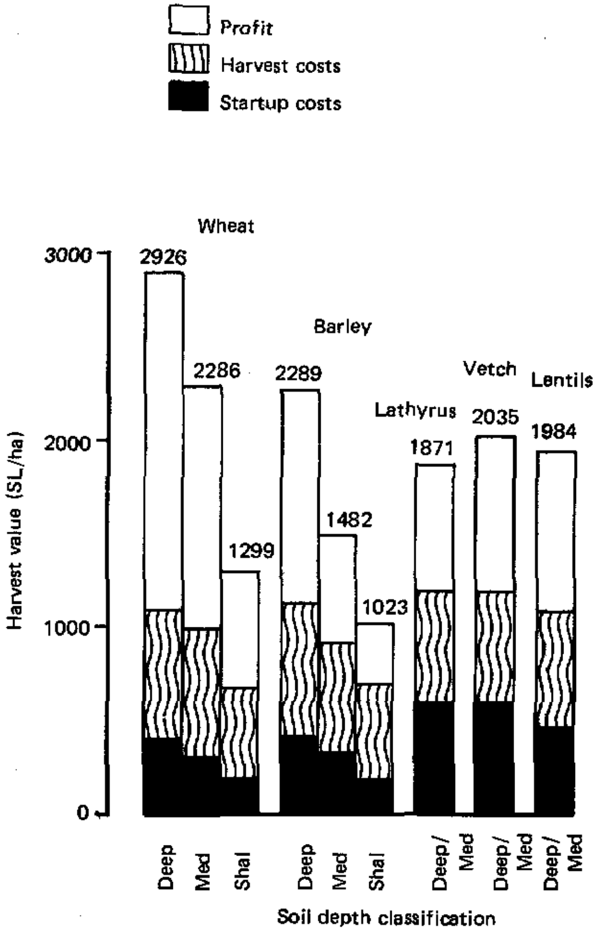


Fig. 10. Costs and benefits by crop and soil type.

Table 27. Seeding rates (kg/ha) for legumes in sample villages.

	Entire sample			Group A (Upper Zone 2)		
	Mean	SD	N	Mean	SD	N
Lathyrus	181	83	11	219	66	6
Vetch	149	44	7	130	38	5
Lentils	119	37	7	125	40	5
Lathyrus/vetch	1.9*	1.2	7	2.2*	1.3	5
Lathyrus/lentils	2.0*	1.1	7	2.3*	1.2	5

*. Indicates that differences between the means of matched pairs are significant at the 0.05 level.

Hand harvesting of barley is a common practice in Syria, but the cost of hand harvesting forage legumes could be a constraint to adoption by farmers unless large yields are obtained.

Current practice in al-Bab, as elsewhere, is to harvest these crops, thresh them, save some seed for sowing in the subsequent year, and use the remaining seed and straw for feed. This maximizes the value of the crop to the farmer, providing both scarce winter feed and also seed to reduce the next season's start-up costs. However, this practice incurs a high harvesting cost. Jaubert (1984) has called attention to the cost of harvesting as the main factor limiting legume cultivation in the Breda/Bueda area.

It is important to note that the harvest labor problem is primarily one of cost. In al-Bab, cereals are usually hand harvested, and the same labor could be available for the legume harvesting season. Even in areas with considerable legume cultivation now, available labor is more than sufficient, but the price is high (Rassam 1984). However, costs and benefits are relative. Currently, harvest costs are seen as prohibitive because of the low economic value of the yield. With increased yields or higher prices, it is probable that higher labor costs could be tolerated.

Harvest labor need not be hired. In Rassam's sample, 34% of legume harvest labor was provided by the household. In a survey of lentil producers in Syria, 29% of the farmers harvested entirely by family labor (Salkini 1984). If introduced forage legumes are limited to a small part of total area, one would expect that family labor could provide an even larger part of the total. It is also possible that the harvest season could be extended by collection of at least some of the crop as hay before maturity, or through the use of non-shattering varieties of forage legumes. These options would permit more of a legume crop to be harvested by family labor.

Since househlod labor is largely provided by women and children, it is likely that they have a say in the decision to grow legumes; indeed, there may be important questions of differing incentives for men and women in legume cultivation. We have no data on this point, but some insights will be gained through interaction with legume growing households in the coming season.

Thus there are two main questions concerning hand harvesting of legume crops. First, what is the availability and cost of hired labor in the target areas, and how do they affect farmer decisions? Second, how available is household labor, and what are the issues pertaining to its mobilization? To address these issues in the next season, two approaches are suggested. On the one hand, a supplementary survey of legume farmers in marginal legume zones will add useful information to the present survey. The survey will focus on current practices, profitability, and labor allocation through monitoring of inputs to and outputs from legume fields. On the other hand, large-plot on-farm trials in areas not currently growing legumes will test the availability of labor and its mobilization. These trials can be combined with monitoring of agronomic variables, but will not directly test agronomic practices.

The sheep feeding cycle is a major factor in determining the feasibility and best possible usage of forage crops. In general, they will be less useful at time when there are alternative feeds available at low cost, and most valuable as substitutes for expensive feed. Winter has been shown to be the time of greatest feed shortage in previous ICARDA work, and this was confirmed in the al-Bab survey. In spring and summer, communal grazing and stubble are freely available, and purchasing feed is rarely necessary for most flocks (Table 28). This is inspite of the fact that al-Bab has relatively little grazing land.

Table 28. Incidence of supplementary feeding in spring and summer, al-Bab, Syria.

	Number of villages	
Feeding practice	Spring	Summer
Always feed	5	2
Bad years only	13	3
Never feed	6	19
Entire sample	24	24

Thus harvesting mature legume crops for winter feed appears to be the favored option for the near future. Spring grazing of barley is practiced to a limited extent, and it is possible that a grazed legume crop could make a contribution to spring feeding as well. However, due to the high cost of seed, the resulting increase in livestock productivity would have to be substantial to make this practice worthwhile. This will be tested in the Bueda area in 1984/85.

In conclusion, survey results suggest that the forage legume area could be expanded, but only if yields can be economically increased. Agronomy research for dry areas and poor soils is required to increase yields. Practices to reduce initial costs are also needed. Labor appears to be sufficient for cultivation of larger areas than are currently grown, but improved yields are needed to make it worthwhile. Further studies next season will assess (a) issues affecting the availability and mobilization of labor, and (b) whether improved management of the forage crop in farmers' fields can raise yields to levels at which they are economically more attractive.
D. Tully.

On-Farm Forage Trials

In the section «Research in Alternative Crop Rotations», results reported on the potential for introducing forage legumes into dryland barley/livestock systems indicate that fallow can be replaced or continuous barley cropping broken by the inclusion of a forage legume. Phosphate addition is important, both for the legume and the subsequent barley production. Two separate sets of trials were undertaken in 1983/84 to evaluate various forage legumes in the presence and absence of phosphate fertilizer in farmers' fields. The residual effects of these treatments on subsequent barley yields will be assessed in 1984/85.

In the first set of trials, three farmers' fields were selected in the Bueda management unit, and five plots of 0.1 ha were marked out in each field. Peas, vetch, and lathyrus were planted by the farmer at a seed rate of 140 kg/ha with and without phosphate as a split-plot treatment. Two of the plots were left fallow. Samples (6 m^2/treatment) were taken on 1 March to estimate dry matter available for green grazing, and on 3 April to estimate dry-matter production of the mature crop (see Fig. 8). At each sampling date, the samples were analyzed for crude protein content and percent *in vitro* digestibility (Table 29).

On the first sampling date, dry-matter production was small. Phosphorus significantly increased production in all three crops. Lathyrus produced less dry matter than vetch or peas, but due to its much higher crude protein percentage, it produced good yields of protein per hectare. By the second harvest date, yields were reasonably good compared with scientist-managed trials at Breda research station (see Long-Term Rotation Trials, discussed earlier). There were no significant differences in dry-matter production between species, but phosphate significantly increased yields in both peas and vetch. Crude protein values were again highest in lathyrus giving it an apparent protein yield advantage. Vetch had the lowest *in vitro* digestibility at the first harvest, but by the second harvest all species were similar.

These on-farm results are encouraging in that

Table 29. Forage yields (kg/ha) and nutritive value on (A) 1 Mar and (B) 3 Apr, 1984.

Treatment		Total DM (kg/ha)	*In vitro* digestibility of DM	% Crude protein	Protein yield (kg/ha)
(A) Pisum	$-P_2O_5$	370	73.8	14.4	53.3
	$+P_2O_5$	617	67.6	12.2	75.3
Vetch	$-P_2O_5$	457	59.8	15.4	70.4
	$+P_2O_5$	674	59.5	14.7	99.0
Lathyrus	$-P_2O_5$	343	73.3	23.2	79.6
	$+P_2O_5$	447	72.1	21.7	97.0
LSD (0.05)		99			
(B) Pisum	$-P_2O_5$	900	54.4	8.8	79
	$+P_2O_5$	1220	59.1	9.6	117
Vetch	$-P_2O_5$	843	54.5	10.4	88
	$+P_2O_5$	1090	56.6	12.6	137
Lathyrus	$-P_2O_5$	923	58.3	13.0	120
	$+P_2O_5$	1053	58.4	15.6	164
LSD (0.05)		225			

Both meat and milk are important end-products in barley/livestock dominated farming systems in West Asia and North Africa.

yields were similar to those obtained on research stations. Work will continue on the agronomy of these forage species as it is clear that improved yields are vital if forage production is to become a viable and economic proposition. However, little on-farm research seems to have been conducted on measuring the conversion of forage dry matter into animal products such as milk and liveweight gain. These are major end-products of barley/livestock systems and are criteria by which farmers will judge the value of introduced forage crops.

First attempts to measure the liveweight gain of lambs grazing forages were made in 1982/83. In the second set of trials in the 1983/84 season the milk-production potential of these forages (with and without phosphate fertilizer) was measured using lactating Awassi ewes. Milk production was chosen because it is a more tangible commodity than liveweight gain. Such grazing trials inevitably require large plots and modified flock management. Although it was intended to conduct three such trials, only one farmer in the study area could be found who would provide sufficient land for the trial. As he did not own sheep, it was agreed that ICARDA sheep would be provided and the farmer would receive the milk and wool. The low rainfall of the season resulted in poor dry-matter yields from the vetch crop grazed by the lactating ewes and thus the plus and minus phosphate areas were grazed as one. Some of the results from this grazing trial are outlined below.

On 21 March dry-matter yields of the vetch, with and without 50 kg P_2O_5/ha, were 459 and 307 kg/ha, respectively. During the 35 days of the grazing trial, the 0.76 ha total plot area sustained five ewes each of which produced 731 g milk/day and gained 52.9 g liveweight daily. These performance levels convert into a stocking rate of 6.6 ewes/ha, 168 kg milk/ha, and 12.2 kg liveweight gain/ha. In spite of these low outputs of milk and liveweight, the approximate gross revenue of SL 638/ha was only SL 22/ha less than the crop establishment costs, excluding a charge for shepherding. This is an encouraging result in view of the fact that dry-matter yields of 1000 to 1200 kg/ha were attained at the same location in the previous year, and in Bueda in 1983/84 (Table 28).

In a drought year such as 1983/84 forage legumes provide valuable extra grazing, especially since communal village grazing tends to be poor and in greater demand. Fewer village flocks go to the steppe, and steppe-based flocks tend to search for grazing in the cultivated areas sooner than usual. However, in order to be attractive to farmers, introduced forage crops must provide economic outputs of milk and liveweight which exceed the levels attained when ewes graze communal village marginal lands or the steppe. The latter practice incurs no cost to the individual farmer but represents a loss to the community due to the degradation of these native pastures. The 1984/85 on-farm forage and livestock research aims to address some of these issues by monitoring the milk and liveweight production of ewes grazing introduced forage legumes as compared with ewes grazing communal village areas. As well as being of benefit to the farmer, this strategy aims to conserve the fragile native pastures which need to be rested in spring. — *R. Jaubert, T. Nordblom, and E. Thomson (PFLP).*

On-Farm Barley Trials

During the last five growing seasons, our barley agronomy research has shown consistent and economic responses to phosphate fertilizer, and in wetter years, but to a lesser extent, nitrogen fertilizer. Even in the very dry 1983/84 season, such responses were again observed (see Agronomy within Fallow/Barley Rotation and Effect of Crop Rotation on Fertilizer Response). Fig. 8 shows that barley is the main source of sheep feed, both as supplementary feed during the winter months, and as stubble grazing after harvest. Even in very poor years, barley provides a major source of feed as a green-grazed crop. Economic increases in barley grain and straw production through fertilizer use could have a large impact on the system in several ways. Less supplementary feed would have to be purchased during the winter months, and the early grazing of the communal marginal areas could be reduced. In addition, a greater supply of stubble feed would be available during the summer months. In drought years, improved soil fertility would result in more rapid early growth, and thus even if barley were green-grazed, a greater supply of feed would be available.

In 1983/84 the impact of fertilizer on barley production was assessed in a series of farmer-managed trials in collaboration with the Ministry of Agriculture and Agrarian Reform, Soils Bureau, Syria.

A 2 × 2 factorial trial (N 0 and 30 kg/ha; P_2O_5 0 and 60 kg/ha) was sown on 20 farmers' fields in barley growing areas in Aleppo Province, Syria. The four treatment combinations were replicated three times at each location. Prior to sowing, soil samples (0-40 cm) were taken from five locations in each field, bulked, and analyzed for available nitrogen and phosphorus. Rainfall was recorded at each location weekly.

The land was prepared by the farmer according to his usual practice of ridging with a duckfoot cultivator. After the plots were marked out, the farmer broadcast the seed (Arabi

Aswad, 100 kg/ha) and fertilizer, and covered the seed either by splitting the ridges with the cultivator, or through the use of a *tabban*, a heavy metal pole which is pulled over the ridges. Sowing was completed between 19 Oct and 19 Nov 1983.

The very dry season and poor distribution of rainfall had a marked effect on this trial. At some locations, germination was poor, and the very dry month of February subsequently killed the crop. At locations where the crop germinated and survived the drought, differences in growth associated with phosphate application were clearly apparent in fallow/barley rotations, and the importance of nitrogen and phosphate was evident in crops preceded by barley. Due to the poor rains, most farmers decided to graze off their barley crops to provide feed for their sheep which was in very short supply. As a result of crop death and grazing, crops at only two of the 20 locations reached maturity (Kafr Abeed and Khanasser) and were harvested.

Details of rotation, soil analyses, and rainfall are presented for each location in Table 30, and

Table 30. Details of 20 locations in NW Syria at which on-farm barley fertilizer trials were conducted, 1983/84.

Site	Rotation	NH^+_4+ NO^-_3 (ppm)	P-Olsen (ppm)	Seasonal rainfall (mm)
Kafr Abeed	F/B	10.53	2.51	196
Bueda	F/B	12.60	2.74	165
Batraneh	F/B	4.94	1.73	159
Batraneh	B/B	3.47	1.86	159
Kafr el-Mansour	F/B	13.39	3.48	116
Ergel	F/B	5.95	2.02	133
Al-Monbateha	F/B	10.13	3.45	147
Tawaleel	F/B	8.30	3.61	75
Hanouteh	F/B	14.92	2.45	80
Nawwara	F/B	49.18	7.24	92
Mezeile	B/B	12.80	5.74	96
Qorbatieh	F/B	61.06	4.24	133
Qorbatieh	B/B	19.98	5.00	133
Khanasser	F/B	21.62	4.22	152
Hawaz	B/B	5.93	3.81	140
Mazraa	F/B	16.90	5.47	134
Roweheb	F/B	13.71	3.93	125
El-Jeneid	F/B	9.72	3.95	113
Qobbatein	F/B	19.91	2.76	128
Qobbatein	B/B	7.02	2.12	128

Table 31. Total dry-matter (kg/ha) production of barley in two farmers' fields in NW Syria, 1983/84.

Location	Rainfall (mm)	Treatment				LSD (0.05)
		N_0P_0	$N+P_0$	N_0P+	N+P+	
Kafr Abeed	196	940	870	1540	1580	325
Khanasser	152	210	230	350	380	170

the total dry matter obtained at two locations is reported in Table 31. The soil analyses data are of interest. At some locations the trial was laid down in adjacent fields in contrasting rotations (see Batraneh, Qorbatieh, and Qobbatein). At the two latter sites, available nitrogen following fallow was much greater than following barley and the same trend was apparent at Batraneh. This supports previous research which showed an increase in available nitrogen during a fallow year (see Effect of Crop Rotation on Fertilizer Response). Soil phosphorus levels were low at all locations. Calibration of the Olsen soil test with cereal responses to applied phosphate has shown that responses would be expected in dryland soils (rainfall < 400 mm) where the soil test gave values less than 9.0 ppm. Data in Table 30 indicate that responses would have been expected at all locations, with very pronounced responses at 80% of the locations where available P-levels were below 4.5 ppm. This indication of widespread phosphate deficiency supports previous soil analyses of barley-producing areas in Syria. A survey of 158 farmers' fields in NW and NE Syria in 1982 showed that in 85% of the fields, P-Olsen values were below 9 ppm.

Reasonable yields were obtained at Kafr Abeed (rainfall 196 mm), but were very low at Khanasser (152 mm) (Table 31). Treatment effects were highly significant at Kafr Abeed ($P < 0.01$), but just failed to reach significance at Khanasser ($P < 0.05$). At both locations, the crop was preceded by fallow, and there was no response to nitrogen fertilizer at either site, but responses to phosphate were observed, in agreement with previous results.

With data from only two locations, firm conclusions cannot be drawn. The residual effects of the treatments applied in 1983/84 will be studied at selected sites in 1984/85, since at many locations this year's production largely mimiced a fallow, and farmers will plant barley for a second year in succession. — *FSP and Ministry of Agriculture and Agrarian Reform, Soils Bureau, Syria.*

Conclusions

Encouraging results were obtained in an unusually dry year. The following conclusions can be drawn.

1. Even in dry years, substantial responses of barley yields to phosphate can be achieved in the year of application. The residual effects of phosphate fertilizer on subsequent crops will make the economics of its use even more attractive.
2. Crop rotation x fertilizer-response interactions occur. In fallow/barley rotations the major response is to phosphate, but in continuous barley, responses to nitrogen are also found.
3. Improvements in barley production are likely to have very beneficial effects on the economics of sheep feeding through a reduction in supplementary feed costs during winter, greater supply of stubble grazing during the summer, and in dry years, a greater supply of green-grazing material combined with improved chances of grain production. Higher production per hectare could also reduce the area of land under continuous barley.
4. Annual-sown forage legumes, capable of providing higher quality sheep feed, continue to show promise as an alternative to fallow, or as a break in continuous barley cultivation.
5. These forages have shown significant responses in BNF and yield through improved management, with correct seed rate, inoculation, and phosphate fertilizer being important. There are indications that both BNF and yields may be further improved through the control of soil pests, principally sitona weevil larvae and nematodes.
6. The introduction of forage legumes could have dramatic effects on current sheep feeding cycles either as green grazing, hay, or a mature crop. However, high seed and

harvest costs are economic constraints to adoption at current yield levels.

7. The evaluation of the economics and implications of the three possible options for using legume forages on the sheep feeding cycle and productivity will need to be carefully assessed in order to establish research priorities and increase the likelihood of farmer adoption.

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Project 3: Intersystems Research

Our intersystems research spans across a range of environmental and socioeconomic conditions. It also covers a wide range of topics, but in all cases has a common rationale. In the ICARDA region, which is climatically and environmentally diverse, it is important to understand the effect of variability on the social and biological factors associated with agricultural production systems. For a proper evaluation of such interactions we utilize the temporal and spatial variability characteristics of ICARDA region.

By conducting our research across a range of environments, we can in many instances reduce the time required to characterize season-to-season variation in response. When the factors associated with seasonal variation can also be found across locations in a given year, then site and season variation can be combined in analyses. Such an approach is especially useful when the environmental parameters affecting response can be clearly identified and measured. As an example, variations in barley yields across four seasons and five locations were related to available soil nitrogen and phosphorus, applied nitrogen and phosphorus, seasonal rainfall, and seeding rate. Here, both season and site variation are attributed to the same critical, but easily measured environmental parameters. This allows both temporal and spatial extrapolation of observed responses to other environments where the same parameters control barley yields. This approach, in which rainfall is one of the critical variables, is complemented by analysis of long-term daily rainfall records in terms of probability of amounts and distribution. Responses of a whole range of factors will depend on rainfall, and an example of how nitrogen fertilizer strategy for contrasting locations can be evaluated in the light of analyses of long-term rainfall records is presented below.

A third important field of research is the production of a comprehensive agroecological zonation scheme. This is a long-term effort and requires an understanding and integration of a complex range of crop x soil x environment interactions. We believe that such a scheme requires the combination of a knowledge of soil conditions, the analyses of long-term weather data and its use with crop growth simulation models which will predict crop performance under the temporal and spatial variations in conditions which occur in our region. Results are presented below which illustrate potential uses of such models, and also a more detailed account of how such models can be used in agroecological zonation.

Analysis of Multiple Site-Multiple Season Trials

A cost-effective way of conducting research in variable environments is to conduct «Multiple Site-Multiple Season» (MS-MS) trials.

To be effective, MS-MS trials require a research area that is fairly homogeneous except for a few critical environmental parameters. More precisely, each site in a given season can be interpreted as «a state of the environment.» When results from these «states of the environment» are analyzed in a pooled manner, the effects of the environmental variables can be assessed quantitatively. Even if many environmental conditions cannot be observed in a given location, information from other locations with different environmental conditions can be used to deduce results for that given location.

The choice of the sites is critical. The sites should be representative of the physical conditions of the area and should also exhibit manageable environmental differences. Such differences need to be sought and identified at the diagnostic stage of FSR and monitored during the experimental phase.

The environmental differences need to be «manageable»; the effects of too many factors will confound the analysis. Furthermore, there will be some measurement problems; while there will be many plot values from each site-season, some environmental variables will have only one value per site per season (e.g. total seasonal rainfall).

Environmental factors are treated as variables along with experimental factors in the regressions analysis.

This approach was used to analyze data from trials which examined barley responses to seed rate, nitrogen, and phosphorus at five locations in northern Syria over four seasons. These data are used mainly to illustrate the approach rather than to assess these trials.

A functional relationship was specified incorporating the environmental variables of rainfall (R, mm/year), available soil nitrate-nitrogen (NA, ppm), and available soil phosphorus (PA, ppm) and the experimental variables of seed rate (S, kg/ha), nitrogen fertilizer (N, kg/ha), and phosphate fertilizer (P, kg P_2O_5/ha) and relating them to grain yields. The model involves linear and quadratic effects as well as interactions. Complete results and specifications are provided in Somel (1984). The regression results are given in Table 32.

The economically optimal fertilizer rates can be found from the general model for average rainfall conditions and actual levels of available nutrients. Then, one can observe how these optimal recommendations would fare given the distribution of rainfall around the mean. This was done for the relatively typical barley production area of Breda, using a seed rate of 100 kg/ha, and using 200 kg/ha grain yields for rainfall under 200 mm (Table 33). (This 200 kg/ha is the grain equivalent of grazeable dry matter when harvest is not feasible due to crop failure.) The predicted yields when current «optimal» levels, as used in trials on farmers' fields, are substituted in the general model are also given in Table 33.

In assessing the results, two important points must be borne in mind. First, the trials were not specifically designed for this type of analysis. In this case, the utilization of «site» to assess the effect of rainfall variation is likely to confound the effects of rainfall and soil type. The soils at Breda are classified as Calcic Xerosol whereas the soils at the two wettest locations, Jindiress and Kafr Antoon, are both Chromic Vertisols, and the soil at the intermediate site, Tel Hadya, is a Vertic (Calcic) Luvisol. Thus, there are likely to be effects associated with barley yields obtained at high rainfall levels which are not accounted for in the model. Second, various imbalances in the

Table 32. Pooled regression results for barley (n = 872) cv Beecher grain yields (kg/ha).

	General model	
Variables	**Coefficient**	**sl (%)**
Constant	-8544.5	0
S	21.8	9
N	-14.8	36
P	56.5	0.1
SN	0.156	16
SP	-0.085	49
NP	0.072	60
S^2	-0.030	58
N^2	0.001	99
P^2	-0.440	0
RS	-0.048	15
RN	0.104	2
RP	-0.144	0.2
RSN	-0.00041	16
RSP	0.00029	38
RNP	-0.00018	61
RS^2	0.00005	73
RN^2	-0.00015	59
RP^2	0.00120	0
R	41.7	0
R^2	-0.034	0.1
NAS	0.010	87
MAN	-0.111	12
NAP	0.105	12
PAS	-0.726	10
PAN	-1.531	0.5
PAP	-0.306	55
NA	-207.6	0
PA	761.3	0
NAR	0.779	0
PAR	-2.451	0
R-square	0.7234	
Adjusted R^2	0.7135	
F	73.3	0
SEE	584	

Note: sl(%) = Significance level in percent. 0 means the significance level is higher than 0.05%.
SEE = standard error of estimate.

number of observations between sites and years would affect the results. Third, during the three seasons in which the data were collected, we did not experience a very dry year, and thus the model is not able to predict crop response very accurately under such conditions. This is evident in Table 33, and as dicussed earlier a grain yield of 1070 kg/ha with fertilizer levels of N_{90} P_{60} was obtained with a rainfall total of 200 mm, and yields over 500 kg/ha were obtained at Khanasser where the rainfall total was only 150 mm. Thus, the actual figures in Tables 32 and 33 should not be critically examined, since they are presented mainly to illustrate the approach.

The data presented illustrate the following points:

1. Even though soil types varied considerably across locations, the general model accounted for over 70% of the variation in barley grain yields through consideration of the six parameters.
2. The use of the model allows the prediction of response surfaces for a range of environmental conditions.
3. It is possible to find optimal levels of inputs based on average (or any other) conditions. Subsequently, it is possible to evaluate how the associated yields will perform under different environmental conditions. This was done for Breda (Table 33).
4. If probability distributions of environmental conditions are available, probability of yields for given recommendations of inputs can be obtained. For Breda, the indications are that fertilizer use will be profitable 80% of the time.
5. The value of environmental information can be calculated. In the present study the value of both rainfall and available nutrient information was found to be positive for the typical barley production area of Breda. This was equal to the value of 141 kg/ha of barley for rainfall information and 99 kg/ha of barley for information on available nutrients.

Table 33. Comparison of grain yields of various input levels at Breda according to rainfall distribution.

Rainfall (mm)	Frequency %	Net returns (kg/ha) General model	Net returns (kg/ha) Current «optimal» input levels	Net returns (kg/ha) No fertilizer	Grain yields (kg/ha) General model	Grain yields (kg/ha) Current «optimal» input levels	Grain yields (kg/ha) No fertilizer
112.5	5.3	-307	-17	200	200	200	200
137.5	5.3	-307	-17	200	200	200	200
162.5	5.3	-307	-17	200	200	200	200
187.5	5.3	-307	-17	200	200	200	200
262.5	21.1	1617	1504	1049	2124	1721	1049
287.5	26.3	1966	1790	1378	2473	2007	1378
312.5	5.3	2272	2033	1664	2779	2250	1664
337.5	5.3	2536	2234	1908	3043	2451	1908
362.5	5.3	2757	2393	2109	3264	2610	2109
412.5	10.5	3074	2584	2386	3581	2801	2386
462.5	5.3	3222	2606	2494	3729	2823	2494
Average		1684	1544	1307	2191	1761	1307

Note: The optimal fetilizer rates for the General Model are N = 81, P_2O_5 = 66 kg/ha.
The current «optimal» input levels are approximately those used on trials on farmers' fields; N = 20 kg/ha, P_2O_5 = 45 kg/ha. The input levels are substituted into the general model to derive distribution.

6. However, it was also found that positive marginal rates of return discourage very quickly the use of fertilizer in typical barley areas like Breda.

The details of these results can be found in Somel (1984). However, one point needs some elaboration. The economically optimal fertilizer levels as determined from the general model are quite high (Table 33). The nitrogen level that has been found necessary to achieve the biological potential is close to 85 kg/ha (ICARDA, Soil Fertility Research, Progress Report 1983/84). The P_2O_5 level of 66 kg/ha is more reasonable but, given the current practices, still high.

These optimal input rates for the average environmental conditions are based on two assumptions:

a. The prices used are government prices. The actual prices to farmers may be different and probably higher due to incorporation of transport costs. This would reduce optimal input rates.

b. It is assumed that the farmers maximize profits with a zero marginal rate of return.

As such, the analysis is limited to the specific case of barley and excludes other interacting or independent activities of the farm household. However, it is possible that due to the existence of other more profitable activities, inflation or interest and risk premiums, the farmer may require a positive marginal rate of return. This can easily be incorporated into the analysis. Instead of equating marginal products to (relative) market prices, they are equated to (relative) market prices times a factor of one plus a positive marginal rate of return:

$$\delta y/\delta x = (1 + MRR)P_x$$

where x is an input and P_x is the relative price of the input.

Sensitivity analyses using MRR of 0, 50, 100, and 150% were conducted. Optimal input rates, costs, returns, and yields are given in Table 34

Table 34. Economically optimal input rates, costs, returns, and yields in Breda under different marginal rates of return.

Marginal rate of return %:	0	50	100	150
N (kg/ha)	81	55	30	5
P_2O_5 (kg/ha)	66	55	45	34
Cost (kg/ha)	507	377	253	127
Net returns (kg/ha)	1684	1667	1582	1455
Graing yield (kg/ha)	2191	2034	1835	1582

Note: Costs and returns have been converted to grain-yield units. The economically optimum input levels are calculated according to average environmental conditions.

for these MRR. It can be seen that increasing MRR implies a decrease in input use due to increasing declines in average net returns. However, one must acknowledge risk factors as well as other factors which do affect input use. As such, the lower optimal input rates, especially those for MRR = 100%, appear to be more realistic: N = 30 kg/ha and P_2O_5 = 45 kg/ha.

The approach developed here is considerably less sophisticated than a crop modeling effort (see The SIMTAG Wheat Growth Model, below). Hence, it does not require the skills necessary for crop modeling. Knowledge of standard regression techniques is adequate. However, it is highly possible that the approach may tax the memory limits of small computers. The model is somewhat more complex than estimating simple regressions for each site in each year. However, the environmental variation in the rainfed areas poses complex problems for agricultural production and research. Seeking simple answers to complex problems in such environments may result in inadequate solutions.

In spite of the limitations inherent in this approach, it clearly has useful implications. We intend to test this technique further in the coming seasons, utilizing a data set from a series of trials specifically designed for this purpose. The trials examine phosphorus and nitrogen responses of barley at 15 representative dryland locations throughout the barley growing region in Syria using a 4 x 4 factorial design. Soil analysis for available soil nitrate and Olsen extractable phosphate will be done for each location, and weekly rainfall will be recorded. In addition, these trials will be located in a more homogeneous research area than was the case for the data set used to illustrate this approach. — *K. Somel.*

Probability Analyses of Long-Term Rainfall Data

The initial analysis of daily rainfall data from six stations in northern Syria outlined in the 1983 Annual Report was completed in cooperation with the University of Reading (Dennett *et al.* 1984).

These results were further evaluated in the 1983/84 season in terms of the manner in which the differences in precipitation regime, highlighted between the six sites, potentially influence the management of crop rotations in northern Syria. The major conclusion of this study is that recommendations for improved management in the broad ecological zones in which barley- and wheat-dominated rotations are found need to be carefully tailored, within these zones, to long-term expectations of precipitation regime. For example, in the case of the wheat-dominated, 350-600 mm seasonal precipitation cropping zone, there is generally a substantial response in cereal crops to applied nitrogen fertilizer when soil phosphate conditions are non-limiting and weeds are controlled. However, this response will be in some degree tempered, particularly in terms of the economic optimum amount of N to apply, by the current season's rainfall. As already reported in the 1983 Annual Report, there is gross interseasonal variability in rainfall at the sites studied in this ecological zone. For example, in 10% of years at Jindiress totals of less than 350 and more than 600 mm of seasonal rainfall can be expected.

A uniform nitrogen fertilizer application strategy is therefore a suboptimal economic solution. The preferred alternative is for farmers to assess the likelihood of a season's productivity being either rainfall or nitrogen limited on the basis of rainfall already received, and to adjust their management accordingly.

The probabilities of having received more than specified amounts of rain, by particular dates covering the period when decisions on topdressing are made, are given in Table 35. These data emphasize the variability in precipitation regime evident between the sites. For example, 200 mm of rain by 1 Feb probably approximates to the lower limit justifying a topdressing at this time. This would occur about 7 years out of 10 at Jindiress, 6 out of 10 at A'azaz, but only 4 years out of 10 at Saraqueb.

Table 35. The probability of receiving more than specific amounts of rainfall between October 1 and the date shown at three locations in northern Syria.

Amount (mm)	1 Feb	14 Feb	1 Mar	15 Mar
		Jindiress		
200	0.70	0.84	0.93	0.97
225	0.56	0.73	0.86	0.94
250	0.43	0.61	0.77	0.89
275	0.30	0.48	0.67	0.83
300	0.20	0.36	0.55	0.72
350	0.08	0.18	0.32	0.50
		A'azaz		
200	0.58	0.74	0.87	0.93
225	0.46	0.63	0.77	0.87
250	0.31	0.49	0.67	0.79
275	0.18	0.38	0.55	0.70
300	0.11	0.25	0.43	0.57
350	0.05	0.11	0.22	0.33
		Saraqueb		
200	0.40	0.59	0.74	0.83
225	0.25	0.43	0.60	0.70
250	0.15	0.29	0.45	0.58
275	0.09	0.18	0.32	0.45
300	0.04	0.10	0.20	0.31
350	0.01	0.03	0.07	0.13

Fertilizer practices can be adjusted to meet the environmental conditions of the current season. If, for example at Jindiress, 300 mm of rain is received by 1 Feb, then that year would be among the wettest 20% of years and a heavy nitrogen topdressing would be sensible (Table 35). However, a more conservative dressing, such as 50 kg N/ha could be applied at this time and a second assessment for a possible further application could be made in mid-March. This judgement would be superior to examining crop growth only, as it helps to predict future growth potential from stored soil moisture rather than merely growing conditions up to the date of observation.

Expectation of future rainfall also can be a useful guide to fertilizer practices. Amounts of rain expected between 14 Feb and the end of the season are given in Table 36. There is considerable variability between years at each site but the differences between sites are also large; for example more than 150 mm rainfall in this period will occur in only the wettest 20% of years at Saraqueb but in about 65% of years at Jindiress. These, of-course, are general predictions rather than for specific years but provide estimates of risk. This example clearly suggests that fertilizer recommendations should be carefully assessed between sites within broad environmental zones and, where possible, indicate the need for a flexible response to the current season's precipitation, which would assist in economically optimizing fertilizer application strategies. — *D. Keatinge.*

Table 36. Amounts of rain (mm) between 14 Feb and 31 May exceeded in various percentages of years.

% Years	Jindiress	A'azaz	Saraqueb
80	135	112	83
50	176	156	116
20	227	206	154

The SIMTAG Wheat Growth Model

The SIMTAG (Simulation of Triticum Aestivum Genotypes) wheat growth model, which is the result of a cooperative program between ICARDA and the University of New England, Australia, was installed at ICARDA's Harry S. Darling computer center in August 1984. Some of the initial results obtained from simulating the response of wheat to environmental variability for four sites in Aleppo province are outlined below.

The sites are spread across the rainfall gradient (Table 37), but experience similar temperatures during the growing season. The only exception is Kafr Antoon, which receives rainfall totals close to those of Jindiress but has approximately 2.5 °C lower winter temperatures.

Table 37. Mean monthly rainfall and temperature for four sites in Aleppo Province.

	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Season
Jindiress													
Aver. max temp. (°C)	32.1	26.4	20.3	13.2	11.9	13.7	17.9	22.7	28.3	32.3	33.6	33.3	2[illegible]8
Aver. min temp. (°C)	17.3	12.3	8.0	4.7	3.7	4.2	6.6	9.2	13.3	17.5	20.6	20.6	1[illegible]5
Monthly LTA rainfall (mm)	1.7	25.1	49.9	102.0	88.7	75.1	61.0	48.3	20.1	3.05	0.0	0.97	4[illegible]6
Kafr Antoon													
Aver. max temp. (°C)	32.7	25.8	15.7	11.2	8.5	10.4	14.9	20.8	26.1	32.5	34.4	34.0	2[illegible]3
Aver. min temp. (°C)	17.6	10.8	2.8	0.9	-0.2	-0.5	2.5	7.4	11.1	16.9	20.7	20.3	[illegible].2
Monthly LTA rainfall (mm) (for A'azaz)	2.1	23.8	41.1	86.6	85.2	64.9	65.1	45.4	22.3	1.7	0.0	0.3	4[illegible]8
Aleppo													
Aver. max temp. (°C)	33.2	27.0	19.1	12.1	9.8	12.4	16.7	22.0	28.4	33.5	35.9	35.8	2[illegible]8
Aver. min temp. (°C)	17.4	12.6	6.6	3.6	1.8	3.0	5.4	9.1	13.3	18.0	20.8	20.6	1[illegible]0
Monthly LTA rainfall (mm)	3.13	21.0	34.5	70.75	71.2	53.3	44.7	33.4	15.3	1.83	0.09	0.37	3[illegible]0
Breda													
Aver. max temp. (°C)	34.7	28.0	17.0	12.6	10.2	11.6	16.7	22.8	28.1	33.8	35.6	36.2	2[illegible]9
Aver. min temp. (°C)	15.6	10.4	3.4	2.2	1.9	1.0	3.9	6.9	11.3	15.7	19.7	18.6	[illegible].2
Monthly LTA rainfall (mm)	1.68	13.08	32.57	60.8	46.9	37.24	36.02	35.99	16.92	1.55	0.27	0.0	2[illegible]3

Optimal Maturity Type

Use of the model permits us to examine which of the wheat maturity types — early, medium, or late — would be the most productive in the environment of northern Syria.

Fig. 11 shows the cumulative probability distributions of simulated grain yields for three cultivars of differing maturity type (early = Sonalika, medium = Mexipak, late = Novi Sad) sown in early November.

For the drier sites, Aleppo and Breda, the obvious choice among the three cultivars would be the early maturing one, whereas at Jindiress, the wettest site studied, there is virtually no difference between the medium and late cultivars, both of which outyield the early cultivar there.

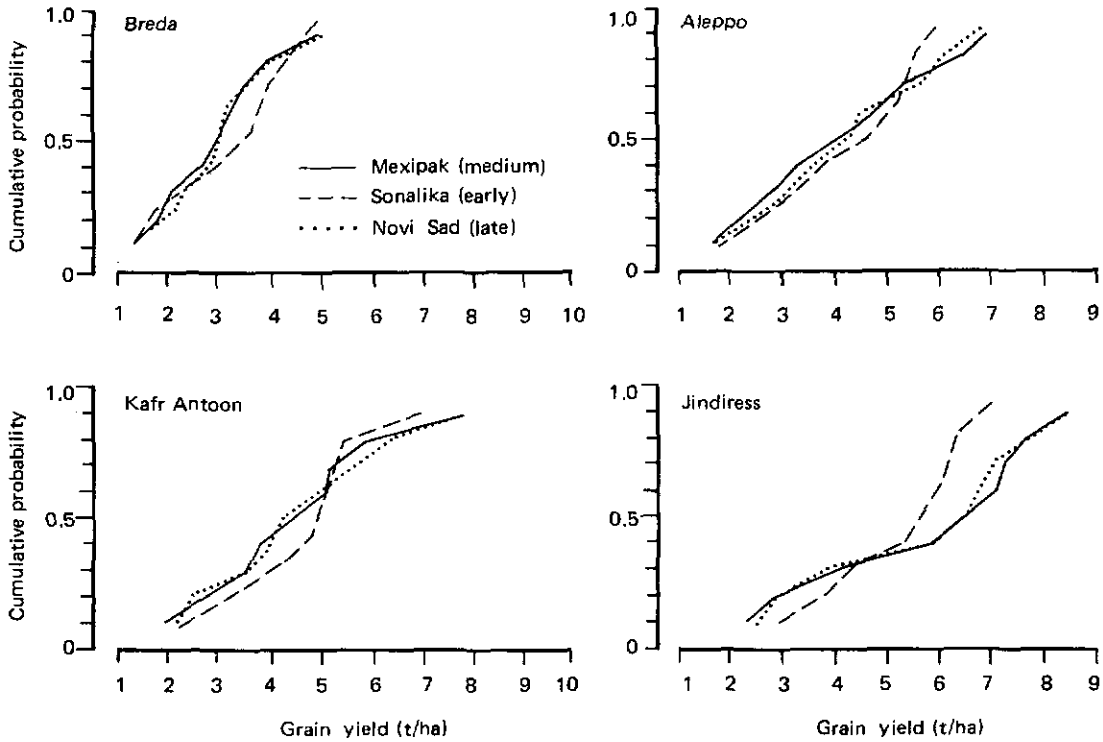

Fig. 11. Cumulative probability distributions of grain yields for three cultivars of differing maturity type sown early November.

At Kafr Antoon, because of the lower winter temperature, only the early cultivar flowers early enough to avoid severe water stress during the grain-filling period in most years, and it outyields the late cultivar at this site in 6 years out of 10.

The ranking of the cultivars at each location does not vary significantly if the sowing date is changed.

Wetting Depth and Rooting Depth

The SIMTAG model can be used to examine the depth of the wetting front in the soil profile and subsequent crop rooting depth.

Fig. 12a shows the simulated development of wetting depth and rooting depth at three probability levels for the cultivar Mexipak at Aleppo. The median wetting depth occurs in five seasons out of 10. Conversely, in another 20% of seasons the wetting front does not penetrate deeper than 35 cm into the soil.

In the model, rooting depth means depth of water extraction. Three different types of growing season can be distinguished on the basis of the relationship between wetting depth and rooting depth:

- Seasons in which rooting depth is not restricted by shallow wetting depth and roots reach the bottom of the profile (this happens approximately in one season out of five).
- Seasons in which the roots reach the depth of the wetting front, usually about the middle of April, and are able to penetrate it and make use of moisture stored in the lower part of the profile during previous

Soil moisture status is measured with a neutron probe. An understanding of soil and crop moisture dynamics is necessary to evaluate improved practices in dryland areas.

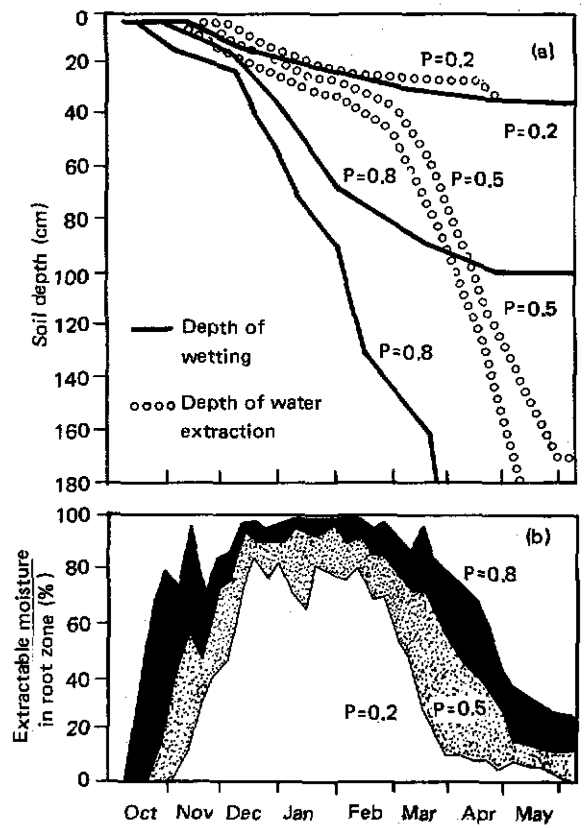

Fig. 12. Simulated depths of wetting and water extraction and simulated percentage of extractable moisture in the root zone for the cultivar Mexipak at Aleppo.

seasons (approximately one season out of two), and

Seasons in which root growth is severely restricted since the roots are unable to penetrate the wetting front at shallow depth because the soil layer underlying it is too dry to permit root growth (approximately one season out of four).

Fig. 12b shows the simulated extractable soil-moisture content in the rooting zone at the same three probability levels. Between sowing and germination, the root zone is taken as sowing depth plus 3 cm.

The differences between the curves early in the season are due to differences in the timing of the break of season from year to year. If crops can be considered free from moisture stress as long as the extractable moisture in the root zone exceeds 40% to 50%, this is the case from the middle of October until early May in the wettest 20% of seasons. In the driest 20% of seasons, however, crops are free of water stress from early December to the middle of March at most.

The results for Breda are very similar to those for Aleppo. At Jindiress and Kafr Antoon, however, the median depth of wetting was approximately 120 cm and the wetting front reached at least 70 cm in 4 years out of 5. Root growth at these locations was never restricted in the simulation by dry soil layers.

The Effect of Fallow on Soil Moisture and Grain Yield

Using the SIMTAG model over a historical run of data also allows productivity of wheat/fallow and continuous wheat-cropping rotations to be compared. Simulated yield totals over 20 years for continuous wheat were significantly higher than those for a wheat/fallow rotation at Jindiress, Kafr Antoon, Aleppo, and Breda. This is because only under certain infrequent conditions does fallowing have a significant effect on available moisture during the subsequent season. This occurs only when rainfall during the fallow season is sufficient to allow deep moisture storage in the profile which can be conserved to the following cropping season, and the cropping season is dry enough to allow a response to stored moisture, but enough rain falls to permit the roots to penetrate the wetting front and utilize the soil moisture stored during the preceding fallow period.

Based on moisture considerations alone, it can be concluded that this combination of events does not occur frequently enough in the study area to warrant fallowing to conserve moisture for a subsequent wheat crop.

It must be emphasized that the simulated predictions of yields in continuous wheat and fallow/wheat rotations do not take into account other important aspects of fallowing such as nutrient availability or the buildup of soil pests and diseases. These are discussed under Improvement in Current Cropping Rotations and Research in Alternative Crop Rotations above.
M. Stapper and W. Goebel.

An Integrated Approach to Agroecological Zoning

A major effort has been put into drawing up a comprehensive methodology for agroecological zoning with the aim of bringing together previously isolated endeavors in this field. The proposed methodology is expected to meet a majority of demands within the center in the context of agrotechnology adaptation, identification and quantification of research and breeding targets, and effective generalization of location-specific research.

The ICARDA region has a highly variable environment, and it is evident that the methodology must take a probabilistic approach and be sensitive to intervarietal differences in response to environmental variability.

The envisaged methodology for agroecological zoning (Fig. 13), therefore, starts with an analysis of the temporal variability of climatic variables. Any series of weather data is condensed into a manageable set of parameters, which allows the generation of series of any length of all relevant climatic variables, adequately representing their interdependence and the site-specific distribution of climatic events. These parameters are amenable to mathematical

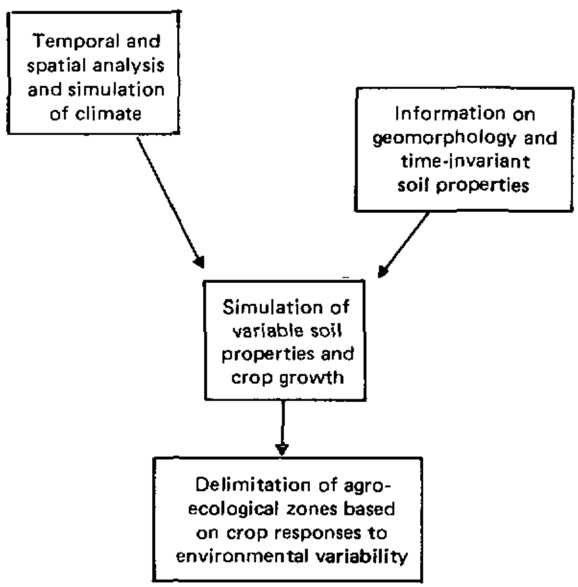

Fig. 13. Simplified flowchart of the discussed approach to agroecological zoning.

spatial modeling, which makes it possible to generate similar series of daily weather data of any length for any location. The results of this process of analysis and simulation of climate can be combined with information on geomorphology and time-invariant soil properties. These combined data sets can then be used to simulate those soil properties which do change with time, and crop growth. Crop growth models which are sensitive to intervarietal differences thus serve as the tool for integrating environmental variables.

Agroecological zones are then defined by clustering a spatial matrix of probabilistic crop response data created by the simulation of the weather-soil-crop system for a sufficient number of years and locations to give representative results for the study area.

The scope of this approach can be widened by attaching monetary values to the physical inputs and outputs of the simulation processes or by introducing livestock models.

Several crop growth models and several models concentrating on soil factors have been collected, in addition to SIMTAG, and are being installed at ICARDA's computer center. Other models of ICARDA's mandated, or closely related, crops have been requested. It is expected that the first zoning results will be generated during 1984/85 and maps for areas with high priority within the ICARDA region will be produced within 2 years. — *W. Goebel.*

Project 4: Cereal/Livestock Systems in Tunisia

Research on cereal/livestock systems in Tunisia is a collaborative effort between Institut National de la Recherche Agronomique de Tunisie (INRAT), Institut National Agronomique de Tunisie (INAT), and ICARDA. Staff of the Office des Cereales and the Ministry of Agriculture personnel in Goubellat also contribute. A list of personnel is provided at the end of this section. The project is funded by the International Development Research Center (IDRC), Canada, and ICARDA.

The objectives of the project are to introduce economically, socially, and technically viable improvements into an agricultural area and to facilitate on-the-job training in farming systems research. The project implementation area is the Goubellat delegation of the Beja Governorate. Beja lies in the middle of fertile plains and is the capital of the Tunisian cereals trade. Goubellat, 60 km SW of Tunis, consists of a fertile plain surrounded by hills. The total agricultural area in Goubellat is around 40,000 of which approximately 32,000 ha can be cultivated.

Climatically, Goubellat lies in the higher and medium semi-arid (semi-aride superieur et moyen) zone, and receives 443 mm average annual precipitation according to the records of the nearest meteorological station in Medjez al-Bab (1960-1980). Seasonal rainfall averages are 132, 169, 107, and 35 mm for autumn, winter, spring, and summer, respectively. Annual rainfall varies substantially around the average.

Project activities started in spring 1984 with a field survey in April and May followed by analysis in June. Two surveys of the research literature, one on agronomy and another on livestock, were also prepared in the summer of 1984. The results of the field and literature surveys were discussed at the coordination meeting in September, and research plans were drawn for the 1984/1985 season. Project implementation began in October 1984.

This report focuses primarily on the field survey activities and the research plans for 1984/1985. The project area is fairly small, although ease of access to all areas is not uniform. The farming enivronment contrasts with those in Syria and Jordan in that all farms are like homesteads, with each family living on the farm instead of in a village. Farms are spread fairly uniformly over the terrain. On-farm research is desirable in such an environment, since farmers become more involved and observe virtually daily

In Goubellat, farmers live on their farms and have small flocks of livestock.

the effects of the trials on their fields. Their evaluation of the trials is hence invaluable. However, the results of the INRAT/INAT/ICARDA FSR project will be generalized to larger areas. It is important that the methods used in this project be scrutinized and adapted for use in other areas.

Preliminary Survey-Spring 1984

In spring 1984 a workshop on FSR methods was held in Aleppo between ICARDA and Tunisian scientists which assigned high priority to «diagnostic» work as a preliminary activity of a project. It was emphasized that this diagnostic work should be preferably done through a structured sample survey.

An intensive formal sample survey was carried out in Goubellat. This was preferred to the informal survey or «sondeo» approach, since, while this latter approach is claimed to be cost-effective, it would not meet the needs of this project. «Several years of extensive research may be devoted to studying the agronomic features, yet the social system itself is presumed to be sufficiently understood after a few weeks of cursory surveys» (Kerven 1984). Social science research is integral to the project, and as such, a thorough survey was desirable.

Of the 1221 farmers in Goubellat, 240 (20% sample) were surveyed in May 1984. The farms were stratified according to size into four groups and the sample was drawn proportionate to this stratification (Table 38). The information sought was kept simple and confined to the less sensitive aspects of farming. The basic purpose was to identify target groups of farmers that exhibited similarities within groups.

Data were analyzed at the ICARDA computer center by the Tunisian project staff assisted by ICARDA/FSP staff. Analysis was completed in June 1984 and the principal results reported by September 1984. Thus, information from formal surveys can be processed quickly and the by-product of training in analytical methods is of great value in itself.

Goubellat is characterized by a skewed land distribution and most operators are small farmers. Almost two-thirds of the land is farmed by 11% of the farmers. While the concept of «big» and «small» farms is relative, a considerable number of farmers are small, relatively and absolutely. On-farm research is thus an effective way of ensuring that research results reach these small farmers.

Nearly half the land lies in hilly areas and part of the land is in fallow each year (Table 39). About half the farmers in Goubellat practice a fallow-cereal rotation, while about a third practice a three-year rotation, mostly fallow-cereal-barley and/or a forage crop (Table 40).

Table 38. Distribution of farm size in Goubellat, Tunisia.

		Farm size (ha)				
		0-10	10-20	20-50	50+	Total
Population	n	900	189	90	42	1221
	%	73.7	15.5	7.4	3.4	100.0
Sample	n	174	39	18	9	240
	%	72.5	16.2	7.5	3.8	100.0

Table 39. Farm size parameters (ha) of sampled farms, Goubellat, Tunisia, 1984 (n = 240).

	Size (ha)				
	0-10	10-20	20-50	50+	Total
Average farm size	4.9	14.7	34.5	260.1	18.3
Average cultivated area	3.6(73)	10.5(71)	20.3(59)	174.2(67)	12.4(68)
Average fallow area	1.0(20)	3.4(23)	10.4(30)	80.1(31)	5.1(28)
Average hilly area	2.1(43)	7.5(51)	11.9(34)	141.3(54)	9.2(50)
Average flat area	2.5(51)	7.2(49)	22.6(65)	118.7(46)	9.1(50)

Figures in parentheses indicate % of average farm size.

Table 40. Principal rotations (% of farmers),[1] Goubellat, Tunisia, 1984.

	Farm size (ha)				
	0-10	10-20	20-50	50+	Total
Two-year rotation	43.8	8.3	5.4	3.3	60.8
(Fallow-cereal rotation)	(36.3)	(7.5)	(5.4)	(2.9)	(52.7)
Three-year rotation	22.1	7.1	2.9	1.7	33.8
Other rotations	9.2	3.8			12.9

1. Adds up to more than 100% due to the existence of more than one rotation on some farms.

In terms of area, cereals are the most important crop group, with durum wheat and barley dominant. Bread wheat is produced mostly on large farms, while olives and forage crops are relatively more important on the small farms (Table 41).

Information on use of purchased inputs is most complete for cereals (Table 42). The proportion of farmers who use fertilizer is quite high. Average yields, however, even allowing for under-reporting, appear to be considerably below potential yields. According to information from various variety and agronomy trials, the biological potential appears to be around 2000 kg/ha (grain yields) for cereals, with yields over 3000 kg/ha not being uncommon.

In contrast to the high proportion of farmers using fertilizer, herbicide use is not widespread. Considering the potential positive effects of herbicide, as well as the interaction effects with fertilizer (more effective use of fertilizer by the crops rather than by the weeds), herbicide use will be included in the on-farm research.

Durum wheat and barley production is more or less equally allocated to on-farm uses and sales (Table 43). While not very apparent from the figures, bread wheat is produced more for sale. Forage crops are produced primarily for marketing. Most livestock are primarily marketed for meat but milk is used almost exclusively on the farm. Among the food legumes, faba beans are mostly marketed, while peas are consumed on the farm. Some of these consumption and marketing phenomena may be transitory and may only reflect a given relative price environment.

In the design of the preliminary survey, it was hypothesized that the proximity of Tunis would provide off-farm employment opportunities and questions about such activities were included in the questionnaire. It appears that 45% of the farms have a person on the farm involved in off-

Table 41. Distribution of average crop areas (ha), Goubellat, Tunisia, 1984 (n = 240).

	Size (ha)				
	0-10	10-20	20-50	50+	Total
Durum wheat	1.2	3.4	7.7	68.2	4.5
Bread wheat	0.1	0.8	1.6	43.3	1.9
Barley	0.8	3.0	4.3	37.0	2.8
Total cereals	2.1	7.1	13.6	148.5	9.2
Forage crops	0.5	1.0	0.9	13.9	1.1
Food legumes	0.2	0.5	0.8	2.2	0.3
Olive trees	0.8	1.7	2.9	9.5	1.4
Alley cropping	0.4	0.6	1.8	0.4	0.6

Table 42. Fertilizer and herbicide use in cereals (% of farmers planting the crop) and average yields (kg/ha), Goubellat, Tunisia, 1984.

	P_2O_5	N	Both P_2O_5 and N	Herbicide	Yield (kg/ha)
Durum wheat	82	84	71	16	812
Bread wheat	92	89	84	32	979
Barley	76	79	57	11	972

Table 43. Uses of principal crops and livestock products (% of farmers producing each commodity), Goubellat, Tunisia, 1984.

	n	Sales	Farm consumption	Sales and farm consumption
Durum wheat	174	49	2	48
Bread wheat	37	16	11	73
Barley	159	53	4	42
Vetch and oats	21	67	28	5
Oats	62	71	8	19
Faba beans	48	56	17	27
Peas	30	20	63	17
Goats	32	78	13	9
Sheep	118	99	1	0
Milk	118	4	96	0
Cattle	118	98	1	1

Table 44. Off-farm activities (% of farmers), Goubellat, Tunisia, 1984.

	Farm size (ha)				
	0-10	10-20	20-50	50+	Total
No off-farm activity	33.3	12.9	6.8	3.3	55.4
Permanent worker	24.2	1.7			25.8
Seasonal worker	4.6				4.6
Employer	0.8		1.3	0.4	2.5
Other	9.6	1.7	0.4		11.7

farm activities and most of these people are employed in permanent jobs (Table 44).

Further research is needed to analyze how off-farm employment affects the farm. Preliminary results, not presented here, indicate that on average, farms with some members involved in off-farm activities appear to have a greater productivity, but this needs further investigation before definite conclusions can be reached.

Most farmers own livestock (Table 45), but the figures are probably misleading and low. The data, supported by field observations, indicate that farms which have livestock have small numbers mostly of sheep and one or two cows (Table 45). The absence of common grazing land plus treatment of fallow as private rather

Table 45. Livestock ownership (% of farmers in each farm size) and average numbers of livestock (n), Goubellat, Tunisia, 1984.

		Farm size (ha)				
		0-10	10-20	20-50	50+	Total
Cows	%	47	49	56	78	49
	n	1.5	1.9	3.1	8.7	2.1
Ewes	%	67	56	78	67	66
	n	8.7	10.8	14.6	70.0	11.9
Goats	%	13	10	11	33	13
	n	4.7	1.8	3.5	4.7	4.3
Donkeys	%	68	46	56	22	66
	n	1.1	1.2	1.1	1.0	1.1
Mules	%	24	36	33	33	27
	n	1.1	1.1	1.0	1.3	1.1
Horses	%	12	20	33	22	11
	n	1.1	1.0	1.0	1.0	1.0

Table 46. Machinery and equipment ownership (% of farmers in each farm size) in each group, Goubellat, Tunisia, 1984.

	Farm size (ha)				
	0-10	10-20	20-50	50+	Total
Tractors	0	8	50	100	9
Seed drills	1	0	17	88	5
Fertilizer hoppers	0	0	6	78	3
Sprayers	1	5	0	78	5
Threshers	0	0	11	78	3

than common land implies that the farm has to meet all animal nutrition needs from its own resources. The small flock size may be a reflection of this.

Finally, tractors and other equipment are owned mostly by big farmers (Table 46). Custom tractor services offered by these farmers seem to be widely used, but the extent of custom services was not assessed. This will be focused on in future research.

On-Farm Research for 1984/85

Identification of Target Groups

Data from the preliminary survey were used to separate farmers into manageable target groups. The basic assumption in this grouping was that the farmers' resources would influence their practices, and hence both resources and some of their manifestations in practices were considered.

1. Farms were first classified into two groups by size; less than, and more than 30 ha. This appears to be a natural cutoff point in that larger farms form a group with areas considerably more than 30 ha. In the 20-50 ha group, farms over 30 ha had an average farm size of 49 ha. Hence, it was assumed that a farm size greater than 30 ha would not fall within the characterization of a small farm. The average farm size for the group having less than 30 ha is 7.3 ha while it is 139 ha for big farms.
2. The second criterion used was tractor ownership. As discussed above, the survey did not cover information on tractor use through custom services. However, the existence of custom services implies that tractor owners would be able to command resources over and above the resources of the farm.
3. The first and the second criteria were combined to define two groups of farmers. The first, «big farms» is defined as having land of 30 ha or more or owning a tractor. This group comprises 10% of the sampled farms in Goubellat (n = 24). The average farm size is 119 ha.
4. Other farms, i.e., farms less than 30 ha of land (average farm size 7 ha) and without a tractor were classified further as follows:
   i. Having a fallow-cereal rotation vs any other rotation. This criterion not only reflects differences in the basic practice of rotation but is also indicative of the quality of land.
   ii. Having livestock vs not having livestock. As a significant proportion of feed requirements is met from farm production, this is likely to influence the choice of crops and practices.
   iii. The existence of off-farm employment. As discussed above, this may influence farm activities.

This grouping of farmers into eight subgroups of small farmers and one of big farmers was discussed by project participants in November 1984. It became clear that nine groups provided an unmanageable number for generalizable on-farm research. Hence, the following adjustments were made.

In 1984/85, around 50 farmers will be monitored. Agronomy trials and livestock monitoring will be conducted on 34 of these farms.

The 34 farmers, all of whom have livestock, will be divided approximately as follows:

a. Big farmers (n = 4).
b. Small farmers who practice a fallow-cereal rotation (n = 15).
c. A subgroup of the farmers who practice a fallow-cereal-barley and/or forage crop rotation (n = 15).

Such a grouping accounts for approximately 55% of the farmers in Goubellat.

The exclusion of farmers who do not have livestock is justified primarily by logistical reasons. In the preliminary survey, livestock information was deliberately not gathered in detail, as we did not want to unnecessarily jeopardize long-term plans by asking detailed questions about the sensitive subject of livestock. Hence, in 1984/85 intensive monitoring of livestock practices will take place on the 34 farms. Some farms which do not have livestock will be monitored outside the set of on-farm trial farmers to represent the 29% of farmers who do not have livestock, so that this group can be focused on in the future.

In each group, particularly of the small farmers, the effects of off-farm employment will be analyzed.

The choice of a subgroup of farmers from those who practiced other rotations stems from the agronomists' dissatisfaction with the nebulous concept of «other» rotations. This group was divided into those who practiced the 3-year rotation of fallow-cereal-barley and/or forage crop, with the remainder being a very diverse group.

On-Farm Trial Details

The decision to hold on-farm trials for these three groups is expedient in that it allows a concerted effort to be focused effectively on a sample representative of about half the farmers in Goubellat. Monitoring about 15 farmers from outside the trials would facilitate a planned expansion of the trials in the future as well as providing a basis for comparison.

The trials are not aimed at developing complex and rigid technology packages, because there is ample evidence that farmers do not adopt complete packages. The trials build upon farmers' practices and aim at developing technology components or practices which can be adopted in a piecemeal fashion by farmers.

The trials planned for 1984/85 are 2 × 2 herbicide-nitrogen fertilizer trials superimposed on farmer practices on a 0.4 ha area, large-scale medicago trials on big farms, and barley variety trials on farmers' fields. The variety trials were cancelled due to unavailability of barley seed from local sources.

The livestock monitoring will focus on feeding and rearing practices as well as monitoring weight gains, sales, purchases, etc.

In on-farm research, information from farmers is as valuable as information from trials on their fields.

In agronomic research, which involves a small area of 0.4 ha, the farmer is assured by agreement of at least his average yieldn, However, the matters are more complicated with livestock monitoring. The farmers are sensitive about allowing their livestock assets to be made known. It appears that certain incentives may be necessary to ensure farmer participation; this may bias results. Further discussion will take place between Tunisian and ICARDA livestock researchers in December 1984 before plans are finalized.

The FSR approach adopted in this project considers the social aspect of the system to be crucial. Social and economic research are not confined to baseline assessment in the beginning and an impact evaluation at the end of the project, but are fully integrated in all phases of research. Monitoring farmers' reactions to the on-farm trials, as well as research focused on specific socioeconomic matters, will continue through the life of the project.

In 1984/85 several activities will be conducted:

1. A study of the historical development of the present farming system in Goubellat will focus on the development of cropping systems, land tenure, process of adoption of improved practices and inputs, marketing, and the relations between different groups in Goubellat. Preliminary to an historical assessment of system development, information will be collected on demographic characteristics and chronology of input use. The actual study will be done in the future after preliminary methodological studies.
2. Crop-livestock interactions and the role of livestock in the farm and for the farm family nutrition will be monitored in conjunction with the livestock monitoring activities.
3. Product utilization, disposal, marketing, and farm/market relations will be analyzed. This study will ultimately constitute the doctoral research dissertation of one of the Tunisian scientists.
4. In conjunction with the collection of information on demographic characteristics, the study of the effects of off-farm activities on the farm will be initiated. In this respect, a broader and dynamic definition of the concept of the family was adopted. Instead of the narrow and static approach of identifying a family with cohabitation in a physical domicile, it was decided that a farm household is comprised of families which share income and resources. This way, the contribution of family members living off the farm, as well as the benefits they derive from the farm, can be assessed.
5. Independent of the field work, a study on recent developments in agricultural policy, especially with reference to the VI Development Plan, will be conducted in 1985. The focus will be on changes in macroeconomic policies with respect to priorities, relative prices, supports, and subsidies.

The field activities started in November 1984 with choosing collaborative farmers for the on-farm trials.

Conclusions

In the INRAT/INAT/ICARDA FSR Project, efforts are being made to identify the objectives of farmers and the constraints that they face. The trials are designed so that certain technical questions are answered and viable alternatives can be offered to farmers. The social and economic research focuses on the farmer and his family with the purpose of understanding the process of allocation of resources.

Farmers' involvement is integral to the on-farm trials. Their impressions of the trials will be sought continuously so that we can understand why some things do work while others do not, and identify constraints that are not necessarily technical in nature. It is clear that, in on-farm trials, the information elicited from farmers about the trials is as valuable as the technical information from the trials.

The following persons contributed to Project 4 in 1984: *Tunisian national program: Ms. R. Khaldi, Habib Halila, G. Khaldi, A. Ghayada, H. Amamou, A. Dahmane, B. Haddad, M. Harrabi, A. Majdoub, M. Hassan, S. Shukry, A. Tounsi, and M. Mejri; ICARDA: P. Cooper, A. Kamel, A. Mazid, K. Somel, T. Stilwell, E. Thomson, and M. Hallajian.*

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Harrabi, M. 1984. A review on agronomic research and experimentation at Goubellat and similar semi-arid areas. INRAT/INAT/ICARDA FSR Project Document. ICARDA, Aleppo, Syria.

Kerven, C. 1984. The impact of wage labour and migration on livestock and crop production in African farming systems. *In* Proceedings of the Kansas State University FSR Workshop. KSU, Manhattan, KS 66506, USA.

Khaldi, R. 1984. Principaux resultats de la pre-enquete effectue dans la delegation de Goubellat. INRAT/INAT/ICARDA FSR Project Document. ICARDA, Aleppo, Syria.

Mazid, A., Khaldi, R. and Hallajian, M. 1984. Farmers' grouping and sampling structure in Goubellat. INRAT/INAT/ICARDA FSR Project Document. ICARDA, Aleppo, Syria.

Training and Agrotechnology Transfer

During 1983/84, FSP staff were involved in a range of Training and Agrotechnology Transfer activities (TAT). These activities included lecturing, organization of short courses, supervision of postgraduate students, organization of and attendance at workshops and field days, production of training modules and handbooks, and regional travel. These activities will be outlined in more detail in subsequent sections. FSP staff also spent considerable time in meetings and discussions with the large number of visitors who came to ICARDA last year. It is difficult to quantify the impact of this latter activity with regard to TAT, but in many cases the time spent is undoubtedly worthwhile and the contacts made are very rewarding for both parties.

Our TAT activities have been substantial, even in the absence of a senior training officer. During 1983/84, intensive efforts were made to identify a suitable candidate for this position, and an appropriate candidate has been identified and will join us in early 1985. FSP therefore looks forward to increased coordination and expansion of TAT activities in the coming years.

ICARDA Residential Course

Trainees for this course are identified by FLIP, CP, and PFLP. As in previous years, FSP has contributed to this course through lectures on a range of topics. This year, staff gave lectures on:

a. Agricultural microbiology
b. Weed control in ICARDA crops
c. Principles of FSR
d. Economic analyses of agronomy trials
e. Farm survey techniques
f. On-farm trial methodology
g. Recommendation domains

Short Courses

Six short courses were held during 1983/84, three of which were on microbiology. Two Sudanese colleagues spent one week with us to become familiarized with the use of gas chromatography in microbiological research.

Another two colleagues from Cyprus also spent a week with us as part of our cooperative research with the Cyprus Ministry of Agriculture on the *Rhizobium*/legume complex. Sixteen food legume trainees spent over two weeks with the staff of the microbiology section and received both laboratory and field training in general agricultural microbiology.

Also, 12 scientists from Tunisia spent 4 days with us in Syria. During this period the philosophy and implementation of FSR was discussed. In this discussion our Barley/Livestock Systems project was used as a working example, and the group travelled to Breda to see the environment under discussion and to comment on our field research plots.

Three Sudanese scientists spent a week with us. During this period the course focused on livestock on-farm trials and included discussions with ICARDA staff, seminars, and field visits to the Livestock Unit at Tel Hadya and on-farm trials in the Breda/Bueda area.

Finally, in response to an invitation from the Desert Research Institute of China, one of our staff was funded for a two-week training visit to China to learn about the reestablishment of dryland agriculture in areas currently threatened by desertification.

Workshops

Two important workshops were held. The first, held in March, addressed the topic of «Fertilizer Use in Dry Barley Producing Areas», and was jointly organized by the Syrian Soils Bureau, who are responsible for formulating fertilizer recomendations, and ICARDA. Eleven papers were presented covering socioeconomic and environmental aspects of the barley producing areas of Syria, the responses obtained to fertilizer (principally phosphate), its effect on crop growth and water-use patterns, and the economic implications of fertilizer use. Proceedings of this workshop are available from ICARDA.

The workshop was attended by 14 Syrian colleagues from the Soils Bureau, ARC, Aleppo University, Directorate of Agricultural Affairs, the Ministry of Planning, and ACSAD. We were also pleased to welcome two scientists from overseas, one from Cyprus and one from England. Stemming from the workshop, we have initiated a joint Soils Bureau/ICARDA cooperative research program to investigate the economic potential for fertilizer use throughout the barley producing regions in Syria. In future years this program will be expanded to include research on alternative crop rotations in barley growing areas.

In the summer, in collaboration with IDRC, we held a workshop on food legume economics. This workshop was attended by 10 scientists, 6 from Egypt, 1 from the Sudan, and 3 from Syria. The main objectives were to examine, country by country, the results and economic implications of on-farm research on lentil and chickpea, and to assess the on-farm trial methodology utilized in each country and produce a manual describing successful on-farm trial techniques. This workshop, with its practical objectives, was considered very useful indeed by the participants and could serve as a model for the future.

A third workshop was planned for the season on «Livestock and Forage Husbandry Systems in Dryland Environments», but had to be delayed until December 1984.

Postgraduate Students

FSP continues to encourage the involvement of postgraduate students in our research program. We feel that this type of individual training is very beneficial for several reasons. We endeavor, wherever possible, to select topics for the research thesis which form an integral component of our core research program. By doing so, the student has access to a substantial set of research results which relate to his own work, and our own program is enhanced by his research. By being with us for 2 to 3 years, the student is continuously exposed to the concept of FSR, and at the same time we establish solid contacts for the future. During the 1983/84 season we enjoyed the support of the following postgraduates.

In addition to these, we will be joined by two M.Sc. students from Yemen in December 1984 who are registered with Aleppo University. They will be involved in on-farm trial research with forage legumes in Project 1, and herbicide x fertilizer trials in Project 2. We will also be associated with funding and supervising two M.Sc. students at the University of Jordan.

As indicated under Research Highlights, we visited many scientists and research instituions in the region for discussions, seminars, field trips, and conferences. This outreach is invaluable. Not only are we being exposed to a wider spectrum of agricultural systems and research problems, but as our own experience increases, we are able to discuss our current program of research in relation to the problems faced by other colleagues in the region.

Name	Degree level	Associated University	Thesis topic
E. Rashed	Ph. D.	McGill, Canada	Crop rotations (barley)
A. Wehbe	Ph. D.	Reading, UK	Barley root development
Y. Sabet	Ph. D.	Paris, France	Rainfall intensity/ soil erosion
M. Mokbel	Ph. D.	Massachusetts, USA	Human nutrition
M.A. Moneim	Ph. D.	Colorado State, USA	N dynamics of urea fertilizer
S. Dozom	M. Sc.	Aleppo, Syria	Crop rotations (wheat)
M. Wahoud	M. Sc.	Aleppo, Syria	Forage barley agronomy
S. Magid	M. Sc.	Gezira, Sudan	Agricultural economics

Miscellaneous Activities

Staff were also involved in other TAT orientated activities. Two slide-show training modules are being produced on *Rhizobium* spp. inoculation and the N-cycle in agriculture. A laboratory training manual has also been prepared for important soil chemical analysis techniques, with special reference to soil nitrogen and phosphorus. Staff also participated in 12 field days for farmers, Syrian Ministry officials, and groups of visitors. These field days were held at the contrasting locations of Tel Hadya, Breda, and Bueda, and enabled us to discuss some of our crop rotation agronomy and on-farm trial research.

We continue to publish the Farming Systems Newsletter, and are receiving a pleasing response to its circulation. Already, we are receiving outside contributions, and we hope that this trend will continue. Many other publications, listed below, have also been produced by staff during the 1983/84 season.

In conclusion, FSP has been involved in a diverse range of TAT activities during the 1983/84 season. As we become increasingly confident of our role in the region, these experiences are likely to expand and become even more rewarding. With the arrival of a senior training officer in 1985, to coordinate and lead our efforts, we believe that the full potential of our flexible approach will become realized.

Publications

Journal Articles

Dennett, M.D., Keatinge, J.D.H. and Rodgers, J.A. 1984. Comparison of rainfall regimes at six sites in N. Syria. Agricultural and Forestry Meteorology 31: 319-328.

Gregory, P.J., Shepherd, K.D. and Cooper, P.J.M. 1984. Effects of fertilizer on root growth and water use of barley in northern Syria. Journal of Agricultural Science (Cambridge) 103: 429-438.

Keatinge, J.D.H., Dennett, M.D. and Rodgers, J.A. 1984. The influence of precipitation regime on management of 3-course rotations in N. Syria. Journal of Agricultural Science (Cambridge). In press.

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Cereal Improvement Program

Contents

Cover: Several national programs in the region have released new wheat and barley varieties from the material provided by the Cereal Improvement Program. These varieties are doing very well in farmers' fields. Here a happy Syrian farmer winnows his rich harvest from one of the new varieties of durum wheat.

Cereal Improvement Program

The major objective of the Cereal Improvement Program (CP) continued to be to increase the productivity and yield stability of barley, durum wheat, and bread wheat, particularly in the rainfed areas in West Asia and North Africa. Priority was given to the development and distribution of broad-based germplasm with higher yield potential, resistance to disease and insect pests, and yield stability. Agronomic research in the program was primarily in cooperation with national programs to develop production practices that make the most effective use of the limited environmental and other resources available to farmers. To meet specific needs of farmers in the region, priority was given to improving genetic resistance to major diseases and insects, drought avoidance/tolerance, and grain and straw quality.

During 1984, the CP conducted an extensive review of its program objectives, priorities, strategies, and research methodologies which involved program scientists, outside consultants, scientists from national programs, and the Deputy Director General (Research). Taken into account were recommendations from ICARDA's external review held in 1983 and the agreement on the division of responsibilities between ICARDA and CIMMYT with respect to barley and wheat research.

Barley research for dry areas (< 300 mm rainfall) will receive more attention than in the past. In these areas barley together with sheep is the main farming system and therefore a major objective of this project will be to increase total biological yield (grain plus straw) and straw quality of barley to help improve the sheep production component of the system. Work on dual-purpose barley for green forage and grain will receive less attention as the practice of green grazing is limited only to wetter areas. The Program moved forward to fulfill its global responsibility for barley improvement and posted a senior barley breeder at CIMMYT to jointly conduct barley research primarily in Central and South America.

ICARDA and CIMMYT jointly developed a work plan in 1984 for durum wheat improvement in the 350-500 mm rainfall areas of the Middle East and North Africa, and CIMMYT seconded a durum breeder to ICARDA to further strengthen durum improvement activities in this region. Priorities are: improvement of grain yield and stability of yield in rainfed areas, incorporation of resistance to stripe rust, stem rust, leaf rust, *Septoria tritici*, common bunt, and other diseases causing yield reductions, improvement of resistance to major insects, e.g. stem sawfly, aphids, suni bug, and Hessian fly, and improvement of grain and straw quality.

The ICARDA/CIMMYT bread wheat improvement project continued to focus on developing high-yielding, disease- and insect-resistant, and management-responsive varieties suitable for the 350-500 mm rainfall areas of the Middle East and North Africa. The project placed emphasis on incorporation of specific characters such as resistance to the bacterial blights and other diseases and insects as well as on identification of lines exhibiting avoidance/tolerance to factors such as drought, heat, cold, and salt. All advanced breeding lines were subjected to industrial and nutritional grain-quality tests in the laboratory.

The triticale improvement project was also critically reviewed. During 1984, the research focus sharpened to concentrate on improving genotypes for low-rainfall areas, high-elevation areas, adaptability in the region, better grain quality, and consumer acceptability.

A report on cereal research in high-elevation areas was produced, highlighting the need for the development and distribution of appropriate germplasm to meet the needs of farmers in high-elevation areas. Despite limited resources and testing facilities, significant advances have been made in developing germplasm and production practices in collaboration with national programs. In 1984, germplasm was made available also to Iran and Turkey.

Cereal pathology aims at further improving resistance in ICARDA's breeding material. Increased emphasis was given to international multilocation testing for disease resistance to generate information on the performance of lines against a wider spectrum of pathogens. Seedling tests were also started in greenhouses to screen against foreign isolates of scald and septoria leaf blotch. An ICARDA cereal scientist posted in Tunisia is focusing on the specific problems in pathology in North Africa, and the Montana State University cooperates closely with the Cereal Program by screening barley germplasm and by providing training opportunities for national program scientists. A major goal for 1984/85 is to start a collaborative project in which national programs will be encouraged to accept responsibility for research on specific diseases. Each «national diseases center» will study the virulence spectrum of one or more important diseases and screen ICARDA's and national programs' germplasm for resistance.

During 1984, physiology/agronomy research in the CP was reviewed and, based on the findings, a physiology/agronomy team consisting of a senior physiologist/agronomist, a postdoctoral fellow, and research support staff will be formed. They will conduct crop management and physiology research to improve and stabilize barley and wheat yields in the semi-arid areas of the Middle East and North Africa. Research will be multidisciplinary and concentrate on: enhancing capacities of national programs to develop their own recommendations for agronomic practices, developing basic understanding of the management practices for new potential varieties, identifying specific plant characters associated with drought avoidance/tolerance and developing practical screening techniques for these characters, developing the research capacity and expertise to study and understand the mechanisms of tolerance to prevalent environmental stresses to assist breeders in tailoring the selection of genotypes to overcome these stresses, and training researchers from national programs.

Initial emphasis will be on drought avoidance/tolerance in barley and durum wheat, and subsequently other stresses associated with drought, such as heat, cold, and salinity, may be included.

During the year, CERINT, the database management system for the Cereal Program, was further improved. This helped in processing data from the base program and international nurseries, and enabled the CP to advise national programs about the most promising lines and resistance levels in the material. The Cereal Program plans to improve networking activities with the national collaborators by a more systematic and continuous flow of scientific information, visits, and sponsoring workshops and conferences.

RACHIS, ICARDA's cereal newsletter, entered into its fourth year of publication and has been well received throughout the region. Efforts are continuing to produce RACHIS in Arabic.

Staff Changes

The following staff members left the program in 1984:

1. Mr. Christian Jung, Ph. D. student, triticale.
2. Dr. Miloudi Nachit, durum breeder (transfer-

red to CIMMYT but posted at ICARDA).
3. Dr. Rients Niks, postdoctoral fellow (durum breeding).
4. Ms. Eva Weltzien, Ph. D. student, salt tolerance.
5. Dr. Mark Winslow, cereal physiologist.

The following staff members joined the Cereal Program in 1984:
1. Dr. Salvatore Ceccarelli, barley breeder.
2. Dr. Dieter Mulitze, postdoctoral fellow (international nurseries).
3. Dr. Hugo Vivar, barley breeder, seconded by CIMMYT.
4. Dr. Sui Yau, postdoctoral fellow (barley breeding).

Research Highlights

Using improved germplasm, provided through the International Nursery system of Cereal Program, the national programs in the region identified and released a number of new cereal varieties (Table 1). Some more lines are expected to be released soon as new varieties (Table 2).

The other significant achievements of the Cereal Program are listed below.

Project I: Barley

1. New genetic material developed from ICARDA's barley germplasm pool and tested in the international nurseries showed large yield potential and wide adaptability in the region (e.g. the Rihane sister lines and ER/Apam) and promise of specific adaptation (Harmal and Soufara).
2. Seed was provided by ICARDA to Arab Republic of Yemen, Egypt, Jordan, Morocco, People's Democratic Republic of Yemen, Syria, Tunisia, and Turkey for large-scale farm trials.

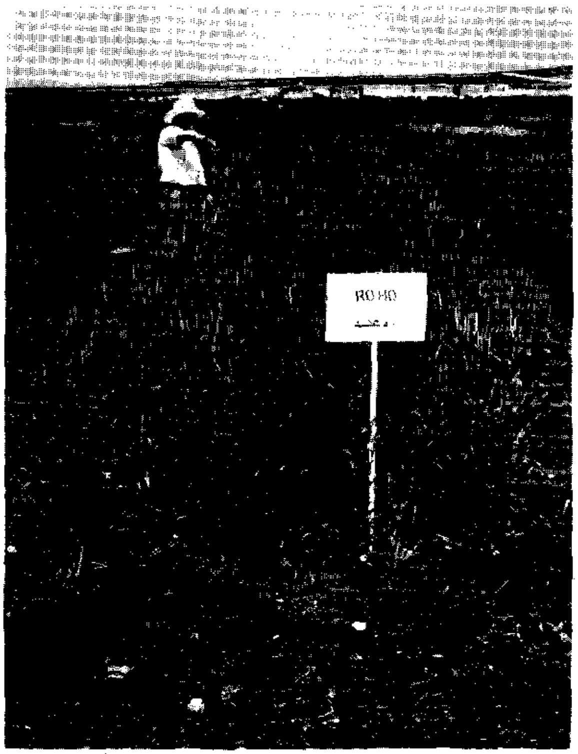
Table 1. Barley and wheat varieties released in the region.

Barley	
Cyprus	Kantara = Roho
Iran	Val Fajr
Morocco	Asni
Qatar	Gulf = Arivat x Athenais
	Harma = 54/Tra//2*(Cer/Toll)/3/2* Avt/Ki//Bz/4/Vt/5/Pro
Durum Wheat	
Egypt	Sohag = Stork'S'
Cyprus	Mesaoria = Anshinga'S' x Volunteer
	Karpacia = Sham 1
Morocco	ACSAD 65 = Stork'S'
Syria	Sham 1 = Plc'S'/Ruff'S'//Gta'S'/Rotte
Portugal	Celta = Sham 1
Bread Wheat	
Iran	Azadi
Morocco	Jouda = Kal x Bb
Pakistan	Zargoon = Cc - Inia/Tob-Cfn x Bb/7C
Sudan	Debeira = HD 2172
Syria	Sham 2 = 7C x Tob-Cno/Kal
Peoples Dem. Rep. of Yemen	Ahgaf = S311 x Norteno

Table 2. Potential candidates for release.

Tunisia	Barley	ER/Apam
		Roho
		WI 2198
Thailand	Bread wheat	SW 9 = Tob 66-Cno'S' x P162/SK9
Morocco	Bread wheat	Pvn (Pato (R) Cal/3/7C//Bb/Cno
		Pavon'S'
		Maya 74-Pvn'S'
	Durum wheat	Belikh = Cr'S'/Stk'S'
		Porzana = 21563 - Cr'S' x Fg'S'
		Toubkal = (Yamen-Cr x Plc/Tebo) Mex
		Grebe'S' = Gs-Cr/21563 - AA x Cit
		Erpel/Ruso'S'
	Barley	ER/Apam
	Triticale	Beagle
		Juanillo 95
		Drira - Outcross

3. Greater emphasis was given to total dry-matter yield and straw quality rather than to grain yield alone, particularly for areas receiv-



Three barley lines from the material provided by ICARDA are potential candidates for release to farmers in Tunisia. Here a national program scientist evaluates the performance of one of these lines, Roho, proposed to be released under the name Taj.

ing less than 300 mm/season of rain, to develop barleys which will integrate successfully into a sheep-barley farming system.

4. Increased emphasis was given to breeding for the driest areas. Considerable efforts were devoted to develop appropriate methodology, and two new test sites (Tel Dhaman and Bouider) were identified (long-term average precipitation rates of 220 mm and 175 mm, respectively). A modified bulk system was applied to segregating populations grown at four to five sites in parallel with the pedigree procedure at Tel Hadya.
5. A thorough documentation of 5000 barley entries was completed in collaboration with the Genetic Resources Unit (GRU) of ICARDA and a catalog is under preparation for publication. Field and laboratory data have been computerized, and specific information can be retrieved easily for scientists in the region. In early 1983/84, an additional 5000 entries were evaluated and cataloged with support from the International Board for Plant Genetic Resources.

Project II: Durum Wheat

1. A number of countries requested nucleus seed of new promising varieties. Seed of Sham I, Korifla, Sebou, Oumrabia, and Belikh was supplied to Turkey, Jordan, Pakistan, Morocco, Syria, and Lebanon.
2. Morocco identified new durum lines Porzana, Toubakal, Grebe, Erpel/Ruso, and Cr/Stk as promising candidates for release as new varieties.
3. It was interesting to note that Oumrabia, Belikh, and Chen performed very well in the dry 1983/84 season.
4. Screening for drought and heat tolerance, and resistance to *Septoria tritici* and sawfly was strengthened.
5. Sebou and Korifla significantly outyielded the locally adapted Haurani for the second season in the Syrian farm trials. They are again being tested and are potential candidates for release.
6. Our work on grain quality helped in identifying lines with good vitreousness and grain appearance for advanced yield trials.

Project III: Bread Wheat

1. Two promising advanced bread wheat lines, FLK'S'/HORK'S' and HD 2206/HOR'S', were selected by 17 countries in the ICARDA region. These lines produced large yields under moderate rainfall (230-400 mm) and showed good disease resistance; they are be-

ing extensively tested by the national programs for possible release.
2. Many bread wheat lines performing well under drought conditions of 1983/84 were identified.
3. International cooperation with national programs in the region increased. Cooperating countries for specific nurseries included Egypt (for aphid tolerance), Jordan (for drought tolerance), Morocco (for Hessian fly resistance), Sudan (for stem rust resistance and heat tolerance), and Tunisia (for drought tolerance).

Project IV: Triticale

1. Progress was made in improving grain yield, kernel plumpness and color, and breadmaking quality of triticale.
2. Suitability of triticale as a poultry feed was investigated in a joint ICARDA/University of Aleppo experiment.
3. There has been increasing interest in triticale in the region. Nucleus seed of Beagle, Drira outcross, and Juanillo 95 was provided to Morocco for multiplication.
4. Our future efforts will concentrate on evaluating triticale for its overall biological productivity (grain plus straw), particularly in dry areas, and on investigating its potential as a dual-purpose (grain and animal feed) crop.

Project V: High-Elevation Cereal Research

1. High-yielding disease-resistant bread wheat varieties/lines Lom 23/Can, Katya A-1, Qt 4081-Pwth/3* Candor, and 'Vratza' are being extensively tested in Baluchistan, Pakistan at elevations above 1000 m. Line Qt 4081-Pwth/3* Candor was also selected in Morocco due to its consistently high yield.
2. Cooperating researchers in Pakistan are testing high-yielding, cold-tolerant, and disease-resistant durum lines. Agronomic trials once again indicated large responses in yield to nitrogen in Baluchistan.
3. *Triticum dicoccoides* lines were screened for cold tolerance, disease resistance, and quality, and two lines possessing the genes for these traits were identified. Crosses of *T. dicoccoides* and *T. durum* were made to widen the genetic base and transfer the genes to durum wheat.
4. Productiveness of higher yielding varieties and suitable production technology are now being demonstrated in the highlands of Baluchistan in PARC (Pakistan Agricultural Research Council)/ICARDA and FAO projects.

Project VI: International Cooperation

1. Close interaction with national programs is a key component in the program's efforts to provide more effective backup to collaborating scientists in national programs. New collaborative projects were started with Egypt, Ethiopia, Iran, Sudan, and Turkey.

Project VII: International Nurseries

1. International nurseries links were strengthened by increased use of computer software and extraction of more information from international nursery data. A draft of a brochure providing general information on the International Cereal Nurseries System has been prepared.
2. All data from nursery cooperators were stored and summarized under CRISP, CERINT, and SPSS-X software on the computer, and information from regional and ICARDA yield trials was grouped by areas.

Project VIII: Training

1. Eight research assistants from national programs participated in a 6-month residential training course which emphasized practical aspects of breeding cereals under rainfed conditions, agronomy, disease and insect resistance, and field verification trials.
2. The Program in collaboration with other ICARDA programs, trained over 50 participants in short courses on germplasm and genetic resources, seed production, mechanization of research plots, and field experimentation.
3. Twenty Moroccan cereal researchers were trained in experimental design and data analysis and interpretation in an in-country course which was greatly appreciated by the national program.
4. Sixteen trainees from 12 countries spent from 1 week to 7 months visiting, discussing, and working with ICARDA scientists at Tel Hadya on specific topics of cereal improvement under rainfed conditions. Also, 131 scientists from national programs, developed countries, and international institutions, as well as many university students and others visited the program during 1983/84.
5. CP scientists lectured in national universities of Syria and Tunisia and supervised five postgraduate students (two M.Sc. and three Ph. D.).
6. ICARDA and CIMMYT jointly sponsored a workshop on cereal improvement which was held in North Africa and the Iberian Peninsula to discuss methodologies for varietal development, disease resistance, and stress tolerance. — *J.P. Srivastava.*

Project I: Barley Improvement

Wheat and barley account for a large percentage of food crop production in West Asia and North Africa. Although wheat ranks first in terms of acreage, production, and economic importance, barley in conjunction with sheep often is the predominant farming activity in the dry areas (200-300 mm annual rainfall). The unpredictable environmental conditions in the dry areas pose a problem of stability of barley production and make it difficult to develop appropriate selection strategies to identify genotypes that would provide larger yields and greater stability. In 1983/84 we continued our efforts to breed genotypes which can perform well across a range of seasonal and environmental conditions and still possess capability for high yields in good years.

To create an appropriate broad-based germplasm pool, utilizing the genetic diversity in the world germplasm collection, over 10,000 crosses have been made at ICARDA since 1977. Whenever possible, one of the parents in these crosses was a good performer in the local environment. Local landraces have been used in 760 of these crosses. Plant characters considered in these crosses were: yield performance of the local parent, phenotype of the parents for other important characters, combining ability, breeding record and pedigree of the introduced parent.

Germplasm from crosses between introductions and adapted types is provided to national programs in the form of segregating populations and advanced lines for selection for stress tolerance (drought, heat, and cold), yield and yield stability, disease resistance, agronomic type, and grain and straw quality. The strategy is to quickly distribute early-generation segregating populations identified at a few representative screening sites for further selection in environments where they are to be grown. These populations are designed to provide cooperators with sources of useful gene combinations and germplasm with the required plant characters. To meet this objective and to achieve larger yields in drier areas, we use the following strategy:

In the very low-rainfall areas, barley and sheep are the backbone of the farming systems. ICARDA is therefore attempting to improve the total biological productivity of barley, including both grain and straw.

1. We work closely with national programs. Results from the international nurseries clearly show that ICARDA's germplasm was better utilized in countries where the cereal program staff have kept close contact. A continuing goal is to improve national research capabilities with the long-term objectives to leave the national programs the responsibility to create lines for their own environments while ICARDA will move into newer research frontiers, though retaining a supportive role to national programs.
2. We screen and select (mainly in the F_2 generation) in several dry locations to identify parental lines and cultivars for the agroclimatic conditions of barley-growing areas. To screen a large number of populations for stress tolerance, replicated selection in three to five environments is needed in any one year to identify superior gene combinations and determine the adaptability of the material.
3. We have started employing a modified bulk selection system at several sites, to replace the expensive pedigree system.
4. We are constantly expanding the barley germplasm pool by utilizing the genetic diversity available in the world barley germplasm banks, including local land-races and close relatives of barley.
5. We accumulate and combine genes for stress tolerance from various sources with help from ICARDA's agronomists and physiologists.
6. By selective crossing we improve the disease resistance of the high-yielding germplasm developed at ICARDA.
7. We screen and select materials in the main reason, and then advance the generation at a summer nursery site.
8. Develop cultivars with a large yield of straw and cultivars for grazing, for areas where straw and grazing are relatively more important than grain.
9. Develop improved agronomic practices for barley-growing areas.

Component I: Breeding

Breeding Procedures

The aim of the breeding program is to develop barley genotypes adapted to dryland conditions and with large stable yields.

The scheme of ICARDA's barley breeding and testing procedures is shown in Fig. 1. Selection at the main station at Tel Hadya is different from that carried out at the drier sites. The main pro-

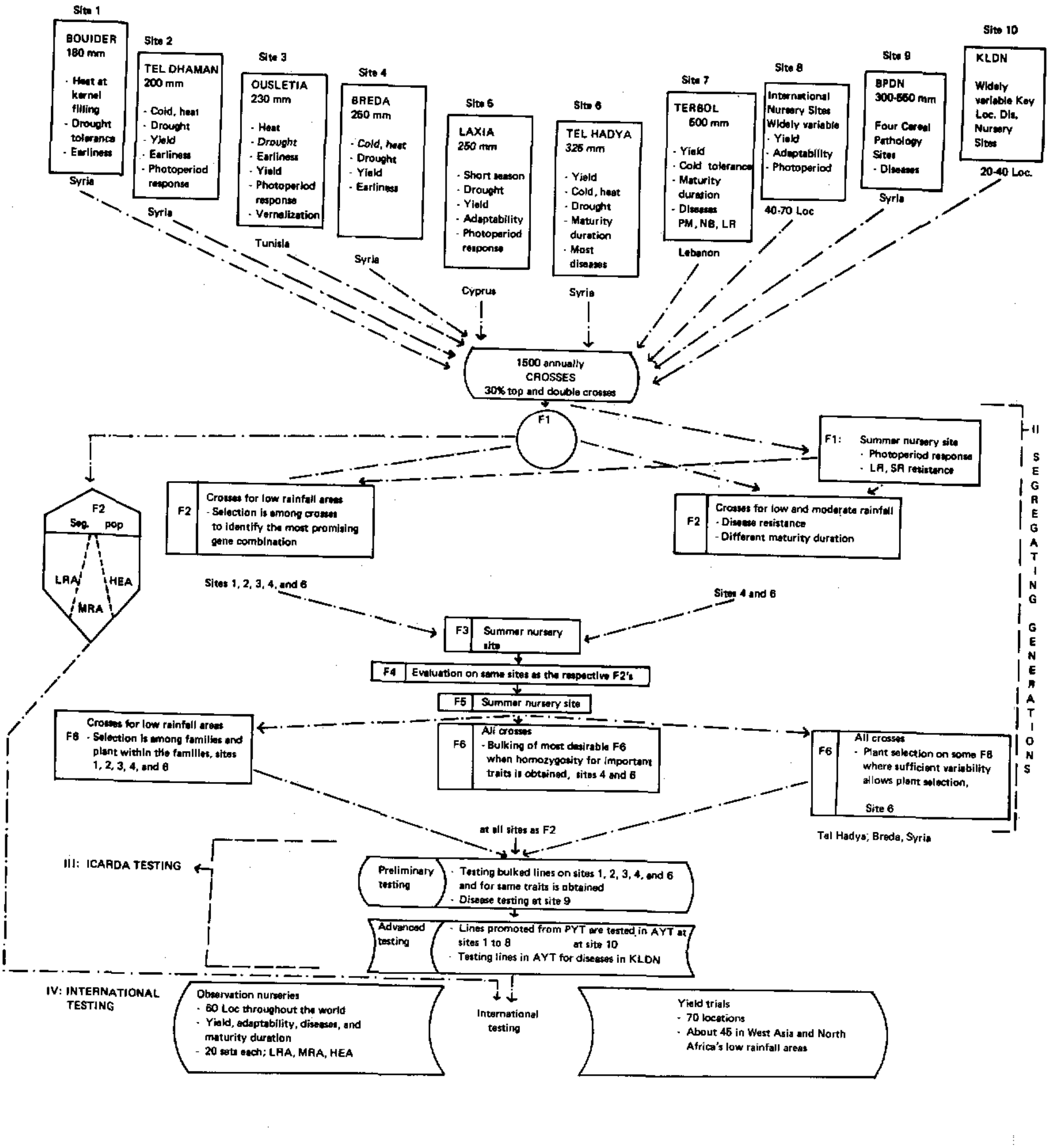


Fig. 1. Barley breeding procedure at ICARDA.

cedure used at Tel Hadya was a modified pedigree system in which selection was based on single plants combining the desirable characters from both parents in the F_2 generation. This procedure will be continued in all those environments where expression of plant characters allows single-plant selection. In later generations, selection of the best families was emphasized, followed by selection of the best plants within those families. Two generations were grown per year unless space in the summer nursery did not permit growing the later generations. Bulking and yield testing were practiced as early as the F_5 generation. Early segregating populations for drought tolerance, however, will be advanced differently using a modified bulk method with emphasis on replicated selection at several dry sites in any one season. The objective is to identify superior gene combinations under dry conditions. Single-plant selection as early as F_2 generation, when desirable, will be carried out simultaneously at Tel Hadya on identified superior crosses. Single-plant selection at all dry sites will be in F_6 generation if sufficient rainfall permits differential expression of the plant characters. Replicated yield testing of bulks will start with F_4 generation.

Prior to distribution to national programs the most promising bulks and cultivars are yield tested in preliminary trials over 2 years and four environments in Syria: Tel Dhaman, Bouider, Breda, and Tel Hadya with average annual rainfall ranging from less than 200 to above 350 mm. The most promising cultivars are promoted to advanced yield trials over eight environments for 1 or 2 years. These, in addition to the four environments in Syria, are: Ousseltia (230 mm) and El Kef (450 mm) in Tunisia, Terbol (650 mm) in Lebanon, and Athalassa in Cyprus (250 mm).

Information on disease resistance is collected as soon as lines are bulked for preliminary yield testing and thereafter when the lines are promoted to advanced testing in the Key Location Disease Nursery (KLDN); the promising lines are then promoted to international nurseries.

Germplasm Development and Evaluation

Information on breeding material tested in this project is presented in Fig. 2. Screening activities were decreased after the two initial seasons (1978-80). The large collections tested in the earlier years have provided a few promising lines which are being examined more intensively for specific characters, mainly disease resistance and stress tolerance.

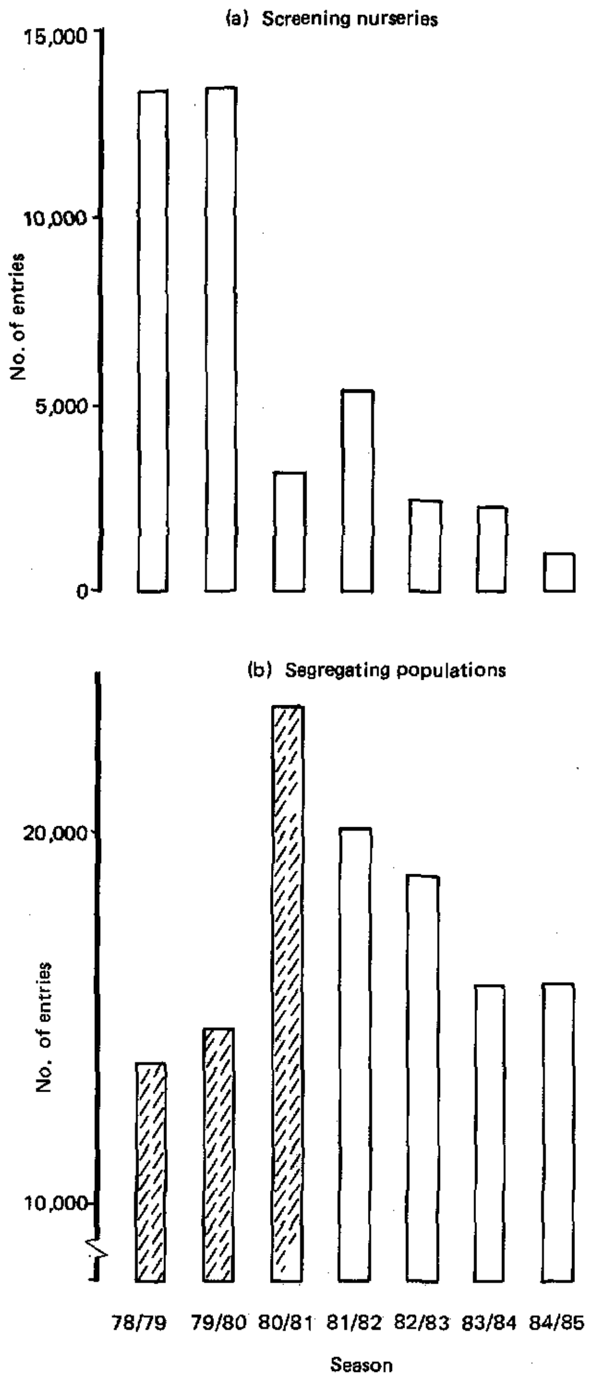
The number of segregating populations increased until 1980/81, because a large number of crosses was made earlier to create the germplasm pool. Then the number started to decline. We now propose to limit the number of crosses to 1000 per year. However, the replicated selection at five sites in Syria and Lebanon (including two new sites, Tel Dhaman and Bouider in Syria) is expected to bring about a new surge in segregating populations.

Segregating populations targeted for specific environments have started to prove their usefulness. During 1983/84 three sets of F_2 segregating populations (for dry areas, moderate rainfall areas, and high-elevation areas) were evaluated both at Tel Hadya (230 mm) and Breda (160 mm). The number of populations selected within each set (Fig. 3) shows that, because of the dry year, a higher proportion of F_2 was selected from the F_2 populations specifically developed for dry areas.

Advanced Yield Trials

The yield improvements of the best performing entries in advanced yield trials at Tel Hadya since the 1980/81 season are shown in Fig. 4. It appears possible to improve yields in the region over the 1000 kg/ha long-term regional average using the newer varieties and appropriate production technologies. The Rihane sister lines, in particular, have maintained a consistently high yield over three cropping seasons. They were promoted to international nurseries and were reported to be performing well over a wide range of environments (ICARDA Annual Report 1983, p.78). Results for 1983/84, a very dry year, show significant yield increase of promising genotypes over Arabi Abiad, the adapted local check (Fig. 4). The yield increases shown for the germplasm tested by ICARDA closely match those obtained by cooperating national programs (see section on Regional Yield Trials).

To supplement the information obtained from dry sites in Tunisia, Syria, and Cyprus and to select for drought resistance in advanced lines, a set of advanced yield trials is usually sown 3 months late (around mid-February) at Tel Hadya. The purpose of late planting is to expose the lines to heat and drought stress during kernel filling, and to assess their resistance to these stresses. Cultivars that yielded well when sown late were generally those that had higher 1000-kernel weight (Table 3); or, vice versa, lines that produced smaller yields when planted late had smaller kernels. The production of large kernels with late sowing seems therefore a good indication of stress resistance. During 1983/84, late planting received less than 30 mm rainfall after sowing. Yields were therefore much lower, and



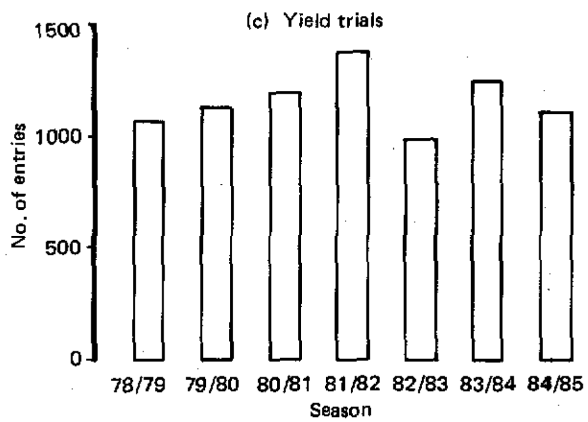


Fig. 2. Number of lines in (a) screening nurseries, (b) segregating populations, and (c) yield trials in the barley breeding program from 1978/79 to 1984/85 (international nurseries included).

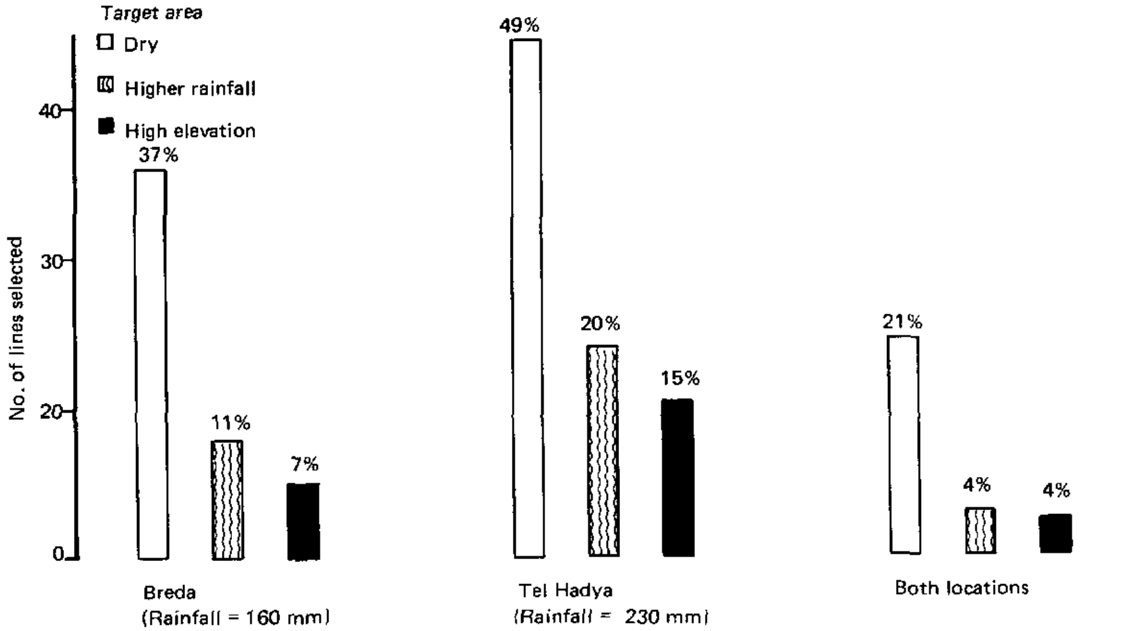


Fig. 3. Number and percentage of lines selected at Breda and Tel Hadya, and those common to both locations, from three groups of F_2 populations targeted for dry areas, higher rainfall areas, or high-elevation areas, 1983/84.

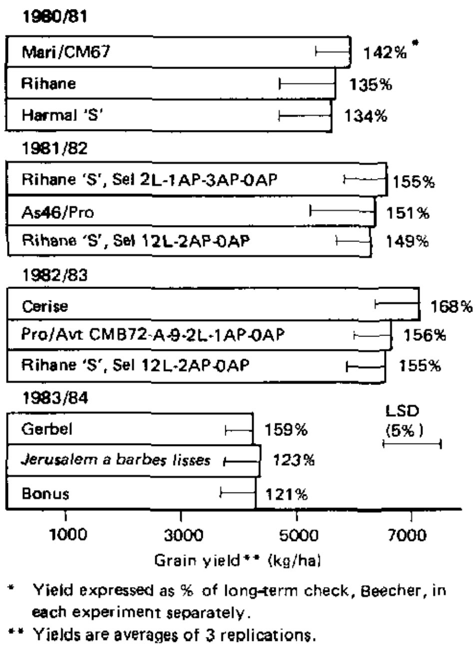


Fig. 4. Highest yielding entries in the advanced yield trials at Tel Hadya from 1980/81 to 1983/84.

kernels smaller, but protein percentage increased as expected. It can be seen, however, that the decrease in kernel weight was much less than in grain yield, suggesting that in higher yielding genotypes kernel weight is much less affected under adverse conditions than other yield components.

Dual-Purpose Barley Yield Trial

In the North African and West Asian regions, barley is often left to be grazed during the early stage of growth, and is then allowed to regrow to obtain grain and straw. Therefore, the aim of this project is to develop dual-purpose genotypes which can provide both large yields of forage for early grazing and large yields of grain and straw after grazing. Efforts have also been directed to the identification of morphological and physiological characters useful as criteria for early-generation selection of dual-purpose barley genotypes.

In the 1983/84 season, 210 genotypes were evaluated at Tel Hadya following essentially the procedures used the previous year (ICARDA Annual Report 1983). Forty-two promising genotypes identified in the previous seasons were also tested at Breda, a dry site.

Forty-one of the 210 genotypes tested at Tel Hadya were found to have high dry-matter yield at grazing as well as good grain and straw yield, and therefore are promising as dual-purpose barley. The performance of some of these genotypes in comparison with those of the forage and grain types is shown in Fig. 5. The dual-purpose type had large green-forage production at the time of cutting as well as large grain yield after cutting. They also had reasonably large grain yield without green-stage cutting and large straw yield after cutting. No results were obtained from the trial at Breda because of the drought encountered.

The time of heading or maturity appeared to be the most important criterion for selecting dual-purpose type of barley. The numbers of days to maturity and heading (without green-stage cut-

Table 3. Variation in mean yield, protein percentage, and kernel weight of barley lines in advanced yield trials under two different planting dates at Tel Hadya, 1983/84.

Line/cross/pedigree	Yield (kg/ha)[1]			Protein (%)		1000-kernel wt. (g)		
	N	L	% of N	N	L	N	L	% of N
Jerusalem a barbes lisses/ CI 10836 ICB77-319-IAP-OSH-2AP-IAP-OAP	4341	1136	26	9.4	15.4	37.9	26.2	[illegible]
Bonus	4277	1233	28	8.5	17.0	36.1	19.3	[illegible]
Legia	4200	686	16	8.4	15.4	33.5	24.3	[illegible]
WI 2197/Cam ICB77-19-IAP-5AP-IAP-OAP	4077	1375	33	8.1	14.8	38.2	24.9	[illegible]
NK 85	4061	1650	40	7.3	14.3	41.9	27.3	[illegible]
Roho/Masurka ICB77-170-4AP-4AP-2AP-OAP	3986	1605	37	8.5	16.2	42.3	31.0	[illegible]
Pitayo/Cam CMB74A-84-7B-1Y-1B-OY507	3819	1500	39	10.0	17.1	41.6	27.0	64
Bahtim/Gva CMB74A-236-4S-OAP	3658	1436	39	6.9	13.1	37.1	26.6	[illegible]
Checks								
Rihane 'S'[2] Sel 2L-1AP-3AP-OAP	3237	955	30	7.5	12.6	39.6	24.6	62
Beecher[2]	2939	1324	45	7.3	12.9	43.5	28.6	66
ER/Apam[3]	3789	1364	36	7.5	12.4	41.4	32.3	78
Harmal[3]	3217	1030	32	8.3	15.9	38.9	29.8	77
Arabi Abiad[2]	3293	931	28	7.5	15.9	41.1	31.6	77

1. N = Normal, L = Late. Mean over three replications in each experiment.
2. Mean over seven experiments.
3. Mean over six experiments.

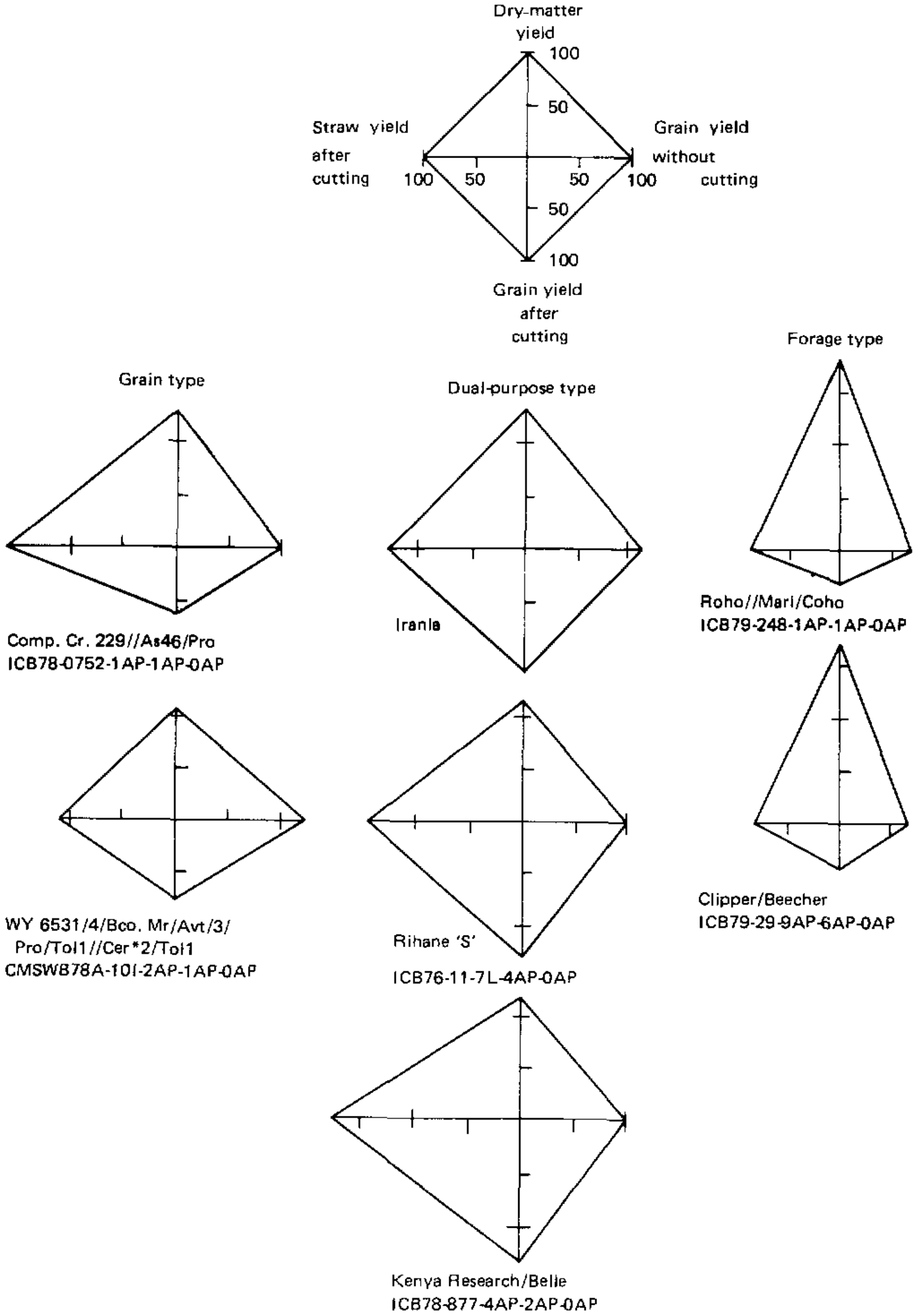


Fig. 5. Performance of dual-purpose type barley in comparison with forage and grain types. Yields of the different genotypes were expressed as percentages of the check, Arabi Abiad.

ting) were significantly and positively correlated with grain yield and straw yield after green-stage cutting (Table 4). On the other hand, days to heading and maturity had moderate but negative linear correlations with dry-matter yield at green-stage cutting. Thus, genotypes of intermediate maturity could be the best compromise for large dry-matter yield at grazing and large grain yield after grazing. It must be emphasized, however, that this season favored production of higher dry-matter yield at grazing by early genotypes and therefore medium to later maturing types were much less affected by grazing. The latter genotypes recovered quicker and produced larger final dry-matter yield. The linear correlation coefficients between grain or straw

Table 4. Coefficients of linear correlation between different characters found in the dual-purpose barley trials of 1983/84. (Upper lines, 2-row barley; lower lines, 6-row barley.)[1]

	With green-stage cutting		
	Grain yield	Straw yield	Dry-matter yield at cutting
(a) Without green-stage cutting			
Days to heading	0.62**	0.58**	-0.40**
	0.62**	0.74**	-0.33**
Days to maturity	0.68**	0.63**	-0.51**
	0.76**	0.84**	-0.52**
Plant height	0.01	-0.08	0.12
	-0.17	-0.06	0.32**
Tiller number	-0.05	0.03	0.13
	0.19	0.13	-0.03
Head number	-0.19	-0.13	0.21
	0.06	0.07	0.06
Tiller mortality	0.02	0.06	-0.03
	0.15	0.06	-0.09
Head score	0.29*	0.29*	-0.38**
	-0.08	-0.06	-0.15
Plant score	0.04	0.11	0.00
	-0.11	-0.05	-0.05
Grain yield	-0.17	-0.38**	0.32*
	0.36**	0.13	0.05
Straw yield	-0.12	-0.38**	-0.11
	0.32**	0.00	-0.20
(b) With green-stage cutting			
Grain yield		0.80**	-0.45**
		0.86**	-0.50**
Straw yield			-0.31**
			-0.44**

* $P<0.01$, ** $P<0.001$.

1. Data for each genotype were computed as percent of the mean of the three checks in each experiment. Information was pooled from the 10 experiments but with the checks and mixed lines excluded from calculation. There were 72 cases for the two-row group and 125-126 cases for the six-row group.

yield after green-stage cutting with the other characters: plant height, head score, plant score, tiller number, head number, and tiller mortality (all without green-stage cutting) were either small or not significant. It should also be noted that grain and straw yield after green-stage cutting were significantly correlated each other, but both of them were negatively correlated with dry-matter yield at cutting. Similar results had been obtained in the previous seasons (ICARDA Annual Report 1982, 1983).

International Nurseries

The emphasis on international nurseries continued, and in 1982/83 we began sending diverse sets of segregating populations to the different barley-growing areas. Three different observation nurseries will be distributed in 1984/85 for the first time: one for dry areas, one for high-elevation areas, and one for moderate rainfall areas.

From the breeding materials provided by ICARDA's barley germplasm, a large number of promising lines were selected by national programs from 1978 to 1984 (Fig. 6). More were selected in countries such as Tunisia where ICARDA was able to maintain closer cooperation. This indicates the need to improve contacts where they are at present inadequate.

Observation Nurseries

Promising advanced lines developed at ICARDA are provided to cooperating national programs for initial screening from Barley Observation Nursery (BON). The 1982/83 nursery consisted of 150 entries, with Badia as check every 20th entry. Eight triticale lines were also included to compare their performance with barley lines in different environments. Data were received from 19 locations. Ten lines were selected at 11 or more of these locations, six of which were developed at ICARDA (Table 5). Moreover, a number of lines were found to have good

Table 5. Lines selected at 11 or more of 19 locations in the 1982/83 Barley Observation Nursery.

Sel. freq.	Cross/line	Pedigree
13	Harmal'S'	Sel, 12L-2AP-0AP[1]
12	WI 2197/CI 13520	ICB78-0014-3AP-0AP[1]
12	Kervana/Prior	ICB77-0372-1AP-0AP[1]
11	Duks Sejet	
11	Athos (B)	
11	Remal	
11	Assala'S'	Sel, 4L-3AP-0AP[1]
11	Matnan'S'	Sel, 1AP-2AP-4AP-0AP[1]
11	WI 2198/Emir	CMB77A-0352-3AP-0AP[2]
11	Roho/Masurka	*ICB77-0169-4AP-2AP-0AP[1]

1. ICARDA - developed genotypes.
2. ICARDA selection.

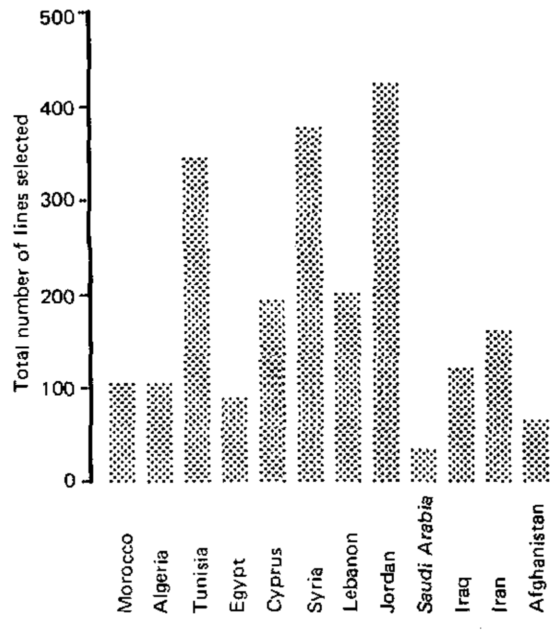


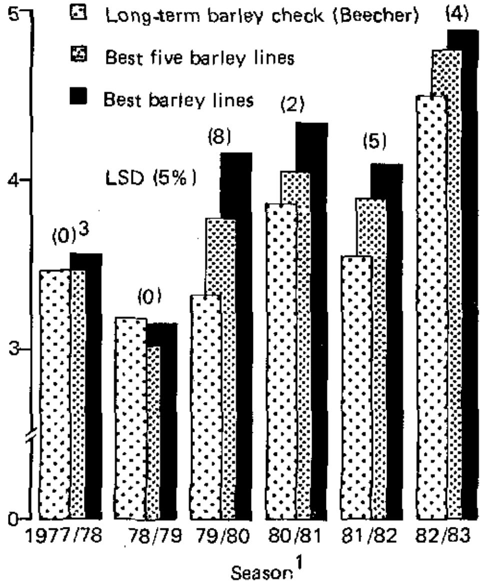
Fig. 6. Total number of promising barley lines selected by each of 12 countries from ICARDA's improved germplasm from 1978 to 1983 in the ICARDA region.

resistance to powdery mildew, scald, net blotch, yellow rust, and leaf rust. A detailed description of the agronomic traits and disease reactions of these lines is presented in the 1982/83 ICARDA Cereal International Nurseries Report.

Regional Yield Trials

The 1982/83 Regional Barley Yield Trial (RBYT) consisted of 21 improved barley lines, with one national check, one triticale, and one durum wheat line included for comparison and grown in a randomized complete block design, replicated three times. Data were received from 25 locations. Rihane'S', which was a new entry, had the largest mean yield (Table 6) as well as good stability across different environments. It was among the top 10 lines at 16 out of the 20 locations from which yield data were available, and yielded better than the local checks at 11 locations. Rihane, which ranked first in the 1981/82 RBYT, dropped to the second position. The triticale and durum entries ranked 20th and 22nd, respectively. There was a large genotypic variation in the agronomic characters, such as *days to maturity, plant height, protein content,* and kernel weight. Moreover, each entry in the RBYT was resistant or moderately resistant to two or more diseases. A detailed presentation of the results obtained at the 25 locations is available in the 1982/83 ICARDA Cereal International Nurseries Report.

Results of the regional barley yield trials from the last six seasons showed that the performance of ICARDA-developed barley lines has improved (Table 7, Fig. 7). Every year, starting from 1979/80, 8 to 13 newly developed lines yielded better than Beecher, the long-term check *in these trials.* Beecher was the third highest yielding variety in 1977/78 and the top yielder in 1978/79, but its rank dropped to 14th, 9th, 14th, and 10th, in the following four seasons, respectively.



1. Means are over 23, 20, 23, 24, 28, and 16 locations for the seasons 1977/78 to 1982/83, respectively. Complete data for 1983/84 were not available at the time of writing the report.
2. Locations were considered as fixed. When locations were considered as random, LSD for 1982/83 was 428 kg/ha.
3. Figures in parentheses indicate the number of barley lines that significantly outyielded Beecher.

Fig. 7. Mean grain yield (kg/ha) of the most promising barley genotypes tested in the Regional Barley Yield Trial during 1977-1983 in the ICARDA region.

Other high-yielding lines were also continuously being replaced by newer lines with even greater yielding ability. For example, in 1979/80 and 1980/81, the line ER/Apam had the highest mean yield, but its ranking dropped to second and fourth place in 1981/82 and 1982/83, respectively. In 1981/82 and 1982/83, the newly developed lines, Rihane and its sib, were the best yielders. Incidentally, despite the seasonal fluctuations, an improvement in the yield of Beecher is discernible over the six seasons. Such a trend probably reflects an improvement in management practices by the national programs. — *M. S. Mekni, S. Ceccarelli, and S. K. Yau.*

Table 6. Performance of the highest yielding lines in the 1982/83 Regional Barley Yield Trial.

Cross/ pedigree	Mean grain yield[1] (kg/ha)	Rank	CHK[2]	SEL[3]
Rihane 'S' Sel, 2L-1AP-3AP-OAP	4906	1	11	16
Rihane[4]	4887	2	10	15
Mari/CM67 CMB72-0140-8Y-1B-3Y-3B-OY	4796	3	10	11
ER/Apam[4]	4728	4	9	12
Beecher (long-term check)	4497	10	9	11
Drira/M2A (triticale) X-15893-OAP	3997	20	7	9
Sahl (durum wheat)	3824	22	7	7
Overall mean	4351			
LSD (0.05)	244			
CV (%)	14			

Yield, rank, and CHK out of 16 locations. SEL out of 20 locations.

1. Mean yields are averaged over three replications.

2. CHK = no. of locations where the line yielded better than the national check.

3. SEL = no. of locations where the line was among the 10 highest yielding entries.

4. Rihane was the top yielder in the 1981/82 RBYT. ER/Apam was the highest yielder in the 1979/80 and 1980/81 RBYT and its ranking dropped to the 2nd in 1981/82.

Locations were considered as fixed. When locations were considered as random, LSD = 428 kg/ha.

Table 7. Ranking of selected barley entries in the regional yield trials from 1977/78 to 1982/83.

	Rank and name of entry				
Year	First	Second	Third	Fourth	Fifth
1977/78	Cr. 366-13-2	Comp. Cr. 89	Beecher[1]	Cr. 366-16-2	H251 3Y-1B-OY
1978/79	Beecher[1]	Cr. 368-4-1	WI 2291	Comp. Cr. 89	Cr. 366-13-2
1979/80	ER/Apam[2]	WI 2198	CM67/SV.Mari	Minnl 26/CM67	Comp. Cr. 89
1980/81	ER/Apam[2]	Ky 63-1294[2]	Carina	Minnl 26/CM67	Emir/Nordgard
1981/82	Rihane[2]	ER/Apam[2]	Khouzama'S'[2]	Rihane'S'[2]	As 54/Tra[2]
1982/83	Rihane'S' -2[2]	Rihane[2]	Mari/CM67	ER/Apam[2]	Khouzama'S'[2]

1. Long-term check variety.

2. *ICARDA-developed germplasm.*

Component 2: Pathology

Screening Advanced Breeding Material

The 1984 Key Location Disease Nursery (KLDN) was planted in 20 «hot spot» locations mainly in West Asia and North Africa. This nursery comprised the advanced yield trial lines and some more lines considered to be sources of resistance, of which 313 lines were tested in the 1983 KLDN. Barley lines in the Observation Nurseries and Crossing Blocks were also planted in most of the KLDN locations to test their resistance.

Useful information from the 1983 and 1984 KLDN was obtained on the following diseases: yellow rust *(Puccinia striiformis)*, leaf rust *(P. hordei)*, powdery mildew *(Erysiphe graminis)*, scald *(Rhynchosporium secalis)*, and Barley Yellow Dwarf Virus (BYDV) from Syria, Lebanon, Yemen, Egypt, Tunisia, Morocco, Portugal, Pakistan, and Mexico (Table 8).

In both years, 16, 20, and 31 lines showed resistance to yellow rust at Tel Hadya (Syria), Terbol (Lebanon), and Islamabad (Pakistan), respectively. However, only eight lines were resistant in all three locations tested over the 2 years. These results indicate the necessity for the repeated multilocation testing.

Promising lines from the breeding program are evaluated at the Key Location Disease Nurseries (KLDN) for their genetic resistance to important diseases. Most advanced lines are evaluated at several «disease hot spots» in many countries for durable resistance.

Table 8. Number[1] of barley lines resistant[2] to yellow rust (YR), leaf rust (LR), powdery mildew (PM), scald (SC), and Barley Yellow Dwarf Virus (BYDV) in different locations and years (KLDN 1983 and 1984).

		Site[3]												Resistant all loc.	
		SYR	SYR	SYR	LEB	YEM	EGY	EGY	TUN	MOR	POR	PAK	MEX		
		Location codes													
Disease	Year	01	51	53	01	01	01	03	01	01	01	01	01	No.	%
	1983	25			281							43		20	5.6
YR	1984	28		106	22							217		13	3.6
	1983+84	16			20							31		8	2.2
	1983					6	196	36	191					0	0.0
LR	1984		77						193				111	26	7.2
	1983+84								103					0	0.0
	1983							132	81	171				35	9.8
PM	1984	289							3	101	59			2	0.6
	1983+84								1	69				1	0.3
	1983	210												210	58.6
SC	1984	218			314				246					155	43.0
	1983+84	157												120	33.5
BYDV	1984		89						288					77	22.0

1. Number of lines planted in 1984 = 360, 313 of which were also planted in KLDN 1983.

2. Selection criteria: Rust, ≦ 5% severity; Powdery mildew and scald, ≦ 3 on 0-9 scale; Barley Yellow Dwarf Virus, ≦ on 0-4 scale.

3. *SYR 01 = Tel Hadya, SYR 51 = Lattakia, SYR 53 = Al Ghab, LEB = Lebanon, YEM = Yemen*, EGY = Egypt, TUN = Tunisia, MOR = Morocco, POR = Portugal, PAK = Pakistan, MEX = Mexico.

Data on leaf rust for 1984 were available from Lattakia (Syria), Beja (Tunisia), and Obregon (Mexico), where 77, 193, and 111 lines, respectively, were resistant to the disease. However, not a single line showed resistance over the 2 years and across all locations, indicating different virulences in different screening sites.

Resistance to powdery mildew was detected in one line at Beja (Tunisia) and in 69 lines at Guich (Morocco). Over all locations and over the 2 years only one line showed resistance to the disease.

Data on scald were obtained in 1984 from Tel Hadya, Terbol, and Beja, where 218, 314, and 246 lines, respectively, were resistant to the disease. A large number of lines (120) showed resistance to scald over the 2 years and in all locations. However, more testing sites with possibly different races are needed.

Data on Barley Yellow Dwarf Virus were obtained from Lattakia (Syria) and Beja (Tunisia) with 89 and 288 resistant lines, respectively. At both locations 77 lines were resistant. For further qualitative screening the KLDN-84 was sent this year to Quebec, Canada. The results are not yet available.

The results of this multilocation testing indicate the efficiency of screening for yellow rust and scald, and the need for a better screening for leaf rust and powdery mildew.

This will be considered in our screening program for the 1984/85 season. — *Omar Mamluk and J. Van Leur.*

Component 3: Agronomy

During the 1983/84 season, agronomy activities included trials to evaluate the response to grazing, the effect of seed rate, sowing date, and nitrogen applications, and the nitrogen efficiency of different barley genotypes. The season was very dry (230 mm in the whole season at Tel Hadya), so care should be taken in interpretation of the results.

Response to Grazing

The experiment was carried out using 10 barley lines classified as forage type and 10 lines classified as dual-purpose type. Seven forage types (Table 9) were tested for the first time in 1983/84, while the other three (Saida, Windsor, Bco. Mr/Mzq) had been tested during the 1982/83 season. In the case of dual-purpose genotypes, six were tested for the first time and

Table 9. Dry-matter and grain yield of forage and dual-purpose barley genotypes at Tel Hadya, 1983/84.

	Grazed					Ungrazed			
Cultivar	Dry matter[1] (kg/ha)	Grain yield[1] (kg/ha)	HDT	MDT	FT	Grain yield[1] (kg/ha)	HDT	MDT	FT
Forage type									
Saida	729	2370	124	153	185	3203	120	150	244
Winsdor	799	1555	131	156	275	2475	125	153	278
Bco Mr/Mzq	888	1461	117	148	256	2475	111	141	322
Lignee 527	1129	2158	125	155	279	3055	118	149	316
M-75-61	1168	1038	124	154	175	1803	110	142	259
WI2197	1230	1654	123	150	271	3017	112	141	361
DPYT 210	1137	480	124	153	127	1826	113	143	264
DPYT 303	791	1656	127	154	233	2693	122	148	259
DPYT 318	1203	1888	121	148	310	3405	109	137	427
DPYT 420	1203	1907	131	157	328	3146	117	145	350
Mean	1027.7	1616.7				2741.1			
LSD (5%)	250	537				613			
CV (%)	14.2	14.7				14.7			
Dual purpose									
Badia	900	2091	119	151	201	3304	114	147	225
Alger/Ceres	779	1662	133	156	321	2168	125	153	342
C 63	896	2027	123	154	226	2355	126	148	219
Antares	760	1777	134	157	273	1655	126	154	266
Arabi Abiad	729	2180	126	150	379	3145	120	145	419
Rihane 'S'	830	1895	118	149	179	2774	119	146	240
Matnan	861	2039	124	151	302	2218	126	148	265
Harmal 'S'	1109	1989	118	146	299	2925	108	138	379
Assala 'S'	869	1909	122	150	240	3040	114	145	331
DPYT 221	748	1751	121	152	214	2990	113	141	275
Mean	848.1	1932.0				2657.4			
LSD (5%)	276	407				1255			
CV (%)	18.9	10.7				10.7			

HDT = Days to heading; MDT = Days to maturity; FT = Number of fertile tillers.
1. Mean of three replications.

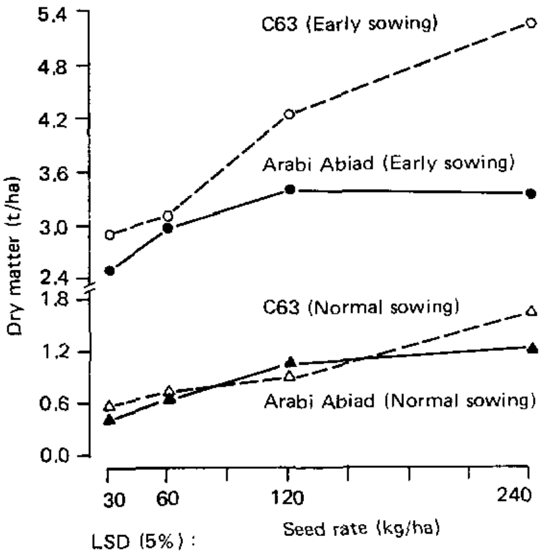
four (Alger/Ceres, C 63, Antares, Arabi Abiad) for the third consecutive season. There was no clear difference between dual-purpose and forage genotypes in their performance. Lignee 527, DPYT 318, DPYT 420, and Harmal'S' were the highest yielding lines both for dry matter at grazing and for subsequent grain yield.

In general, grazing resulted in reduced grain yields: 26-48% in forage types and 8-41% in the dual-purpose types. Only in one genotype (Antares) did the grain yield increase after grazing. This result contrasted sharply with those of previous seasons. The number of fertile tillers in both forage and dual-purpose types declined after grazing (Table 9), which could be due to the drought period of 22 days after grazing. The result of this season did not agree with those of previous years, in which an increase in tillering after grazing had been found (ICARDA Annual Report 1981, 1982, 1983). The height of most varieties was reduced by grazing while the number of days from sowing to maturity was slightly increased in both maturity groups after grazing.

Response to Seed Rate and Sowing Date

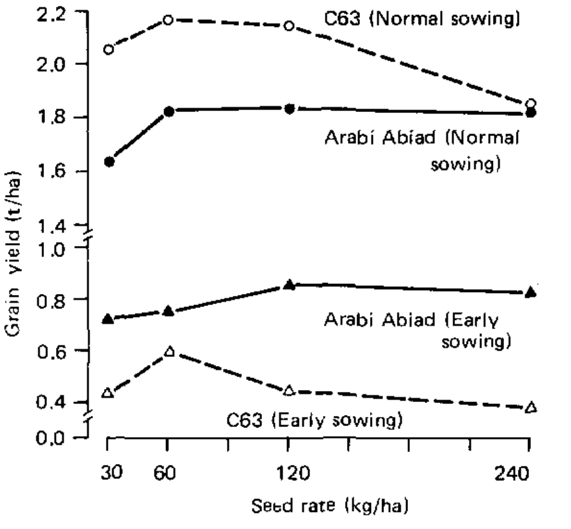
The effect of increasing seed rate on dry-matter production at tillering was positive (Fig. 8). For both sowing dates, mean dry-matter yields increased significantly up to a seed rate of 240 kg/ha. The maximum dry matter at grazing for both dates of sowing was achieved at a seeding rate of 120 kg/ha for Arabi Abiad and up to 240 kg/ha for C 63. Early sowing produced significantly more dry matter at tillering than normal sowing.

The seed rate resulting in maximum grain yield after grazing at the normal sowing was 60 kg/ha for both genotypes (Fig. 9). In general, early



LSD (5%):
Seeding rate = 281 kg/ha.
Variety x Seeding rate = 398 kg/ha.
Variety x Seeding rate in sowing date = 562 kg/ha.

Fig. 8. Effect of sowing date and seed rate on dry-matter production at grazing time for two barley genotypes, 1983/84.



LSD (5%):
Seeding rate = 281 kg/ha.
Variety x Seeding rate = 398 kg/ha.
Variety x Seeding rate in sowing date = 562 kg/ha.

Fig. 9. Effect of sowing date and seed rate on grain yield after grazing of two barley genotypes, 1983/84.

sowing reduced the yield sharply at each seed rate for each genotype. However, there were significant interactions between cultivars and sowing dates. In general C 63 outyielded Arabi Abiad at the normal sowing date, and Arabi Abiad outyielded C 63 under early sowing.

These data indicate that there is a large difference between the optimal seed rate required for dry-matter production at tillering and for optimal grain production after grazing. The best choice of seed rate will depend upon the producer's relative utility for green grazing compared to grain.

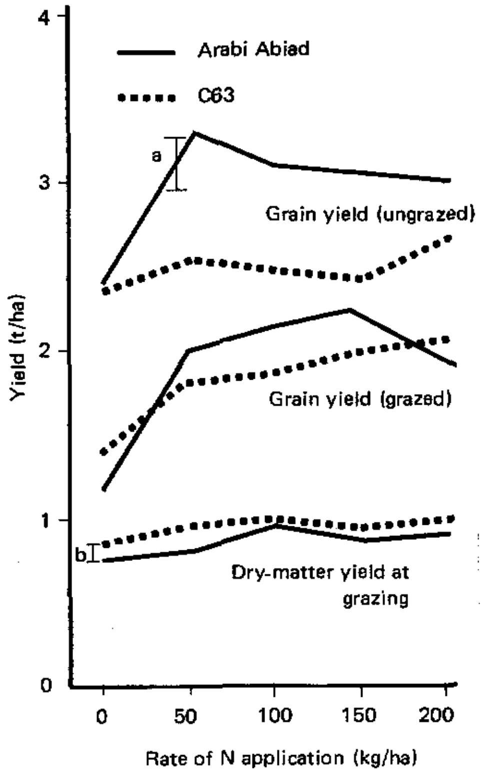
Response to Nitrogen

The objective of this experiment is to determine the effect of five nitrogen rates: 0, 50, 100, 150, and 200 kg N/ha, and two ratios of splitting nitrogen: 100/0 and 50/50 (sowing/tillering) on dry-matter yield at tillering and on grain yield in the grazed and ungrazed conditions for two varieties of barley.

Grazing decreased grain yield for both varieties (Fig. 10). Applied nitrogen at 50 kg/ha resulted in significant yield increases on ungrazed plots for Arabi Abiad but not C 63. When grazed both varieties responded positively to a nitrogen rate of 50 kg N/ha. This limited response to nitrogen after grazing probably was due to the lack of soil moisture after grazing. The mean grain yield difference between the two varieties was in favor of Arabi Abiad when ungrazed but not significant when grazed.

Dry-matter production following grazing (Fig. 10) was significantly affected by nitrogen application, with the optimal rate at 50 kg N/ha.

Nitrogen splitting had no effect on grain yield except for grazed Arabi Abiad, where splitting 200 kg N/ha at sowing and tillering induced a significant yield reduction. As a result, the factor was not considered in the above presentation. — *I. Naji.*



a. LSD (5%) for N rates x varieties within grazing treatment.
b. LSD (5%) for N rates.

Fig. 10. Mean grain and dry-matter yields for two barley genotypes, Arabi Abiad and C63, at five nitrogen rates under two grazing treatments at Tel Hadya, 1983/84.

Component 4: Grain Quality

Barley germplasm is evaluated for the following important seed characteristics: kernel weight, protein content, seed size, seed size distribution, and diastatic power.

Kernel weight is important in barley. Larger grains are preferred since they tend to be positively correlated with both hot water extract (malting) and energy production (feed). Uniformity of kernel size is also important in malting. The diastatic potential of barley indicates the potential energy production value in the feed industry, as well as fermentable sugars for the fermentation industry. Barley lines with the best grain quality (for both feeding and fermentation purposes) are reported in Table 10.

An additional test was established to determine lysine percentage in barley. This is determined by using the near-infrared reflectance spectroscopy. The instrument was calibrated against standard ion exchange chromatography data obtained from the Grain Research Laboratory, Winnipeg, Canada. The lysine percentage indicates the nutritional value of barley lines which will be used for feed. A total of 6998 barley lines were analyzed for lysine and another 3000 are being processed.

Test weight determination was included for 1983/84 season since this is also an important parameter in barley quality. — *P. Williams and F.J. El Haramein.*

Table 10. Barley lines with the best grain quality, 1982/83.

Line/pedigree	% of kernels over 2.8 mm	% of kernels over 2.5+2.8 mm	1000-kernel wt. (g)	Protein (%)	Rank[1]
Pot/U.Sask 1766//RM 1508/3/Apm					
AB 65//A16					
CMB 74A-6502-A-1B-1Y-1B-1Y-1B	78	93.5	48.7	14.4	7
11012.2/Impala//Birence					
CMB 74A-1697-D-2B-2Y-500B-500Y	70.9	94.6	48.4	13.3	6
Badia*	64.4	92.7	51.6	13.1	9
Harmal 'S'*					
ICB 76-38-12L-2AP-OAP	55.9	89.8	46.2	12.2	14
IFB 1015	54.2	88.6	45.1	12	15
2762/Beecher*					
L-2Y-OAP	86.3	97.3	53.5	11.5	1
WI 2291/Bussel*					
ICB 78-603-5AP-OAP	81.9	93.3	48.6	11.9	3
CC 89//BCO-MR/D202-391*					
ICB 78-750-6AP-OAP	62.1	93.9	43	12.7	12
WI 2291//Mzq/DL 7*					
ICB 78-637-2AP-OAP	78.1	96.4	52.8	10.4	1
Comp. 29/C 63*					
ICB 78-173-6AP-OAP	53.7	92	46.5	12.1	13
Rihane 'S'*					
Sel 2L-1AP-3AP-OAP	61	92.9	47	10.6	8
WI 2269	57.7	92	47	10.6	10
Rihane 'S'*					
ICB 76-11-12L-2AP-OAP	57.5	91	47.3	10.4	10
Lignee 131 (Montpellier)	57.8	95.4	46.3	10.2	5
Kervana/Mosul 72*					
ICB 78-379-1AP-OAP	62.7	93.9	46.6	9.5	3

1. Overall ranking, based on ranking of individual parameters.
* ICARDA - developed germplasm.

Component 5: Entomology

As in previous seasons most emphasis in barley entomology in 1983/84 was on the search for sources of resistance to wheat stem sawfly and aphids.

Resistance to Wheat Stem Sawfly

Screening for resistance to this insect was conducted at Suran under natural high infestation and at Tel Hadya under artificial infestation (Table 11). A number of promising lines were identified at both testing sites (Table 12).

During 1983/84, 306 barley lines were screened at Suran in an unreplicated trial for *wheat stem sawfly resistance* under natural infestation. The percentage of infestation was calculated on 60 stems taken at random from each line. A significant correlation (Fig. 11) was found between the percentage of infestation and both days to heading (r = 0.31) and days to maturity (r = 0.25). Usually the wheat stem sawfly females deposited one egg per stem under the ear. The early-maturing barley lines were much more susceptible than late-maturing lines because their heading coincided with the *time of sawfly appearance. — C. Cardona and A. Rashwani.*

Table 11. Screening of barley lines for resistance to wheat stem sawfly at Suran and Tel Hadya, 1983/84.

Location	No. of lines tested and % infestation	% infestation in the check (Arabi Abiad)	No. of promising lines and range of infestation
Suran	80 (1.7-70.0)	43.2	6 (0.6-3.9
	1800[a] (0-83.3)	43.2	164 (0 - 0)
Tel Hadya	80 (0-13.3)	11.7	6 (0-0.6)

a. Unreplicated.

Table 12. Most promising barley lines and percent of wheat stem sawfly infestation during two seasons at Tel Hadya and during 1983/84 at Suran.

Line/pedigree	% infestation Tel Hadya 1983	Tel Hadya 1984	Suran 1984
80-5116	1.1	0	0.6
Lignée 1242	1.7	0	1.7
TH. UNK. 32	1.7	0	1.7
TH. UNK. 48	1.7	0	2.2
Choya/M64-76			
CMB73-225-1Y-1B-3Y-1B-1Y-0B	1.1	0.6	2.2
Deir Alla 106	1.1	0	3.9

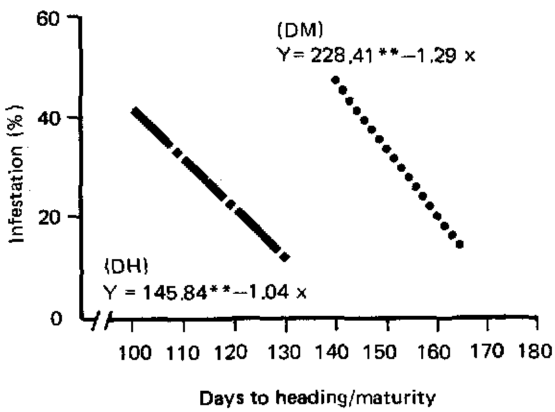


Fig. 11. Correlation between days to heading (DH) and days to maturity (DM) with percentage wheat stem sawfly infestation, Suran, 1984.

Project II: Durum Wheat Improvement

In 1984 a working arrangement between ICARDA and CIMMYT was reached and a joint durum wheat project was drawn up with the aim of developing complementary research between ICARDA- and CIMMYT-based durum wheat programs, to initiate coordinated distribution of genetic materials and to place emphasis on close interaction with national programs.

The major objective of the ICARDA-based program at this stage is to improve durum wheat in the North African and West Asian countries under rainfed conditions. The main responsibilities are to:

- improve yield and stability in the rainfed areas,
- incorporate resistance to stripe rust, stem rust, leaf rust, *Septoria tritici*, common bunt, and other diseases prevalent in the region,
- improve resistance to major insects, such as stem sawfly, suni bug, Hessian fly, and aphids,
- maintain and improve grain quality aspects, and
- encourage national programs to develop appropriate agronomic practices to improve durum wheat production in North Africa and West Asia.

The durum wheat area in the North African and West Asian countries is approximately 8.6 million hectares. About 98% of the total durum wheat is grown under rainfed conditions in North Africa and West Asia. Of this, about 3.7 million hectares are grown in the high-rainfall zones (over 400 mm), 4.7 million hectares in the low-rainfall zones (less than 400 mm), and 0.2 million hectares in irrigated areas.

The average yield of durum wheat is 1000 kg/ha in the high-rainfall areas and 600 kg/ha in the low-rainfall areas; both these averages are about 30% less than the yield of bread wheat in the region.

Component I: Breeding

Germplasm Development

In order to meet the germplasm needs of the rainfed areas in the Middle East and North Africa, a project has been established to develop durum wheat germplasm capable of coping with environmental stresses, diseases, and insects. In addition, this project aims at developing germplasm with a relatively satisfactory performance in favorable years.

Plant breeders and physiologists are looking for the desirable plant types that will adapt to rainfed areas of the region. This durum wheat genotype with vigorous early growth, tillering, and small erect leaves is an example of such plant types.

Parental materials for tolerance to stresses prevalent in the region are evaluated and the desirable characteristics identified at appropriate sites in North Africa and the Middle East. Superior parental lines are then combined and the early-generation populations are exposed to stress environments to allow the identification and selection of superior gene combinations under the following conditions:

- Rainfed, 230-370 mm annual precipitation, 40 kg N/ha and 60 kg P_2O_5/ha.
- Early planting and supplementary irrigation, approximately 450 mm precipitation simulated, 100 kg N/ha and 60 kg P_2O_5/ha.
- Breda, 160-270 mm annual precipitation, 20 kg N/ha and 30 kg P_2O_5/ha.
- Late planting, 40 kg N/ha, 60 kg P_2O_5/ha.

The purpose and the number of crosses made in 1983/84 are shown in Table 13. The seed of many of these crosses was planted in an off-season nursery in Shawbak (Jordan), to provide the seed for the F_2 which will be evaluated in 1984/85.

Table 13. Durum wheat crossing program in the 1983/84 season with purpose and number of crosses made.

Purpose	Number of Crosses
1. Commercial Varieties x High Yield x Yellow Rust Resistance	368
2. High Yield x Earliness	115
3. Earliness x Multiple Disease Resistance x Earliness	293
4. High Yield x *Septoria tritici* Resistance	394
5. Cold Tolerance x Earliness	85
6. Drought Tolerance x Earliness	353
7. Grain Quality x High Yield and Disease Resistance	56
8. Bunt Resistance x High Yield	105
9. *Xanthomonas* Resistance x High Yield	23
10. Tan Spot Resistance x High Yield	101
11. BYDV Resistance x High Yield	13
12. Aphid Resistance x High Yield	5
13. Sunibug Resistance x High Yield	23
14. *Hessian* Fly Resistance x High Yield	51
15. Stem Sawfly Resistance x High Yield	20
16. Landraces x High Yield	60

Segregating Populations

Each segregating family, developed from the crosses, is planted under two environments at Tel Hadya: relatively high input conditions and rainfed conditions, in order to gain information about the potential of a family to withstand rainfed conditions and at the same time about disease resistance and agronomic performance under more favorable conditions.

The selection under relatively high-input environment (early planting and irrigation) in 1983/84 was affected by a high incidence of yellow rust resulting in a wide range of variability for heading and maturity dates. The rainfed selection was influenced by drought, as the precipitation in the 1983/84 season (230 mm) was only two-thirds of that of an average year in northern Syria. Stem sawfly was a serious problem also this year in the rainfed nurseries.

In addition, single-plant selections were done for heat tolerance (late planting) and at Breda for drought tolerance.

Preliminary Yield Testing

Selected lines from F_5 and later segregating generations enter the yield testing phase when they become homozygous for important phenotypic characters such as maturity, height, and chaff color. The first replicated testing is in Preliminary Durum Yield Trials (PDYT). PDYT is laid out as a randomized complete block design with three replications and a plot size of 3 m^2. In the PDYT 1983/84, 14 yield trials were tested under supplementary irrigation and also under rainfed conditions at Tel Hadya. Each trial comprised 21 entries and three checks (Stork, Sahl, and Haurani). Based on their yield performance under both environments and disease resistance, grain quality, and crop duration, the best lines are promoted for further evaluation in the Advanced Durum Yield Trial (ADYT).

Fig. 12 shows the number of lines in PDYT 1983/84 which significantly exceeded the yield of each check. Stork was the best check in 1983/84 and this was mainly due to its earliness and yielding capacity.

Table 14 shows the highest yielding lines in PDYT 1983/84, with their yield percentage over Stork and Sahl in both growing conditions.

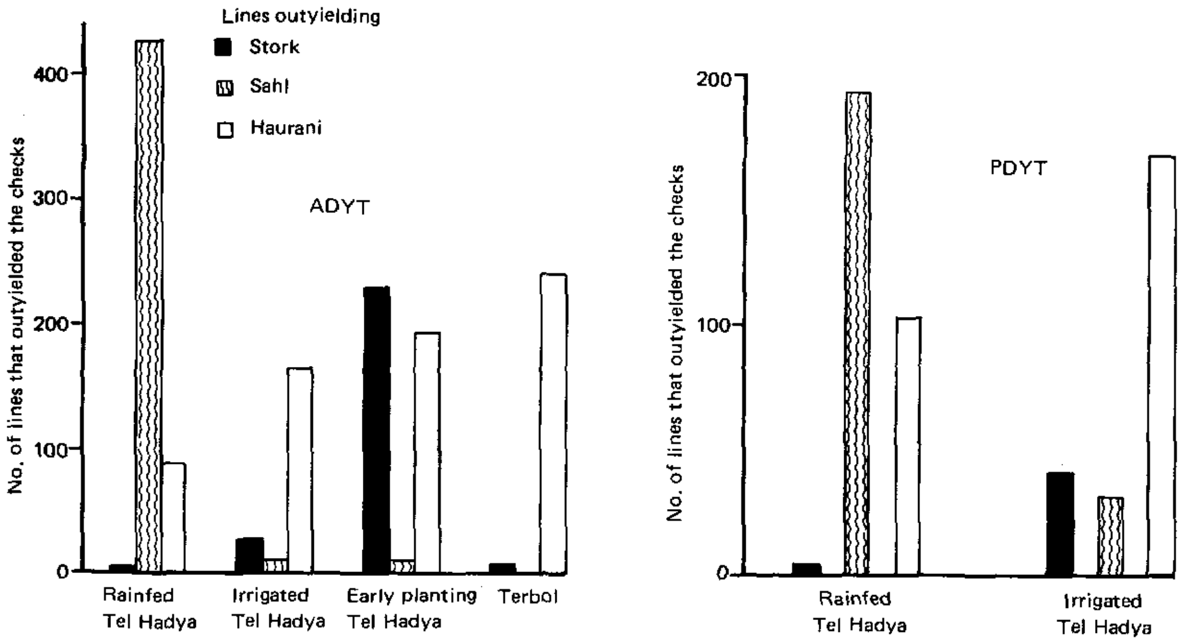


Fig. 12. Number of durum wheat lines that significantly outyielded the check varieties, Stork, Sahl, and Haurani, in 1983/84.

Table 14. Durum wheat lines in the PDYT that outyielded Stork under rainfed conditions and Sahl under high input management, Tel Hadya, 1983/1984.

	Rainfed			Irrigated		
Cross/pedigree	**Yield (kg/ha)**	**LSD**	**% Stork**	**Yield (kg/ha)**	**LSD**	**% Sahl**
Pg//ch/21563/3/Scarcies ICD78-0362-4AP-3AP-6AP-0AP	4477*	1050	129	5422	934	110
Stk//Ch/Bit ICD78-0415-2AP-2AP-2AP-0AP	4366*	891	122	5283	782	116
Plc/Cll//Jo/RD119/3/Oyca ICD78-0623-4AP-4AP-2AP-0AP	4288*	891	120	5450*	782	121
Rabi/Fg//Gdovz579/3/Bit CD26109-0AP-2TR-1AP-1AP-0AP	4033*	505	119	5077	1097	98

* Significant at $P<0.05$.

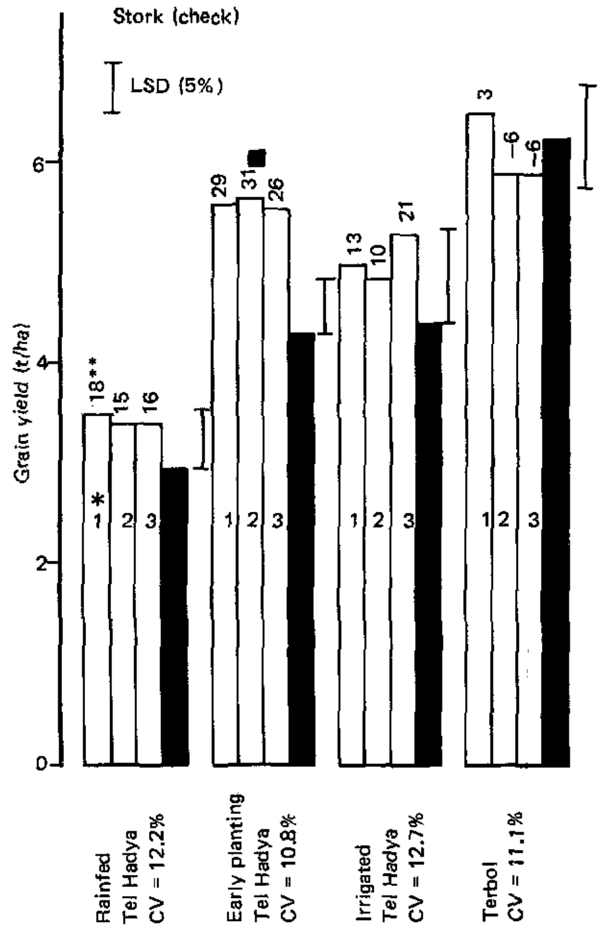
Advanced Yield Testing

The lines found promising in the preliminary testing are included in the advanced testing program, which involves yield testing under more contrasting environments, diseases and insect screening at hot spots in the region, screening for tolerance to frost, drought, heat, and quality analysis.

Fig. 12 shows that, as in the PDYT, Stork was an excellent check for rainfed as well as high-input environments in 1983/84.

Fig. 13 shows the performance of some durum wheat lines which produced a relatively large grain yield under different environments. They are compared to the high yielding check, Stork. These lines could perform well across different environments perhaps due to their being relatively early maturing.

The average yield of the durum wheat lines tested in the ADYT at Tel Hadya is shown in Fig. 14. Early planting favored large grain production per unit area, followed by the supplementary irrigation and the rainfed conditions. The differences between early planting and rainfed, and between supplementary irrigation and rainfed were significant. The coefficient of variability between entries was 14.7 for early planting and 12.8 for rainfed conditions, while for the irrigated conditions it was 9.4 only.



1* = Shwa//21563/AA/3/Bit
2 = Ovi/Cp//Cando
3 = Shwa/Mexi75//Bit
** % increase or decrease over Stork.

Fig. 13. Performance of three advanced durum wheat lines with high yielding ability and stability across four environments in 1983/84.

Environmental Stress Testing

The objective of this project is to develop and distribute genotypes combining good yield potential, yield stability, and tolerance to environmental stresses, such as drought, frost, heat, and salt.

Drought tolerance. The 399 durum wheat lines which constituted the advanced durum yield trials were visually evaluated for their relative drought tolerance in the 1983/84 season in a series of environments: Tel Hadya under supplementary irrigation (approximately 450 mm); Tel Hadya rainfed (230 mm); Breda (approximately 160 mm); early planting (450 mm), late planting (February); and Terbol (approximately 500 mm). Forty-five lines were selected at Breda. There was a large variation among the selected lines in heading time (Fig. 15).

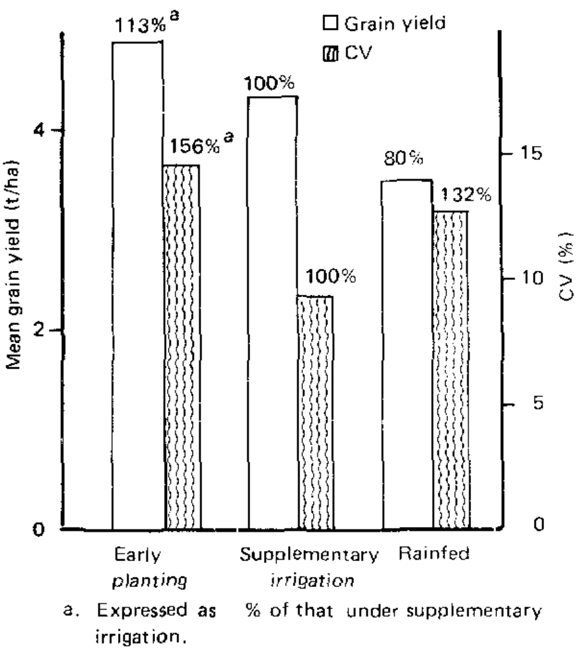
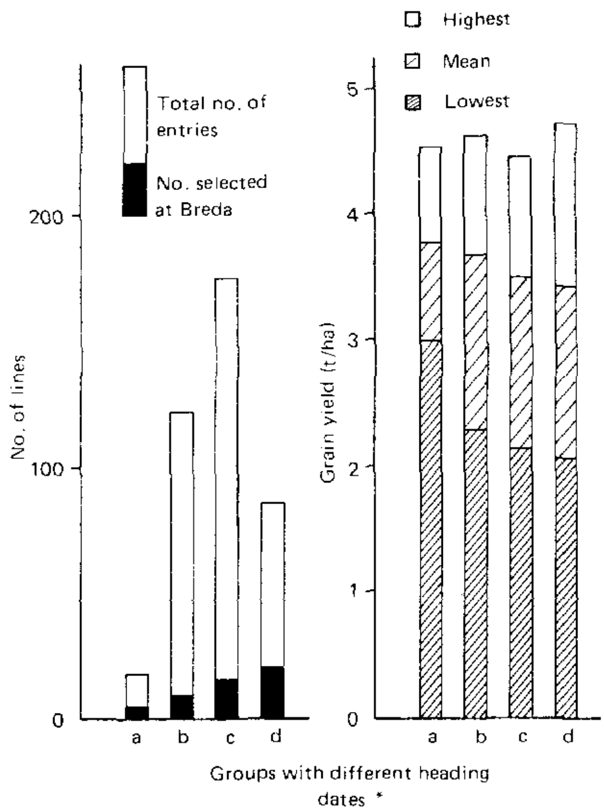


Fig. 14. Mean grain yield of durum wheat entries and coefficient of variation (CV) of the experiments in three growing conditions at Tel Hadya, 1983/84.



*** Heading date (days after sowing); a = 135 - 138 (Stork); b = 139 - 147 (Waha); c = 148 - 155 (Haurani); d = 156 - 163 (Gezira 17).**

Fig. 15. Number of entries selected at Breda and their mean grain yield and the range of heading dates, out of four groups of durum wheat lines, 1983/84.

From the 399 advanced lines, 17 were classified as early heading ones, and out of these, four were selected at Breda as drought tolerant. These four lines are similar to Stork in their heading date. However, the number of selected lines that were similar to Haurani and Gezira 17 in heading date was much higher (Fig. 15). These results confirmed that screening for drought tolerance at Breda is affected by the occurrence of low temperatures, particularly during the vegetative growth stage, which favors the selection of medium-late to late genotypes similar to Haurani and Gezira 17. More attention has to be given to the early lines with tolerance to drought to meet the needs of other environmental conditions in the region where earliness is an important factor for securing high and consistent yield and where the effect of low temperature during the vegetative stage is insignificant. Fig. 15 shows the average yield of different heading date ranges.

Heat tolerance. Relating grain yield to precipitation and temperature in different growth stages for the last 5 years at Tel Hadya demonstrates (Table 15) clearly the importance of both these factors. The precipitation during the reproductive stage was most decisive for yield, followed by precipitation during the early stages of plant development; however, the number of rainfall days during the vegetative stage was also important.

Table 15. Correlation between grain yield of durum wheat lines and rainfall and temperature at different growth stages from 1978/79 to 1982/83 (Tel Hadya, rainfed yield trials).

Factor	Seedling stage	Vegetative stage	Reproductive stage	Seasonal average
Rainfall (mm)	+0.78*	+0.57	+0.96***	+0.65
No. of rainy days	+0.66	+0.82*	+0.76*	+0.74*
Temp (°C): (Mean)	+0.21	−0.63	−0.92**	−0.66
Min. Temp. (Mean)	+0.78*	−0.69	−0.91**	−0.70
Max. Temp. (Mean)	+0.39	−0.54	−0.86*	−0.52

New durum wheat varieties have been identified that fill grains and produce reasonably good yield in spite of moisture deficiency and heat stress at the time of grain filling.

The mean temperature was correlated negatively with yield, especially during the grain-filling stage. The higher the temperature, the lower was the yield. However, the minimum temperature during the early stages of plant establishment and development had a positive effect on final grain yield.

The influence of drought in 1983/84 season caused a general reduction on all yield components, especially on the number of heads per unit area and the number of kernels per head (*Figs 16 and 17*).

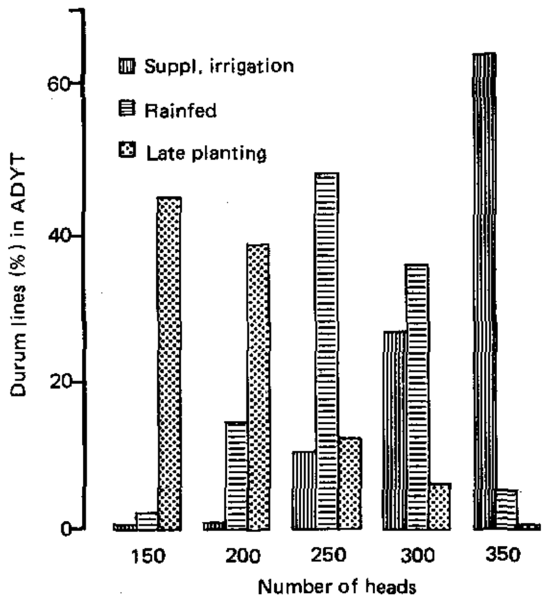


Fig. 16. Frequency distribution of number of heads per unit area in the ADYT 1983/84 in three environments at Tel Hadya.

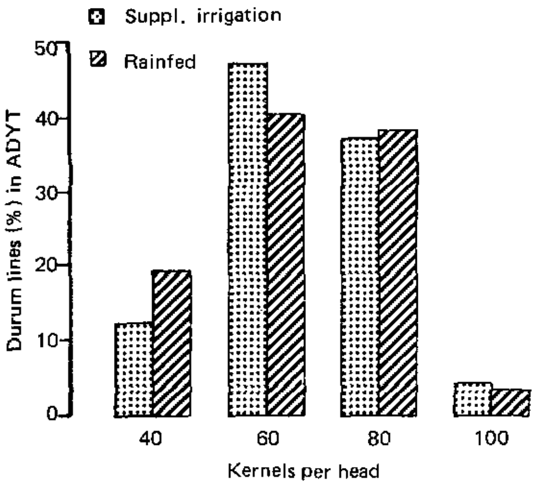


Fig. 17. Frequency distribution of kernels per head in the ADYT 1983/84 in two environments at Tel Hadya.

Regional Testing

The objective of this project is to develop and distribute advanced lines and genetic stocks combining grain yield potential and stability, adaptation to different environmental conditions, resistance to diseases and insects, and acceptable technological and nutritional quality. The lines are tested at different sites and over several years, and the best ones are advanced for distribution to national programs. The national programs provide us with information on the performance of these lines. The combined results from all sites are reported back to the national programs.

Observation nursery. The regional Durum Wheat Observation Nursery (DON) provides a vehicle for a preliminary screening of promising advanced lines at the national program testing sites by national program researchers. Selected data from the 31 sites of 1982/83 DON are reported in Table 16.

The time to heading and maturity are important factors for selection in the region. This is shown in the phenotypic correlations between frequency of selection and number of days to heading (r = -0.195, P = 0.014) and the *number of days to maturity* (r = -0.25, P = 0.003). This indicates the importance of earliness of durum wheat germplasm intended for North Africa and the Middle East. The correlation between the number of days to heading and to maturity was the highest (r = +0.81, P = 0.001), followed by the frequency of selection and actual grain yield (r = +0.62, P = 0.001).

Tan spot and Barley Yellow Dwarf Virus (BYDV) are the major constraints to grain yield in the region. This is reflected in the negative correlation between grain yield and BYDV (r = -0.17, P = 0.026), selection frequency and BYDV (r = -0.28, P = 0.002), and grain yield and tan spot (r = -0.19, P = 0.015). However, in most of our advanced germplasm we also need to incorporate additional resistance to *Puccinia striiformis, P. recondita* and *P. graminis*.

Earliness was associated not only with higher yield but also with the avoidance of attacks by diseases, e.g. *P. graminis*. However, in a comparison between early and late heading durum wheat lines, the early lines were found to be more damaged than the late ones by powdery mildew, *Septoria tritici* and *Helminthosporium tritici-repentis*.

Regional yield trials. Two types of Regional Durum Yield Trials, each comprising the best performing lines from the Regional Durum Wheat Observation Nurseries, were distributed in 1982/83. The Regional Durum Yield Trial (RDYT) is intended for favorable environments, and the Regional Rainfed Durum Yield Trial (RFDYT) for the rainfed areas in the Mediterranean region. Yield data were received from 17 locations for RDYT and 16 for RFDYT. For both trials the yield performance and other important

Table 16. Agronomic and disease data of the most frequently selected lines (14 or more sites) in the Rainfed Durum Wheat Observation Nursery, 1982/83.

Line	FR	DH	DM	Ht	Pro. (%)	Vitr. (%)	1000-kernel weight	ACI YR	ACI LR	ACI SR	ST	PM	TS	BYDV
Cr'S'/T.D.Vern//Gll'S'	16	122	164	81	12.0	96	44.5	23	5	11	5	5	2	1
Win'S'/USA.02237// Gad'S'	16	125	164	82	12.0	98	44.4	19	4	19	4	6	2	1
Rabi'S'/3/Ld 390// Gelle/Tc60	15	126	167	87	12.6	100	46.2	12	0	0	4	7	1	1
Fg'S'/Jo'S'//Gu'S'/ 61-130Kds	14	119	163	88	13.8	99	42.6	6	4	1	5	4	2	1
Shwa//Magh'S'/Bit	14	120	163	78	12.3	98	42.9	10	3	10	3	6	1	2
Duro3/Ibis'S'//1150/ KR569	14	119	162	81	12.8	96	49.1	12	3	8	4	7	2	1
USA.0640/Fg//Fg/Ruff	14	122	164	82	13.6	98	40.5	7	1	3	4	7	2	3
Waha7 (Reg.check)		119	162	83	13.0	100	42.6	2	3	3	5	5	3	2
Sahl 5 (Reg.check)		121	162	78	11.4	96	42.5	1	1	8	5	7	3	1

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

characteristics of the best two lines are summarized in Tables 17 and 18.

From RDYT, two durum wheat lines, Mallard and Oum Rabia, were selected for their yield performance for 2 years consecutively. Both entries are early heading and maturing.

The results from RFDYT show that out of the 24 entries tested, two lines Cr'S'/Stk'S' = Belikh and Rabi/PI-94587//Cit/3/Mex/4/Valn = Po were the highest yielding entries in 1982/83.

A negative correlation (r = -0.55, P = 0.007) between grain yield and number of days to heading in RDYT is found for 1982/83 season (Table 19). However, durum wheat lines with larger kernel weight were affected by high temperature during the grain-filling period. This is reflected in the negative correlation between kernel weight and grain yield (r = -0.59, P = 0.005). But when the climatic conditions were favorable during the grain-filling stage, several lines were able to increase their yield potential through better kernel filling. This is shown in the correlations between the number of days to maturity and the 1000-kernel weight. Most of the entries with large kernel weight were late heading, as demonstrated by the correlations between the 1000-kernel weight and number of days to maturity (r = +0.85, P = 0.001) as

Table 17. Performance of the largest yielding entries and Sham 1 in the Regional Durum Yield Trial in 1981/82 and 1982/83.

	1981/82[a]		1982/83[b]							
Entry	Yield (kg/ha)	Rank	Yield (kg/ha)	Rank	% of check	Days to heading	Days to maturity	Protein (%)	Vitreous-ness (%)	1000-kernel weight (g)
H505-71A/BGL2 (triticale)			4638	1	104	116	162	13.1		34.9
Stk'S'//chap/ 21563 = Mallard	4627	3	4600	2	103	119	163	14.5	99	36.6
Oum-Rabia	4697	2	4544	3	102	118	163	14.7	99	38.1
Sham 1 (Reg.check)	4772	1	4456	7	100	120	164	14.8	99	37.0
Nursery Mean	4377		4261		95					
LSD (5%)	200		237							
CV (%)	16		17							
Observation per mean = 4										

a. 23 locations.
b. 17 locations.

Table 18. Performance of the largest yielding entries and Sahl in the Regional Durum Yield Trial-Rainfed in 1981/82 and 1982/83.

	1981/82[a]		1982/83[b]							
Entry	Yield (kg/ha)	Rank	Yield (kg/ha)	Rank	% of check	Days to heading	Days to maturity	Protein (%)	Vitreous-ness (%)	1000-kernel weight (g)
JII089(Triticale)			4386*	1	116	115	159	15.1		40.6
Cr'S'/Stk'S' = Beilikh	3759	2	4222*	2	111	119	160	14.1	98	38.6
Rabi/PI-94587// Cit/3/Mex/4/ Valn = Po	3710	4	4192*	3	111	126	161	14.2	99	40.8
Sahl (Reg.check)	3579	11	3791	15	100	118	158	13.6	100	38.9
Nursery Mean	3562		3852							
LSD (5%)	192		209							
CV (%)	17		15							
Observation per mean = 4										

a. 23 locations.
b. 17 locations.
* $P<0.05$

Table 19. Correlation between grain yield, days to heading, days to maturity, and 1000-kernel weight in the RDYT (17 locations) and RFDYT (16 locations).

		Yield	Days to heading	Days to maturity
Days to heading	(a)	-0.55**		
	(b)	(-0.45)		
Days to maturity	(a)	-0.35	+0.78***	
	(b)	(-0.24)	(+0.56*)	
1000-kernel weight	(a)	-0.59**	+0.34	+0.85***
	(b)	(-0.16)	(+0.31)	(+0.31)

(a): RDYT, (b): RFDYT.
*, **, ***, P<0.05, 0.01, 0.001, respectively.

well as the number of days to heading and the 1000-kernel weight (r = +0.34, P = 0.010). — *M.M. Nachit.*

Component 2: Pathology

Screening for Resistance to Common Bunt

In the Common Bunt Nursery I, 670 lines (520 from KLDN-84) were planted in 1983/84. The seed was inoculated before planting with chlamydospores of the pathogens, *Tilletia foetida* and *T. caries,* collected from bunted heads at different locations within Syria. From the KLDN, 10 lines showed resistance (<5% infected heads) to the disease (Table 20). These lines will be retested next season.

In the Common Bunt Nursery II, 11 advanced lines and commercial varieties were tested for their resistance to 12 different bunt isolates: 3 from Syria, 2 from Turkey, 1 each from Lebanon, Tunisia, and Iran, and 4 isolates with identified virulences. The nursery was harvested by hand and evaluation was done in the laboratory. Two entries showed resistance (<5% infected heads) to common bunt and for all isolates used. These were Haurani and Stork (Table 20).

Screening for Resistance to Septoria Leaf Blotch

The Durum Septoria Nursery (DST-84), initiated in the cropping season 1983/84, included 150 durum lines selected from a preliminary screening the year before at Afrin in Syria. The nursery was planted at Tel Hadya and Lattakia (Syria), Beja (Tunisia), and Elvas (Portugal). At all sites artificial inoculation with isolates of *Septoria tritici* prevailing in the country was applied. Three sets of the nursery planted in the plastic houses at Tel Hadya were inoculated with three isolates, one each from Turkey, Tunisia, and Syria. The resistant lines (Table 21) will be included in the DST-85 to reconfirm their resistance over many locations.

Screening Advanced Breeding Material

The 1984 Key Location Disease Nursery (KLDN) included lines from advanced yield trials, out of which 243 had been tested in the 1983 KLDN. This nursery was planted in 20 «hot spot» locations and data on yellow rust *(Puccinia striiformis)*, leaf rust *(P. recondita)*, septoria leaf blotch *(Septoria tritici)*, and Barley Yellow Dwarf Virus (BYDV) were obtained from Syria (Tel Hadya, Lattakia, and El Ghab), Lebanon (Terbol),

Table 20. Cultivars/lines of durum wheat with resistance (< 5% infected heads) to common bunt, *Tilletia foetida* and *T. caries,* in two screening nurseries at Tel Hadya, 1983/84.

Cultivar/cross/pedigree	% infected heads
Common Bunt Nursery 1 (Average infection 29.4%)	
Ch/21563//Cr'S'/3/Gediz ICD 77-0085-2AP-1AP-OAP	1
CR'S'/3/21563//61-130/Ld/4/Ente'S' ICD78-0029-2AP-4AP-OAP	5
Gediz 75/Bit'S' CD26820-1AP-1AP-OAP	5
Shwa/Pt1'S' CD 20632-2AP-2AP-3AP-OAP	5
OVI/CP//Cando ICD78-0001-7AP-2AP-2AP-OAP	5
W-2057	5
Gdovz 469/P1c'S'//Jo ICD77-0027-4AP-2SH-1AP-OAP	5
Ato'S'/D-10 ICD77-0080-8AP-6SH-2TL-OAP	0
Cit'S'/Gdovz 579 ICD74-0105-4L-1AP-2AP-1AP-OSH-OAP	5
Haurani	1
Common Bunt Nursery II (Average infection 16.4%)	
Haurani	1.4
Stork	2.1

Inoculum density: 2.2 x 10^5 spores/seed.
Spore germination *in vitro:* 23.6-48. 5% in Nursery I
55.7% in Nursery II

T.foetida	: *T.caries*	
1	: 0.1	in Nursery I
1	: 0.1-25	in Nursery II

Yemen (Taiz), Tunisia (Beja), Portugal (Elvas), and Canada (Quebec).

Table 22 presents the number of lines resistant to these diseases in different locations and years. In both 1983 and 1984, almost the same number of lines (68, 66) were resistant to yellow rust at two locations, Tel Hadya and Terbol; however, at all locations tested and over both years, 34 lines (14% of the lines scored) proved to be resistant to yellow rust.

A large number of lines were resistant to leaf rust in 1984 at Tel Hadya, Lattakia, Terbol, and Elvas: 367, 94, 475, and 391, respectively. Over all locations in the same year, 82 lines were resistant; however, considering both years' data, only one line was resistant to the disease. For a better screening, late planting of a set of this nursery at Tel Hadya and Terbol is planned for the next season.

Data on septoria leaf blotch were obtained from Tel Hadya, Lattakia, El-Ghab, Beja, and Elvas, where 63, 30, 34, 57, and 462 lines, respectively, were resistant to the disease. Considering all locations and both years of screening, not a single line showed complete resistance. To improve the level of resistance to septoria blotch, a special nursery (Durum Septoria Nursery) was initiated in the 1983/84 season and planted in three «hot spots» for septoria blotch.

Information on Barley Yellow Dwarf Virus was available from Beja and Elvas. One hundred and fifty-eight lines showed resistance to the disease in both locations. — *Omar Mamluk and J. Van Leur.*

Component 3: Agronomy

Nitrogen Application: A Strategy

Durum wheat is grown under conditions where modest amounts of nitrogen fertilizer are applied. The magnitude of the grain yield response to applied nitrogen is likely to be variable in Zones A and B (250-350 mm rainfall), the most important growing areas for durum wheat in West Asia and North Africa. The risk of using N fertilizer for durum wheat in these areas is quite high.

Productivity of cereals is relatively low in the region and the gap between farmers' and research station yields has been estimated to range from 53 to 74% for durum wheat. The use of unimproved varieties, low inputs of fertilizers, and poor weed control are among the main reasons.

Table 21. Durum wheat lines resistant to septoria leaf blotch in the DST-84.

Entry	Pedigree	Source DST-84
Shwa'S'/Bit'S'	CD 20626-5M-4Y-2Y-OY	1
Pg'S'/3/Gll'S'//T.D.Vern/Gll'S'	L 0532-1L-2AP-1AP-OAP	15
Gs'S'/AA'S'//Plc'S'/3/Cit71	L 0576-2L-1AP-2AP-OAP	19
Snipe'S'//Amarele jo/Haynaldia	ICD77-0216-1AP-OAP	33
ZF/Lds//Kohak2916/3/61-130/4/ Stk'S'/Fg'S'	ICD77-0233-2AP-2AP-OAP	34
Jo'S'/Cr'S'/5/Gll'S'/4/Br 180/ LK//GZ220/3/21563/AA'S'	ICD77-0045-4AP-OSH	50
Algerian 83/Mexi75	CD 32954-2TR-1AP-OAP-OSH	112
Gdo VZ385/GS'S'/4/D.dwarf S15// T.D.Vernum/Gll'S'/3/Plc'S'	ICD77-0134-4AP-1AP-4AP-OAP-OSH	113
Riccya (Winter)-1149	YE 023-26-1-1-4-OE	136
PI 29847		141
Ente'S'/Stk'S'	CD 08153-12M-3Y-3M-1Y-OM	146
Reichenbachi/BD 1645	FAO 25 190	147

Table 22. Number[1] of durum wheat lines resistant[2] to yellow rust (YR), leaf rust (LR), septoria leaf blotch (ST), and Barley Yellow Dwarf Virus (BYDV) in different locations and years (KLDN 1983 and 1984).

Disease	Site / Year	SYR 01	SYR 51	SYR 53	LEB	YEM	TUN	POR	CAN	Resistant all loc. No.	Resistant all loc. %
		Location code									
YR	1983	129			224					123	51.0
	1984	188			148			387		87	18.0
	1983+84	68			66					34	14.0
LR	1983	223			243	7	228		158	4	2.0
	1984	367	94		475			391		82	17.0
	1983+84	163			231					1	0.5
ST	1983	22								22	9.0
	1984	63	30	34			57	462		1	0.2
	1983+84	8								0	0.0
BYDV	1984						492	158		158	32.0

1. Number of lines planted in KLDN 1984 = 485 of which 243 were also planted in KLDN 1983.
2. Selection criteria: Rust ≦5% severity
Septoria ≦3 on 0-9 scale
BYDV ≦2 on 0-4 scale.

SYR 01 = Tel Hadya; SYR 51 = Lattakia; SYR 53 = E1 Ghab.

Table 23. Grain yield (kg/ha) of Sham 1 durum wheat as influenced by nitrogen rate at Tel Hadya, 1983/84.

	N rates (kg/ha) at sowing					
N rates (kg/ha) at tillering	0	30	60	90	120	Mean
0	2044	2359	2099	1945	2404	2170
30	1791	2276	2252	2322	2220	2172
60	2257	2375	2022	2264	2086	2201
90	2099	2286	2058	2283	2202	2186
120	2070	2063	2245	2006	2138	2104
Mean	2052	2272	2135	2164	2210	

LSD (5%) = 397.
CV (%) = 13.

Table 24. Heading date of Sham 1 durum wheat as influenced by nitrogen rate and ratio at Tel Hadya, 1983/84.

	N rates (kg/ha) at sowing					
N rates (kg/ha) at tillering	0	30	60	90	120	Mean
0	111	114	115	115	116	114
30	113	114	116	115	116	115
60	114	115	115	115	117	115
90	114	115	115	115	116	115
120	114	115	116	116	117	116
Mean	113	115	115	115	116	

LSD (5%) = 1.2.
CV (%) = 0.71.

Apart from the problems of low capital availability for purchasing improved inputs and sometimes the unavailability of the inputs themselves, the problem of risk associated with climatic uncertainty is often paramount in farmers' decisions. Various strategies may be adopted to minimize this risk, one of which is the use of split nitrogen fertilizer applications. Some of the nitrogen may be applied at sowing, whilst the remainder is applied in spring during the tillering stage, when seasonal conditions and crop growth prospects can be better assessed. In some cases no N is applied at sowing and the total amount is then applied at tillering. This strategy reduces or delays the cash outlay for what is a relatively expensive and risky input.

During the 1983/84 season an experiment on nitrogen strategy (rate and ratios of nitrogen use) was carried out to study the effect on durum wheat of applying N at different rates at the sowing and tillering stages, and to determine the optimal rate and ratio of application for the newly released durum wheat variety of Syria, Sham 1. There was no significant difference in grain yield between N application at the sowing and tillering stages. Moreover, the grain yield difference was not significant between the different N rates (Table 23). There was no significant interaction between rate and ratio as well. These results confirmed the data from the last year's experiments. The absence of response to nitrogen may be due to the prevalence of drought during the vegetative growth of the crop in 1983/84 season. However, the heading date of Sham 1 was affected by nitrogen rate and ratio (Table 24). There was a significant delay in heading date when nitrogen was applied at higher rate, especially during the tillering stage. — *I. Naji.*

Component 4: Grain Quality

The number of durum wheat lines tested by the cereals quality laboratory during 1983/84 is presented in Table 25.

Table 25. Number of durum lines tested for different quality parameters at Tel Hadya, 1983/84.

Test	Number of lines tested
Protein	4208
Vitreousness	4330
1000-kernel weight	4330
Sedimentation test	[illegible]
Color [illegible]	[illegible]

Durum wheat quality is affected by both location and rainfall. During the 1983/84 season, the protein content was the most location-dependent parameter, and kernel weight and sedimentation test showed insignificant variation across sites. Fig. 18 shows the variation in four quality parameters across rainfall zones. In the wetter zones, the protein content and vitreousness percentage were lower, as expected. There was a positive association between protein content and kernel weight but a negative association between protein content and SDS sedimentation. (The SDS sedimentation test gives an estimate of strength of the wheat and is an alternative test to the wheat meal fermentation test.) Differences in quality parameters were also noticeable from location to location even under irrigation, which suggested that some other factors such as temperature may have been affecting the quality.

Table 26 shows the distribution of SDS sedimentation score for entries in different nurseries under different management. Sedimentation score from 40-55 is best suited for bread baking and pasta preparation and only one (out of 262 tests) entry had this value. In general the potential baking strength can be measured by the Brabender farinograph. Correlations between SDS sedimentation and

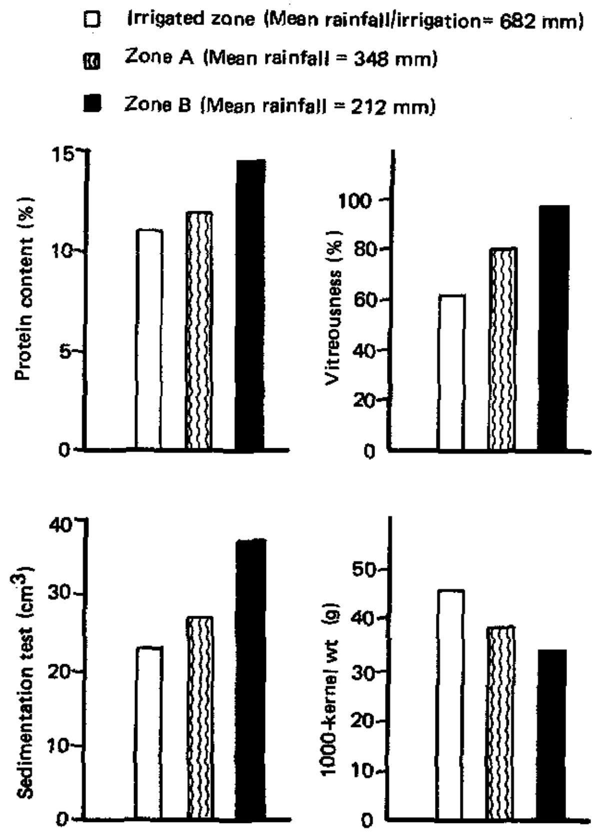


Fig. 18. Differences in four quality parameters of durum wheat over three different rainfall zones, 1983/84.

farinograph stability for durum wheat (range from r = 0.69 to r = 0.91) are better than between wheat meal fermentation time and farinograph stability.

The color of durum wheat is more or less yellow or amber and is caused by the presence of carotenoid pigments, mainly xanthophyll. The darker the color the better is durum suited for burghul, semolina, and pasta making and for the export market. For *khobz* (bread) baking, durum lines with lighter color are acceptable. The distribution of color for entries in different nurseries under different management is shown in Table 27. It may be noted from the table that the lower the transmission the darker is the color.

Table 26. Distribution of SDS sedimentation score for durum wheat entries in different nurseries under different management.

Nursery	Management	SDS Sedimentation Score				
		0-20	20-30	30-40	40-50	50-60
RFDYT	Rainfed	2	8	13		
RDYT	Irrigated	9	4	8	1	
RFDYT	Rainfed early planting	4	9	9	1	
RDYT	Irrigated early planting	3	9	7	5	
On farm trials:						
Irrigated	Irrigated	12	16	3	1	
Zone A(high rainfall)	Rainfed	23	27	20	7	1
Zone B(moderate rainfall)	Rainfed	2	14	19	25	
Total no. of lines		55	87	79	40	1
% of grand total		20.99	33.2	30.15	15.26	0.38
Description		Exceptionally weak	Very weak	Weak	Fairly weak	Medium strength

Table 27. Distribution of transmission percent (yellow pigment content) for entries in different nurseries under different management.

Nursery	Management	Transmission (%)					
		20-30	30-40	40-50	50-60	60-70	70-80
ADYT	Irrigated, early planting	2	18	51	49	20	2
RFDYT	Rainfed, ealy planting		2	8	12	1	1
RDYT	Irrigated, early planting			5	8	10	1
RFDYT	Rainfed			10	8	4	1
RDYT	Irrigated			4	7	12	1
Total		2	20	78	84	47	6

Out of 237 tests, two entries gave a transmission as low as 20-30% — *P. Williams and Ms. A. Sayegh.*

Component 5: Entomology

Resistance to Wheat Stem Sawfly

The resistance of 99 durum wheat lines was assessed at Suran under natural infestation and at Tel Hadya under artificial infestation. Thirty-two lines were rated as resistant (Table 28).

Resistance to Suni Bug

Ninety-nine durum lines were tested for their resistance to suni bug at Tel Hadya under artificial infestation and at a'Azaz under natural infestation. Four lines were rated as resistant (Table 29). — *C. Cardona and A. Rashwani.*

Table 28. Screening of durum wheat lines for resistance to wheat stem sawfly at Suran and Tel Hadya, 1983/84.

Location	No. of lines tested and range of % infestation	%infestation in the check (Hammari)	No. of resistant lines and range of % infestation
Suran	99(0-46.7)	15.3	32(0-1.7)
Tel Hadya	99(0-13.3)	8.3	32(0-1.7)

Table 29. Screening of durum lines for resistance to suni bug at Tel Hadya and A'azaz, 1983/84.

Location	No. of lines tested and range of % infestation	%infestation in the check (Hammari)	No. of resistant lines and range of % infestation
Tel Hadya	99(5-89)	11	4(6-11)
A'azaz	99(5-51)	12	4(5-8)

Project III: Bread Wheat Improvement

Bread wheat ranks first among cereals grown in the ICARDA region. About 10% (approximately 47.8 million tonnes) of the total world wheat in 1983 was produced in West Asia and North Africa. Of this, 77.7% was bread wheat and 22.3% durum wheat (Fig. 19). Bread wheat production in the region increased by 13.8 million tonnes during 1969 to 1983. This was largely due to the use of better agronomic practices and the adoption of high-yielding varieties.

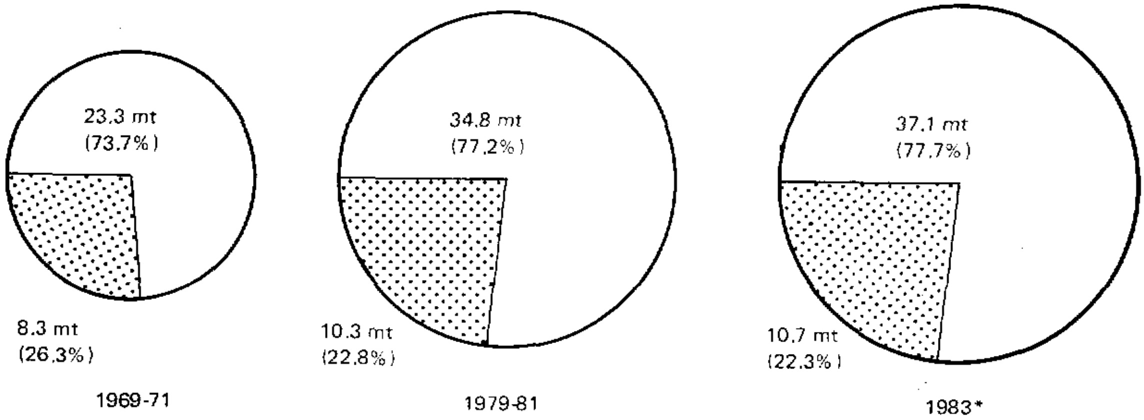
The great majority of the area in the ICARDA region planted with bread wheat is without irrigation. It has been estimated that over 50% of the bread wheat crop is grown in areas receiving less than 400 mm annual rainfall. Stress factors such as drought, heat, cold, and salt as well as diseases, insect pests, and poor management are responsible for poor yields and therefore need attention.

The ICARDA/CIMMYT cooperative bread wheat improvement program aims to develop high-yielding, disease and insect resistant as well as management responsive varieties suitable for the lower rainfall zones.

Component 1: Breeding

Germplasm Development and Evaluation

Six hundred and twenty-two crosses (simple and topcross type) were made during 1983/84 (Fig. 20). Special emphasis was placed on incorporation of specific traits such as resistance to the three rusts, bunt, loose smut, bacterial blights and *Septoria tritici*, resistance to insects such as sawfly, Hessian fly, suni bug, and aphids as well as tolerance to stress factors such as drought, heat, cold, and salt into widely-adapted, good nutritional and industrial quality, high-yielding lines and varieties.



* Estimated, FAO Monthly Bulletin of Statistics, Vol 7, March 84.

Fig. 19. Production (million tonnes) of bread wheat and durum wheat (shaded portion) in the ICARDA region for the periods 1969-71, 1979-81, and 1983.

Wild progenitors of barley and wheat are being studied with a view to transfer some of the desirable characteristics, such as resistance to diseases and insects, earliness, and nutritional quality, to commercial varieties.

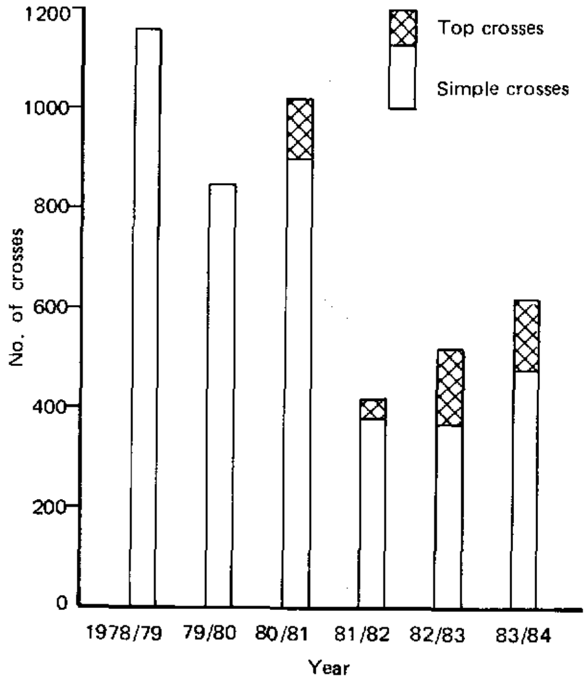


Fig. 20. Number of crosses made in the bread wheat program from 1978/79 to 1983/84.

During the 1983/84 crop season, 10,133 segregating crosses and advanced lines were tested (Table 30). Of this, 8002 lines (79%) were ICARDA developed, the rest (21%) of the material was received from international cooperators such as USA, Turkey, CIMMYT-Mexico, Egypt, Lebanon, and others. The total material received from outside Syria has remained more or less constant at 21% of the entire material tested during the last 4 years. This material, received in the form of international observation nurseries or as seed exchange, provides additional genetic variation needed in the program to meet the demands of the diverse environments and problems encountered in the ICARDA region.

Segregating generations and yield trials of the program are grown and evaluated at Tel Hadya experimental station with two forms of management. The first consists of a rainfed crop supplied with a small amount of fertilizer; the second with supplementary irrigation and optimal fertilizer conditions. This is done with the objective of making simultaneous selection for high yield and yield stability. To complement the breeding effort at Tel Hadya, other stations and substations inside and outside Syria are used for multilocation testing and breeding. Genetic material developed in this way is distributed to cooperators in West Asia and North Africa through ICARDA's international and regional nurseries.

Selection for Yield Potential and Stability

Table 31 shows the results from preliminary and advanced yield trials and the progress achieved during the last 2 years on developing higher yielding lines over the regional check, Mexipak 65, and the improved checks, Golan and Sham 2. In the three environments: Tel Hadya rainfed, Tel Hadya supplementary irrigation, and Terbol (high rainfall) in Lebanon, where these yield trials were tested, a few lines yielded significantly higher (5% level) than Mexipak 65 and Golan in 1982/83. In 1983/84, a much higher number of lines were superior to Mexipak 65. This was due to the higher selection pressure for diseases,

Table 30. Summary of the bread wheat germplasm grown at Tel Hadya from 1980/81 to 1983/84.

	Number of lines			
Type of nursery	1980/81	1981/82	1982/83	1983/84
Yield trials	2970	1440	1606	1416
Regional wheat yield trials	24	24	24	24
International yield trials	110	186	186	134
Regional nurseries (ICARDA)	1264	1335	1077	1349
International nurseries	1700	2259	1286	1187
Seg. populations F_2	2222	2000	1655	1287
Seg. populations F_3-F_6	8870	7420	8317	4211
F_1 populations	853	1336	423	526
Total ICARDA material	14781 (82%)	11997 (75%)	11545 (79%)	8002 (79%)
Total non-ICARDA material (from outside Syria)	3232 (18%)	4003 (25%)	3023 (21%)	2131 (21%)
Grand Total	18013	16000	14568	10133

Table 31. *Number of bread wheat lines that were significantly (5% level) higher yielding than the local check Mexipak 65 and the improved checks Golan and Sham 2 in the 1982/83 and 1983/84 yield trials.*

	Average yield (kg/ha)		No. of lines tested		No. of lines sig. higher yielding than			
					Mexipak		*Golan*	*Sham 2*
Location/trial	1982/83	1983/84	1982/83	1983/84	1982/83	1983/84	1982/83	1983/84
Tel Hadya RF								
PWYT	3592	3661	858	528	9	228	8	25
AWYT	4137	4196	176	144	0	45	7	13
Tel Hadya SIR								
PWYT	4928	4713	396	456	9	245	30	89
AWYT	5266	4949	176	144	17	95	7	49
Terbol								
AWYT	5495	6282	176	144	0	10	15	50

RF = Rainfed; SIR = Supplementary irrigation; PWYT = Preliminary wheat yield trials; AWYT = Advanced wheat yield trials.

agronomic type, and yield applied to the lines promoted to preliminary and advanced yield trials in combination with an increase in the yellow rust susceptibility suffered by Mexipak 65 during 1983/84. It appeared that a high level of yellow rust resistance was present across the lines in preliminary and advanced trials. In the same year, some lines were superior to the improved check Sham 2, especially in the more favorable irrigated environments. The number of lines yielding higher than Sham 2 in the rainfed environment was 25 and 13 for the preliminary and advanced yield trials, respectively. It should be noted that Sham 2 is an improved high-yielding variety widely adapted in the area.

Selection for Drought Tolerance

Our efforts continued on the development and identification of high-yielding lines for the limited rainfall areas of the region. From advanced yield trials planted under low moisture conditions (230 mm annual precipitation), some lines superior to the improved check Sham 2 were identified (Table 32). The highest yield achieved was 4211 kg/ha, and one of the lines outyielded the improved check by as much as 41%. These lines were promoted to crossing block and will be used as parents in the next crossing season. In addition to the identification of advanced drought-tolerant material, F_2-F_8 segregating populations were grown at Tel Hadya under limited moisture and suboptimal fertilizer conditions. Criteria for selection in these segregating generations included seedling vigor, tillering ability, and large fertile heads. Other locations such as Breda (approximately 275 mm rainfall), Khanasser (approximately 240 mm rainfall), and Tel Hadya-late planting are used to complement our effort in this regard.

Selection for Earliness in Dry Environments

Early-maturing high-yielding varieties are needed in lower rainfall zones of the ICARDA region. Earliness in crop maturity results in an escape of the effect of drought and as such is not a true genetic resistance mechanism. However, it has been demonstrated that each day of earlier maturity in bread wheat imparts a yield advantage of approximately 54 to 120 kg/ha under limited water conditions. Table 33 shows several advanced bread wheat lines that combine earliness with a high yield potential when compared with the improved check Sham 2 at Tel Hadya under rainfed conditions (230 mm). These lines headed earlier by 6 to 8 days and matured earlier by 7 to 10 days than the improved check Sham 2. Most of them had the same yield level as Sham 2, and some were even superior. These lines will be used extensively in the crossing program next year.

Table 32. Highest yielding lines under low rainfall conditions (230 mm), in comparison to the improved check Sham 2 in the advanced wheat yield trial 1983/84, Syria.

	Yield (kg/ha)				
Cross/pedigree	Line	Sham 2 (Check)	% of check	LSD (5%)	CV (%)
FLK''s''/HORK''s'' CM 39816-1S-1AP-OAP	4211	3522	119	502	8.8
II 58-57/4/MAYA/CGN/3/CC/INIA//CAL CM 40742-27M-1Y-2M-3Y-3M-1Y-OB	4144	3461	119	576	10.8
CROW'S' CM 40457-5M-3Y-2M-2Y-OM	3894	3205	121	673	12.9
PVN'S'/SPRW'S' CM 46702-2AP-OAP-2AP-1AP-OAP	3755	2655	141	579	11.5
PCO/PVN''s'' CM 46710-1AP-1AP-1AP-1AP-OAP	3588	2655	135	579	11.5

Table 33. Comparison of advanced bread wheat lines that combine earliness with a high yield potential with the improved check, Sham 2, at Tel Hadya under rainfed conditions (230 mm), 1983/84.

	Days to heading		Days to maturity		Yield (kg/ha)[1]		Relative yield[2]
Cross/pedigree	Line	Sham 2	Line	Sham 2	Line	Sham 2	(%)
ARZ/SA 42 ICW 77162-K—1AP-1AP-4AP-2AP-OAP	126	134	168	176	3144(a)	3522	89
CHR/5/TP//CNO/INIA/3/SR/4/HORK CM 46934-2AP-OAP-1AP-1AP-OAP	129	136	168	178	3027(a)	2655	114
PVN''s''/OLN CM 46693-1AP-1AP-4AP-1AP-OAP	130	136	168	178	3372(b)	2655	127
PRL''S'' CM 25988-8Y-3Y-2Y-1M-1Y-OB	127	133	170	177	3050(a)	3277	93
CMH 72-428/MRC//FLK''S'' CM 46869-2AP-OAP-2AP-1AP-OAP	128	136	170	178	2872(a)	2655	108
BJY''S'' CM 5287-J-1Y-2M-2Y-3M-OY	129	133	170	177	3272(a)	3277	100
CROW''S'' CM 40457-5M-3Y-2M-2Y-OM	129	136	170	176	3894(b)	3205	122

1. The LSDs (5%) for comparing mean yield of these lines with their respective checks are: 502, 579, 579, 788, 579, 788, and 673 kg/ha, respectively.
2. Yield of line as a % of Sham 2.
(a) Not significantly different; (b) Significantly different.

Selection for Grain Characteristics and Wide Adaptation

Bread wheat provides the principal staple for the majority of the population in the ICARDA region where the consumption is estimated to be more than 150 kg wheat/caput *per annum*. Because it is an important component in the diet of the people, nutritional and grain quality receive special attention in the program to ensure that while improving yield, grain quality is not sacrificed. Lines which combined high protein content and high 1000-kernel weight with good adaptation in the region are presented in Table 34. These lines, identified through ICARDA's regional testing system, show a substantial increase in protein content and 1000-kernel weight over the regional check Mexipak 65. They were selected by various national programs in the region for further testing with the possibility of being released as varieties. To complement efforts of identifying and developing widely adapted material with good grain characteristics, the program started to evaluate early segregating material (F_3s) for several quality traits.

Performance of Bread Wheat Lines in the Region

In the 1982/83 Bread Wheat Observation Nursery (WON), 19 lines were selected at 9 or more of 30 locations from which data are available. The agronomic, disease resistance, and quality characteristics of the lines are shown in Table 35. The lines were selected by national programs in the region because of their superiority to both local and long-term checks. They are from different origins, including ICARDA, CIMMYT, Egypt, and Turkey. WON was evaluated in a wide range of environments within and beyond the ICARDA region with the help of cooperators. The national programs provide data to ICARDA, then combined results from all locations are reported back to the cooperators. The

Table 34. Lines that combine high protein content and 1000-kernel weight with good adaptation in the region in the Wheat Observation Nursery, 1982/83 (20 locations).

Cross/pedigree	Protein[1] (%)	1000-kernel weight (g)	Loc.[2] selected
SAKHA 18//CNO/CAL/4/SAKHA/3/T2PP//SN64/NAPO S 2896-100-1S-3S-OS	13.6	49.6	11
CNO/GLL//BB/INIA CM 21840-5S-9S-OS	15.1	49.7	8
ANA/MON"S" CM 51743-S-2714-1GM-2GM-OGM	15.4	48.9	8
SPRW"S"/BCH"S" CM 35216-35M-1Y-2GM-OGM	14.2	48.8	7
L 2451.134.611/PVN"S"/VCM/3/CNO/7C CG 3049-1Gm-1Gm-OGm	15.2	47.2	6
SAKHA 14/5/INIA//TOB/Napo/3/CNO/SI OB3/4/MAB S 2377-200-1S-2S-OS	14.3	47.2	6
MEXIPAK 65 (Regional Check)	12.9	40.2	5

1. Data from two locations.
2. Number of locations where the entry was selected as promising, based on visual evaluation of agronomic type and disease resistance.

outstanding lines in this nursery will be promoted to the regional yield trial and to the crossing block for further crossing.

A summary of the highest yielding lines in the Regional Wheat Yield Trial (RWYT) 1982/83 is presented in Table 36. The grain yield and other

Table 35. Agronomic and disease data of the most frequently selected lines in the Wheat Observation Nursery (WON), 1982/83 (30 locations).

Lines	FR	DH	DM	HT	Protein (%)	1000-kernel weight (g)	ACI YR	ACI SR	ACI LR
BB/2*7C//Y50E/3*KAL CM 29014-7S-2AP-1AP-4AP-OAP	11	103	152	93	13.0	41.5	5	3	10
SAKHA 18//CNO/CAL/4/SAKHA/3/TZPP//SN64/NAPO S.2896-100-1S-3S-OS	11	97	146	89	13.6	49.6	18	0	1[illegible]
SNB"S" CM 34630-D-3M-3Y-1M-1Y-OM	9	108	153	87	12.7	41.9	10	0	[illegible]
7C-PVN"S" CM 36596-8Y-1M-1Y-2M-OY	9	102	150	88	14.5	43.5	5	0	[illegible]
GV/ALD"S" L.0882-1AP-OAP-2AP-OAP	9	105	152	88	14.5	44.9	8	0	[illegible]
SAKHA 69	9	99	146	89	12.5	47.1	22	4	1
MEXIPAK 65 (Regional Check)	5	102	149	87	12.9	40.2	36	29	4

FR = Number of locations where the entry was selected as promising, based on visual evaluation of agronomic type and disease resistance; DH = Days to heading; DM = Days to maturity; HT = Height (cm); ACI = Average coefficient of infection; YR = Yellow rust; SR = Stem rust; LR = Leaf rust.

Table 36. Performance of the highest yielding lines in the Regional Wheat Yield Trial at 30 locations, 1982/83.

Cross and pedigree	Yield (kg/ha)	CHK	SEL	DM	HT	Protein (%)	1000-kernel weight (g)
DRIRA OUTCROSS (Triticale) X21295-OAP	4862	16	20	158	116	11.1	46.4
HD 2206/HORK"S" CM 39808-62M-1Y-1M-OY	4845	15	19	159	86	11.7	33.3
FLK"S"/HORK"S" CM 39816-1S-1AP-OAP	4832	17	21	159	80	11.8	35.1
INIA/NAPO//3*CAL/3/CJ/4/KPK NCP 212-A-IK-3AP-OAP	4815	16	17	158	88	12.0	31.2
MEXIPAK 65 (bread wheat Check)	4518	14	12	158	89	11.6	34.1
WAHA (durum wheat Check)	4256	8	10	158	84	12.8	41.0
Overall Mean	4308						
LSD (5%)	488						
CV (%)	14						

CHK = Number of locations where the line was higher yielding than the national check.
SEL = Number of locations where the lines were among the 10 highest yielding entries; DM = Days to maturity; HT = Plant height (cm).

agronomic data were compiled from 30 different locations, including two environments at Tel Hadya. The overall average yield of the entries, excluding the national checks, was 4308 kg/ha, with individual entry means ranging from 3851 to 4862 kg/ha. The yield of the top entries in this trial was not significantly superior to the bread wheat check Mexipak 65. However, the first four entries presented in Table 36 were significantly better than the durum check Waha. The triticale line Drira outcross was the highest yielding line. The highest yielding bread wheat line, HD 2206/Hork'S' ranked among the top 10 entries at 19 locations and was superior to the national check at 15 locations. This line was moderately susceptible to leaf and stem rust. FLK'S'/Hork'S', an ICARDA-developed line, ranked third and combined high yield with a good yield stability. It ranked among the top 10 entries at 21 locations and yielded better than the national check at 17 locations. — *G. Ortiz Ferrara.*

Component 2: Pathology

Screening for Resistance to Common Bunt

In the Common Bunt Nursery I, 180 lines of the KLDN-84, along with 60 lines selected for bunt resistance in 1982/83 were planted. The seed was inoculated before planting with chlamydospores of both pathogens, *Tilletia foetida* and *T. caries*, collected from bunted heads at different locations in Syria. The average number of infected heads over all entries was very high (52.2%) and only two lines showed resistance to the disease with 5% or less infected heads (Table 37).

Additionally, 1304 lines were planted in this nursery for evaluation and multiplication[1]. They represent a valuable collection of wheat. Some of these lines are known to have resistance to one or more races of bunt; others are resistant to highly virulent races of bunt. A large number of these lines has been collected from Turkey and from mountain areas in Yugoslavia. Some of the Turkish lines (143) have been already screened for resistance to selected races of bunt at Pendleton, Oregon. Screening for Syria bunt isolates in this nursery revealed that 624 lines were resistant (<5% infected heads) and 99 were moderately resistant (<10% infected heads) to common bunt.

In the Common Bunt Nursery II, 15 advanced lines and commercial varieties were tested for their resistance to 12 different bunt isolates: 3 from Syria, 2 from Turkey, 1 each from Lebanon, Tunisia, and Iran, and 4 isolates with identified virulences. The nursery was harvested

Table 37. Varieties/lines with resistance (<5% infected heads) to common bunt, *Tilletia caries* and *T. foetida*, in two screening nurseries at Tel Hadya, 1983/84.

Cultivar or cross/pedigree	% infected heads
Common Bunt Nursery I	
Average infection 52.2%	
1. PVN'S'/5/FR/K58N//NIOB/3/GV55/4/ SN64/TZPP*2/AN CM32828-4AP-2AP-OAP-2AP-OAP	1
2. CHR/4/INIA'S'/7CI/CNO'S'/GII/3/PCI'S'//BB/ INIA CM 46935-2AP-OAP-4AP-2APOAP.	5
Common Bunt Nursery II	
Average infection 19.8%	
1. Nugaines	5
2. Moldova	5.1
3. Kirac 66	0.2
4. Sham 2	4.9

Inoculum density: 2.2 x 10^5 spores/seed.
Spore germination in vitro: 23.6 - 48.5% in Nursery I
55.7% in Nursery II
T. foetida : *T. caries*
1 : *0.1 in Nursery I*
1 : 0.1-25 in Nursery II

1. Furnished by courtesy of Dr.R.J. Metzger, USDA-Oregon State University, Corvallis.

by hand to avoid any possible dispersal of the bunt spores; evaluation was done in the laboratory. Out of the 15 tested entries, 4 were resistant (<5% infected heads) to common bunt, with Kirac 66 showing the least infection (0.2%) (Table 37).

Multilocation Testing for Disease Resistance

The KLDN-84 with 171 lines was planted at 20 hot spot locations. Useful information on resistance to yellow rust *(Puccinia striiformis)*, leaf rust *(P. recondita)*, and septoria leaf blotch *(Septoria tritici)* was obtained from Syria, Lebanon, Tunisia, Portugal, and Pakistan. Table 38 lists the lines that showed resistance to these diseases.

For yellow rust, 72, 92, 81, and 125 lines were resistant at Tel Hadya, El Ghab, Terbol, and Elvas, respectively. Across all locations 47 lines (= 27%) showed resistance to the disease. Data on leaf rust from Lattakia, Elvas, and Islamabad showed that there were 91, 159, and 44 resistant lines, respectively, with 42 lines resistant to the disease across the three locations.

The severe epidemic of septoria leaf blotch at Beja and Elvas resulted in 58 and 24 resistant lines. At Lattakia, the disease, though well developed on durum wheat, was negligible on bread wheat. This could be due to the different virulences or environment at each of the two locations.

Screening for Resistance to Septoria Leaf Blotch *(Septoria tritici)*

This nursery, WST-84, initiated in the cropping season 1983/84, included 50 bread wheat lines selected from a preliminary screening the previous year at Afrin in Syria. The nursery was planted at Tel Hadya and Lattakia (Syria), Beja (Tunisia), and Elvas (Portugal); however, the disease development at Tel Hadya and Lattakia was negligible, so data from Beja and Elvas were considered. Twelve lines were resistant (<5 on the 0-9 scale) at both locations. These lines will be included in the WST-85 to reconfirm their resistance at different locations. — *Omar Mamluk and J. Van Leur.*

Table 38. Number of bread wheat lines resistant[1] to yellow rust (YR), leaf rust (LR), and septoria leaf blotch (ST) at different locations (KLDN-84).

Site	SYR	SYR	SYR	LEB	TUN	POR	PAK	Resistant all loc.	
	Location codes								
Disease	01	51	53	01	01	01	01	No.	%
YR	72		92	81		125		47	27
LR		91				159	44	42	25
ST					58	24		13	8

1. Selection criteria; Rust: <5% severity
Septoria: <5 on 0-9 scale

SYR 01 = Tel Hadya; SYR 51 = Lattakia; SYR 53 = Al Ghab; LEB = Terbol; TUN = Tunisia; POR = Portugal; PAK = Pakistan.

Component 3: Agronomy

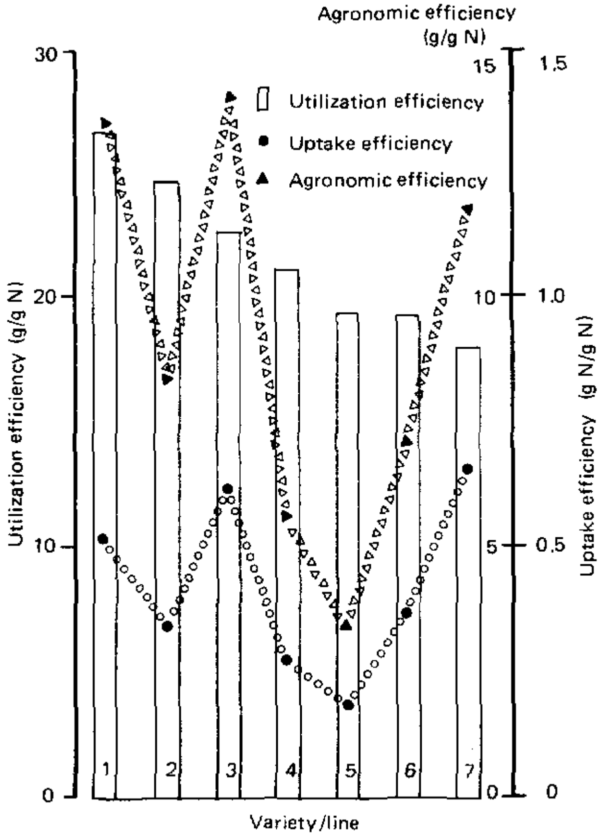
Varietal Difference in Response to Applied Nitrogen

Varietal difference in grain yield response of cereals to applied nitrogen has previously been demonstrated in the field in a wide range of conditions by several workers. Differences have chiefly been found between tall, unimproved or landrace varieties (unresponsive) and short, improved or high-yielding varieties (responsive). It is not clear to what extent differences in nitrogen response are repeatable from season to season or to what extent they may be modified by other limiting factors. The possible range of such responses among winter cereal genotypes has not yet been fully investigated. If varietal differences in grain yield response to nitrogen prove to be of practical significance and are to be exploited by plant breeders, appropriate methods for their measurement are required. Such methods should be efficient in terms of cost, accuracy, and repeatability.

During 1983/84 crop season, an experiment on nitrogen efficiency was carried out with the following objectives:

1. To determine the efficiency of the material in N utilization and identify lines highly responsive to low rates of nitrogen fertilizers.
2. To measure the plant nitrogen uptake and its relation to grain yield.
3. Examine the associations discussed above to *assess the feasibility of breeding for increased* nitrogen efficiency in cereals.

Fig. 21 shows the lines found to be more efficient in N utilization. The values ranged between 17.9 and 26.5 for the utilization efficiency. Uptake efficiency was positively related to agronomic efficiency. This observation supports the results of other researchers that there is more scope for increasing agronomic efficiency through increasing uptake efficiency than through increasing utilization efficiency. The experimental data show that rarely were high utilization and high uptake efficiency found in the same variety. There is thus scope to attempt to combine these efficiencies by breeding.



1 = Kal/Bb/Ald'S' CM37127-16Y-1M-0Y-1Mm-0AP
2 = Golan
3 = Anza
4 = Tzpp 2 x Ana - Inia/Jar - Kvz
5 = Peg'S' SWM 1368-500Y-1B-501Y-503M-0M
6 = Chat'S'
7 = Pavon 76.

Fig. 21. Nitrogen utilization and uptake efficiencies, and *agronomic efficiency* of seven promising bread wheat lines, 1983/84. Utilization efficiency = (Grain yield at 60 kg N/ha - grain yield at 0 kg N/ha) /(N uptake at 60 kg N/ha - N uptake at 0 kg N/ha).
Uptake efficiency = (N uptake at 60 kg N/ha - N uptake at 0 kg N/ha)/ 60 kg N/ha.
Agronomic efficiency = (Grain yield at 60 kg N/ha - grain yield at 0 kg N/ha)/60 kg N/ha.

One important finding in this experiment was that some cultivars are capable of yielding more under low fertility conditions, while others are capable of responding more to higher levels of nitrogen fertilizers. There was, in general, a negative correlation between yield at zero applied nitrogen and agronomic efficiency. It is postulated that cultivars capable of efficient utilization of soil nitrogen may be less efficient users of applied nitrogen. — *I. Naji*

Component 4: Grain Quality

The most important quality characters in bread wheat are hardness and protein quality (strength). The hardness of wheat affects the flour yield, starch gas production (during fermentation), and water absorption. For highest milling yields, wheats of medium hardness are the best and harder wheats give much more damaged starch. Protein strength or flour "strength" means the capacity of the flour to bind the particles of flour into a dough which is elastic and gives good biting texture to the finished baked product. The two quality factors (hardness, and protein strength) are easily tested: hardness, by near infrared reflectance, and protein strength by the Pelshenke test or Farinograph. The wheat meal fermentation time (WMFT) is strongly correlated to farinograph stability, thus is a good overall indication of strength. Some bread wheat lines which have medium hardness and protein strength are listed in Table 39. — *P. Williams and F.J. El Haramein.*

Component 5: Entomology

As in previous seasons most emphasis was placed upon screening for resistance to wheat stem sawfly, aphids, and suni bug. Studies on the economic importance of the suni bug are proposed to be discontinued.

Resistance to Wheat Stem Sawfly

Sixty-two bread wheat lines were screened for resistance to wheat stem sawfly at Suran under natural infestation and at Tel Hadya under artificial infestation. Twenty-three of the tested lines were rated as promising (Table 40).

Table 39. Selected high-yielding bread wheat lines with suitable grain quality for milling and baking.

Variety/cross	PSI %	WMFT (min)	1000-kernel weight (g)	Protein %
MAYA 74'S'/NR-RESEL				
CM 40691-3KE-1AP-0AP-3AP-1AP-0AP	50	191	33.7	15.6
II.58-5714/MAYA74'S'/CGN/3/CC/INIA//CAL				
CM 40742-27M-1Y-2M-3Y-3M-1Y-0B	50	193	35.4	16.9
YR/PAM'S'				
CM 46091-4M-1Y-5M-0Y	52	184	37.4	15.0
KVZ//CNO/PJ				
SWM 1285-2Y-3M-1Y-0M	52	179	36.1	13.2
YMH/ALD'S'				
SWM 3142-8L-4AP-0AP-1AP-0AP	53	153	35.7	14.9
YMH/ALD'S'				
SWM 3142-8L-4AP-0AP-2AP-0AP	50	179	35.2	16.1

PSI = potential size index (40 is very hard, 70 is very soft).
WMFT = Wheatmeal fermentation time, in minutes; 30 is very weak, over 200 is very strong; 120-180 is suitable for flat bread baking.

Table 40. Number of bread wheat lines tested and number of lines found promising for resistance to wheat stem sawfly at Suran and Tel Hadya, 1983/84.

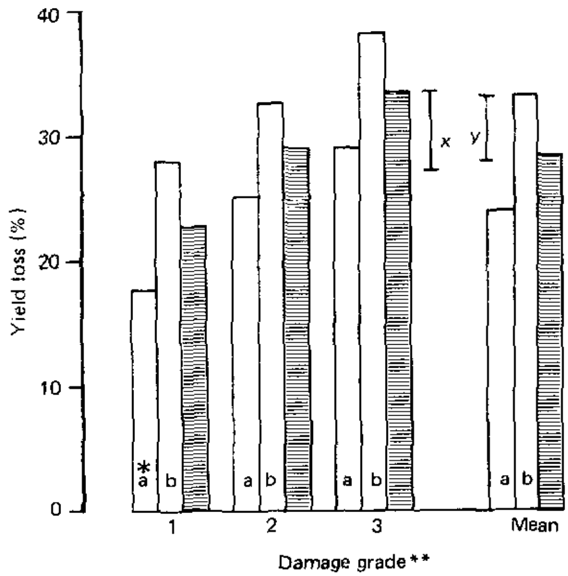
Location	No. of lines tested and range of % infestation	% infestation in the check (Golan)	No. of promising lines and range of % infestation
Suran	62 (0-26.1)	9.5	23 (0-1.7)
Tel Hadya	62 (0-8.3)	8.3	23 (0-1.1)

Resistance to Suni Bug

None of the 62 bread wheat lines tested in 1983/84 season was rated as resistant to suni bug. Lines which had initially been found promising showed susceptibility to this insect and the search for resistance to suni bug is to be discontinued.

Economic Importance of Suni Bug

The effect of planting suni bug damaged seeds was again studied at Tel Hadya. Seeds were classified in damage grades: 0 = sound seeds (check); 1 = 1/3 of each grain affected; 2 = 2/3 of each grain affected; 3 = complete grain affected. Increasing proportions of affected seeds of each damage grade were mixed with sound seeds and then planted. The results indicated that planting of suni bug damaged seeds reduced the final yield (Fig. 22), germination (up to 85% reduction), and vigor at different growth stages of the crop. — *C. Cardona and A. Rashwani.*



* a. 50% seed affected in mixture; b. 100% affected seed.

** 1 = 1/3 of each grain affected; 2 = 1/2 of each grain affected; 3 = Whole grain affected.

x. LSD (5%) between grades.

y. LSD (5%) between mixtures.

Fig. 22. Yield loss (%) in Mexipak bread wheat due to planting suni bug damaged seeds.

Project IV: Triticale Improvement

During the last few years considerable progress has been made in breeding triticale for good grain yield, seed type, grain color, and bread making quality. The yielding ability of triticale in stress environment and grain nutritive value have drawn the attention of researchers in USA, Cyprus, Tunisia, Morocco, Portugal, Spain, and Italy. The utilization of triticale has been almost solely in the livestock and poultry feed industries. China and Kenya are the only countries known to utilize a substantial proportion of the crop for human consumption.

Until 1979 triticale received very little attention in the ICARDA Cereal Program. In the 1979/80 season, heavy selection pressure was imposed and a crossing program was initiated, and in 1980/81 germplasm from other sources was introduced. Since then, emphasis has been on the identification and development of germplasm for higher yield, good grain quality, and wide adaptability under stress environment in the ICARDA region. The triticale breeding material handled during 1983/84 is listed in Table 41.

Germplasm Development

The acceptance of triticale as a commercial crop by the farmers and consumers depends on good grain quality and high yield. Triticale can give more yield than wheat but is inferior in grain quality (color and plumpness). Therefore, improvement of grain type and quality is of high priority.

About 350 crosses of Tcl × Tcl, Tcl × wheat, and Tcl × rye were made this year at Tel Hadya. Emphasis was placed on using parents of high combining ability and with desirable characters. Selected F_2 segregating populations are sent to some locations for family selection and also planted at Tel Hadya and Breda for individual plant selection. Single-head selection in segregating populations is the common approach of selection applied to triticale at ICARDA.

Yield Trials

Severe drought in 1983/84 allowed selection of the most drought-tolerant genotypes from the yield trials and screening nurseries.

Table 41. Triticale nurseries, 1983/84.

Title of experiment	No. of expt/entries	Site
Advance Trials (ATYT)	6 Expt	Tel Hadya & Breda
Preliminary Trials (PTYT)	7 Expt	Tel Hadya
PTYT as Observation Nursery	168 Entries	Breda
EUCARPIA Yield Nursery	1 Expt	Tel Hadya
ITYN-CIMMYT	1 Expt	Tel Hadya
ITSN-CIMMYT	207 Entries	Tel Hadya
Initial Observation Nursery	232 Entries	Tel Hadya & Breda
Rye Improvement Nursery	236 Entries	Tel Hadya & Breda
Crossing Block (3 dates of planting)	120 Entries	Tel Hadya
No. of crosses (TclxTcl)	300	Tel Hadya
(TclxW)	50	Tel Hadya
(TclxRye)	50	Tel Hadya
F1-AP	595	Tel Hadya & Shawbak
F2-FN	2135	Tel Hadya & Breda
TON	143 Entries	Terbol (Lebanon) Quetta (Pakistan) Karaj (Iran) Rabat (Morocco) Kabul (Afghanistan)

Improved bread wheat check Golan and durum check Sahl, performed poorer than most of the triticale lines tested in yield trials at Tel Hadya and Breda. Badia, the best check of barley, performed well at Tel Hadya but poorly at Breda. Some of the ICARDA crosses, tested for yield for the first time, had yields close to the barley check at Tel Hadya.

Preliminary Trials

Selected lines from Initial Screening Nurseries, F_4-F_n bulked populations, and ITSN were tested for yield potential and for moisture stress in PTYT at Tel Hadya (350 mm average rainfall) and as an observation nursery at Breda (250 mm average rainfall). A total of 133 lines including 11 lines selected from ICARDA-made crosses, were tested in 7 yield trials.

Triticale lines in PTYT performed slightly better than the lines tested in ATYT (Fig. 23, Table 42). Numbers of triticale lines outyielding checks Bgl, Golan, and Sahl were 1, 47, and 12, respectively. Twenty-eight and 15 triticale lines gave slightly higher yield (nonsignificant) than Drira Outcross-7 and Badia. Jillo 234, Jillo 90, Ars /Pi//Fs/3/IA/Kla//Cal (ICARDA cross) and S-Roq (ICARDA selection) were the highest yielding lines and their performance is presented in Table 43.

Advanced Trials

Advanced lines of high yield potential were tested at Tel Hadya and Breda under rainfed conditions. A total of 114 lines, including those selected from previous year's PTYT, and a few top yielding ones from ATYT and ITYN, were tested in six experiments. Five checks (two triticale, one bread wheat, one durum, and one barley) were used in each experiment. The trials were conducted with three planting dates: early planting, normal planting, and late planting at Tel Hadya. The results of late planting are not reported here because of the high coefficient of variation, which was probably due to nonuniform and poor germination partly due to bird damage.

Table 42. Yield performance of triticale lines relative to checks.

Trials	Highest yielding lines		Selected lines		All lines	
	No.	Average yield	No.	Average yield	No.	Average yield
ATYT-NP	1	1361	25	1089	114	894
ATYT-EP	5	2621	21	2306	114	1836
PTYT	1	1541	32	1315	133	1100

	Average yield of checks (kg/ha)		
Checks	ATYT-NP (6 Expts)	ATYT-EP (6 Expts)	PTYT (7 Expts)
Badia	1356	1456	1382
Drira outcross-7	1019	1928	1262
Beagle	935	1894	1150
Golan	910	972	936
Sahl	742	478	986

Table 43. Performance of the highest yielding lines in the triticale yield trials, 1983/84.

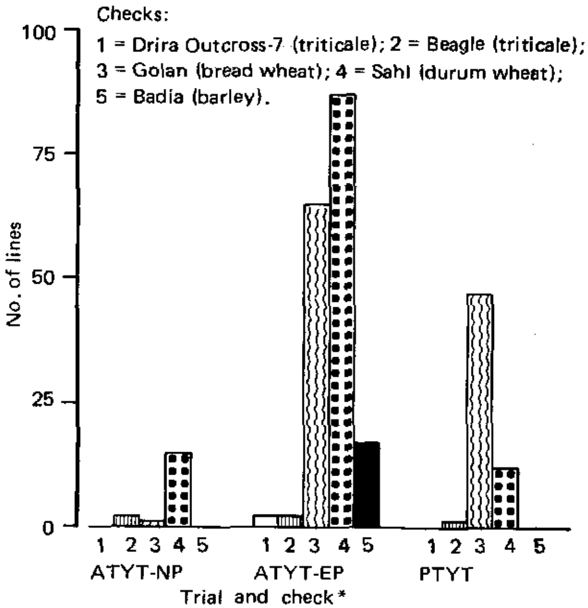
Variety/line	Yield	% increase over checks T1	B	BW	D	LSD (5%)	1000-kernel weight (g)	Prot. (%)	DM	PH (cm)
Jillo 234	1361	132	107	145	187	374	30	13	174	65
Jillo 90	1180	110	108	131	113	166	31	13.1	173	65
Ars/Pi//FS//3/IA/Kla//Cal (ICARDA Cross)	1222	114	103	140	128	155	29	12.6	174	68
S-Roq (ICARDA Selection)	1541	111	125	216	179	367	34	12	171	70
Badia (barley)							40[a]	11	165	53
Doc-7 (triticale)							31	14	173	69
Bgl (triticale)							25	15	173	64
Golan (bread wheat)							28	12	173	49
Sahl (durum wheat)							29	13	172	46

DM = Days to maturity
a. = Means over all experiments for the five checks

Overall performance of triticale lines in comparison to checks is shown in Fig. 23 and Table 42. The number of triticale lines outyielding durum check Sahl was the highest in comparison to other checks. The number of lines outyielding the checks Bgl, Golan and Sahl in normal planting was 2, 1, and 15, respectively; and for Drira outcross and Badia (nonsignificantly) was 26 and 1, respectively.

Similarly, in case of early planting, 2, 2, 65, 87, and 17 triticale lines significantly outyielded Drira Outcross-7, Bgl, Golan, Sahl, and Badia, respectively. In general, yield performance of triticale lines was better in early planting in comparison to wheat and barley checks. IRA/Bgl/Jllo and Iga/Ira//Mpe'R' performed well with all planting dates both at Tel Hadya and Breda.

In the regional wheat yield trials for 1982/83, the triticale lines H505-71A/Bgl 2, Jillo 89 and Drira Outcross 9, were the top yielding lines. In other words the highest yielder in RDYT, RFDYT, and RWYT was a triticale line. Multilocation testing is important in developing lines with wider adaptability and high yield potential.

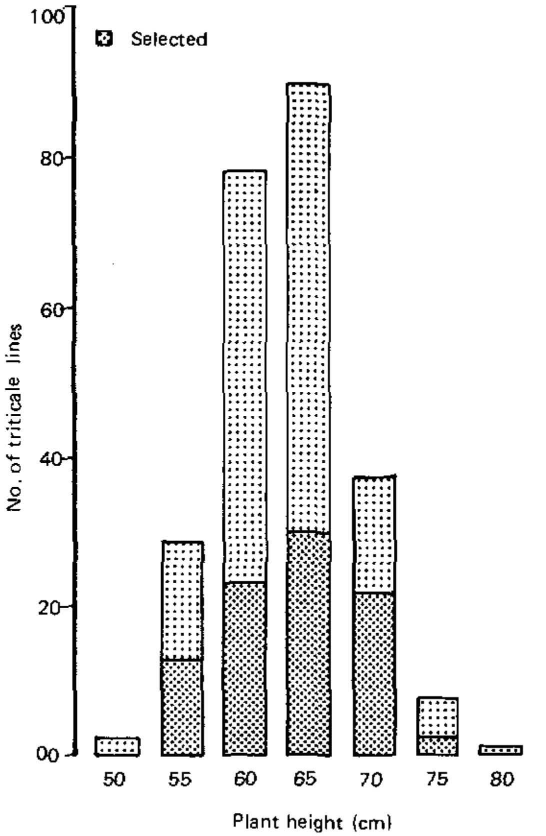


* ATYT = Advanced triticale yield trial; PTYT = preliminary triticale yield trial; NP = normal planting; EP = early planting.

Fig. 23. Number of triticale lines that yielded significantly ($P<0.05$) more than the checks in three yield trials, 1983/84.

Early maturity was the most important character for selecting triticale lines suitable for dry areas. Therefore, necessary steps for breeding for earliness have been taken up.

Plant height is also important, in consideration of mechanical harvesting of the crop under low moisture conditions. General performance of triticale lines for their plant height in comparison to wheat and barley checks is summarized in Fig. 24. A higher precentage of selected lines comes in the range of 66-70 cm plant height, which is more than the height of wheat and barley checks.



Plant height (cm) of checks: Drira Outcross 7-69, Beagle -64, Badia -53, Sahl - 49, Golan - 46.

Fig. 24. Plant height distribution of triticale lines in the yield trials, 1983/84.

Dual-Purpose Triticale

It has been shown that triticale may have the potential as a dual-purpose crop, i.e. for green-stage grazing and then for grain yield at maturity. Due to limited resources, work on developing dual-purpose triticale is not much expanded. However, in 1980/81 suitable parents of grain and forage types were specifically selected and some crosses were made with the objective of producing suitable genotypes of dual-purpose triticale. Selected segregating populations from this material were planted as bulks at Tel Hadya, and exposed to grazing at tillering stage. Plants with high tillering and good regrowth capacity were selected and bulked. This procedure is followed up to F_5 generation. In 1984/85, seed of selected F_5 plants will be planted in separate rows and selection will be done after grazing. Work on developing dual-purpose triticale will be continued on a very small scale. — *M. Malik and M.M. Nachit.*

Grain Quality

Grain quality is one of the most important factors considered in the triticale improvement project. Progress in improving grain quality of triticale is under way. Quality analysis has demonstrated that as good flat bread from pure triticale flour can be made as from wheat flour.

One hundred and nineteen advanced lines of triticale were tested for protein content, hardness, 1000-kernel weight, and wheat meal fermentation time. Some of the high-yielding lines have been identified for reasonably good quality suitable for bread making (Table 44). A wide variability in quality parameters has been

Table 44. Quality characters of some high yielding triticale lines.

Line	PSI (%)	WMFT (min)	Prot. (%)	1000-Kernel weight (g)
Juanillo 97	55	158	14.1	29.9
Bgl/IRA	55	148	13.2	28.9
IA/Kla//Cal/3/Bgl/4/Jllo	54	130	13.8	28.0
Jllo 234	54	167	12.9	29.7
Drira-Outcross	51	168	15.9	29.0
IRA/Bgl//Jllo	52	181	13.7	28.4
Golan (BW-Check)	59	53	12.0	29.0

PSI-Particle size index; WMFT-Wheat meal fermentation time; PROT-Protein content.

noted in advanced lines as well as in segregating populations. — *P. Williams and F.J. El Haramein.*

Disease Control

Disease development in triticale is slightly increasing. Therefore, care has been taken for proper screening against common diseases. Some good locations have been identified in ICARDA region where disease development in triticale is high enough for satisfactory screening. Last year's disease data in KLDN showed that most of the high-yielding triticale lines are resistant to all rusts. — *Omar Mamluk and J. Van Leur.*

Insect Control

Eighteen high-yielding lines were included in insect screening nursery last year for studying infection by wheat stem sawfly, suni bug, and aphid. Out of these lines, 274/320//Ci'R', Drira//Kiss/Arm's', IA/Kla//Cal/3/Bgl/4/Juanillo, and IRA/Bgl//Jllo were found to be resistant to aphid. None of the triticale lines was resistant to stem sawfly and suni bug. Among the lines, BVR/Arm was the one with the least suni bug damage. — *C. Cardona and A. Rashwani.*

Project V: High-Elevation Cereal Research

It is an interdisciplinary project encompassing bread wheat, durum wheat, barley, and triticale. Due to the complexity of the agroenvironmental factors, lack of adequate research infrastructure, and use of indigenous, unimproved varieties and production practices at the national level in the high-altitude areas of the region, the approach followed to improve the cereal production has been aimed at: (1) strengthening the research capabilities of the national programs; (2) development of desired type of germplasm by using the local cultivars and landrace varieties; (3) development of a network of satellite testing and selection sites in the high-altitude areas; and (4) development of a package of production practices in collaboration with national programs.

For on-site testing and selection of desirable cereal germplasm, six satellite sites, i.e., Quetta, Pishin, Kan Mehterzai (Pakistan), Sarghaya (Syria), Terbol (Lebanon), and Annoceur (Morocco) have been successfully used. The objective is to identify adapted lines and cultivars from winter x winter or winter x spring types of local and exotic origin. Selection starts from the F_2 generation. Hopefully, testing sites in Iran and Turkey will also be used for this work.

For cold and dry high-altitude areas, it is essential to develop germplasm possessing tolerance to cold and drought, high tillering capcity, and resistance to *P. striiformis* (yellow rust), *Tilletia caries* and *T. foetida,* (common bunt), and *H. tritici-repentis* (tan spot).

Component 1: Varietal Improvement

Germplasm Development

Eight hundred and fifty single, double and top crosses in bread wheat and 250 in durum wheat were carried out to transfer the required characteristics (cold tolerance, disease resistance, good quality and high yield) into the new germplasm. The lines/varieties employed in these crosses originated from 22 countries including Iran, Afghanistan, Pakistan, Turkey, Morocco, and Ethiopia. Whenever possible one parent is adapted to the target country and possesses the required adaptability and quality characteristics. However, for high yield and disease resistance (yellow rust especially), germplasm from other institutions was used.

To incorporate high tillering capacity, cold tolerance, disease resistance, high protein and drought tolerance into durum wheat and bread wheat from *T. dicoccoides,* 120 crosses were made. The F_1s of *T. durum* x *T. dicoccoides* were backcrossed to durum wheat and bread wheat varieties for simultaneous transfer of those characteristics to the bread wheat lines also.

Selection in F_2 Generation.

F_2s of bread wheat, durum wheat, and barley specifically developed for high-altitude conditions were supplied to cooperators at Quetta and Annoceur. Thirty-seven (27%) and 69 (46%) populations of winter bread wheat were selected at Quetta and Annoceur, respectively. In durum wheat, only 16 populations at Quetta and 26 at Annoceur were selected (Table 45). The low frequency of selected progenies in durum is due to the narrow genetic base for disease and cold

Table 45. Number of selected lines/progenies out of breeding material.

Name of nursery.	Total lines	No. of lines selected at: Quetta	Annoceur	Terbol	Sarghaya	Tel Hadya
WBWON	90	27	45	40	11	28
WDON	125	15	23	45	5	49
WBON	150		26	19	24	
TON	143	31				
F_2 Seg. Pop. WBW	150	37	69			263 (353)
F_2 Seg. Pop. WD	150	16	26			156 (208)
F_2 RSP (HA) B	150		47			
F_3 Fn Seg. Pop. WBW	960				556	
F_3 Fn Seg. Pop. WD	690					293

WBWON: Winter Bread Wheat Observation Nursery.
WDON: *Winter Durum Observation Nursery.*
WBON: Winter Barley Observation Nursery.
TON: Triticale Observation Nusery.
Figures in parentheses indicate the total number of populations tested.

Table 47. Top yielding cold-tolerant durum wheat lines at Quetta, Annoceur, and Tel Hadya, 1983/84.

Entry No.	Variety/cross and Pedigree	Maturity (days)	Plant height (cm)	Yield (kg/ha)
Quetta				
18	AA'S'/3*Cpe/Gz//3Tc/3/ 2*Bye/Tc/4/Fg'S'/Gdovz466 ICD 7437*-1AP-1AP-OAP	203	75	1782
17	Ibi'S'/Rabi/31810 LO 17-1AP-1AP-2AP-4AP-5AP-OAP	210	74	1741
24	Zargoon (National Check)	211	85	1730
9	So179/So179//Durum 6/3/Gta'S'//21563/AA'S' CD 20258-3AP-1AP-1AP-4AP-OAP	203	68	1652
12	Waha (Durum Check)	207	68	1641
21	Cr'S'/4/21563/3/61-130//Lds/5/Camel Tooth/ 6/Gs'S'/Durum 6 CD 21860-2AP-1AP-1AP-OAP	208	72	1533
23	Haurani (Durum Check)	208	85	1408
	LSD (5%)	3.08	8.38	628.7
Annoceur				
4	mg 5215 CR. Gerardo 562	234	77	2480
12	Waha (Durum Check)	229	73	2120
10	So179/So179//Durum 6/3/Gta'S' // 21563/AA'S'	230	78	2013
24	Zargoon (National Check)	227	78	1973
9	So179/So179//Durum 6/3/Gta'S' //2156311/AA'S'	230	70	1760
19	AA'S'/3*Cpe/Gz//3*Tc/3/2*Bye /Tc/4/Fg'S'/Gdovz466 ICD 7437-3L-1AP-2AP-1AP-4AP-OAP	226	75	1627
	LSD (5%)	11.9	6.9	969
Tel Hadya				
7	Qfn//2*Zbw/3/Tme/2*Tc//Boy'S' /T.A.dwarf. D72/Gdz CD 1986-H-3Y-1AP-1AP-OAP	195	93	5211
17	Lbi'S'//Rabi/31810 LO 17-1AP-1AP-2AP-4AP-5AP-OAP	190	87	4811
9	So179/So179//Durum 6/3/Gta'S'//21563/AA'S' CD 20258-3AP-1AP-1AP-4AP-OAP	192	93	4811
22	Ovi/cp//Fg'S' LO 38-4AP-2AP-2AP-2AP-OAP	194	92	4700
10	So179/So179//Durum 6/3/Gta'S' //21563/AA'S' CD 20258-3AP-1AP-2AP-1AP-OAP	194	97	4467
12	Waha (Durum Check)	188	85	4644
23	Haurani (Durum Check)	190	120	3700
LSD	(5%)	0.9	5.38	N.S

None of the tested entries significantly outyielded the check varieties at Annoceur but entries 4, 10, 9, and 19, which were similar in their yielding ability to that of check, possessed superior disease resistance. These lines also had the same maturity range as the check varieties.

Entry number 17 was among the top yielding lines at all sites whereas entry number 9 gave higher yield at Quetta and Tel Hadya. On the other hand entry number 10 which has the same parentage as number 9 but with a different pedigree was selected at Annoceur. The good performance of entries 18, 19, and 9 suggested that there are some similarities in the two high-altitude sites. The good performance of certain lines at more than one location also indicates flexibility and stability in performance of those lines under highly variable environments of high-elevation areas. Durum wheat is considered to have narrow adaptation and weak genetic base for disease resistance as compared to bread wheat, but the good performance of entry number 9 at all the three sites and that of entry numbers 18 and 19 at Quetta and Annoceur, respectively, indicates the possibility of identifying genotypes with wide adaptability. However, efforts to widen the genetic base for disease resistance and cold tolerance are still needed. — *M. Tahir.*

Component 2: Grain Quality

The development of germplasm with desirable grain characteristics for a variety of environments is essential. The breeding material is screened starting from early generations for grain type and high grain protein. In ICARDA region the farmers' preference is for large to medium sized grain with amber or white color.

During 1983/84, 120 promising bread wheat lines were bulked. The 1000-kernel weight of these lines ranged from 25.9 to 55.1 g. The lines were classified into six weight groups, and 67% of them were in the range of 35-45 g. The distribution of lines in each group is given in Fig. 25. Twenty lines had over 45 g 1000-kernel weight. The checks, Zargoon and Zamindar, had 29.1 and 38.7 g 1000-kernel weight, respectively.

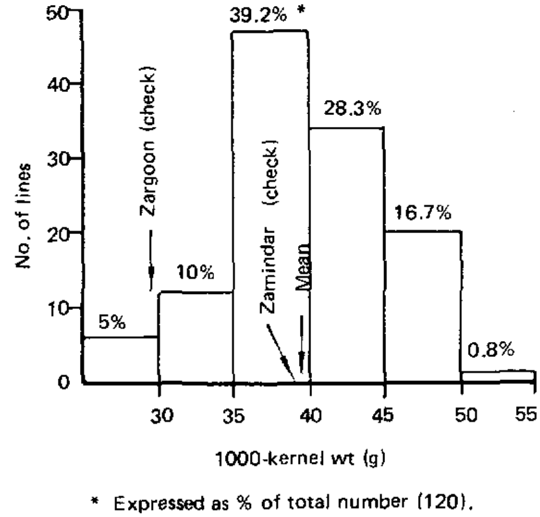
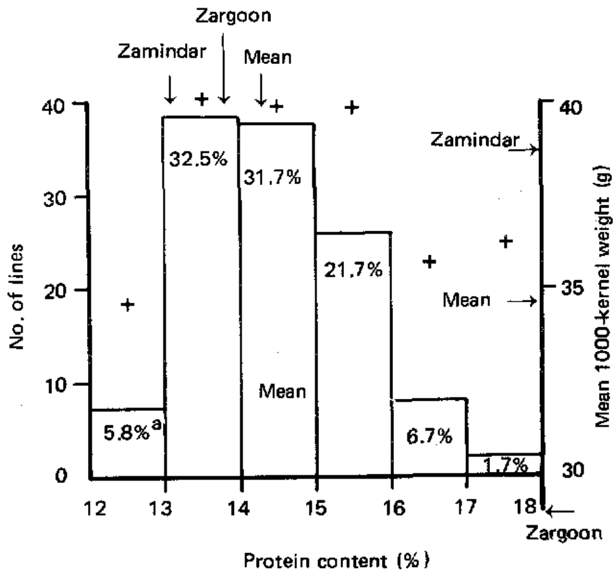


Fig. 25. Distribution of 1000-kernel weight in the advanced cold-tolerant bread wheat lines.

These lines were further tested for grain protein and were grouped into six classes on the basis of their protein content. The distribution pattern of these lines under different classes is given in Fig. 26. The average protein content of the check varieties, Zargoon and Zamindar was 13.7 and 13.1%, respectively, whereas overall mean protein content of 120 bulked lines was 14.4%. A small number of lines (5.8%) had lower grain protein than the checks. More than 50% of the lines had higher protein than the checks. Grain protein content very often has been found to be associated with 1000-kernel weight, indicating that the two quality characteristics can be successfully combined. — *P. Williams and F.J. El Haramein.*



a. Expressed as % of total number of lines (120).
+ = Mean 1000-kernel weight.

Fig. 26. Protein content and 1000-kernel weight distribution of the advanced cold-tolerant bread wheat lines.

Component 3: Agronomy

Agronomic experiments on seed rate, fertilizer application, method of sowing, time of sowing, etc. at three sites, Kan Mehterzai, Pichin and Mustung in Baluchistan,were continued. The objective is to develop a package of production technology. The weather conditions were very unfavorable in 1983/84 and the total rainfall in Baluchistan during the crop season was 30 mm. This type of severe drought was experienced about 100 years ago in 1878. Due to very severe drought the experiments failed.

On-Farm Demonstration Trials

On-farm demonstration trials, under a collaborative FAO/ICARDA/PARC project, involving varieties, fertilizer use, seed treatment, and weed control were laid out at Kalat, Mustung, Dasht, Khanozai, Gwandel, and ARI-Sariab. With the exception of Mustung and Sariab sites, where one supplementary irrigation was applied, all other experiments failed due to severe drought. The results of the variety x fertilizer trial at Mustung site are discussed here.

There were three wheat varieties, Zargoon, Zamindar, and Local White and two fertilizer treatments, i.e. no fertilizer and fertilizer at 46 kg N + 23 kg P_2O_5. The experiment was carried out in a split-plot design with three replications. The fertilizer application increased yield significantly for all the three varieties (Fig. 27). The yield dif-

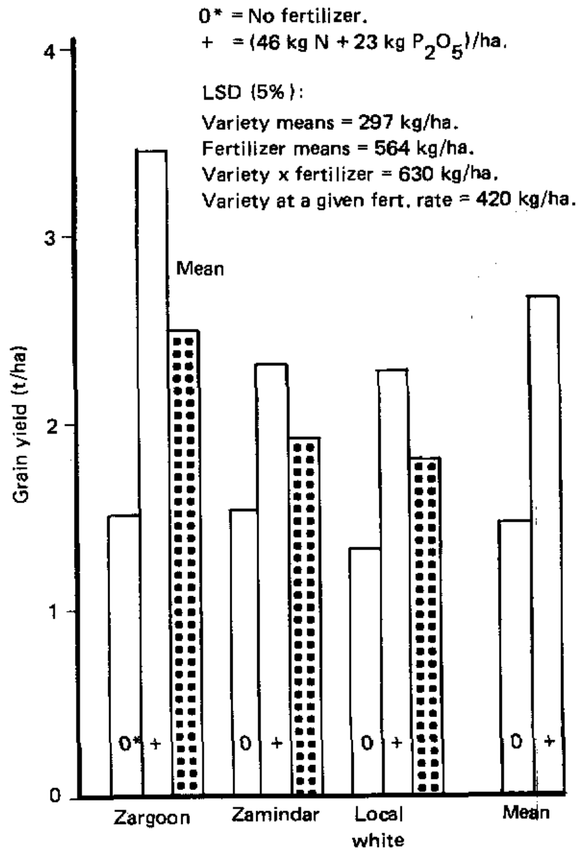


Fig. 27. Grain yield of the different treatments in the variety x fertilizer trial at Mustung, Baluchistan, 1983/84.

ferences among the three varieties were non-significant without fertilizer application, but the application of fertilizer made the differences significant. Zargoon gave the largest yield response, followed by Zamindar and Local White. Yield differences between Zamindar and Local White were not significant. — *Pakistan national program scientists, M. Tahir, and I. Naji.*

Project VI: International Cooperation

Syria

Thirty-three variety verification trials including barley, durum wheat, and bread wheat were conducted jointly by the Syrian Ministry of Agriculture and Agrarian Reform (through ARC-Douma) and the Cereal Improvement Program of ICARDA in 1983/84 throughout the country. The purpose of these joint trials is to test on relatively large plots in farmers' fields a number of cereal varieties that proved to be promising at Tel Hadya research station. The varieties tested came from ICARDA, the Syrian National Program, and ACSAD. Also, a total of 15 agronomic trials were conducted on farmers' fields with the objective of determining appropriate fertilizer combinations for cereal crops under different agricultural conditions. In addition, advanced yield trials, segregating populations, crossing blocks, and disease nurseries of wheat and barley were planted at a number of research stations in Syria. Joint visits were made to the sites by ICARDA and Ministry scientists. Selections were made for high yield, adaptability, disease and insect resistance, and agronomic traits. The Ministry staff made crosses to combine desirable characters. It involved most of the cereal research workers in Syria. Joint planning, visits, and discussions proved very useful. Training, which ranged from short term, intensive courses on specific topics, to informal instruction, was an important feature of the collaborative program.

Durum and bread wheats were tested under irrigation and in Zone A; durum and bread wheats and barley in Zone B; and only barley in Zone C. Each varietal verification trial was laid out according to randomized complete block design with three replications. Plots consisted each of 16 rows, 10 m long and 20 cm apart. Seed rate was 100 kg/ha for barley and bread wheat and 120 kg/ha for durum wheat. Field histories, including previous crops and fertilizers, were collected for each site. Soil analysis was carried out in the soils laboratory of the Farming Systems Program. The 1983/84 season was dry at most of the sites. Rainfall was particularly low during February and plant development was very poor at all sites in Zone C and relatively poor at most sites in Zone B. A detailed report of findings from field verification and agronomic trials is available from the Cereal Improvement Program.

Sham 1, the newly released durum wheat variety in Syria, generally showed a yield advantage over the improved check, Gezira 17, under irrigation and in Zone A, and over Haurani in Zone B. The most promising new durum lines were Sebou and Khabur for moderate to higher rainfall and Korifla and Sebou for moderate rainfall conditions.

In bread wheat, Sham 2, the newly released variety in Syria, ranked first and significantly outyielded the improved check, Mexipak, under irrigation. In Zone A, the best yielding lines were Seri 82, Pato-Cal/7C × Bb and FLK'S'-Hork'S'. Sham 2 was better than or equivalent to Mexipak.

Because of good performance in earlier years as well as in 1983/84, varieties Pato-Cal/7C × Bb and Sebou, Khabur, and Korifla are in initial seed increase, and will be subjected to verification trials in 1984/85.

In barley, Rihane appeared to be promising. However, due to poor plant development in Zone C, no yield data could be obtained from the trials. Disease and insect development was monitored by pathologists and entomologists throughout

ICARDA and national program scientists inspecting the nucleus seed multiplication plots in Syria.

the season and very useful information was collected.

Results of agronomic trials showed responses to nitrogen and phosphorus. Responses to nitrogen reached 24 kg of grain per kilogram of nitrogen in Zone A, but were mostly in the range of 10-20 kg. It was clear that the degree of response to either N or P could be explained by soil analysis information and the amount of rainfall. Soil tests would be very helpful in determining the fertilizer application. Availability of such tests to farmers will effectively contribute to increasing their net income. — *National Program (ARC) Scientists, J.P. Srivastava, S. Ahmed, Cereal Program Scientists, and M. Michael.*

Jordan

Based on 5 years of experiment station research and on-farm trials, the Jordanian and ICARDA scientists found that with a proper choice of improved technologies, cereal grain as well as straw yields could be increased at least by 30%, particularly in areas with an average rainfall of 250-400 mm. There are indications of a gradual adoption of the new technology by farmers and the possibilities of gains in wheat yields in Jordan.

Based on cumulative results from the 5 years of research, two broad agroclimatological zones were identified. One zone represents more favorable crop growing conditions with an average annual rainfall of more than 250 mm. The other zone, with less than 250 mm of annual average rainfall, is characterized by harsh and dry weather.

In more favorable environments, grain and straw yield of durum wheat, which represents the major cereal crop in Jordan, could be substantially increased through adoption of the improved technologies including varieties, fertilizer, precision drilling, optimum rate and time of seeding, and weed control. The study also showed that adoption of improved technology depends, to a great extent, on availability of inputs and price incentives. In the unfavorable environments, cereal production may continue to be a low-input, high-risk enterprise, with emphasis on barley grain and straw for animal feed. In these areas the improved practices may not be adopted, except perhaps for fertilizers and herbicides.

Results of this cooperative project were tested in the 1983/84 season by the Ministry of Agriculture and the University of Jordan scientists with assistance from ICARDA scientists and a Ford Foundation supplementary grant. Information from the project presents enough promise (ICARDA Research Highlights 1982, 1983) that the improved practices could be tested on a large scale in targeted areas with the objective of encouraging adoption by farmers. A collaborative project for demonstration of such promising findings is under formulation with the Government of Jordan with outside funding. — *M. Duwayri (Univ. of Jordan), N. Katkhuda (Ministry of Agric., Jordan), A.M. Tell (Univ. of Jordan), and J.P. Srivastava.*

Lebanon

The program made intensive use of Terbol station as a high rainfall (750 mm), colder site with higher disease incidence. Results from this station were used to complement the data from ICARDA's main station at Tel Hadya. Yield trials, observation nurseries, segregating populations, crossing blocks, and disease screening nurseries for barley, durum wheat, bread wheat, and triticale were planted at Terbol. The most promising wheat and barley lines were multiplied and provided to Lebanese scientists. In spite of difficulties in Lebanon, a close cooperation exists between ICARDA and the Lebanese National Program as well as with the American University of Beirut (AUB). The graduate students of AUB have visited the cereal program and used the germplasm and crossing blocks.

An attempt to grow a summer cereal crop at Terbol has been encouraging and requires further evaluation. — *N. Rubeiz and A. Aziz.*

Morocco

Barley and wheat annually occupy 80% of the total area under food crops in Morocco. Fifty percent of this area is devoted to barley while durum and bread wheats occupy 35% and 15% respectively. Unavailability of improved insect and pest resistant varieties, high incidence of plant pathogens, particularly *Septoria* spp., insects such as Hessian fly, moisture and nutrient deficiency, and competition from weeds continue to depress yields.

Close informal research cooperation exists between the Moroccan Cereal National Program and ICARDA. The program continued to provide germplasm, limited research support, and small field equipment to the Moroccan program. An in-country Cereal Training Course was conducted in March 1984 at INRA, Rabat, focusing on experimental design and statistical analysis. More than 20 research staff from different research stations participated in ICARDA's training courses and this was considered very valuable by the participants and the Directorate. A Cereal Travelling Workshop was organized in April 1984 jointly by ICARDA and CIMMYT. Scientists from Portugal, Spain, Tunisia, and

Morocco, and ICARDA and CIMMYT staff visited different research stations and helped in note taking and plant selection. This exercise provided valuable interaction and exchange of information and experiences between the participating scientists.

There have been frequent visits by ICARDA and CIMMYT scientists to Morocco and Moroccan scientists to ICARDA's base program. Besides regular international nursery germplasm, special germplasm was provided for high-elevation areas of Morocco; disease and insect screening nurseries, particularly for *Septoria* spp. and Hessian fly. As a result of increased research activities, Morocco in 1984 released several barley and wheat varieties (see Table 1). The lines identified as potential candidates for release are listed in Table 2.

Nasma/Potam 70 and Potam/Nasma were developed by the Moroccan National Program; other lines were from germplasm provided through ICARDA/CIMMYT nurseries. All these lines are under seed increase. Seed of several of these lines was supplied in 1984, on request, to Moroccan authorities for large-scale increase. Thus, the close interaction between the Moroccan National Program, ICARDA, and CIMMYT is proving its usefulness. A number of lines, selected at Annoceur Research Station in the Atlas mountains, appear to be better adapted and resistant to diseases than the presently grown cultivars in high-elevation areas. — *National Program scientists and ICARDA Cereal Program scientists.*

Cyprus

Relatively early maturing barley and wheat lines selected in Cyprus through this project are proving useful in other countries in the region. One of the durum lines, Sebou, that has given high grain yields in several countries, was selected by Cypriot scientists. This collaborative project continues to provide a valuable testing and selection site and Cypriot scientists have benefited from, and contributed to, the overall program objectives. In the last few years, Cyprus has released one barley and two durum wheat varieties for commercial cultivation (see Table 1). — *A. Hadjichristodoulu and C. Josephides, Agric. Res. Inst., Nicosia.*

Tunisia

The favorable weather conditions as well as government measures to deal with prices for wheat and barley at the beginning of the 1983/84 season and the supply of fertilizers and herbicides allowed the planting to be done under good field conditions.

Karim and Ben Bechir, the two durum wheat varieties released during the last 5 years, now cover more than 50,000 ha sown with certified seed sold by the two seed multiplication cooperatives.

In 1982/83, a few lines were promising and they perfomed well again this year. Their yield was 2 to 15% superior to the highest check Karim under favorable conditions at Beja. The most promising line was Erget'S'/4/Cit71/3/21563/AB//CP/Gz D77-93-6B-5B-6B.

From the 1983/84 international trials a few lines were found superior to the checks; they were selected for further testing:

RFDYT: Gdo 512/Cit'S'//Ruff'S'/Fg'S'
CD 10549-M-7M-2Y-1M-OY-OKE
RDYT: Cr'S'/t.dic.Vern//G11'S'
RDYT: Win'S'/USA 02237//Gad'S'
CD 16559-C-7M-2Y-2M-1Y-OM
EDYT: Shwa'S'-Yav'S'
CD 26406-1B-1Y-2Y-1M-1Y-OB
EDYT: 15 = Shwa'S'-Yav'S'
CD 26406-1B-1Y-2Y-OM-9Y-OB

The two recently released varieties, Salambo and Tanit, and the variety Dougga, released in 1974, covered this year nearly 40,000 ha from a total of 140,000 planted to bread wheat. The yield superiority of Tanit in microplots was also confirmed in farmers' fields.

Table 48. Yield of improved and local checks over four locations in Tunisia.

	Yield (kg/ha)			
Variety/cross/pedigree	Tedjerouine	Boulifa	Beja	Koudiat
Roho (improved check)	2544	4222	2889	3423
WI 2198 (improved check)	3072	4044	2664	3562
ER/Apam (improved check)	2255	3544	3500	3692
Ceres (Check)	*2022*	*1967*	*2131*	*1334*
Martin (Check)	211	3105	2378	2976
Location Mean	2244	3543	2444	3443
CV (%)	13.6	12.4	11	7.5
SE ±	153	220	134	129

From the international yield trials distributed by ICARDA/CIMMYT and on the basis of the notes we had taken during the travelling workshop in *Morocco and Spain, as well as on those taken* here in Tunisia, and on the basis of grain quality characteristics and grain yield, the following five lines are promising:

ISWYN: Bow 1
ESWYT: Seir 28 (20th ISWYN 22)
ESWYT: Vee'S'
CM 3302A-F-15M-500Y-0M-98B-0Y
RBWYT: (Pato (R)-Cal/7CxTob-Cno) Yd'S'
CM 33115-1L-1AP-0AP
RBWYT: Bow'S'
CM 33203-F-4M-4Y-1M-1Y-0M

The barley program was carried out this year in two different agroclimatic areas in Tunisia: the semi-arid region represented by Boulifa (350 mm), Tedjerouline (230 mm), and Hindi Zitoun (220 mm); and the sub-humid area represented by Beja (600 mm) and Koudiat (400 mm).

Two local and three improved checks were used in the advanced yield trials depending on the area. The varieties Martin, Roho, and WI 2198 were used for the semi-arid areas and *ER/Apam and Ceres for the moderate rainfall* areas.

Over four stations, the new checks ER/Apam, Roho, and WI 2198 outyielded the local checks Ceres and Martin significantly (Table 48). The results obtained by Office des Céréales indicate that these three lines (WI 2198, Roho, and ER/Apam) outyielded Martin by 50% and 42%, at Siliana (327 mm) and Ouslettia (183 mm), respectively (Table 49).

To sum up, the high yield potential and stability of performance of ER/Apam, WI 2198, and Roho was confirmed again in 1983/84 by both INRAT and Office des Céréales. Consequently, the national program in Tunisia recommended to release all three lines. Although they are all adapted to Tunisia, ER/Apam could be released to higher rainfall barley areas, and Roho and WI 2198 for the drier areas.

Grain quality was assessed for 1200 samples from the national and international barley and wheat yield trials. Quality traits included

Table 49. Performance of Roho, WI 2198, and ER/Apam in the varietal verification and demonstration trials, Office des Cereales, Tunisia, 1983/84.

	Location and yield (kg/ha)	
Line/variety	Siliana	Ouslatia
Roho	3190	1230
WI 2198	3140	1180
ER/Apam	3040	1190
Martin (Check)	2030	830

1000-kernel weight (g), test weight (kg/hl), and grain protein content (% dry matter) for all cereal crops. In addition, carotenoids, vitreousness, and spaghetti making were evaluated for durum wheat and bread wheat.

The ICARDA cereal scientist posted in Tunisia will now give increased attention to cereals pathology. His work is carried out in cooperation with Institut National de la Recherche Agronomique (INRAT) and with the Breeding Department of the Institut National Agronomique (INAT). He is putting more emphasis on septoria leaf blotch and tan spot of wheat; scald, net blotch, powdery mildew, and leaf rust of barley.

Other major diseases and insect pests prevailing in the Maghreb countries during the cropping season 1983/84 were studied. Disease nurseries of the season 1983/84 were grown at Beja station with supplementary irrigation to favor infection and disease development. About 8000 entries of wheat and barley, representing ICARDA, CIMMYT, and the national program germplasm, were inoculated artificially with septoria leaf blotch, tan spot, scald, and net blotch (barley). Other diseases such as BYDV, powdery mildew, and leaf rust on barley developed well naturally and enabled a reasonable screening. Results on the pathology components of each crop are presented in the report of the Tunisia/ICARDA Cooperative Project 1983/84. — *A. El Ahmed; INRAT: A. Maamouri, M. Deghais, M.L. Faleh; INAT: M. Harrabi, and A. Daaloul.*

Pakistan

The collaboration between ICARDA and PARC in the Baluchistan Province of Pakistan has made considerable progress during the past 3 years. A number of promising lines of bread wheat, such as Qt 4081 - PWTH/Candor, Lom 23/Cans, Chambord/5133, and others, have been selected at Agricultural Research Institute, Sariab, Quetta, from ICARDA-supplied germplasm for further yield testing at a number of locations in the high-altitude environments of Baluchistan. There is also a growing interest on durum wheat and lines such as AA'S'/3*Cpe/GZ//3TC/3/2*Bye/TC/4/Fg'S' Gdovz 46, Ibi'S'//Rabi/31810 have been selected for adequate disease and cold tolerance and as high yield as the improved bread wheat check variety Zargoon.

The work on the development of a package of production practices is continuing and the results on the response of wheat to the application of nitrogen and phosphorus are being demonstrated to farmers under a collaborative project "FAO/ICARDA/PARC On-Farm Demonstration Trials in Wheat." The essential equipment such as Oyjord seeder, plot threshers, and reaper binders, etc. were purchased out of the project funds to carry out the on-farm demonstration trials more efficiently. — *S. Mohammed, Sariab, Quetta, and M. Tahir.*

ICARDA/CIMMYT Barley Program for Latin America

Implementation of working arrangements for barley research agreed upon between CIMMYT and ICARDA started in 1984 and the following workplan was developed:

— An ICARDA-employed barley breeder was jointly appointed for the Mexico-based program.

Although the reciprocal awareness of the two barley projects in Mexico and in Aleppo has been considerably upgraded in the last few months, there is still room for further improvement. The main responsibilities identified for the Mexico-based project are to:

1. Develop barley germplasm specifically suited to meet the needs of Latin America with particular attention to the Andean Region.
2. Develop germplasm specifically adapted to warm winter short-season environments.
3. Develop BYDV-resistant germplasm for areas where it is a constraint and other diseases mutually agreed upon.

4. Encourage national programs to develop appropriate agronomic practices to improve barley production in Latin America.

In addition, the following items were discussed:

— CIMMYT support for the joint barley project will continue at the same level as in the past years.

— Every effort will be made to initiate a coordinated distribution of materials. This coordination will be fully implemented as soon as possible, preferably within a year or so. The information collected by cooperators and by national programs will be fully shared within the project.

— A more intensive exchange of germplasm, information and visits between the two projects is recommended.

— The Aleppo-based project will be responsible for the overall coordination of the research activities. The Mexico-based project will be fully integrated with CIMMYT wheat program under the general direction of the Director of Wheat Improvement Program, CIMMYT, Mexico.

Objectives and achievements will be reviewed and discussed periodically and modified whenever considered necessary to maintain the usefulness of the project.

Benefits such as improved breeding material and techniques arising from this cooperative effort may be used by either or both parties, with due acknowledgement of each party's contribution. — *H. E. Vivar.*

Collaboration with the University of Saskatchewan, Canada

Informal collaborative work between ICARDA and the University of Saskatchewan on collection, evaluation, and conservation of barley and durum wheat germplasm and their wild relatives began in 1978 when Dr. S.Jana spent his sabbatical year at ICARDA. In the first year of the project, about 2200 individual plant samples of wild barley (*H. spontaneum* Koch) from 28 sites were collected from Syria and neighboring countries. These materials have been evaluated for a variety of characters including 23 isozyme traits and seedling tolerance of salt stress. Dr. John Moseman of the USDA, Beltsville, Maryland, has been assessing genetic diversity for barley diseases in these accessions.

The initial collaboration has been extended to cultivated barley, durum wheat, and wild emmer, *Triticum dicoccoides* Desf. Evaluation of these accessions and identification of useful lines for possible use in crop improvement has been the focal theme in the past 3 years and this research is partly supported by the National Sciences and Engineering Research Council of Canada. The objectives of the expanded current project are as follows:

1. Collection of barley and durum wheat and their wild relatives from their primary center of diversity in the Fertile Crescent.
2. A systematic assessment of accessions under two contrasting environmental conditions, short-day Mediterranean and long-day temperate, to determine adaptive features of germplasm lines.
3. Identification of germplasm lines with tolerance to biotic and physical stresses, especially drought and salinity stresses.
4. Utilization of promising lines in germplasm enhancement of barley and durum wheat.
5. Assessment of spatial and temporal differences in genetic diversity in the cultivated and wild forms to identify sites of high variability and low genetic erosion.

The project places emphasis on the collection of landraces and wild species from diverse ecological conditions to capture a wide spectrum of genetic variability.

Collection

Altogether 136 locations were sampled in 1983/84. Each sample included single or multiple species. The sampling strategy consisted of collecting a single ear per plant from 30-150 random plants depending on the population size. *T. dicoccoides* was found to be the least abundant species and deserves serious attention in future exploration. *Aegilops trianciale* and *H. spontaneum* accessions have been collected from highly saline sites which may have high degree of salt tolerance. These accessions will be evaluated in 1984/85.

Evaluation

Three salt-tolerant durum wheat lines have been identified. About 3500 durum wheat accessions which were evaluated for agronomic traits at Tel Hadya in 1978/79 were further evaluated for drought stress tolerance and 35 morphological characters in Swift Current, Saskatchewan, Canada by Drs. P.L.Gautam and J.M.Clarke. Fifty drought-tolerant durum wheat lines have been tentatively identified.

Temporal changes in genetic variability in ICARDA's advanced breeding lines (Barley Observation Nuseries) from 1979 to 1983 were assessed. Twenty-five morphological descriptors were employed for the study.

Germplasm Enhancement

Using the evaluation data on available wild accessions, an introgressive hybridization program has been initiated at Saskatoon. Promising wild barley and emmer lines have been crossed to multiple cultivars of barley and durum wheat, respectively. The introgression populations will be subjected to transgressive segregation for several desirable traits (e.g. biotic and physical stresses, high biomass and grain production, large grain size and protein content, and slow senescene). — *S. Jana (Univ. of Saskatchewan, Canada) and J.P. Srivastava.*

Collaboration with the University of Reading, UK

Two barley projects are established as collaborative investigations between ICARDA and the University of Reading.

Project I: Root Studies

The aims of the project, established in January 1982, are to study the extent of varietal differences in root systems and to determine how root growth and the utilization of water and nutrients can be manipulated to improve crop yields.

The study in 1983/84 was undertaken in two short-term experiments and one long-term experiment. The main objectives for each of the three, respectively, are to: determine the effect of the rooting medium on several barley genotypes, check the dependency of plant growth on position in the glasshouse, and determine the effect of shortage of soil water at different times on the growth of four varieties of barley.

The following results were obtained:

1. The glasshouse experiments showed that varietal variation of root and shoot growth occurred in young plants of barley.
2. There was an influence of the growing medium on the varietal differences observed.
3. Work in Syria showed significant effects of site and fertilizer on the growth of roots of three varieties of barley.
4. There were also significant differences between varieties in their distribution of roots in the soil profile. — *P. Gregory (Univ. of Reading, UK) and Cereal and FSP Scientists.*

Project II: Photoperiod Study of Barley

The objective of this project, initiated in April

1984, is to study the photothermal responses (flowering) of diverse barley genotypes. Ranges of photoperiod and temperature conditions encountered under different barley growing areas are simulated in controlled environments.

Genotypes comprising 20 early heading, 2 medium-late heading, and 2 late-heading types (1 two-rowed and 1 six-rowed type in each category) are exposed to the following photoperiod-temperature combinations:

Day length(hr)	Day temp.(°C)	Night temp.(°C)
10	18	5
13	28	13
16		

— *R.J. Summerfield (Univ. of Reading, UK) and M.S. Mekni.*

Collaboration with the University of London

During 1984, a collaborative project between Birkbeck College (University of London) and ICARDA was started with funds from the United Kingdom Overseas Development Administration (ODA). The aim of the project is to develop screening techniques for resistance to drought in barley and durum wheat. Physiological and biochemical responses of plants to drought are studied to assess their importance in drought tolerance and their possible use in screening for drought resistance. In particular the use of a 'Metabolic Index of Stress,' constructed from the relative concentrations of amino acids, betaine and secondary metabolites in the plants is being assessed. An understanding of the plant characteristics involved in drought resistance is important in developing varieties with increased resistance to this stress.

In the 1983/84 season the research was funded by a UK Agricultural and Food Research Council Wain Fellowship to Dr. N. Smirnoff. Effect of water stress on nitrate reductase in barley and durum wheat was investigated. Nitrate reductase is the first enzyme of the pathway of nitrate assimilation into protein and is thought to be highly sensitive to environmental stresses such as drought. The plants were subjected to irrigation gradients from a line-source sprinkler irrigation in three environments differing in rainfall (204 and 230 mm over the growing season) and nitrogen fertility. Decreasing irrigation along the gradients caused increased plant water deficits as measured by leaf water potential. Nitrate reductase activity during the heading stage was either unaffected or, in some cases, increased towards the drier ends of the gradients. Nitrate reductase activity was highest in the high nitrogen environments irrespective of water regime. However, nitrogen concentration in the plants at harvest reflected their nitrate reductase activity. In contrast to field-grown plants, seedlings of the same cultivars subjected to rapidly developing water stress in soil or osmotic stress in polyethylene glycol solutions had decreases in leaf nitrate reductase activity. The results show that the plants do not lose nitrate reductase activity during field-water deficit suggesting that they have the capacity, and opportunity, to adapt perhaps by osmotic adjustment. It is suggested that maintenance of nitrate assimilation during water stress allows for continued synthesis of nitrogenous compatible solutes while using the excess photochemical energy available during stomatal closure. The difference in response between field and laboratory-stressed plants emphasizes the importance of investigating drought resistance under field conditions. — *N. Smirnoff (Birkbeck College, Univ. of London) and M.D. Winslow.*

Project VII: International Nurseries System

The Program continued to provide the national institutions with superior germplasm for their breeding programs. Summary and analysis of the data in the form of preliminary and final reports were provided to the cooperators.

In 1983/84, 793 sets from 19 different nurseries (including the Key Location Disease Nursery) with a total of 2,955 entries were distributed to 87 cooperators in 46 countries. This represented an increased distribution of 15%, or an additional 109 sets, over 1982/83. The numbers and types of germplasm distributed in 1983/84 to seven areas (West Asia, North Africa, Mediterranean Europe, Other Africa, East Asia, North America, and Other) appear in Table 50. For the purposes of this report, West Asia includes the countries east of Egypt to Pakistan; North Africa includes Morocco to Egypt plus Sudan; East Asia includes the countries in Asia east of Pakistan; and North America includes Canada, USA, and Mexico. The countries of the ICARDA region are thereby included in the West Asian and North African areas.

Essentially, three different types of germplasm constituted the international nurseries: parental genotypes, segregating populations, and advanced lines.

Computerization of the data of the international nurseries and the base program continued in 1984. Newly developed CERINT modules for ranking, sorting, transforming, selecting, and printing the data have enhanced the interpretation and presentation of the results from the cooperators in the region. CERINT modules and the SATURN word processor were used to produce master copies for printing all the fieldbooks of the 1984/85 international cereals nurseries.

Table 50. Distribution of ICARDA's international cereals nurseries and trials for the season 1983/84.

		Number of sets distributed							
Nursery/trial	No. of entries	West Asia	North Africa	Med. Europe	Other Africa	East Asia	North America	Others	Total
Barley									
Regional Yield Trial (RBYT)	24	21	23	8	6	7	3	1	69
Observation Nursery (BON)	150	24	18	7	6	7	3	2	67
Crossing Block (BCB)	162	10	11	3	4	3	5	1	37
Segregating Populations									
- High-Altitude Areas (SPB-HAA)	150	6	7	3	2			1	19
- Low-Rainfall Areas (SPB-LRA)	150	8	8	1	1				18
- Higher-Rainfall Areas (SPB-HRA)	150	9	5	2	1			2	19
Key Loc. Disease Nursery (BKLDN)	400	9	6	1	2		4	1	23
Durum Wheat									
Regional Yield Trial (RDYT)	24	16	18	7	3	2	3		49
Regional Yield Trial-Rf (RFDYT)	24	20	16	8	4	2	2		52
Observation Nursery (DON)	100	16	20	12	4	6	6		64
Observation Nursery-Rf (DON-Rf)	90	15	20	12	4	6	6		63
Crossing Block (DCB)	154	9	9	5	4	6	5		38
Segregating Populations (DSP)	150	9	10	8	2	1	1	1	32
Key Loc. Disease Nursery (DKLDN)	520	11	6	1	2		4	1	25
Bread Wheat									
Regional Yield Trial (RWYT)	24	28	21	9	6	5	2	1	71
Observation Nursery (WON)	150	28	20	8	4	7	1	3	71
Crossing Block (WCB)	108	11	4	2		1	2		20
Segregating Populations (WSP)	125	16	9	2	1	3	1		32
Key Loc. Disease Nursery (WKLDN)	300	10	6	1	2		4	1	24

A preliminary report was sent in December 1984 to cooperators in the region. New, additional analyses to be considered for the international nurseries include phenotypic and genotypic correlations, combined analyses for subregions, pattern analyses of genotypes or environments, and various performance plots. A final report is scheduled for early 1985. — *D. Mulitze and other Cereal Program scientists.*

Project VIII: Cereal Training

I. Long Residential Training Course

The course started early January and ended mid-June. During the first month, the trainees were given an intensive English language course as well as lectures on genetics, pathology, entomology and statistics. These lectures were common to all ICARDA trainees and were given at Aleppo.

In the following month, the trainees started their specific training at Tel Hadya which lasted until the end of the training period in June with a 1 week recess in April. Lectures were more concentrated in February and March while field activities predominated in April and May. A list of classroom or field lectures is given in Table 51. Field activities included practical sessions and were either common to all cereal trainees or specific according to trainee's assigned project.

The common field activities, covering 29% of all practical sessions, comprised entomology, pathology, selection of barley, durum and bread wheat, cereal crops for high elevation, weed control, agronomy, mechanization, field verification trials, and cereal and food legumes field days. As for the specific activities (71%), intensive training was provided within each cereal commodity on various important aspects of cereal improvement in accordance with the project chosen by and assigned to the trainees.

Table 51. Classroom and field lectures in the 1984 residential cereal training course.

Topic	Duration (hr)
Genetics and breeding	54
Physiology and agronomy	36
Pathology and entomology	25
Statistics and field plot techniques	31
Miscellaneous:	41
ICARDA programs	9
Communication	8
Farming systems	6
Germplasm	6
Seed production	4
Computer use	4
Field verification trials	2
Seminar	2
Total	187

These included hybridization, disease scoring, agronomic scoring, selection and harvesting. A list cereal trainees in this course along with assigned research projects is given in Table 52. Project reports were written by the trainees a few days before the end of the course.

When considered in its totality, the long residential training course emphasized more the practical sessions than theoretical lectures, the field activities covered over 60% of the total schedule.

II. Short Courses

The Program participated mainly in three short training courses:

1. A course on germplasm and genetic resources was jointly organized in April by IBPGR, ACSAD, and ICARDA. Fourteen trainees from 11 Arab countries participated in this course. They spent one day at the Cereal Crops Improvement Program where they attended a lecture on cereal germplasm at ICARDA and visited field plots (cereal wild species) and seed storage facilities.

Training of young scientists from national programs is one of the important activities of the Cereal Improvement Program. Here some of the trainees evaluate the performance of advanced lines at the Tel Hadya research farm.

Table 52. Names and assigned projects of cereal trainees in the 1984 cereal residential training course.

Trainee's name	Country	Assigned project
N. Habbal	Syria	Barley breeding: seed production
L. Sakouhi	Tunisia	Barley breeding: early vs late planting
A. Ziaee	Iran	Barley breeding: barley for grazing
M. Aloui	Morocco	Durum breeding: North African germplasm
S. Wafai	Syria	Durum agronomy: seed rate and spacing
A. Zaatari	Syria	Durum breeding: Syrian germplasm
H. AL Ashoor	Saudi Arabia	Bread wheat breeding: yield trials
M. El Fitoory	Libya	Bread wheat agronomy: seed rate and spacing

2. Seed Production Course II - This course was organized in May by ICARDA under the sponsorship of RPVZ (Netherlands) and GTZ (Germany). Twenty-two trainees from 12 countries of the region attended the course. The course covered several aspects of seed production including genetic purity, seed quality, seed-borne diseases, laboratory tests, and field inspections. The crops emphasized were cereals, food legumes, and forages.

3. The Program also participated in a training course at Lattakia on experimental design and data analysis organized by ICARDA for Syrian trainees.

III. Morocco In-Country Training Course

A 1-week course was organized in Morocco by the Cereal Program in collaboration with INRA in March 1984. Twenty trainees from different research stations in Morocco benefited from this course. Two scientists from ICARDA and three from INRA conducted the course which included classroom lectures, laboratory applications, and field visits. The major topics of the course concentrated on basic experimental designs (completely random, randomized complete block, split-plot), factorial experiments, simple linear correlation and regression, genotype x environment interaction and varietal stability.

Special attention was paid to ways of avoiding common errors in field plot techniques including those related to field layout, plot harvesting, and data collection. Although techniques of data analysis were given in detail, more time was devoted to drawing sound conclusions from analysis results. A special emphasis was placed in this regard to problems encountered in highly variable environments typical of rainfed agriculture.

IV. Individual Training

Individual training is provided to persons coming from national programs for a short or long period to learn specific research techniques and methodologies that would be useful to them back home. During their stay at ICARDA, the participating trainees work closely with the scientists involved in the research activities related to their field of interest. One trainee from People's Republic of China spent 6 1/2 months working on barley improvement with special emphasis on agronomy. Another trainee from the Netherlands spent 7 1/2 months working in triticale improvement. Three trainees (one each from Syria, YAR, and Morocco) pursued a 2-week training in cereal disease methodology.

In addition, several scientists from national programs visited us to exchange information and get acquainted with aspects of the cereal improvement work. These visiting scientists came from Iran, Syria, Tunisia, Yemen Arab Republic, Sudan, Egypt, Jordan, Libya, Pakistan, and Bangladesh. — *Habib Ketata and other Cereal Program scientists.*

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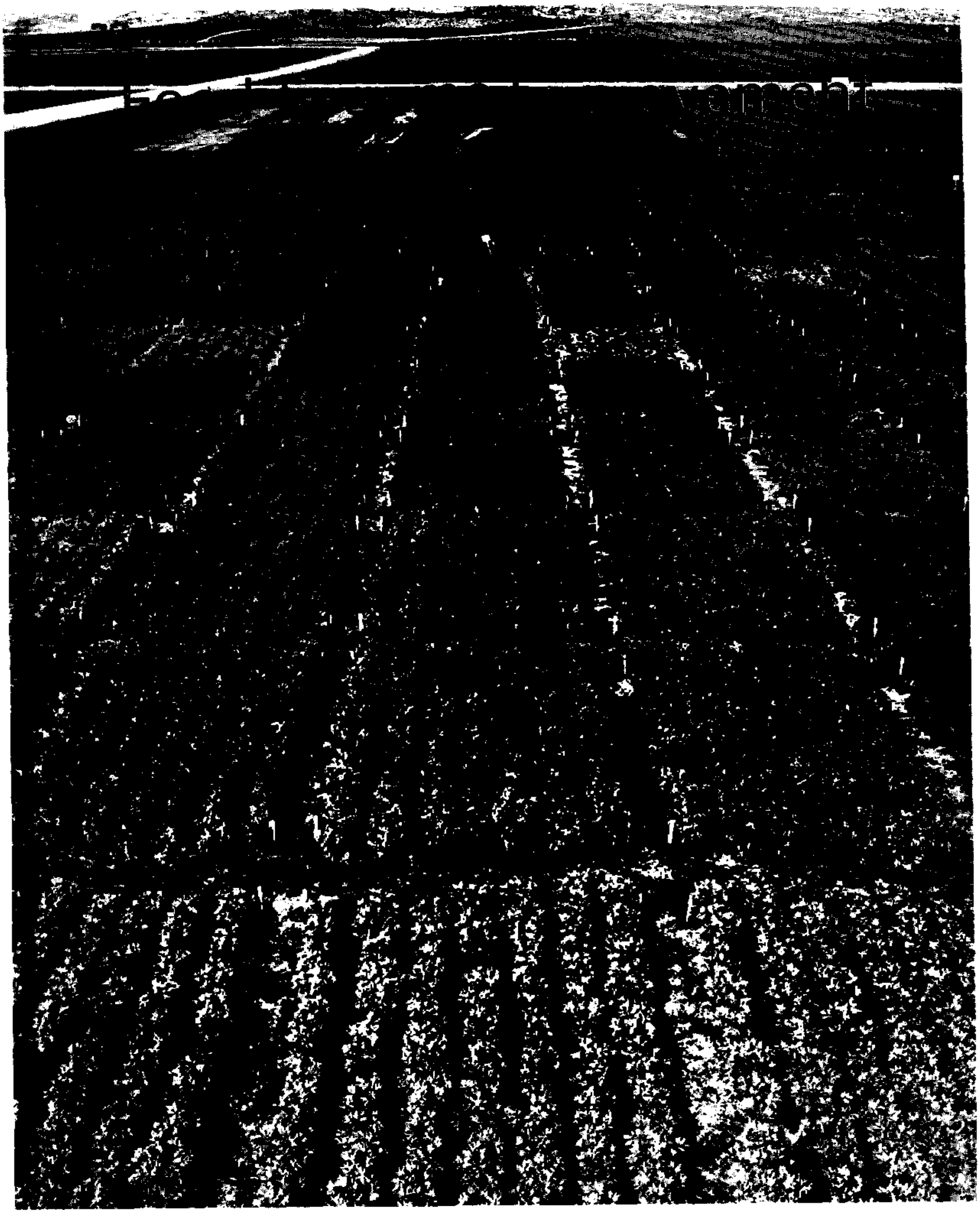


Contents

Cover: Faba bean breeding plots and cages at the Tel Hadya research farm.

Food Legume Improvement

The major objective of the Food Legume Improvement Program (FLIP) continued to be to increase the productivity and yield stability of faba beans (*Vicia faba*), lentils (*Lens culinaris*), and kabuli-type chickpeas (*Cicer arietinum*). These food legumes are a cheap source of high quality dietary protein in ICARDA region countries and elsewhere. Their by-products are also of significant economic importance to farmers in these countries. They are particularly important in the farming systems of many dry areas due to their ability to symbiotically fix the atmospheric nitrogen. The cropping systems in such areas are predominantly cereal-based, but farmers use little nitrogen fertilizer because of its high cost and the inherent risk in dryland agriculture. Therefore, increased use of legumes in the cropping system is a very economical way to improve and stabilize the productivity of these areas.

Productivity of faba beans, lentils, and chickpeas is currently low and very unstable, due to the inherently low yield potential of the landraces, their susceptibility to diseases and insect pests, the vagaries of weather, and the use of traditional production practices. FLIP's research emphasis in 1983/84 continued to be on developing genotypes and production techniques to overcome these constraints. Work on kabuli-type chickpea continued to be a joint activity with ICRISAT (International Crops Research Institute for the Semi-Arid Tropics), based in India, which has a world responsibility for chickpea improvement. A chickpea breeder and a chickpea pathologist from ICRISAT work with FLIP on the improvement of kabuli-type chickpeas.

Although research on each crop is conducted by multidisciplinary teams of scientists, the results are presented here by discipline for the convenience of the readers. The program's research strategy and linkages with national programs are shown in Fig. 1. The breeding strategies followed are outlined in the respective sections of this report.

Staff Changes

The senior staff consisted of the faba bean breeder, faba bean pathologist, ICRISAT chickpea breeder, ICRISAT chickpea pathologist, lentil breeder, legume entomologist, training officer, legume breeder in Tunisia, and agronomist/program leader. These were supported by three postdoctoral fellows; one in faba bean breeding through the Nile Valley Project (NVP), one in agronomy/crop physiology, and one in the international testing program; and four research associates (one each in agronomy, lentil breeding, faba bean breeding, and the North African Regional Project (NARP) based in Tunis). Dr. K.B.Singh, the chickpea breeder, proceeded on 1-year sabbatical leave in September 1984, without any replacement. Dr. R.S. Malhotra joined the team in January 1984 to take up the new position of International Trials Officer. Dr. M.V. Murinda, postdoctoral fellow left the program at the end of 1984 upon completion of 3 years. Also, as of end 1984, the four research associates left the program and these positions

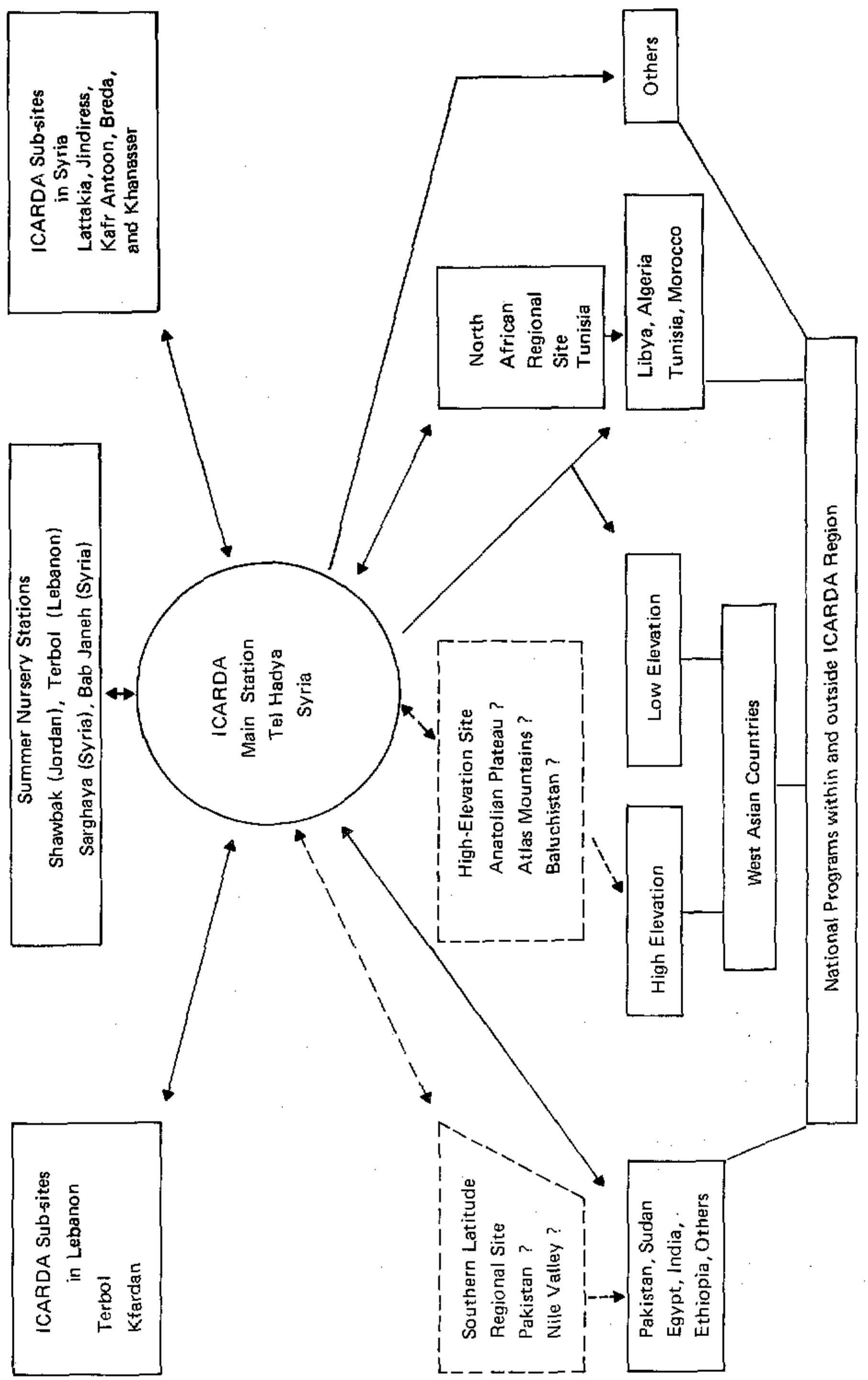


Fig. 1. Development of improved germplasm at ICARDA and its flow to the national programs.

have been used to provide postdoctoral assistance to lentil and chickpea breeding subprograms, as per recommendations of the first EPR of ICARDA.

The program also had four visiting research associates, two from China (in germplasm and faba bean breeding), one from Spain (faba bean breeding with emphasis on *Orobanche* spp. resistance) and one from Holland (laboratory technique in screening legumes for *Orobanche* spp. resistance), and they provided valuable input in the on-going research projects in the program.

Research Highlights

Some of the major achievements of the program in 1983/84 are listed below.

Faba Beans

1. The pure-line accessions were further increased by another cycle of selfing and the current number stands at 3354. The seed inventory was partially computerized. A total of 2402 lines were distributed to the cooperators.
2. Determinate faba beans with high yield, large seed size, and good field tolerance to common foliar diseases have been developed. In the yield tests they yielded as large as the best indeterminate checks.
3. Nine and seven new sources of resistance to chocolate spot and ascochyta blight, respectively, were identified.
4. National programs in several countries (including Ethiopia and Egypt) have started using ICARDA-derived faba bean material in their yield trials and prerelease multiplication.
5. Agronomic studies showed that application of 50 kg P_2O_5/ha along with use of glyphosate to control *Orobanche* sp. and use of Temik to control root lesion nematode resulted in more than 90% increase in yield.
6. The Nile Valley Project in Egypt demonstrated an economic increase in the yield with the control of *Orobanche* sp. and weeds. Giza 402 was made available to the Egyptian farmers as the first cultivar with high field tolerance to *Orobanche* sp. The NVP in Sudan demonstrated that improved agronomic package in the on-farm trials increased the seed yield significantly giving a net benefit of Sudanese £ 658, 531, and 766/ha, respectively, in Zeidab, Aliab, and Selaim regions. In the pilot production plots scheme in Zeidab in which 77 farmers participated and about 140 ha area was covered, the yield increased by 75% with improved package.
7. IFAD carried out the external review of the NVP project. The review team was highly appreciative of the achievements of the project and has recommended further extension of the project. It is proposed that Ethiopia may be included in the next phase, and Ethiopians have formally requested for their involvement in it.

Lentils

1. A lentil germplasm catalog has been published, containing passport and evaluation data on more than 4500 accessions. A total of 1455 accessions were distributed to 12 countries.
2. In the on-farm trials in Syria, the ICARDA-derived genotypes yielded 26 and 43% higher yields in the small- and large-seeded genotype groups, respectively, over their respective local checks.
3. ICARDA selections are being used in the on-farm trials and multilocation testing in Egypt, Ethiopia, India, Jordan, Morocco, Pakistan, Sudan, Syria, Tunisia, and USA.
4. Ethiopia has started large-scale multiplication of ILL 358 lentil which is slated for release as soon as adequate amount of seed is ready.

5. A project on lentil harvest mechanization has been submitted to the IDRC for special funding and is likely to be approved within the 1985 financial year.

Kabuli Chickpeas

1. Ascochyta blight has been successfully transferred into the background of large kabuli-type seed and early maturity.
2. About nine different national programs have identified lines from ICARDA material for prerelease multilocation testing or for release. Cyprus has released ILC 3279 because of its tall growth habit and suitability for winter sowing.
3. Large quantities of breeders' seed of ILC 195, 482, 484, and 3279 chickpeas have been provided for on-farm work in Jordan, Lebanon, Morocco, Tunisia, and Turkey.
4. A chickpea annotated bibliography of genetics and plant breeding has been published.
5. An audio-tutorial module was developed for screening of chickpeas for ascochyta blight.
6. In ICARDA/INRAT cooperative project progress was made in resolving the identity of the wilt complex, and genotypes with combined resistance to blight and wilt are being developed.

International Testing

Nearly 1200 international nurseries and trials were supplied for the 1984/85 season to about 127 cooperators in 52 different countries. Report of the 1981/82 season was printed and distributed.

Training

1. An in-country training course was organized in Pakistan on the ascochyta blight of chickpeas. A manual is being developed from the lectures and practical exercises given to the participants.
2. A residential training course was conducted at Tel Hadya. In this course 12 participants from seven countries (Syria, Sudan, Egypt, Iran, Libya, Morocco, and Ethiopia) participated.
3. The second seed production training course was conducted jointly with the Cereal Improvement Program.
4. Three senior research fellows and four training research associates, were given individual training. Also, five research scholars were associated with the program for their thesis research.
5. Two workshops/conferences were held: the Third International Symposium on Parasitic Weeds in May, and the First FABIS/LENS User's Seminar in November. The proceedings of the first are already published; those of the second are under preparation.
6. Printing of FABIS, LENS, and Faba Bean and Lentil Abstracts continued.
7. The proceedings of the International Conference on Faba Beans, Lentils, and Kabuli Chickpeas in the 1980s were submitted to IDRC for publication.
8. A multiauthor book "The Chickpeas" is being developed.

The program continued to collaborate with advanced institutes in Canada, France, Italy, The Netherlands, UK, and West Germany for basic research, for which resources at ICARDA are currently limited. — *M.C.Saxena.*

Faba Bean Improvement

Research on faba bean improvement continued to be conducted under the following four projects: (1) development of improved cultivars and production practices for high-rainfall/assured moisture environment, (2) development of trait-specific genetic stocks, (3) development of cultivars and production practices for low-rainfall conditions, and (4) development of alternative plant types and studies on breeding methodologies. In addition, work on the germplasm resources continued in collaboration with the Genetic Resources Unit (GRU). Research on faba bean improvement carried out in the Nile Valley of Egypt and Sudan and in the North African Regional Project in Tunisia is reported under International Cooperation.

Since faba beans are predominantly grown in the high-rainfall/assured moisture environments, the development of genotypes and production and plant protection techniques for such environments received the highest priority.

Germplasm

The ILB[1] collection stood at 3200 accessions in 1983/84. A total of 221 ILB accessions from China, Canada, Ethiopia, Sudan, India, Columbia, Poland, and Ecuador were multiplied in the screenhouse for the first cycle of selfing to produce BPL[2] accessions (Table 1). Approximately 800 new BPL accessions will be derived from these ILB accessions. Nearly 3350 BPLs were grown in 1984 in various stages of pure-line development. Table 2 shows the number of BPLs in different selfing generations in 1983. Over 1300 BPL accessions were at the fourth or higher cycle selfing. Approximately 1600-1800 BPL accessions should be ready for evaluation in 1985/86.

In 1984 the BPL Seed Stock Inventory was computerized, including information on BPL, the ILB from which the BPL was derived, the selfing generation, and important seed traits to help maintain purity of lines. Fig. 2 shows the seed size distribution scores in the BPL collection as of 1983.

Table 1. Faba bean germplasm lines grown in 1983/84 and planned to be grown in 1984/85.

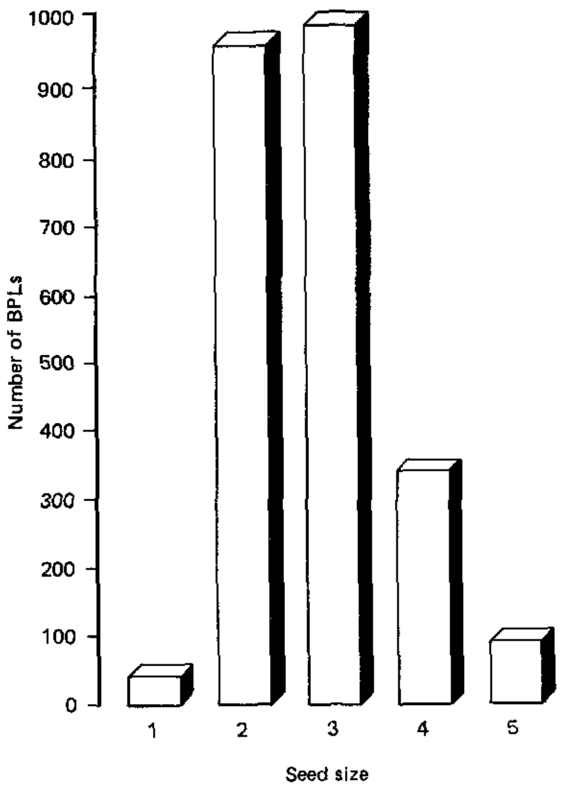
Stage of development	Number of lines 1983/84	Number of lines 1984/85
Increase	107	24
Purification	758	485
Cycle 5	459	376
Cycle 4	328	491
Cycle 3	302	161
Cycle 2		1540
Cycle 1	1400	1849
ILB	221	196
Total	3575	5122

Table 2. Number of BPLs in different selfing generations at ICARDA up to 1983.

Self generation	No. of BPL	Frequency %
1	58	2.4
2	501	20.4
3	512	20.8
4	535	21.8
5	497	20.3
6	296	12.1
7	54	2.2
Total	2453	

A total of 542 germplasm accessions from both the ILB and BPL collections were distributed to 11 countries, and 2402 breeding lines were distributed to 17 countries. — *L.D. Robertson and M. El-Sherbeeny.*

1. ILB = ICARDA Legume Faba Beans (open pollinated populations).
2. BPL = Faba Bean Pure Line.



Seed size: 1 = Small rounded (<50 g/100 seeds), 2 = Small (<50 g/100 seeds), 3 = Medium (50-100 g/100 seeds), 4 = Medium large (100-150 g/100 seeds), 5 = Large (>150 g/100 seeds).

Fig. 2. Distribution of seed size in the BPL collection as of 1983.

Development of Cultivars and Genetic Stocks

Development of Trait-Specific Genetic Stocks

The demand for genetic stocks with specific traits such as adaptation to a particular environment, resistance to one or more common pathogens and pests, was given high priority in 1983/84 due to the increasing demand for such material. BPL accessions were screened for resistance to *Ascochyta fabae, Botrytis fabae,* and *Uromyces fabae* at our disease screening site in Lattakia (Syria), and international nurseries were distributed.

Germplasm for disease resistance. One hundred BPL accessions were screened for resistance to chocolate spot *(Botrytis fabae)* and nine single-plant selections made. These will be rescreened in 1984/85. Another 100 BPL accessions were screened for ascochyta blight *(Ascochyta fabae)* and rust *(Uromyces fabae)* resistance and 169 and 26 single-plant selections were made, respectively. Screening will continue with BPL accessions in 1984/85. — *S. Hanounik and L.D. Robertson.*

Disease-resistant inbred lines. In 1982/83 the best lines resistant to chocolate spot, ascochyta blight, and rust were grown in bee-proof cages, and the progenies were grown again in bee-proof cages in 1983/84. There are now 53 chocolate spot, 27 ascochyta blight, and 26 rust-resistant lines purified through two cycles of disease inoculation and single-plant selection. This process will be repeated in 1984/85. This will provide pure sources of disease resistance and also material for studying the inheritance of disease resistance. — *S. Hanounik, L.D. Robertson, and M. El-Sherbeeny.*

International disease screening nurseries. Seed of lines resistant to chocolate spot, ascochyta blight, and rust was distributed to Canada, Egypt, The Netherlands, Sweden, Syria, and UK as international disease nurseries in 1983/84. Four lines (BPL 710, 1179, 1196, and 1278) were found resistant or moderately resistant to chocolate spot across all four locations (Egypt, The Netherlands, Syria, and UK) where the international chocolate spot nursery (FBICSN-84) was grown. Multilocation resistance of nine new resistant sources was confirmed.

In the international ascochyta blight nursery (FBIABN-84), seven out of 30 lines were rated resistant to moderately resistant in Sweden, Syria, and UK (Sel. 80LAT-14200-1, 14422-2, 14434-1, 14435-2, 15035-2, Sel. 79LAT-70015-1, and Sel. 79LAT-70015-3). In this nursery multilocation resistance was observed in seven new resistant sources.

Data were returned from only Canada, Syria, and Egypt for the international rust nursery (FBIRN-84). *Seven lines were rated resistant or* moderately resistant in all three countries. Four chocolate spot resistant lines (Sel. 81LAT-24948-1, 24948-2, 24857-1, and 24694-1) included in this nursery were also found to be resistant to rust in these countries. — *S. Hanounik and L.D. Robertson.*

Recombination of disease resistance with local adaptation. Germplasm from Morocco, Egypt, and Sudan was crossed with disease-resistant and early and determinate lines at Tel Hadya. In 1984/85 crosses will be made with Ethiopian and Chinese germplasm to introduce disease resistance. — *L.D. Robertson and S. Hanounik.*

Resistance to *Orobanche crenata.* In 1983/84, orobanche-resistant BPL accessions were tested and 15 lines were found more resistant than Syrian Local Large (Table 3). These lines will be tested for multilocational resistance in the 1986 Faba Bean International Orobanche Nursery. — *L.D. Robertson and S. Kukula.*

Table 3. Selection of 15 accessions from rescreening 120 BPLs for *Orobanche crenata* resistance in 1983/84 at ICARDA.

	Number of *Orobanche crenata* shoots/faba bean plant			
BPL	**1983/84[a]**	**1983/84**	**1981/82**	**1979/80**
1190	1.6	1.10		1.12
734	1.6	1.10	3.10	
497	2.1	1.50		2.39
1024	3.3	2.00		
257	3.9	2.20	4.30	
1323	4.7	2.90		0.68
856	3.7	3.10		
100	4.7	3.20	2.36	
1342	3.7	3.20	4.00	
579	6.0	3.30		
160	5.4	3.40	2.50	
170	4.4	3.60	11.20	
762	5.4	3.60		
1122	5.4	3.60		0.53
24	6.5	2.70	4.80	
F402[b]	3.7	2.99		
SLL[c]	10.9	8.14		
LSD (5%)		4.2		

a. Highest score in 1983/84.
b. Resistant check.
c. Susceptible check.

Resistance to *Bruchus dentipes*. Twenty BPL accessions that showed resistance to *Bruchus dentipes* in the 1982/83 season at Tel Hadya were rescreened in a replicated trial in 1983/84 (Table 4). BPL 856 again showed a high level, and BPL 747 a moderate level of resistance. In 1984/85 the mechanism of resistance will be studied. — *O. Tahan, C. Cardona, and L.D. Robertson.*

Table 4. Percent seed infestation on the basis of penetration dots for BPL accessions screened for resistance to *Bruchus dentipes* over two seasons, 1982/83 and 1983/84, at Tel Hadya. Sample size was 100 seeds.

	B. dentipes infestation (%)	
BPL	1982/83	1983/84
20	76	66.5
32	50	64.5
33	30	25.3
40	52	62.8
100	21	39.3
160	29	39.0
178	22	38.4
182	19	27.1
286	30	14.8
460	30	53.3
494	71	67.5
747	20	28.5
755	21	23.7
761	24	26.6
856	7	16.0
1024	23	33.9
1027	27	26.9
1164	28	57.8
1171	29	43.5
1190	22	20.0
Reina Blanca	59	60.0
Syrian Local Small	54	64.0
Syrian Local Medium	72	68.0
Syrian Local Large	65	61.0
LSD (5%)		10.57

Variation in vicine and convicine content. Vicine and convicine have been implicated in causing favism in susceptible humans upon consumption of faba beans. In 1000 BPL accessions tested by the near-infrared spectroscopy, vicine content varied between 0.2 and 0.6% and convicine between 0.2 and 0.4%, indicating the possibility of developing pure lines of faba beans with low favogen contents. — *L.D. Robertson and P. Williams.*

Variation in nitrogenase activity. Nitrogenase activity was evaluated in 100 faba bean genotypes by the acetylene reduction assay (ARA) technique at various stages of growth from 3 March to 6 May 1984. The aim was to identify lines that displayed higher rates of ARA for the longest time after the onset of flowering, as this would increase availability of fixed nitrogen to the plants during pod filling. Large variability was observed (Table 5). The ARA profiles of three contrasting genotypes, 39 MB, BPL 770, and ILB 1814 are given in Fig. 3. It is clear that 39 MB showed a higher level of nitrogenase activity throughout the season than the best local check, ILB 1814. Further, 39 MB maintained this high level over an extended period of reproductive growth (1-22 April), whereas the ARA of BPL 770 fell rapidly over this period. — *L.D. Robertson and J.G. Stephens.*

Development of Improved Cultivars and Genetic Stocks for Assured Moisture Environments

Faba beans in most of the ICARDA region are grown under high rainfall/supplementary irrigation. In order to obtain high and stable yields, genotypes with high yield potential and resistance to *Ascochyta fabae, Botrytis fabae, Orobanche crenata,* and *Ditylenchus dipsaci* are needed. Emphasis was, therefore, placed on developing such genotypes. In 1983/84, 209

Table 5. Nitrogenase activity of some selected faba bean genotypes as measured by ARA from 3 March to 6 May 1984, Tel Hadya.

Line	ARA (µM C_2H_4/ml/plant/hr) Maximum	Minimum	Mean	Ranking out of 100 test genotypes
39 MB	58.225	0.258	15.855	1
New Mammoth	47.386	1.060	11.227	5
ILB 1814	17.748	0.011	8.535	20
BPL 496	30.605	0.023	12.033	4
BPL 310	20.474	0.337	8.642	18
BPL 24	14.604	0.930	6.410	36
BPL 8	14.083	0.206	4.856	54
BPL 170	7.036	0.049	3.085	78
BPL 13	5.057	0.404	2.568	85
BPL 856	3.728	0.070	1.629	95
BPL 770	1.236	0.224	0.808	100

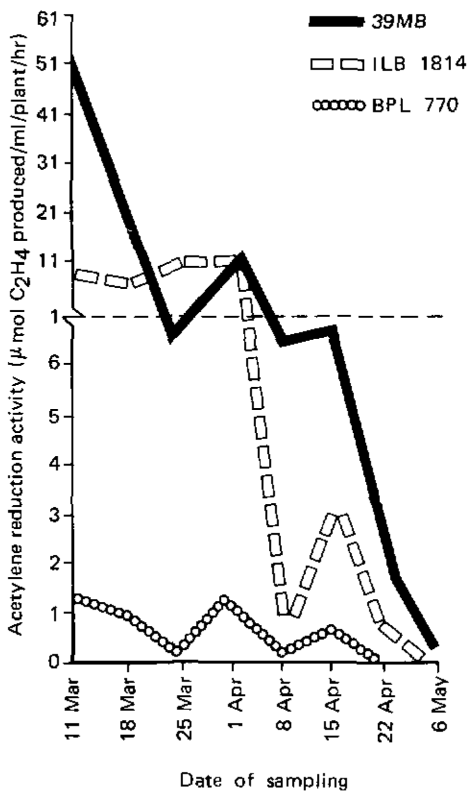


Fig. 3. Acetylene reduction activity of three contrasting faba bean lines after the onset of early flowering, Tel Hadya, 1984 (Means of six plants).

of the 250 crosses made involved at least one parent resistant to a pest (Table 6). Three-way and back-crosses to disease resistance sources will be made with some of the crosses listed in Table 6 in the 1984/85 season. This should increase the frequency of disease-resistant selections in the segregating populations.

Table 6. Number of crosses made for each trait in the 1983/84 season (excluding crosses for determinate plant type).

Trait	Number of crosses
Ascochyta fabae resistance	40
Botrytis fabae resistance	95
Bruchus dentipes resistance	10
Orobanche crenata resistance	45
Uromyces fabae resistance	4
Multiple resistance	15
Low rainfall environments	15
Yield (European germplasm introgression)	26
Total	250

Yield potential. The faba bean breeding program at ICARDA is schematically presented in Fig. 4. This scheme makes use of an off-season nursery at *Shawbak, Jordan at the* F_1*- and* F_3*-progeny-*row stage, resulting in a 2-year time saving. *Brassica napus* is used to reduce outcrossing in segregating populations, progeny rows, and preliminary yield trials. Single-plant selections are made among and within the F_2 populations (at Tel Hadya for yield and at Lattakia for disease resistance) and F_3 and F_4 progeny rows grown where selections are made for preliminary yield *trials (after off-season increase).* Selections are made from progeny rows and seed from acceptable plants within rows is bulked. Lines are then advanced through preliminary, advanced, elite, and international trials using multilocation testing

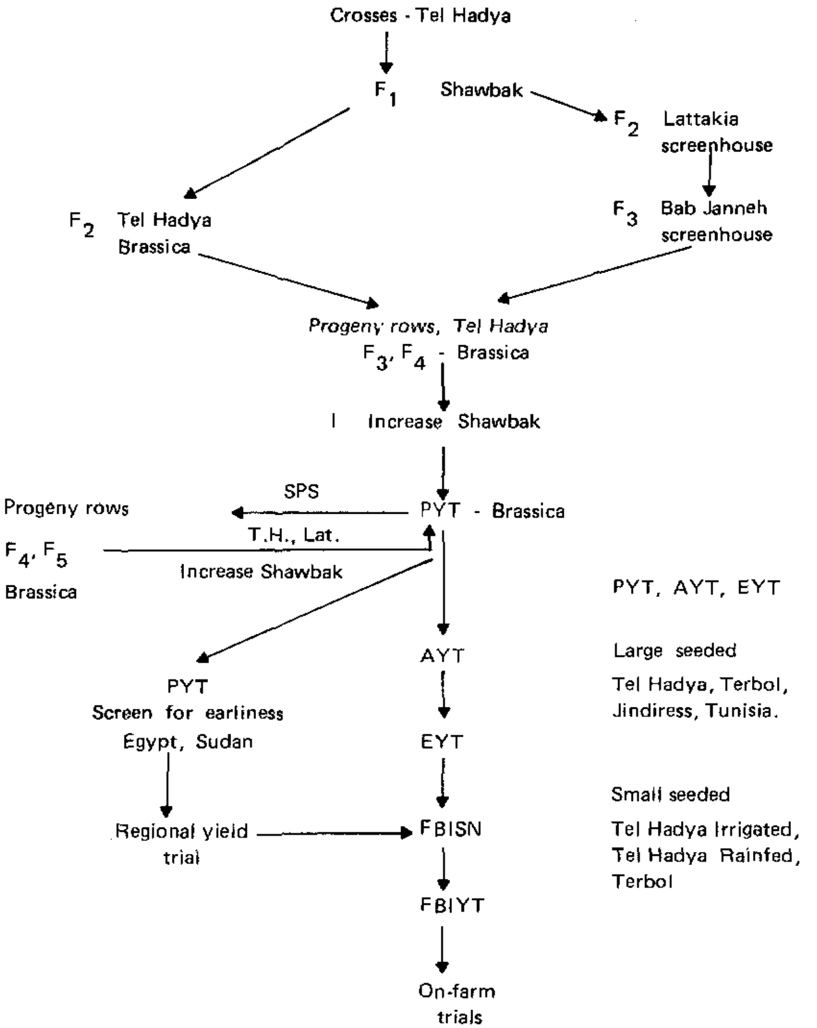


Fig. 4. Faba bean breeding program at ICARDA.

Brassica napus was used for pollination control for growing F_2 populations, F_3 progeny rows, and preliminary yield trials, and should have reduced the intermixing of genotypes caused by bee pollination. This will allow multilocation testing of genotypes earlier in the selection scheme because trial seed can be used for seed multiplication purposes.

Replicated yield trials of 1009 lines were conducted at Tel Hadya with irrigation during the 1983/84 season (Table 7). The highest yield reported in a replicated trial was 4.9 t/ha. A total of 204 entries exceeded the best check at the 5% probability level. Of these, 46 were large- and 158 were small-seeded. At Terbol (Table 8), 152 lines were tested in 4 replicated trials, with 7 lines exceeding the best check at the 5% probability level.

Thirty-six entries from the large-seeded faba bean international nursery and 48 entries from the small-seeded trial were tested at both Tel Hadya and Terbol. At Tel Hadya, 4 and 8 lines

Table 7. Summary of results from faba bean yield trials, grown at Tel Hadya, Syria, during 1983/84.

Trial	No. of tested lines	No of lines exceeding best check at 5%	Grain yield (t/ha) Best line	Trial x	Best check	LSD[1] (5%)	CV (%)	Best check
FBIYT-L	22	0	2.1	1.7	2.0±0.24	NS	28.2	ILB 1814
FBIYT-S	21	0	2.1	1.5	1.7±0.30	NS	38.7	ILB 1813
FBRYT-I	23	0	4.9	1.2	1.3±0.44	NS	56.4	ILB 1814
FBAYT-L	46	0	3.2	2.1	3.2±0.49	0.96	32.5	ILB 1814
FBAYT-S	84	1	3.0	1.4	1.8±0.16	0.43	28.3	ILB 1816
FBPYT-L	450	46	4.6	2.8	3.2±0.09	0.50	14.6	ILB 1817
FBPYT-S	279	137	3.9	2.4	2.8±0.09	0.47	15.7	ILB 1814
FBISN-L[2]	36	0	3.1	2.3	3.0±0.36	1.00	30.7	ILB 1814
FBISN-S[2]	48	20	2.1	1.5	0.9±0.22	0.61	30.2	ILB 1820

1. Line vs. check.
2. Also replicated.
NS = Not significant.

Table 8. Summary of results from faba bean yield trials, Terbol, Lebanon, 1983/84.

Trial	No. of tested lines	No of lines exceeding best check at 5%	Grain yield (t/ha) Best line	Trial x	Best check	LSD[1] (5%)	CV (%)	Best check
FBIYT-L	22	1	2.7	1.9	1.9±0.22	0.62	23.5	ILB 1817
FBIYT-S	21	0(4)[b]	2.1	1.6	2.6±0.21	0.60	27.4	ILB 1813
FBAYT-L	46	2	4.6	2.9	3.0±0.05	1.04	17.9	ILB 1817
FBAYT-S	63	0	4.0	2.7	3.2±0.06	1.22	22.3	ILB 1816

1. Lines vs. check.
b. *Number of lines significantly outyielding best small-seeded check (ILB 1816).*

exceeded the best check in the large- and small-seeded trials, respectively, and at Terbol 19 and 3 exceeded the best check in large- and small-seeded trials, respectively.

From 88 small-seeded and 274 large-seeded lines tested in the preliminary screening nurseries, 7 and 30 lines, respectively, were selected for testing in preliminary yield trials in 1984/85. Fifty-six determinate lines were grown in a preliminary screening nursery from which 8 lines were selected for preliminary yield trials in 1984/85. Also 43 single plants were selected for increase and further evaluation. — *L.D. Robertson.*

Disease resistance. Most disease resistance work was carried out at Lattakia where environmental conditions are conducive to the development of natural epiphytotics. But in order to ensure proper screening, artificial epiphytotics were developed.

Ascochyta blight: Various sources of resistance were used to make 40 crosses for ascochyta blight in 1983/84 and these will be screened in 1984/85 at Lattakia. Of 22 F_4 lines 6 were found resistant, with a disease score of 3 or lower on a 1-9 scale. Of 88 F_5 and 59 F_6 lines screened, 26 and 36 lines, respectively, were rated 3 or lower. The seed of these lines was increased in off-season and the lines will be yield-tested in 1984/85.

Chocolate spot: By adopting a two-cycle screening technique considerable progress was made in identifying promising sources of resistance to *Botrytis fabae.* Of 56 F_4 lines tested, 46 single-plant selections were made and from 45 F_5 lines, 13 lines were found resistant. Seed from the F_4 and F_5 selections was increased in the off-season and will be yield-tested in 1984/85. From F_2 populations 46 single-plant selections were made for screening in the 1984/85 season. A total of 95 crosses were made and the F_1 grown in the off-season. These will be screened at Lattakia in the 1984/85 season.

Multiple disease resistance: Selections were made in the F_4 for crosses combining resistance to two or more diseases. From 7 F_4 lines combining ascochyta blight and chocolate spot resistance 45 single plants with resistance to both diseases were selected. Twenty-two single-plant selections were made from 2 F_4 lines combining chocolate spot and rust resistance and 18 single-plant selections were made from 2 F_4 lines combining ascochyta blight and rust resistance. These selections will be rescreened at Lattakia in 1984/85. In addition, 15 crosses were made in 1984/85 for multiple disease resistance.

Durable disease resistance: Crosses have been made between different sources of resistance to ascochyta blight, chocolate spot, and rust. From 17 F_2 chocolate spot resistant populations, 31 single-plant selections were made, from 32 F_2 ascochyta blight resistant populations, 68 single-plant selections were made. From one F_4 population each for ascochyta blight and rust resistance, 5 and 8 single-plant selections were made, respectively. These F_2 and F_4 selections were increased in the off-season and will be rescreened for disease resistance in 1984/85. Their agronomic performance will be evaluated at Tel Hadya in 1984/85. — *S. Hanounik and L.D. Robertson.*

Determinate faba bean genetic stocks. The determinate growth habit is of potential importance in faba bean production areas which are either irrigated or highly fertile. By curtailing vegetative growth, which is currently excessive under these conditions, a corresponding increase in harvest index can be obtained.

Large seed size and long pod characters are being incorporated into the determinate-type faba beans.

The determinate mutant from Northern Europe is poorly adapted to the Mediterranean environment, and efforts are being made to transfer the character into an adapted background. In 1983/84, 323 crosses were made involving at least one determinate parent. Progenies were increased in the off-season and F_2 populations will be screened for determinate plants in the 1984/85 season.

From F_2 populations grown in the 1983/84 season, 3000 single plants for F_3 progeny rows were harvested and 66 single-plant selections were increased in the off-season and will be tested in yield trials in the 1984/85 season. Seed of 290 determinate single plants from determinate preliminary yield trials and 43 single plants from determinate preliminary screening nurseries was increased in the Shawbak off-season nursery and will be tested at Tel Hadya in preliminary yield trials in 1984/85 for determinate lines.

Yield tests of 93 determinate lines were conducted in the 1983/84 season. Table 9 gives the results for the 10 best determinate lines and the check. These results are more encouraging than in previous years in that yields of the 10 best determinate lines were in the same range as

Table 9. Performance of the 10 best determinate lines and the check in preliminary determinate yield trials, Tel Hadya, Syria, 1983/84.

Line	Grain yield (t/ha)	100-seed weight (g)	Flowering date (days)	Plant height (cm)
S82223-2	2.12	55	92	43
S82226-37	2.50	80	96	33
S82229-38	2.18	85	99	50
S82229-35	2.02	75	94	44
S82236-4	2.14	65	100	40
S82237-31	2.40	90	96	52
S82237-50	2.34	90	95	45
S82238-38	1.98	90	95	40
S82238-40	2.57	100	94	41
S82238-45	2.53	90	99	38
ILB 1814	2.79±0.187	230	96±0.6	64±2.0
LSD (5%)	0.645		3.2	6.9

the indeterminate check. Last year the yield of the best determinate line was 40% less than that of the best indeterminate check. This indicates that continued backcrossing is increasing the adaptability of the determinate lines and breaking unfavorable linkages. — *L.D. Robertson.*

Cultivars for Low-Rainfall Environments

Efforts were continued to develop high and stable yielding faba bean cultivars and agronomic practices capable of producing an economic yield of dry seed in low-rainfall (300-350 mm) environments so that farmers there may get another crop option and may diversify their cropping. The total seasonal rainfall during 1983/84 at Tel Hadya was 230 mm. Faba beans are normally grown only with supplementary irrigation with this amount of rainfall.

A total of 15 crosses were made with lines selected for low-rainfall conditions. Seed of these crosses was increased in the off-season and will be screened in 1985/86.

In 1983/84, 289 lines were tested in rainfed yield trials. Because of very low rainfall, yields were lower than normal and differences among lines were less pronounced. A total of 51 lines outyielded the best check ($P \leq 0.05$), and the highest yield in a replicated trial was 1.17 t/ha (Table 10). Work now is being concentrated on small-seeded lines for low-rainfall conditions to facilitate mechanical seeding and harvest. — *L.D. Robertson.*

Breeding Methods

Studies on Outcrossing

In breeding programs, outcrossing due to insect pollinators is undesirable because it makes it difficult to maintain the genetic identity of different lines. To prevent outcrossing, cumbersome and costly methods of isolation, such as widely separated plots, insect-proof cages, or individual bagging of plants with nylon nets are usually employed. In the 1982/83 season, 9 m x 12 m faba bean plots were surrounded by 6 m wide strips of *Brassica napus* or triticale. In another field the plots were separated by 6 m strips of bare ground as a check. The results of bee counts on faba beans showed greatly reduced bee activity with *Brassica napus* isolation (ICARDA Annual Report 1983). The outcrossing

Table 10. Summary of yield trials grown under rainfed conditions at Tel Hadya during the 1983/84 season.

Trial	No. of tested lines	No of lines exceeding best check at 5%	Grain yield (t/ha) Best line	Trial x	Best check	LSD[1] (5%)	CV (%)	Best check
FBPYT-S (Rainfed)	124	45	0.96	0.57	0.54±0.03	0.11	15.3	ILB 1814
FBAYT-S	84	6	1.17	0.84	0.87±0.04	0.12	12.4	ILB 1816
FBAYT-Rainfed	22	0	1.02	0.83	0.98±0.09	0.18	13.2	ILB 1814
FBRYT-Rainfed	16	0	0.99	0.79	0.72±0.08	NS	20.4	ILB 1814
FBIYT-L	22	0	0.58	0.44	0.55±0.08	NS	35.5	ILB 1814
FBIYT-S	21	0	0.83	0.60	0.67±0.08	NS	28.0	ILB 1814

1. Line vs check; NS = Nonsignificant.

rates in these plots were scored in 1984 but did not relate to bee activity recorded, with no significant differences among the treatments. The average outcrossing was 11.0% ± 4.19%, regardless of the isolation method.

This discrepancy between bee activity and outcrossing counts may be because of late planting of the bare-ground check, which affected plant growth and perhaps, therefore, bee visits. Another possibility is that the bee counts consider the number of times bees come in a faba bean plot and how long they stay, while the outcrossing marker design used measures only the number of times bees come into a plot, that is crossing between different plots of faba beans. Crossing within the plot would not affect the outcrossing rate measured. So if bees came in the bare-ground plot the same number of times but stayed longer than with *Brassica napus* that would not show. Outcrossing can be broken down into intra- and intergenotypic crossing. Simple marker gene method does not permit measurement of intragenotypic crossing.

In 1984/85, crossing within faba bean plots under the different isolation methods will be studied by planting rows of white-hilum lines within a black-hilum plot of faba beans. Crossing between single and double rows will be studied on bare ground. This, with the continuation of the previous study, should give measures of crossing between and within plots separated by bare ground and *Brassica napus*. Also, the effect of 1-, 2-, and 4- m wide strips of *Brassica napus* will be studied with faba bean plots of different sizes (6 m x 12 m, 12 m x 12 m, and 12 m x 18 m). — *L.D. Robertson and C. Cardona.*

Studies on selection criteria. A subset of the F_2 populations from 15 crosses (5 large x large, 5 large x small, and 5 small x small-seeded parents) was grown at Tel Hadya and studied for yield and yield components. Table 11 shows the correlations among the various yield components and yield. The highest correlation with yield was number of seeds/plant, while the easiest trait to select for, number of pods/plant, also had a very high correlation with number of seeds/plant. The relation of these traits to yield will be studied by path coefficient analysis to determine direct and indirect effects. — *L.D. Robertson, Lang Li Juan, and M. El-Sherbeeny.*

Faba Bean Diseases and Their Control

The most important diseases of faba beans in West Asia and North Africa are chocolate spot, ascochyta blight, rust, and stem nematodes. Use of resistant cultivars is believed to be the most practical means of control of these diseases, and

Table 11. Correlations among yield and yield components for 2998 F_2 single plants, Tel Hadya, 1983/84.

Trait	No. of pods/plant	No. of seeds/plant	No. of seeds/pod	100-seed weight	Podded nodes/plant	Pod length	Pods/ node
Seed yield/plant	0.415**	0.587**	0.233**	0.293**	0.288**	0.405**	0.144**
No. of pods/plant		0.834**	−0.225**	−0.419**	0.685**	−0.330**	0.350**
No. of seeds/plant			0.218**	−0.440**	0.561**	−0.125**	0.302**
No. of seeds/pod				−0.044**	−0.161**	0.336**	−0.079
100-seed weight					−0.267**	0.533**	−0.185**
Podded nodes/plant						−0.267**	−0.311**
Pod length							−0.091

** Correlation coefficient significant at P ≤ 0.01.

efforts in this direction have been outlined in the previous section on development of genetic stocks and cultivars. For developing suitable protection strategies, studies on epidemiology of the diseases and scope of chemical control in combination with host resistance were undertaken in the 1983/84 season at the Lattakia subsite.

Epidemiological Studies

Susceptibility of different plant parts to *B. fabae* and *A. fabae*. Information on the susceptibility of different faba bean plant parts to *Botrytis fabae* and *Ascochyta fabae* was collected to gain a better understanding of the epidemiology of these diseases, and also to help improve the current fungicidal control strategies and screening techniques for host resistance. Healthy leaves, pods, and 5 cm segments of a similar physiological stage were taken from the sixth node of Syrian Local Large (ILB 1814) faba bean grown in the field, laid flat on moist sponge sheets in metal plates and inoculated separately with *B. fabae* and *A. fabae*. After 6 days, infection was rated on a 1-9 scoring scale where 1 = 1-25% necrosis, 3 = 26-50% necrosis, 5 = 51-75% necrosis, 7 = 76-100% necrosis, and 9 = necrosis spreading beyond the inoculating droplet. Results indicated that plant organs were in general less susceptible to *B. fabae* and *A. fabae* (Fig. 5) at the 10% podding stage than at

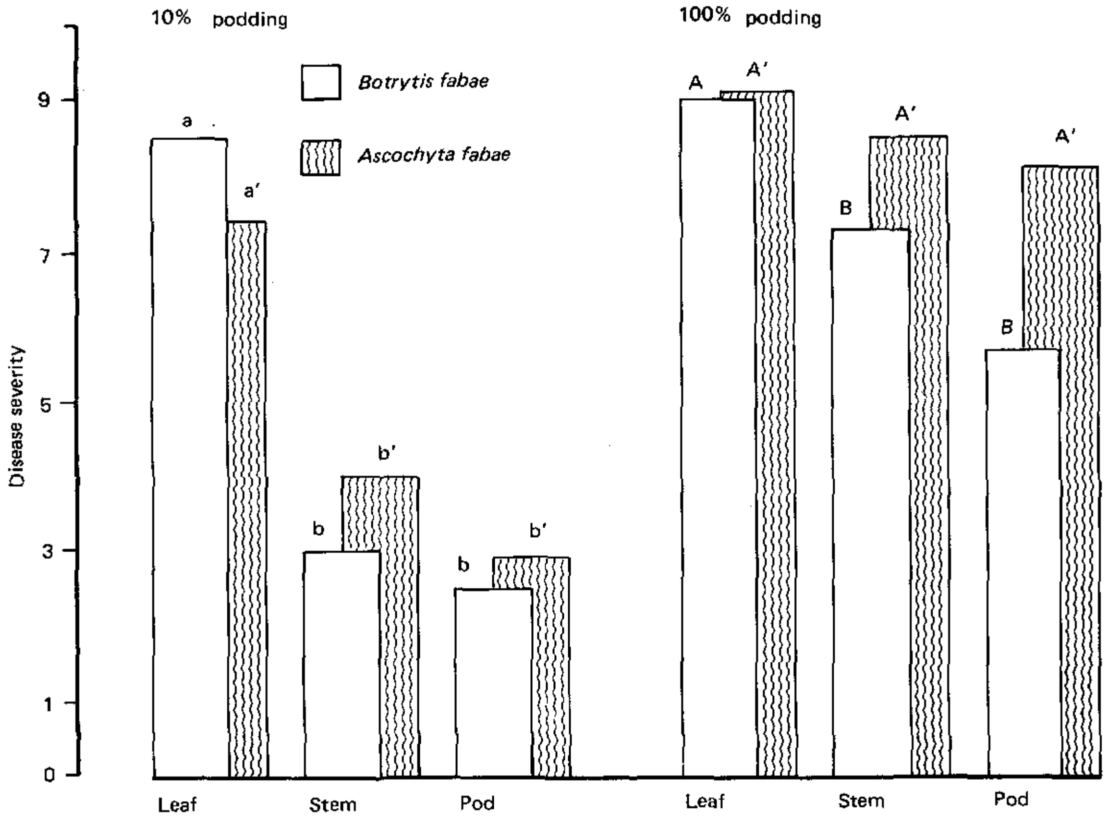


Fig. 5. Laboratory test on the susceptibility of different plant organs in faba beans to *Botrytis fabae* and *Ascochyta fabae*. Means with different letters are significantly different ($P<0.01$) according to Duncan's Multiple Range Test.

the 100% podding stage. At 10% podding stage, leaf tissue was significantly ($P \leqq 0.01$) more susceptible to these diseases than either stem or pod tissues. However, at the full podding stage, leaf tissue was significantly ($P \leqq 0.01$) more susceptible than stem and pod tissues only in case of *B. fabae*, and all the tissues were equally susceptible to *A. fabae* (Fig. 5). These results indicate that plant tissues become increasingly susceptible to these diseases with age and thus early chemical treatment is important to prevent inoculum build up.

Survival of *A.fabae* in stored seed and stem debris. Survival of *Ascochyta fabae* in stored seed and infected stem debris in the field was studied during the 1981-83 seasons at Lattakia. Results indicated that the fungus survived for a significantly ($P \leqq 0.01$) longer period in stored seed (Fig. 6) than in unburied or buried stem debris in the field (Fig. 7). The viability of *A.fabae* was maintained for 12 months in the stored seed, after which the percentage of seeds that yielded the pathogen decreased significantly (Fig. 6). In the unburied debris, the pathogen retained viability for 9 months and by 15 months the recovery of the pathogen was negligible (Fig. 7), while recovery of the pathogen from buried stem debris decreased significantly after 6 months. The *A.fabae* isolates from stored seeds and unburied and buried stem debris retained their pathogenicity for at least 24, 12, and 6 months, respectively (Fig. 8).

These results indicate that the recurrence of ascochyta blight in faba bean fields is due mainly to the survival of *A.fabae* in infected seeds and unburied stems. Therefore, plowing infected plant debris in the soil and the use of clean seed should reduce the spread of the pathogen.

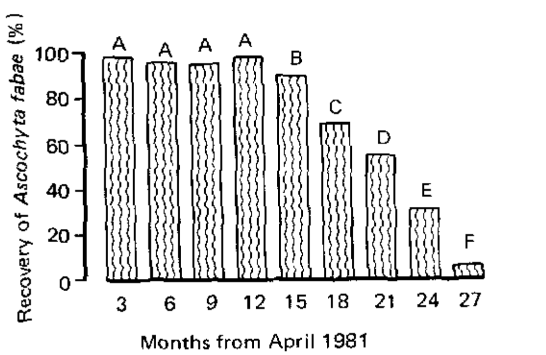


Fig. 6. Longevity of *Ascochyta fabae* in faba bean seeds stored under normal ambient conditions at Lattakia. Means with different letters are significantly different ($P<0.01$) according to Duncan's Multiple Range Test.

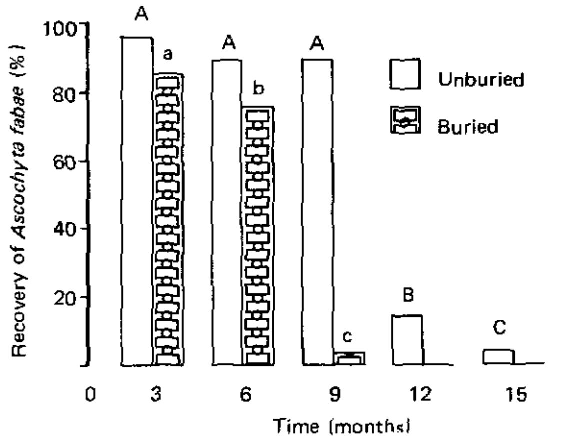


Fig. 7. Longevity of *Ascochyta fabae* in faba bean stems in the field at Lattakia. Means with different letters are significantly different ($P<0.01$) according to Duncan's Multiple Range Test. Buried debris was not detectable after 9 months.

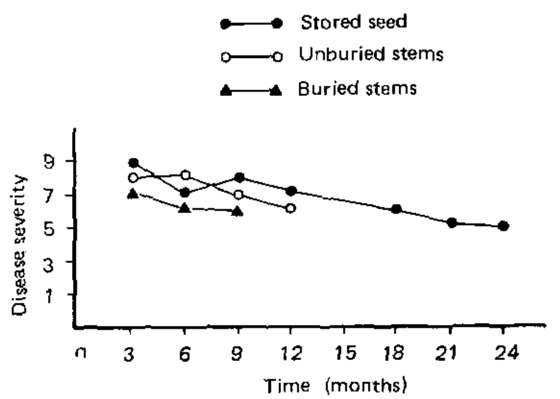


Fig. 8. Pathogenicity of *Ascochyta fabae* from stored seeds and unburied and buried stems of faba beans as affected by time.

Chemical Control of *A.fabae* and *B.fabae*

Two experiments were conducted to study the influence of some fungicides on the development of chocolate spot and ascochyta blight using a modified detached leaf technique. Healthy leaves of similar physiological stage were taken from the sixth node of plants of Syrian Local Large (ILB 1814) faba bean and laid flat on a moist sponge lining in shallow metal pans. They were sprayed with a fine mist of eight different fungicides and inoculated separately for each disease with 0.1 ml droplets of spore suspension containing either 5×10^5 or 3×10^5 spores of *B.fabae* or *A.fabae*, respectively. The pans were then covered immediately with polyethylene sheets and incubated for 6 days at room temperature (20 ± 2 °C). Infection was scored on a 1-9 scale, as indicated earlier.

The results indicated that Ronilan 50 WP (vinclozolin) and DCNA (dicloran) were significantly more effective against chocolate spot (Table 12), whereas chlorothalonil and mancozeb were significantly more effective against ascochyta blight (Table 13), than the other fungicides tested. All fungicides significantly reduced disease development compared with the untreated control.

A study was conducted in 1982/83 at Lattakia relating time of fungicide application to various durations of leaf wetness and its effect on chocolate spot development. This study was continued in the 1983/84 season but included additional disease-related parameters that could easily be seen in the field and used by growers to determine timing of fungicide application. Six treatments were evaluated: A = chemical spray started when disease first observed, and sprays continued at 2-week intervals unitl 4 sprays were given; B = spray started when disease first observed, then one application for each increase of 2 lesions (2 mm diameter) per leaf C = spray started when disease first observed, then one application for each increase of 4 lesions per leaf; D = spray started when disease first observed, then subsequent sprays whenever water film stayed on leaf until 9 a.m.; E = first application at early bloom (10% plants in flower)

Table 12. The influence of chemical treatments on severity of chocolate spot *(Botrytis fabae)* in faba beans in detached leaf test in laboratory.

Treatments and rates	Disease reaction[1]
Vinclozolin (Ronilan 50 WP) 1.25 g/l	1.00 a
DCNA (Allisan 50 WP) 1.25 g/l	1.67 a
Mancozeb (Dithane-M45) 1.25 g/l	3.67 b
Metiram (Polyram 50 WP) 1.25 g/l	4.33 c
Chlorothalonil (Bravo 500) 2.5 cc/l	5.00 c
Metalaxyl (Ridomil-M 272) 1.25 g/l	5.67 d
Copper Oxychloride (Cupravit 50 WP) 3 g/l	6.33 d
Benomyl (Benlate 50 WP) 0.3 g/l	6.33 d
Untreated (water only)	9.00 e

1. Disease reaction was evaluated on ICARDA's 1-9 rating scale (numbers followed by different letters are significantly different ($P \leq 0.01$) according to Duncan's Multiple Range Test).

Table 13. The influence of chemical treatments on severity of ascochyta blight *(Ascochyta fabae)* in faba beans in detached leaf test in laboratory.

Treatments and rates	Disease reaction[1]
Chlorothalonil (Bravo 500) 2.5 cc/l	1.00 a
Mancozeb (Dithane-M45) 1.25 g/l	1.67 a
DCNA(Allisan 50 WP) 1.25 g/l	3.67 b
Vinclozolin (Ronilan 50 WP)1.25 g/l	4.33 b
Benomyl (Benlate 50 WP) 0.3 g/l	4.33 b
Copper Oxychloride (Cupravit 50 WP)3 g/l	4.33 b
Metiram (Polyram 80 WP) 1.25 g/l	4.33 b
Metalaxyl (Ridomil-M 272) 1.25 g/l	5.00 c
Untreated (water only)	8.33 d

1. Disease reaction was scored on ICARDA's 1-9 rating scale (numbers followed by different letters are significantly different ($P \leq 0.01$) according to Duncan's Multiple Range Test).

then one application every 2 weeks until late podding; and F = untreated check. Study was carried out with the faba bean genotype ILB 1814 and the fungicide used was Ronilan 50 WP (vinclozolin) at 2g/liter. Observations of disease development on leaves at the fifth and sixth nodes were collected daily from randomly selected plants in all treatments. The first spray was applied on 26 February in treatment E, and on 1 March in A, B, C, and D. The test was terminated on 30 April 1984. The number of fungicidal applications and disease severity are given in Table 14. Although the disease severity was lowest in treatment E, which received most sprays, delaying the application until disease was observed and following the regime of subsequent sprays as given in treatments B and C resulted in a reduction of 2 and 3 sprays, respectively, while maintaining good disease control. The results highlight the importance of scheduling fungicide application according to disease development rather than crop phenology.

Table 14. Chocolate spot severity as affected by timing of initiation of Ronilan 50 WP (vinclozolin) spray schedules in ILB 1814 faba bean at Lattakia, 1983/84.

Treatments[1]	Number of sprays of Ronilan	Disease severity[2]
E	5	2.0 a
B	3	3.0 b
A	4	3.5 b
C	2	3.5 b
D	2	6.0 c
F (water only)	0	7.5 d

1. See text for treatment description.
2. Disease ratings were made on ICARDA's 1-9 rating scale (numbers followed by different letters are significantly different (P ≦ 0.01) according to Duncan's Multiple Range Test).

Survival of Stem Nematode

The stem nematode (*Ditylenchus dipsaci*) is a destructive seed- and soil-borne pathogen of faba bean. Its wide host range makes it of particular importance. Knowledge concerning its survival in faba bean seeds and debris is fragmentary. Therefore an experiment was initiated in 1981 to study the survival of *D. dipsaci* in heavily infested seeds of ILB 1814 faba bean stored at normal room temperature (20 ± 2°C) and in infested faba bean stems buried 10 cm deep in a plastic mesh in the field. Nematode larvae were extracted at various time intervals and their pathogenicity tested. The nematode survived for a significantly (P ≦ 0.01) longer time in stored seed than in buried stems (Fig. 9). The number of nematode larvae which could be extracted from seeds and stem tissues declined slowly over 24 and 9 months, respectively, thereafter falling rapidly. The seed-borne larvae remained pathogenic to faba beans during the entire 3-year period. Larvae extracted from buried stems remained pathogenic up to 9 months of storage, beyond which pathogenicity tests were not possible due to lack of recovery of larvae from the buried stems. The results illustrate the need for clean seed and removal of infested debris to reduce perpetuation of infection from one season to the other. — *S. Hanounik.*

Faba Bean Insects and Their Control

Studies on insect control for different crop growth stages were continued. The comparative economic importance of sitona weevils and aphids was evaluated and critical periods and damage levels for appropriate aphid control were identified. Further studies on the economic importance of *Sitona* spp. were conducted and the relative efficiency of insecticidal combinations to control this pest evaluated. The biology of the

(Fig. 10), although the scattering of the points suggests that it can still be improved. These scales are easy to use for timing of aphid control.

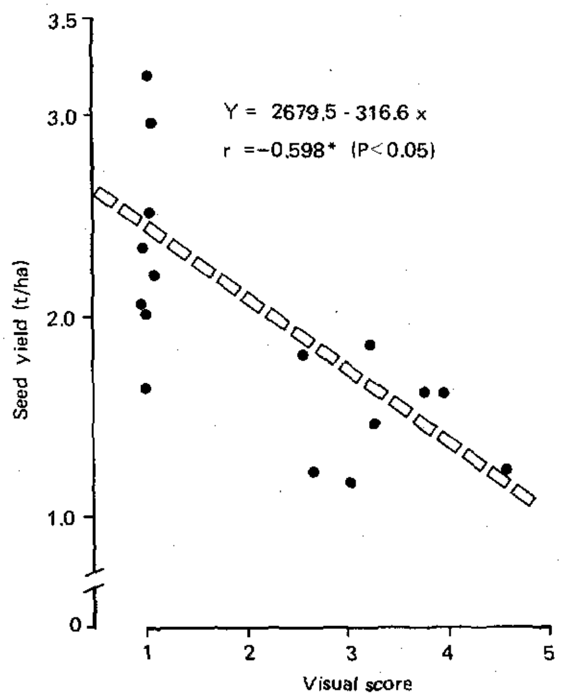


Fig. 10. The regression of aphid visual damage and infestation scores on the yields of faba beans, Tel Hadya, 1983/84.

Another important finding from these studies was that the pod-filling stage seems to be a critical period for aphid damage. As shown in Fig. 11 single spray late in the flowering period, prevented insect damage during the pod-filling stage, and gave a significant increase in yield (Table 16).

In another trial in which aphids were controlled too early, reinfestation occurred during the pod-filling period. Yield losses in this case were 56% (Table 17), whereas when the spray was

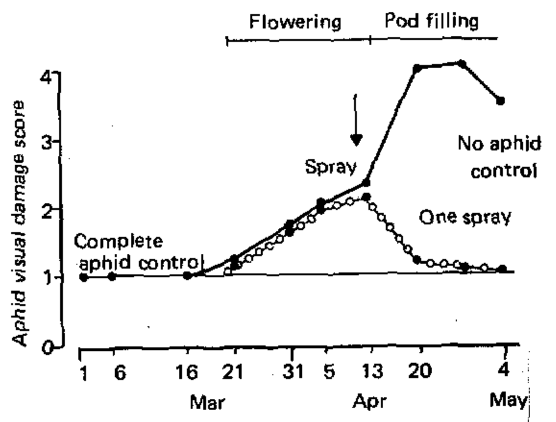


Fig. 11. Effect of one critical spray with pirimicarb on the levels of damage caused by the faba bean aphid, *Aphis fabae*, Tel Hadya, 1983/84.

Table 16. Damage levels and yields of Syrian Local Medium faba bean associated with selective control *Sitona* spp. and *Aphis fabae*, Tel Hadya, 1983/84.

Control of		% nodules damaged by *Sitona* spp.	Aphid[3] damage scores	Seed yield		
Sitona[1] spp.	Aphids[2]			kg/ha	% increase	MYIR[4] (kg/ha)
Yes	Yes	2.2	1.0	2552	82.8	96.3
No	Yes	32.9	1.0	2234	60.0	12.6
Yes	No	0.3	3.8	1786	27.9	83.7
No	No	40.3	4	1396		
SE±		4.0	0.3	224.1		
CV (%)		55.5	31.7	22.5		

1. Soil insecticide (carbofuran, 1.0 kg a.i./ha) at planting.
2. One spray with pirimicarb, 0.15 kg a.i./ha.
3. On the basis of 1-4 visual scale (1 = no damage; 4 = severe damage).
4. Minimum yield increase requirement = increase in cost/ price of the commodity.

Table 17. Yield of Syrian Local Medium faba beans under different aphid control regimes, Tel Hadya, 1983/84.

Regime	Visual damage scores[1] at pod-filling stage	Seed yield kg/ha	Seed yield % loss
Sprayed periodically	1.0	1676	-
One preflowering spray[2]	3.8	733	56.2
One postflowering spray[3]	2.6	1371	18.2
Unsprayed (check)	4.0	66	96.0
SE±	0.16	108.2	-
CV (%)	11.1	22.5	-

1. Scale: 1 = no damage; 4 = severe damage.
2. *Pirimicarb, 0.15 kg a.i./ha, at the onset of flowering.*
3. Pirimicarb, 0.15 kg a.i./ha, at the initial pod-filling stage.

delayed until the beginning of the pod-filling stage, yield losses were only 18%. Combinations of different insecticidal regimes based upon visual and infestation scores at different crop growth stages will be studied next season.

Economic Importance of *Sitona* spp.

The evaluation of the economic importance of *Sitona* spp. (mainly *Sitona limosus*) continued. The results confirmed our previous findings: even at the relatively high level of 40% nodule damage, there was no significant response in yield (Table 18) to highly efficient larval control with granular insecticides or to the combination of larval and adult control. This pattern has been consistent throughout the trials and seasons and it is now proposed to discontinue the study of the economic importance of *Sitona* spp.

Table 18. The efficiency of insecticidal combinations to control *Sitona* spp. weevils in faba bean and their effect on yields, Tel Hadya, 1983/84.

Adult control[1]	Larval control[2]	% efficiency against adults	% efficiency against larvae	Seed yield kg/ha	Seed yield % increase
Yes	Heptachlor	56	98	2392	22.7
	Carbofuran	63	99	2374	21.8
	No	37	17	2271	16.5
No	Heptachlor	18	100	2310	18.5
	Carbofuran	54	96	2324	19.2
	No			1949	

F for yields: NS
CV for yields: 25.5%

1. Four sprays with methidathion, 0.5 kg a.i./ha.
2. With heptachlor G, 2.0 kg a.i./ha or carbofuran, 1.0 kg a.i./ha.

Biology and Phenology of the Stem Borer

Studies on the biology and phenology of *Lixus algirus* were completed. Fig. 12 shows a typical pattern of biological development. Adults come out of diapause in late December/early January, mate, and lay eggs on normally sown (November) crops. The peak of adult and oviposition activity occurs during January and February. Egg hatching starts in mid-February and by early March nearly all of the plants will be infested with an average of one larva/stem. By this time chemical control is practically impossible because the larvae are well protected inside

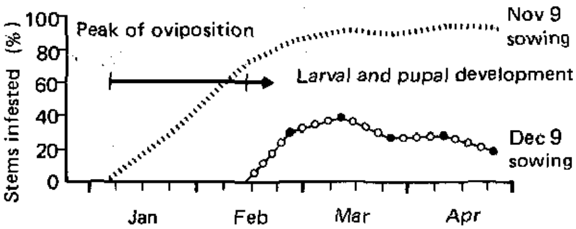


Fig. 12. Seasonal development and relative abundance of faba bean stem borer as affected by two sowing dates, Lattakia, 1983/84.

the stems. Any control measures would have to be taken in January when the adults are feeding, mating, and laying eggs. Later-sown crops are less affected (Fig. 12) because they escape the period of maximum adult activity. — *C. Cardona.*

Pollinating Insects and Pollination

The survey and identification of faba bean pollinators in Syria continued. *Eucera cincta* and *Synhalonia* aff. *hungarica* were found to visit faba bean flowers less than honey bees (*Apis mellifera*) and solitary bees (*Anthophora canescens*). As in 1982/83, *A.mellifera* and *A.canescens* accounted for approximately 90%

Table 19. Activity of faba bean pollinators as affected by different widths of *Brassica napus* strips surrounding faba bean isolation plots (Means of four scoring dates, four replications), Tel Hadya, 1983/84.

Treatment	Insects/3 min. observation[1] Honey bees	Solitary bees[2]
4-m *Brassica* strip	0.8	0.7
4-m bare ground check	1.9	2.4
2-m *Brassica* strip	0	0.3
2-m bare ground check	2.3	2.0
1-m *Brassica* strip	0.2	0.1
1-m bare ground check	2.3	2.3
SE±	0.21	0.25
CV (%)	36.1	42.8

1. Bees making visits to faba bean flowers.
2. Mainly *Anthophora canescens.*

of the visits to faba bean flowers. *A.mellifera* was more abundant than *A.canescens* throughout the season.

The effect of different widths of *Brassica napus* strips on the number of pollinators visiting faba bean flowers was studied. No significant differences were found between 4-m, 2-m, and 1-m strips (Table 19), suggesting that the area planted to *Brassica napus* can be reduced without losing its effectiveness. — *C. Cardona and L.D. Robertson.*

Weed Control

The yield reduction due to weeds in rainfed faba beans at Tel Hadya and Terbol was estimated to be 50 and 35.7%, respectively. The dominant weed species at both locations were *Sinapis arvensis, Carthamus syriacus, Phalaris brachystachys, Avena sterilis,* and volunteer cereals.

A preemergence spray of terbutryne (Igran) at 2.5 kg a.i./ha along with 0.5 kg a.i./ha of pronamide (Kerb) gave good weed control and significantly increased seed yield ($P \leq 0.01$) over weedy check at both locations. At Tel Hadya, preemergence application of 3.0 kg a.i./ha of methabenzthiazuron (Tribunil) followed by postemergence application of 0.5 kg a.i./ha of fluazifop-butyl (Fusilade) also gave good broad-spectrum weed control.

Studies were also carried out on herbicidal control of *Orobanche crenata*. None of the newly tested chemicals (trifluralin, maleic hydrazide, mefluidide, and pronamide) proved effective. Three glyphosate applications at 0.08 kg a.i./ha proved good, and gave a highly significant increase in seed yield of ILB 1814 faba bean grown in rainfed conditions at Tel Hadya. — *S.Kukula and M.C. Saxena.*

Crop Physiology and Production Agronomy

Environmental Constraints to Production

The cooperative study with the faba bean research group of the European Economic Community on "Growth and development of faba beans in relation to specific environmental conditions" was continued during the 1983/84 season, using two European (Minica and Herz Freya) and two Mediterranean (Aquadulce and Giza 3) types. The effect of soil moisture supply as well as major mineral fertilizer nutrients was studied using the following three treatments:

A. Maximum growth conditions: artificial rooting medium, fertilized four times with liquid fertilizer (100 kg N + 33 kg P + 33 kg K/ha, each time), assured moisture supply through supplemental irrigation, complete protection against diseases, pests, and lodging.
B. Normal soil and cultural environment, fertilized with 100 kg triple superphosphate/ha, assured moisture supply through supplemental irrigation.
C. Same as B, but without supplemental irrigation.

The effects of these treatments on productivity, harvest index, and water-use efficiency of the four genotypes are shown in Table 20.

The results confirm our last year's observations that the Mediterranean genotypes are more productive and exhibit better water-use efficiency than those of European origin. Since rainfall in 1983/84 was low (230 mm), supplemental irrigation resulted in large increases in yield. Improved nutrient supply further increased yield, without greatly affecting the harvest index in the Mediterranean types and only slightly reducing the harvest index of Minica. Herz Freya was damaged by a severe infestation of *Orobanche crenata* in treatment B, and hence no yield data could be obtained. The Mediterranean genotypes had higher harvest indexes in all three treatments than the European genotypes.

The effect of the above treatments on the nitrate reductase activity (NRA) of faba bean was also studied, in collaboration with Birkbeck College, London. The NRA values are given in Table 21. The genotypes tested had only small differences in their NRA, and the values were relatively lower than those usually recorded for cereals. As would be expected for an inductive enzyme, application of large amounts of N fertilizer increased NRA several-fold. Differences in moisture supply did not conspicuously affect NRA. — *M.C. Saxena, M.V. Murinda, N. Smirnoff (Birkbeck College, London).*

Cold Tolerance

Faba beans in parts of West Asia are frequently exposed to periods of low temperature (below 0°C). During winter 1981/82 and 1982/83 there were 39 and 51 nights of subzero temperatures, respectively, and extensive damage was observed in early-planted crops. This reduced the yield advantage expected from

Table 20. Total biological yield (TBY), seed yield (SY), harvest index (HI), and water-use efficiency (WUE), based on total seasonal moisture supply (TSM, total of rainfall and irrigation), of four genotypes of faba beans as affected by soil fertility and moisture supply at Tel Hadya, 1983/84.

Genotype	Treatment[1]	TBY (kg/ha)	SY (kg/ha)	HI	TSM (mm)	WUE (kg/ha/mm) TBY	WUE (kg/ha/mm) SY
Minica	A	9637	3564	0.37	404	23.8	8.8
	B	4455	1842	0.41	386	11.5	11.5
	C	967	191	0.20	230	4.2	0.8
Aquadulce	A	14691	6073	0.41	404	36.4	15.0
	B	6611	3040	0.46	386	17.1	7.9
	C	2061	897	0.44	230	9.0	3.9
Giza	A	13552	5976	0.44	404	33.5	14.8
	B	5762	2618	0.45	386	14.9	6.8
	C	2029	1074	0.53	230	8.8	4.7
Herz Freya	A	10364	3080	0.30	404	25.6	7.6
	C	904	211	0.23	230	3.9	0.9

1. Treatment details in text.

Table 21. Nitrate reductase activity (NRA) of four genotypes of faba bean on 29 March 1984 as affected by soil fertility and soil moisture supply, Tel Hadya. Each value is a mean of 3 samples.

Genotype	NRA (μmol/hr/g fresh weight)[1] A	B	C
Minica	3.78 ± 0.28	0.52 ± 0.10	0.45 ± 0.02
Aquadulce	3.32 ± 0.20	0.56 ± 0.15	0.54 ± 0.10
Giza 3	3.50 ± 0.50	0.22 ± 0.05	0.60 ± 0.16
Herz Freya	3.24 ± 0.22	0.37 ± 0.12	0.40 ± 0.10

1. Assay was carried out using top-most expanded leaf with petiole visible.
A = Artificial rooting medium with supplemental irrigation and large amount of fertilizer nitrogen.
B = Irrigated.
C = Rainfed.
More details of these treatments in text.

early sowing. Hence in 1983/84 a trial was conducted to evaluate the cold tolerance of 36 genotypes originating from different agroecological regions from Sudan to North Europe, by sowing them in October and December 1983. The 1983/84 season, however, was not as cold as previous seasons and only the very early genotypes Hudeiba 72, Brimo, Lawi, Jubilee Hysor and Burnyard Exhibition showed frost damage to flowers and some mortality was observed in Hudeiba 72 and Beryl. No effects were observed on the other genotypes. The study will be repeated in 1984/85.

Growth and Flowering Studies on Determinate Types

The growth, flower- and pod-set, and yield of a determinate mutant bulk line (DMB) were compared with those of the indeterminate Syrian Local Large faba bean (ILB 1814) at normal (22.2 plants/m²) and high (50 plants/m²) plant population levels at Tel Hadya during the 1983/84 season. Dry-matter production of ILB 1814 was double that of the DMB at various stages of growth (Fig. 13). Interplant competition, as determined by comparing the dry matter per plant in the two populations, did not occur until the early podding stage in ILB 1814 and in DMB it occurred still later. DMB produced more flowering stems per plant because of greater branching, associated with breaking of apical dominance due to the terminal inflorescence. The flower- and pod-set in the two genotypes is shown in Fig. 14. Only a small percentage of flowers set pods, of which approximately 50% did not reach maturity. Only 2.2 and 3.7% of flowers produced mature pods in ILB 1814 and DMB, respectively, at 22.2 plants/m², and 2.5 and 5.3%, respectively, at 50 plants/m², showing the large wastage of flowers. Incorporation of an independent vascular supply character, may reduce abortion, and work on this has started in collaboration with the University of Durham, UK.

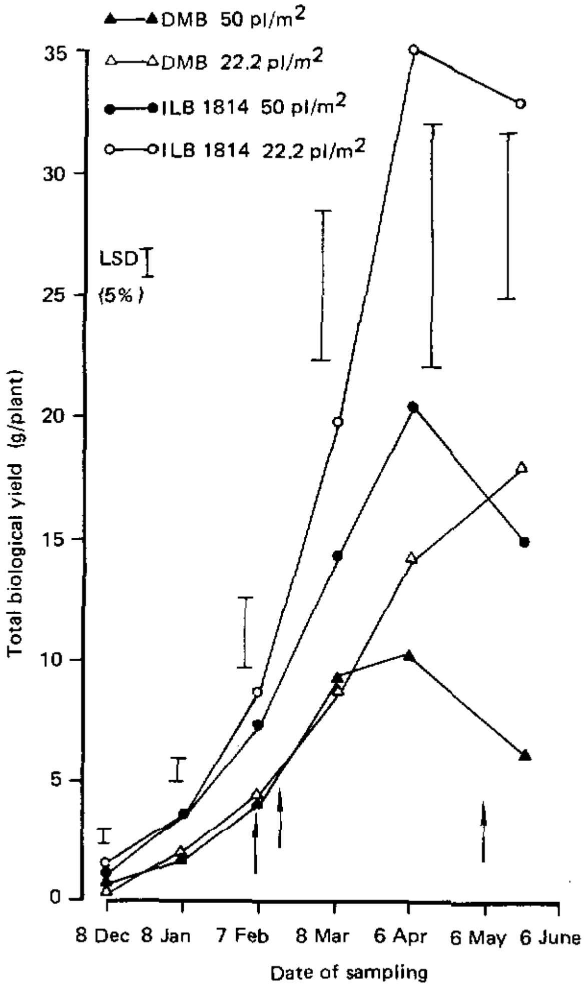


Fig. 13. Total biological yield (g/plant) of ILB 1814 and DHB sown at 22.2 and 50 plants/m² at Tel Hadya, 1983/84.

Water-Use Efficiency in Faba Beans for Low-Rainfall Environments

In very low-rainfall environments, the growth of faba bean is poor. The canopy cover is generally inadequate, permitting evaporative losses of soil moisture. At a given plant population, reducing row spacing by increasing the spacing within rows might result in complete canopy cover early in the season, which would reduce evaporative loss from bare ground and permit greater light interception, and thus increase productivity and water-use efficiency. In 1983/84, a trial was initiated to investigate the yield performance and water-use efficiency of some faba bean genotypes known to do well under low rainfall, grown at two populations (22 and 44 plants/m²) and two row spacings (22.5 and 45 cm). Soil moisture was determined for all treatment combinations for Syrian Local Large (check genotype) and in one treatment combination (22

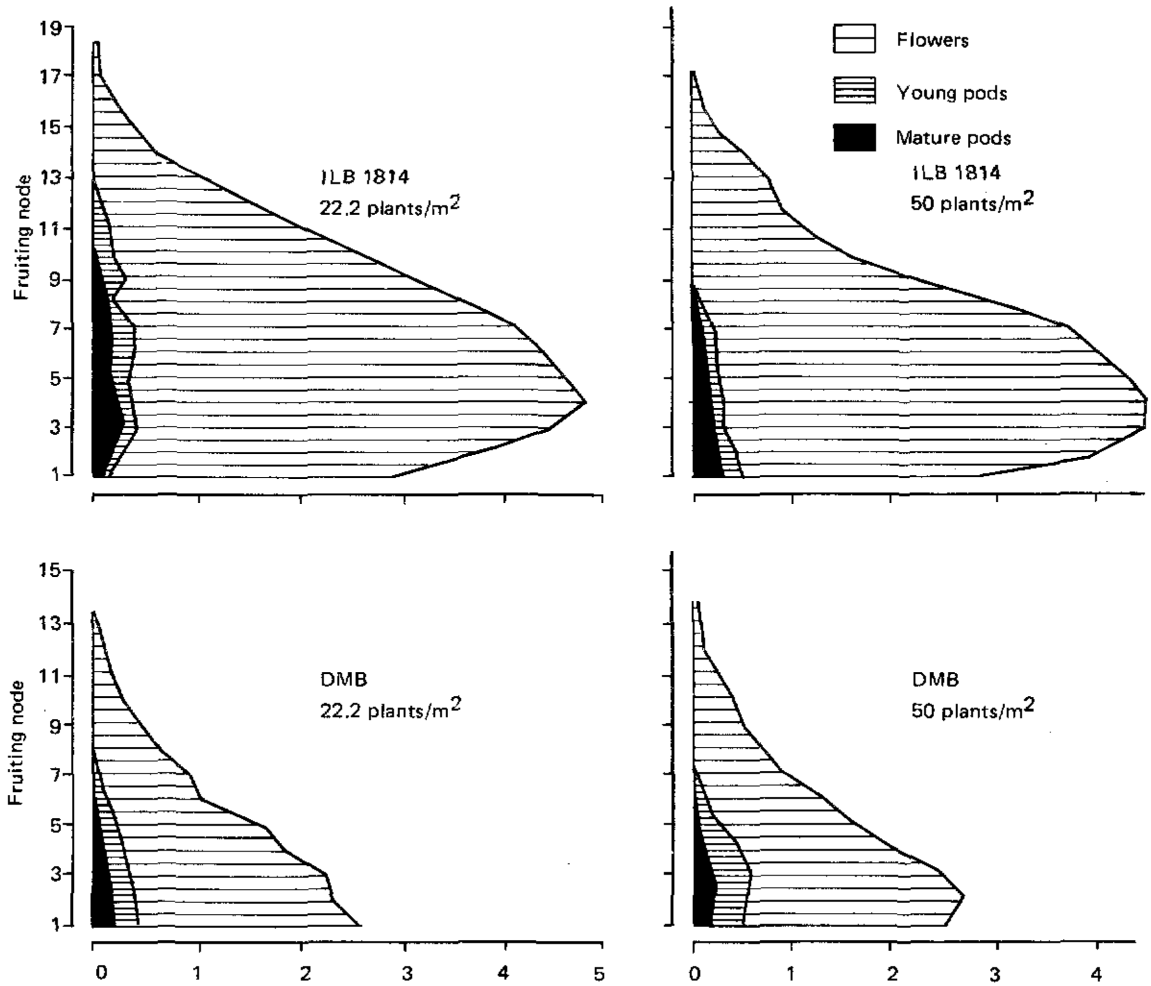


Fig. 14. Mean number of flowers, young pods, and mature pods per node per stem in ILB 1814 and DMB at 22.2 and 50 plants/m², Tel Hadya, 1983/84.

plants/m² in 45 cm row spacing) of the other seven test genotypes, using a neutron probe. The early root growth of these genotypes was also studied separately in pot-culture in the plastic house.

Because the season was very dry (230 mm, with unsatisfactory distribution), the growth and yield were extremely poor and the main effects were nonsignificant. Genotype x plant population, genotype x row spacing, and the second-order interaction were significant but with little logical trend (Table 22). Data on evapotranspiration and water-use efficiency are presented in Table 23. Lines 80S 44358 and 80S 44367 were more efficient in their water use than the other genotypes including ILB 1814. Narrow row spacing resulted in greater water-use efficiency at both population levels in ILB 1814.

Changes in the soil moisture profile for ILB

Table 22. Seed yield (kg/ha) of ILB 1814 and seven other genotypes (identified for rainfed conditions) at 22 and 44 plants/m² and 22.5 and 45.0 cm row spacing, Tel Hadya 1983/84.

	Seed yield kg/ha			
	45.0 cm row spacing		22.0 cm row spacing	
Genotype	22 pl/m²	44 pl/m²	22 pl/m²	44 pl/m²
80S 64214	476	633	499	490
80S 43856	462	490	490	596
80S 44358	666	369	499	481
80S 45057	513	365	666	536
80S 44815	504	550	638	420
80S 44367	656	462	425	434
80L 90121	434	564	518	555
ILB 1814	494	485	559	569
Mean x Population	526	490	537	510
CV(%) = 19.6				

	F values	LSD (5%)
Genotype G	NS	R in G 100
Row spacing R	NS	
G × R	S	G in R 100
Population P	NS	
P × G	S	P in G 100
P × R	NS	G in P 100
P × G × R	S	

Table 23. Seed yield, evapotranspiration (E_T), and water-use efficiency of ILB 1814 at 22 and 44 plants/m² and at 22.5 and 45.0 cm row spacing and for seven other genotypes at 22 plants/m² and 45.0 cm row spacing at Tel *Hadya under rainfed conditions (230 mm), 1983/84.*

Genotype	Population and row spacing combination[1]	Seed yield (kg/ha)	E_T (mm)	Water-use efficiency (kg/ha/mm E_T)
80S 64214	$P_1 R_2$	476	150.2	3.17
80S 43856	$P_1 R_2$	462	157.8	2.93
80S 44358	$P_1 R_2$	666	163.7	4.07
80S 45057	$P_1 R_2$	513	161.5	3.18
80S 44815	$P_1 R_2$	504	152.6	3.30
80S 44367	$P_1 R_2$	656	155.4	4.22
80L 90121	$P_1 R_2$	434	158.0	2.75
ILB 1814	$P_1 R_2$	494	160.1	3.09
ILB 1814	$P_1 R_1$	559	165.3	3.38
ILB 1814	$P_2 R_2$	485	161.6	3.00
ILB 1814	$P_2 R_1$	569	162.4	3.50
Mean			159.0	

1. R_1 and R_2 = 22.5 and 45.0 cm row spacing; P_1 and P_2 = 22 and 44 plants/m².

1814 for different treatment combinations are shown in Fig. 15. At low population and wider row spacing (22 plants/m² and 45 cm spacing), ILB 1814 extracted moisture from deeper layers. At the increased population, extraction was more from top layers. Visual observations revealed that plots with higher population showed signs of moisture stress earlier than those with lower population and perhaps the increased interplant competition for water early in the season affected the growth so adversely that plants could not extract moisture from deeper layers.

Response to Plant Population and Row Spacing

Response of local faba bean landraces to three plant populations (30, 45, and 60 plants/m²) and four row spacings (30, 40, 50, and 60 cm) was studied with assured moisture supply at Terbol and Tel Hadya, and with limited moisture supply (rainfed, 230 mm) at Tel Hadya. With assured moisture supply, there was no significant effect of increasing plant population, although the light interception showed a considerable increase (Fig. 16). This reflects the growth plasticity of the faba bean landraces used. There was a positive response to reducing row spacing from 60 to 30 cm at both sites, reflecting an advantage from less rectangular planting geometry, particularly at high population levels.

In the rainfed environment at Tel Hadya, with prolonged drought in mid-season and a total seasonal precipitation of only 230 mm, the crop showed severe moisture stress, particularly at high plant populations. The overall yield in this trial which was sown on 4 November was only 261 kg/ha as against about 600 kg/ha obtained with the same genotype in an adjoining experiment sown on 1 December 1983. The early

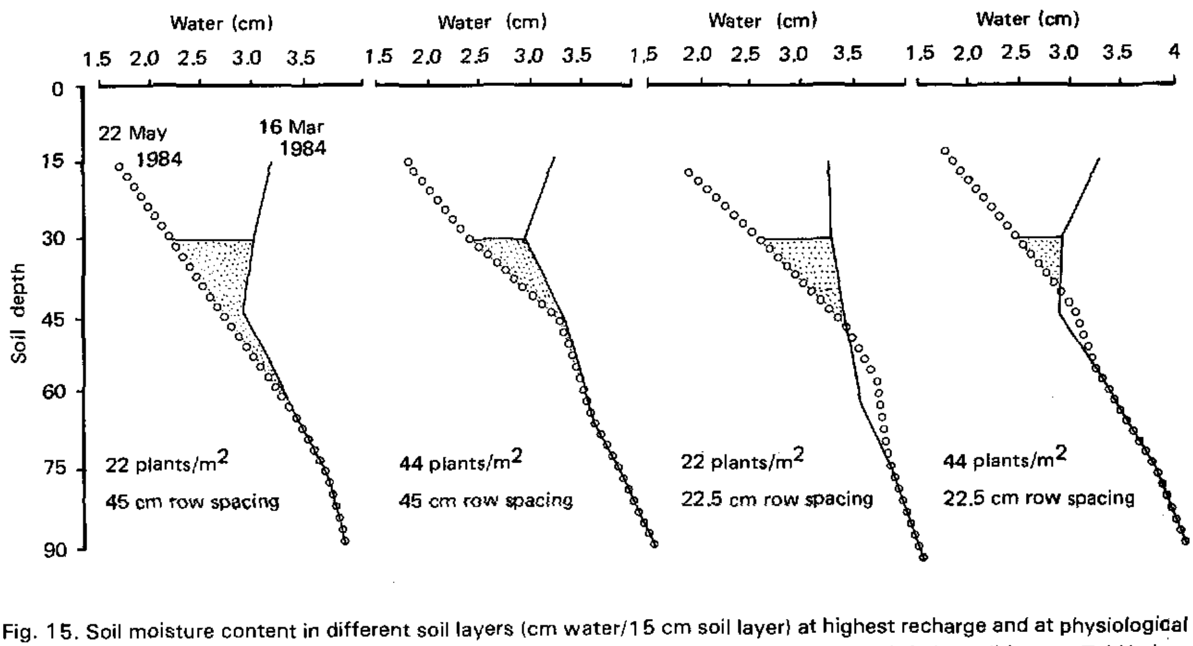


Fig. 15. Soil moisture content in different soil layers (cm water/15 cm soil layer) at highest recharge and at physiological maturity of ILB 1814 at 22 and 44 plants/m² and 45 and 22.5 cm row spacing under rainfed conditions at Tel Hadya, 1984.

Light interception of faba bean canopy being measured to evaluate the effect of plant density on productivity.

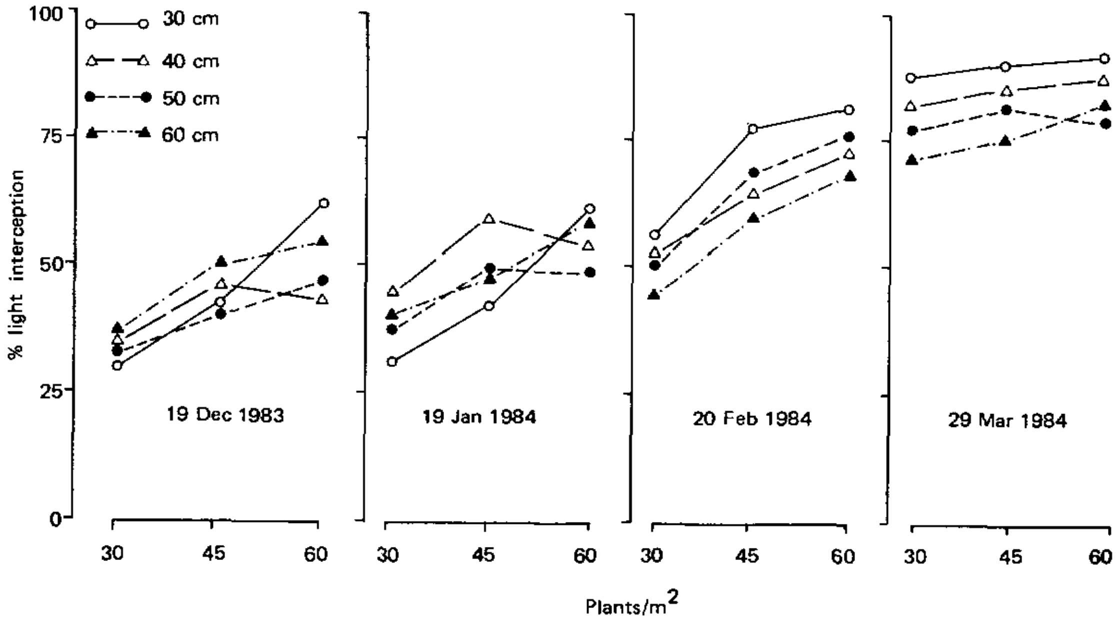


Fig. 16. Percentage of light interception in irrigated ILB 1814 faba bean at different stages of growth in four row spacings and four plant population levels, Tel Hadya, 1983/84.

onset of rain and warm weather early in the season encouraged the vegetative growth of the crop in November-sown experiments, which probably exhausted the limited moisture supply well before the major reproductive growth and thus resulted in poorer seed yield.

Management Practices

The performance of an irrigated crop of ILB 1814 faba bean was examined at Tel Hadya in a factorial trial with two levels of four different management practices: plant population (22 and 44 plants/m²), phosphate fertilizer, aldicarb (Temik) to control nematodes, and glyphosate (Lancer) to control *Orobanche crenata*. The field was low in available phosphorus (Oslen's extractable P<2 ppm) and was infested with root lesion nematode (*Pratylenchus thornei*) and *Orobanche crenata*. The results are shown in Fig. 17. Seed yield was not significantly affected when any of the management treatments was applied at improved level singly. Application of 10 kg a.i./ha of aldicarb along with 50 kg P_2O_5/ha significantly increased seed yield by 1239 kg/ha over the low-input check, making the treatment economically viable. The combination of glyphosate (0.08 kg a.i./ha, three times, starting at 10% flowering and repeated at 15-day intervals), aldicarb, and phosphate fertilization gave the largest increase in seed yield of 1897 kg/ha over the low-input check.

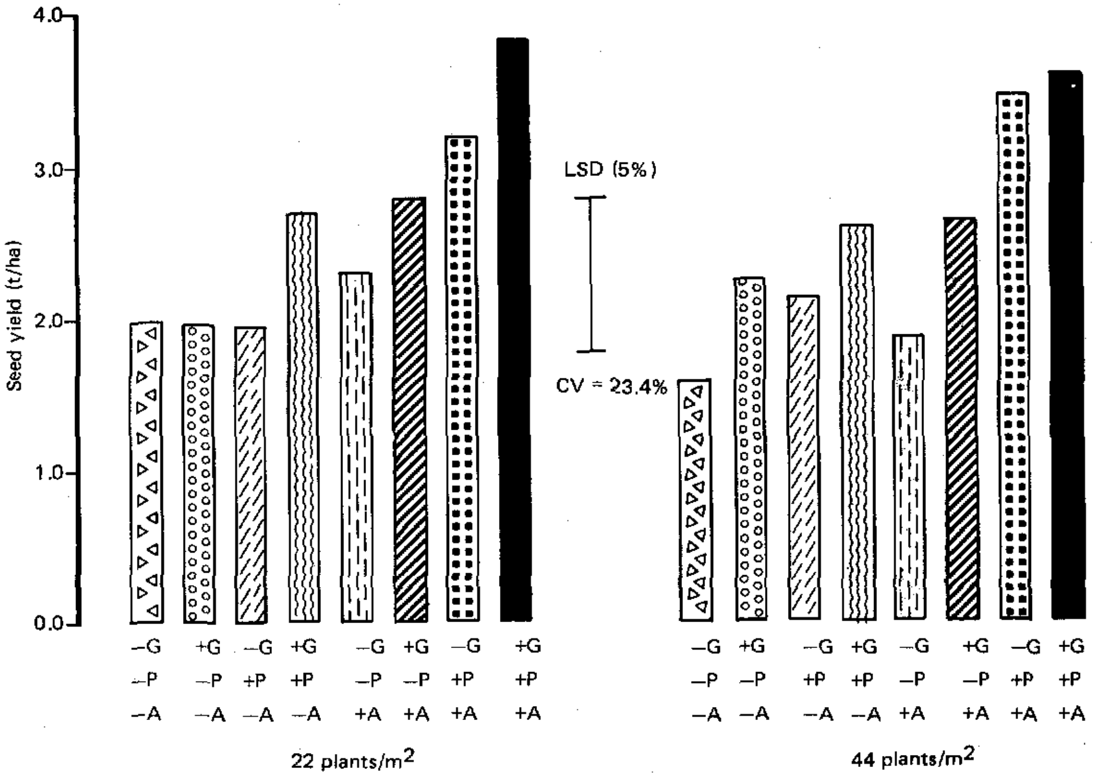


Fig. 17. Effect of four management practices (plant population, aldicarb application, glyphosate application, and phosphate fertilization) at two levels on the seed yield of irrigated ILB 1814 faba bean.

This trial clearly shows the importance of combining improved management factors in realizing the high yield potential inherent in faba beans. — *M.C. Saxena and M.V. Murinda.*

Lentil Improvement

The emphasis of lentil improvement work at ICARDA continued on development of cultivars and genetic stocks with appropriate phenology and high and stable yields for each of the three major agroecological regions of lentil production. Information on the agroecological regions and their specific needs was given in the 1983 ICARDA Annual Report.

Germplasm

Lentil Germplasm Catalog

A lentil germplasm catalog has been produced with passport data on 5420 accessions and evaluation data for 19 characters on 4550 accessions. The "query" facility on the computerized germplasm data base is particularly useful in deciding on accessions for distribution. For example, a request for large-seeded, non-native lentil germplasm accessions was received from Iran. The "query" facility provided a list of the requisite large-seeded, non-Iranian accessions for despatch. A total of 1455 accessions were distributed to 12 countries during the 1983/84 season (Table 24).

Table 24. Number of lentil accessions distributed in the 1983/1984 season together with their country of destination.

Country	Number of accessions
Bangladesh	200
China	77
Egypt	2
Ethiopia	173
France	31
Iran	100
Italy	100
Netherlands	9
Pakistan	17
Sudan	500
Turkey	210
UK	36

Variation Between and Within Lentil Landraces

The lentil germplasm collection at ICARDA comprises some accessions which are landraces collected from farmers' fields, and others which are pure lines contributed by plant breeders. Each landrace accession of the autogamous lentil may be expected to contain genetic variation. This variation may necessitate different handling in the germplasm collection from pure-line accessions. But estimates of the variation between and within landraces are not available. Accordingly, the variation between and within 31 lentil landraces collected in the Yemen Arab Republic by the International Board for Plant Genetic Resources was studied. Twenty single plants were selected at random from each landrace, and multiplied individually. The progenies were grown at Tel Hadya in a replicated trial. Characters with a known high heritability were measured.

The presence or absence of seedling pigmentation was scored, and the frequency of pigmented morphs varied across landraces from 0.33 to 0.98. For plant height, the variance between accessions was three times the variance within accessions. The mean plant height for landraces varied from 21.2 to 24.0 cm. For time to flower, the ratio of between-landrace and within-landrace variances was 48.8, emphasizing the greater variability between different landrace collections. There was a range of 94.4 - 104.7 days between the landraces in time to flower. The results show the overriding importance of the variation between landraces and the individuality of separate collections.

These results indicate that landrace collections should not be subdivided into different germplasm accessions and that collection from many different locations, rather than extensive sampling within an individual location, will be appropriate for lentil germplasm exploration.

Development of Lentil Cultivars and Genetic Stocks

Development of Genetic Stocks

A total of 356 crosses were made in the 1983/84 season. The objective of the recombinations and their targert regions are shown in Table 25. Amongst the crosses aimed at the

Table 25. Lentil crossing program in 1984, showing target regions, aims of recombinations, and number of crosses made.

Region	Aims of recombination	No. of cross combinations
High plateau	Cold tolerance × high yield (Turkey)	20
	Subtotal	20
Mediterranean (Low elevation)	High yield (large seeds) × high yield (large seeds)	77
	High yield (small seeds) × high yield (small seeds)	65
	High yield (North Africa) × high yield and attributes for mechanical harvest	16
	High yield (North Africa) × high yield (North Africa)	8
	High yield (large seeds) × attributes for mechanical harvest	10
	Mechanical harvest × high yield	24
	Drought avoidance: early and high yield × high yield (small seeds)	12
	Subtotal	212
Southern latitudes	High yield (Ethiopia) × disease resistance (India)	16
	High yield (India) × early and high yield (elsewhere in S. zone)	34
	Irrigated conditions: high yield (Egypt) × high yield (Sudan)	16
	Subtotal	66
	Crosses for Jordan National Program	20
	Crosses for Chile National Program	17
	Adaptation diallel	15
	Cultivars × *L. orientalis*	6
	Grand total	356

three major agroecological zones of lentil production, 7% were for the high-plateau region, 22% for the southern latitudes, and 71% for the Mediterranean, low-elevation region.

In regional yield trials conducted in Jordan and Syria, one of the highest yielding entries was a *selection from a cross with one parent of Lens orientalis.* In view of the apparent value of crosses with wild species, six more cross-combinations with *L. orientalis* were made during the 1983/84 season. *L. orientalis* was used as the male parent. Expressing the success in crossing as the percentage of crossed seeds collected per pollination, the wild x cultivated crosses resulted in 23% success. The corresponding success in the cultivated x cultivated crosses was greater at 32%, illustrating the lower crossability of *L. orientalis* with the cultivated lentil. The wild x cultivated crosses will be handled within the main breeding program for yield improvement.

The segregating populations are advanced to the F_4 generation by the bulk breeding method using two generations per year, one at Tel Hadya in winter, and the other at Shawbak in Jordan in summer. An experiment on screening bulk segregating populations for seed size is reported in a later section on breeding methods.

Single-plant selections are made at the F_4 generation on the basis of phenology, growth habit, and seed characters. An experiment on the methodology of single-plant *selection in lentil* was conducted and is reported in the section on breeding methods. The breeding scheme in Fig. 18 shows the flow from progeny rows (1 m long) through unreplicated screening nurseries (1.5 m^2 plot size) sown in an augmented experimental design, and into replicated yield trials (4.5 m^2 plot size) at three locations with contrasting rainfall. The selection intensity at different genera*tions is shown by the acuteness of the triangular* diagram (Fig. 18).

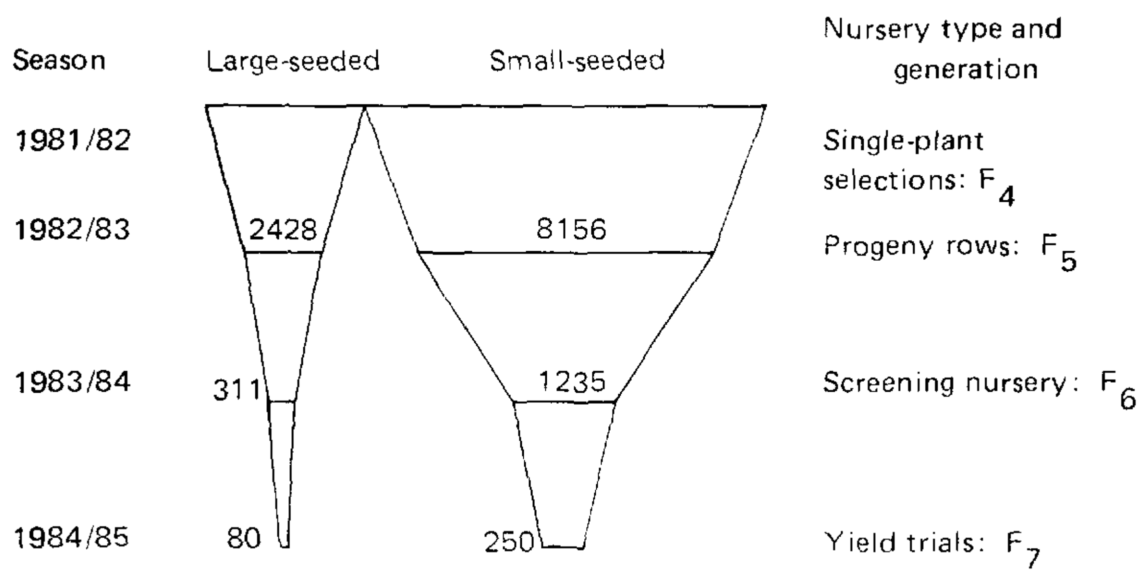


Fig. 18. Diagram of the selection practiced on 11,000 single-plant selections made at the F_4 generation in the 1981/82 season, the F_5 progeny rows (1982/83), the F_6 screening nursery (1983/84), and into yield trials in the 1984/85 season. The number of selections tested are indicated for both large-seeded (>4.5 g/100 seeds) and small-seeded material.

Yield Trials

The lentil yield trials comprise selections made on the basis of yield in the screening nursery (Fig. 18) in the previous year. The yield trials are grown at Tel Hadya and Breda in Syria and at Terbol in Lebanon. These represent three contrasting test environments, differing particularly in precipitation. The annual average rainfall figures are 338, 282, and > 500 mm, respectively.

A total of 187 entries were tested at Tel Hadya, 175 of which were also tested at Breda and Terbol (Table 26). Twenty percent of the entries were large-seeded (> 4.5 g/100 seeds), and the remainder were small-seeded. The very low yields at Breda and meager yields at Tel Hadya (Table 26) reflect the low seasonal rainfall totals of 204 and 230 mm, respectively. By contrast, the rainfall total at Terbol was 596 mm. Nine yield trials were conducted at each location and the plot size was 4.5 m^2. At Tel Hadya four replicates were generally used, whereas at Terbol and Breda only two replications were sown. A pooled analysis of the nine yield trials was done at each site.

At Tel Hadya, Terbol, and Breda the percentages of test entries which ranked higher than the check were 33, 45, and 50, respectively (Table 26). The percentages of the test entries significantly ($P < 0.05$) outyielding the check were 4, 11, and 14, respectively, at the three locations. When the means across locations are considered for the 175 entries repeated across all the sites, then 45% of test entries ranked higher than the check mean.

Phenotypic correlations were calculated between characters in each yield trial. The average correlation was then calculated across trials at each location. At Tel Hadya, plant height and lowest pod height were closely correlated ($r = 0.93$, $P < 0.05$), but both characters were correlated to lodging ($r = 0.66$ and 0.73, $P < 0.05$, respectively). Clearly tall plants are prone to lodging, suggesting that a height adequate for mechanical harvesting, but not of excessive stature, should be sought. The correlation between lodging and yield was positive but not strong ($r = 0.26$), showing that plants heavy with pods did not always lodge. In Terbol grain yield was correlated to straw yield ($r = 0.56$, $P < 0.05$), providing further evidence of the positive association between these two economic characters.

Table 26. Results of local lentil yield trials conducted for large (L) (>4.5 g/100 seeds) and small (S) seeded entries at Tel Hadya and Breda in Syria and at Terbol, Lebanon, 1983/84.

	Tel Hadya		Breda		Terbol	
	L	S	L	S	L	S
No. of test entries[1]	38	149	31	149	27	148
% of entries significantly exceeding check (P≤0.05)	3	4	3	17	0	14
% of entries ranking above check (excluding above)	29	29	32	43	15	37
Check mean yield (kg/ha)[2]	831	1051	71	59	1536	1213
Location mean (kg/ha)	779	957	62	67	1275	1226
SE of an entry mean (±)	122.7	122.7	16.7	16.7	180.6	180.6
CV (%)	32	26	38	35	20	21

1. The same entries were tested at each location.
2. Large-seeded check = ILL 4400 (Syrian Local Large); small-seeded check = ILL 4401 (Syrian Local Small).

Two regional yield trials of lentil, one large-seeded and one small-seeded, were conducted in Syria with the Research Directorate of the Syrian Ministry of Agriculture and Agrarian Reform at five locations. The average seed yield of the large-seeded trials was 465 kg/ha, which was lower than the corresponding mean of 549 kg/ha of the small-seeded trials. This difference was greater than in previous years, and probably resulted from the effect of dry conditions on the later maturing, large-seeded material. In the large-seeded trial, all ICARDA selections yielded more than the two local checks overall. The yield of the best entry, ILL 842, was 106% more than the best check.

On-Farm Trials in Syria

On-farm trials of four ICARDA selections and two local checks were continued for the second season in cooperation with the Research Directorate of the Syrian Ministry of Agriculture and Agrarian Reform. The tested lines comprised one group of three yellow-cotyledon and large-seeded entries (two ICARDA selections and a check), and a second group of small-seeded and red-cotyledon entries (two ICARDA selections and a check). The on-farm trial was conducted in 40 m^2 plots with the entries replicated twice in each location. The ICARDA selections again outyielded the local checks (Table 27). The small-seeded line 78S 26013 yielded an average of 22% more than the smaller seeded check over the two seasons. Similarly, amongst the larger seeded lines, 78S 26002 yielded 25% more than Kurdi 1, the larger seeded check. The trial will be continued for another year.

Use of Genetic Material by National Programs

A number of ICARDA lines have been selected from the international nursery program by national programs. In Ethiopia ILL (NEL) 358 has been submitted to the National Seed Release Committee. On-farm trials are under way in Syria and are being initiated in both Punjab and Baluchistan Provinces in Pakistan, and Yemen Arab Republic. Material from lentil international trials is in national yield trials in Argentina, India, Jordan, Morocco, Sudan, and Tunisia (Table 28). — *W. Erskine.*

Table 27. Mean lentil seed yields (kg/ha) from on-farm trials in Syria, 1982/83 and 1983/84.

Selection	Mean of 6 sites 1982/83	Mean of 7 sites 1983/84	Overall mean	Rank
Yellow cotyledon, large seeds				
78S 26002	1110	1058	1084	1
78S 26004	1146	965	1056	2
Kurdi 1 (check)	922	737	865	3
Red cotyledon, small seeds				
78S 26013	1054	990	1022	1
76TA 66088	877	1076	977	2
Haurani 1 (check)	823	855	839	3
SE ±	73.3	60.1		

Table 28. ICARDA selections used/proposed to be used in either multilocation testing or on-farm trials by national programs in 1984 and 1985.

Country	Identifier
Argentina	74TA 19, ILL 707, ILL 4400, 76TA 66136
Ethiopia	ILL 358
India	ILL 4605
Jordan	ILL 4400, 78S 26002, 78S 26013
Morocco	74TA 19
Pakistan	ILL 784, ILL 2022, ILL 2580-2, ILL 4236, ILL 4403, ILL 4605
Sudan	ILL 813
Syria	78S 26002, 78S 26004, 78S 26013, 76TA 66088
Tunisia	74TA 19, ILL 4354, ILL 4400
Yemen Arab Republic	78S 26004, ILL 1939, FLIP 84-62L

Cold Tolerance

The ability to survive cold winter conditions is important for winter sowing of lentils above 1000 m elevation in areas such as the Anatolian plateau of Turkey, and parts of Afghanistan and Iran.

Selection for cold tolerance has continued at Leonessa, Italy (925 m elevation) for a second winter season in cooperation with the University of Perugia. During the 1982/83 season the average minimum temperatures during January, February, and March were -0.8, -3.4, and -1.3 °C, respectively, at Leonessa, with an absolute minimum air temperature of -9.3 °C. Forty-six germplasm accessions, previously found to be cold tolerant in Turkey, were sown in October 1982, and single-plant selections from five promising accessions were made and resown in the following year in progeny rows: ILL 39 (Syria), ILL 45 (Syria), ILL 669 (Turkey), ILL 1827 (Chile), and ILL 1878 (Turkey). These selections will be used in the crossing block as sources of cold tolerance. In the forthcoming season further screening for cold tolerance will be undertaken at Haymana, Turkey, in cooperation with the Turkish national program. — *W. Erskine and F. Bonciarelli (Univ. of Perugia, Italy).*

Development of Drought Tolerance in Lentils

The search continued for drought-avoiding genotypes which mature early enough to escape severe drought and temperature stress during the reproductive period of growth. In 1983/84 the rainfall received in Syria was below average (230 mm as against long-term average of 338 mm). Consequently, drought stress was apparent at most Syrian test locations. The importance of drought avoidance through early maturity was confirmed in a regional yield trial (large-seeded), grown at five sites in Syria, by the phenotypic correlation of r = -0.63 between mean time to maturity and mean seed yield. The corresponding correlation between time to flower and seed yield was r = -0.57.

Within the breeding program early-maturing material is being generated with the additional advantage of a growth habit suited to a mechanized harvest (Table 29). The progeny matured 3 weeks before the Syrian Local Large

Table 29. Results from the lentil screening nursery at Tel Hadya during the 1983/84 season.

Entry	Time to flower (days)	Time to maturity (days)	Plant height (cm)	Seed yield (g/m²)
Syrian local (ILL 4400)	130	174	26	107
Precoz (ILL 4605)	105	152	29	113
83S 50066 (Precoz × Laird)	102	152	38	187

(ILL 4400) and was also taller. These data are from an unreplicated trial with a plot size of 2.25 m^2 and, thus, must be regarded as preliminary. As mentioned in the earlier section, the yield trials of the mainstream breeding program are now being grown at three sites, with one of these locations (Breda) in a dry area with a long-term average rainfall of only 282 mm. — *W. Erskine.*

Resistance to Ascochyta Blight

Ascochyta blight (*Ascochyta lentis*) on lentils is a widespread foliar disease of particular importance in parts of the Indian subcontinent. Research on the disease was initiated at Tel Hadya during the 1983/84 season. The 76 genotypes in the lentil breeding crossing block were planted in the plastic house in plots and inoculation with a spore suspension of *A. lentis* propagated in the laboratory. A preliminary rating scale (1-9) of disease severity on lentil seedlings was developed using the percentage of leaf blight, stem lesion size, and the extent of sporulation, to assess the disease reaction of the lentil genotypes. Tolerant and resistant lines were then sown in pots in a growth chamber and inoculated with *A. lentis* to verify our earlier results. Eight lines were confirmed as tolerant or resistant sources to ascochyta blight: ILL 857, 4605, 5244, 5562, 5582, 5588, 5590, and 5593. — *W. Erskine and M. V. Reddy.*

Screening for ascochyta blight resistance in lentil has revealed considerable genotypic differences.

Resistance to *Orobanche crenata*

Screening lentil genotypes for resistance to *Orobanche crenata* was continued during the 1983/84 season, when 176 genotypes were rescreened in the field at Tel Hadya. Of these, 11 genotypes were found to have significantly ($P < 0.05$) lower infestation than the local large-seeded check (ILL 4400). These were ILL 2714, 2843, 2874, 2958, 3115, 3153, 3213, 3282, 3366, 3601, and 3611. Line ILL 3366 had the lowest level of infestation. — *W. Erskine and S. Kukula.*

Breeding Methodology Studies

Methodology of Single-Plant Selection

The recommended crop density for lentil production is around 200 plants/m² in West Asia. However, the tendrilous habit of the crop, together with the high seed rate, makes single-plant selection for yield difficult in bulk segregating populations. An experiment was conducted to measure the response to (1) visual single-plant selection for yield, and (2) random selection at three different levels of plant population: 67, 133, and 200 plants/m². Fifteen single plants at the F_5 generation from each of two bulk segregating populations were selected from the six selection environments in 1980, each with a selection intensity of less than 1%. The selected plants from both crosses were increased in the following year. Thereafter they were grown in both 1982 and 1983 at Tel Hadya in two replications with 4-m-long rows.

The mean yield of the plants individually selected for yield was the same as the mean yield of the randomly selected plants. There were no significant differences in mean yield of the plants selected at different levels of plant population. The implications are that visual single-plant selection for yield is ineffective, and that single-plant selection in lentils should be carried out on the basis of more heritable characters such as growth habit, phenology, and seed characters. The level of plant population in the selection environment had no effect on selection response, and it is easier to assess plants individually for these characters at a low population of 67 or 133 plants/m² rather than at the higher population of 200 plants/m². Thus, a plant population level below that for crop production may be recommended for bulk segregating populations of lentil wherein single-plant selection is intended. — *W. Erskine and J. Issawy (Univ. of Aleppo).*

Screening for Seed Size in Bulk Populations

With the bulk breeding method in use at ICARDA, there is a risk that, in crosses between parents differing in seed size, larger seeded segregants may be eliminated from the bulk segregating populations because of their lower seed number per unit weight. When large-seeded selections are needed from these crosses it is necessary to guard against their loss by some means. Accordingly, the effects of screening for seed size with a 4 mm sieve on 27 F_2 generation, bulk-harvested, segregating populations from crosses between parents differing in seed size were measured in the F_3 and F_4 generations. In the F_3 generation the mean 100-seed weight of the large seed size fractions was 4.34 g, in contrast to the weight of 3.57 g for the smaller sized fractions, giving an average difference of 0.77 g. The difference was 0.92 g in the following generation. A detailed analysis, by sieving, of the F_3 seed size distribution for two crosses is shown in Fig. 19, illustrating the effect of sieving. Despite the marked effect of sieving, there are small seeds in the large seed size fraction and also large seeds in the smaller seed size fraction, partly because of segregation for seed size. The effects of sieving on other morphological characters were also investigated. There was a

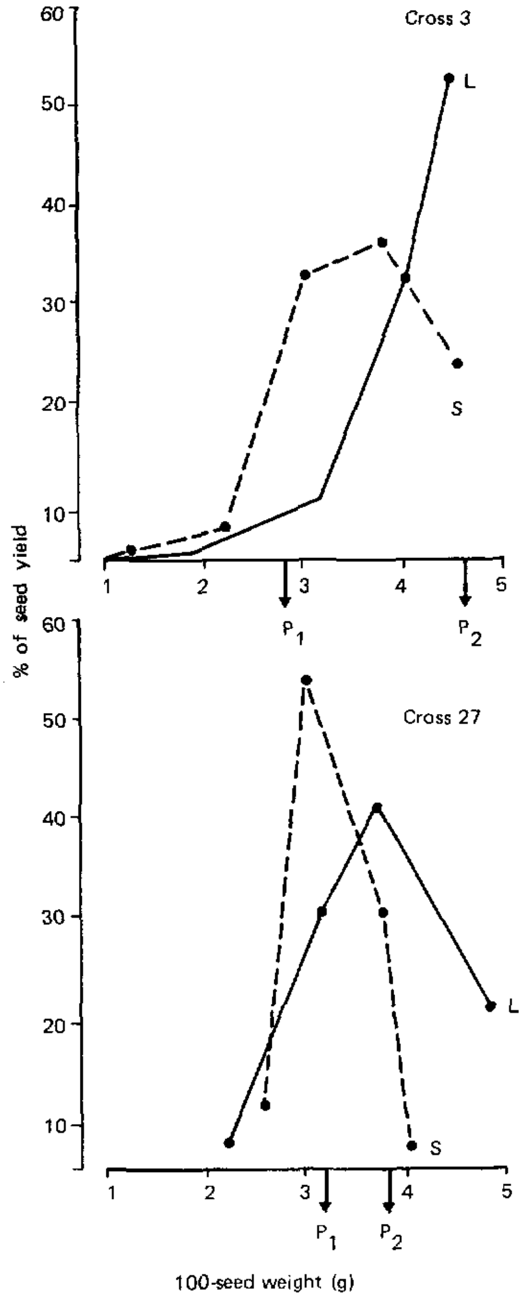


Fig. 19. The 100-seed weight (g) of fractions, formed by sieving, of the F_3 bulk seed yield expressed as a percentage in two crosses. The two populations in each cross were established by sieving into large (L) and small (S) fractions at the F_2 generation. The seed weights of the parents (P_1 and P_2) are also indicated.

positive correlation between seed size and plant height as shown by the positive indirect response of plant height to selection for seed size. But no effect of sieving was found on time to flower, the lowest pod height, and the number of seeds per pod.

The experiment established the value of sieving in early generations those bulk segregating populations with parents differing in seed size in order to retain larger seeded segregants. The frequency of larger seeded segregants in such bulks could possibly be further increased by sieving again in subsequent generations. — *W. Erskine and A. Hamdi.*

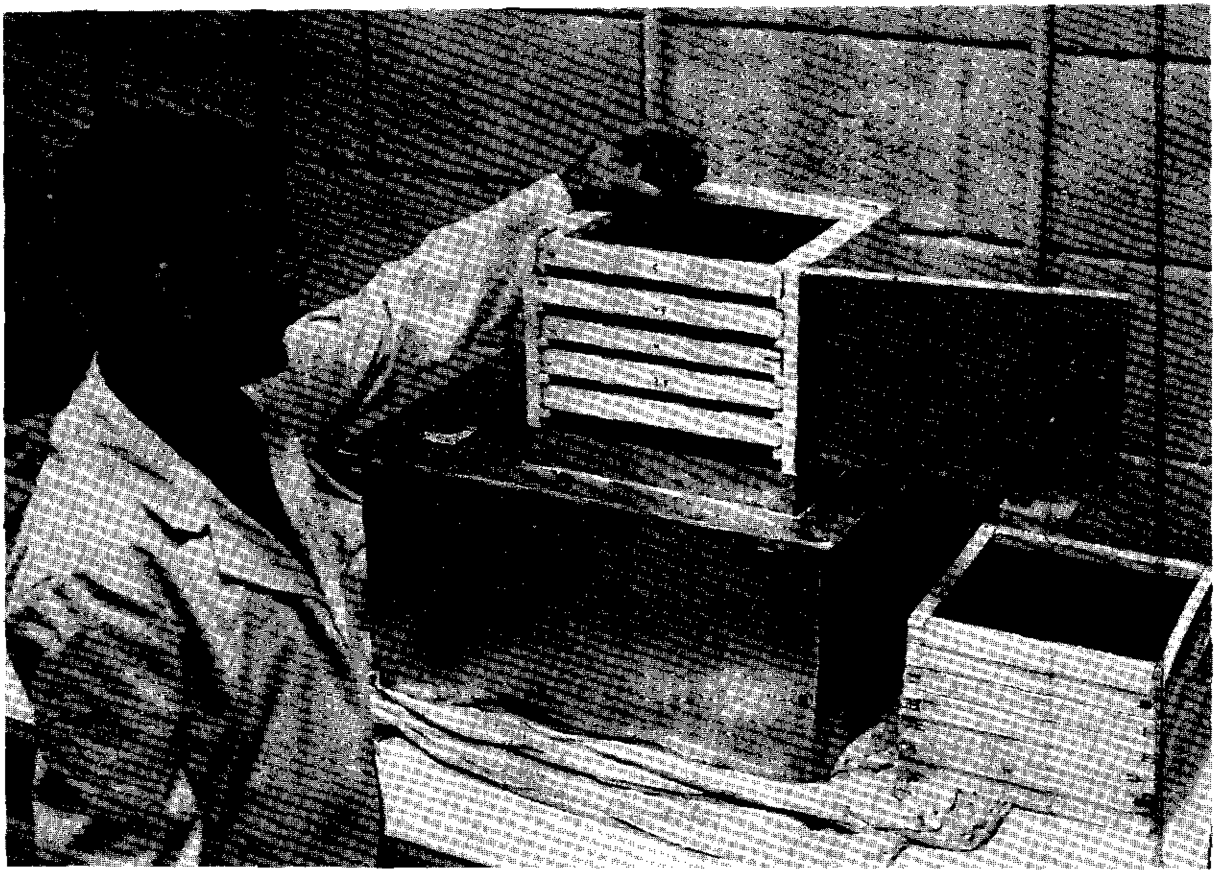
Seed Quality

Seed Size Distribution

Sets of screens were developed, with round holes, for determination of seed size distribution in large- and small-seeded lentil cultivars. Screen sizes were 6.0, 5.0, 4.5, and 4.0 mm for *macrosperma* lentils and 4.5, 3.5, and 3.0 mm for *microsperma* lentils. These will be used for studying the genetic variability in seed size as well as for studying the effect of growing conditions on this trait, which is of great economic importance.

Decortication Studies

A laboratory-scale lentil decorticator was designed and developed for decortication of small-seeded lentils. Using a sample size of 100 g, studies were carried out on the conditions for decortication, including tempering, hydration, and temperature of drying before decortication. Standing time between wetting and drying, the air temperature for drying, and seed size were found to be important variables in determining the recovery of fully-decorticated lentils. Strong



Sets of screens, developed at ICARDA, are used to study the genetic variability in lentil seed size.

genotypic variation was found to affect the relationship between the decortication conditions and recovery. — *P. Williams and W. Erskine.*

Insects and their Control

Studies on the determination of insect control recommendations for different crop growth stages were continued. Most emphasis was placed on the detailed analysis of the economic importance of the *Sitona* spp. complex and on the evaluation of chemical, cultural, and resistance control alternatives for this pest.

Insect Control Recommendations

Based on 1982/83 results, a trial was designed to partition yield losses between *Sitona* spp. and foliar insects. *Sitona* spp. (mainly *S. lineatus* and *S. crinitus*) damaged up to 98% of the root nodules. Among the foliar insects, only the black aphid (*Aphis craccivora*), the green aphid (*Acyrthosiphon pisum*), and thrips were present in significant numbers. Total insect control, through a granular insecticide applied at planting and one foliar spray in mid-flowering, significantly increased yield by 33% (Table 30). Partition of this simple insecticidal regime indicated that

Table 30. Effect of different insecticidal regimes on *Sitona* spp. weevils damage levels,foliar insect-pest populations and yields of Syrian Local Large lentils, Tel Hadya, 1983/84.

Control of		Sitona weevil		Foliar insects/50cm²			Seed yield	
Sitona[1] spp.	Foliar[2] insects	% leaflets damaged	% nodules damaged	Black aphids	Green aphids	Thrips	kg/ha	% increase
Yes	Yes	17.5	4.8	1.1	5.5	2.2	2579	32.6
No	Yes	35.3	87.7	1.0	1.1	2.1	2178	11.9
Yes	No	15.5	3.0	191.9	141.7	66.6	2388	22.8
No	No	41.0	97.7	239.1	132.2	207.5	1945	
SE ±		3.6	4.4	25.1	21.8	18.3	162.4	
CV (%)		25.7	22.3	118.5	89.4	93.6	14.3	

1. With carbofuran, 1.0 kg a.i./ha at planting.
2. One foliar spray with methidathion at 0.5% a.i. by seed weight.

Sitona spp. control significantly increased yield by 23%, whereas the yield response to foliar insect control was only 12%. These results confirm our previous findings that *Sitona* spp. are the key pest in lentils.

Economic Importance of *Sitona* spp.

High levels of *Sitona* spp. infestation (96% nodule damage in check plots) reduced straw and seed yield by 4.0 and 20.6%, respectively. Both heptachlor and carbofuran applied as granules at planting were highly effective and improved yields by 18.0 and 17.4%, respectively (Table 31). More significant increases in seed yield were obtained when larval control was complemented with adult control through foliar sprays. But as in the previous season, sprays against adults had a detrimental effect on straw yields.

Table 31. Efficiency of insecticidal combinations to control *Sitona* spp. weevils in Syrian Local Large lentils and their effect on straw and seed yields, Tel Hadya, 1983/84.

Adult control[1]	Larval control[2]	% efficiency		Yield (kg/ha)		% Seed yield increase
		against adults	against larvae	straw	Seed	
Yes	With heptachlor	63.9	97.1	5849	1724	24.7
No	With heptachlor	30.5	94.4	6136	1631	18.0
Yes	With carbofuran	59.4	99.1	5833	1741	26.0
No	With carbofuran	55.8	98.6	6411	1622	17.4
Yes	No	50.8		5687	1630	17.9
No	No			6135	1382	
SE ± for yields				NS	135.4	
CV (%) for yields				12.9	16.7	

1. Four sprays with methidathion, 0.5 kg a.i./ha.
2. With carbofuran, 1 kg a.i./ha or heptachlor, 2 kg a.i./ha.

Control of *Sitona* spp.

Cheaper, safer, and new alternative insecticides for *Sitona* spp. control were tested. Lower dosages of heptachlor (1.5 and 1.0 kg a.i./ha) were as efficient as the previously tested dosage of 2 kg a.i./ha and significantly increased seed yield by 21.5 and 17.9%, respectively (Table 32). The effect of seed treatment with methiocarb at the rate of 0.5% a.i. by seed weight compared favorably with those of heptachlor at 2 kg a.i./ha and carbofuran at 1 kg a.i./ha, although its residual effect lasted 35 days less. The minimum yield increase requirement for methiocarb was calculated at 12 kg/ha, whereas that for heptachlor and carbofuran was estimated at 290 kg/ha. This suggests that, pending reconfirmation, methiocarb could provide a significantly cheaper alternative control measure.

The effect of three sowing dates on *Sitona* spp. population and damage levels was studied. Protected checks for each sowing date were included. No significant differences among sowing dates were detected in terms of adult damage, percentage leaflets damaged, and number of neonate adults emerged. Plots sown in late November showed slightly less nodule damage (89%) than those sown in early November and mid-December (97 and 96%, respectively). Yield losses ranged from 15% in plots sown in late November to 23% for those sown in early November or late December, but no significant differences ($P < 0.05$) were detected.

The response of 23 widely diverse lentil genotypes to *Sitona* spp. adult attack was studied in detail. The genotypes were rated by a visual damage score, number of notches/plant, and percentage leaflets damaged. At different sample sizes some significant differences were detected using the visual damage score but none with the more precise, quantitative estimates of damage (notches and percent leaflets damaged). When a final count of nodule damage was taken, all genotypes were found equally susceptible. These results confirm that resistance to *Sitona* spp. does not have as a major scope as a control alternative. — *C. Cardona.*

Table 32. Effect of chemical treatments on *Sitona* spp. weevils damage levels and populations and the seed yield of Syrian Local Large lentils, Tel Hadya, 1983/84.

Treatment	% leaflets damaged 48 DAA[1]	Eggs/ 300 cc of soil[2]	% nodules damaged		Neonate adults/ 1500 cc soil	Seed yield	
			107 DAA	134 DAA		kg/ha	% increase
Heptachlor 2.0 kg a.i./ha	31.6	52.6	0	1.6	9.2	1680	28.4
Heptachlor 1.5 kg a.i./ha	38.5	35.1	1.9	6.5	16.0	1589	21.5
Heptachlor 1.0 kg a.i./ha	33.1	36.0	1.6	5.4	18.2	1542	17.9
Carbofuran 1.0 kg a.i./ha	20.3	39.0	0.1	1.5	2.0	1720	31.5
Methiocarb 0.5%[3]	20.7	49.0	14.4	87.0	93.5	1679	28.4
Methiocarb 1.0%[3]	26.4	57.6	23.5	85.6	97.5	1574	20.3
Check	53.1	82.4	38.0	93.2	177.2	1308	
SE ±	3.0	8.3	1.5	2.8	16.7	87.6	
CV (%)	18.8	33.1	16.9	14.0	56.4	11.0	

1. DAA = days after application.
2. Means of counts taken 48 and 60 DAA.
3. Percentage a.i. by weight as seed dressing.

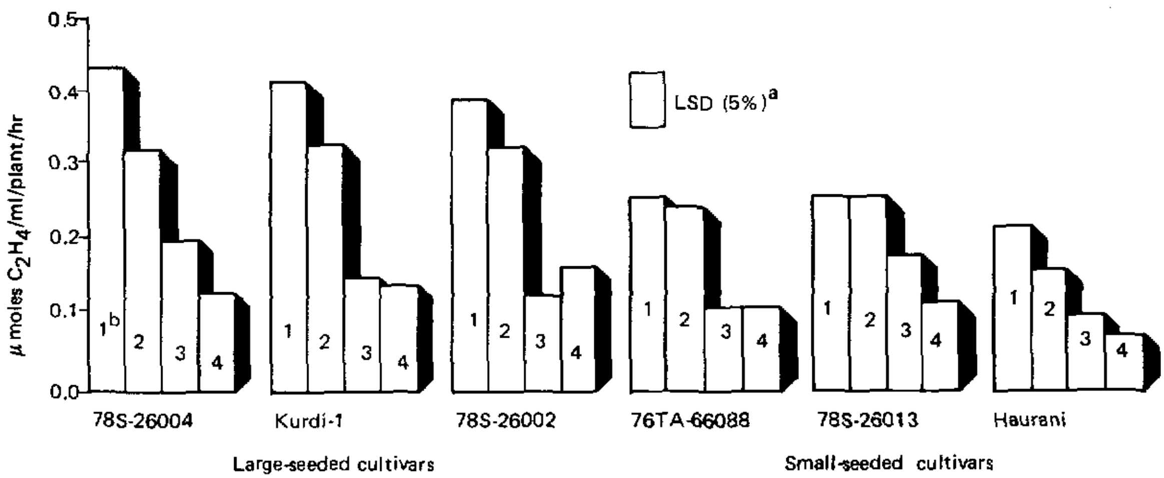
Nitrogenase Activity in Relation to *Sitona* spp. Control

Studies in 1982/83 of the nitrogenase activity of the root systems of the lentil genotypes included in the on-farm trial, as assessed by the acetylene reduction activity (ARA), showed that the large-seeded yellow-cotyledon type cultivars had higher ARA values than the small-seeded red-cotyledon types. It was also observed that a disproportionate amount of plant dry weight was produced after the rapid decline of ARA, suggesting that this accumulation of dry matter occurred without any concurrent input of fixed nitrogen. The 1983/84 trials were designed to clarify these observations on the same cultivars with and without the control of *Sitona* spp. larvae.

Acetylene reduction activity data in Fig. 20 are whole-season means for four treatment combinations (T_1-*Sitona* spp. control; T_2-inoculation with *Rhizobium* spp. + *Sitona* spp. control; T_3-inoculation alone, and T_4-no treatment, check) *for each of the six genotypes.* Large-seeded lentils again had higher ARA than the small-seeded genotypes. *Sitona* spp. larvae control significantly increased the ARA, whereas *Rhizobium* spp. inoculation had no effect.

Fig. 21 illustrates a typical comparison of a high and a low ARA cultivar in terms of ARA, dry-matter accumulation, and plant protein content over an extended period of time. These data *confirm last year's observations that a* considerable proportion of total dry matter is accumulated in both types of cultivar after the start of decline of ARA. The protein content showed large fluctuations over the period of study, with a clear decline on the last sampling date. This decline is understandable in view of the large increase in dry-matter production with little ARA.

These results confirm the genotypic dif*ferences in nitrogenase activity and the impor*tance of control of *Sitona* spp. larvae in maintaining a high level of ARA. — *C. Cardona and J. G. Stephens.*



a. LSD (5%) between any two cultivars and the same treatment or between differing treatments for the same cultivar.

b. 1 = Heptachlor treatment (Sitona larvae control), 2 = Inoculation + heptachlor treatment, 3 = Inoculation only, 4 = Control, no treatment.

Fig. 20. Acetylene reduction activity (C_2H_4 production) whole season means for six lentil cultivars grown under differing *Sitona* spp. weevil larvae control and inoculation treatments, Tel Hadya, 1983/84.

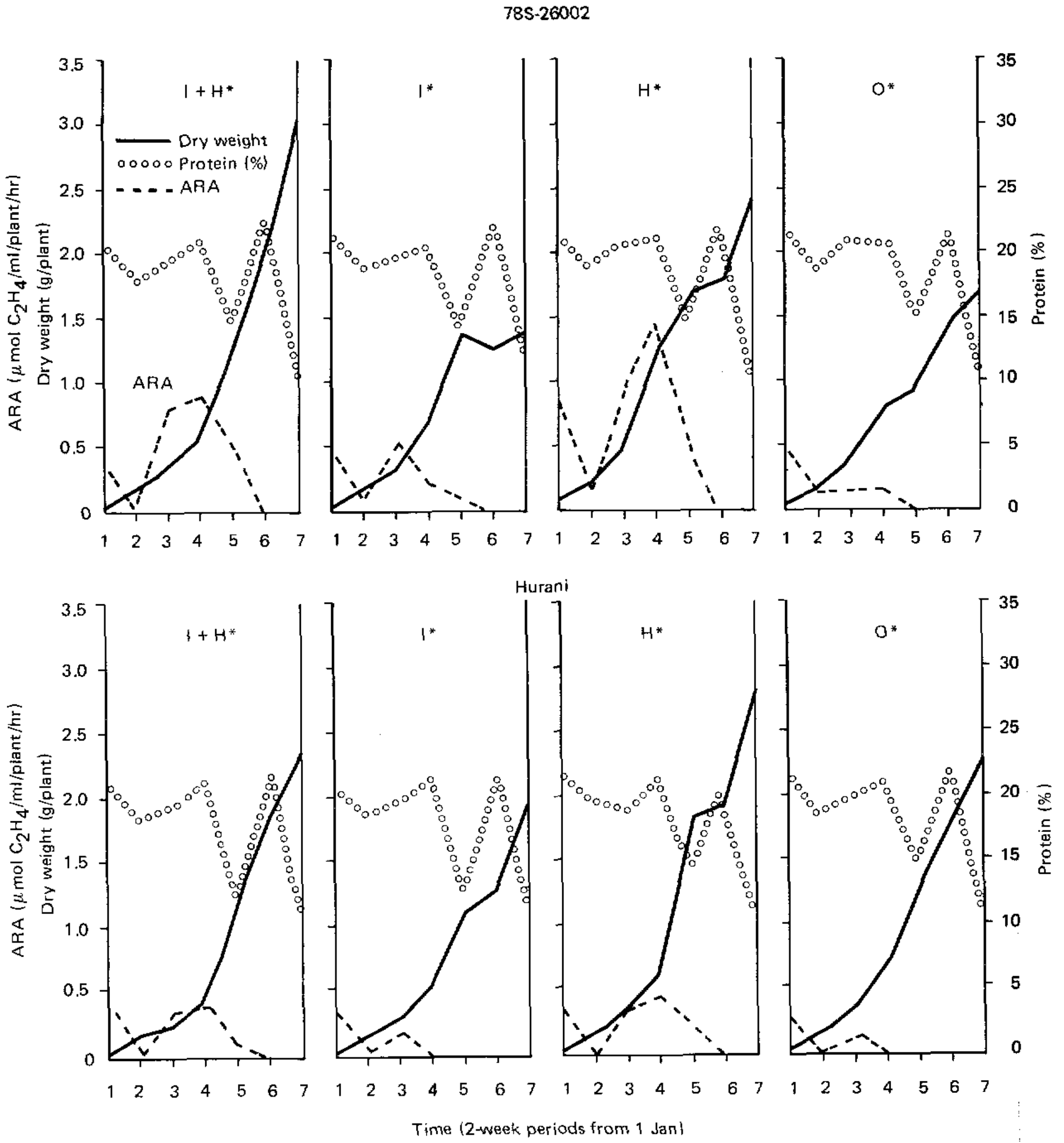


Fig. 21. A comparison of two lentil lines, 78S-26002 and Haurani for dry-matter production, acetylene reduction activity (C_2H_4 production), and percentage whole-plant protein when grown under different inoculation and *Sitona* spp. weevil larvae control conditions, Tel Hadya, 1983/84. Treatment details in Fig. 20.

Weed Control

High levels of weed infestation significantly reduced yields by 39.7 and 42.1% at Izra'a (*Syria*) and Terbol (*Lebanon*), *respectively*, compared with the weed-free treatment. At Tel Hadya, weed infestation was low and yield reduction was about 9% and nonsignificant. In an International Weed Control Trial conducted at Izra'a and Terbol a preemergence application of Tribunil (methabenzthiazuron) at 2.0 kg a.i./ha or Blade x (cyanazine) at 0.5 kg a.i./ha gave very good control of weeds and resulted in yields similar to those obtained by handweeding. At Terbol, where grassy weeds predominated, combination of Bladex with 0.5 kg a.i./ha of Kerb (pronamide) or Maloran (chlorbromuron) at 1.5 kg a.i./ha with Kerb as a preemergence spray proved very effective (Fig. 22). — *S. Kukula and M.C. Saxena.*

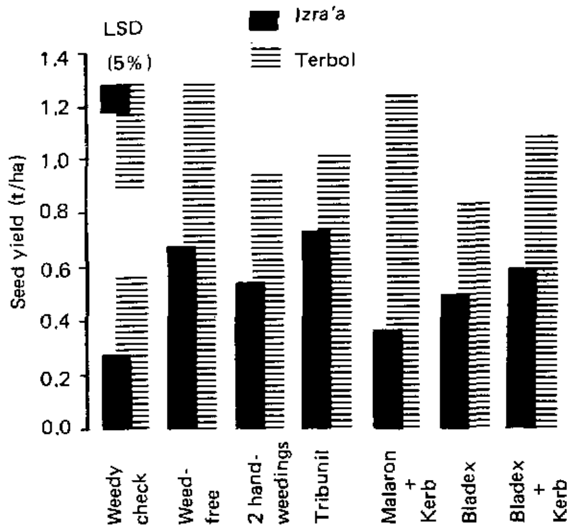


Fig. 22. Effect of some selected weed control treatments on the seed yield of lentils at Izra'a and Terbol, 1983/84.

Crop Physiology and Production Agronomy

Growth and Yield Relationship

Lentils are generally sown in late winter in the low-elevation areas in the ICARDA region. Date-of-sowing studies at ICARDA have shown that total dry-weight production and seed yield can be increased by advancing the sowing date, thus extending the growing season. However, it was also observed that the advantage of early sowing is nullified if the winter is severe and the genotypes are not cold tolerant. A trial was started in 1982/83 to study the relationship between the length of the growing season, early growth, and yield in six high-yielding lentil genotypes developed in the program. The results of *1982/83 revealed that genotypes that had* fast growth in the early stages and were early maturing, such as ILL 8, yielded more.

This study was repeated in 1983/84 using the same six genotypes (ILL 8, 9, 16, 223, 4400, and 4401). Two dates of sowing (10 November 1983 and 12 February 1984) were used to expose the test genotypes to different thermal regimes. The dry-matter accumulation pattern of three contrasting genotypes is shown in Fig. 23. Genotypic differences in early growth were ap*parent in both November and February sowing.* ILL 8 maintained the highest dry weight/plant up to 13 April in the November-sown crop. In the February-sown crop, a similar trend was maintained almost throughout the growing period. The advantage of the extended growth period of the November-sown crop and faster early growth was not reflected in seed yield (Table 33), first because of drought occurring early in the season and secondly because of heavier infestation of *Orobanche crenata* at the start of reproductive growth in the November-sown crop. However, the November-sown crop had higher total dry-matter yield. Perphaps, besides the effect of *orobanche, the winter-sown crop also* experienced greater drought stress during the reproductive phase because of early exhaustion of available moisture by the crop in extended

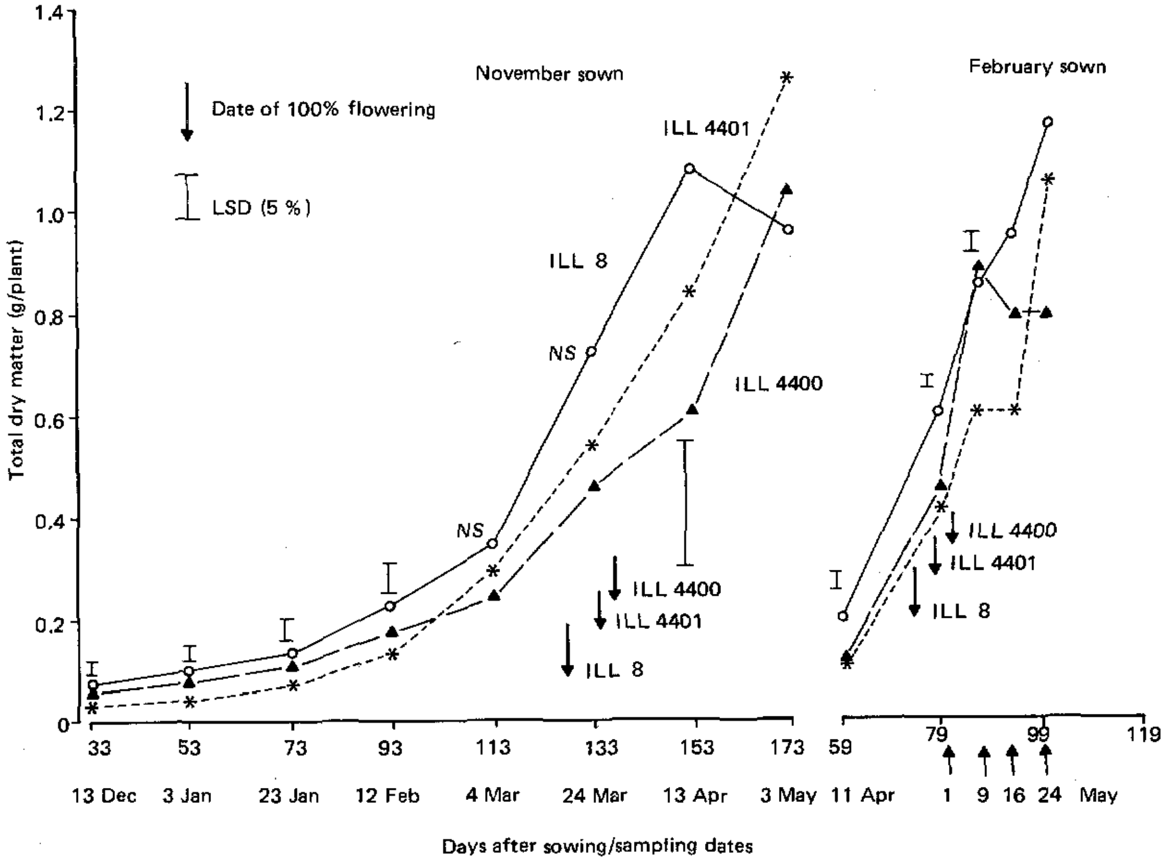


Fig. 23. Total dry-matter production (g/plant) of some promising lentil genotypes sown in November and February at Tel Hadya, 1983/84.

vegetative phase. This is clearly reflected in the lower harvest index of the November-sown crop than in the February-sown crop (Table 33).

The results of this study highlight the significance of seasonal moisture supply and infestation by *Orobanche* sp. in affecting the response of lentils to earlier sowing.

Study of Moisture Use and Drought Tolerance

Response of 12 diverse genotypes to seasonal moisture supply was studied by growing them under rainfed conditions at Tel Hadya (seasonal rainfall 230 mm) and Breda (seasonal rainfall 204 mm) and also with supplemental irrigation (165 mm total in three irrigations between March and May) at Tel Hadya. Intensive soil moisture studies were carried out on nine of these genotypes to determine evapotranspiration and water-use efficiency.

Averaged over all the genotypes, the yield was closely related to total seasonal moisture supply (Table 34). There were significant differences between genotypes under each moisture supply/location treatment. The four genotypes which showed least reduction in total biological

Table 33. Total biological yield (TBY) and seed yield (SY) in kg/ha and harvest index (HI) of different lentil genotypes as affected by sowing date, Tel Hadya, 1983/84.

Genotype (ILL)	Date of sowing: 10 November SY	TBY	HI	12 February SY	TBY	HI
8	274	2742	0.100	814	2631	0.309
9	289	2788	0.103	685	2344	0.292
16	457	3026	0.151	545	2242	0.243
223	317	2841	0.112	369	1603	0.230
4400	441	2282	0.193	358	1633	0.219
4401	537	3145	0.171	409	1858	0.220
Mean	386	2802	0.138	530	2052	0.258

	SY CV (%)	SY LSD (5%)	TBY CV (%)	TBY LSD (5%)
Dates (D)	65.0	NS	49.3	NS
Genotypes (V)	30.6	143	20.3	511
V in D		202		723

Table 34. Effect of total seasonal moisture supply on total biological yield and seed yield of 12 diverse genotypes of lentil in northern Syria, 1983/84.

Genotype	Origin	Seed yield (kg/ha) Breda Rainfed (204 mm)	Seed yield Tel Hadya Rainfed (230 mm)	Seed yield Tel Hadya Irrigated (395 mm)	Total biological yield (kg/ha) Breda Rainfed (204 mm)	Total biological yield Tel Hadya Rainfed (230 mm)	Total biological yield Tel Hadya Irrigated (395 mm)
ILL 8	Jordan	173	547	794	958	2524	3446
ILL 9	Jordan	163	556	703	1029	2451	2846
ILL 16	Jordan	251	590	944	1071	2234	3614
ILL 101	Syria	190	455	802	1054	1901	3024
ILL 223	Iran	148	564	951	788	2155	3291
ILL 470	Syria	213	628	945	842	1974	3313
ILL 793	Egypt	143	396	679	742	1653	2825
ILL 1861	Sudan	232	665	798	904	2387	3297
ILL 4349	USSR	32	303	541	946	1838	2706
ILL 4354	Jordan	187	548	690	971	2304	2770
ILL 4400	Syria	182	487	760	1229	2338	2936
ILL 4401	Syria	213	515	947	833	1957	3542
Mean		177	521	796	947	2143	3138
CV (%)		20.5	24.3		10.1	18.9	
LSD (5%)		52	226		137	705	

yield under rainfed, as compared with assured soil moisture conditions, were ILL 9, 4354, 4400, and ILL 8, yield being reduced by 15.4, 16.8, 20.4, and 26.8%, respectively. The four genotypes whose seed yield was least affected were ILL 1861, 4354, 9, and ILL 8, with yield reductions of 16.7, 20.6, 20.9, and 31.1%, respectively.

There was a significant rank correlation ($r = 0.594$, $P \leq 0.05$) between the performance of the genotypes at Breda and under rainfed conditions at Tel Hadya. This may be attributed to the less-than-average rainfall at Tel Hadya this year. It appears, therefore, that the genotypic evaluation at Tel Hadya under rain-out shelters to reduce moisture supply might give results that would be applicable to other drier areas. There was a significant positive correlation ($r = 0.611$, $P \leq 0.05$) between visual score of tap root growth early in the season in the plastic house and total biological yield for different genotypes. Thus this could serve as another important parameter in selecting genotypes for low-rainfall conditions.

The soil moisture profiles at maximum recharge and at maturity for nine genotypes are shown in Fig. 24. Genotypes ILL 9 and 470 extracted water from deeper layers than other genotypes. ILL 8 and 9 extracted more water than others. ILL 8 and 9 had the highest water-use efficiency in terms of total biological yield, whereas in terms of seed yield ILL 470 ranked first (Table 35).

This study shows that genotypic differences exist in the ability to extract soil moisture, and in susceptibility to reduced moisture supply and that these can be identified by evaluating performance of genotypes at Tel Hadya using rain-out shelters to limit soil moisture supply. — *M.C. Saxena and M.V. Murinda.*

Photothermal Regulation of Flowering

Most lentils originating from northern latitudes tend to flower late because of their greater "long day" requirement. When such types are taken to southern latitudes, where day lengths are relatively short, they tend to perform poorly because of excessively delayed flowering, or in some cases they may even fail to set pods if the season was restricted by excessive rise in temperature. On the other hand, temperatures during the growing season in southern latitudes are higher than in the north. If higher temperatures could hasten flowering in some genotypes they could perform well in southern latitudes. Study of genotypic differences in

Table 35. Total extractable moisture (EM), evapotranspiration (E_T), 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, 1983/84.

Genotype	Date of maturity	EM (mm)	E_T (mm)	WUE TBY	WUE SY
ILL 8	May 6	63.5	191.4	13.19	2.86
ILL 9	May 8	64.1	192.6	12.73	2.89
ILL 16	May 8	59.6	184.4	12.11	3.20
ILL 101	May 12	48.9	178.6	10.64	2.55
ILL 223	May 4	53.2	181.4	11.88	3.11
ILL 470	May 8	59.8	181.1	10.90	3.47
ILL 793	May 15	52.6	174.5	9.47	2.27
ILL 4349	May 15	51.4	180.2	10.20	1.68
ILL 4401	May 8	59.7	186.5	10.49	2.76

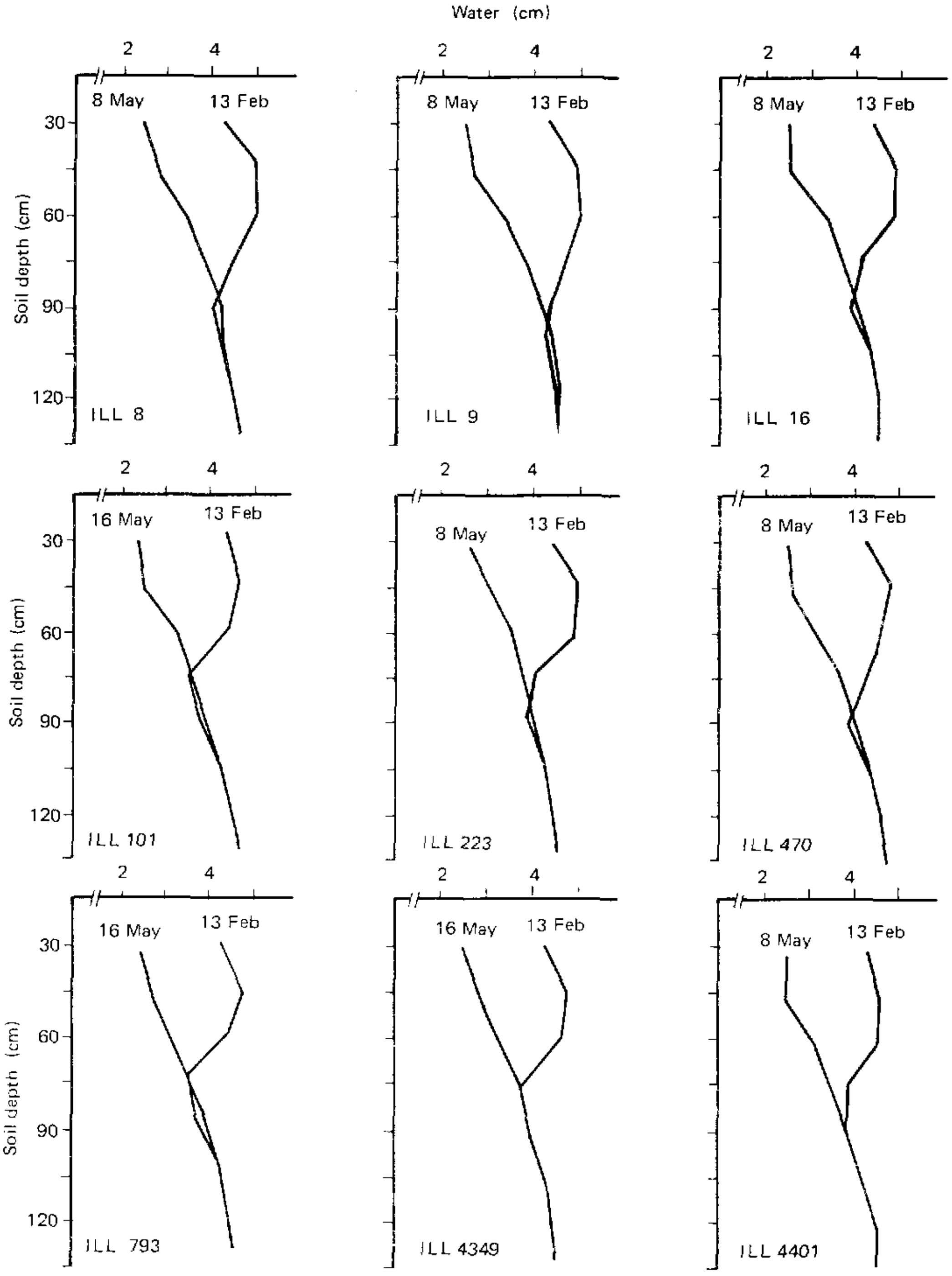


Fig. 24. Soil moisture content in different soil layers (cm water/15 cm soil layer) at the highest recharge and at physiological maturity of some contrasting lentil genotypes under rainfed conditions at Tel Hadya, 1983/84.

response to changes in photothermal conditions is therefore of interest. In 1983/84, 10 genotypes from different geographical regions (Table 36) were grown under two photoperiod conditions: extended day of 16 hr, and normal photoperiod ranging from 9-11 hr. Under each photoperiod there were two thermal regimes: normal ambient conditions (max. temp. 17.1 and min. temp. 5.4°C) and heated plastic house (25.1 and 9.9°C max. and min. temperature, respectively).

Progress to flowering (reciprocal of days to flowering) was increased by longer days and warmer temperature in all the genotypes (Table 36). Genotype ILL 4605 originating from Argentina was the least sensitive to photoperiod both under low and high temperature regimes. ILL 2526 originating from India was also relatively insensitive to changes in the photoperiod under the high temperature regime.

There is a clear trend for the material originating from northern latitudes to respond more to day length, whereas material originating from more southernly latitudes shows greater hastening in flowering due to increase in temperature (Fig. 25). This reflects the adaptation of the genotypes to the environment of their origin. — *M.C. Saxena and M.V. Murinda.*

The Overseas Development Administration, UK, has supported a collaborative project between the Plant Environment Laboratory at the University of Reading and ICARDA which aims to quantify the effects of the photothermal environment on the growth and reproductive ontogeny of lentils. After having established suitable growing media, pot sizes, irrigation solutions and method of application, spectral quality of light, and general plant culture and husbandry techniques, a large factorial investigation, comprising 144 treatment combinations, was conducted. The huge amount of data collected is under analysis, and will be reported in detail later. However, the results have already shown that the time to flower in lentils is modulated by vernalization, photoperiod, and average growing temperature. Further, when data are considered as rates of progress toward flowering, these factors do not interact, and thus rate of progress to flowering could be described as a linear function of the photoperiod and average growing temperature. Such equations for six test genotypes have been developed and a

Table 36. Time taken to flower and rate of progress towards flowering (reciprocal of time taken to flower) in 10 genotypes from a wide range of latitudes grown in pots under two temperature and two day-length regimes, Tel Hadya, 1983/84.

		High temperature				Lower temperature			
		Long day		Short day		Long day		Short day	
Genotype (ILL)	Latitude and country of origin	Days to flower	Rate (x 10³)	Days to flower	Rate (x 10³)	Days to flower	Rate (x 10³)	Days to flower	Rate (x 10³)
8	32° 0′ N Jordan	60.4	16.6	96.4	10.4	85.3	11.7	124.8	8.0
16	32° 2′ N Jordan	58.8	17.0	128.4	7.8	92.8	10.8	128.3	7.8
92	48° 0′ N USSR	78.4	12.8	132.4	7.6	108.1	9.3	147.1	6.8
183	40° 58′ N Turkey	72.3	13.8	134.3	7.4	104.3	9.6	146.6	6.8
223	38° 0′ N Iran	61.8	16.2	121.7	8.2	83.7	11.9	126.5	7.9
857	36° 25′ N Algeria	62.7	15.9	115.0	8.7	94.4	10.6	122.5	8.2
1694	8-9° N Ethiopia	68.5	14.6	102.7	9.7	98.1	10.2	116.1	8.6
2526	28° 39′ N India	61.9	16.2	97.0	10.3	98.6	10.1	113.4	8.8
4400	36° 10′ N Syria	62.9	15.9	124.9	8.0	100.7	9.9	130.7	7.7
4605	26° 48′ S Argentina	63.8	15.7	61.7	16.2	89.5	11.2	103.3	9.7

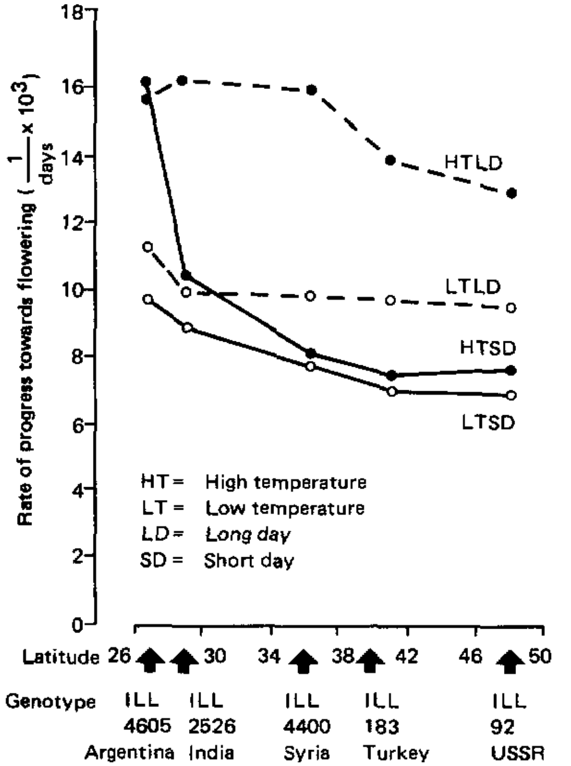


Fig. 25. Rate of progress towards flowering of lentil genotypes originating from diverse latitudes, under pot culture in Aleppo under two thermal regimes and two photoperiods.

preliminary examination reveals that the values predicted by these equations show very high correlation with field data collected from ICARDA's Lentil Adaptation Trials. An experiment is planned for the 1984/85 season at Tel Hadya to further test this model under actual field conditions. — *R.J. Summerfield and E.H. Roberts (Univ. of Reading), M.C. Saxena, and W. Erskine.*

In a preliminary study on the effect of the duration of vernalization at 5°C ± 2°C on two genotypes (ILL 4400 and 4401), it was observed that vernalization of ILL 4401, for 3, 4, and 5 weeks significantly ($P \leq 0.05$) reduced the days to flowering by 6, 12, and 15 days, respectively. Vernalization, however, had little effect on genotype ILL 4400. Possibly, either the temperature regime was not appropriate for ILL 4400, or the genotype did not have a vernalization requirement. This aspect will be further investigated. — *M.C. Saxena and M.V. Murinda.*

Production Agronomy

Response of lentils to four levels of plant population (100, 200, 300, and 400 plants/m²) and four row spacings (20, 30, 40, and 50 cm) was studied at Tel Hadya and Terbol. The total biological yield of ILL 223 lentil increased significantly ($P \leq 0.05$) as the population level was raised from 100 to 300 or more plants/m², but seed yield was not affected. The response of Lebanese Local lentil landrace was similar at Terbol, where, because of better moisture supply, the yield levels were almost double of those at Tel Hadya. Row spacing effects were non-significant at both locations. These studies reveal that a population of about 200 plants/m² is adequate. — *M.C. Saxena and M.V. Murinda.*

Kabuli Chickpea Improvement

This is a collaborative activity with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India.

Kabuli chickpea is grown as a spring-sown crop on conserved soil moisture in West Asia, North Africa, and southern Europe, and as a winter-sown crop in the Indian subcontinent, the Nile Valley, and Latin America.

Important needs in the former region are for ascochyta blight resistant cultivars, which can be winter-sown, and for tall cultivars, which can be mechanically harvested, thereby reducing labor costs. For the spring-sown crop, early-maturing cultivars, which avoid drought during the reproductive growth phase, are needed; early maturity will also help the crop to fit into rotations in winter-sown areas.

These needs, and the consumer's preference for large seeds, are addressed by the breeding program.

Since winter sowing of ascochyta blight resistant cultivars has shown the greatest promise for increasing yields in the Mediterranean region, efforts are directed to developing only ascochyta blight resistant material at Tel Hadya. Plants which are susceptible to cold, heat, iron deficiency, *Orobanche crenata,* and leaf miner are discarded. Advanced segregating populations are grown in both winter and spring seasons to assess their performance. Lines selected are then evaluated for seed yield in winter- and spring-sown trials at three locations with different agroclimatic conditions and altitudes. Lines with superior performance are distributed to national programs for local evaluation and use in their breeding work. — *K.B. Singh.*

Germplasm

A total of 1797 kabuli chickpea germplasm accessions were grown during winter. Data were collected on days to flower, days to maturity, plant height, pods per plant, pod dehiscence, biological yield, seed yield, harvest index, resistance to leaf miner, and susceptibility to iron deficiency. These lines are being evaluated for protein content and cooking time.

Cold tolerance

A total of 1411 accessions were sown on 25 October 1983, 1 month before the normal winter sowing date. Early sowing induces more crop growth and allows greater exposure to cold and is thus more reliable for screening for cold tolerance than late sowing. Only 24 nights had subzero temperatures during 1983/84, compared with 52 nights in 1982/83, so effective screening could not be made. To ensure effective screening for cold tolerance a site at higher elevation than Tel Hadya is needed. — *K.B. Singh and R.S. Malhotra.*

Resistance to *Orobanche* sp.

Orobanche sp. is not a problem in spring-sown chickpea but could become a problem in winter-sown crops. During 1983/84, 193 elite lines were screened for resistance to *Orobanche* sp. and 170 lines were found intermediate or better in their reaction (Table 37).

Table 37. Reaction of elite breeding lines to *Orobanche* sp. at Tel Hadya, 1983/84.

Reaction	Number of lines	% of total
Highly resistant	18	9.3
Resistant	69	35.8
Intermediate	83	43.0
Susceptible	21	10.9
Highly susceptible	2	1.0
Total	193	100

Highly resistant = less than 0.25 *Orobanche* sp. *shoots/plant*
Resistant = 0.25 – 0.50 shoots/plant.
Intermediate = 0.5 – 1.0
Susceptible = 1.0 – 1.5.
Highly susceptible = more than 1.5.

Five hundred promising lines were screened in an *Orobanche crenata* infested field and 11 resistant lines were identified (Table 38). These lines will be used in the hybridization program to incorporate genes for *Orobanche crenata* resistance. — *K.B. Singh and S.Kukula.*

Ascochyta Blight Resistant Genetic Stocks

The original sources of resistance to ascochyta blight have a seed type intermediate between

Table 38. Reaction of selected chickpea entries to *Orobanche* sp. at Tel Hadya, 1981/82 and 1983/84.

Entry	*Orobanche* sp. shoots/plant 1981/82	1983/84
ILC 3274		0.05
348	0.00	0.10
202	0.15	0.11
171	0.06	0.14
299	0.00	0.15
1346	0.35	0.15
83	0.00	0.16
2506	0.89	0.17
132	0.24	0.18
201	0.19	0.18
134	0.00	0.19

kabuli and desi, and are late maturing. As such they are poor donors for resistance genes. Therefore, efforts have been made to transfer the genes for resistance into a better genetic background. Eight resistant lines with larger, kabuli-type seed, and early flowering have been developed (Table 39), and will be used in the hybridization program. — *K.B. Singh and M.V. Reddy.*

Improved Kabuli Chickpea Cultivars and Genetic Stocks

Crossing

During the 1983/84 season, 401 crosses were *made at Tel Hadya: 275 for the development of* genetic stocks and cultivars, 90 for the national programs of Egypt, Italy, Jordan, Morocco, and Tunisia, and 36 for genetic studies of ascochyta blight, fusarium wilt, and leaf miner resistance. Most of the crosses made this year were between lines bred at ICARDA and germplasm accessions, a significant departure from early years when almost all the crosses were made among germplasm accessions. Such crosses are expected to produce better segregants.

Segregating Populations

The F_1 generation was grown at Sarghaya during the off-season with 24-hour light. The F_2 through F_4 generations were grown during winter and the F_5-F_7 progeny rows during both winter and spring seasons at Tel Hadya. The segregating material

Table 39. Seed type, 100-seed weight, days to 50% flowering, and reaction to aschochyta blight over three seasons, 1981-84, of eight ascochyta blight resistant kabuli chickpea lines and an intermediate-type ckeck, ILC 3279, Tel Hadya.

Entry	1981/82	1982/83	1983/84	Seed Type flowering	Days to 50%	100-seed weight (g)
FLIP 82-93	3	3	3	K	146	27
82-127	3	2	4	K	144	30
82-130	3	2	3	K	146	25
82-144	3	2	3	K	144	26
82-243	3	2	3	K	145	25
83-13		3	3	K	144	31
83-15		2	3	K	141	29
83-46		2	3	K	145	32
ILC 3279	3	2	3	I	148	26

1 = Highly resistant; 3 = Resistant; 4 = Moderately resistant; K = Kabuli; I = Intermediate.

grown, single plants selected, and promising progenies bulked are shown in Table 40. The number of progenies grown and plants selected decline with advancing generation. Nearly 50% of the total area sown was assigned to F_2 populations and 40% to F_3 progenies.

The 1983/84 season was unique in many ways. First, in the ascochyta blight screening nursery the disease development at the vegetative stage was more severe than in previous years because of favorable weather conditions, but much less so at the podding stage due to poor rainfall and warm weather. Second, selection for drought tolerance was possible during spring due to low total seasonal rainfall (230 mm). It was for the first time that tall progenies with true kabuli seed and large-seeded progenies with 100-seed weights of more than 50 g could be bulked. One hundred and ninety newly developed lines were further evaluated for photoperiod sensitivity for early maturity.

Large-Seeded Chickpeas

Consumers' preference has always been for the large-seeded chickpeas, and it is mostly these that enter the world trade. But it is difficult to breed large-seeded, high-yielding, and disease-resistant cultivars. For the first time, 20 lines have been bred combining these characters and the 10 best are shown in Table 41. Given acceptable seed yields these lines with both large seed and ascochyta blight resistance will help to introduce winter sowing of chickpeas in countries such as Spain.

Tall Chickpeas

Efforts were continued to develop high-yielding, ascochyta blight resistant, tall chickpeas. Over 20 tall germplasm accessions have been assembled, mainly from the USSR, but unfortunately these lines have intermediate-type seed. Previously, breeding efforts have failed to produce lines combining the desired traits, but a number of such lines were developed during the 1983/84 season. The plant height, seed weight, seed type, and reaction to ascochyta blight of 10 lines bulked last season are shown in Table 42. These lines will be evaluated for yield and the best lines distributed to the national programs.

Table 40. Number of chickpea segregating breeding lines grown, plants selected, and progenies bulked during 1983/84 main season at Tel Hadya and 1983 off-season at Sarghaya.

Generation	No. of segregating lines grown	No. of single plants selected	No. of progenies bulked
F_1	305		
F_2 Population	242	5112	
F_3 Progeny	4927	2345	
F_4 Progeny	3164	1741	28
F_5 Progeny	1998[a]	517	97
F_6 Progeny	1860[a]	520	44
F_7 Progeny	966[a]		21

a. Includes some progenies grown during both winter and spring.

Table 41. The 100-seed weight (g) and ascochyta blight reaction of 10 newly-bulked large-seeded chickpea lines at Tel Hadya, 1983/84.

1984 Plot No.	Parentage	100-seed weight	Blight reaction
56[illegible]73	ILC 470 × ILC 2956	46	3[a]
56[illegible]69	ILC 2956 × ILC 3279	42	3
56288	ILC 191 × ILC 262	49	3
56326	ILC 202 × ILC 256	42	3
56401	ILC 112 × ILC 191	42	3
56403	ILC 112 × ILC 191	50	3
56418	ILC 202 × ILC 3355	44	3
56478	ILC 3279 × ILC 3355	44	3
56497	ILC 3279 × ILC 3355	46	3
56519	ILC 72 × ILC 1922	43	3
Check	ILC 464	46	9

a. 3 = Resistant; 9 = Highly susceptible, killed.

Table 42. Seed type and weight and reaction to ascochyta blight of 10 newly-bulked tall chickpea lines at Tel Hadya, 1983/84.

Parentage	Seed type	Plant height (cm)	100-seed weight (g)	Blight[2] reaction score
ILC 610 × ILC 72	K[1]	65	33	3
ILC 1920 × ILC 2956	K	65	34	3
ILC 1920 × ILC 2956	K	70	35	4
ILC 1920 × ILC 2956	K	60	32	3
ILC 72 × ILC 482	K	60	32	3
ILC 72 × ILC 482	K	65	32	3
ILC 72 × ILC 484	K	60	31	3
ILC 72 × ILC 484	K	70	35	3
ILC 72 × ILC 484	K	65	31	3
ILC 72 × ILC 73	K	70	38	3
ILC 3279 (check)	I	67	28	3

1. K = *Kabuli*; I = *Intermediate*.
2. 3 = Resistant; 4 = Moderately resistant.

Yield Trials in Spring Season

The seed yield of 203, 63, and 140 newly-developed lines was evaluated during the spring season at Tel Hadya, Jindiress, and Terbol, respectively. Although a number of lines outyielded the local check at each site the differences were not significant (Table 43). The coefficients of variation for the trials at Tel Hadya were very high due to inadequate moisture at planting and at other critical phases of crop growth. Yields were extremely poor due to low rainfall (230 mm). Chickpeas are seldom grown in areas which receive less than 350 mm annual rainfall. Because of the droughty conditions many crops failed completely. Yields at Jindiress and Terbol, though slightly less than usual, were acceptable.

Table 43. Yield performance of newly developed lines in spring - sown trials at Tel Hadya and Jindiress (Syria), and Terbol (Lebanon), 1984.

Location	No. of trials	No. of entries	Entries exceeding check	Entries significantly exceeding check	Range of highest yields (kg/ha)	Range for CV (%)
Tel Hadya	10	203	14	0	147-331	42.4-93.6
Jindiress	3	63	3	0	1379-1621	14.4-20.1
Terbol	7	140	4	0	1611-2000	17.0-29.4

Yield Trials for Winter Sowing

The seed yield of the same lines as used for spring trials was also evaluated in winter-sown trials at the same three locations. Eleven lines significantly ($P \leq 0.05$) outyielded the check at Tel Hadya (Table 44), and many others outyielded the check at each site, though not significantly. Coefficients of variation were lower in the winter-sown than in the spring-sown trials.

The largest yield in the winter-sown trials at Tel Hadya was 3070 kg/ha, compared with only 331 kg/ha in the spring-sown trials, and the seed yield of some entries exceeded 3500 kg/ha at Jindiress and Terbol.

On-Farm Trials

On-farm trials at 17 locations were conducted for the fifth season in 1983/84 in collaboration with the Ministry of Agriculture and Agrarian Reform, Syria. The results summarized in Tables 45 and 46 are for 15 locations, two trials having been destroyed. ILC 482 again gave the heaviest yield in the winter-sown trials. The Syrian landrace gave the largest yield in the spring-sown trials, in contrast to the previous two seasons in which ILC 482 outyielded the Syrian landrace. Seed weights and yields were, however, less than in 1982/83, due to poorer rainfall in 1983/84. ILC 482 and ILC 629 appear to be possible replacements for the Syrian landrace, given their ascochyta blight tolerance and large seed, respectively.

The dry conditions in 1983/84 did not favor ascochyta blight disease development, and the lines were rated as resistant at all locations except one, where ILC 620, ILC 629, and Syrian landrace (ILC 1929) proved susceptible.

Table 44. Yield performance of newly developed chickpea lines in winter-sown trials at Tel Hadya and Jindiress (Syria), and Terbol (Lebanon), 1983/84

Location	No. of trials	No. of entries	Entries exceeding check	Entries significantly exceeding check	Range of highest yields (kg/ha)	Range for CV (%)
Tel Hadya	10	203	102	11	2362-3070	16.0-31.8
Jindiress	3	63	4	0	3400-3567	17.6-20.6
Terbol	7	140	30	0	1875-3600	15.2-23.5

Table 45. Performance of the eight largest yielding chickpea lines in winter-sown on-farm trials, Syria, 1983/84 (Means of 15 locations).

Entry	Yield (kg/ha)	Rank	Days to 50% flowering	Days to maturity	Plant height (cm)	100-seed weight (g)	Mean ascochyta blight score
ILC 72	1161	5	146	183	63	30	1
ILC 195	1180	4	143	182	53	23	1
ILC 202	1130	7	145	184	59	27	1
ILC 484	1410	2	135	176	41	26	1
ILC 3279	1088	8	148	185	64	30	1
FLIP 82-64	1153	6	144	183	63	31	1
FLIP 82-236	1278	3	143	183	54	32	1
ILC 482 (check)	1455	1	134	176	41	29	1
Grand mean	1232		142	182	55	29	
CV (%)	20.67		0.49	0.41	1.38	1.95	
LSD (5%)	134.9		2.82	1.98	4.43	0.28	

Table 46. Performance of the six largest yielding chickpea lines in spring-sown on-farm trials, Syria, 1984 (Means of 15 locations).

Entry	Yield (kg/ha)	Rank	Days to 50% flowering	Days to maturity	Plant height (cm)	100-seed weight (g)	Mean ascochyta blight score
ILC 482	850	3	73	109	31	26	1
ILC 620	822	4	78	117	34	37	1
ILC 629	871	2	77	116	34	37	1
FLIP 82-64	699	6	80	119	41	31	1
FLIP 82-236	811	5	78	116	35	28	1
Local (check)	922	1	73	111	30	31	1
Grand mean	829		76.6	115	34	31.6	
CV (%)	16.69		0.67	0.71	2.07	1.26	
LSD (5%)	73.78		1.51	1.80	2.03	0.21	

Use of ICARDA Material by National Programs

The national programs in nine countries have selected genotypes from the international nurseries for on-farm trials or multilocation testing (Table 47). Besides these, many other lines have been selected for use in hybridization programs and for further evaluation at principal stations.

Release of ILC 3279 In Cyprus. Chickpea cultivar ILC 3279, a selection from an introduction from the USSR, has produced consistently high yields over 3 years in winter-sown trials in Cyprus. It is highly resistant to ascochyta blight, cold tolerant, and tall and thus can be mechanically harvested. Its tall character was one of the main considerations for its release in Cyprus.

One of the main usages of chickpeas in Cyprus is for *Homos-bi-tihineh*. ILC 3279 was rated as slightly better than the local check for this purpose (Table 48). It has slightly higher protein content than Cyprus Local but has a smaller seed size. With regard to other characters, such as cooking time, and swelling and hydration capacity, both were rated at par. — *K.B. Singh and M.V. Reddy.*

Table 47. Promising chickpea lines included in multilocation or on-farm trials by national programs, 1983/84.

Country	Cultivar
Syria	ILC 72, 195, 202, 3279, 620, 629, FLIP 82-64C, FLIP 82-236C
Jordan	ILC 484, 202
Lebanon	ILC 482
Cyprus	ILC 3279
Egypt	ILC 195, 482, 484
Tunisia	ILC 482
Morocco	ILC 195, 482, 484
Pakistan	FLIP 82-8C, FLIP 82-52C, FLIP 82-69C, FLIP 82-5C, FLIP 82-43C
Muscat	ILC 3279, FLIP 80-5

Table 48. Mean values of some quality parameters[1] in chickpea cultivars ILC 3279 and Cyprus Local.

Preparation/trait	Cyprus Local	ILC 3279
Homos-bi-tihineh		
Texture	3.86	4.07
Odor	3.64	3.86
Color	3.79	4.07
Taste	3.57	4.07
Cooking time (min.)	115	109
Swelling capacity (%)	151	150
Hydration capacity (%)	117	115
Protein content (%)	20.03	23.92
100-seed weight (g)	29	26

1. Scale: 5 = Excellent, 4 = Good, 3 = Fair, 2 = Poor, 1 = Very poor. Evaluated by a taste panel.

ILC 3279, a tall, ascochyta blight resistant, and cold-tolerant cultivar has been released for winter sowing in Cyprus, and is being tested in on-farm trials in Syria.

Chickpea Diseases and their Control

Disease Situation in West Asia and North Africa

Ascochyta blight, which has caused serious yield losses in the region during the past 3-4 years, was a lesser problem this season because of dry weather. Ascochyta blight and chickpea production in the region seem to be in a vicious cycle. When the season is dry, there is little ascochyta blight but crop yields are poor. When the season is wet, there is potential for good yields but the crop is destroyed by blight. Thus, blight control measures are essential to increase and stabilize chickpea production in the region.

A survey of nematodes parasitizing leguminous crops in Syria showed that chickpea is affected by 12 nematode genera: *Aphelenchoides, Ditylenchus, Helicotylenchus, Heterodera, Meloidogyne, Paratylenchus, Pratylenchus, Pratylenchoides, Trophurus, Tylenchorlynchus, Tylenchus,* and *Xiphinema.* Of these *Heterodera* sp., *M. artiellia,* and *Pratylenchus thornei* were extracted from 24, 12, and 60% of the samples, respectively, and appeared to be the most damaging nematodes. The distribution and importance of these nematodes in the region will be studied further.

Isolations from wilted plants from Tunisia and Syria indicated presence of *Verticillium* sp. in addition to *Fusarium oxysporum.* — *M.V. Reddy.*

Screening for Ascochyta Blight Resistance

Forty-one sets of 70 blight-resistant lines identified at ICARDA were supplied to 18 national programs mainly in the West Asia and North Africa region through the Chickpea International Ascochyta Blight Nursery-84. These lines included 21 desi and 22 kabuli germplasm accessions and 27 kabuli lines developed through hybridization.

A large amount of breeding material, including segregating populations and elite lines in yield trials, was screened against a mixture of four races of blight under severe artificial epiphytotic conditions. Scoring of the material was done both for vegetative and pod resistance.

In the advanced screening of germplasm for resistance to blight, 10 new lines were found to be resistant for the second year at three locations, Tel Hadya and Lattakia in Syria, and Terbol in Lebanon. These were ILC 3803, ICC 4181, ICC 4475, ICC 8486, ICC 9189, ICC 9501, ICC 9514, ICC 12023, CAM 72, and CAM 94. In the preliminary screening at Tel Hadya none of 140 new germplasm lines screened for the first time was resistant. — *M.V. Reddy and K.B. Singh.*

Ascochyta Blight Severity and Yield Loss Relationship

The relationship between ascochyta blight severity on 1-9 scale and yield was studied in a field trial involving 16 kabuli and four desi lines. The trial was planted in the winter season at Tel Hadya in a split-plot design, with genotypes in subplots and protected and unprotected treatments in main plots. Epiphytotics of blight were created by inoculating the plots with diseased debris and spraying with fungal spore suspension propagated in the laboratory. Blight protection was obtained by spraying with chlorothalonil (Bravo 500, 5ml/l water) at 7-10 days intervals from germination to maturity. The loss in yield of kabuli lines rated as resistant or moderately resistant was very little but in desi lines it was substantial (Table 49).

In another trial, the yield reduction due to ascochyta blight infection was estimated in 12 kabuli and six desi lines rated as resistant or

The emphasis in chickpea breeding program is to combine earliness and large seed size with typical kabuli character and ascochyta blight resistance. Such lines are being evaluated in the Chickpea International Ascochyta Blight Nursery (CIABN).

Table 49. Ascochyta blight severity and yield loss relationship in kabuli and desi chickpeas.

Blight severity	Type	No. of entries	Mean yield (kg/ha) Protected	Mean yield (kg/ha) Diseased	Percent yield loss
Resistant	Kabuli	4	1440	1400	2.8
	Desi	1	2250	1240	44.9
Moderately resistant	Kabuli	6	2162	2027	6.2
	Desi	2	2200	1180	46.4
Tolerant	Kabuli	2	2536	2041	19.5
	Desi	1	2636	1355	48.6
Susceptible	Kabuli	4	2519	38	98.5
CV (%) main plot		19.7			
subplot		15.1			
LSD (5%) main plot at same subplot level		504.8			
LSD (5%) subplot at same main plot level		453.8			

moderately resistant. Surprisingly, the resistant and moderately resistant kabuli lines yielded *more in the diseased plots than in those treated* with chlorothalonil. Yield reduction in the moderately resistant desi lines was quite high (Table 50). The yield of the susceptible kabuli check was higher than the resistant and moderately resistant lines when ascochyta blight was controlled, but it was killed in the unprotected plots.

Sources of Resistance to a Virulent Race of *A. rabiei*

Over the past 3 years about 5000 germplasm accessions comprising both desi and kabuli types were screened under controlled conditions in the plastic house against the newly identified race 6 of *A. rabiei.* Most of the lines which were resistant to race 3 showed susceptibility against this race. In the repeated screening tests, five lines, ICC 6988 (desi), ILC 187, ILC 202, ILC 3346, and Pch 128 (all kabuli) showed a resistant-tolerant reaction to the new race.

Durable Sources of Resistance to Ascochyta Blight

In an attempt to identify lines with durable resistance to blight, lines were screened against six races of *A.rabiei* with a range of inoculum concentrations and under different relative humidity regimes. Thirty lines identified as resistant to race 3 at ICARDA or found to be resistant in multiple locations in the international blight resistance testing program were tested. Five lines (ILC 72, 187, 2506, 3856, and 3864) showed low disease severity and low sporulation (Table 51). Disease severity and sporulation were measured 1 month after inoculation in the seedling stage.

The reaction of 10 genotypes to race 3 was studied under different periods of 100% relative humidity and spore concentrations (0.1 to 7.5 million/ml) to identify lines resistant under a range of conditions. Changing the duration of 100% relative humidity from 2 to 30 days and inoculum concentration from 0.1 to 7.5 *million/ml did not significantly change the reaction of many lines* (Table 52).

Table 50. Estimation of yield loss due to ascochyta blight in resistant and moderately resistant kabuli and desi chickpea lines, Tel Hadya, 1983/84.

Blight reaction	Type	No. of entries	Yield (kg/ha) Protected	Yield (kg/ha) Diseased	Percent Yield decrease/ increase
Resistant	Kabuli	5	1940	2047	+ 5.6
	Desi	3	2287	2068	− 9.6
Moderately resistant	Kabuli	7	1909	1986	+ 4.0
	Desi	3	2569	1506	− 41.4
Susceptible	Kabuli	1	2788	0	−100
CV (%) main plot		19.87			
subplot		15.17			
LSD (5%) main plot at same subplot level		250.5			
LSD (5%) subplot at same main plot level		499.0			

Table 51. Chickpea lines with low disease severity and sporulation against 6 races of *Ascochyta rabiei*, Tel Hadya, 1983/84.

Chickpea genotype	Blight severity on 1-9 scale						Million spores/g					
	Race 1	Race 2	Race 3	Race 4	Race 5	Race 6	Race 1	Race 2	Race 3	Race 4	Race 5	Race 6
ILC 72	3	3.5	3	3	3	4	0	0	0.32	0	0.45	0
187	3	3.5	3	3	3.5	3	0.42	0.41	0.45	0	0	0
2506	3	3	4	3	3	3	0	0.78	1.34	0	0	0
3856	2.5	3	4	4	3	3.5	0.44	0	1.25	0	0	0
3864	2.5	3	4	4	3	3	0	0	0.66	0.39	0	0
ILC 1929 (Susc. check)	7	9	8	9	9	8	33.13	215.60	40.37	152.99	74.32	9.70
CV (%) races			7.46						132.64			
LSD (1%) races at same genotype level			1.68						14.39			
LSD (1%) genotypes at same race level			1.66						35.24			

Table 52. Reaction of some chickpea genotypes to race 3 of *A. rabiei* at different humidity periods and inoculum concentrations, Tel Hadya, 1983/84.

Chickpea genotype	Blight severity (1-9 scale)					
	% relative humidity period (days)			Inoculum concentration (million spores/ml)		
	2	10	30	0.1	1.0	7.5
ILC 72	4	4	3.5	2	3.5	3
ILC 187	3	3.5	4	2	2	2
ILC 200	2	2	2	2	2	2
ILC 482	4	3.5	4.5	2	2.5	2
ILC 3279	4.5	4	4	1.5	3.5	3
ILC 3346	4.5	5	4.5	3	4.5	5
ICC 3996	2	2	2.5	1	2	2
ILC 1929 (Suscep check)	7	8.5	9	7.5	6.5	8
CV (%) main plot		15.12			23.33	
subplot		15.18			24.85	
LSD (1%) main plot at same subplot level		1.91			1.60	
LSD (1%) subplot at same main plot level		1.91			1.57	

Epidemiology of Ascochyta Blight

The effect of temperature and relative humidity on development of ascochyta blight was examined in the field for the second year in 1983/84. Results were similar to those obtained in 1982/83. Blight builds up rapidly when daily mean temperatures rise above 10°C and relative humidity above 60% (Fig. 26). During 1984 these conditions prevailed in the first week of February.

Integrated Control of Ascochyta Blight

Earlier studies indicated that ascochyta blight control through foliar fungicides is not economical with highly susceptible cultivars due to the large number of sprays required. In tolerant cultivars, particularly in lines with reasonable resistance in the vegetative stage but susceptibility in the podding stage, fungicidal protection appeared to be feasible. A field trial was conducted for the third season in 1983/84 using tolerant cultivar ILC 482 to test the effect

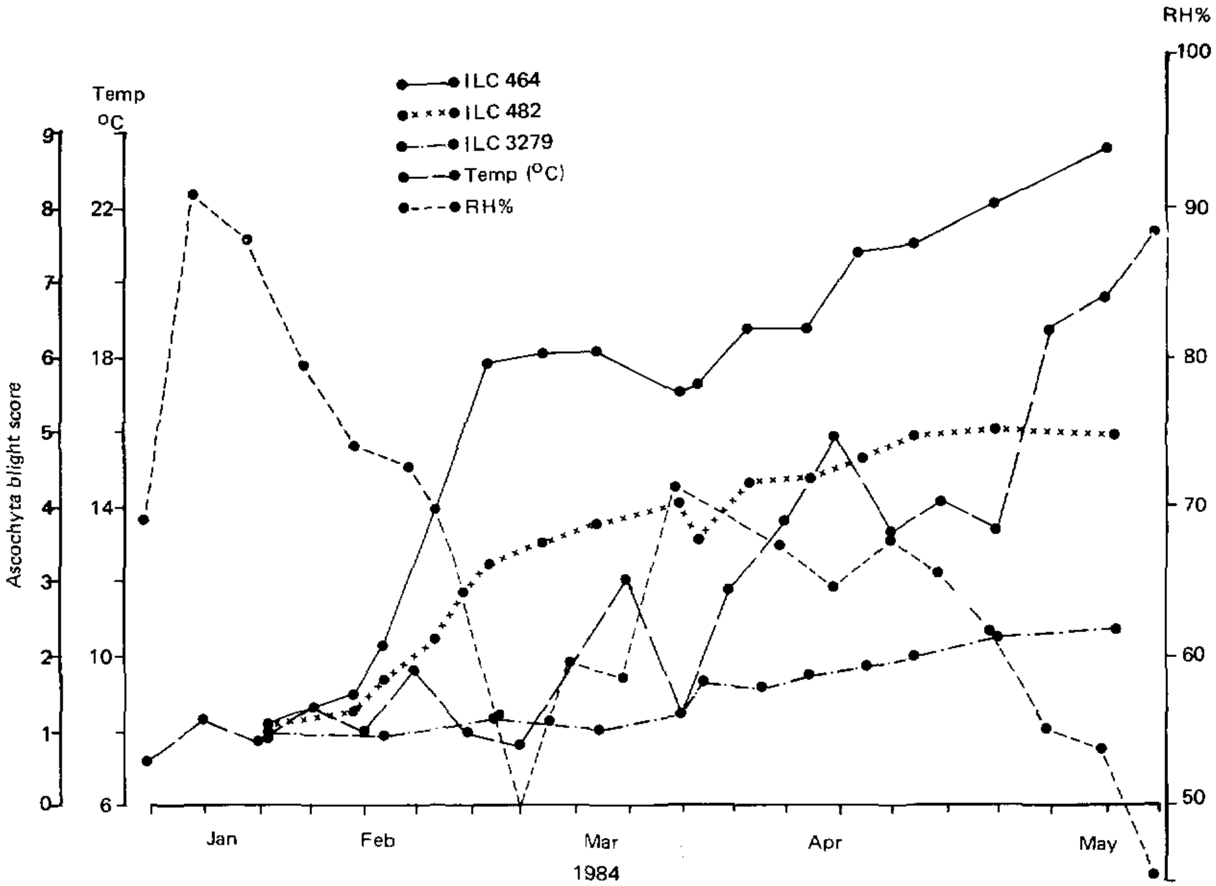


Fig. 26. Ascochyta blight development in three cultivars of chickpea in relation to temperature and relative humidity, Tel Hadya, 1984.

Table 53. Effect of foliar chlorothalonil on ascochyta blight and yield of blight-tolerant cultivar ILC 482, Tel Hadya, 1983/84.

Treatment	Blight severity on vegetative parts (1-9 scale)	Pod infection (%)	Seed infection (%)	Yield (kg/ha)	Days to 50% flowering
No sprays	5.33	7.7	1.23	1565	127
1 spray in SS	4.67	16.7	0.97	1873	125
1 spray in EPS	4.67	2.3	0	1894	128
1 spray in LPS	5	10.2	0	1602	127
2 sprays, SS + EPS	3	0.9	0	2602	124
2 sprays, SS + LPS	4.33	20.0	0.6	2259	125
2 sprays, SS + LPS	4.67	0.2	0	2063	127
Complete protection	3	0	0	2329	127
CV (%)	13.21	65.86	274.11	16.91	0.86
SE ±	0.32	2.63	0.51		
LSD (5%)	0.93	7.72	1.5	572	1.84

SS = Seedling stage, EPS = Early podding stage, LPS = Late podding stage.

of chlorothalonil (Bravo 500) on blight severity. Two sprays, one at the seedling stage and the other either in the early or late podding stage, prevented yield loss. Spraying in the seedling and early podding stages significantly reduced the extent of pod infection (Table 53) and spraying at the podding stage also reduced seed infection. In the earlier experiments response to spraying was observed only in podding stage and none in the vegetative stage. In 1983/84 the disease severity in the vegetative stage was higher and pod infection comparatively less.

Cross-Protection Between Isolates of *A.rabiei*

An experiment to study whether any cross protection exists between isolates of *A.rabiei* indicated that in some genotypes blight severity was significantly reduced when they were first inoculated with a less virulent race (race 3) and then challenge inoculated with a more virulent race (race 6) than when inoculated with the virulent race alone (Table 54). — *M.V. Reddy.*

Table 54. Cross protection between two isolates of *A. rabiei*, Tel Hadya, 1983/84.

Genotype	Blight severity		
	Race 3	Race 6	Race 3-Race 6
ILC 182	3.5	5	4
187	3	5	4
200	3	5	3
215	5.5	9	5
482	3	9	5
1929	9	9	9
3279	3.5	4.5	3.5
3346	4.5	6	5.5
ICC 4935	4	7.5	5.5
CV (%) races			14.8
CV (%) genotypes			13.46
LSD (5%) races at same genotype level			1.65
LSD (5%) genotype at same race level			1.45

Effect of Ridge Planting and Fungicidal Seed-Dressing on Plant Stand and Yield of Chickpeas

A field experiment to study the effect of ridge and flat planting and fungicidal seed dressing on plant stand and yield of chickpeas was conducted in the spring season at Terbol in Lebanon for the third year in 1983/84. The results confirmed earlier findings that ridge planting and some fungicidal seed dressings such as Captan and Ridomil significantly increased the stands and yields in spring-sown chickpea (Table 55). — *M.V. Reddy and M.C. Saxena.*

Host Range of Cyst and Lesion Nematodes

The host ranges of cyst and lesion nematodes were examined using 46 crop species common to the Mediterranean region. The crops included food and forage legumes, cereals, and others, and were grown in the winter, spring, and summer seasons. For cyst nematode, testing was done in artificially infested soil in pots in the plastic house and for lesion nematode in naturally infested field plots.

Cyst nematode infestation was only observed on chickpea, lentil, *Lathyrus sativa,* peas, soybean, lupines, *Phaseolus* beans, medics, and vetch indicating that its host range is confined to legumes. However, it did not infest faba bean. The host range of lesion nematode was much wider and included legumes, cereals and some cruciferous crops, but not *Lathyrus.*

Screening for Resistance to Cyst and Lesion Nematodes

In a preliminary evaluation, 290 genotypes of chickpea were screened for resistance to cyst and lesion nematodes in pots in the greenhouse. These genotypes were mainly ascochyta blight resistant lines comprising kabuli and desi germplasm accessions and newly developed kabuli lines. Ten seeds of each accession were sown in pots (20 cm diameter). When some of the

Table 55. Effect of method of planting and fungicidal seed dressing on plant stand and yield of chickpeas at Terbol, spring 1984.

Fungicidal treatment	Plant stand[1]		Yield (kg/ha)	
	Flat	Ridge	Flat	Ridge
Control	83	130	1681	2551
Captan	140	142	2324	2611
Thiram	110	141	2092	2658
Ridomil	133	148	2375	2648
Benelate + *Thiram*	*87*	*136*	*1861*	2634
CV (%) Methods	10.4		6.3	
Treatments	13.1		12.3	
LSD (5%) methods at same treatment level	28.3		441	
LSD (5%) treatment at same method of planting	26.8		445	

1. Per 200 seeds planted.

Cyst nematode can cause serious damage to chickpeas. Genotypic resistance is being searched for. Left: a healthy plant; right: a cyst nematode infected plant.

susceptible lines were killed, the remainder were evaluated for the extent of defoliation, root necrosis, and number of cysts on the roots. Damage was scored on a 0-10 scale, where 0 = no damage and 10 = completely killed. *Twenty-seven lines were rated* 4 and less: ILC 196, 197, 446, ICC 6306, FLIP 82-20C, 82-40C, 82-118C, 82-129C, 82-144C, 82-167C, 82-191C, 82-197C, 82-215C, 82-221C, 82-245C, 83-7C, 83-8C, 83-11C, 83-29C, 83-32C, 83-36C, 83-65C, 83-74C, 83-78C, 83-82C, 83-85C, and 83-91C.

One hundred ascochyta blight resistant lines were evaluated for resistance in a field infested with lesion nematode. The nematode population *before sowing ranged from* 101 to 969 (SE ± 288)/500 cc of soil. Little variation in the extent of damage was observed between genotypes. — *M.V. Reddy, K.B. Singh, M.C. Saxena; N. Greco and M. Di Vito (Inst. of. Nematology, Bari, Italy).*

Chickpea Insects and their Control

Studies on the economic importance of the chickpea leafminer and pod borer continued. The population dynamics of leafminer and nature of damage caused were studied in detail. Critical periods for control of leafminer were identified. Most emphasis was placed upon studies related to resistance to leafminer, including identifying possible mechanisms of resistance to this pest.

Chemical Control of Leafminer and Pod Borer

In a winter-sown trial, plots treated with low dosages (0.25 kg a.i./ha) of monocrotophos gave significantly larger yields than those treated with the four other chemicals tested. Monocrotophos increased yields by 19% and *provided 93 and 100% control of leafminer and* pod borer, respectively, compared with the untreated control. As in the previous season, *Bacillus thuringiensis* at commercial rates failed to provide acceptable levels of control for pod borer and has now been discarded.

Proper separation of leafminer and *Heliothis* spp. damage was again obtained by means of cages which acted as physical barriers to prevent access of the pod borer. Through this device and the use of high *B.thuringiensis* dosages in comparison with monocrotophos, yield losses due to *Heliothis* spp. in the Tel Hadya area were estimated at 3.9%.

Leafminer Adult Population Fluctuations

With the introduction of the D-Vac vacuum sampler, our capability to monitor leafminer adult populations was substantially improved. The D-Vac sampling correlated well ($r = 0.65$, $P \leq 0.01$) with sticky-trap catches and indicated that adults emerge from diapause in early March and *oviposit in winter-planted chickpeas. Initially, Phytomyza* (= *Chromatomyza*) sp. was more abundant than *Liriomyza* sp. but the latter gradually became dominant. Both leafminers complete one generation in winter-planted chickpeas and move to spring plantings in late March or early April, where they complete two generations, one in late April and a second, larger one, in mid-May. As in winter, *Phytomyza* sp. is an early season pest in spring-planted chickpeas. These studies are essential to understand the nature of the damage caused by the leafminer and its relation to control practices.

Nature of Plant Damage due to Leafminer and Critical Periods of Control

Counts of damaged and sound leaflets every 2 or 3 days indicated that after the initial oviposition by colonizing adults, the percentage of leaflets mined in spring chickpeas increased rapidly to about 30%. As the plants grew, the actual levels of damage throughout the vegetative and flowering periods were reduced to 12-15%. Higher levels of damage (50-60% leaflets mined) were found only after pod setting when the second generation of adults had emerged from pupation and had oviposited heavily on the plants. By monitoring the number of leaflets dropped on sticky boards in protected and non-*protected plots, we found that in the vegetative* stages and up to the initial flowering period, leafminer damage was responsible for practically all defoliation (Fig. 27). As the season progressed, defoliation caused by leafminer decreased

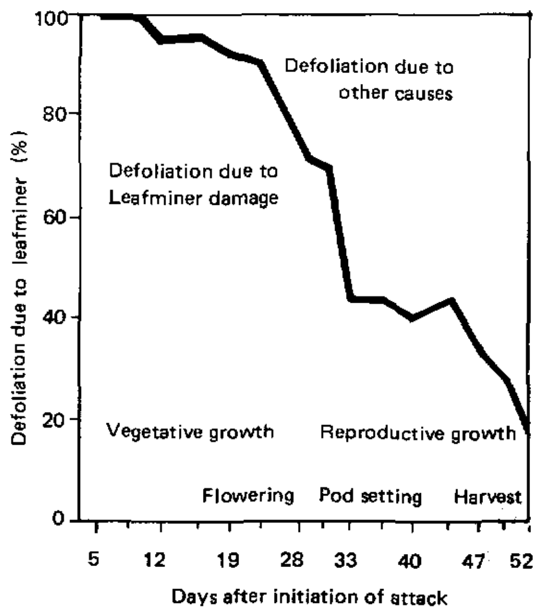


Fig. 27. Contribution of leafminer damage to defoliation in spring-planted chickpeas as related to the phenology of the crop, Tel Hadya, 1983/84.

and that due to physiological maturity became more important.

To relate these findings to practical control recommendations, a trial was conducted in order to measure the importance of leafminer damage at different crop growth stages. As shown in Table 56, large, significant yield increases were obtained whenever the crop was protected during the preflowering or vegetative period. Conversely, full insect control except during the preflowering period improved yields by only 11.9%, a nonsignificant gain. These observations highlight the importance of damage early in the season and confirm last season's preliminary data. In addition, they suggest the possibility of timing a single, early application on the basis of adult population counts. This approach increased yields by 29.8% (Table 56) and was the best in economic terms. — *C.Cardona.*

Host-Plant Resistance to Leafminer

Over 2500 genotypes, including germplasm and breeding lines, were screened for resistance to leafminer. Only 5 (0.2%) were rated as resistant and 15 (0.6%) as intermediate. These, together with 20 additional genotypes previously selected will be rescreened in 1984/85. The visual damage score was retested by planting 15 previously selected genotypes with varying degrees of resistance. The rank correlation coefficient between previous ratings and those obtained in 1983/84 season was highly significant (r_S = 0.72, P ≦ 0.01). In addition, when 35 previously selected genotypes were rescreened in winter and spring, the rank correlation coefficient between seasons was also highly significant (r_S = 0.80, P≦ 0.01).

The F_2 populations of two crosses made in 1982/83 were evaluated. Twenty-two individual selections were made and these will be tested in F_3 progeny rows in 1984/85. Simultaneously, three new resistant parents (ILC 1003, 1776, and 2319) were selected and crosses made. The F_2 populations will be evaluated in 1984/85.

To find a possible association between morphophysiological characters and leafminer resistance (discriminant function), 24 genotypes

Table 56. Effect of chemical control of leafminer at different crop growth stages on the yields of spring-planted ILC 482 chickpea, Tel Hadya, 1983/84.

Kind of protection	No. of sprays[1] Total	During preflowering period	Seed yield kg/ha	% increase	Ranking for net benefit
Full	4	2	1268	43.3	3
Full	3	1	1139	28.7	5
Less preflowering	3	0	990	11.9	6
Less flowering	3	2	1141	28.9	4
Less pod setting	3	2	1172	32.4	2
At initial flowering[2]	1	1	1149	29.8	1
Never sprayed (check)	0	0	885		7
SE ±			93.6		
CV (%)			17.0		

1. With methidathion 0.5 kg a.i./ha.
2. Spray timing based on adult counts; when second generation adults started to emerge from pupation.

with widely diverse characteristics were evaluated for leafminer resistance. A significant correlation (r = 0.334, P ≤ 0.05) between lateness and resistance was found, but to obtain more conclusive data, a wider genetic base would be needed. This study will be repeated with more materials.

Yield testing as a tool to select parents and measure levels of resistance detected so far, continued in 1983/84. When 21 genotypes were grown under protected and nonprotected conditions, yield losses ranged from 1.7 to 36.3% (mean = 20.3%). Table 57 illustrates the performance of 10 of these lines. As on previous occasions, the visual damage score did not correlate well with the percentages of yield loss.

In an attempt to determine the causes for yield differences under leafminer attack, the performance of one resistant, two intermediate, and two susceptible genotypes was studied in greater detail. Weekly adult counts suggested a possible nonpreference mechanism during the preflowering period. However, as the season progressed, there was a definite tendency for the adults to move from the deteriorating highly susceptible check (ILC 3397) to the less damaged resistant genotype (ILC 2319), disproving the nonpreference hypothesis.

Yield losses in this experiment ranged from 8.6% in the resistant genotype to 28.8% in the highly susceptible check. The best parameter to explain differences in resistance ratings was the net rate of defoliation due to leafminer, which was calculated by carefully monitoring leaflet drop in protected and nonprotected plots. The regression lines for four of the genotypes (ILC 3397 was not included due to its completely different growth pattern) are shown in Fig. 28. Paired t-tests on the slopes of the regression lines revealed that the susceptible variety was defoliated at a signifcantly faster rate and the resistant variety at a singifcantly slower rate than the others. No significant difference was found between the two intermediate genotypes. This confirms preliminary data (ICARDA Annual Report 1983) on the occurrence of differential genotypic responses to leafminer attack. — *C. Cardona and K.B. Singh.*

Table 57. Resistance ratings, protected and nonprotected yields, and comparative yield losses in chickpea cultivars selected for varying degrees of resistance to leafminer, Tel Hadya, 1983/84.

Cultivar	Resistance rating[1] Previous season(s)	Resistance rating[1] 1983/84 season	Yield (kg/ha) Protected	Yield (kg/ha) Nonprotected	% yield loss
1776	R	R	932	916	1.7
2618	R	I	1064	998	6.2
782	I	I	1050	955	9.0
482	I	I	1141	1022	10.4
2319	R	R	1029	889	13.6
2871	S	S	1453	1044	28.2
2759	S	S	1145	814	28.9
3397	S	S	1266	862	31.9
3307	S	S	1476	940	36.3
Local	S	S	1414	1227	13.2

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

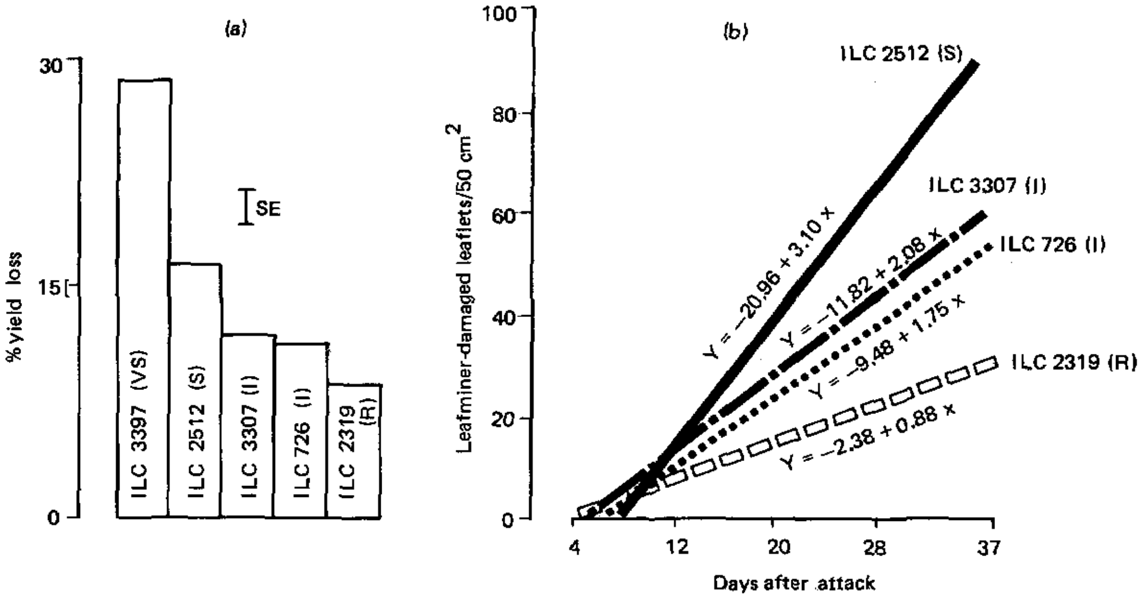


Fig. 28a. Percentage yield losses due to leafminer in five chickpea varieties, Tel Hadya, 1983/84. *S = Susceptible, VS =* Very susceptible, I = Intermediate, R = Resistant.

Fig. 28b. Regressions of leafminer damage on days after initial attack in four chickpea varieties, Tel Hadya, 1983/84.

Weed Control

In the International Weed Control Trial conducted at Tel Hadya, Jindiress, and Gellin in Syria and at Terbol in Lebanon, the reduction in yield of winter-sown chickpeas due to weeds was estimated to be 41.9, 34.0, 51.4, and 54.8%, respectively. These decreases were highly significant ($P \leqq 0.05$). At each location both volunteer cereals and broad-leaved weeds were a problem. Terbutryne (Igran) at 4 kg a.i./ha or cyanazine (Bladex) at 0.5 kg a.i./ha with 0.5 kg a.i./ha of pronamide (Kerb), applied preemergence, were as effective in controlling weeds as handweeding twice, and gave equivalent seed yields at all four locations. Thus, chemical weed control in winter-sown chickpeas looks feasible. — *S.Kukula and M.C. Saxena.*

Soil Microbiology, Crop Physiology, and Production Agronomy

Nitrogenase Activity of Some Chickpea Genotypes

A study was started in 1983/84 to monitor the nitrogenase activity of five promising cultivars of chickpea by acetylene reduction activity (ARA) measurements throughout the major growing period of the crop. Results in Fig. 29 indicate that not only did the ARA values differ significantly ($P \leqq 0.05$) between cultivars on any given sampling date, but also that the pattern of ARA was dissimilar. ILC 482 reached a peak on 5 March, ILC 484, 3279, and 195 on 30 April, and ILC 202, which had the lowest ARA

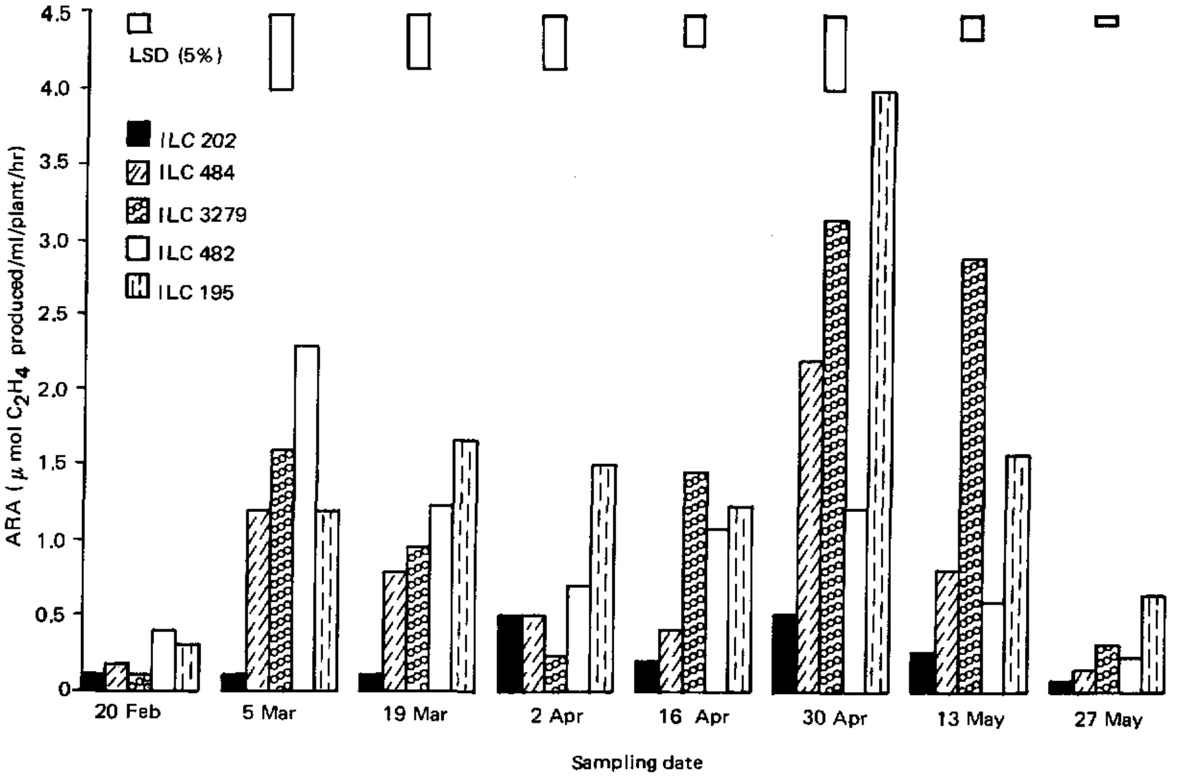


Fig. 29. Mean acetylene reduction activity (ARA) on eight sampling dates for five chickpea cultivars, Tel Hadya, 1983/84.

values throughout the season, had equal peaks on 2 and 30 April. The general pattern of ARA appears to have been related to soil moisture stress. As shown in Fig. 30 the total seasonal rainfall was low in 1983/84 and also poorly distributed. As a result, the crop was subjected to moisture shortage during February and March. Although rainfall increased over the following three sampling dates, it did not appear to be adequate to overcome the water stress until 30 April. The crop was also irrigated in late April because of the shortage of rainfall.

These are initial observations, but the study will be repeated in 1984/85. However, it is evident that not all the chickpea cultivars monitored have the same ARA potential under the existing trial conditions. It is possible that the poor ARA values evident for ILC 202 may be a result of *Rhizobium* sp. strain/host-plant incompatability which is known in many other legumes. Should the 1984/85 results produce the same ARA trends, further work on relating *Rhizobium cicer* strain to particular cultivars will be undertaken. — *J.G. Stephens and K.B. Singh.*

Growth and Yield Relationship

A trial was started in 1981/82 to evaluate the relationships between the length of the growing period, early growth, and productivity of some promising chickpea genotypes. Plots were sown in both winter and spring to vary the length of the various growth phases. This trial was repeated in

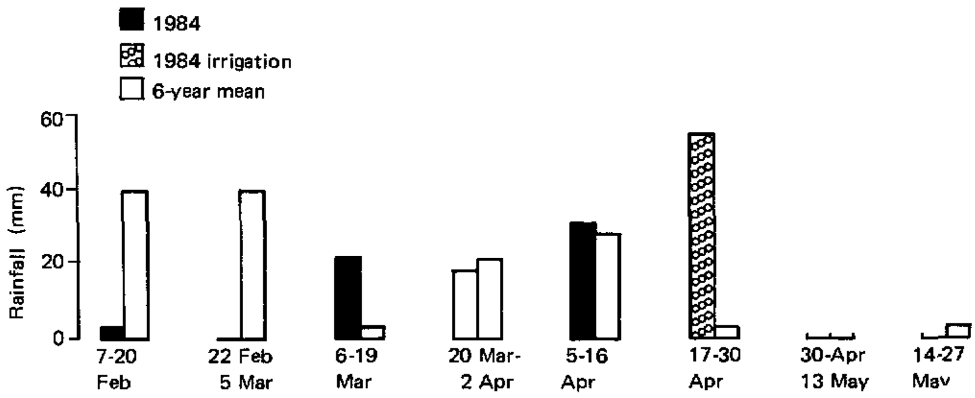


Fig. 30. Rainfall values for 1984 and 6-year averages for 2-week periods prior to sampling of chickpea cultivars, Tel Hadya.

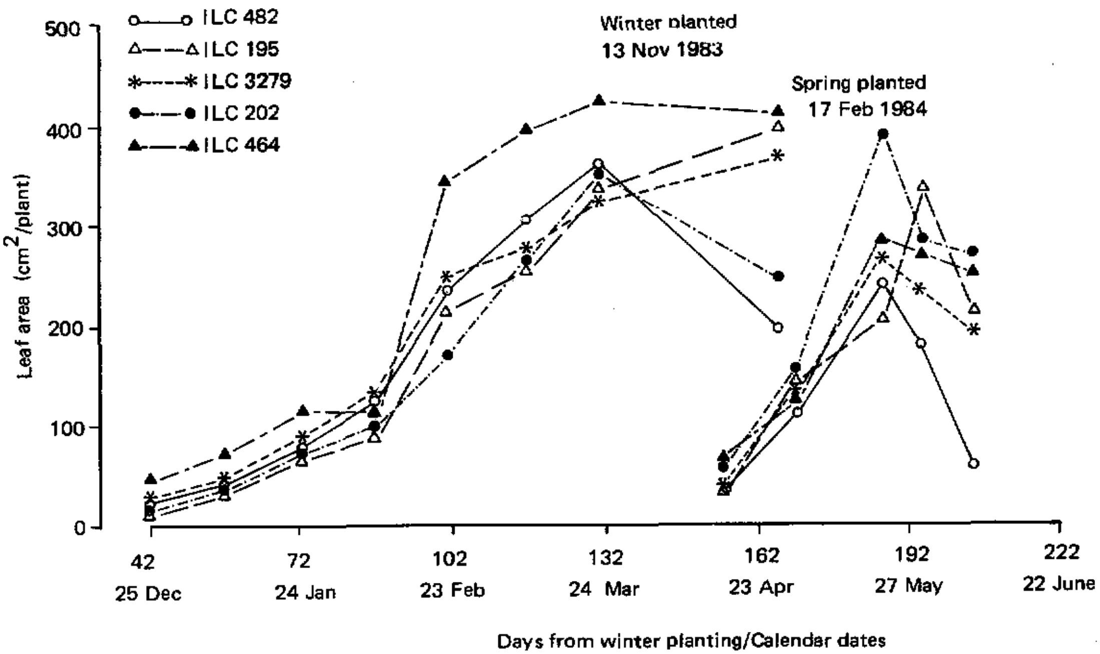


Fig. 31. Leaf area production (cm²/plant) of five promising winter chickpeas, planted in winter and spring, Tel Hadya, 1983/84.

1983/84 using the same five genotypes (ILC 195, 202, 464, 482, and 3279). Winter sowing was done on 13 November 1983 and the early spring sowing on 17 February 1984. The crop was rainfed and experienced drought.

The winter-sown crop achieved better ground cover, and maintained it for a longer period, than the spring crop. The growing period for the winter crop was about 192 days as against 114 days for the spring crop.

In the winter-sown plots, ILC 464 had the largest leaf area throughout the season (Fig. 31) and produced most dry matter (Fig. 32), whereas in the spring-sown plots ILC 202 generally maintained the largest leaf area and also produced the largest amount of dry matter per plant.

Consistent with the trend in leaf area and dry-matter production, ILC 464 gave the largest seed yield and harvest index in winter-sown plots (1342 kg/ha and 0.36, respectively). However, in the spring-sown plots ILC 482 gave the highest values (864 kg/ha and 0.46, respectively). Late-maturing genotypes such as ILC 3279 and ILC 202 gave smaller yields, particularly in the spring sowing, because of poorer harvest index (0.19 and 0.08 for winter- and spring-sown ILC 3279, and 0.19 and 0.15, respectively, for ILC 202). The late-maturing genotypes perhaps used most of the available moisture in vegetative growth, so reproductive growth suffered. The phenology of the relatively

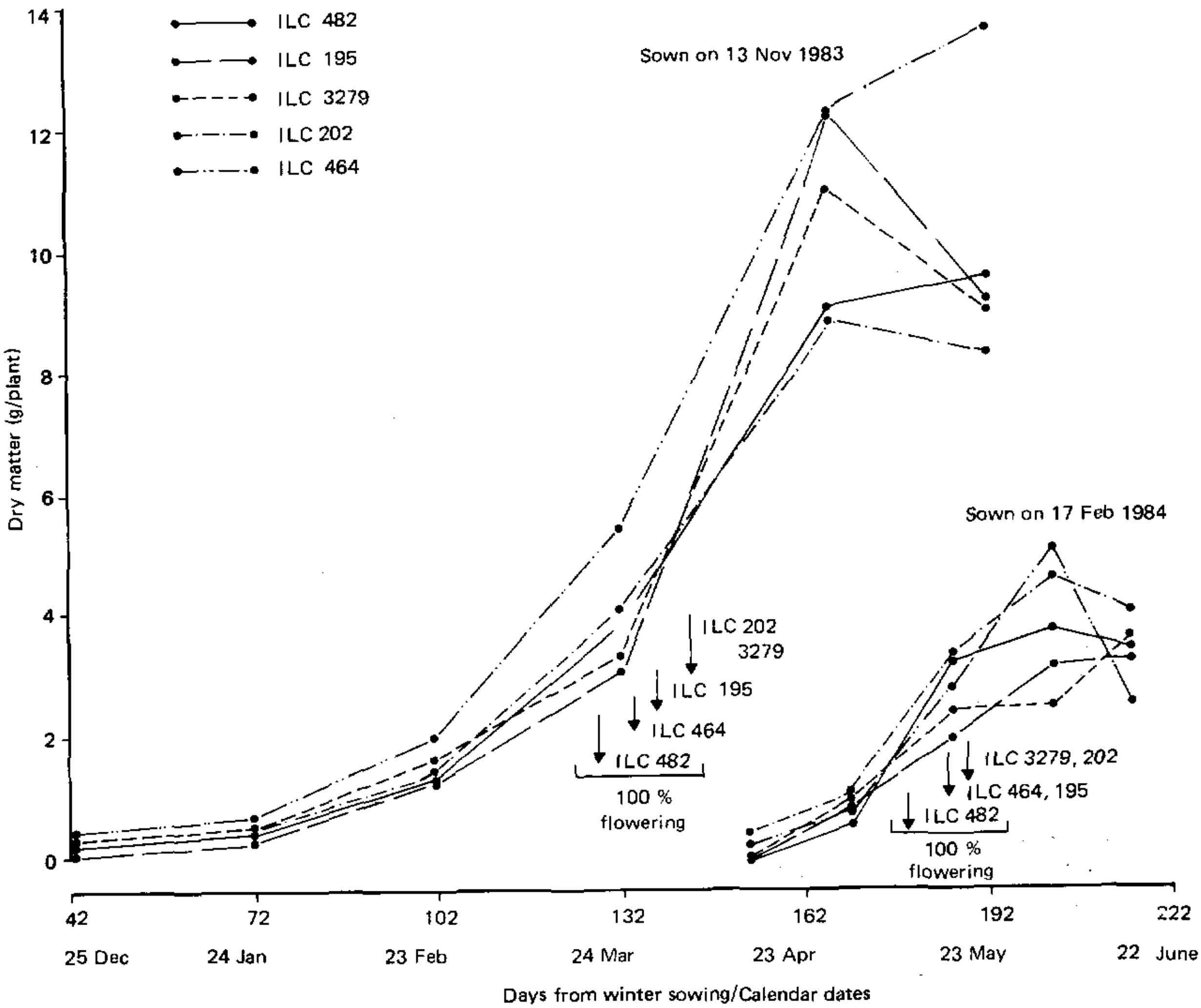


Fig. 32. Dry-matter production of five promising winter chickpeas sown in winter and spring, Tel Hadya, 1983/84.

early-maturing genotypes such as ILC 482 and 464 allowed them to make better use of the available water and thus produced higher yields than the other genotypes when sown in spring.

High Density Cropping to Increase Water-Use Efficiency

At traditional seed rates a winter-sown chickpea crop does not achieve ground cover during the first part of the growing season, which allows soil moisture to be lost as evaporation from the bare soil surface. If a large part of this evaporative loss could be converted to evapotranspiration, the productivity of the season's precipitation could be markedly increased. This was investigated for the second year in 1983/84 with chickpea planted at different row widths and with rows of barley planted between the chickpea rows. Treatment details and results are given in Table 58. Biological yield was maximized by growing barley between rows of chickpea planted at 30-cm row width, and then thinning it at the flowering stage of the chickpeas. However, this markedly reduced the chickpea seed yield, which was highest in the crop planted at 15-cm row width. Planting chickpea at 15-cm row width and then thinning to 30-cm row width at the flowering stage gave a significantly higher total biological yield without significantly reducing the chickpea seed yield. Intercropping chickpea with barley could be of significance in farming systems in which livestock play an important role.

Response to Date of Sowing and Population Density

An International Chickpea Date of Planting and Plant Population Trial was started in 1982/83 to determine the advantage of winter sowing over spring sowing in different production areas and

Table 58. Seed and total dry-matter yields (kg/ha) of ILC 482 as affected by cropping system, Tel Hadya, 1983/84.

Treatment	Seed yield (kg/ha)	Total dry matter (kg/ha): During vegetative phase	At flowering stage	At harvest (seed + straw)	For whole season
Chickpea at 15 cm row spacing	1360			2340	2340
Chickpea at 30 cm row spacing	1054			1816	1816
Chickpea at 60 cm row spacing	980			1706	1706
Thin from 15 to 30 cm during vegetative stage, removing 1 row of chickpea	1226	462		2050	2512
Thin from 15 to 30 cm at flowering, removing 1 row of chickpea	1225		938	2089	3027
Thin from 15 to 60 cm in two stages, removing 2 rows of chickpea	782	404	626	1222	2252
Thin from 15 to 30 cm during vegetative stage, *removing 1 row of barley*	1089	860		1842	2702
Thin from 15 to 30 cm at flowering, removing 1 row of barley	880		2644	1455	4099
Thin from 15 to 60 cm in two stages, removing 2 rows *of barley*	704	835	1048	1179	3062
CV (%)	16.6			17.2	12.1
LSD (5%)	250			439	460

also to determine optimum plant populations. During 1983/84, this trial was conducted at Tel Hadya, Jindiress, (Syria) and Terbol (Lebanon) using chickpea cultivar ILC 482. The winter sowing was done in November 1983 and the spring sowing in February 1984. Combinations of three plant populations (30, 45, and 60 plants/m²) and three row spacings (30, 40, and 50 cm) were used as subplot treatments, with the date of sowing as the main plot treatments.

The winter-sown crop produced significantly ($P \leq 0.05$) more total biological yield (5162, 3590, and 2232 kg/ha at Terbol, Jindiress, and Tel Hadya, respectively) than the spring-sown crop (3630, 1904, and 1438 kg/ha, respectively). The seed yield of the winter-sown crop was 43 and 121% more than that of the spring-sown crop at Tel Hadya and Jindiress, respectively, while at Terbol there was no significant differences due to cold weather during the reproductive growth phase.

Plant population did not affect the seed yield at any location in winter sowing, whereas in spring sowing the yield was significantly higher at 60 and 45 plants/m² than at 30 plants/m² at Tel Hadya and Terbol, respectively. Perhaps the extended reproductive period of the winter-sown crop permits greater plasticity than in the spring-sown crop.

The 30-cm row spacing appeared to be the best at all three locations, but gave significantly higher yield only at Terbol.

Management Practices

The effects of supplemental irrigation, plant population (22 vs 44 plants/m²), inoculation with *Rhizobium cicer*, phosphate fertilizer (0 vs 50 kg P_2O_5/ha), and nematicide (0 vs 10 kg a.i. aldicarb/ha) was investigated at Tel Hadya in 1983/84. A split-split-plot design was used, with irrigation (with and without) as main plots, inoculation treatments (with and without) as subplots, and a 2^3 factorial combination of the other factors as sub-subplots.

Supplemental irrigation had the greatest effect, significantly ($P \leq 0.01$) increasing seed yield by 105% over the nonirrigated treatment. Inoculation with *Rhizobium cicer* increased seed yield, but not significantly. The sub-subplot treatments showed no significant interaction with either irrigation or inoculation treatments. The main effects of plant population, phosphate application, and nematicide were significant, as were their interaction. The effects of these treatments, averaged across irrigation and inoculation treatments, are shown in Fig. 33. At the lower plant population only phosphate and aldicarb together significantly increased seed yield, while at the higher plant population

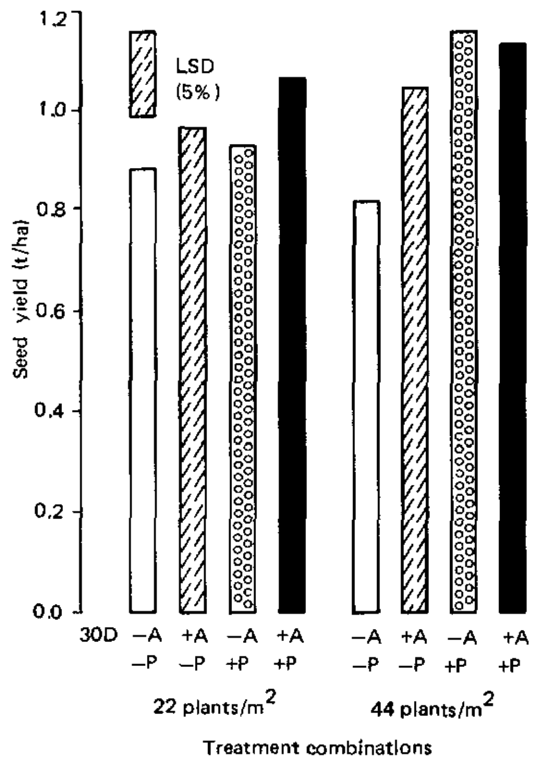


Fig. 33. Seed yield of ILC 3279 at two plant populations with and without P_2O_5 (50 kg/ha), and with and without aldicarb (10 kg a.i./ha) at Tel Hadya, 1983/84. The results are averaged over two levels of moisture supply (rainfed and irrigated) and with and without *Rhizobium cicer* inoculation. P = Phosphate, A = Aldicarb.

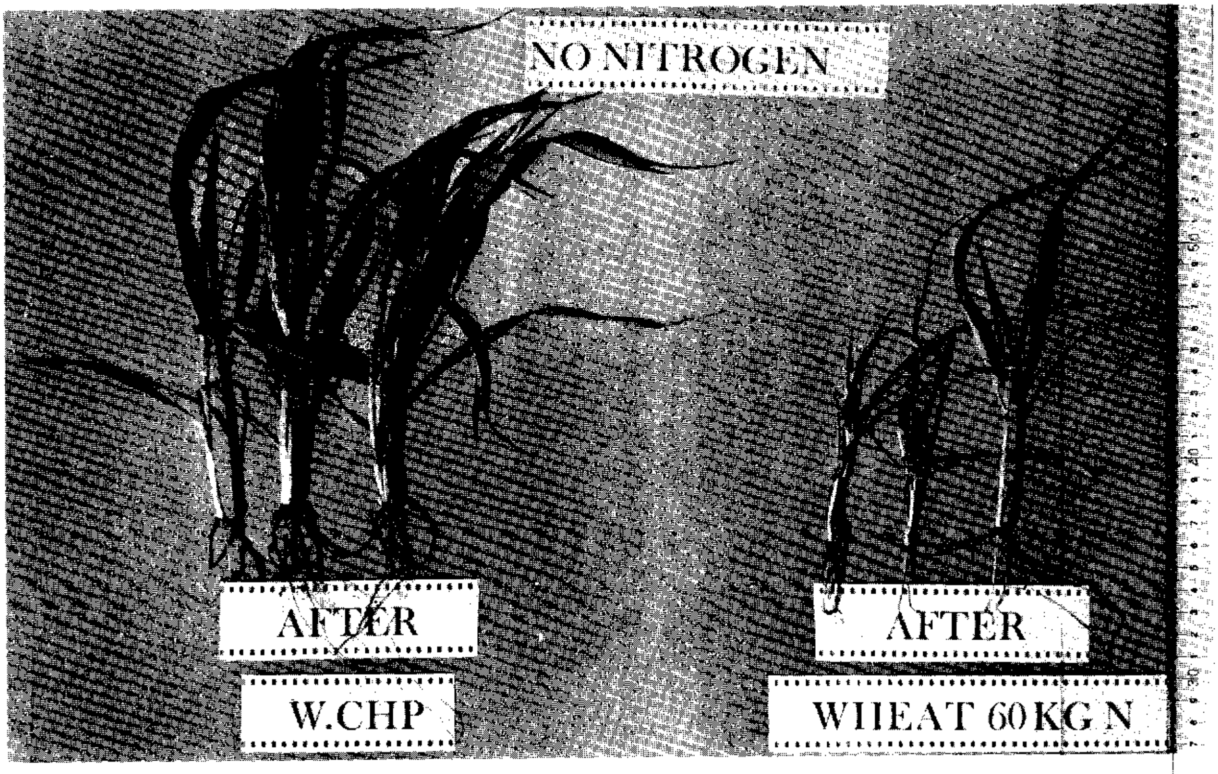
phosphate and aldicarb applied alone gave significant yield increases and there was no significant additive effect. The higher plant population plus phosphate gave the highest yield, while the lower population without phosphate or aldicarb gave the lowest yield.

The effects of phosphate and aldicarb can be explained by the low available phosphorus (< 2 ppm Olsen's P) and presence of cyst and lesion nematodes in the soil of the trial site. This study will be repeated in 1984/85. — *M.C. Saxena and M.V. Murinda.*

Role of Food Legumes in Dryland Agriculture

Cereals dominate in the dryland cropping systems in West Asia and North Africa. Despite very low soil nitrogen contents, farmers are reluctant to use nitrogen fertilizers due to their high cost and the risk of crop failure due to inadequate rainfall. As a result, cereal yields are low and inputs of nitrogen are needed to increase productivity. Legumes can provide a cheap source of nitrogen through their ability to fix atmospheric nitrogen. The productivity of cereal crops following annual food legumes, compared with following a fallow or cereal crop, has been studied at Tel Hadya since 1978/79. In 1983/84 wheat (S311 x Norteno) was used to assess the effects of different cropping treatments applied in 1982/83, details of which are given in ICARDA Annual Report 1983. The results for 1983/84 are reported here.

The wheat was sown in early November 1983. Each main plot representing the previous

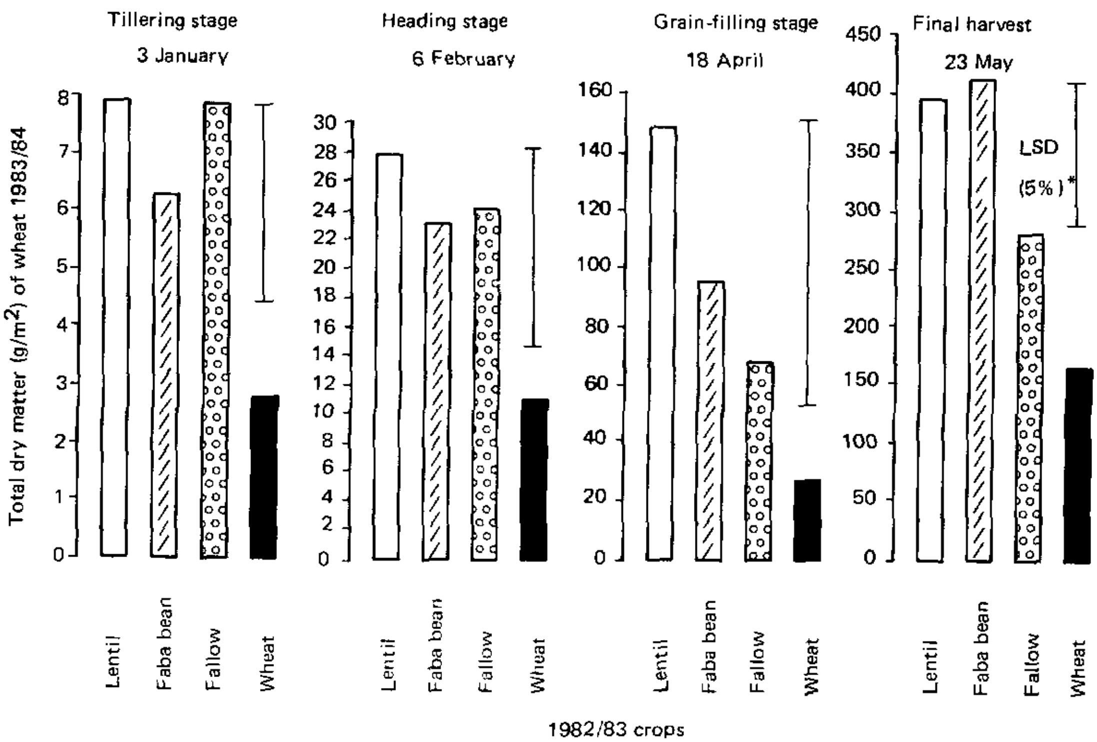


The beneficial effect of legumes over continuous cereal cropping becomes evident at a fairly early stage of crop growth. Left: wheat after winter chickpea; right: wheat after wheat. In both experiments, no fertilizer was applied.

season's cropping treatment was split into three subplots, which received 0, 30, or 60 kg N/ha as urea. All plots received a uniform basal application of 100 kg triplesuperphosphate/ha. The different rates of nitrogen were used to develop a nitrogen response curve for each treatment, from which the cropping-treatment effect on soil nitrogen status could be assessed. The N^{15} dilution technique was also used in a microplot in each of the subplots receiving 30 kg N/ha. Since the results of N^{15} analysis are not yet available from the International Atomic Energy Agency, data on growth, nitrogen accumulation, and yield of wheat in response to the previous season's cropping treatments and directly applied nitrogen fertilizer are reported here.

By mid-December the wheat crop which was preceded by wheat started showing conspicuous nitrogen deficiency. Plant analysis at tillering stage (3 January 1984) revealed that, without direct N fertilizer application, the nitrogen concentration in wheat following faba bean, peas, lentils, winter chickpeas, and fallow was significantly higher than in wheat following wheat. The total dry-matter accumulation of wheat following either a legume crop or a fallow was significantly higher throughout the season than in wheat following wheat (Fig. 34).

The effects of the previous season's cropping treatments on the grain yield of wheat at three levels of applied nitrogen fertilizer are shown in Fig. 35. Wheat following wheat gave the lowest grain yield. Wheat following faba beans or lentils harvested green for hay yielded more than wheat



* For comparing the 1982/83 crops' effect.

Fig. 34. Total dry-matter production (g/m²) in wheat (Norteno × S311) receiving no nitrogen, following various crops (1982/83), Tel Hadya, 1983/84.

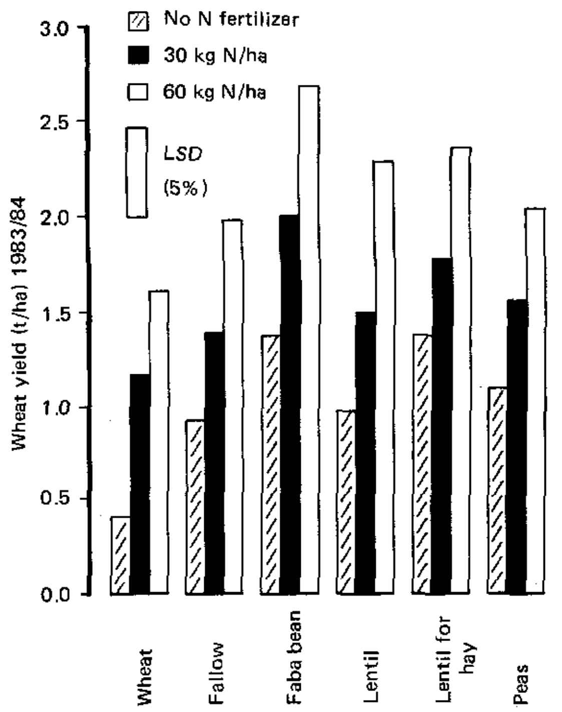


Fig. 35. Grain yield of wheat receiving three levels of nitrogen fertilizer (0,30, and 60 kg/ha) following wheat, fallow, peas, faba bean, and lentil, Tel Hadya, 1983/84.

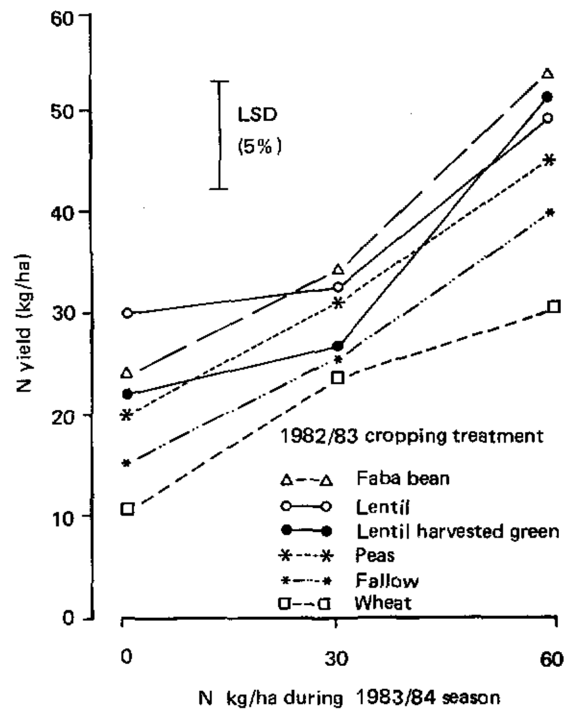


Fig. 36. Total nitrogen yield (kg/ha) in a wheat crop (Norteno × S311) grown at three levels of nitrogen (0, 30, 60 kg N/ha) as affected by previous cropping treatment, Tel Hadya, 1983/84.

preceded by a fallow. Yields of unfertilized wheat following fallow, lentil harvested green, and faba bean were 106, 205, and 211% larger, respectively, than the yield of wheat following wheat.

Comparing the nitrogen response surface indicated that unfertilized wheat following faba bean gave equivalent yield to wheat following wheat fertilized with about 40 kg N/ha (Fig. 35). The nitrogen yield of the wheat crop following the different cropping treatments (Fig. 36) also demonstrates the advantage of legumes over wheat or fallow under the rainfed cropping conditions of Tel Hadya. These results confirm those of previous seasons. — *M.C. Saxena and M.V. Murinda.*

Collaborative Projects

International Testing Program

The international nurseries play a significant role in disseminating improved germplasm to cooperators in different countries. We continued coordinating the international testing program between ICARDA and the legume scientists in the national programs. The main thrust continued to be on the identification of superior genotypes with wide adaptation, resistance to diseases, acceptable seed quality, and finding an optimum package of practices for food legumes in varying environments.

During 1983/84 we supplied nearly 1200 sets of 39 different types of nurseries and trials to 127 cooperators in 52 countries. Requests received for 1984/85 exceeded 1400 sets. The increasing awareness and interest of food legume scientists in the national programs in ICARDA materials is clearly shown by the increasing demand for these trials since 1977/78 (Fig. 37). For 1984/85 the Chickpea International Leaf Miner Nursery (CILMN) and the Faba Bean *Orobanche* Chemical Control Trial (FBOCCT) were introduced to meet the needs of the cooperators.

A number of cooperators requested large quantities of seed of some of the genotypes identified from the international nurseries and trials supplied by ICARDA and we have attempted to meet their requests. These genotypes will be tested by them in their multilocation or on-farm trials during 1984/85.

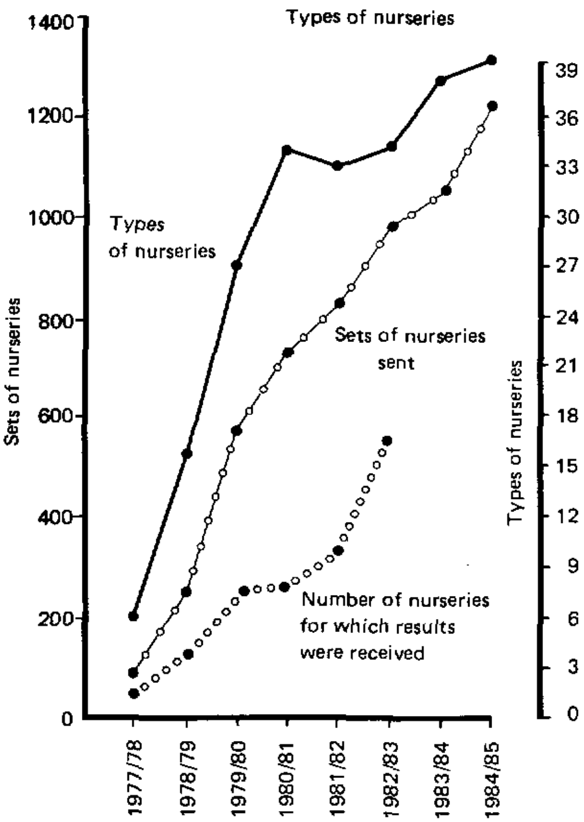


Fig. 37. *Food legume nurseries/trials supplied to cooperators from 1977/78 through 1984/85.*

During 1983/84 a new chickpea genotype, ILC 3279, with tall stature suitable for mechanical harvesting and with ascochyta blight resistance was released in Cyprus for winter sowing and was identified for possible release by the national program in Syria. Similarly, two genotypes, ILC 72 and ILC 202, have been identified for registration in Spain.

The international nursery report for the 1981/82 season was distributed to the cooperators with the international nurseries and trials in September 1984. The results for the 1982/83 season have been analyzed and the report is under preparation. The salient features of 1982/83 are presented here. — *R.S. Malhotra, W. Erskine, L.D. Robertson, M.C. Saxena, and K.B. Singh.*

Chickpeas

The yield data for the Chickpea International Yield Trial (CIYT) were reported from 23 locations, and at 12 locations several lines performed significantly better than the local checks. At Kufra (Libya), Merchouch (Morocco), Beja (Tunisia), Highmore (USA), and Setif and Guelino (Algeria) some lines outyielded the local checks by as much as 100%. The five best entries across locations were FLIP 81-65 (1396 kg/ha), ILC 482 (1386 kg/ha), FLIP 81-54 (1367 kg/ha) FLIP 81-52 (1365 kg/ha), and ILC 237 (1358 kg/ha).

In the Chickpea International Yield Trial-Winter reported from 40 locations, the local check was excelled by a significant ($P \leq 0.05$) margin by some entries at 16 locations: Setif (Algeria), Perugia (Italy), Marrow (Jordan), Islamabad, Lahore, and Peshawar (Pakistan), Patacao (Portugal), Breda, Hama, Homs, Izra'a, Jable, Jindiress, Lattakia, and Tel Hadya (Syria), and Bonn

(West Germany). All the test lines were resistant to ascochyta blight. The five best lines across locations were FLIP 81-56 W (1927 kg/ha), FLIP 81-41 W (1920 kg/ha), ILC 482 (1910 kg/ha), FLIP 81-57 (1843 kg/ha), and ILC 484 (1820 kg/ha).

In the Chickpea International Yield Trial-Large Seeded, a number of lines were superior to the local checks at 13 of the 30 locations: Setif and Khansai (Algeria), Saskatoon (Canada), Shandweel (Egypt), Apollinare (Italy), Zawia (Libya), Karia (Morocco), Sevilla (Spain), Al Ghab and Izra'a (Syria), Beja (Tunisia), and Pullman and Rapid City (USA). On the basis of performance across locations, ILC 72 (1550 kg/ha), ILC 165 (1545 kg/ha), ILC 451 (1532 kg/ha), ILC 134 (1515 kg/ha), and ILC 629 (1512 kg/ha) were the top yielders.

In the Chickpea International Screening Nursery at 21 locations, the test lines were among the 10 top yielders at 7 locations. FLIP 81-230, 81-225, 81-95, 81-37, and 81-208 gave the largest yields across locations but none of these was resistant to ascochyta blight under Tel Hadya conditions.

The Chickpea International F_3 Trials A and B revealed that out of 14 and 9 locations reporting yield performance, some of the F_3 populations excelled the local checks by a significant ($P \leqq 0.05$) margin at 8 and 3 locations, respectively. The best cross populations across locations in trial A were X81TH 111, X81TH 104, X81TH 56, X81TH 126, and X81TH 101, and in trial B were X81TH 117, X81TH 48, X81TH 55, X81TH 203, and X81TH 49.

Results from the Chickpea International Ascochyta Blight Nursery were reported from 12 locations in five countries. At three locations in Tunisia there was no disease infection. Out of the 49 lines tested, only one line, ILC 2380, was resistant/tolerant across locations. However, at each individual location several lines were resistant/tolerant.

The Chickpea Weed Control Trial revealed that weeds cause a heavy loss (43%) in seed yield. Igran (terbutryne) and Maloran (chlorbromuron) were found most effective as preemergence treatments to control weeds in chickpeas.

In the Chickpea Fertility-cum-Inoculation Trial across 8 locations, phosphate significantly ($P \leqq 0.05$) increased yields only at Karak in Pakistan and Jindiress in Syria. At Setif in Algeria, however, rhizobium inoculation alone or with potash application gave significantly higher yields than the control.

The results of the Chickpea Date of Planting-cum-Plant Population Trial showed that spring planting (in March) gave much smaller yield than winter planting (in November or December) and higher plant population densities gave more yield than the lower ones.

The Chickpea Iron Efficiency Trial conducted using two genotypes, one iron efficient and the other inefficient, revealed that spray of 0.5% ferrous sulphate did not increase the yield though the iron deficiency symptoms were apparently removed. — *R.S. Malhotra, M.C. Saxena, and K.B. Singh.*

Lentils

Some test lines outyielded the local checks in the Lentil International Yield Trial-Large Seeded at 7 of the 25 locations for which results were reported: Graneceros (Chile), Sakha (Egypt), Karadj (Iran), Leonessa (Italy), Sevilla (Spain), and Beja and Mateur (Tunisia). On the basis of overall performance across locations, the five best lines were ILL 707, ILL 28, ILL 8, ILL 842, and ILL 20 with 1272, 1265, 1197, 1174, and 1131 kg/ha seed yield, respectively.

In the Lentil International Yield Trial-Small Seeded, the seed yields of some of the lines were significantly ($P \leqq 0.05$) superior to local checks at Sidi Bel Abbis (Algeria), Mallawi (Egypt), Marrow (Jordan), Terbol (Lebanon), Merchouch (Morocco), Karak (Pakistan), Izra'a and Tel Hadya (Syria), and Izmir (Turkey). The highest yield across locations was reported for ILL 1 with

1476 kg/ha, followed by ILL 9, ILL 16, ILL 8, and ILL 975 with 1422, 1378, 1366, and 1304 kg/ha, respectively.

Yield results from four Lentil International Screening Nurseries (LISN) comprising Large (L), Small (S), Early (E), and Tall Erect (T-E) were reported from 19, 19, 15, and 19 locations respectively. Some test lines outyielded local checks significantly ($P \leqq 0.05$) at only 6, 6, 9, and 8 locations, respectively. The five best lines across locations in the four nurseries are shown in Table 59.

Results for the Lentil International F_3 Trial (LIF$_3$T) and Lentil International F_3Trial-Early (LIF$_3$T-E) were reported from 11 and 10 locations, respectively. In the LIF$_3$T, only one population, X81S 106, significantly ($P \leqq 0.05$) outyielded the local check only at Pullman in USA, while in the LIF$_3$T-E none of the populations performed better than the local check at any location.

In Weed Control Trials, weeds reduced the yield across locations by 44%. The herbicides Gesagard (prometryne) and Bladex (cyanazine) were effective in controlling weeds.

In the Lentil Fertility-cum-Inoculation Trial, inoculation and fertilizer application alone or in combination had no significant ($P \leqq 0.05$) effect on seed yield.

Early planting (November vs January) and higher plant populations increased seed yields in the Date of Planting and Plant Population Trial.

Faba Beans

Results of the Faba Bean International Yield Trial-Large Seeded were received from 21 locations in 14 countries. Only at one location, Perugia in Italy, did some of the lines outyield the local check by a significant ($P \leqq 0.05$) margin. The five best lines at Perugia were New Mammoth (ILB 1269), 80S 44027, 78S 49044, 75TA 26062, and Seville Giant (ILB 1933), with seed yields of 5980, 5688, 5375, 5238, and 5213 kg/ha, respectively, as against 3988 kg/ha for the local check.

The International Yield Trial-Small Seeded, reported from 24 locations, revealed that some of the test lines were significantly ($P \leqq 0.05$) better than the respective checks at Duralaman (Afghanistan), Saskatoon (Canada), Gorgan (Iran), Perugia (Italy), el-Marg (Libya), Patacao (Portugal), Sevilla (Spain), Tel Hadya (Syria), Beja (Tunisia), and Ankara (Turkey). The five best lines across locations were ILB 1217, ILB 407, ILB 1816, ILB 49, and ILB 1812 with average yield of 2654, 2563, 2553, 2543, and 2524 kg/ha, respectively. — *R.S. Malhotra, W. Erskine, and M.C. Saxena.*

Results from the two Faba Bean International Screening Nurseries (FBISN), Large Seeded (L) and Small Seeded (S), were received from 27 and 24 locations, respectively. At 11 locations in FBISN-L and 9 locations in FBISN-S some of the lines yielded significantly ($P \leqq 0.05$) more than

Table 59. The best five lines across locations in lentil screening nurseries, 1983/84.

	Name of nursery			
	LISN-L[1]	**LISN-S**	**LISN-E**	**LISN-T-E**
1	80S 42541	80S 41664	80S 44174	ILL 8
2	80S 42434	80S 41672	ILL 1	80S 44174
3	80S 41667	ILL 2194	80S 41672	ILL 23
4	80S 41671	80S 36013	ILL 2149	80S 41120
5	ILL 39	80S 41649	80S 41648	80S 41815

1. LISN = Lentil International Screening Nursery.
L = Large seeded, S = Small seeded, E = Early, T-E = Tall-Erect.

the respective local checks. The five best entries across locations in FBISN-L were 80S 44539, 80S 44371, 80S 81054, 79S 4, and 80S 46341, and in FBISN-S were X77TA 48, X77TA 101, X75TA 10, X77TA 48, and X77TA 33.

Among the two International F_3 Trials, including normal $FBIF_3T$ and early $FBIF_3T$-E, only one test population significantly ($p \leqq 0.05$) exceeded the local check in $FBIF_3T$ at Salerno in Italy and Tel Hadya-Irrigated in Syria. The best F_3 populations across locations in this trial were X81S 50, X81S 54, X81S 184, and X81S 45. In the $FBIF_3T$-E, however, none of the populations exhibited superiority over the local checks.

In the Weed Control Trial, weed infestation reduced yields by 29% across locations. Preemergence application of Igran (terbutryne) or Igran + Kerb (pronamide) gave effective weed control.

The Fertility-cum-Inoculation Trials, reported from six locations, showed that inoculation or fertilizer alone or in combination did not significantly ($P \leqq 0.05$) affect seed yield except at Setif in Algeria where inoculation or application of potash or both significantly increased yield.

The Date of Planting-cum-Plant Population Trial in Lebanon and Morocco revealed that early planting in November gave more yield than the January planting. Similarly, high plant population density gave better yield than low densities. — *R.S. Malhotra, S. Hanounik, L.D. Robertson,* and *M.C. Saxena.*

ICARDA/IFAD Nile Valley Project

This special project was started in 1979/80 season, and 1983/84 was the first year of Phase II. The objectives of the project are to test recommended faba bean cultivars and cultural practices in farmer's fields in the Nile Valley of Egypt and Sudan, identify constraints to their adoption, and to carry out back-up research to remove these constraints. A multidisciplinary team of national scientists from the two countries is responsible for planning and executing the project, with technical and logistical support from ICARDA, using funds provided by IFAD. Since the 1982/83 cropping season, a component of research on lentils has been included in the program of work for Sudan, in view of the increasing demand for and limited supply of this important food legume there. The achievements of the project in 1983/84 are given below.

On-Farm Trials in Egypt

On-farm research was carried out in three governorates with farmers' participation. Twenty-four trials in Kafr El-Sheikh, 18 in Minia, and 5 in Fayoum were conducted to study the following factors at test and farmers' levels: plant population and fertilizer, weed control, irrigation (in Minia and Fayoum governorates), and Diathane M 45 (mancozeb) spray (in Motobus district, Kafr El-Sheikh governorate).

The disaggregated analysis of data based on the concept of recommendation domain (RD) for each agronomic factor was adopted.

In Kafr El-Sheikh district, the test package increased yield by 0.46 t/ha (26.5%) over the farmers' practices in researcher-managed trials at 6 RD sites. In the farmer-managed trials the yield advantage of the test package was higher at 1.32 t/ha (58.4%) (Table 60).

In Motobus district the test package increased yield by about 27% (about 1.0 t/ha) over the farmers' package at 4 RD sites in both farmer- and researcher-managed trials (Table 60).

In Fayoum governorate, the researcher-managed on-farm trials at 3 RD sites gave consistently higher seed yields with test levels of plant population, fertilizer, and irrigation, and use

On-farm trials in the Minia Governorate of Egypt to demonstrate the advantages of the recommended test practices. Here, an Egyptian scientist (extreme left), in charge of the on-farm trial, discusses the recommended practices with farmers.

Table 60. Effect of test factors on seed and straw yields (% increase over farmers' practices) in on-farm trials in Kafr el-Sheikh and Motobus districts, Egypt, 1983/84.

	Researcher-managed trials				Farmer-managed trials			
	Kafr el-Sheikh		Motobus		Kafr el-Sheikh		Motobus	
Treatment	Yield %	Straw %	Yield %	Straw %	Yield %	Straw %	Yield %	Straw %
Plant population and fertilization	11.1	14.3	16.2					
Weed control with Igran	14.5	2.5	8.9					
Effect of the whole package	26.5	12.4	25.4		58.4	31.4	27.7	25.2

of Igran to control weeds (Table 61). The whole test package gave an average seed-yield increase of 1.68 t/ha (61.0%) over the farmers' package at three sites.

In Minia governorate, researcher-managed trials at 8 RD sites gave consistently higher seed yield at the test plant population and fertilizer levels. At 7 RD sites with moderate weed infestation, use of Igran herbicide increased seed yield by 9.3% (0.37 t/ha) over the farmers' weed control practice. The whole test package increased seed yield, on an average of 11 RD sites, by about 8% in these researcher-managed trials. In the farmer-managed trials in Minia district, the increases with the whole test package were larger at 0.96 t of seed/ha (29.5%) than in the researcher-managed trials (Table 61).

Three on-farm trials on *Orobanche* sp. control were conducted in Minia in naturally infested fields to test four treatment combinations involving the use of Giza 402 (tolerant) and Giza 2 (susceptible) cultivars with a test package of high population and fertilizer application and use of glyphosate, compared with farmers' practices. The test package increased seed yield by 119, 33, and 7% at the three sites.

Economic analysis of these trials revealed a high net return from the test package at the RD sites. The partial budget revealed that in the researcher-managed on-farm trials the net benefit from the test package ranged from Egyptian £ 72 to 85/ha in Kafr El-Sheikh, 20-105/ha in Minia, and was £ 323/ha in Fayoum. In the farmer-managed trials, the test package gave higher net benefits, at Egyptian £ 202, 150, 119, 159, and 202/ha in Kafr El-Sheikh, Motobus, Samalot, Abo Korkas, and Fayoum respectively.

On-Farm Trials in Sudan

On-farm trials were conducted in the Zeidab, Aliab, and Selaim areas in the Northern Province of Sudan during the 1983/84 season. The improved package, consisting of early planting, frequent irrigation, pest control, and timely weeding, resulted in very significant yield increases at most test sites in all three areas. The average seed yield increase over farmers' practice was 100% (1.53 t/ha) in Zeidab, 66.7% (1.11 t/ha) in Aliab, and 24.1% (0.59 t/ha) in Selaim. Averaged across locations, the recommended package increased net benefits by Sudanese £ 658 at Zeidab, 531 at Aliab, and 766 at Selaim.

Table 61. Increase over the farmers' level in seed and straw yields due to different test factors in on-farm research-managed trials (RMT) and farmer-managed trials (FMT) in Fayoum and Minia Governorates, Egypt, 1983/84.

	Minia				Fayoum			
	RMT		FMT		RMT		FMT	
Treatment	Seed %	Straw %	Seed %	Straw %	Seed %	Straw %	Seed %	Straw %
Plant population and fertilization	16.6	15.6			15.0	24.9		
Weed control (Igran)	9.3	4.4			21.1			
Irrigation	6.9				23.0	34.6		
Plant population and irrigation	20.0	21.2						
Whole package	7.8	7.8	29.5	32.9	61.0	72.0	22.3	29.7

Pilot Production/Demonstration Program in Zeidab Scheme

Farmer-managed trials conducted in the Zeidab and Aliab Schemes in 1982/83 showed that the recommended package of early planting, more frequent irrigation, and pest control was highly profitable. Encouraged by these results, a pilot production/demonstration program was started in 1983/84 to evaluate the recommended package on larger plots managed entirely by farmers.

The grain yield of the individual pilot production/demonstration plots was considerably higher than that of neighboring farms (general practices) throughout the Zeidab scheme (Table 62). The yield gap ranged from 0.34 to 2.39 t/ha (16-276%), with an overall mean of 0.92 t/ha (75.4%).

The net return from the pilot production/demonstration plots was S£ 119 more than that from local farms, with a marginal rate of return of 159%. Moreover, the coefficients of variation indicated less variability in both returns from and costs of the improved package.

Back-Up Research in Egypt and Sudan

Most of the back-up research was carried out at research stations in the two countries. In Sudan,

Table 62. Grain yield of pilot production/demonstration plots compared with neighboring farmers' fields in Zeidab scheme, Sudan, 1983/84.

	Pilot production/demonstration plots				Av. yield of neighboring farms	Increase in yield over neighboring farms	
Section	Plot No.	No. of farmers	Total area (ha)	Average yield (t/ha)	(t/ha)	t/ha	%
Northern Sect.	1	3	6.9	1.94	1.28	0.66	51
"	2	4	6.6	2.81	2.14	0.67	31
"	3	6	7.8	3.04	1.69	1.35	80
"	4	13	18.3	2.44	2.09	0.34	16
Abu Selaim	5	3	4.9	2.01	1.14	0.87	76
"	6	2	5.0	2.30	0.77	1.53	198
"	7	2	3.6	2.39	1.90	0.48	25
"	8	1	1.3	2.77	0.76	2.01	263
"	9	2	2.9	3.48	1.09	2.39	218
Section 4	10	5	8.6	1.93	0.76	1.17	153
"	11	4	5.5	1.62	0.95	0.67	70
"	12	3	3.5	1.66	0.95	0.70	74
"	13	2	1.9	1.47	0.95	0.52	55
"	14	1	1.8	2.28	1.09	1.18	108
"	15	4	12.6	1.79	0.47	1.31	276
"	16	7	11.5	2.04	1.02	1.02	100
"	17	5	8.4	1.63	1.26	0.37	29
Southern Sect.	18	1	2.5	1.64	1.00	0.64	64
"	19	5	13.2	2.17	1.62	0.56	34
"	20	1	3.8	1.50	1.05	0.45	43
"	21	3	8.9	1.97	1.52	0.44	29
Mean			1.81	2.14	1.22	0.92	75.4

emphasis was on the development of agronomic practices and identification of faba bean genotypes suitable for both traditional (northern Sudan) and nontraditional (south of Khartoum) areas, with higher and more stable yield, resistance to wilt, root rots, powdery mildew, and aphid damage, and tolerance to high temperature and drought stress. Also, studies were carried out on aspects of lentil improvement with emphasis on production practices.

In Egypt, emphasis was on development of agronomic practices and identification of higher yielding breeding lines for different cropping systems and development of lines resistant to *Orobanche* sp. and major foliar diseases. — *National program scientists from Egypt and Sudan.*

Collaborative Research with the Syrian National Program

Applied research in collaboration with the Syrian national program (ARC-Douma) on the improvement of food legumes (kabuli chickpeas, *lentil, and faba bean) continued during* 1983/84. This collaboration included the conduct of yield trials (44 breeding trials and 47 disease and pest screening nurseries and control trials), agronomic experiments (8), and on-farm trials (29) in various parts of the country covering *different environments.* Results of chickpea and lentil on-farm trials have already been reported in an earlier section.

Cooperation on faba bean improvement consisted of regional irrigated (FBRYT-I-84) and rainfed (FBRYT-R-84) yield trials and special disease screening nurseries. In the irrigated trial, Cyprus local and H4 gave the highest average yield across all locations. Cyprus local showed good yield stability across sites. The top yielding lines in the rainfed faba bean regional trial during the 1983/84 season were Cyprus local, 78S 33202, and 78S 49897, yielding an average of 0.9 t/ha. The best lines for both 1983 and 1984 were 78S 49395 and 78S 33202 giving an average of 1.9 t/ha.

Food legume agronomy trials, conducted at three locations, included fertilizer, rhizobial inoculation, and weed control. Weeds significantly ($P \leq 0.05$) reduced chickpea seed yields at all locations, but a number of herbicides provided good weed control. At Gellin, Tribunil (methabenzthiazuron) at 3 kg a.i./ha plus Kerb (pronamide) at 0.5 kg a.i./ha applied preemergence gave best control of weeds.

At Izra'a, lentil yield loss due to weeds was estimated at 754 kg/ha. A number of herbicide treatments significantly ($P \leq 0.05$) increased seed yield, the best of which were Maloran (chlorbromuron) at 1.5 kg a.i./ha plus Kerb at 0.5 kg a.i./ha and Bladex (cyanazine) plus Kerb at 0.5 kg a.i./ha each, applied preemergence.

At Hama, weed infestation was low and did not significantly affect faba bean seed yields. — *Syrian national program scientists.*

ICARDA Tunisia Cooperative Project

In this cooperative project between ICARDA and the Institut National de la Recherche Agronomique de Tunisie (INRAT), a food legume breeder from ICARDA and Tunisian food legume scientists worked together to identify superior genotypes and production techniques for all three food legumes. This season, the program for all three species involved yield-testing advanced breeding lines and populations in replicated yield trials, agronomic assessment of a large number of preliminary breeding lines and early generation populations in observation nurseries, and screening genetic material in a range of disease nurseries. The data presented in this report are mainly results from the replicated yield trials. Results from the disease nurseries are reported where adequate levels of infection were obtained to ensure effective resistance screening. The results from agronomic studies are also reported.

Faba Bean Breeding

The program encompasses the improvement of large- and small-seeded types through selection of larger yielding genotypes and identification of sources of resistance to prevalent pests and diseases such as chocolate spot, *Orobanche* spp., and stem nematodes. Generally, disease incidence was low during 1983/84, but there were localized attacks of *Orobanche* spp. and stem nematodes, and the former resulted in very high coefficients of variation for the yield data from the Beja location. However, disease screening will continue to receive considerable emphasis.

Fifty-seven large-seeded advanced breeding lines were assessed for yield at two or three locations in three trials; an international yield trial from ICARDA (IYT) with 23 lines, an advanced yield trial (AYT) with 14 lines, and a preliminary yield trial (PYT) with 20 lines. In these trials, only 10 lines in the AYT at one location significantly outyielded the local check (Table 63). However, a number of lines exceeded the check at in-

Table 63. Seed yield (SY) in kg/ha and as percent of local check of superior-yielding large-seeded faba bean lines in three trials in Tunisia, 1983/84.

		Location							
		Beja		el-Kef		Mateur		Mean	
Trial	Entry	SY	%	SY	%	SY	%	SY	%
IYT	ILB 1269 New Mammoth	1025	129	2358	93			1692	101
	1280 Reina Blanca	933	118	2267	89			1600	96
	282 79 SL 48950	1075	136	2083	82			1579	95
	1933 Seville Giant	1173	148	1917	75			1545	93
	1814 79 S4	1125	142	1775	70			1450	87
	Tunisian Local	792	100	2542	100			1667	100
	CV (%)	46.1		14.0					
	SE ±	216.2		154.1					
AYT	ILB 10	981	133	2700	107	3291[a]	165	2324	133
	398	1075	146	3306	131	2497	125	2293	131
	1266	1481	201	2425	96	2728	137	2211	126
	1217	1100	150	2575	102	2787	139	2154	123
	1269 New Mammoth	1194	162	2388	162	2787	139	2123	121
	Tunisian Local	735	100	2519	100	1998	100	1751	100
	CV (%)	39.6		20.2		19.2			
	SE ±	210.5		253.9		245.9			
PYT	BPL 472	713	82	4625	160			2669	141
	552	813	93	3700	128			2257	120
	2488	1163	133	3175	110			2169	115
	435	713	82	3550	122			2132	113
	1814 Syr. Loc. Large	950	109	3150	109			2050	109
	Tunisian Local	875	100	2900	100			1888	100
	CV (%)	44.2		29.2					
	SE ±	234.3		630.1					

a. Values underlined significantly ($P \leq 0.05$) exceeded the local Tunisian check.

dividual locations. Yield data for the five heaviest-yielding lines across locations in each trial are given in Table 63.

Ninety-five small-seeded advanced breeding lines were tested at two or three locations in six trials, an IYT from ICARDA with 23 lines, two AYTs with 25 lines, and three PYTs with 47 lines. Within these trials only one line in an AYT at one location showed a significant yield improvement over the local check. Again a number of lines exceeded the check, and yield data for the five heaviest-yielding lines across locations in AYT-1 are given in Table 64.

These results reflect those of the previous two seasons, in that little or no consistent improvement in seed yield over the local check has been evident. In all three seasons the material tested comprised lines selected at ICARDA, Aleppo, and cultivars from Europe, and the failure of this strategy to produce significant yield improvements suggests that faba bean genotypes/cultivars exhibit limited adaptability. To overcome this the breeding strategy is now placing greater emphasis on testing and selecting early generation breeding lines and populations from the ICARDA Aleppo program and material contained in ICARDA's germplasm collection under local environmental conditions.

Chickpea Breeding Program

Sowing date trials in 1983/84 again confirmed the yield advantage of winter versus spring sowing, and these practices will be extensively tested in farmers' fields next season. At present, however, the chickpea crop is largely planted in spring and the program is breeding for both winter- and spring-sown crops. Ascochyta blight resistant genotypes are a prerequisite for winter planting, and although little blight occurred naturally this season it is always a potential danger for both winter and spring sowings. All the genetic material received from ICARDA had been previously screened for resistance to ascochyta blight, and this season a number of winter-sown trials at Beja were artificially inoculated with a locally occurring race of the pathogen.

Last season's report indicated that a *Fusarium* sp. caused the wilt symptoms observed on experiment stations and in farmers' fields, and that this disease could prove as big a constraint to production as ascochyta blight. More detailed work this season, both field surveys and in the laboratory, has confirmed the importance of wilt. Also, both *Fusarium* spp. and *Verticillium* spp. have been isolated from wilt-infected plants and

Table 64. Seed yield (SY) in kg/ha and as percent of local check, of superior-yielding small-seeded faba bean l[illegible] in AYT-1, Tunisia, 1983/84.

			Location							
			Beja		el-Kef		Mateur		Mean	
Entry			SY	%	SY	%	SY	%	SY	%
× 77 Sd	11	80S 45676	881	110	1950	100	3546	122	2126	1[illegible]3
ILB	9	74 TA 22	500	63	1963	100	3727[a]	129	2063	1[illegible]0
	269	74 TA 367	713	89	2000	102	3421	118	2045	1[illegible]9
	269	78S 48821	994	124	1931	99	3175	110	2033	1[illegible]8
	407	78S 49395	725	91	1806	92	3421	118	1984	1[illegible]5
Tunisian Local			800	100	1956	100	2896	100	1884	1[illegible]0
CV (%)			47.7		26.7		16.7			
SE ±			178.2		240.9		256.6			

a. Significantly ($P \leq 0.05$) outyielded Tunisian Local check.

it seems likely that other as yet unidentified fungi may also be involved, suggesting that there is a root rot/wilt complex.

In the winter program, 99 advanced breeding lines and 42 F_3 populations were assessed for seed yield at two locations in eight trials: two international yield trials (IYT 1 and 2) from ICARDA each with 23 lines, one advanced yield trial (AYT) with 16 lines, three preliminary yield trials (PYT) with 37 lines, and two F_3 populations trials (F_3YT) each with 21 entries. The trials at Beja inoculated with ascochyta blight showed a good level of infection, whereas at el-Kef only a low level of natural infection occurred. Also, at Beja an unidentified soil problem caused very poor growth in half of the replicates of a number of trials resulting in very high (> 50%) coefficients of variation for seed yield.

A number of lines/populations in the IYTs, AYT, F_3YTs, and PYT 1 yielded more than the local check at one or both locations but none did so significantly. Yield data on the five heaviest-yielding lines at el-Kef in the IYT-1, F_3YT-1, and F_3YT-2 are given in Table 65. In the PYT 2 and 3, however, eight and three lines, respectively, significantly outyielded the local check but only at one location (Table 66). Unfortunately none of these lines showed a good level of resistance to either ascochyta blight or wilt, but could prove useful as parents in a crossing program after further yield evaluation. Single-plant selections from the best F_3 populations will be advanced for disease screening.

In the spring program, 120 advanced breeding lines and 30 F_4 populations were yield tested in seven trials at one or more locations. Of the 120 lines 42 lines were in the two ICARDA IYTs (IYT 1 and 2) but none significantly outyielded the local check. Of the remaining lines, 43 stemmed from single-plant selections for resistance to wilt made in the local landrace "Amdoun" from the Beja region, and were tested in two trials (WT 1 and WT 2) in the wilt-sick plot (WSP) at Beja. All lines, except two, yielded significantly more than the local (unselected) check and yield data on the best five in each trial are given in Table 67. Both their yield levels and wilt ratings confirmed the levels of resistance observed in nurseries during the previous two seasons. Twenty-eight F_4 populations, stemming from 1982/83 ICARDA trials, were also grown in the WSP in two trials. In both trials it appeared that the local check had undergone some previous selection for wilt resistance as both wilt rating and seed yield of

Table 65. Seed yield (SY) in kg/ha and as percent of local check, of superior-yielding chickpea lines in the IYT-I and F_3 populations in the F_3 YT-I and F_3 YT-2 at el-Kef, Tunisia, 1983/84.

Trial								
IYT-I			F_3YT-I			F_3YT-2		
	SY			SY			SY	
Entry	kg/ha	%	Entry	kg/ha	%	Entry	kg/ha	%
FLIP 81-293	1975	113	× 82 TH 80	1749	107	× 82 TH 156	1608	153
81-57 W	1950	112	168	1691	103	152	1575	150
ILC 482	1944	111	82	1650	100	77	1525	145
1929	1888	108	88	1650	100	99	1442	137
FLIP 81-29	1738	100	102	1599	97	158	1442	137
Tunisian Local	1744	100	Tunisian Local	1642	100	Tunisian Local	1050	100
CV (%)	5.3		CV (%)	17.7		CV (%)	21.0	
SE ±	106.5		SE ±	152.9		SE ±	152.8	

Table 66. Seed yield (SY) in kg/ha and as percent of local check, of superior-yielding chickpea lines in the PYT-2 and PYT-3 in Tunisia, 1983/84.

		Location					
		Beja		el-Kef		Mean	
Trial	Entry	SY	%	SY	%	SY	%
	FLIP 81 - 131	1411	102	2367[a]	175	1889	138
	- 176	1622	117	1933	143	1778	129
	- 156	1478	106	2067	152	1773	129
	- 149	1567	113	1822	134	1695	123
	- 187	1478	106	1878	138	1678	122
PYT-2	- 180	1378	99	1833	135	1606	117
	- 181	1167	84	1922	138	1545	113
	Tunisian Local	1389	100	1356	100	1373	100
	CV (%)	24.8		18.5			
	SE ±	198.9		184.5			
	FLIP 81 - 218	1833	141	911	104	1372	146
	- 251	1788	138	879	100	1334	142
	- 229	1655	127	989	113	1322	141
PYT-3	- 391	1400	108	1167	133	1284	137
	- 208	1155	89	1322	151	1239	132
	Tunisian Local	995	100	878	100	937	100
	CV (%)	23.7		31.0			
	SE ±	182.2		186.7			

a. Values underlined significantly (P ≦ 0.05) exceeded the local check.

Table 67. Seed yield (SY) in kg/ha and as percent of local check, of superior-yielding chickpea lines tolerant to wilt, grown in the WSP at Beja, Tunisia, 1983/84.

Trial					
WT 1			WT 2		
Entry	SY	%	Entry	SY	%
PL - Se - Be-81 - 87	1881[a]	409	FTA (82) 39	1375	352
103	1794	390	13	1375	352
84	1738	378	41	1263	323
6	1731	376	12	1188	304
120	1654	360	33	1175	301
Tunisian Local	460	100	Tunisian Local	391	100
CV (%)	22.6		CV (%)	26.4	
SE ±	155.1		SE ±	177.4	

a. Values underlined significantly (P ≦ 0.05) exceeded the local check.

the check were reasonable, and no population significantly outyielded the check. In spite of the high coefficients of variation for seed yield, F_5 progeny-bulks, stemming from F_3 single-plant selections, from the best populations will be evaluated in 1984/85 simultaneously for resistance to wilt and ascochyta blight.

In view of the importance of ascochyta blight and wilt, the aim is to breed cultivars combining resistance to both diseases. As such, all the genetic material entering the program was screened in the WSP for wilt resistance. Most of the material was found to be highly susceptible but some lines showed a good level of resistance (less than 5 on a 1 to 9 scale, where 1 = no symptoms and 9 = complete kill). For example, in two winter-planted trials, one out of 23 lines in the IYT and four of 63 lines in a screening nursery showed acceptable levels of resistance to wilt, and such lines can be expected to have a good level of blight resistance. Furthermore, in the International Ascochyta Blight Nursery good levels of infection were recorded for both blight and wilt and it was encouraging that 18 out of the 70 lines tested proved to be resistant to both diseases (Table 68). All the lines that showed dual resistance will be further evaluated for yield and disease resistance next season, and those

Table 68. Ascochyta blight ratings (ABR) and wilt ratings (WR) for selected entries in the International Ascochyta Blight Nursery at Beja, Tunisia, 1983/84. (Disease rating on 1-9 scale where 1 = no symptoms and 9 = complete kill).

Entry	ABR	WR	Entry	ABR	WR
ILC 182	2	2	FLIP 81-71	3	3
196	2	4	75	4	3
200	2	4	82-1C	4	1
201	2	3	26C	4	3
215	4	4	61C	2	1
3856	4	4	74C	4	3
4421	4	2	91C	4	4
ICC 6304	4	3	99C	4	3
6306	2	3	100C	4	3

with acceptable seed quality will be used as parents in crosses with wilt-resistant selections from "Amdoun".

Other work on dual resistance concerns the cross ILC 237 × ILC 191 which was an entry in a 1982/83 F_3 population trial. Last season it was noted that ILC 237 was resistant to wilt and ILC 191 is known to be resistant to blight. Accordingly F_3 single-plant selections were made and the resulting F_4 progenies screened this season in the WSP. A large number exhibited good wilt resistance and those with acceptable seed quality will be simultaneously screened for wilt and blight resistance next season.

Lentil Breeding Program

In the previous two seasons the number of entries that significantly outyielded the local check suggested that meaningful advances could be achieved over the local cultivar. In 1982/83, however, when four local cultivars were tested in two trials it was evident that the local cultivar from Beja, which had been used as the check in the previous two seasons, was considerably lower yielding than the other three. Accordingly it seems possible that the potential for achieving advances over the local cultivar(s) had been over estimated and further evaluation was required using the heaviest yielding of the local cultivars, from Oueslatia, as the local check in all trials.

During the 1983/84 season, 153 advanced breeding lines were tested at one or two locations in replicated yield trials, namely an international yield trial from ICARDA (IYT) with 23 lines, an advanced yield trial (AYT) with 19 lines, and six preliminary yield trials (PYT) with 111 lines. In addition, 78 F_3 populations from ICARDA were tested in two F_3YTs, with 40 and 38 entries respectively.

Ten lines in the IYT and three in the PYT 3 (Ta) significantly outyielded the local check at Beja (Table 69). Those from the latter trial are tall types that can be harvested with a cutter bar. A

Table 69. Seed yield (SY) in kg/ha and as percent of local check, of superior-yielding lentil lines in the IYT and PYT 3 (Ta) in Tunisia, 1983/84.

		Location					
		Beja		el-Kef		Mean	
		SY		SY		SY	
Trial	Entry	kg/ha	%	kg/ha	%	kg/ha	%
IYT	ILL 19 78 S 26018	1692[a]	153	1442	104	1567	126
	20	2167	196	767	55	1467	118
	26 78 S 26033	1625	147	875	63	1250	100
	28 74 TA 19	1558	141	1275	92	1417	114
	762 74 TA 276	1692	153	1050	76	1371	110
	842	1617	146	1400	101	1509	121
	4400 Syrian Local	1583	143	975	70	1279	103
	4523	1567	141	1208	87	1388	111
	4606 Nablus	1850	167	767	55	1309	105
	FLIP 84 - IL	1508	136	983	71	1245	100
	Tunisian Local	1108	100	1383	100	1246	100
	CV (%)	16.5		24.7			
	SE ±	140.7		152.9			
PYT 3 (Ta)	ILL 8	1806	143	1038	106	1422	127
	9	1750	139	788	81	1269	113
	Tunisian Local	1263	100	975		1119	100
	CV (%)	21.6				23.3	
	SE ±	154.2				106.8	

a. Values underlined significantly (P ≤ 0.05) exceeded the local check.

further 15 lines from the PYT 4 and PYT 6 also showed a significant improvement in seed yield over the check at the INRAT station in Tunis (Table 70). These 15 lines had previously been rejected on the basis of yield in the base program at ICARDA, Aleppo, and although the mean yields at INRAT were low and the coefficients of variation high, the results indicate that selection pressure at ICARDA could be eliminating material of potential value for Tunisia. However, further yield evaluation is required before any definite conclusion can be reached. Of the 78 F_3 populations only eight in the F_3YT 2 significantly outyielded the check at Beja (Table 70).

In spite of the exclusive use of the Oueslatia check in all trials, this season's results still indicate that there are lines which yield more than the local cultivars. The yield data presented in Table 71 for four lines over 3 years tend to confirm this, although it may be pointed out that Beja was the local check in the first 2 years of testing.

Agronomic Studies

Agronomic experiments were conducted at Beja and el-Kef research stations to determine optimum production practices for the three legumes. Factors tested were date of planting, plant population, fertilizer application, and weed control. In all these studies the best adapted local cultivars were used and the crop was protected from pests and diseases.

Table 70. Seed yield (SY) of superior-yielding lentil lines in the PYT 4 and PYT 6 at the INRAT station and F_3YT-2 at Beja, Tunisia 1983/84.

PYT 4		PYT 4		F_3YT-2	
Entry	SY (kg/ha)	Entry	SY (kg/ha)	Entry	SY (kg/ha)
81 S - 31341	577	81 S - 35563	164	× 82 S- 180	1325
28055	336	34744	258	186	1450
33045	497	35777	202	207	1225
33706	269	33726	311	230	1125
33488	390	32654	218	238	1313
32430	348	35786	256	243	1263
Tunisian Local	75	35836	161	245	1163
		35553	165	246	1288
		28082	292	Tunisian Local	604
		Tunisian Local	21		
CV (%)	47.7	CV (%)	59.5	CV (%)	34.2
SE ±	68.4	SE ±	46.7	SE ±	208.9

Table 71. Seed yield (kg/ha) of four lentil lines over three seasons at Beja (B) and el-Kef (K), Tunisia.

	Season						
	1981/82		*1982/83*		*1983/84*		
Entry	B	K	B	K	B	K	Mean
ILL 4354	1634	1716	1904	1253	1358	792	1443
ILL 4400	1774	1334	1796	1350	2000	1167	1570
Tunisian Local	1059	625	1225	633	1592	475	935
SE ±	227.1	139.5	141.5	74.3	232.8	138.1	
ILL 28	1685		1583	1363	1558	1275	1493
ILL 262	1683		1562	1304	1692	1050	1458
Tunisian Local	665		754	1113	1108	1383	1005
SE ±	219.3		65.5	138.1	140.7	152.9	

Faba beans. Date of sowing and plant population affected the seed yield of both *major*- and *minor*-type faba beans at both sites (Fig. 38). At el-Kef, planting before 10 December gave the largest yields and there was a sharp decline in yield as the planting was further delayed. At Beja, where the site was heavily infested with *Orobanche* spp., the crop planted in November was more heavily infested by the parasite than the December-sown crop, and thus yielded less. However, delaying sowing after early December caused significant yield reductions at this site as well. Increasing the plant population from 5.0 to 12.5 plants/m² for faba bean *major* types and 12.5 to 50 plants/m² for *minor* types resulted in an almost linear increase in seed yield (Fig. 38).

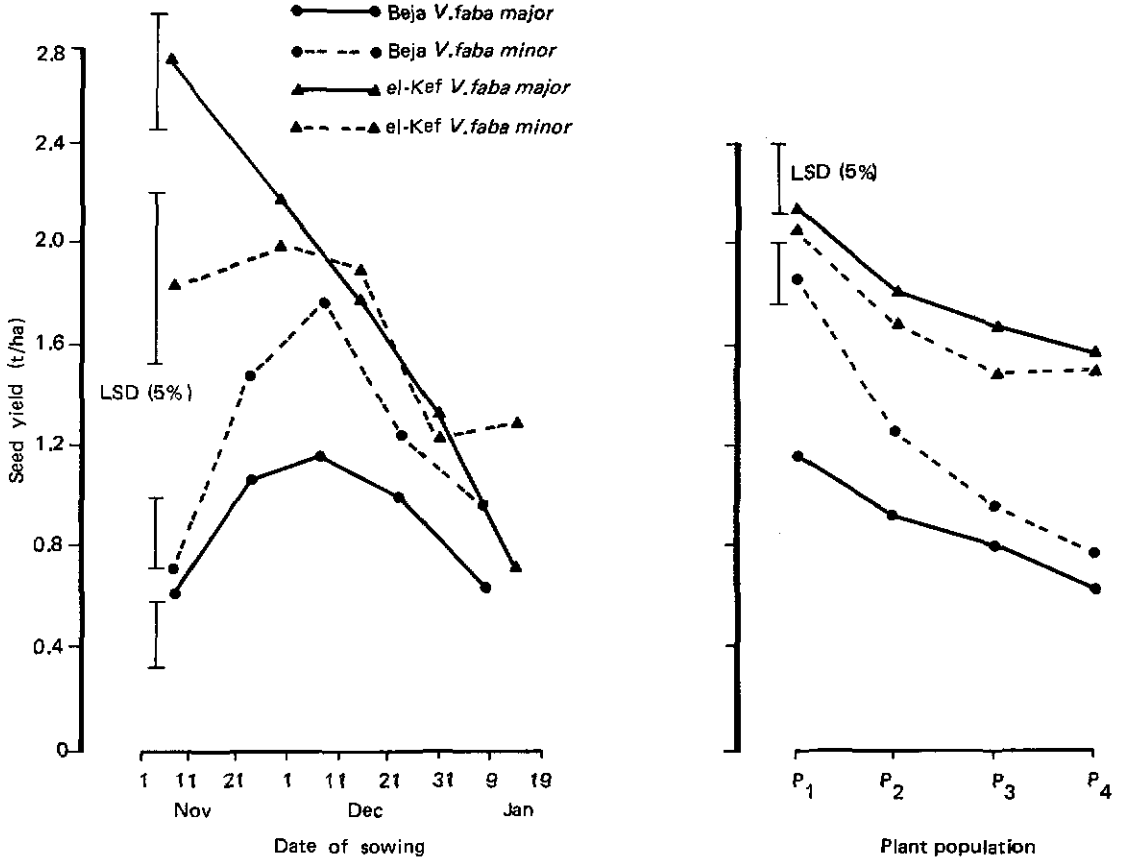


Fig. 38. Effect of date of sowing and plant population on seed yield of Tunisian local *V. faba major* and *V. faba minor* at Beja and el-Kef, Tunisia, 1983/84. P_1, P_2, P_3, and P_4 refer to 12.5, 8.3. 6.2, and 5.0 plants/m², respectively, for *major* and 50, 25, 16.6, and 12.5 plants/m², respectively, for *minor* faba beans.

N, P, and K fertilizers, singly or in combination, had no effect on the productivity of faba beans at either site.

The yield loss due to weeds in small-seeded faba bean was estimated to be about 28% at Beja and 92.5% at el-Kef, reflecting the differences in the weed infestation at these sites. Handweeding twice 45 and 90 days after sowing gave as good seed yield as the completely weed-free treatment. Igran, Maloran + Kerb and Tribunil + Kerb, applied preemergence, showed promise at Beja where weed infestation was low. At el-Kef, where weed infestation was very high, *none of the tested preemergence* herbicide combinations gave satisfactory weed control. There is a need to evaluate more herbicides and perhaps at higher application rates than these used during the 1983/84 season.

Chickpeas. Some of the experiments on the date of planting and plant population trials conducted on chickpeas were severely affected by root rot/wilt and unidentified factors, and hence their results are not included in this report. Studies on weed control in chickpeas at el-Kef revealed that weed infestation could cause total crop loss, but that two handweedings provided effective weed control. The herbicides Maloran at 2.5 kg a.i./ha, Tribunil at 3.0 kg a.i./ha, Igran at 3.0 kg a.i./ha, Bladex at 1.0 kg a.i./ha singly or in combination with Kerb at 0.5 kg a.i./ha did not provide satisfactory weed control and resulted in much less yield than that obtained with hand-weeding. A range of other chemicals at various rates will be tested in 1984/85.

Lentils. At el-Kef, delaying planting beyond 30 November resulted in significantly reduced lentil seed yield (Fig. 39). At Beja, the yield level was rather low and delaying the sowing up to 21 December had no significant effect on yield, but a significant reduction in yield occurred when sowing was delayed beyond this date (Fig. 39). There was a linear increase in seed yield at Beja when the population was gradually increased from 41 to 165 plants/m². At el-Kef also, the seed yield increased significantly as the population level was raised from 41 plants to 82.5 plants/m², but increasing the population to 165 plants/m² caused little further yield increase (Fig. 39).

Weeds offered more serious competition to lentils than to faba beans at both Beja and el-Kef sites, and lentil seed yields were reduced by 40% at Beja and 95% at el-Kef. Seed yield from plots handweeded twice was as high as under completely weed-free conditions obtained by repeated handweeding. Tribunil (at 2.0 kg a.i./ha) combined with Kerb (at 0.5 kg a.i./ha) gave very effective control of weeds at Beja and gave yield at par with that obtained with hand-weeding. However, none of the tested herbicides controlled weeds effectively at el-Kef. There is a need, therefore, to undertake further investigations to identify optimum rates of application of these preemergence herbicides and their combinations as well as to test new herbicides. — *Tunisian national program scientists and Howard Gridley.*

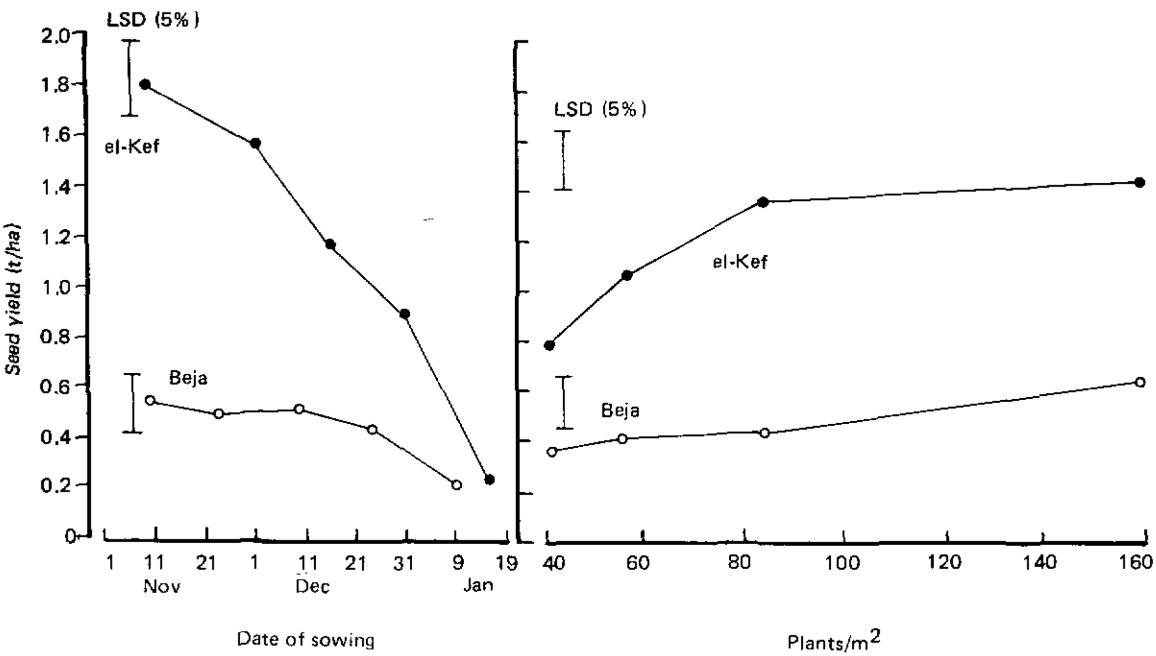


Fig. 39. Effect of date of sowing and plant population on seed yield of lentils at Beja and el-Kef, Tunisia, 1983/84.

Training

Group Training

Food Legumes Residential Course

The Food Legume Improvement Program again held a 6-month (January - July) residential course at Tel Hadya research station in 1984. The course hosted 12 trainees from seven countries (Syria, Sudan, Egypt, Iran, Libya, Morocco, and Ethiopia). The course syllabus focused on field and laboratory techniques with some classroom lectures to provide background. Training reference material, which included publications and visual aids, was provided. Each individual was assigned a small experiment according to academic background, and was supervised by a senior scientist. This exercise aimed to give the trainee experience in planning, conducting, analyzing, and reporting of simple experiments.

Neutron-probe technique to measure the soil moisture, being demonstrated to a Sudanese trainee.

Seed Production Course II

This course focused on production of good seed of food legume crops (lentil, chickpea, and faba bean). Most of the participants were food legume research scientists from North Africa and West Asia.

In-Country Course on Ascochyta Blight Resistance in Chickpeas in Pakistan.

FLIP held an in-country training course at Islamabad, Pakistan, 3-10 March 1984, in collaboration with the national research program on food legumes (Pulses) of the National Agricultural Research Center (NARC), Pakistan. The course focused on ascochyta blight resistance in chickpea. The aim of the course was to train research workers from Pakistan in developing chickpea cultivars resistant to the disease. Eighteen national program research workers from different provinces of Pakistan participated in the training program. Most of the trainees were actively involved in chickpea research in the nationally coordinated program in Pakistan.

The instructors came from NARC and universities in the Punjab province, and scientists from ICARDA gave lectures in pathology and breeding. ICARDA supplied training aids including an audiotutorial module, "Screening Chickpeas for Resistance to Ascochyta Blight." The course combined theory and practical training on disease identification, laboratory techniques, inoculum procedure, data recording and crossing. The proceedings of the course will be published in 1985.

Individual Training

Food legume scientists (senior research fellows) from two national research programs were trained during 1984 (Table 72). These scientists

Table 72 Participants in individual training in FLIP, ICARDA, during 1984.

Training category	Subject	Duration	Country	No.
Senior Research Fellow	Faba bean breeding and germplasm	6 months	China	2
	Faba bean breeding	One week	Cyprus	1
Training Research Associate	Legume quality	One month	Sudan	2
	Legume agronomy	One year	UK	1
	Crossing and data analysis	3 months	Tunisia	1
Research Scholar	Breeding	3 years (Ph.D.)	Egypt	1
	Agronomy	3 years (Ph.D.)	Egypt	1
	Economics and statistics	2 years (M.Sc.)	Sudan	1
	Pathology	2 years (M.Sc.)	Sudan	1
	Agronomy	2 years (M.Sc.)	Syria	1

worked with ICARDA scientists on various research topics, for periods ranging from 1 week to 1 year. Two technicians from Sudan and one from Tunisia were trained in food legume quality assessment, crossing, and data analysis.

Table 72 also provides information about degree training, in which the students register at a university and conduct thesis research at ICARDA research stations. Food legume scientists at ICARDA supervise the students' thesis research. — *H. Ibrahim and other FLIP scientists.*

Conferences and Workshops

Third International Symposium on Parasitic Weeds

FLIP hosted the Third International Symposium on Parasitic Weeds, 7-9 May 1984 at Aleppo. The symposium was sponsored by the International Parasitic Seed Plant Research Group (IPSPRG), the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), and ICARDA, and was attended by scientists from all over the world. It focused on biology, physiology and biochemistry, host resistance, and control techniques. The proceedings were published by ICARDA.

FABIS and LENS Users' Workshop

The first FABIS/LENS Users' Workshop was held jointly by FLIP and the Communications and Documentation Department at Aleppo, 28-29 November 1984. The workshop aimed to evaluate the performance of the faba bean and lentil information services and the two newsletters, as well as to make suggestions for making them more useful. The workshop unanimously agreed that the two newsletters were invaluable sources of research information for scientists working on faba bean and lentil and were good vehicles for quick dissemination of research information amongst this network of researchers. — *M.C. Saxena.*

Participants to the Third Parasitic Weed Symposium examining a faba bean field infested with *Orobanche crenata*.

Publications

Journal Articles

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Pasture, Forage, and Livestock Improvement

Contents

Cover: Training young scientists is receiving increased emphasis in the Pasture, Forage, and Livestock Program.

Pasture, Forage, and Livestock Improvement

The Pasture, Forage, and Livestock Program (PFLP) has the broad objective of improving livestock production and stability of rainfed farming systems in West Asia and North Africa. In attempting to do this it has identified two major agroecosystems: farms in the cereal zone whose basic product is wheat or barley, and nonarable *grazing lands (marginal lands) within and adjacent* to the cereal zone. The Program is structured into four projects: (1) forage breeding and agronomy, (2) annual pastures to replace fallows, (3) marginal-land improvement, and (4) livestock management and nutrition.

The first two projects are designed for the first agroecosystem, specifically to replace fallows in cereal/fallow rotations with either annually resown forage crops or self-regenerating pastures. In the case of forage crops, the objectives are to breed adapted cultivars of vetches (*Vicia* spp.), peas *(Pisum sativum)*, and lathyrus *(Lathyrus spp.)*, and to develop appropriate agronomy packages. In the case of annual pastures the objective is to introduce self-regenerating pastures of annual legumes, and to devise *management systems* suitable for local economic and social conditions. This system being new to the ICARDA region is described in more detail in this report.

The objective of the marginal land improvement project is to increase stability and productivity of the second agroecosystem, the nonarable lands within and adjacent to the cereal zone. It was only in 1983/84 that this project received a major allocation of resources. The specific aim of the work is to define the resource base: nature and fertility status of soils, kind of plants found, soil productivity, and management practices. From these initial studies new proposals are being formulated to develop this greatly undervalued resource.

Livestock management and nutrition is the Program's integrating project. It takes results from other projects and attempts to develop appropriate *farming systems. Previously it was part* of the Farming Systems Program, with which it still maintains a very close collaboration. However, its transfer to PFLP has resulted in a more integrated approach to pasture and forage research, with more emphasis on systems development and the real world of farmers. This is reflected in the Program's new research proposals.

Research Highlights

Some of the research highlights of PFLP for 1983/84 are presented below.

1. Several problems emerged about using peas as forage crops: compared with vetches they were less palatable both when green and as hay; they were more susceptible to disease, and their total herbage yield was less.
2. Some of the wild vetches showed promise, especially narbon vetch *(Vicia narbonensis)* and woolly-pod vetch *(V. dasycarpa)*.
3. Low winter yield of medic pastures was associated with low plant numbers, and at realistic plant populations pasture growth appeared to be sufficient to support large numbers of sheep.

4. Both medics and vetches responded to inoculation with rhizobia (in certain circumstances): when adequately nodulated, medics fixed 150-250 kg of elemental nitrogen/ha.
5. Many medic flowers, especially those which appeared late in the growing season, failed to mature: the high abortion rate appeared to reduce seed yield by several orders.
6. First-year medic pasture, with the help of stubbles, maintained 4 sheep/ha (8/ha on the medic itself) without supplementation for 20 weeks during late spring and summer, in spite of severe drought during the growing season.
7. Legume populations on marginal lands were diverse: therefore, marginal-land development may be possible without the introduction of new species.
8. A supplement of small amounts of cottonseed cake greatly enhanced the amount of stubble or straw eaten by grazing or pen-fed sheep: sheep fed in this way increased weight during summer.
9. Simple methods for evaluating barley straw were developed. Furthermore, it was found that breeding for high grain yield and good straw quality are not incompatible objectives.
10. Surveys at Tel Hadya revealed that endoparasites are not likely to be a problem in ICARDA sheep with one exception: severe infestations by lungworms (*Dictyocaulus* sp. and *Muellaria* sp.) were observed.

The Program wishes to acknowledge many collaborators. The Italian Government and the University of Perugia are assisting with the marginal lands project, the Tropical Development and Research Institute of the Overseas Development Administration, UK, is collaborating in the straw project, the Japanese International Cooperation Agency is collaborating in the animal health work, and the Syrian Agricultural Research Council and Steppe Directorate are major collaborators in all our work. — *P.S. Cocks.*

Forage Breeding and Agronomy

Forage crops are defined as annually-resown crops used for production of hay, seed, or straw, specifically to feed livestock. They are one of the alternatives being studied to replace fallows in cereal/fallow rotations. The major species are *Vicia sativa* (common vetch), and *Pisum sativum* (forage peas), although there are a number of other species of potential importance, including *Lathyrus* spp., *Vicia narbonensis, V. ervilia,* and *V. dasycarpa.*

Research on forage crops is carried out in two projects: forage breeding, in which a large collection of vetches and peas is being screened for herbage and seed yield; and forage agronomy, in which an agronomy package is being developed to improve production techniques. The two topics are integrated in that selection is aimed at identifying varieties suitable for the agronomy package. The agronomy research also includes forage utilization, especially the place of forages in rotations and the effect of forage crops on subsequent cereal yields.

In 1983/84, research concentrated on forage legumes, but use of cereals in mixtures with legumes remained an important component. In previous years the use of cereals often resulted in increased yields, and certainly it is easier to make hay if they are included. This topic was reexamined in 1983/84, together with the effect of grazing on hay production, palatability of vetches and peas, time of hay making, and value of inoculating seed with rhizobia. The broad-based selection program was continued, and several new vetch and pea lines emerged as superior to the local controls.

It is worth mentioning that hay yields in 1983/84 were low at most sites, except the high-rainfall sites at Terbol and Hama, where exceptionally good yields were recorded.

Breeding and Selection

Preliminary Screening in Nursery Rows

A total of 144 pea accessions were screened in nursery rows in a cubic lattice design with three replicates. In this preliminary adaptation experiment the accessions were visually scored (0-5 scale) for establishment, winter and spring growth, seedling vigor, leafiness, growth habit, plant vigor, time to flowering and maturity, and reaction to diseases.

From the 144 accessions, 33 promising lines were identified for further evaluation of herbage and seed yield in 1984/85. This year's results show, as they have in the past, that there is a wide genetic variability in peas (Fig. 1), which has been fully documented for reference and future exploitation. Of great interest is that, although the local control was one of the best genotypes, there were more than 20 superior genotypes. There was no vetch nursery in 1983/84. — *A. Abd El Moneim.*

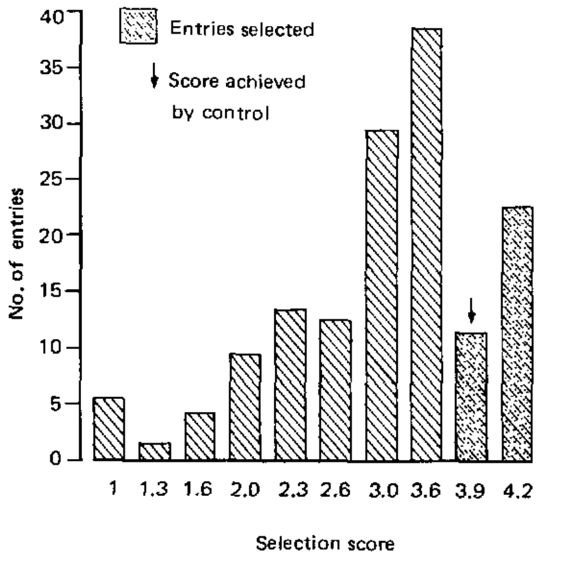


Fig. 1. Variability in selection coefficient (0, very poor; 5, very good) of pea germplasm grown in nursery rows at Tel Hadya, 1983/84.

Evaluation in Microplots and Advanced Yield Trials

The study of variation in agronomic characters is of significant practical value: it helps breeders to establish a suitable breeding program and of itself may result in the selection of improved varieties. Objective selection for herbage and seed yield begins in microplots in the year following nursery-row evaluation, and continues in advanced yield trials at Tel Hadya before regional testing of selected varieties.

Microplots of both vetch and peas were planted at Tel Hadya in 3.5m^2 plots arranged in a triple lattice design. For both crops seed rate was 80 kg/ha and fertilizer, 40 kg P_2O_5/ha. These replicated microplot experiments were duplicated: one trial was harvested at 100% flowering for quantitative determination of herbage and the other for seed yield. — *A. Abd El Moneim.*

Results from the Vetch Selection Experiments

A total of 49 selections were tested in microplots and 16 genotypes which combined both high seed yield and dry-matter production were identified for more critical evaluation in advanced yield trials.

Large differences in dry-matter and seed yield were found between genotypes. Selection 2097* had the lowest dry-matter yield averaging 3530 kg/ha, while Selection 2058 had the highest, averaging 6410 kg/ha. Yield of the local check, Accession 2541**, was exceeded by 15 selections, significantly so ($P<0.05$) by eight selections. The control produced less yield

* Selection from an earlier accession (all numbers have been allotted by ICARDA).

** Early accession number, from which no selection has been drawn.

Seed production of vetch at the Tel Hadya research farm.

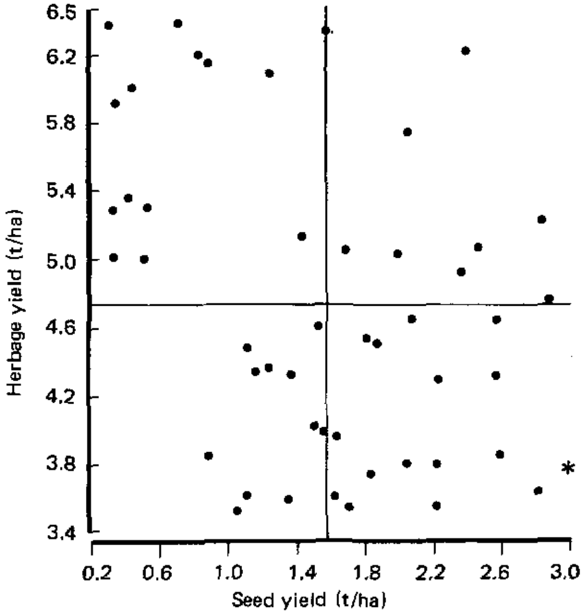


Fig. 2. Relationship between herbage and seed yield in 49 genotypes of *Vicia sativa* at Tel Hadya, 1983/84. The asterisk (*) indicates herbage and seed yield of the control, and the vertical and horizontal lines indicate mean seed and herbage yield, respectively.

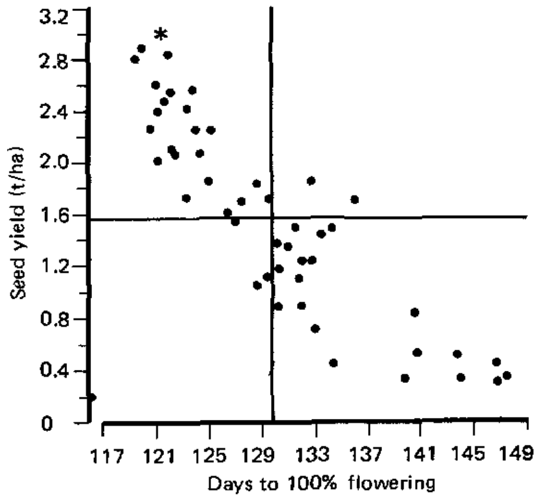


Fig. 3. Relationship between seed yield and days to 100% flowering in 49 genotypes of *Vicia sativa* at Tel Hadya, 1983/84. The asterisk (*) indicates yield and flowering time of the control, and the vertical and horizontal lines indicate mean days to flowering and mean seed yield, respectively.

than in 1982/1983 (3770 vs 4820 kg/ha), an indication that in 1983/84 it was relatively more influenced by drought than many of the other genotypes. Seed yield ranged from 2980 kg/ha (control) to 312 kg/ha (Selection 2034). The control yielded significantly more seed ($P<0.05$) than all other selections except Selection 2073 and Accession 713 (Fig. 2). Seed yield was negatively correlated ($100\ r^2 = 79$, $P<0.001$) with time to reach 100% flowering (Fig. 3). The results indicate a clear need to continue the search for early maturing genotypes combining high, stable herbage yield with high seed production.

Results from Pea Selection Experiments

Eighty-one selections of peas were evaluated in microplots at Tel Hadya. Herbage yield, seed yield, days to 100% flowering, and maturity date differed significantly, indicating the existence of significant variability between genotypes. Herbage production varied from 510 to 3240 kg/ha and seed yield from 16 to 1140 kg/ha (Fig. 4).

Thirty genotypes were selected for further testing. Of these, five produced more herbage (but not significantly more) and 26 (of which eight were significant at $P < 0.05$) produced more seed than the control.

Variation in seed yield was due to variation in individual seed weight, which ranged from 29 g/100 seeds in large-seeded genotypes to 8 g/100 seeds in small-seeded genotypes. Low herbage production and seed yield were also attributed to severe attacks by nematodes and *Orobanche* sp., both of which reduced plant population. This indicates the importance of screening pea genotypes for tolerance and resistance to nematodes in particular.

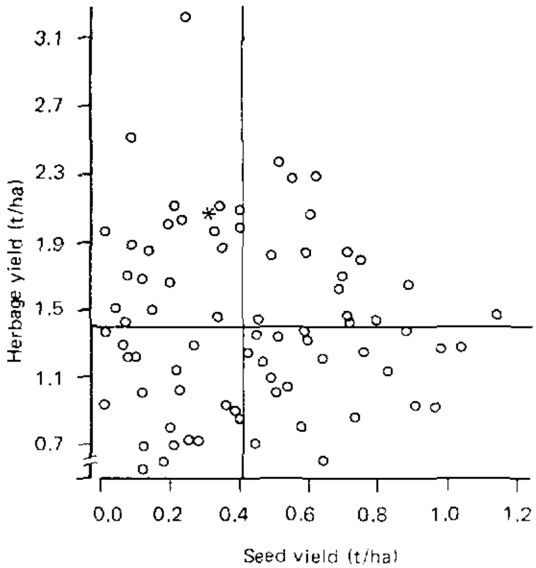


Fig. 4. Relationship between herbage and seed yield in 81 genotypes of *Pisum sativum* at Tel Hadya, 1983/84. The asterisk (*) *indicates seed and herbage yield of the control*, and the vertical and horizontal lines indicate mean seed and herbage yield, respectively.

The great variability in herbage and seed yields and flowering time give the breeder an opportunity to select genotypes combining high herbage and seed yields to be used for early grazing, hay making, or seed production.

The superior yield of vetches compared with peas is a similar result to that of earlier years, especially 1982/83, but in 1983/84 the difference was even more marked than before. While peas may have a role to play in future, at Tel Hadya at least, vetches seem to be the more valuable crop. That this is not always so is indicated in the results from other experiments performed by the Program in previous years. — *A. Abd El Moneim.*

Selection of Nonshattering Genotypes of Vetch

Loss of seed from maturing pods in vetch constitutes a serious economic problem in seed production and severely restricts its use as a forage crop. Furthermore, late harvesting causes a severe "vetch weed" problem in subsequent cereal crops.

Twenty genotypes were evaluated first under greenhouse conditions, where intense summer heat was conducive to pod shattering, and then under normal field conditions. Visual scoring of shattering was done using a 0-5 scale (0, complete shattering; 5, about 90% nonshattering). Genotypes were classified into three categories, nonshattering (Selection 1448, Accessions 1416, 2014), intermediate shattering (Accessions 1351, 1390, 1403, 1771, 1887, 674, 708, 719, 736, 744, 1332, 1352, 1439, and 1539), and shattering (Accessions 2062 and 716 and the local control).

The nonshattering selections are of low yield with poor agronomic characteristics. Accordingly, a hybridization program will commence in which the nonshattering characteristic will be combined with high herbage yield and seed production. Specific objectives are to identify factors controlling seed retention, determine heritability, identify morphological appearance associated with seed retention, and develop genotypes combining seed retention with high herbage and seed yields. — *A. Abd El Moneim.*

Multilocation Testing of Vetches and Peas

Twenty-four promising vetches and 25 promising peas were tested at six locations, five in Syria (Tel Hadya, Qamishly, Homs, Izra'a, and Salamieh) and one in Lebanon (Terbol). The locations were chosen to represent the range of environmental conditions likely to be experienced in Syria and Lebanon, and to obtain information on whether the genotypes respond differently when grown under different environmental conditions. Meteorological data from the six locations are presented in Table 1.

At each location both legumes were planted in 28 m² plots in a randomized complete block design, with three replicates. Sowing rate was 80 kg seed/ha, and the sites were fertilized with 40 kg P_2O_5/ha. Half of each plot was harvested at 100% flowering to measure herbage yield and the other half was left to measure seed yield.

In vetches, mean herbage yield across the six locations was 3445 kg/ha. Between locations it varied from 620 kg/ha at Salamieh to 7890 kg/ha at Terbol. In comparison mean seed yield varied from 10 kg/ha at Salamieh to 2010 kg/ha at Izra'a (Table 2). The results emphasize the enormous effect of environmental variation on yield.

The data in Table 2 are "location means" and they provide a numerical grading of the en-

Table 1. Summary of location and meteorological data for six sites in Syria and Lebanon where multilocation testing of forage crops was performed in 1983/84.

Location	Latitude	Longitude	Altitude (m)	Mean max. air temp. (Oct to May) (°C)	Mean min. air temp. (Oct to May) (°C)	Seasonal rainfall (mm)
Syria:						
Tel Hadya	35° 55'N	36° 55'E	362	19.7	6.5	227
Qamishly	37° 03'N	41° 13'E	467	23.3	6.8	206
Homs	34° 45'N	36° 39'E	446	22.3	4.2	319
Izra'a	32° 51'N	36° 15'E	575	26.3	1.1	300
Salamieh	35° 00'N	37° 02'E	480	23.7	2.8	213
Lebanon:						
Terbol	33° 50'N	36° 00'E	950	19.2	1.7	597

Table 2. Mean herbage and seed yield for vetch genotypes at six testing sites in Syria and Lebanon, 1983/84.

	Syria					Lebanon
	Tel Hadya	Qamishly	Homs	Izra'a	Salamieh	Terbol
Herbage yield (kg/ha)	3420	890	4040	3810	620	7890
Seed yield (kg/ha)	1220	40	1550	2010	10	690

vironment at each location. Using location means as a base, the data will be analyzed for genotype x environment interaction after 3 years of experiments.

The mean dry-matter and seed yield of individual genotypes also varied widely, showing that some of them have wide adaptation. An accession of *Vicia narbonensis* (Accession 67) had the highest mean seed yield and that of *Vicia dasycarpa* (Accession 683) had the highest mean herbage yield. The local control (Accession 2541) had relatively high herbage and seed yield at all locations, indicating that it too has wide adaptability. The success of the two accessions from species other than *Vicia sativa* is of considerable interest: it suggests that our selection program should reexamine some of the other vetch species.

At Terbol, where rainfall was high (597 mm), although herbage yield was high, seed yield was low compared with Izra'a and Homs. This was apparently due to infection by botrytis blight *(Botrytis cinerea)* at flowering when wet, cold weather must have encouraged infection.

In peas, mean herbage yield across the six locations was 2670 kg/ha, and location mean herbage yields varied from 420 kg/ha at Qamishly to 4400 kg/ha at Homs. Mean seed yield across the six locations was 1330 kg/ha and location mean seed yields varied from 100 kg/ha at Qamishly to 3930 kg/ha at Homs. Thus, Homs was characterized by both high herbage and seed yields, whereas Qamishly and Salamieh were both low-yielding locations (Table 3).

Peas produced less herbage at Terbol than at Homs and Izra'a, due to infection by bacterial blight *(Pseudomonas pisi).*

Average performance of the genotypes over all locations varied from 1870 to 3620 kg of herbage/ha and 630 to 2170 kg of seed/ha. The control (Accession 205) produced relatively large amounts of both herbage and seed. — *A. Abd El Moneim in collaboration with the Syrian national program.*

Screening for Disease Resistance

Twenty-four promising vetches and 25 promising peas were screened in the field using artificial inoculation of ascochyta blight and downy mildew *(Peronospora viciae)* in vetches; and ascochyta blight type diseases *(A. pisi, Mycosphaerella pinodes, Phoma medicaginis* var *pinodella),* bacterial stem blight *(Pseudomonas pisi),* and powdery mildew *(Erysiphe pisi)* in peas.

Vetches varied from resistant to intermediate or moderately resistant to downy mildew, and resistant or moderately resistant to ascochyta blight, except for Selections 2108, 2096, and 1135 which were susceptible. No peas exhibited multiple disease resistance, although six lines were moderately resistant to bacterial blight, two were moderately resistant to ascochyta blight, and one was tolerant and one moderately resistant to powdery mildew.

Observations in the microplots showed that none of the 81 pea genotypes showed symptoms of ascochyta blight or bacterial blight.

Table 3. Mean herbage and seed yields for forage pea genotypes at six testing sites in Syria and Lebanon, 1983/84.

	Syria					Lebanon
	Tel Hadya	Qamishly	Homs	Izra'a	Salamieh	Terbol
Herbage yield (kg/ha)	3430	420	4400	3840	580	3340
Seed yield (kg/ha)	1440	100	3930	1420	190	870

However, in the case of powdery mildew only two accessions (284 and 552) failed to show symptoms. In vetches, only two accessions were severely affected by ascochyta blight and only one showed susceptibility to downy mildew. It should be remembered, however that when relying on natural infection there is always a chance that there may have been no opportunity for infection. The 1983/84 season, being very dry, was probably not a good year for leaf and stem diseases, so the above results should be viewed with caution. — *A. Abd El Moneim and O. Mamluk.*

Agronomy of Forage Crops

The objectives of forage agronomy research during 1983/84 were (1) to investigate for a second season the possibility of using forage mixtures for grazing during winter to be followed by hay making in spring, (2) to evaluate, using grazing animals, palatability of several peas and vetches at various growth stages, (3) to compare productivity and nutritional quality of two forage mixtures in relation to stage of harvesting, (4) to investigate the effect of different rhizobia inocula on productivity of three vetch species, (5) to validate the results of previous seasons on the effects of seed rate and seed ratio on yield and hay quality, and (6) to investigate, in collaboration with the Syrian national program, the potential of different forage crops for hay production in a range of environments.

Winter Grazing of Forage Mixtures

Studies were carried out for a second season on the effects of winter grazing on hay productivity and quality of two legume/cereal mixtures. The mixtures comprised vetches or peas, each grown at a seed ratio of 33:66 (legume: cereal) with three barley genotypes, one triticale, one oat, and one wheat.

The experimental design was randomized complete block with factorial arrangement (two legumes x six cereals x two grazing treatments) replicated three times. All mixtures were sown in November in plots 8.4 m × 5 m at a sowing rate of 160 kg/ha and fertilized with 40 kg P_2O_5/ha in the form of triple superphosphate. The grazing treatment was applied on 13 February when plants were 15-20 cm tall. Data collected included percent forage composition (by hand separation), herbage consumed by grazing animals (the difference in herbage before and after grazing), and total herbage, crude protein (CP), and digestible dry-matter (DDM) yields.

Legume species again affected the grazing pattern of forage mixtures, confirming the first season's results: sheep preferred vetch to pea regardless of the cereal component present. The results (Table 4) indicate that vetch accounted for 46-57% of total herbage consumed by the sheep, while pea was only 1-3%. Also, the amount consumed was generally higher with vetch-containing mixtures (0.4-0.5 t) than with pea-containing mixtures (0.2-0.3 t).

After grazing, the legume content of pea/cereal hay was consistently higher (46-89%) than that of vetch/cereal hay (Table 5). Similarly, values of total CP and total DDM

Table 4. Herbage and percent composition of mixtures consumed by sheep in early winter, 1984.

Forage mixtures[1]	Herbage consumed (kg/ha)	Legume (%)	Cereal (%)
Barley/vetch	400	46	54
Barley/pea	200	3	97
Oats/vetch	400	46	54
Oats/pea	300	1	99
Triticale/vetch	480	57	43
Triticale/pea	210	2	98
Wheat/vetch	380	47	53
Wheat/pea	200	1	99

1. Values represent means for three lines of barley and one line each of oats, triticale, and wheat.

Table 5. Effects of winter grazing on total herbage, percent composition of hay, total crude protein, and total digestible dry matter of different forage mixtures at Tel Hadya, 1984.

	Ungrazed					Grazed[1]				
Forage mixtures	Herbage (kg/ha)	Legume (%)	Cereal (%)	Total CP (kg/ha)	Total DDM (kg/ha)	Herbage (kg/ha)	Legume (%)	Cereal (%)	Total CP (kg/ha)	Total DDM (kg/ha)
Barley/vetch	1868	63	37	273	1141	685	46	54	108	447
Barley/pea	1776	62	39	219	1050	1040	67	33	128	588
Oats/vetch	1691	61	39	271	1049	634	43	57	106	429
Oats/pea	1753	56	44	241	1111	1066	72	28	154	687
Triticale/vetch	1495	72	28	236	942	616	37	64	89	412
Triticale/pea	1485	64	36	198	809	800	69	31	109	542
Wheat/vetch	1543	57	43	220	951	579	38	62	76	358
Wheat/pea	1668	51	49	200	852	951	58	42	126	581
Av. Vetch/cereal	1949	63	37	250	1021	629	41	59	95	412
Av. Pea/cereal	1671	58	42	215	956	964	67	34	129	600

1. Does not include amounts consumed by grazing animals early in the season.

were, respectively, 16-19% and 31-66% higher in pea/cereal hay than in vetch/cereal hay.

Grazing affected yield of vetch/cereal mixtures more than pea/cereal mixtures. The mean reductions due to grazing (over all cereals) in herbage, CP, and DDM were 62, 62, and 59%, respectively, in vetch/cereal compared with 42, 40, and 37% for pea/cereal mixtures.

It is concluded that pea/cereal mixtures are likely to be more suitable for a combination of early grazing and hay making, but this will be discussed later. Grazing significantly reduced the total yield of both mixtures but more so in vetch/cereal mixtures, which therefore seem unsuitable for winter grazing. — *A.E. Osman.*

Palatability of Peas and Vetches

Results from previous seasons indicate that sheep prefer to graze vetches rather than peas during winter (see also previous section). It is not clear, however, whether this is true for other vetches (narbon vetch, woolly-pod vetch) and whether the preference persists throughout the season. Accordingly, in 1983/84, eight genotypes of *Vicia sativa*, one of *V. narbonensis* (narbon vetch), one of *V. dasycarpa* (woolly-pod vetch), and 10 of *Pisum sativum* were compared for palatability at three stages of growth.

Three adjacent experiments, each of which consisted of 20 legumes, were established in November. In each experiment the legumes were sown in plots 2.1 m × 5.0 m in a randomized complete block design with three replicates. The plots were fertilized with 40 kg P_2O_5/ha, in the form of triple superphosphate at sowing.

Palatability of the legumes was assessed at three stages: before flowering, at 10% flowering, and at full pod formation, on 13 February, 28 March, and 18 April, respectively. Using one experiment at a time, 100 sheep were allowed to graze the available herbage for one day during the first two stages and for two days at full podding. Herbage consumption was measured by the difference in herbage before and after grazing.

Total availability of herbage was 22, 146, and 223 kg/ha before flowering, at 10% flowering, and at full podding, respectively. Total herbage consumed at the three stages was 19, 77, and 171 kg/ha.

The contribution of the different legumes to total herbage and that consumed by sheep is shown in Fig. 5. Of the 20 legumes, *Vicia*

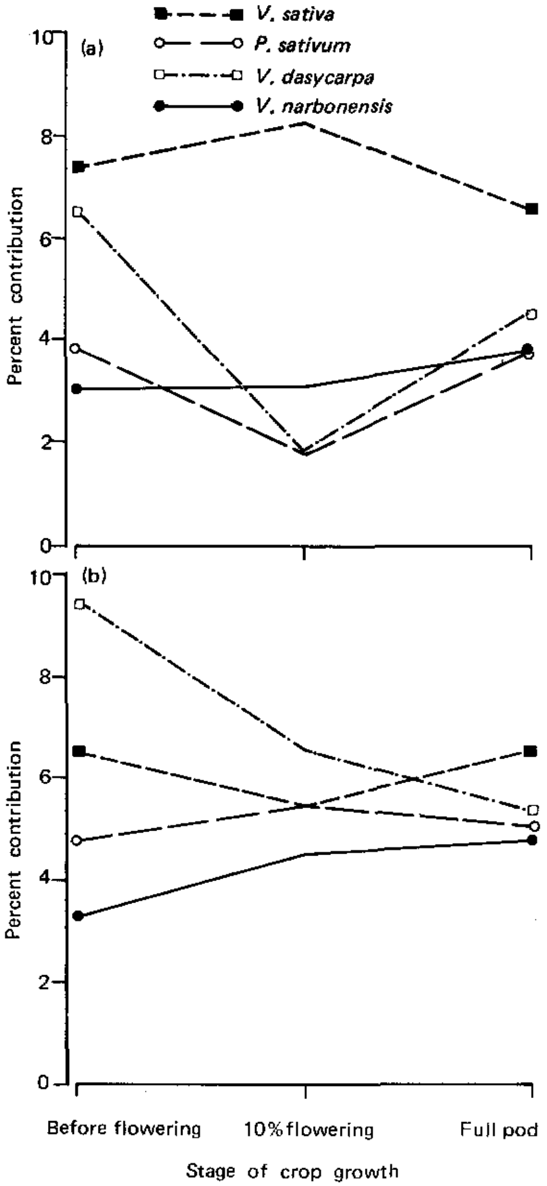


Fig. 5. Percentage contribution of four legumes to (a) herbage consumed, and (b) available herbage before grazing at three times of grazing.

dasycarpa yielded most herbage before flowering and at 10% flowering, while *V. narbonensis* yielded most at full podding. The lowest contribution was from *Pisum sativum*. Considering the amounts consumed by sheep, *V. sativa* was most palatable. The high consumption of *V. dasycarpa* at the early stage (before flowering) may have been due to insufficient herbage from *V. sativa* to satisfy the sheep's appetites, resulting in higher than expected intake of *V. dasycarpa*. There were only small differences within each species, so the results are presented as averages of all genotypes of each species.

The results confirm that sheep prefer vetches to peas at all stages of growth. We now need to know whether this preference exists also for hay. This subject is discussed in the next section. — *A.E. Osman and E.F. Thomson.*

Productivity, Quality, and Utilization of Hay in Relation to Harvesting Stage

The objective of this study was to define the optimum stage for harvesting hay mixtures in relation to yield, harvesting losses, quality, and utilization. In 1982/83, three mixtures (vetch/barley, vetch/oats, vetch/triticale) were compared. The study was continued in 1983/84 to compare vetch/barley with pea/barley.

The two legumes were sown in November in mixtures with barley (33:66) in a replicated trial with a randomized complete block design on an area of 1.3 ha. The two crops were sown at 160 kg seed/ha and fertilized with 40 kg P_2O_5/ha in the form of triple superphosphate. The hay was harvested on three dates related to legume maturity: 10% flowering, 100% flowering, and full pod formation. Measurements included herbage yield, crude protein (CP), and digestible dry matter (DDM). The nutritional value of hay was also determined by feeding it to sheep in digestibility crates. Crop growth after the first and second harvest was also measured.

Growth during 1983/84 was seriously affected by the dry season: only 230 mm of rain was received compared with 320 mm in 1982/83. Accordingly, total herbage production was only 40% of that obtained in 1982/83. During the second harvest the hay-making operation on pea/barley was interrupted by rain (18.5 mm). Nevertheless, the same relationship existed this year as last year between yield and stage of harvesting: total herbage and hay yields increased with crop maturity, and the maximum was recorded at full podding (Table 6). Losses in yield associated with hay making were high at the first two harvests as a result of stunted plant growth, but were much less at full podding when crop height was between 30 and 40 cm. Crop regrowth was substantial at early harvests and this could be used for grazing under normal farm conditions.

Dry-matter digestibility (%) and crude protein (%) both decreased with crop maturity. These reductions were associated with higher proportion of cereal, especially at full podding (Table 6). Total DDM and CP yields, however, were highest at the last harvest, a reflection of higher herbage yields.

The results in Table 7 show that at the early stages of crop harvest (10% and 100% flower-

Table 6. Herbage production and quality in relation to maturity stage in vetch/barley and pea/barley mixtures at Tel Hadya, 1983/84.

	Vetch/barley			Pea/barley		
Stage of harvesting[1]	a	b	c	a	b	c
Dry matter (kg/ha)	1319	2072	2283	1177	2027	2155
Harvested hay (kg/ha)	678	843	1640	334	769	1554
Loss of harvesting (%)	48	59	28	71	62	28
Yield of regrowth (kg/ha)	673	651	nil	547	330	nil
Proportion of cereal in hay	37	38	44	32	35	51
Dry-matter digestibility (%)	69	66	56	64	58	55
Crude protein (%)	19	15	11	13	15	11

1. a, b, and c represent harvesting at 10% flowering, 100% flowering, and at full pod stage.

Table 7. Amount of intake by sheep of herbage, digestible organic matter, digestible crude protein, and metabolizable energy in relation to maturity stage of vetch/barley and pea/barley harvested for hay at Tel Hadya, 1983/84.

	Vetch/barley			Pea/barley		
Stage of harvesting[1]	a	b	c	a	b*	c
Herbage intake (kg/45 kg sheep per day)	1.56a	1.70a	1.58a	1.04b	0.62c	1.40ab
Digestible organic matter intake (kg/45 kg sheep per day)	0.99a	0.97a	0.96a	0.67b	0.39c	0.84ab
Estimated digestible crude protein intake (kg/day)	0.16b	0.19a	0.09d	0.11c	0.04c	0.07d
Estimate metabolizable energy intake (MJ/day)	14.58ab	16.14a	11.08bc	9.78c	5.90d	12.28bc

1. a, b, and c are the harvesting stages of the forage crop. Values in the same line which are followed by the same letter(s) are not significantly different ($P < 0.05$).

* Rain damaged.

ing), intakes by sheep of dry matter, digestible organic matter, digestible crude protein, and metabolizable energy from vetch/barley were all significantly higher than pea/barley, although at 100% flowering this difference was partly due to rain damage to pea/barley hay. At full pod stage, however, there was no significant difference between intakes from vetch or pea mixtures. Indeed this is true for dry matter, digestible organic matter, digestible crude protein, and metabolizable energy (Table 7). These results are in full agreement with findings reported earlier which indicated a distinct preference by sheep for vetch under free grazing conditions. The results also support the suggestion that the pea/cereal mixture can be used for early grazing (where animals will feed mostly on the cereal component) and hay making afterwards, provided that the mixture is harvested at full podding. — *A.E. Osman and E.F. Thomson.*

Response to Rhizobia Inoculation by Three Vetch Species

Although *Rhizobium leguminosarum*, required for nitrogen fixation by vetches and peas, is believed to be present in soils of the Mediterranean region, it has often been observed that these crop species fail to produce high yields even under favorable climatic and soil conditions. The purpose of this research was to investigate the possibility of improving growth of these vetch species *(Vicia sativa, V. dasycarpa,* and *V. narbonensis)* using specific strains of *R. leguminosarum* under field conditions.

Seeds of the three vetches were inoculated with five strains of *R. leguminosarum* (VS-4a, VS-1b, VS-13b, VS-5a, and Nodulaid Group E — a commercial strain) and planted in plots 2.1 m × 5 m in November. Two levels of inoculation — normal (N) at 10^8 organisms per gram of peat, and high (H) at 10^{12} organisms per gram of peat — were included for the first four strains, while one level (N) was used for the commercial strain. A control treatment (no inoculum) was also included for each species. The experiment was laid out in a split-plot design with vetch species as main plots and inoculation (N, H, and control) treatments as subplots, and was replicated three times. The plots were fertilized with 40 kg P_2O_5/ha in the form of triple superphosphate at sowing.

Plant growth was measured every month through the growing season, each sample consisted of five plants including their root system to 15 cm depth of soil. Numbers of nodules were counted, shoots and roots were separated and oven dried (70°C), and weights were recorded. Concurrent with the above, six more plants were removed from each treatment and taken to the laboratory to measure nitrogenase activity using the acetylene reduction technique.

Nodule numbers were greatest under *V. narbonensis* at all sampling dates regardless of rhizobia treatment. However, differences in numbers of nodules were not statistically significant for any of the three legumes. Response to rhizobia treatment in terms of plant weight was highest in *V. dasycarpa,* followed by *V. narbonensis,* and least in *V. sativa* (Fig. 6). Applying rhizobia at the high (H) level resulted in increased plant weight ranging from 17 to 62% in *V. dasycarpa,* 16 to 30% in *V. narbonensis,* and only 6 to 23% in *V. sativa.*

Due to the small plots used, information on yield per hectare could only be estimated using the following formula:

$$Y = \frac{(R \times P)}{W} \times \frac{D}{1000}$$

Where Y = herbage production (t/ha), R = seed rate (g/ha), W = 1000-seed wt (g), D = plant dry weight (g), P = percent germination.

The calculated curves of herbage production were similar to those plotted for actual plant weights. Accordingly, dry-matter yields on a per hectare basis were calculated and are presented in Table 8. At all sampling dates the rhizobia treatments produced higher yields and the differences increased with time. However, they

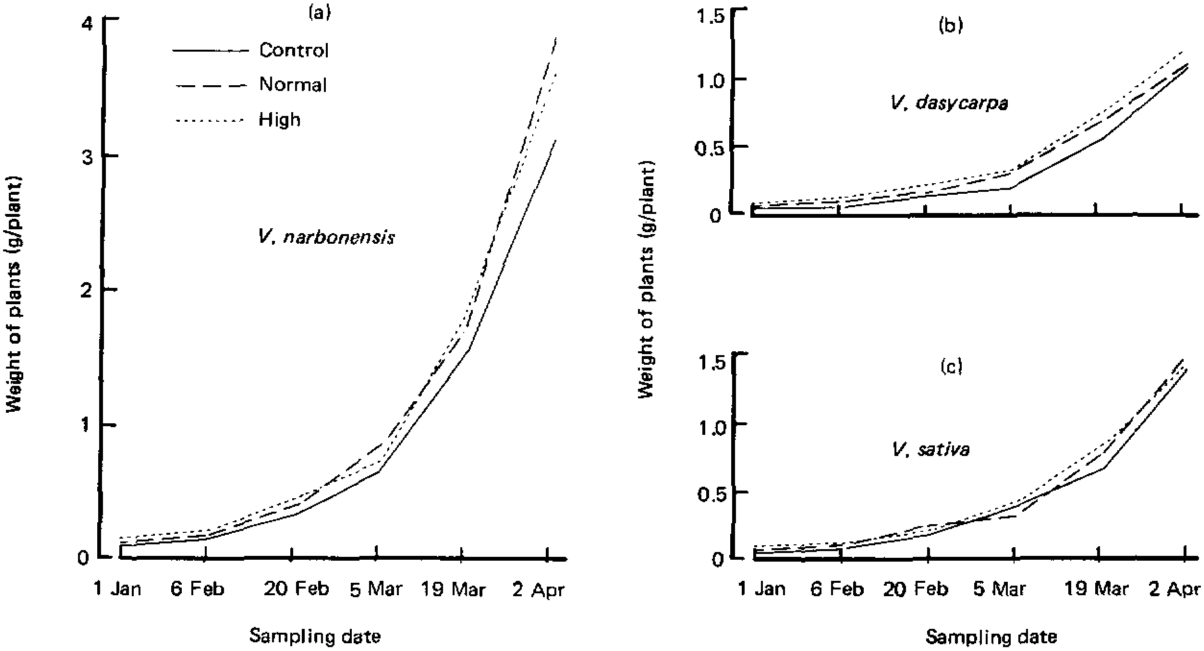


Fig. 6. Weight (g/plant) of (a) *Vicia narbonensis*, (b) *V. dasycarpa*, and (c) *V. sativa* after inoculation with normal and high amounts of rhizobia, and in the absence of inoculation, at six harvests in the growing season.

Table 8. Effects of different strains of rhizobia on herbage production[1] (kg/ha) at different sampling dates during 1983/84.

Rhizobia strain	23 Jan	6 Feb	20 Feb	5 Mar	19 Mar	2 Apr	Mean
Control	62	103	230	427	929	1890	607
VS-4a (N)	63	114	258	476	946	2229	681
VS-1b (N)	68	122	298	444	1031	2106	678
VS-13b (N)	70	119	274	568	1021	2172	704
VS-5a (N)	69	123	300	559	1407	2231	782
Nodulation group E (N)	67	117	276	550	1069	1594	614
VS-4a (H)	70	135	255	495	1008	2295	710
VS-1b (H)	70	131	281	498	1155	2136	712
VS-13b (H)	72	109	298	596	1102	1946	687
VS-5a (H)	69	126	330	461	1419	2073	746
LSD (5%)	NS	NS	53	NS	290	NS	

1. Average of three vetch species.
NS = Not Significant.

were significant only on 20 February and 19 March. The strain VS-5a resulted in the best overall performance whether applied at normal (N) or high (H) levels.

The study of nitrogenase activity indicated that in all three legumes maximum activity was recorded in late February. Also, there was a significant interaction between rhizobia strain and legume species. In this respect the best average performance for *V. sativa* was recorded with strain VS-5a (N), while VS-1b (N) and VS-5a (H) were best for *V. narbonensis* and the commercial strain was best for *V. dasycarpa.*

The results suggest that further investigation of the effects of inoculation are needed on a much larger scale. The Tel Hadya site is fertile, and responses to inoculation may be limited by high levels of available soil nitrogen. Moreover, the field used had previously been used (though not in 1982/83) for growing vetches. If vetch production is extended to areas in which it has not previously been grown, responses to inoculation should be much higher. — *A.E. Osman and J.H. Stephens (FSP).*

Yield and Quality of Forage Mixtures in Relation to Seed Rate and Seed Ratio

Apart from achieving best establishment and maximum yield, defining the optimum seed rate is important in minimizing the costs farmers pay each year to grow their crops. Seed ratio of legume to cereal also affects both quality and yield of forage, and may have an effect on the yield of subsequent cereals. The objective of this study was to validate earlier information on optimum management for maximum hay production and forage quality in legume/cereal mixtures.

In 1983/84, six forage mixtures (vetch/barley, pea/barley, vetch/triticale, pea/triticale, vetch/oats, and pea/oats) were sown at three seed rates (120, 160, and 200 kg/ha) and five legume/cereal ratios (0:100, 33:66, 50:50, 66:33, and 100:0). In each experiment a split-plot design was used with seed rates as main plots and seed ratios as subplots with three replicates. Fertilizer was applied in the form of triple superphosphate at 40 kg P_2O_5/ha.

Plots were harvested when the legumes reached 100% flowering. Samples from each treatment were separated into their components and oven dried (70°C). Subsamples of oven-dried material were used for crude protein analysis and *in vitro* digestibility.

Dry-matter yields in all mixtures were lower than in previous years as a result of the dry season. In all mixtures, use of seed rates higher than 120 kg/ha did not result in any statistically significant differences in herbage production except in vetch/oats, in which herbage yield was significantly increased by using 160 kg seed/ha. Unlike previous seasons, lowest herbage yields were recorded for cereals grown in pure stands (Table 9) and presence of the legume compo-

Table 9. Effects of ratio of legume to cereal in seed mixture on herbage yields (kg/ha) at Tel Hadya, 1983/84.

Mixture	Legume/cereal ratio at sowing					LSD (5%)
	0:100	33:66	50:50	66:33	100:0	
Vetch/triticale	817	1546	1678	2050	2570	213
Vetch/barley	633	1396	1595	1661	1658	265
Vetch/oats	954	1529	1766	1940	2744	399
Mean vetch/cereal	801	1490	1679	1883	2333	
Pea/triticale	706	1259	1522	1868	1883	221
Pea/barley	719	1177	1454	1710	1686	216
Pea/oats	684	1204	1552	1878	2087	276
Mean pea/cereal	703	1211	1509	1818	1885	

nent significantly increased herbage yield. Highest yields were recorded by legumes grown in pure culture although in vetch/barley there were no significant differences between yield of pure legume and mixtures containing 50% or more legume. In pea/cereal mixtures, pure legume again yielded significantly more than mixtures up to 66:33 pea/cereal.

At any one seed ratio, there were only small, nonsignificant differences in crude protein and digestible dry matter due to seed rate. The results are presented as averages of all seed rates in each of the two groups (Table 10).

Crude protein and dry-matter digestibility were higher in vetch/cereal than in pea/cereal, suggesting better quality in vetch. Higher total CP and DDM yields in vetch/barley are therefore due to higher quality as well as higher herbage yield.

In summary, these findings confirm our previous results that legume mixtures are superior to pure cereals. This year's results are unique in that pure legume yielded most, though not significantly more than most mixtures. They also confirm that a seed rate of 120 kg/ha is optimum for maximum herbage production.

The important question still to be answered is the effect of including a cereal in forage mixtures on yield of subsequent cereal crops. Research has been started which will attempt to answer this question. — *A.E. Osman.*

Collaborative Research and Multi-location Testing

Joint activities with the Syrian Agricultural Research Council (ARC) and the Syrian Steppe Directorate (SD) were continued through 1983/84. A total of 45 experiments (29 with ARC and 16 with SD) were carried out at 12 locations in six provinces. The trials included multilocation testing of new genotypes (see forage breeding), impact of early grazing on final hay production, effects of forage crops on subsequent cereal crops, on-farm trials introducing different forages to farmers, and assessment of the potential of forage species on marginal lands receiving less than 200 mm rainfall. The details of all these experiments will be reported in a separate publication, "Collaborative Research between ICARDA and the Syrian Ministry of Agriculture 1983/84." Only a few of the experiments are highlighted here.

Vetches and peas grown in mixtures (33:66) with barley, oats, triticale, and wheat were evaluated at two locations (Hama and Qamishly) for early forage grazing (February) followed by hay making in May. All mixtures were sown in November in plots 5.6 m × 4 m at a seed rate of 160 kg/ha and fertilized with 40 kg P_2O_5/ha in the form of triple superphosphate. The ex-

Table 10. Average values for different quality aspects of mixtures in relation to legume/cereal ratio at Tel Hadya, 1983/84.

	Legume/cereal ratio									
	0:100	33:66	50:50	66:33	100:0	0:100	33:66	50:50	66:33	100:0
	Vetch/cereal					Pea/cereal				
Crude protein(%)	9	15	16	17	19	8	12	13	14	16
Crude protein total (kg/ha)	71	222	260	320	448	56	145	196	258	301
Digestible DM(%)	59	67	67	68	69	57	64	64	65	67
Digestible DM total (kg/ha)	474	997	1125	1288	1610	402	769	969	1184	1255

perimental design was randomized complete block with factorial arrangement — four cereals x two legumes × two grazing regimes (grazed and ungrazed) replicated three times. The plots were grazed in February when plants were 15 to 30 cm tall. Hay yields from both grazed and ungrazed plots were estimated at the end of the season by harvesting quadrats 2 m × 2 m in the middle of each plot.

Grazing did not affect final hay production at either location (Table 11). Yields at Hama were 7 to 14 t/ha compared with 1.6 to 3 t/ha at Qamishly. Highest herbage yields were recorded for pea mixtures at Qamishly and vetch mixtures at Hama.

In a series of experiments aimed at improving productivity of dry-areas pastures, ICARDA assisted the Syrian national program to commence evaluating new legumes and grasses it had acquired in the previous year. It was hoped that, of the various species, some would be adapted to the dry marginal lands, that is, those lands on the edge of the steppe which are too dry for arable agriculture. A total of 40 genotypes belonging to 19 species were tested for establishment and yield on marginal land at five locations (Table 12) with long-term rainfall of 150-296 mm. Soils in all locations were shallow or rocky, and alkaline. The genotypes were sown in small plots (2 m × 2 m) and fertilized with triple superphosphate at 40 kg P_2O_5/ha in November.

During 1984, rainfall was lower than average at all locations and most of the species failed to establish. Only *Lathyrus* spp. grew at some locations. The best yields of *Lathyrus* spp. (340-950 kg/ha) were obtained a Sewada (Arri) where rainfall was highest (190 mm). In view of these results it seems that there will be very limited success of seeding marginal land in Syria with herbaceous species when rainfall is less than 200 mm.

As a result of these and other considerations, this approach to marginal-land improvement has been abandoned. Henceforth the approach outlined later will be adopted on a broad basis in collaboration with the Syrian national program. — *A.E. Osman.*

Table 11. Meteorological data during the growing season, and effects of early grazing on final hay production (kg/ha) from different forage mixtures at Qamishly and Hama, 1983/84.

Crops	Meteorological data	Qamishly			Hama		
	Rainfall	206 mm			264 mm		
	Av.max.temp.	23.3°C			19.5°C		
	Av.min.temp.	6.8°C			7.4°C		
	Av. temp.	15.1°C			13.5°C		
		Grazed	Ungrazed	Mean	Grazed	Ungrazed	Mean
Vetch/barley		2230	1600	1920	13650	9460	11550
Pea/barley		2140	1800	1970	10580	12940	11760
Vetch/oats		1590	2230	1910	7830	7910	7870
Pea/oats		2160	2510	2340	8820	9590	9210
Vetch/wheat[1]		2330	2260	2300	14430	12350	13390
Pea/wheat[1]		2190	2950	2570	14270	8860	11570
Vetch/triticale		2670	2030	2350	10290	12710	11500
Pea/triticale		2440	2780	2610	10490	11570	11030
Mean		2220	2270		11300	10670	

1. Senator Capelly.

	Qamishly	Hama
LSD (P< 0.05) for difference between means of grazed and ungrazed treatments	NS	NS
LSD (P< 0.05) for difference between means of two mixtures	410	229

Table 12. List of legume and grass species tested for establishment on marginal lands at four locations in Syria, 1983/84.

Species	No. of lines	Species	No. of lines
Agropyron elongatum	3	*Oryzopsis meliaca*	1
Coronilla varia	1	*Phalaris aquatica*	4
Lolium rigidum	2	*Poterium sanguisorba*	1
Lathyrus sativus	2	*Scorpiurus muricatus*	1
Lathyrus ochrus	2	*Trifolium alexandrinum*	5
Lathyrus cicera	1	*Trifolium resupinatum*	5
Medicago rigidula	6	*Trigonella arabica*	1
Melilotus alba	1	*Trigonella graecum*	1
Melilotus officinalis	1	*Trigonella sp.*	1
Ornithopus compressus	1		

Annual Pastures to Replace Fallow

The concept of using pastures comprising annual herbaceous legumes is based on farming systems in southern Australia. In these systems, fallows have been replaced in rotations by self-regenerating pastures whose roles are to provide livestock with nutritious grazing throughout the year, to replenish soil fertility, and to provide a disease-controlling break between cereal crops. These systems have been so successful that in parts of southern Australia livestock numbers have increased four-fold and cereal yields doubled since their inception.

The system is simple to manage because the pasture plants themselves do not need sowing except for initial establishment. In the year the farmer begins the system, he sows a pasture comprising various species of annual legumes. As soon as possible he introduces sheep at a rate which controls weeds but allows good flowering and seed set of the legumes. Sheep continue to graze the pasture after it ceases growing at the end of spring, and, by eating the leguminous seeds and pods, maintain their weight through the summer. At this stage the farmer must be careful that, while allowing his sheep to eat seeds, enough seeds remain for pasture survival in later years.

The farmer also allows his sheep to graze cereal stubbles. In this way sheep are easily maintained through summer.

The second year is the cereal year. In this season the farmer waits until the autumn rains and then, after germination of weeds and pasture plants, tills the soil and sows the cereal. Most legume seeds remain dormant (or hard), and it is important that depth of tillage is such that seeds are placed at a depth (about 5-6 cm) from which they can later emerge.

In the third year the pasture regenerates from dormant seed set in the first year. By this time plant numbers are high and a productive pasture is achieved rapidly.

Success of the system depends on several factors. First, the time of greatest feed shortage is usually autumn and winter, when low temperatures and light intensity inhibit plant growth. Indeed many scientists believe that one of the most important differences between West Asia and North Africa on the one hand, and southern Australia on the other, is that temperatures are about 5 °C lower in the former.

A research assistant evaluates annual legumes collected from Syria.

Secondly, the survival of pastures depends on their ability to produce enough seed to provide grazing in the first summer, and a dense pasture in the third autumn. Thirdly, seeds of pasture plants must be able to resist germination in the crop year, and germinate promptly in the third, or pasture year. Finally, the pasture must fulfil its role as a source of nitrogen to the farming system, and, in association with nitrogen-fixing rhizobia, fix sufficient atmospheric nitrogen for its own and the cereal's requirements.

ICARDA has for several years screened annual species of *Medicago* (medics) for adaptability to its region and to the system. Species screened include commercial species developed in Australia (*M. truncatula, M. scutellata, M. rugosa,* and others) and also those of common occurrence in noncultivated land of the ICARDA region itself (especially *M. rigidula, M. polymorpha, M. noeana, M. aculeata,* and *M. rotata*). In 1983/84, two of the most promising species were studied in detail and compared with an Australian cultivar for ability to grow in winter, seasonal nitrogen fixation, and aspects of seed production and survival. Rhizobia requirements of eight species were studied, and a rotation experiment commenced in which the place of medics in regional farming systems is being studied. The rotation experiment is also being used to select medics adapted not only to the soils and climate of the region but also to the new farming system.

Seasonal Productivity

An experiment was designed to measure potential productivity of three medic species inoculated with strain CC 169, an appropriate culture of rhizobia. Twelve rates of sowing were used (from 0.5 to 512 kg/ha) and herbage yields measured on nine occasions from 27 December until 29 April. Potential growth was calculated at each harvest from the relationship between sowing rate and density. Both leaf area and total herbage were recorded: in this way it was possible to calculate potential growth rate from the time the most dense treatment completely intercepted incident light until the end of the growing season.

The three medic species were *M. rigidula* Selection 1919, originally collected at Jisr Al Shoughour, west of Aleppo; *M. noeana* Selection 1938 from Turkey; and *M. truncatula* cv. Jemalong, a widely used strain which was originally found in the wheat zone of Australia. Jemalong was chosen as being representative of Australian medics, and *M. noeana* and *M. rigidula* for their high herbage and seed yield, respectively.

Plot size was 10 m × 1.5 m which allowed for nine harvests of 0.5 m × 1 m. At each harvest herbage was sampled at ground level, subsampled to determine leaf area (using an electronic planimeter), and dried for 24 hours at 90°C.

Seasonal climatic conditions are compared with averages in Fig. 7. Near-average temperatures were recorded, but rainfall was much below average, so much so that in February the experiment was irrigated to maintain growth. Even with the extra 50 mm of irrigation, precipitation (rainfall plus irrigation) remained below average.

Growth in early winter was estimated from harvests on 27 December and 19 January, when relationships between yield and density remained linear (the slight curvilinearity on 19

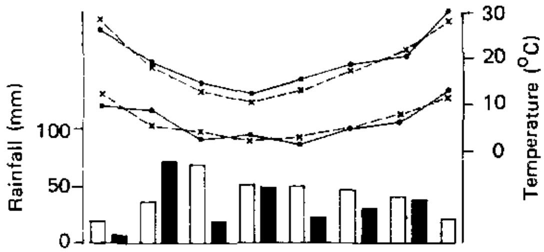


Fig. 7. Seven-year mean maximum and minimum temperatures, 1983/84 mean maximum and minimum temperatures, seven-year mean rainfall, and rainfall received in 1983/84.

January was not significant). Fig. 8 shows that at high density, all three species had produced over 1 t/ha by 19 January. The data demonstrate very clearly that winter production depends heavily on density and is barely affected by genotype: analysis of variance (Table 13) shows that, of the two factors, density is by far the most significant. What this means in terms of selection of genotypes for winter production will be discussed later.

From harvest 4 onward the yield relationship with density became curvilinear (Fig. 9). In Fig. 9 quadratic polynomials were fitted to the relationships between the logarithm (base 10) of herbage yield and the logarithm (base 10) of sowing rate: these have been transformed back to natural numbers in the Figure. The herbage yield of the three species was approximately equal until 1 April when *M. truncatula* fell behind. This was particularly so at low densities, although it remained true at all densities. *M. noeana* and *M. rigidula* continued to yield similar amounts.

However, even on 19 February density seemed to be less important, and by 15 April neither *M. noeana* nor *M. rigidula* responded to densities above 50 kg/ha.

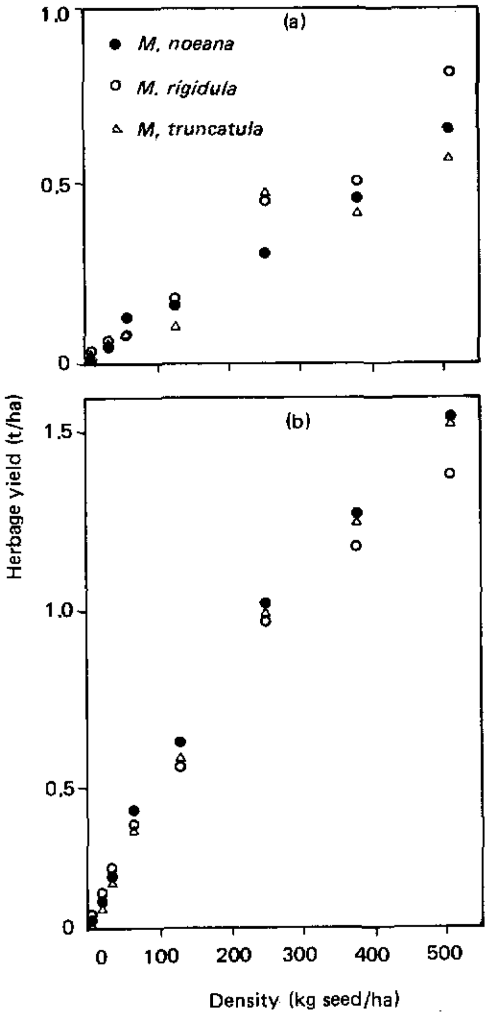


Fig. 8. The relationship between herbage yield and sowing density of *M. noeana*, *M. rigidula*, and *M. truncatula* on (a) 27 December and (b) 19 January.

Growth rates were calculated from the curves in Figs 8 and 9. The curves fitted for the calculations were quadratic polynomials except where statistical analysis revealed that a cubic polynomial gave a better fit. The amount of variation accounted for by the fitted curves is shown in Table 14. From the calculated yields at each density it was possible to determine rates of growth (by subtraction between harvests), and the potential growth rate (fastest growth over all treatments) for each species at each harvest has been plotted in Fig. 10.

The data show that from 19 January (which represents growth rate between 27 December and 19 January) growth rates remained above 40 kg/ha per day (except for *M. rigidula* in the first period) and reached more than 160 kg/ha per day in early spring. Growth rates fell in later spring, probably due to lower than average rainfall.

It is well known that potential rates of growth are not realized until leaf area index (LAI) reaches 3.0 to 4.0 depending on light intensity. In the experiment, no treatment reached this LAI until after 19 January, at which stage it was reached by *M. truncatula* sown at 512 kg/ha (Fig. 11). Thereafter, *M. noeana* and *M. rigidula* achieved complete light interception 16 and 48 days, respectively, after *M. truncatula*. As density decreased, time to reach complete light interception increased, the last treatment reaching this figure being *M. noeana* sown at 16 kg/ha (on 10 April). It is interesting that, below 128 kg/ha no *M. truncatula* treatment achieved LAI of 3.5,

Table 13. Analysis of variance of herbage yield ($\log_{10}$ kg/ha) at harvest 1 (27 December).

	DF	SS	MS	F
Density	11	103.1451	9.3768	189.8***
Species	2	0.1228	0.0614	1.24 NS
Density x species	22	0.9045	0.0411	0.83 NS
Replicates	2	0.0104	0.0052	0.11 NS
Residual	70	2.8172	0.0494	
Total	107	107.0000		

*** $P < 0.01$

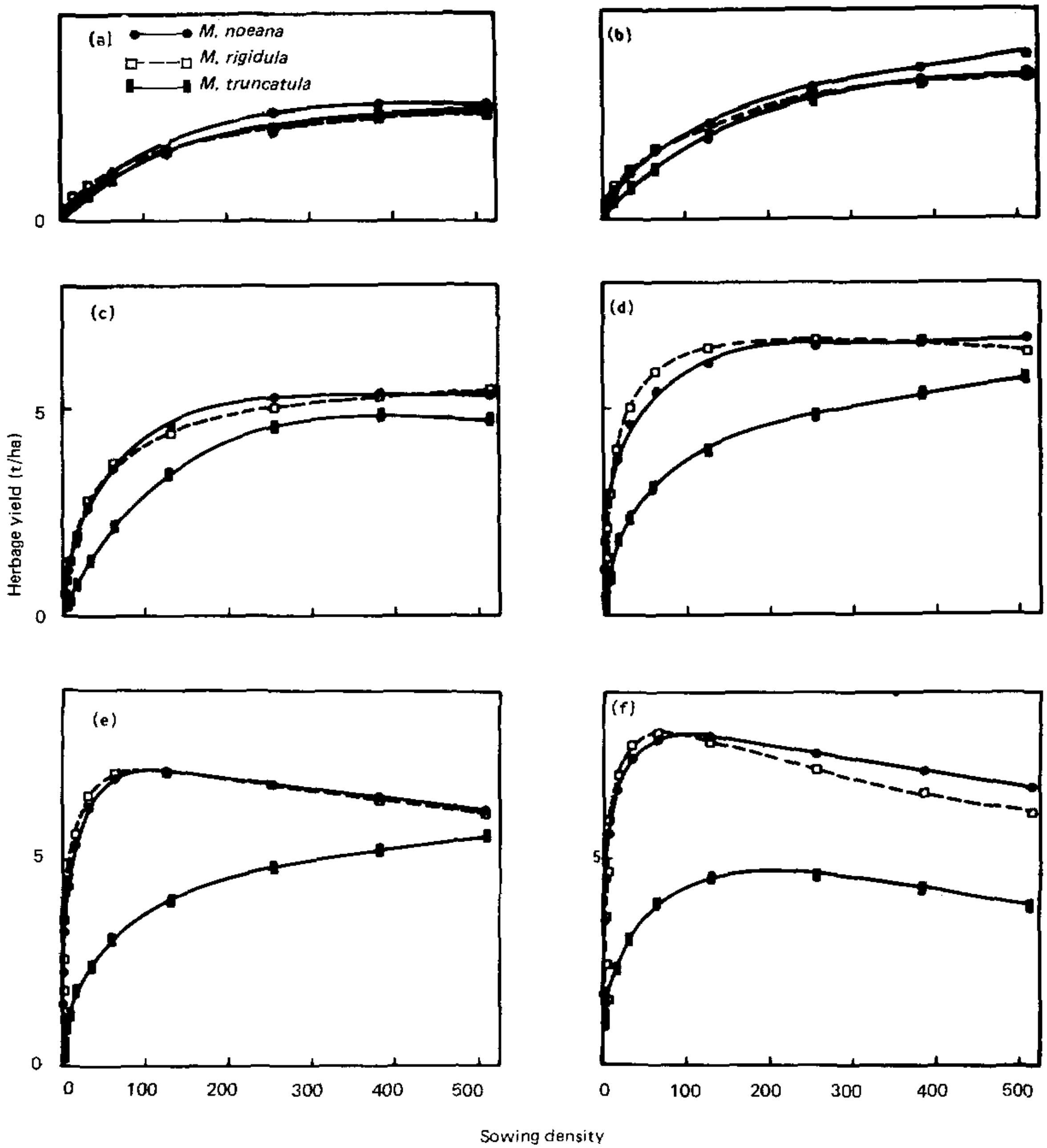


Fig. 9. Fitted curves showing the relationship between herbage yield and sowing density of *M. noeana, M. rigidula,* and *M. truncatula* on (a) 19 February, (b) 4 March, (c) 10 March, (d) 1 April, (e) 15 April, and (f) 29 April. Curves were fitted using quadratic polynomial equations except where cubic polynomials gave significantly ($P<0.05$) better fit. Amount of variation accounted for by the relationships is shown in Table 14.

Table 14. Percentage of variation (100 r^2) accounted for by the equations used to calculate the curves presented in Figs 8 and 9. Quadratic polynomials were used in Fig. 9 except when a cubic polynomial gave significantly better fit. Linear regression was used in Fig. 8 (all relationships in both Figures were significant at $P < 0.01$).

	Date of harvest								
Species	27 Dec	19 Jan	5 Feb	19 Feb	4 Mar	18 Mar	1 Apr	15 Apr	29 Apr
M. rigidula	99	97	99	99	99	99	96	95	98
M. noeana	99	98	99	98	99	99	99	99	86
M. truncatula	97	98	99	99	99	98	94	78	89

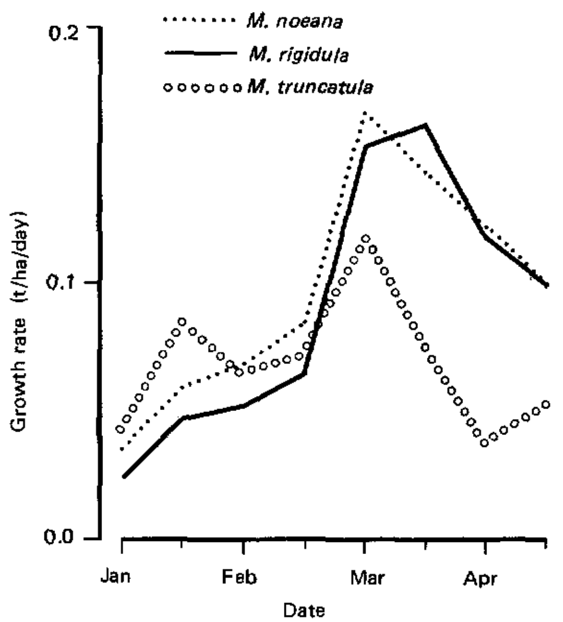


Fig. 10. Seasonal growth rate of *M. noeana, M. rigidula,* and *M. truncatula,* calculated using the yield/density relationships in Fig. 9.

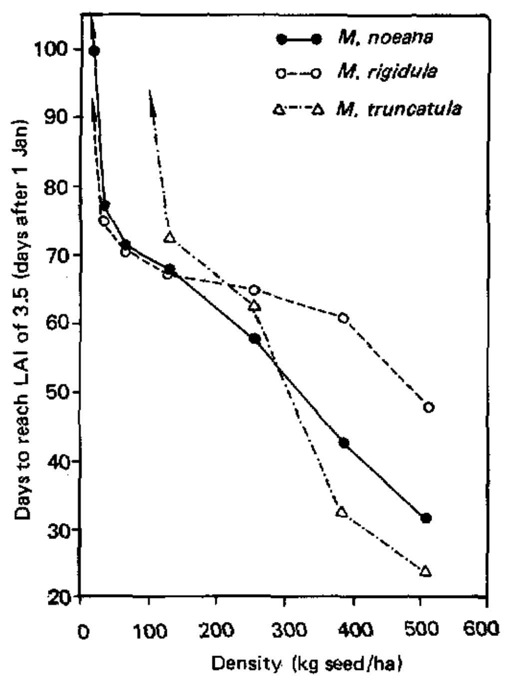


Fig. 11. Relationships between density and the number of days (after 1 January) before each treatment reached leaf area index (LAI) of 3.5 for *M. noeana, M. rigidula,* and *M. truncatula.* Treatments of lower density than those attached to arrows did not reach LAI of 3.5.

reflected in the poor performance of this species at low density.

The data throw considerable light on the value of medics as grazed pastures. The simplest form of grazing management is continuous grazing where sheep are maintained on pasture throughout the year. To be able to do this excess pasture must be produced in spring for summer grazing, and sheep must be maintained by pasture in winter. Stocking rate can therefore be calculated using spring and winter growth rates obtained from the experiment, as described below.

If we assume winter growth rates of 50 kg/ha per day, and assume that sheep can eat half of what grows, then approximately 25 kg/ha per day will be available for grazing. If a grazing sheep eats 2 kg/day, then about 12 sheep/ha can be maintained. If growth rate increases to 100 kg/ha per day for the 10 weeks of spring from early March, excess growth over the sheep's requirements will be 75 kg/ha per day, or a total of 5.3 t/ha. Again assuming consumption of 2 kg/head per day and the same efficiency of grazing (50%), excess spring production will provide 100 days grazing in summer. Together with cereal stubbles the pasture will therefore be able to maintain 12 sheep/ha for most of the year.

While this analysis is necessarily theoretical it supports the assumption that stocking rate for the whole year can be predicted from stocking rate in winter. The data clearly show that high growth rates can be maintained in "cold winter" environments if pasture genotypes are able to maintain high plant numbers.

It is worth commenting that these growth rates compare favorably with those in southern Australia. The results therefore provide considerable support for the feasibility of introducing a medic-based farming system to the region, especially in view of the similarity of winter temperatures at Aleppo and those of a wide range of sites in West Asia and North Africa. It remains now to test these assumptions in the presence of grazing animals. — *P.S. Cocks.*

Flower and Seed Production

Survival of Flowers

In studying flower and seed production the concepts of demography have been, used. Demography in this context is the study of individual plants and how they reproduce. It is a very valuable concept when studying adaptability since adaptability of pasture species in crop rotations can be defined as their ability to produce large numbers of plants in the pasture phase.

What happens to plant populations was studied using the same experiment as that in which seasonal production was measured. Plant populations were counted at each harvest, and from the date at which flowers were first observed, and the numbers of flowers and pods were monitored. Total seed yield was recorded (in quadrats of 1.25 m²), and the components of seed yield (pod numbers, seeds/pod, and seed size) were measured. At regular intervals 10 flower heads were tagged on plants of each species and at two densities (4 and 256 kg/ha), and the numbers of these flowers which produced mature pods were recorded.

M. rigidula easily produced most seed: at the 32 kg/ha seed rate its seed yield was nearly 1 t/ha compared with 0.25 t of *M. noeana,* and less than 0.2 t of *M. truncatula* (Fig. 12). Density significantly influenced seed yield of *M. rigidula,* but had little or no effect on *M. noeana* and *M. truncatula* (F ratios were insignificant for both species). These results contrast strongly with the effect of density and species on herbage production.

Apart from seed weight of *M. rigidula,* individual seed weight and seed number per pod were not related to density (Table 15). However,

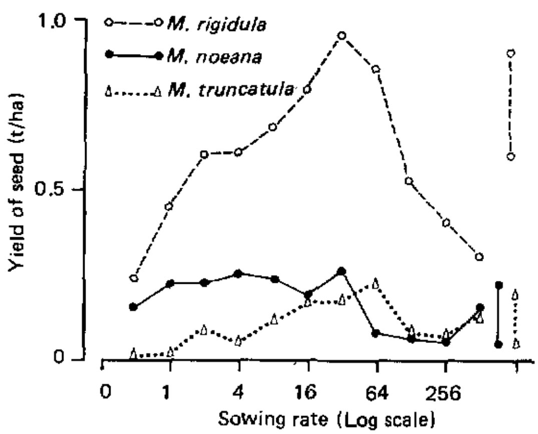


Fig. 12. The relationship between seed yield and rate of sowing (log scale) for *M. rigidula, M. noeana,* and *M. truncatula.* Bars represent least significant differences ($P<0.05$): however the F ratios from analysis of variance of *M. noeana* and *M. truncatula* did not achieve significance.

Table 15. Individual seed weight (mg), number of seeds/pod, weight of seeds/pod (mg), and number of pods/m² of *M.rigidula*, *M. truncatula*, and *M. noeana*, at seed harvest time.

Species	Seed weight	Seed number	Seed weight/pod	Pods/m²
M. rigidula	4.91[a]	6.2	30.4	1923
M. truncatula	3.11	5.3	16.5	712
M. noeana	3.12	3.3	10.3	1550

a. Significant negative relationship to density of sowing ($P < 0.01$, $100\ r^2 = 79$).

number of pods per m² was significantly related to yield of seed in all three species, and in the cases of *M. rigidula* and *M. noeana*, accounted for about 90% of variation in seed yield (Table 16). Between species, *M. rigidula* had significantly heavier seeds than the other species and produced more and bigger pods. *M. noeana* produced more pods than *M. truncatula* but the number of seeds per pod was less, resulting in similar yield.

Since the number of pods was the most important component of seed yield, the number and fate of flowers produced is of interest. Infloresence counts revealed that *M. rigidula* flowered first (commencing in early March), followed a few days later by *M. truncatula*, and almost three weeks later by *M. noeana* (Fig. 13). The largest number of flowers was achieved in *M. rigidula* about 2 weeks after it began flowering; thereafter flower and pod numbers dropped steadily until seed harvest in June. Indeed, of pods present on 18 March, only 21% produced mature pods. Similarly, of *M. noeana* pods only 19% and of *M. truncatula* only 31% were mature pods at harvest.

The number of flowers surviving declined sharply with time of flower appearance in both *M. rigidula* and *M. noeana*, but remained stable in *M. truncatula* except at the last date of tagging (Fig. 14). The number of flowers per infloresence remained approximately constant (about 3 in *M. rigidula*, 3 in *M. noeana*, and 2 in *M. truncatula*). Of early *M. rigidula* flowers, 50% reached maturity, while of those which flowered in late April, none survived. Nearly all of the early

Table 16. Correlation coefficients and significance levels of the relationships between, on the one hand, individual seed weight, number of seeds/pod, and number of pods/m², and on the other, total seed yield.

Species	Seed weight	Number of seeds	Pods/m²
M. rigidula	0.20 NS	0.51 NS	0.93***
M. noeana	0.41 NS	0.45 NS	0.95***
M. truncatula	0.33 NS	0.01 NS	0.74**

NS = Not significant.
*** Regression significant at $P < 0.001$; ** $P < 0.01$.

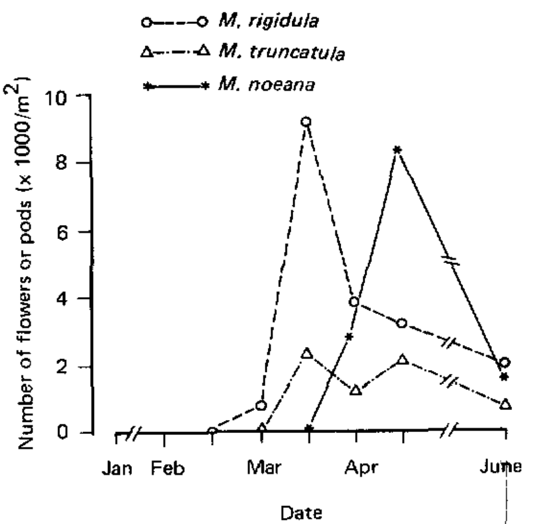


Fig. 13. Number of flowers and pods (mean of all densities) present in *M. rigidula*, *M. truncatula*, and *M. noeana* from the commencement of flowering until seed maturity.

M. noeana flowers survived, dropping to 10% of late flowers, while of *M. truncatula* about 20-30% of all flowers survived.

The data are important because they indicate

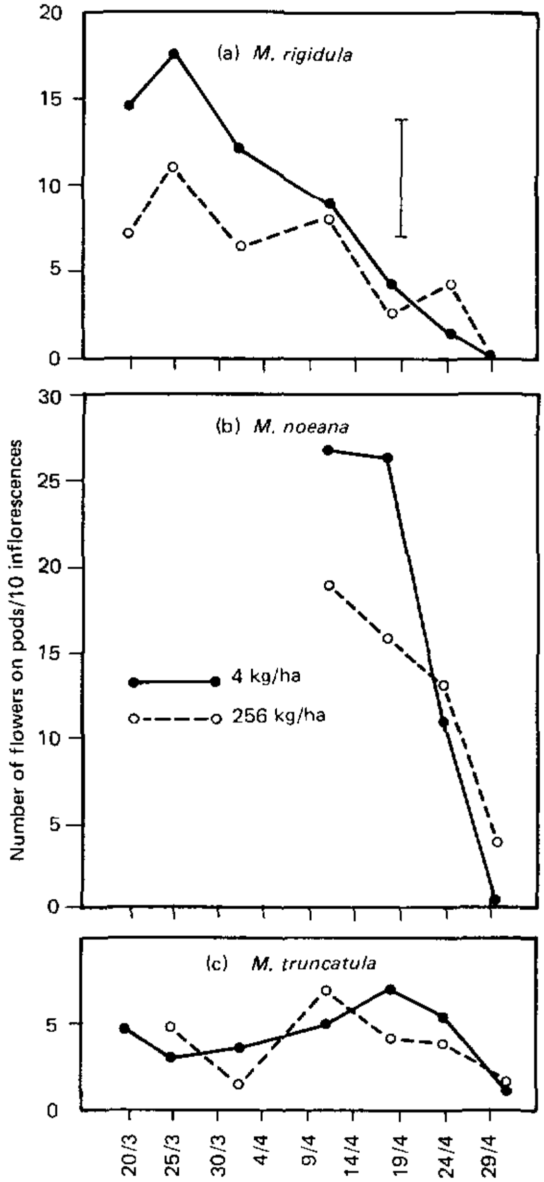


Fig. 14. The number of flowers per 10 inflorescences reaching anthesis at the dates shown and which subsequently matured, at densities of 4 kg/ha and 256 kg/ha for (a) *M. rigidula*, (b) *M. noeana*, and (c) *M. truncatula*.

the huge loss in seed yield involved in loss of flowers and pods. Why does it happen? In the case of *M. truncatula* the fungus disease *Phoma medicaginis* seems to play a role and may explain why even the early flowers of this species often fail to mature. The other species appear resistant to the disease and it will be necessary to look for reasons associated with plant competition and the environment.

Survival of Seeds

In a pasture/cereal rotation seeds must survive through a year of cereal before the pasture reestablishes. In most situations some seeds will germinate as crop weeds and some will survive to form pasture. The proportion of seed in each category is clearly important and, in medics, as in other annual legumes, depends on the proportion of hard seeds: seeds which have coats able to resist penetration by water.

The number of hard seeds in the seed population was determined at regular intervals commencing 3 June, and ending 22 October: in all, 16 estimates were made. On 3 June all populations were more than 94% hard, but by 22 October the *M. truncatula* population dropped to 80% hard. Although there were some fluctuations, seeds of the other species remained practically unchanged for the whole period.

These studies of *M. truncatula* seeds (Fig. 15) are of interest for two reasons: first, there was a significant effect ($P < 0.001$) of sowing density on hardseededness, and secondly there were statistically significant fluctuations in hardseededness ($P < 0.01$). The effect of sowing density is important because it indicates that pasture management has an effect on seed survival: seeds of the less dense swards were softer possibly because there was less protection from impact of the sun's heat. Such effect opens up the possibility of controlling hardseededness through grazing management. Fluctuations in hardseededness are important because they throw into doubt the concept of irreversible hardseededness, and question whether a single

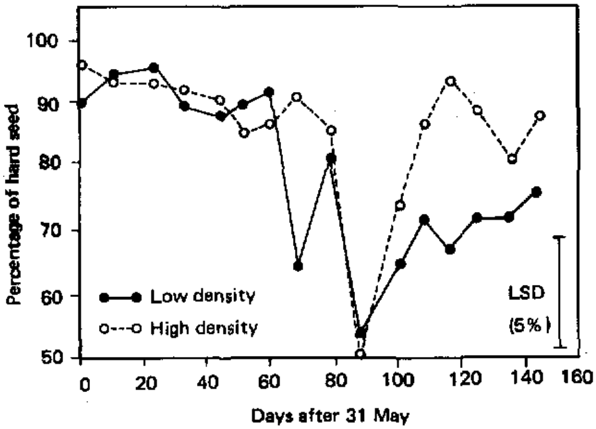


Fig. 15. Changes in the percentage of impermeable (hard) seeds of *M. truncatula* with time originating from low density (4kg/ha) and high density (256 kg/ha) treatments.

sampling of pods gives an accurate measure of seed permeability. — *P.S. Cocks.*

Nitrogen Fixation

Inoculation Experiments

Recently the need to inoculate annual medics with appropriate strains of rhizobia has been demonstrated in Jordan and Iraq. Inoculation produced plant growth responses in four of five sites tested (Unpublished work of P.S. Cocks, and B.C. Bull, SAGRIC International). Surprisingly, the pre-1982 commercial Australian rhizobia strain proved ineffective, and a new strain, WSM 244, isolated in Iraq (D. Chatel, personal communication), proved most effective. The new commercial Australian strain, CC 169, was also effective, although less than WSM 244. In the experiments, successful inoculation alleviated the more severe symptoms usually attributed to the effect of excessive cold on Australian medic cultivars.

The results have two implications for ICARDA's attempt to introduce the medic system to West Asia and North Africa. First, they indicate that the apparent lack of adaptability of Australian medic cultivars may simply be the inability of the Australian rhizobia strains to grow and multiply. Secondly, since presumably strains are effective on Australian cultivars in Australia, there may be an important site × rhizobia interaction, where strains effective in Australia are ineffective at many West Asian sites. This may explain the success of *M. rigidula* near Aleppo, where it occurs naturally and where suitable wild rhizobia are likely to be present. It is interesting that *M. rigidula* often fails in Jordan where appropriate wild rhizobia may not occur.

An experiment was designed in which nine medic species were sown uninoculated, or inoculated with rhizobia strains WSM 244 or CC 169. The experiment was repeated at eight sites, four in Syria, three in Jordan, and one in Lebanon. The species were sown in rows of about 100 plants, the rows spaced 1 m apart. There were four replicates at each site.

The seeds were inoculated by mixing peat inoculum with molasses as a sticker, immediately before sowing. Approximately half the plants were harvested at the end of winter, and the remainder during spring. The number of plants harvested was counted, and the plants were oven dried and weighed.

The species used were as follows: *M. aculeata* (Sel. 2008 from Libya), *M. blancheana* (Sel. 2099 from Syria), *M. littoralis* cv Harbinger (an Australian cultivar), *M. noeana* (Sel. 1938 from Turkey), *M. rigidula* (Sel. 716 from Syria), *M. rotata* (Sel. 1943 from Turkey), *M. tubinata* (Sel. 2100 from Jordan), *M. truncatula* cv Jemalong (an Australian cultivar), and *M. scutellata* cv Robinson (an Australian cultivar).

Significant responses were obtained at only two sites: Tel Hadya (Syria) and M'shaqa (Jordan). Because the season was so dry the results at Sweida (Syria) and Ramtha and Rabba (Jordan) are inconclusive, while there appeared to be no need for inoculation at Terbol (Lebanon) and Souran (Syria) (Table 17). The last site, Qamishly in northeast Syria, was abandoned due to drought.

Table 17. Mean yields (g/10 plants) of the eight medic species after no inoculation, or inoculation with strain CC 169 (Australian commercial) and WSM 244 (isolated from Iraq) at seven of the eight sites in Syria, Jordan, and Lebanon.

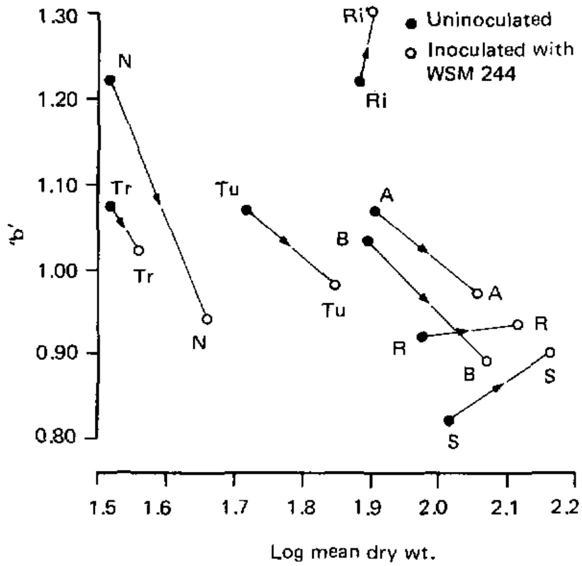
Rhizobia strain	Tel Hadya	Sweida	Souran	M'Shaqa	Ramtha	Rabba	Terbol
Nil	5.21	2.84	4.15	0.47	3.07	0.17	49.9
CC 169	7.24	2.77	4.17	0.86	3.40	0.20	51.2
WSM 244	7.76	3.07	4.86	0.91	3.48	0.21	51.0
Significance of F ratios[1]	**	NS	NS	NS	***	NS	NS

1 Analysis of variance conducted on $\log_{10}$ g per 10 plants.
** $P < 0.01$, *** $P < 0.001$.

Although the results were inconclusive they do indicate that responses to rhizobia may be widespread. While it is recognized that in the absence of statistically significant responses interpretation is difficult, analysis of data did reveal some interesting relationships (Fig. 16).

Fig. 16 is based on the result of a Findlay and Wilkinson (1963)* analysis of genotype × environment effects when the nine species were uninoculated, or inoculated with strain WSM 244. The y-axis represents the slope of the relationship between individual species yield at any site and the mean yield of the site, while the x-axis is the mean yield of the species over all sites. Points to the left of the figure represent low yielding species, and to the right, high yielding, while points above a slope of b = 1 indicate site specialization, and below it, increasing yield stability. The best-adapted species have high mean dry weight and a slope of approximately b = 1.

Fig. 16 indicates that inoculating the medics tended to increase adaptability and stability compared with uninoculated controls. In this experiment (which included only vegetative growth), *M. aculeata*, *M. rotata*, *M. blancheana*, and *M. scutellata* were most widely adapted, while *M. truncatula*, and *M. noeana*, were least widely adapted. However, the Figure is included to indicate the beneficial effect of inoculation: adaptation of the medics themselves cannot be measured in plots such as these. — *P.S. Cocks and B.C. Bull (Sagric International, Adelaide, Australia).*



N = *M. noeana*, Tr = *M. truncatula*, Tu = *M. turbinata*, Ri = *M. rigidula*, A = *M. aculeata*, B = *M. blancheana*, R = *M. rotata*, and S = *M. scutellata*.

Fig. 16. The relationship between 'b' (slope of the relationship between treatment yield and site yield of the eight species either inoculated or uninoculated) and the mean dry weight of each treatment over all sites.

* Findlay, K.W. and Wilkinson, G.N. 1963. Australian Journal of Agricultural Research 14: 742-754.

Rate of Nitrogen Fixation

In our 1983 Annual Report we highlighted the low nitrogen-fixing ability of annual medics. Indeed, using the acetylene reduction method, maximum nitrogenase activity was found to occur when the plants had reached only 4% of their maximum dry weight. It appeared that nitrogen available from fixation had little, if any, bearing on the plant's final yield.

If this is so then medics will not fulfil their role of increasing the soil fertility through nitrogen fixation in pasture/cereal farming systems. Clearly, the question needs much closer attention than it has hitherto received.

The opportunity was taken to measure seasonal nitrogen fixation in the experiment on seasonal production discussed earlier. This was attained by analyzing all herbage for total nitrogen, estimating root growth, and including in the experiment a treatment of pure grass where amount of nitrogen absorbed indicates available soil nitrogen. Fixed nitrogen can then be calculated from the difference in nitrogen uptake between medic and grass.

Root growth was measured in soil cores of 60 cm^2 area and 22 cm depth. Roots were separated from soil by careful washing in a jet of water.

The grass used was *Lolium rigidum* (annual ryegrass) sown at 100 kg of seed/ha. Because there was only one treatment accuracy was increased by using six replicates instead of the three medic replicates. Herbage yields were measured in the same way as for medic.

This method of measuring nitrogen fixation assumes that grasses and legumes have equal access to soil nitrogen. Root yields indicated that this may not have been so at early harvests, but that from 5 February onward, when medic and grass root yields became equal, or nearly so, the assumption probably held good (Table 18). The small amount of error involved, even that at the early harvests, has been ignored in interpreting the results.

Nitrogen fixation rates varied from less than 1 kg/ha per day to more than 4 kg/ha per day (Fig. 17). Fixation rates reflected growth rates, reaching a peak in March, and declining during April. In spring, *M. truncatula* fixed markedly less nitrogen than the other species although its winter fixation rate was similar. It is clear that nitrogen fixation continued throughout the growing period and, in contrast to earlier results at Tel Hadya, made an important contribution to final yield. Indeed, total fixation of *M. noeana* approached 300 kg N/ha.

It is worth reiterating that these measurements represent potential nitrogen fixation. Actual amounts of nitrogen fixed are usually less than the calculated potentials. Nevertheless, even these demonstrate the considerable ability of annual medics to fix nitrogen (Table 19).

Analysis of the Kjeldahl nitrogen data on relationship between nitrogen percentage and density in *M. rigidula* and *M. noeana* showed that either nitrogen percentage was not affected by density, or it fell slowly as density increased. Such relationships are normal and indicate the effect of plant competition on the efficiency of photosynthesis. In the case of *M. truncatula,* however, the relationship was quite different: as density increased nitrogen percentage at first fell

Table 18. Mean root weight (kg/ha) of the medics sown at high density and of ryegrass over the nine harvests.

	Date of harvest								
Species	27 Dec	19 Jan	5 Feb	19 Feb	4 Mar	18 Mar	1 Apr	15 Apr	29 Apr
Medic	370	490	730	940	850	1070	970	820	840
Ryegrass	59	150	620	560	610	1060	1100	1190	880

Table 19. Total amount of nitrogen fixed in the best treatment on 29 April (kg/ha), density of the best treatment, and potential yearly nitrogen fixation (kg/ha) as calculated using potential growth rates.

Species	Density (plants/m²)	Nitrogen fixed (kg/ha)	Potential fixation (kg N/ha)
M. rigidula	64	139	229
M. noeana	128	153	272
M. truncatula	256	71	202

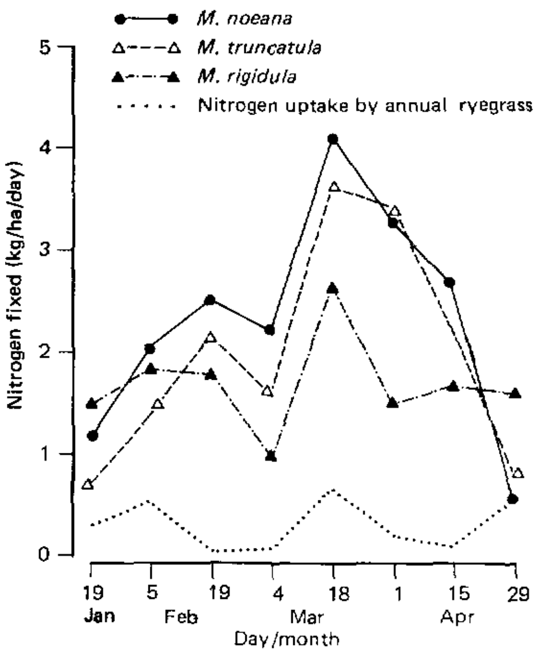


Fig. 17. Seasonal rate of nitrogen fixation of *M. noeana, M. rigidula*, and *M. truncatula*.

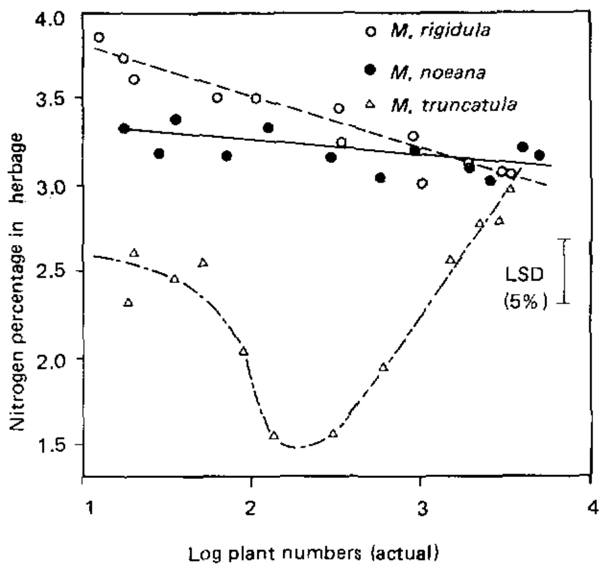


Fig. 18. The relationship between nitrogen percentage in herbage and plant numbers (log 10/m²) of *M. rigidula, M. noeana*, and *M. truncatula*. The straight lines were fitted by linear regression in the cases of *M. rigidula* (100 r^2 = 88***) and *M. noeana* (100 r^2 = 48), but the curve of *M. truncatula* was fitted by eye. Least significant difference ($P < 0.05$) between any two *M. truncatula* percentages are indicated by the bar.

sharply then increased with increasing density such that at highest densities amount of nitrogen was similar to that of the other species (Fig. 18).

The explanation is that the *M. truncatula*/CC 169 relationship is inefficient. At low densities this strain is unable to fix sufficient nitrogen for plants whose growth is not inhibited by other environmental stresses. As density increases individual plant size declines due to inter-plant competition, and at high density an individual plant has such a small demand for nitrogen that its low fixation rate is sufficient. At this point nitrogen percentage in the herbage increases (higher nitrogen percentage at very low densities reflects the ability of the soil to provide nitrogen to the very low number of plants). That this particular host/rhizobia relationship is inefficient is supported by the rhizobia strain experiment at Tel Hadya where strain CC 169 on *M. truncatula* produced much smaller plants than strain WSM 244. — *P.S. Cocks.*

Results from the Two-Course Rotation Experiment

The rotation experiment has two objectives: (1) to monitor important variables in a pasture/cereal system compared with continuous cereal and food legume/cereal, and (2) to enable natural selection of medics adapted to two-course rotations. The experiment is jointly managed by the Farming Systems Program and the Pasture, Forage, and Livestock Program.

Lack of commercial use is a major obstacle to designing research projects aimed at developing a pasture/cereal system. For example, on the one hand, the best way to select adapted medics is to select from within farming systems in which they are or will be used. On the other hand, without adapted medics it is difficult to develop such a system. Moreover, it is hard to convince farmers, or even national research and extension organizations, of the benefits of a system based solely on southern Australian experience, seen as alien by people in West Asia. What is needed is a "best bet" system in which a number of parameters can be monitored, and from which a farming system can be derived based on experience of a particular environment.

At Tel Hadya the new two-course rotation experiment offers an excellent opportunity to develop such a system. The seven rotations being tested are continuous wheat, wheat alternating with a summer crop, wheat with each of four legume crops — lentils, chickpeas, vetch, and peas — and wheat with medic pasture. The experiment began in November 1983 with the sowing of both phases of each rotation and will continue indefinitely. There are three replicates and individual plot size is 0.5 ha.

The experiment is too large to monitor completely, so three treatments were chosen: continuous wheat, wheat/lentils, and wheat/medic. As well as factors which affect cereal production — soil fertility, presence of weeds, and incidence of disease — parameters of importance to pasture survival are also being monitored. These include changes in medic seed population, and rate of breakdown of hard seeds.

The experiment also offers a unique opportunity to select medics adapted to a two-course rotation. The approach is to use natural selection within the pasture/cereal system, and to this end a physical mixture of 113 genotypes was sown (Table 20). The seed population will be sampled each year, and surviving genotypes will be subject to more conventional selection procedures.

In this report only three results are presented: medic seed yields and their rate of decline under grazing, liveweight of sheep grazing the pastures during late spring and summer, and seed production and seed survival of species in the mixture.

Although drought severely affected herbage and seed production, sheep, at the rate of 8/ha (4/ha counting the crop) were introduced on 8 April, and were totally sustained either by pasture or cereal stubble, until 3 September. The sheep lost weight when first introduced but this was attributed to disturbance by wild dogs, which eventually attacked and maimed several ewes. A new group of sheep was then introduced, and for the following 8 weeks grazed nothing but dry medic residues and medic seed. During this period the sheep steadily gained weight (Fig. 19) until removal to stubbles where they remained until 3 September, their liveweight slowly declining.

During the period of grazing, medic seed yield declined from 64 kg/ha to 18 kg/ha.

The results are very encouraging. Even in this drought year, a first-year pasture/cereal farm was able to support four sheep per ha for 20 weeks without supplementary feeding. However, seed yield fell to a level at which satisfactory regeneration cannot be expected, and it may be necessary to resow the pasture after the cereal phase.

The seed population was sampled on four occasions and sorted into species on the basis of pods. If the original proportion of each species is adjusted to the base 100, the data in Fig. 20 represent changes as a result of the growing

Table 20. Species, numbers of accessions, weight, and percentage of the total weight of each species, of the mixture sown in the long-term rotation experiment at Tel Hadya.

Species	Number of accessions	Weight (kg)	Percentage of total weight
M. aculeata	22	6.75	14.9
M. blancheana	1	2.00	4.4
M. constricta	9	1.20	2.6
M. littoralis	1	2.00	4.4
M. noeana	4	3.20	7.0
M. polymorpha	7	1.00	2.2
M. rigidula	30	13.35	29.4
M. rotata	13	4.75	10.5
M. rugosa	1	0.20	0.4
M. scutellata	1	2.00	4.4
M. truncatula	12	4.84	10.7
M. turbinata	12	4.15	9.1
Total	113	45.44	100

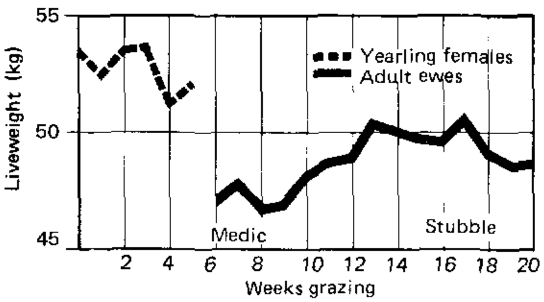


Fig. 19. Change in liveweight of yearling females and adult ewes grazing medic pastures from 8 April to 16 July and wheat stubbles from 17 July to 3 September.

season (yields on 3 June) and as a result of summer grazing. The data show that during the growing season, seed yields of *M. rigidula, M. rotata*, and *M. blancheana* increased while *M. noeana, M. truncatula*, and *M. aculeata* decreased. By 15 July, however, only *M. rotata* was present in greater numbers than originally sown.

However, it is far too early to conclude that *M. rotata* is the species best adapted to the system at Tel Hadya. It will have to survive cultivation and sowing of the cereal crop and regenerate in the next pasture year: only then will it have survived *all* phases of the rotation, and only then can reliable conclusions be drawn of its suitability for this farming system. — *P.S. Cocks.*

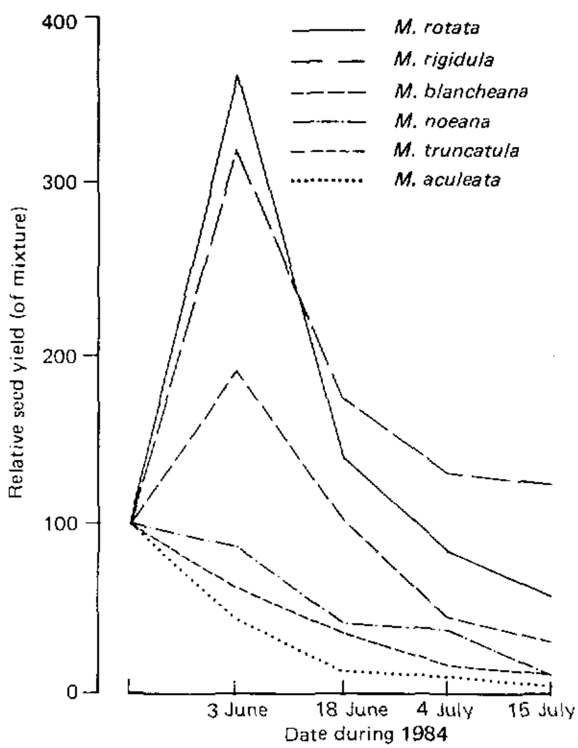


Fig. 20. Seed yield of the various medic species included in the mixture sown in the long-term two-course rotation experiment at Tel Hadya. Yields are expressed to the base 100 at sowing time, and seed yields were measured on four occasions from 3 to 15 July.

Measuring biomass production on marginal lands.

Marginal Land Improvement

Research in this project focuses on the improvement of the permanent grazed pastures of the "marginal lands". In this report "marginal land" refers to nonarable land within and adjacent to the cereal zone, used for grazing by flocks of sheep and goats. The land is controlled either by individual or groups of villages, only rarely by single farmers, and provides grazing mainly in spring. Since such land constitutes about 30% of the total land of western Syria that receives more than 200 mm of rain, and up to 60% of the land of some villages, it is important to the economy of these villages and to Syria as a whole. Furthermore, such land extends beyond the borders of Syria to include huge areas of West Asia and North Africa.

Improvement of marginal lands presents many problems. By definition they are not arable: they are often steep, usually stony, and the soil is usually shallow. Soil fertility is low but economic considerations may preclude use of fertilizers. They are intensively grazed and plant populations are therefore likely to be low. In many cases soil erosion is severe. Nevertheless, if productivity could be increased, especially in winter, village sheep numbers would rise, thereby improving stability and productivity of village farming systems as a whole.

The most effective way of increasing livestock productivity is to increase the supply of pasture. The alternatives, better location of watering points, selection of more productive livestock, control of animal diseases, and so on, will have little impact unless supply of pasture is increased. Accordingly, the biological and environmental constraints to pasture productivity are being examined in order to formulate strategies for increasing pasture production. Soil fertility, rainfall, plant numbers, plant genetic resources, and grazing intensity are being measured and will be related to available herbage and potential productivity using multivariate analysis.

The first study, near the village of Bueda, is part of a wider study being conducted by the Farming Systems Program to understand interactions between biological and environmental resource bases, social organization of production, and techniques used by farmers. It will also, by analyzing the current resource base, indicate the future direction of research and development of marginal lands. Much of this work is discussed in the Farming Systems section of this report.

The second study, an ecological survey of medics and other annual legumes on the marginal lands of Syria and Jordan, is important both for the marginal lands project itself, where it helps describe the resource base, and for the annual pastures project, where it establishes relationships between species and environment. Rhizobia were also collected during the survey, and it is expected that the material and data so obtained will be of value in extending the use of pasture legumes to new areas. A second survey is being conducted in 1984/85, and preliminary results are presented by the Genetic Resources Unit.

Ecology and Productivity of Marginal Land Near the Village of Bueda

Bueda is a low rainfall (about 280 mm average) barley- and livestock-producing village surrounded by large areas of marginal land. On the plains, barley is grown, in rotation with fallow. Sheep and goats are kept by farmers for milk and meat. The animals are maintained on barley grain during late summer, autumn, and early winter; on weedy fallows, roadsides, and grazing lands during late winter and spring; and on cereal stubbles during summer. Some leguminous forage crops are grown (principally *Lathyrus sativus*), and farmers may purchase concentrate food (especially cottonseed cake) in times of shortage.

In this system, marginal lands assume importance principally in spring, when they feed most of the livestock. Shepherds take their flocks to the hillsides during the day, and utilize pastures as quickly as possible. Pastures are therefore grazed intensively while they are flowering and setting seed. There is little, if any, management of pastures for the long-term benefit of the range.

It is extremely difficult to measure carrying capacity of Bueda's grazing lands, but it is likely to be less than one animal every 2 ha. A higher stocking rate is achieved at higher rainfall sites, of course, and we estimate that grazing lands at Tel Hadya, for example, may carry nearly one animal per ha. Similar lands in other Mediterranean environments may carry more than double this amount.

At Bueda the land is generally steep, with hills rising 200-300 m above the plain. The soils are developed from limestone, although the tops of hills are covered with a thin layer of basalt. The slopes have been cultivated by the villagers as far as possible: even the hill tops, where stones permit, have been cultivated with the *fedan* plow. Indeed, the large number of stones, covering about 30% of the land surface, is the most striking characteristic of the site.

Primary productivity was measured along two transects (transect 1 at Bueda itself, and transect 2 at the tiny village of Noumania, about 1 km away) from the base to the peak of a range of hills. Plant population, available herbage and total primary productivity were measured at 108 quadrat sites, together with an extensive soil analysis. Total productivity was measured in protected cages, and available herbage at matched sites near each cage. No attempt was made to select uniform sites: indeed variability in both soil and topography is an essential part of the analytical technique which will be used.

The cages covered 60 cm × 60 cm of land surface, were 60 cm high, and all exposed sides were clad with chicken wire. In view of the stoniness of the land it was necessary to choose sites carefully, avoiding those with large stones. Furthermore, small stones were removed from inside the cages to facilitate harvesting, but in the event, as will be discussed later, this proved to be a mistake.

Total herbage yield was 480 kg/ha, and available herbage at the time of harvesting total herbage, was 460 kg/ha. Of the 108 quadrats, 70 produced less than 500 kg of herbage/ha (Fig. 21), an amount normally accepted as the minimum necessary for sheep to maintain weight. That the difference in total and available herbage was so slight is an indication of the very small amount of herbage consumed by the grazing animals, even though long periods were spent at grazing.

Inadequate herbage is reflected in the amount of supplementary feed provided to the livestock in order to maintain their weight. Sheep grazing the marginal land required a greater amount of supplementation to maintain liveweight than those sheep fed concentrate rations only: 2.2 kg/head compared with 1.7 kg/head, a reflection of the extra energy requirements needed to walk to the marginal lands each day (see Farming Systems Report).

Herbage production itself was related to plant numbers, although the relationship became less close as the season progressed (Fig. 22). The

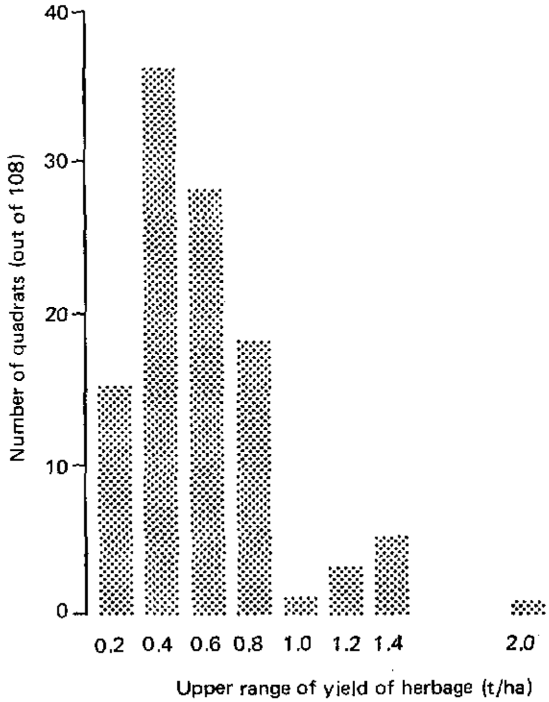


Fig. 21. distribution of herbage yields of 108 protected quadrats at marginal land sites near the villages of Bueda and Noumania. *Each column represents a range of 200 kg/ha, e.g. 200-400, 400-600, etc.*

herbage was dominated by annual grasses, although up to 50% of the numbers in some quadrats comprised annual legumes. However, the legumes produced on average rather less herbage than numbers predicted: at 30% of numbers for example, they comprised only 25% of the herbage. Given that grass growth was restricted by low nitrogen this result indicates that legume growth too is restricted by some aspect of the environment, possibly low phosphorus.

It was mentioned earlier that removal of stones from inside the cages was probably a mistake. This was because plant numbers were lower inside compared with outside the cages on the same date: 2670 plants/m² compared with 2230, a highly significant difference. Evidently, stones provide protection, probably in the form of conserving water at germination.

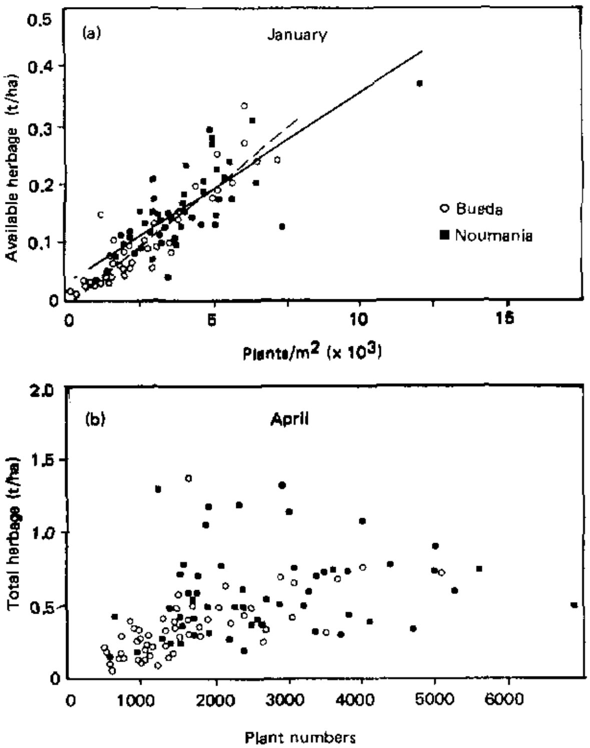


Fig. 22. The relationship between available herbage and plant numbers in January and April at marginal land sites at Bueda and Noumania. The relationships were significant in January at both *Bueda* (100 r^2 = 90*) and *Noumania* (100 r^2 = 65***) and in April at Bueda only (100 r^2 = 36***).**

Seed was collected from within the cages, and from the open range. Total seed yields were 220-330 kg/ha at both sites, and each population was dominated by annual grasses (Table 21). Noumania had slightly lower total yields, but the proportion of legume was higher. Protecting the range increased seed-set at Bueda by 34% but by only 10% at Noumania, and at the latter site the amount of legume actually increased in the open range. At neither site did protection affect the weight or number of herb seeds.

Grazing was monitored only at Bueda, and it was at that village that the necessity to feed high amounts of concentrate, mentioned earlier, was observed. The total effect of grazing the Bueda marginal lands was, therefore, to increase feeding costs and reduce the seed population by more than 30%, a high cost indeed. It is clear that more rational management systems must be developed for marginal lands associated with these villages.

The vegetation itself was extremely complex. A preliminary botanical analysis revealed that many grass species, both perennial and annual, were present, as well as several legumes, other herbs, and a few shrubs. Foremost among the grasses were *Heteranthelium piliferum, Echinaria capitata, Stipa capensis, Bromus fascilatus, B. sericeus, B. intermedium, B. lanceolatum, Phalaris paradoxa,* and *Poa* spp. Of the legumes, *Trigonella stellata, T. monspeliaca, Trifolium stellatum, T. scabrum, T. campestre, T. cherleri, Medicago coronata, M. praecox, M. rigidula, Onobrychis crista-galli, Scorpiurus muricatus,* and *Hymenocarpis circinnatus* were found, while at least 16 composites, crucifers, and other herbs were present. This list is by no means exhaustive. The diversity of legumes in particular is one of the more interesting characteristics of marginal lands, as we shall see later.

Table 21. Seed yields (kg/ha) and seed numbers (seeds/m²) in protected cages and on the open range at (a) Bueda (transect 1) and (b) Noumania (transect 2). Seed numbers are in parentheses.

	Grass	Legumes	Others	Total
(a) Bueda				
Protected	285 (5650)	17 (790)	24 (1060)	326 (7500)
Unprotected	208 (4080)	9 (550)	26 (900)	243 (5530)
(b) Noumania				
Protected	188 (5890)	16 (1850)	38 (1650)	242 (9390)
Unprotected	145 (5100)	39 (2430)	36 (1960)	220 (9490)

Analysis of the data is incomplete pending soil analyses. When these are available the data will be subject to multivariate analysis which, it is hoped, will reveal the interrelationships between plant numbers, species diversity, soil fertility, and primary productivity.

The results were obtained in a year of very low rainfall. It is highly likely that in a normal year primary productivity will exceed the amounts recorded here. The measurement will therefore be repeated in 1984/85. Nevertheless, it is clear that primary productivity is very much below its potential and that ways must be found to increase pasture production. — *P.S. Cocks.*

Ecological Study of Annual Legumes in the Marginal Lands of Syria and Jordan

Improvement of marginal lands involves increasing the legume population, either by sowing improved species or by encouraging those legumes already present. For either objective to be attained it is necessary to know what legumes are growing naturally on marginal lands, what physiological characters they possess, what is their specific habitat, and what potential do they offer for increasing productivity. Such information will not only be of value for our marginal lands work, but also for our annual-pasture improvement.

Syria and Jordan are ideal locations to study ecology of the annual legumes. Very many medics are native to the region, as are many species of *Trifolium, Astragalus, Trigonella, Coronilla, Onobrychis,* and others. Should it be possible to describe habitats in terms of climatic and edaphic variables it should also be possible to predict, for any new area, the genus and species most likely to succeed. Such information would increase the likelihood of success in any selection program, which is complex enough in other respects.

Some broad parameters affecting distribution are already known: for example it has long been recognized that most medics inhabit alkaline soils while subterranean clover *(Trifolium subterraneum)* inhabits acid soils. *M. polymorpha* requires wetter soils than *M. minima,* and it is possible that *M. rugosa* inhabits only heavy, well-structured black clays. Nothing is known of the natural habitat of potentially important species such as *M. rigidula, M. noeana, M. aculeata,* and *M. orbicularis,* nor is anything known of the habitat of most other annual legume genera.

A transect from Raqqa to Lattakia was drawn, and, at intervals, the natural vegetation searched for presence of annual medics. On discovery of medics a sample of the seed population (of all legumes) was drawn from an area of 5 m × 5 m. At each site, the soil was sampled to a depth of 15 cm. Both seed and soil samples were bulked and subsampled for transport to Tel Hadya.

In Jordan, similar samples were taken from areas adjacent to demonstration sites managed by the Australian/Jordan Dryland Farming Project[1]. These sites included environments ranging from 250 mm to 400 mm of annual rainfall.

In the laboratory at Tel Hadya, legume seeds were separated from the remaining seed population in the samples. Burrs were threshed and seeds planted in rows for identification and measurement of some morphological and physiological characters, including leaf area, petiole length, internode length, days to flowering, burr weight, seed weight, and number of seeds per burr. Each plant was identified to the specific level, and where possible, to the variety level.

Rhizobia were collected by growing a sample of seed in a portion of the soil sample. Nodules formed were assumed to be representative of the population. The rhizobia were collected for further tests with the ultimate aim of identifying strains adapted to the climate and soils of Jordan and Syria.

1. Seed samples supplied by Mr. B.C. Bull, of Sagric International, Adelaide, South Australia.

Table 22. Maximum, mean, and minimum values of some characteristics of the environments at which annual legumes were collected at 59 sites in Syria and Jordan[1].

	Rainfall (mm)	pH	$CaCO_3$ (%)	Conductivity (mmhos/ml)	Organic matter (%)
Maximum	1200	8.5	77	11.3	8.8
Mean	460	7.9	23	1.6	3.8
Minimum	250	7.0	3.2	0.6	0.9

1. Chemical analysis of the soils is not completed: other parameters being measured are available phosphorus, total nitrogen, trace elements, and mechanical analysis.

The remaining portion of the soil sample is being analyzed for available phosphorus, total nitrogen, organic carbon, available potassium, pH and copper, zinc and other trace elements. A mechanical analysis of the soil was undertaken, and the color described using a Munsell color chart.

On completion of chemical analysis of the soil, the various parameters will be related using multivariate analysis.

All soils contained free calcium carbonate, and all had pH values greater than 7.0 (Table 22). Organic-matter content was generally high (about 4%) compared with arable lands where organic matter content is often below 1%. Mechanical analysis showed that most soils can be classified as sandy clay loams and clay loams.

The vegetation was predominantly annual, as one might expect in a Mediterranean environment. Legumes were common, not only the medics, but also *Trifolium* spp. (clover), *Trigonella, Scorpiurus,* and many others. A total of 43 species were collected (Table 23), of which 15 were medics and 19 clovers. Of the medics, three species were widespread: *M. rigidula* was found at 30 sites, *M. polymorpha* at 23 sites, and *M. orbicularis* at 21 sites. Together, these species were present at all but 11 sites: of the latter, five were occupied by *M. rotata* alone, and medics were absent from four.

Of the less common medics it was noteworthy that *M. minima* (11 sites) and *M. constricta* (5 sites) were usually accompanied by *M. rigidula. M. rotata* was restricted to soils low in organic matter and free calcium carbonate: in fact to black soils derived from basalt. Otherwise, there were few effects of soil type on distribution of plant species, even amongst clovers, which normally inhabit soils of lower pH.

Table 23. Annual legume species found in a survey of marginal lands between the Syrian desert and the Mediterranean Sea in September/October 1983.

Astragalus asterias	*Scorpiurus muricatus*
A. hamous	*Trifolium aintabense*
Hymenocarpus circinnatus	*T. alexandrinum*
Hippocrepis unisiliquosa	*T. argutum*
Medicago aculeata	*T. bullatum*
M. blancheana	*T. campestre*
M. constricta	*T. cherleri*
M. coronata	*T. clusii*
M. granadensis	*T. dasyurum*
M. intertexta	*T. hirtum*
M. minima	*T. lappaceum*
M. orbicularis	*T. physobes*
M. polymorpha	*T. pilulare*
M. radiata	*T. purpureum*
M. rigidula	*T. resupinatum*
M. rotata	*T. scabrum*
M. scutellata	*T. scutatum*
M. truncatula	*T. stellatum*
M. turbinata	*T. subterraneum*
Onobrychis aequidentata	*T. tomentosum*
O. crista-galli	*Trigonella monspeliaca*
O. caput-galli	

A most important interaction was observed between distribution of the subspecies of *M. rigidula*, rainfall, and winter temperature (Fig. 23). Subspecies *rigidula* was restricted to sites with low rainfall and cold winter, while subspecies *cinerascens* was found in wet environments with mild winters. Subspecies *agrestis* bridged the two environments. The results illustrate the great importance of obtaining this kind of information: ICARDA hopes to introduce *M. rigidula* as a commercial pasture species suited to Syria. It has concentrated on subspecies *cinerascens* and *submitis*: perhaps it should be concentrating on subspecies *rigidula* and *agrestis* for the drier areas. However, the number of *submitis* and *cinerascens* samples was insufficient to draw any firm conclusions.

The results also provide information about the adaptation of species to the environment. For example, in some species flowering time was closely related to total rainfall (Fig. 24). This indicates natural selection for early maturity at dry sites, and for extended growth at wet sites. Many other studies have shown similar relationships: what is surprising is that in Syria flowering times of many other species were not related to rainfall, indicating that in the range of environments studied, flowering time is often not a good indication of adaptability. Furthermore, at any single site a very wide range of flowering

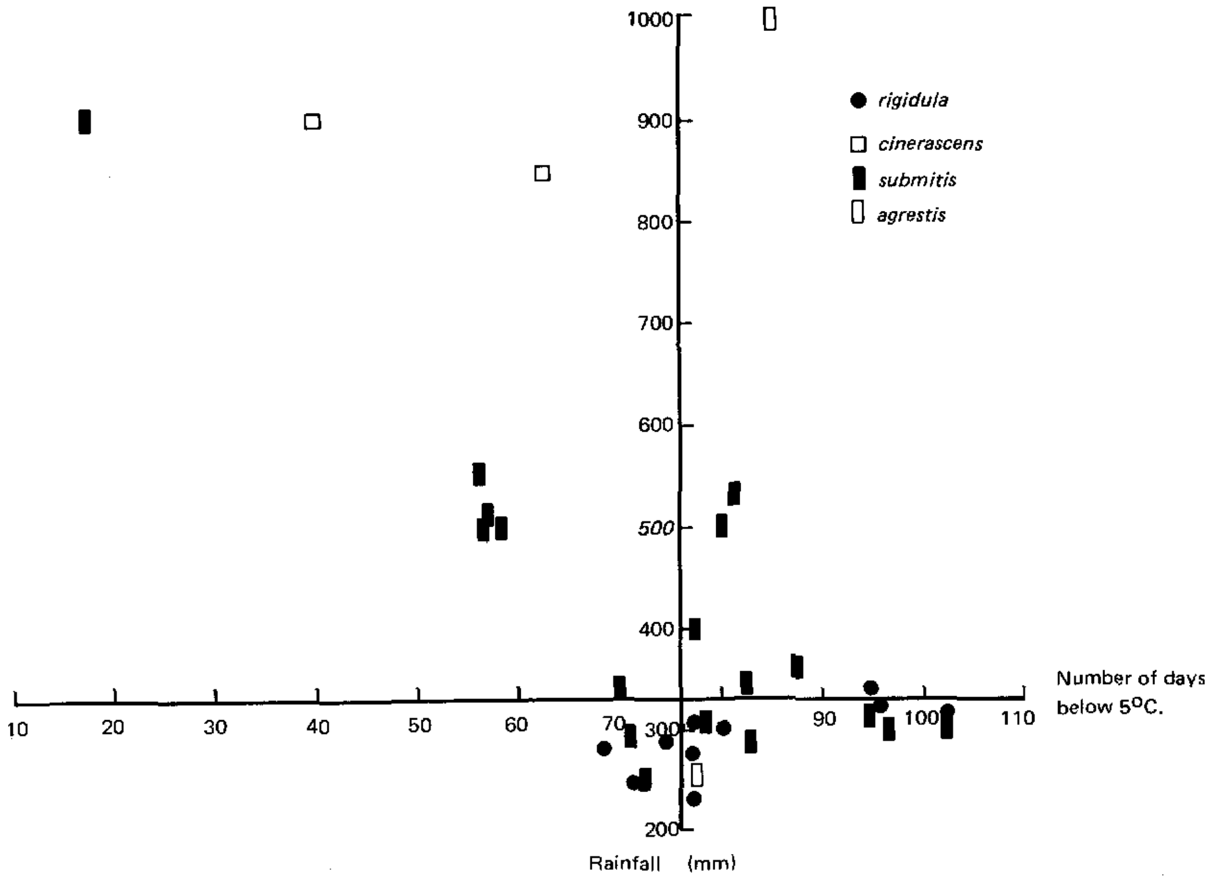
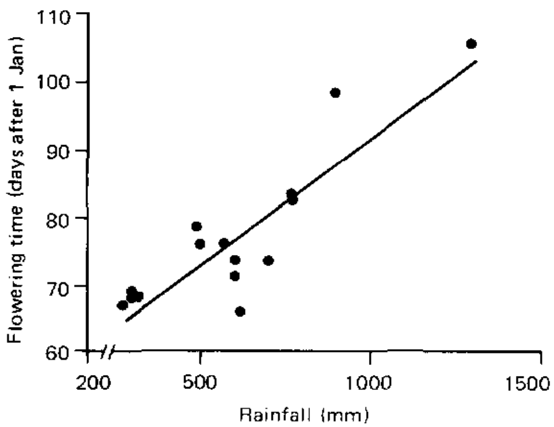


Fig. 23. Distribution of *M. rigidula* subspecies in relation to total rainfall and number of days per year when the minimum temperature fell below 5°C.

Table 24. Species present at five collection sites, and the number of days after 1 January at which flowering commenced (± = standard error).

Species present	Site number 1	2	3	4	5
Astragalus hamosus			80 ± 3		94 ± 3
Hymenocarpus circinnatus		69 ± 7	74 ± 0		
Medicago aculeata					61 ± 5
M. minima	63 ± 2			74 ± 0	
M. orbicularis			76 ± 3		82 ± 2
M. polymorpha			63 ± 4	51 ± 1	63 ± 5
M. radiata	71 ± 8				
M. rigidula	64 ± 0	64 ± 6	72 ± 9	55 ± 6	
Onobrychis crista-galli	81 ± 6	75 ± 2	103 ± 0	103 ± 10	
Scorpiurus muricatus		81 ± 1			
Trifolium argutum			106 ± 4	100 ± 5	101 ± 2
T. campestre		90 ± 5			
T. cherleri			84 ± 0	95 ± 3	
Mean	70	76	82	80	80
Average rainfall (mm)	280	340	500	550	750



time was observed, again indicating that either it was not important in the evolution of the ecotypes, or that different species have different strategies for coping with the environment (Table 24).

It is worth noting that in a few instances farmers are successfully managing pastures for high productivity. Perhaps the most striking example is that of a farmer at Tah, north of Hama, who is managing a stand of *M. polymorpha* so successfully that in 1983/84 the yield of pasture was 4.5 t/ha, the yield of seed was 350 kg/ha, and the carrying capacity of the pasture exceeded 10 sheep/ha. ICARDA has started a program of cooperation with this farmer, and others in the village, to establish pastures on a wider scale and to monitor effects of pasture improvement. In the other village fields, ICARDA scientists and Syrian Ministry officials will collaborate in sowing and managing improved pastures of annual medics. Several small experimental projects will be used to resolve which medic cultivars should be used, the need for inoculation with rhizobia, and how much phosphate should be applied to the pasture. It is hoped that in this way the concept of sowing and using pastures will be learnt first at Tah, and from there at similar villages in Syria and beyond. — *P.S. Cocks.*

Livestock Management and Nutrition

Livestock research integrates the results of the other three projects. Livestock products are the major concern of the Pasture, Forage, and Livestock Program, and our research results must express the way in which they affect productivity and efficiency of livestock production systems. For this reason livestock research is concerned mainly with the way in which forage crops, pastures, marginal lands, and cereal by-products are utilized for meat and milk production. There is also an important animal health component, the study of internal parasites, but it too reflects problems concerning the food and feeding habits of sheep.

As mentioned in the Introduction, livestock research was transferred from the Farming Systems Program to the Pasture, Forage, and Livestock Program at the beginning of 1984. Livestock research continues to be conducted in a farming systems context, but collaboration with pasture and forage scientists is now more effective. However, contacts with the Farming Systems Program have been maintained, and some of the research conducted in the Pasture, Forage, and Livestock Program is reported by the Farming Systems Program.

The 1983/84 season was difficult because of drought but progress was achieved on priority issues of sheep husbandry, forage utilization, and, especially, straw evaluation. Results of feeding trials show how liberal feeding during early lactation is a rational practice provided that ewes weigh at least 50 kg after lambing. First attempts at determining the level of helminth parasites in experimental flocks were successfully completed and it was found that only lung worms pose a threat to sheep productivity at Tel Hadya. We believe that prediction of barley straw quality from plant morphology is now possible, and that high grain yield and good straw quality are mutually compatible breeding aims. On-farm forage and livestock experiments could not be carried out due to drought. — *P.S Cocks.*

Winter Supplementary Feeding of Ewes

The main lambing season in Syria extends from November until February and it is in November that cereal stubbles and irrigated crop residues, for example, cotton, become exhausted. Grazing of marginal lands cannot begin until spring, so a severe nutrient deficiency exists at this critical time, filled for the last 20 years by supplements based on barley grain and cereal straw.

Surveys conducted by the Farming Systems Program have shown how the amount of supplement fed appears to cover all energy and protein needs of pregnant and lactating ewes. In the past such feeding has been economic because of the high price of lamb relative to the price of supplements. However, if this price relationship changes the economics of feeding such large amounts may also change. It was therefore considered essential to study feeding strategies which make the best use of supplements, and research was conducted at Tel Hadya for three winters. Over 250 individually-fed ewes from experimental and non-experimental flocks were used.

Experiment 1 (1981/82) investigated high (HH), moderate (MM), and low (LL) levels of supplementary feeding: first and second letters refer to level of feeding during late pregnancy and early lactation, respectively. Experiment 2 (1982/83) included the same treatments as experiment 1, but also added treatments in which the level of feeding was increased from pregnancy to lactation to give the combinations LM, LH, and MH, as well as LL, MM, and HH. The overall level of feeding was also increased. In experiment 3 (1983/84) the only combinations were LM, LH, MN, and MH since mortality levels of the LL treatment were excessive and treatment HH was obviously uneconomic. The three feeding levels were chosen arbitrarily to provide from 40% below (L) to 20% above (H) the energy needs of ewes. Use of such widely contrasting levels was necessary since the major objectives of the research were to study biological and economic outputs of lactating ewes in terms of lamb liveweight and milk production. The energy levels of the supplements were estimated from *in vivo* digestibility.

In this report we first present biological results from the lactation phase. This provides information for the economic interpretation which follows. Results from the 3 years are included since experiment 1 and parts of experiment 2 have not previously been reported, and since year-to-year variation is an important component of the analysis.

There were large differences in liveweight gains of lambs between experiments but these were poorly related to ME intake of ewes (Table 25). For example, in treatment MM, ME intake was 7.9, 9.3, and 9.4 MJ in experiments 1, 2 and 3, respectively, but increase in lamb

Table 25. Metabolizable energy intake of ewes, liveweight after lambing, daily liveweight losses during early lactation, and lamb liveweight gain.

	Nutritional regime						
	LL[1]	LM	LH	MM	MH	HH	S[2]
Ewe metabolizable energy intake (MJ)							
Experiment 1	3.8[a][3]			7.9[b]		10.3[c]	0.48
Experiment 2	5.3[a]	8.9[b]	12.4[c]	9.3[b]	12.9[c]	13.9[d]	0.35
Experiment 3		9.4[a]	14.4[b]	9.4[a]	15.2[b]		0.82
Ewe liveweight after lambing (kg)							
Experiment 1	40.0[a]			49.0[b]		56.5[c]	4.40
Experiment 2	31.2[a]	33.2[a]	34.4[a]	39.6[b]	39.1[b]	50.5[c]	3.54
Experiment 3		42.9[a]	42.2[a]	41.5[a]	46.8[b]		4.45
Liveweight loss, first 56 days lactation (g)							
Experiment 1	98[a]			203[b]		204[b]	51.0
Experiment 2	73[ab]	29[b]	16[b]	126[ac]	51[b]	137[ac]	57.9
Experiment 3		107[a]	47[a]	79[a]	38[a]		113.2
Lamb daily liveweight gain[4] (g)							
Experiment 1	211			235		276	nc[5]
Experiment 2	91	171	159	144	189	198	nc
Experiment 3		223	256	196	232		nc

1. First and second letter refer to level of feeding during last 56 days of pregnancy and first 56 days of lactation, respectively (L = low, M = medium, H = high).
2. S = $\sqrt{\text{Residual mean square}}$
3. Mean followed by different superscripts are significantly different ($P < 0.05$).
4. Up to 8 weeks.
5. nc = Not calculated because male and female lambs combined.

liveweight was 235, 144, and 196 g/day, respectively. Within the same experiment, *however, lamb liveweight gain was positively* related to ME intake of ewes (Fig. 25a). To explain this anomaly, the influence of ewe liveweight after lambing was used in the relationship between ewe and lamb liveweight (Fig. 25b) in preference to liveweight at the end of pregnancy since it represents weight after removal of the lamb and fetal membranes. A fairly close relationship was then found ($100r^2$ = 0.57) which was independent of year of experiment.

This relationship is important in the economic interpretation of contrasting feeding strategies. The margin-over-feed-costs (MOFC) is the sum of the revenue from lamb and milk sales minus the cost of feeding. Constant prices (from 1982/83) have been used for the three experiments. Large differences between experiments are apparent but the explanation seems *to lie in the relationship* between ewe weight after lambing and daily weight gain of lambs, referred to in the previous paragraph. Although a clear relationship between supplementary feed cost and MOFC was demonstrated only in experiment 2 (because the treatments LL and HH were included), it is suggested that the relationships in experiments 1 and 3 are similar even though they only show part of the curve (Fig. 26).

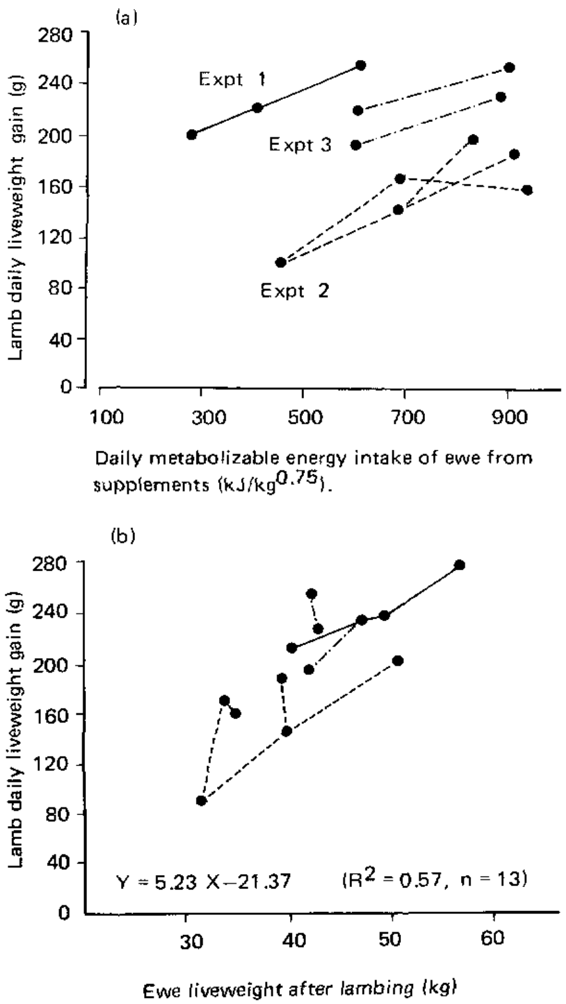


Fig. 25. The relationship of liveweight gain in lambs (g/day) to (a) metabolizable energy intake of ewes, and (b) liveweight of the ewe after lambing.

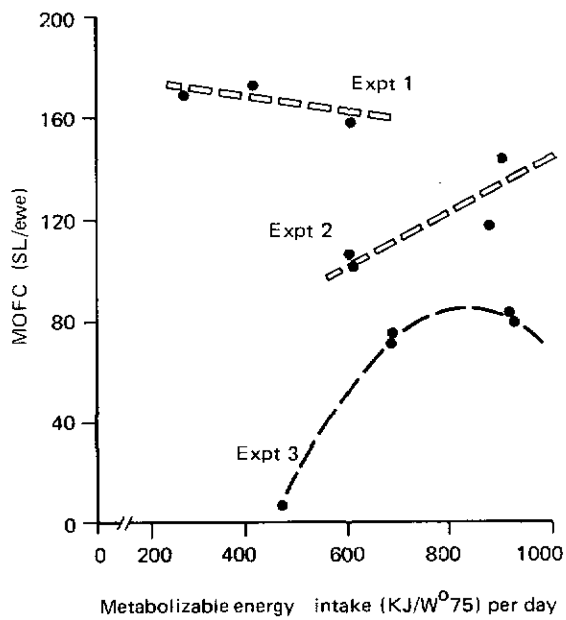


Fig. 26. Relationship between margin-over-feed-costs (see text), expressed as Syrian pounds (SL) per ha and metabolizable energy intake of ewes per day in three experiments. The lines and curves have been fitted by linear and polynominal regression.

These results indicate that a major factor affecting flock revenue is growth rate of lambs. This is expected since lamb sales represent over half of the ewe's production. Liveweight of ewes after lambing appears to have an effect on performance of lambs up to 8 weeks of age. Thus, in order to ensure that lambs grow as fast as possible ewes should weigh a least 50 kg after lambing, or 55 to 58 kg at the end of pregnancy.

The simplest way of maintaining liveweight during lactation may be to postpone lambing until February when medic pastures, forage crops, and marginal lands become available for grazing. At present peak lambing is in December and January and grazing is not available until March in most years. It would therefore appear that, pending pasture development, supplementary feeding will be a common practice for many years. For farmers whose ewes weigh 50 kg after lambing, the current liberal feeding strategy appears rational. However, ewes that weigh less are likely to give birth to lambs which are underweight and therefore fail to reach their potential even when feeding is generous. Indeed, the MOFC may even increase by reducing the level of feeding.

It is interesting to compare feeding levels used in this experiment with real-life examples. Our highest levels of feeding were above those found in the 1978-81 Steppe Survey (10.5 MJ ME), but below that reported in the Bueda study (19 MJ ME, see FSP Report). In the case of the steppe, adequate grazing is generally available in winter and less supplementation is necessary. At Bueda, however, which lies within the barley-producing zone, only limited grazing of poor quality is available, and farmers therefore feed more supplements. — *E. Thomson and F. Bahhady.*

Cereal Straw Evaluation

Barley straw forms an important part of the diets of sheep in North Africa and West Asia and farmers consider the quality of straw to be important. For this reason evaluation of cereal straw began in 1982, and is being conducted in collaboration with the Tropical Development and Research Institute (TDRI), Overseas Development Administration, London, and with other ICARDA research programs.

Factors affecting the quality of straw and stubble are a subject of intense study in the PFLP.

In the following sections, research on evaluation of barley straw is reported. The main objectives are to:

- define *in vivo* digestibility and voluntary intake by sheep of straw from three barley varieties with contrasting morphological characteristics,
- investigate the effect of contrasting agronomic practices on *in vitro* digestibility and chemical composition of barley straw,

investigate the relationship between easily measurable morphological characteristics of mature barley plants and nutritive value of straw, with a view to predicting nutritive value,

investigate the effect of protein and energy supplementation on liveweight changes of ewes grazing cereal stubbles, and

measure the liveweight changes, *in vivo* digestibility and voluntary intake of barley straw by sheep with and without cottonseed cake supplementation.

Nutritive Value of Barley Straws

Feeding trials completed in 1983 showed that Arabi Abiad straw was superior to Beecher straw in terms of daily voluntary feed intake and digestibility. Observations on the morphology of Arabi Abiad, ER/Apam, and Beecher straw suggested that varietal differences in straw nutritive value might be caused by row type, plant height, stem diameter, leaf proportion or chemical composition, principally the lignin content of leaf and stem. Feeding trials completed in 1984 (Table 26) supported these suggestions and indicated further that combine harvested straw tended to be superior to hand harvested straw. Grain yield of ER/Apam was higher than that of Beecher, suggesting that grain yield and straw quality need not be incompatible objectives in a barley breeding program.

Subsequent research was designed to test these conclusions and to understand how morphological and chemical composition might interact to produce variations in straw feeding

Table 26. Results of feeding trials with straw of three barley varieties.

	Barley variety					
	Beecher		ER/Apam		Arabi Abiad	
Row type	6		2		2	
Plant height (cm)	74.0		47.4		36.2	
Stem diameter (cm)	0.33		0.20		0.21	
Grain yield (kg/ha)	2720		3057		1830	
Straw yield (kg/ha)[1]	1731		1819		1009	
Method of harvest[2]	C	H	C	H	C	H
Leaf proportion	0.35	0.42	0.43	0.56	0.44	0.57
Voluntary intake ($g/kg^{0.75}$ per day)						
Dry matter	29.4[ba][3]	25.9[a]	36.3	32.2[b]	39.6	39.5[c]
Organic matter	25.8[a]	22.2[a]	32.9	27.0[a]	34.4	34.7[b]
Digestibility (%)						
Dry matter	35.0[ba]	32.9[a]	41.8	36.7[b]	42.9	36.7[b]
Organic matter	39.5[a]	38.6[a]	50.5	41.6[a]	47.5	44.0[a]
Intake of digestible organic matter ($g/kg^{0.75}$ per day)	10.2[ba]	8.6[a]	16.6	11.2[b]	16.3	15.2[c]

1. Estimates for combine harvested straw.
2. C = combine harvested, H = hand harvested.
3. Means in the same row with different superscripts were significantly different ($P < 0.05$). Owing to a limited number of observations statistical analysis was not possible on results from combine harvested ER/Apam and Arabi Abiad straw.

value. *Since agronomic practices* (such as nitrogen fertilization, sowing date, and seed rate) and management practices (such as grazing at the tillering stage) might influence straw value, various experiments were sampled to determine the extent of such influences.

The first material to be studied originated from the dual-purpose barley trial reported by the Cereal Crops Improvement Program in 1982/83. *In vitro* digestibility and chemical analyses of samples of cut straw support the results of earlier feeding trials and in particular the association of nutritive value with varietal characteristics such as row type and plant height (Table 27). Although grain yield tended to be lower and straw yield higher in varieties with good straw, correlations were low and non-significant. Straw quality was significantly higher in later maturing varieties but lodging was largely unrelated to straw quality. Multiple regression

Table 27. Selection correlation coefficients (r) between some laboratory characteristics of barley straw, and several agronomic characteristics for dual-purpose barley yield experiment 1982/83, experiment 1, ungrazed.

	In vitro digestibility and chemical analyses			
Variety characteristic[1]	IVD DM[2]	D[3]	CP(%)[4]	NDF(%)[5]
Row type (2,6)	-0.36	-0.45*[6]	-0.31	0.17
Plant height[7](cm)	-0.18	-0.22	-0.29	0.19
Grain yield (kg/ha)	-0.23	-0.18	0.08	-0.24
Straw yield (kg/ha)	0.30	0.37	0.41*	-0.41*
Days to heading	0.65***	0.64***	0.58**	-0.52*
Days to maturity	0.56**	0.53*	0.48*	-0.52*
Lodging (%)	-0.10	0.04	0.19	-0.16

1. Data provided by Cereal Crops Improvement Program, 24 varieties.
2. *In vitro* dry-matter digestibility.
3. *In vitro* digestible organic matter (g/100 g dry matter).
4. Crude protein percentage (dry-matter basis).
5. Neutral detergent fiber percentage (dry-matter basis).
6. Statistical significance: * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.
7. Cutting height for samples was 15-20 cm.

Table 28. Selected multiple regressions from the dual-purpose barley yield experiment 1982/83, experiment 1, ungrazed, predicting *in vitro* D value.[1]

Variety characteristic	Regression
Days to heading (DH), plant height (PH)	D = 0.346 DH - 0.047 PH - 14.7 (r^2 = 0.43, **, d.f. = 23)[a]
Days to maturity (DM), plant height	D = 0.476 DM - 0.035 PH - 51.1 (r^2 = 0.30, *, d.f. = 23)
Days to heading, plant height, row type (RT)	D = 0.329 DH - 0.001 PH - 0.56 RT - 14.3 (r^2 = 0.55, ***, d.f. = 23)
Days to maturity, plant height, row type	D = 0.518 DM - 0.033 PH - 0.74 RT - 61.6 (r^2 = 0.50, **, d.f. = 23)

1. See Table 27 for definition.
a. r^2 = multiple correlation coefficient, see Table 27 for levels of statistical significance; d.f. = total degrees of freedom.

equations (Table 28) show that variety characteristics, for example, plant height, days to heading, days to maturity, and row type, only explained about half of the variation in digestibility, suggesting the presence of additional factors.

The second set of experiments involved agronomic and management factors. Analyses of straw from these experiments (Tables 29 and 30) indicate that influences of nitrogen fertilization, sowing date, seed rate, and amount of grazing may be very small compared with differences between varieties. These one-year results do not preclude the possibility of these factors being important, but it was decided in the light of these results to focus attention on factors influencing varietal differences.

To do this, 20 varieties from a grain-recovery experiment conducted in 1982/83 were cut at a height of 15 to 20 cm and the cut straw separated into leaf and stem fractions. In 1984, hand-pulled material from a similar experiment was separated into leaf blade, leaf sheath, and stem fractions. Plant fractions were analyzed for *in vitro* digestibility, and crude protein and neutral detergent fiber contents.

Table 31 shows that leaf proportion reduced as plant height increased. Plant fractions contrasted widely in nutritive value (Table 32) confirming that variation in leaf proportion is one of the factors influencing quality. An increase in plant height resulted in reduced digestibility, whereas an increase in leaf proportion led to improved digestibility (Table 31). However, the equation relating digestibility to leaf proportion is not statistically significant, suggesting that some other factors contributed to the relationship between digestibility and height. While stem diameter did not appear to be an important determinant of digestibility, days to heading and days to maturity increased both leaf proportion and digestibility.

Table 29. Effect of nitrogen fertilization on *in vitro* digestibility and chemical composition of straw of a six-rowed (C 63) and a two-rowed (Arabi Abiad) barley.

	In vitro digestibility and chemical analyses[2]			
Treatment/variety[1]	IVD DM	D	CP (%)	NDF (%)
Nitrogen splitting	*[3]	NS	NS	NS
Sowing 100: tillering 0	48.8	41.7	3.9	81.0
Sowing 50: tillering 50	50.4	43.0	4.4	80.9
Nitrogen rate (kg/ha)	NS	NS	*	*
0	50.1	42.7	3.8	82.5
50	49.6	42.7	4.1	80.3
100	48.2	41.1	3.7	80.0
150	49.8	42.5	4.5	80.8
200	50.2	42.9	4.7	81.0
Grazing at tillering	NS	NS	NS	NS
Ungrazed	48.9	42.2	4.1	81.3
Grazed	50.2	42.5	4.3	80.5
Variety	**	**	***	*
C 63	47.3	39.8	3.3	79.6
Arabi Abiad	51.8	45.0	5.0	82.2
Overall mean	49.6	42.4	4.2	80.9

1. Trial grown by Cereal Crops Improvement Program.
2. See Table 27 for definitions.
3. NS, Not significant; * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

Table 30. Effect of time of sowing and seed rate on *in vitro* digestibility and chemical composition of straw of a six-rowed (C 63) and a two-rowed (Arabi Abiad) barley.

Treatment/variety[1]	*In vitro* digestibility and chemical analyses[2]			
	IVD DM	D	CP (%)	NDF (%)
Sowing	NS[3]	*	*	NS
Early	45.5	38.7	3.0	78.4
Normal	46.9	40.4	3.3	78.2
Seed rate (kg/ha)	NS	NS	NS	NS
30	45.7	39.4	2.9	78.1
60	46.0	39.3	3.4	77.9
120	46.9	40.0	3.1	78.1
240	46.3	39.4	3.2	79.0
Grazing at tillering	NS	NS	*	NS
Ungrazed	45.5	39.0	3.0	78.5
Grazed	46.9	40.1	3.3	78.1
Variety	**	**	**	NS
C 63	44.4	37.0	2.5	78.2
Arabi Abiad	48.0	42.0	3.8	78.4
Overall mean	46.2	39.5	3.1	78.3

1. Trial grown by Cereal Crops Improvement Program.
2. See Table 27 for definitions.
3. NS, Not significant; * $P < 0.05$; ** $P < 0.01$. Comparisons down columns within experiments.

Table 31. Regression equations relating leaf proportion (LP) and digestibility (D) to plant height (PH), days to heading (DH), and days to maturity (DM) in barley straws.

Experiment[1]	Dependant variable	Independant variables	Equation	r	Sig.	d.f.
GRE[2] 1982/83	LP	PH	LP = 0.490 − 0.002 PH	−0.57	**	18
GRE 1983/84	LP	PH	LP = 0.801 − 0.003 PH	−0.60	**	18
GRE 1983/84	LP	DH	LP = 0.222 + 0.004 DH	0.61	**	18
GRE 1983/84	LP	DM	LP = 0.022 + 0.004 DM	0.55	*	18
GRE 1983/84	LP	PH,DH	LP = 0.423 − 0.003 PH + 0.003 DH	0.77	***	17
GRE 1983/84	LP	PH,DM	LP = 0.207 − 0.003 PH + 0.004 DM	0.79	***	17
GRE 1983/84	D	PH	D = 42.3 − 0.16 PH	−0.60	***	18
GRE 1983/84	D	PH,DH	D = 32.3 − 0.14 PH + 0.08 DH	0.66	**	17
	D	PH,DM	D = 31.2 − 0.15 PH + 0.07 DM	0.64	*	17
GRE 1983/84	D	LP	D = 25.2 + 14.7 LP	0.31	NS	18

1. Experiments grown by Cereal Crops Improvement Program.
2. Grain Recovery Experiment.

r = correlation coefficient; NS, not significant; * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$; d.f. = regression degrees of freedom.

Table 32. Contrasts in the *in vitro* digestibility and chemical composition of fractions of mature barley straw.

Experiment[1]	Material	*In vitro* digestibility and chemical analyses[2]			
		IVD DM	D	CP (%)	NDF (%)
GRE 1982/83	Leaf	49.37	43.41	3.19	67.84
(cut at 15-20 cm)	SE ±	0.63	0.54	0.09	0.46
	Stem	38.11	31.88	1.32	85.63
	SE ±	0.74	0.54	0.04	0.26
GRE 1983/84	Leaf blade	50.47	43.07	7.22	62.25
(hand harvested)	SE ±	0.50	0.47	0.18	0.36
	Leaf sheath	49.30	38.89	4.49	71.89
	SE ±	0.62	0.54	0.13	0.42
	Stem	27.69	26.00	2.69	83.45
	SE ±	0.57	0.66	0.04	0.86

1. Experiment grown by Cereal Crops Improvement Program.
2. See Table 27 for definitions.

Table 33. Characteristics of eight barley varieties grown at Tel Hadya 1983/84.

Variety	Grain yield (kg/ha)	Straw yield[1] (kg/ha)	Row type	Days to maturity	Stem length (cm)	Leaf proportion	
						Hand harvested	Cut at 15-20 cm
Antares	2120	1134	6	156	43.3	0.67	0.64
Arar	2379	814	6	142	48.0	0.63	0.62
Badia	2329	1291	6	147	69.0	0.56	0.54
Beecher	2692	1543	6	146	69.6	0.56	0.53
C 63	1715	1479	6	151	61.2	0.63	0.69
ER/Apam	2345	1028	2	143	39.2	0.63	0.63
Rihane 'S'	1954	1064	6	144	49.3	0.62	0.65
Arabi Abiad	NA[2]	NA	2	145	36.8	0.64	0.66

1. Actual baled straw, cutting height 15 - 20 cm.
2. NA = Not available.

Further studies have been conducted on eight varieties grown at Tel Hadya in which straw was harvested by hand pulling and by cutting at a height of 15 to 20 cm. Row type, days to maturity, and stem length were recorded and straw samples divided into leaf and stem. In the hand-pulled straw, leaf blade and leaf sheath were separately measured. Leaf proportion was generally much higher in this experiment than in 1982/83 (Table 33). It appears that under dry conditions more leaf is produced (relative to stem), and this may lead to improved quality. Simple and multiple regression equations are given in Table 34 which show that leaf proportion was reduced with increasing plant height and increased with days to maturity, particularly in hand-pulled material (Fig. 27).

In vitro digestibility and chemical analyses of the morphological fractions (Table 35) and their relations with varietal characteristics (Table 36) show that longer stems result in more acid detergent fiber and more stem lignin and hence lower digestibility. Also tall varieties had more lignin in leaf sheaths than shorter varieties,

Table 34. Regression analyses for leaf proportion (LP) based on information in Table 33.

Variety characteristic	Method of harvest: Hand	Method of harvest: Cut at 15 - 20 cm
Row type (2,6) (RT)	LP = 0.64 - 0.006 RT (r = -0.28[1], NS[2])	LP = 0.66 - 0.008 RT (r = -0.27, NS)
Stem length (cm) (SL)	LP = 0.75 - 0.002 SL (r = - 0.83, *)	LP = 0.77 - 0.003 SL (r = -0.64, NS)
Days to maturity (DM)	LP = 0.21 + 0.003 DM (r = 0.33, NS)	LP = 0.29 + 0.002 DM (r = 0.19, NS)
SL, DM	LP = 0.16 - 0.003 SL + 0.004 DM (r^2 = 0.90[3], **)	LP = 0.30 - 0.003 SL + 0.003 DM (r^2 = 0.48, NS)
SL, DM, RT	LP = 0.25 - 0.003 SL + 0.003 DM + 0.005 RT (r^2 = 0.93, **)	LP = 0.38 - 0.003 SL + 0.003 DM + 0.005 RT (r^2 = 0.49, NS)

1. r = correlation coefficient.
2. NS, Not significant; * $P < 0.05$; ** $P < 0.01$.
3. r^2 = Multiple correlation coefficient.

Table 35. Mean chemical composition and *in vitro* cellulose digestibility of morphological fractions of straw of eight barley varieties.

Morphological fraction	*ADF (%)*[1]	*Silica (%)*	*Lignin (%)*	IVCD[2]
	Chemical composition and *in vitro* cellulose digestibility			
Hand harvest				
Basal leaf	44.3	11.6	4.8	55.9
SE ±	0.88	1.22	0.17	1.40
Stem	54.1	1.4	10.9	20.4
SE ±	0.46	0.28	0.38	0.77
Blade	41.8	10.9	4.9	55.0
SE +	0.68	0.73	0.21	0.83
Sheath	42.3	5.8	2.7	37.5
SE ±	0.78	0.17	0.20	0.70
Cut[3]				
Stem	49.5	2.7	8.5	27.6
SE ±	1.04	0.40	0.41	1.05
Leaf	39.1	6.2	3.2	52.0
SE ±	0.96	0.14	0.33	0.78

1. Acid detergent fiber percentage.
2. *In vitro* cellulose digestibility.
3. Cutting height was 15-20 cm.

although this relationship just failed to reach statistical significance. Leaf sheaths of late varieties were more digestible than those of early varieties but leaf blades of late varieties tended to be more highly lignified and hence of lower digestibility. The degree of stem lignification above 15-20 cm was less than that of stems from hand-pulled harvested straw which included the lower stem, and this resulted in higher digestibility.

Table 36. Selected correlations (r) relating variety characteristics to chemical composition and *in vitro* cellulose digestibility of morphological fractions of eight barley varieties.

Morphological fraction	Variety characteristics	Chemical composition and *in vitro* cellulose digestibility			
		ADF(%)[1]	Silica(%)	Lignin (%)	IVCD[2]
Hand harvest					
Basal leaf	Row type (2,6)	0.001	0.036	0.425	0.625
	Stem length (cm)	0.356	0.585	0.177	0.588
	Days to maturity	-0.670	-0.447	-0.200	0.037
Stem	Row type (2,6)	0.214	-0.422	0.671	-0.367
	Stem length (cm)	0.524	-0.476	0.795*[3]	-0.791*
	Days to maturity	-0.256	-0.263	0.106	0.111
Blade	Row type (2,6)	-0.532	-0.503	-0.155	0.390
	Stem length (cm)	-0.148	0.108	-0.504	0.089
	Days to maturity	-0.857**	-0.540	0.381	-0.445
Sheath	Row type (2,6)	0.324	-0.054	0.708*	-0.166
	Stem length (cm)	0.593	0.462	0.667	-0.316
	Days to maturity	-0.434	-0.376	-0.048	0.821*
Cut straw[4]					
Stem	Row type (2,6)	0.810*	-0.415	0.836**	-0.257
	Stem length (cm)	0.835**	-0.667	0.669	-0.756*
	Days to maturity	0.538	0.364	0.098	-0.155
Leaf	Row type (2,6)	0.006	-0.718*	0.579	0.353
	Stem length (cm)	0.155	-0.427	0.569	0.186
	Days to maturity	-0.657	-0.799*	0.121	0.804*

1. Acid detergent fiber percentage.
2. *In vitro* cellulose digesibility.
3. * $P < 0.05$; ** $P < 0.01$.
4. *Cutting height was 15 - 20 cm.*

Results in Tables 35 and 36 help to resolve a number of questions. First, combine harvested straw contained less lignified stem and even though its leaf proportion was lower, it tended to be superior to hand-pulled straw in feeding trials (see Table 26). Secondly, if late varieties have both higher leaf-sheath quality and lower leaf-blade quality than early varieties, then the value of time to maturity as a predictor of digestibility is limited. This may explain some of the unaccounted variability in multiple regression equations reported in Table 28. It is also apparent that plant height affects digestibility in two ways, by increasing internode length, thereby reducing leaf proportion, and by increasing the degree of lignification. As noted from Table 29, leaf proportion alone will not fully predict digestibility.

Straw of barley grown at Tel Hadya and at Cambridge (UK) was compared. A major difference was that leaf proportion can be as high as 0.70 at Tel Hadya, whereas at Cambridge it was 0.30-0.45 (see Fig. 27). This suggests that, particularly in a dry year, straw from the ICARDA region is a more valuable commodity than thought by farmers and researchers in other temperate areas. It is important, therefore, to recognize that the greater emphasis given to straw by farmers in the ICARDA region may be based on a realistic assessment of feed value and not just on the consideration of the shortage of alternative feeds. Certainly the intakes of unsupplemented straw routinely recorded in trials at Tel Hadya far exceed the straw intake values reported in the scientific literature.

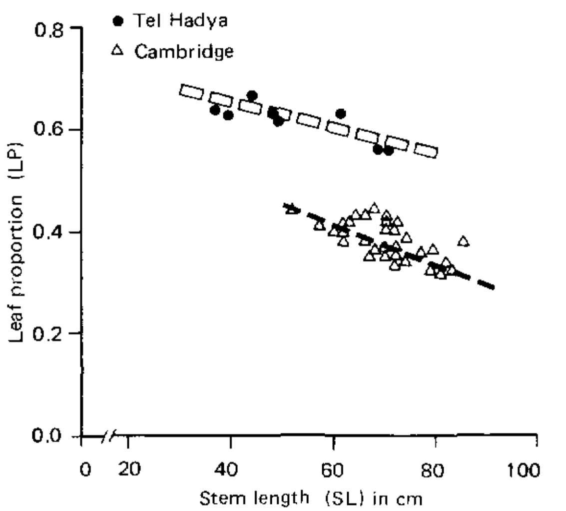


Fig. 27. The effect of stem length (SL) on leaf proportion (LP) in hand-harvested barley grown at Tel Hadya compared with barley grown at Cambridge (UK). The relationships were significant, 100 r^2 = 69 ($P<0.01$) and 100 r^2 = 55 ($P<0.001$), respectively, and are expressed as follows: LP = 0.75 − 0.002 SL at Tel Hadya, LP = 0.65 − 0.004 SL at Cambridge.

Future work will involve study of *in vivo* digestibility of straw harvested from the eight varieties grown in 1983/84. The influence of supplementing different quality straws with grain and cottonseed cake will be examined. Analysis is proceeding of a wider selection of varieties grown in the 1983/84 dual-purpose barley yield trial. In a further extension of collaboration, TDRI is studying the morphology and chemical composition of straws harvested at the Plant Breeding Institute, Cambridge. Results so far show that there is very little influence of date of sowing on leaf proportion, that it increases with plant height and days to flowering (LP = 0.14DF - 0.004PH + 0.539; $r^2 = 0.84$, $P < 0.001$, df = 31; symbols in Table 31, and that two-rowed barleys have more leaf than six-rowed barleys. These results suggest a worldwide as well as regional significance to the work being carried out at ICARDA.

The importance of work on straw quality is that it offers farmers the potential to improve nutrient supply to livestock without additional cost. Current indications are that Arabi Abiad straw is only about half way in the range of straw quality. Many promising varieties being tested by the Cereal Crops Improvement Program appear to have the potential of both higher grain yields and better straw quality. — *B.S. Capper (TDRI, London), E. Thomson, M. Mekni (Cereal Program), and W. Anderson (formerly with Cereal Program).*

Stubble Grazing and Straw Supplementation

In addition to being an important component in winter diets, cereal stubbles are the major source of feed from harvest in June until October. This period coincides with mating, and in order to ensure maximum fertility ewes must remain in good condition. This is not always possible because quality and quantity of stubbles decrease as the season progresses. Low levels of supplementation with energy or protein are likely to help ewes maintain body condition, and perhaps even gain some weight.

It is known that small amounts of protein supplement, such as cottonseed cake, increase intake of low quality roughages and improve their digestibility. Cottonseed cake is available in large quantities since cotton is one of Syria's most important crops. An energy supplement is an alternative, but is unlikely to have the same beneficial effect on straw intake and utilization. Experiments were, therefore, conducted to investigate the effect of protein and energy supplements on ewes grazing stubbles, and to measure intake of supplemented and unsupplemented straw fed to sheep for 120 days.

Ninety-six Awassi ewes were allocated to three treatments: stubble grazing alone (So), stubble grazing with 100 g of cottonseed cake/day per ewe (Sp), and stubble grazing with 300 g of barley grain/day per ewe (Se). All flocks grazed the same stubbles, which had previously been cleared of surplus straw by racking and baling. The trial started on 19 June and continued for 91 days. Fresh stubble was allocated to flocks on a weekly basis. Changes in liveweight were assessed and cost/benefit ratios of the three treatments were calculated.

All flocks initially lost weight (Fig. 28a) but supplemented flocks soon started to gain weight, those receiving barley at a faster rate than those receiving cottonseed cake. At the end of 91 days, flocks Sp and Se were significantly heavier ($P < 0.001$) than flock So (Table 37).

Differences in daily weight gain across treatments were significant ($P < 0.05$). During the experiment, ewes in treatment So lost 35 g/day, ewes in treatment Se gained 38 g/day, and treatment Sp was intermediate. The difference between the value of weight change per hectare and cost of feeding was greatest in treatment So (SL 136.8/ha) and least in treatment Sp (SL 21.3/ha); that is, feeding cottonseed cake was the most economical way of maintaining the flocks.

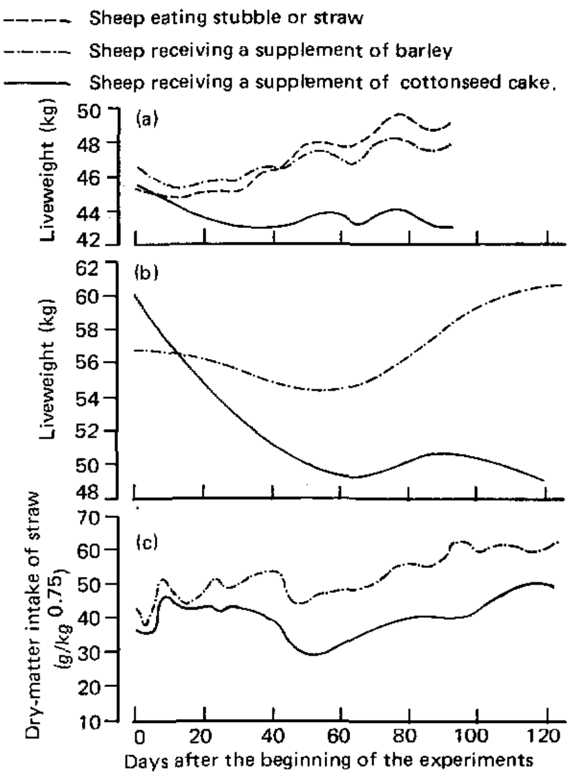


Fig. 28. The effect of protein and energy supplements on (a) liveweight of ewes grazing cereal stubble, (b) liveweight of penned castrates receiving straw, and (c) straw intake of penned castrates.

Table 37. Liveweight changes of ewes grazing cereal stubbles alone or when receiving energy or protein supplementation, 1983/84.

	Treatment[1]			
	S_o	S_e	S_p	S[2]
Number of ewes	31	32	33	
Start liveweight (kg)	45.9	45.4	46.4	5.27
End liveweight (kg)	42.7[a3]	48.8[b]	47.5[b]	4.83
Daily liveweight (g)	−35	38	13	17.37
Grazing pressure (ewe/ha per day)	445	445	445	
Liveweight change (kg/ha)	−15.2	15.2	5.2	
Value of liveweight (SL/ha)[4]	−136.8	136.8	46.6	
Cost of supplement (SL/ha)	0.0	203.7	67.9	
Difference (SL/ha)	−136.8	−66.7	−21.3	

1. S_o = Stubble alone; S_e = Stubble + energy supplement (300 g of barley grain/day); S_p = Stubble + protein supplement (100 g of cottonseed cake/day). 2. S = $\sqrt{\text{residual mean square}}$. 3. Means followed by same superscript are similar ($P < 0.001$), comparisons are along rows. 4. SL = Syrian pounds.

Table 38. Digestibility, daily voluntary intakes, and liveweight changes of Awassi castrates offered chopped Arabi Abiad straw alone or with cottonseed cake supplementation, 1983/84.

	Treatment			Significance[3]	
	Straw	Straw + CSC[1]	S_d[2]	Trt	Period
Number of sheep	4	4			
Digestibility (%)					
dry matter	40.9	43.8	1.67	**	*
organic matter	48.3	50.6	1.79	*	*
acid detergent fiber	38.3	36.8	2.59	ns	**
'D' value[4]	43.3	45.3	2.07	ns	**
Metabolizable energy (MJ/kg DM)	6.5	6.8	0.31	ns	**
Dry matter intakes (g):					
straw	625.8	904.7	103.63	***	ns
total intake	625.8	1054.9	113.44	***	ns
Organic matter intakes (g):					
straw	527.6	820.4	101.27	***	ns
total intake	527.6	955.5	107.97	***	ns
Crude protein intake (g):					
straw	23.3	35.5	4.88	***	ns
total intake	23.3	87.5	8.27	***	ns
Intake per kg MBW[5]·					
dig. organic matter (g)	13.4	23.3	1.67	***	**
metabolizable energy (kJ)	198.5	348.0	54.60	***	**
Liveweight at start (kg)	59.0	56.3	5.09	ns	
Liveweight at end (kg)	49.0	60.5	5.52	ns	
Days on trial	122	122			
Liveweight change (g)	-82	35	22.8	**	

1. Cottonseed cake.
2. Standard error of difference.
3. Level of significance: ns = Not significant; * = $P < 0.05$; ** = $P < 0.01$; *** = $P < 0.001$.
4. Digested organic matter (g/100 g dry-matter ingested).
5. Metabolic body weight ($W^{0.75}$).

The value of stubbles for maintaining sheep during one phase of the breeding cycle was clearly demonstrated. These results were achieved in a very dry year after much of the loose straw had been collected and removed. Such research is a clear demonstration of a cheap summer feeding strategy for drought years.

In this experiment it was clearly shown that *supplementing a diet of straw with protein and* energy has a beneficial effect on liveweight. In order to show that the result was caused by increased straw intake, chopped Arabi Abiad straw alone was offered *ad libitum* to four castrate Awassi sheep for 122 days, and another four Awassi castrates received the same straw plus 2.85 g cottonseed cake/kg liveweight per day (Table 38). It was thought that this level of protein would increase the protein content of the *diet from a submaintenance level (3.5% in the* dry matter) to a maintenance level (7.0%). Digestibility and voluntary-intake were measured using standard procedures. Insufficient straw was available to investigate the effect of extra energy on straw intake, and this aspect is currently being investigated.

Marked differences in liveweight and intakes quickly appeared (Figs 28b and 28c). During the first 56 days, weight loss of sheep receiving no extra protein far exceeded that of sheep receiving the protein supplement. Thereafter, sheep eating only straw suffered no further weight loss but sheep eating both straw and cottonseed cake started to gain weight (Fig. 28b). In summary, sheep eating straw alone lost 82 g/day while sheep eating extra protein gained 35 g/day ($P < 0.01$).

Intake of penned sheep fed straw alone decreased for about 56 days but then increased steadily until the end of the experiment (Fig. 28c). When sheep received a small supplement of cottonseed cake, intake of straw increased dramatically and continued to increase throughout the experiment (Fig. 28c).

It is clear that supplementing a straw diet with protein has a large significant effect on dry-matter intake ($P < 0.001$). Although the supplement probably marginally improved dry-matter digestibility of the straw, it is very likely that increased rate of digestion is due to enhanced microbial activity and that this was the major reason for increased intake of straw. — *E. Thomson and F.Bahhady.*

Parasitic Burdens in Sheep

While surveys have determined levels of sheep and goat mortality in Aleppo Province they have not revealed the effects of subclinical disease on productivity and profitability. Nor do we know the effects of new and modified farming systems, such as including pasture and forage crops, on sheep health. In 1983/84 it became possible to study these questions through generous assistance from the Japanese International Cooperation Agency which is supporting a veterinary scientist for 2 years.

The initial studies focused on establishing and testing techniques to determine the endoparasitic burden of ewes in three experimental flocks at Tel Hadya. These flocks comprise (1) ewes which received liberal feeding during winter and, with their lambs, grazed vetch for about three months in spring; (2) ewes which received less supplement and which grazed rangeland in spring; and (3) a poorly managed flock with still lower supplementation..The mean liveweight of ewes in these three flocks was 52, 47, and 42 kg, respectively, at the end of pregnancy in January 1984 when the study of helminth parasites of the lungs and gastrointestinal tract started.

Between mid-February and mid-May rectal samples of feces were taken every 14 days from six ewes, six yearling ewes, and six ewe lambs in each flock. Thereafter, sampling of lambs continued every month and ewes and yearlings every 2 months, until October when monthly sampling of all sheep recommenced. The number of eggs of easily identifiable gastrointestinal parasites (genera *Nematodirus* and *Marshallagia)* were counted using McMaster slides after floatation in staturated salt solution. Lungworms (genera *Dictyocaulus* and *Muellaria)* were counted as first-stage larvae after extraction from feces. Results of *Nematodirus* and *Marshallagia* counts are presented as eggs/g, *Dictyocaulus* and *Muellaria* are presented on a scale 0 to 3, where less than 0.5 and more than 1.5 represent low and heavy infections, respectively. *Moniezia* was also recorded, as either present or absent, and no conclusions about its populations or severity can be drawn. The three experimental flocks had not previously been treated with anthelminthics.

The patterns of egg numbers in yearlings and ewes were similar to those reported in the literature. There was a peak in spring (Fig. 29) followed by a decline during the hot, dry conditions of summer, when parasites pass into the gastrointestinal epithelium (arrested, or hyopiotic

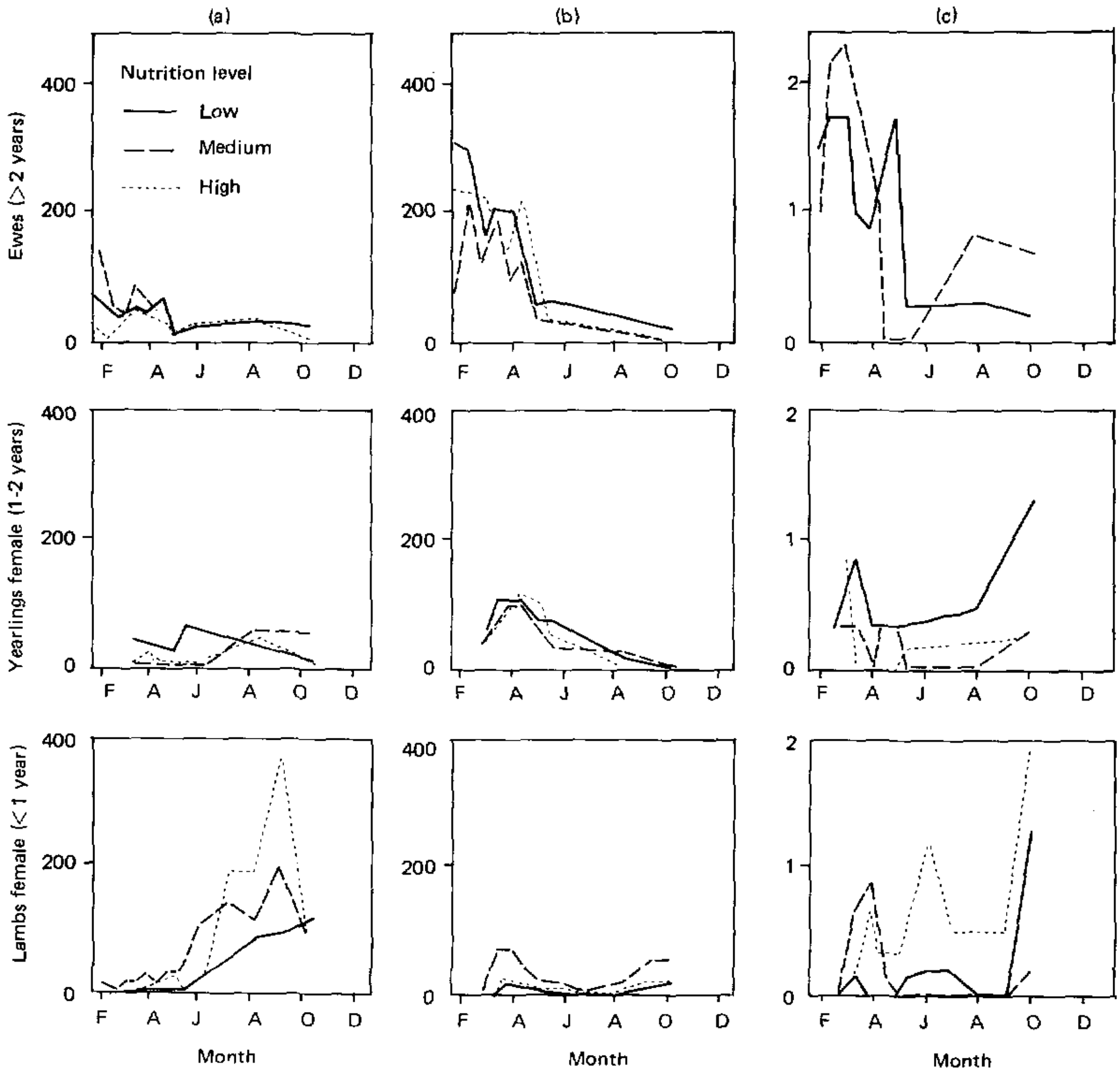


Fig. 29. Seasonal changes in faecal egg counts of (a) *Nematodirus* (eggs/g), (b) *Marchallagia* (eggs/g), and (c) *Dictyocaulus* and *Muellaria* (scored from 0-2, where less than 0.5 is light infection, 0.5 to 1.5 is moderate infection, and more than 1.5 is heavy infection).

phase of the life cycle). At the November 1984 sampling, numbers of *Nematodirus* and *Marshallagia* eggs in ewes and yearlings were still declining. However, *Dictyocaulus* and *Muellaria* in yearlings and lambs started to increase, and also in ewes to a lesser extent. Numbers of *Nematodirus* eggs also rapidly increased in lambs.

Except in the case of *Dictyocaulus* and *Muellaria*, where egg number reached a severe level in spring, peak egg counts were below 400 eggs/g, classified as a moderate level of infection. Over 600 and 2000 eggs/g of feces are considered heavy infections for *Nematodirus* and *Marshallagia*, respectively.

Differences in egg counts of the three age categories were apparent. At birth, lambs are free from gastrointestinal parasites but eggs soon begin to appear in the feces. Relative to older sheep, numbers in lambs increase during summer. All species of parasites were present in ewes and female yearlings at the start of sampling in February, but levels of infection were higher in ewes, particularly of *Dictyocaulus* and *Muellaria*.

The results have to be interpreted with caution since fecal egg count can be a poor indicator of host parasite burden. It does, however, serve as a simple technique for use on live animals. Except for lungworms, the general level of parasites in the three flocks was low, and unlikely to lead to significant losses of productivity. The contrasting nutritional regimes applied to the three flocks had no detectable effect on parasite infestation levels.

Grazing on vetches in spring had no apparent effect on the parasite burdens of ewes and lambs. However, with the advent of a considerably extended grazing season using medic pastures, greater attention to the effect of high stocking rates on some endoparasites will become necessary. This, together with monitoring of farmers' flocks in contrasting rainfall zones, will be one of the focuses of ICARDA's sheep health studies during 1985. — *G. Orita (Japanese International Cooperation Agency) and E. Thomson.*

Training

Training plays an important role in the program's activities. It aims to improve the technical skills of researchers in the area of pasture, forage, and livestock in the ICARDA region. Training offered by PFLP also seeks to acheive a network of pasture ,forage and livestock research workers within the region, thereby strengthening the research capabilities of national programs, facilitating the exchange of new technology, genetic resources, and reference materials. The program offered the following types of training in 1984:

1- Long residential course.
2- Short courses in specialized subjects.
3- Individual training for junior scientists.

Long Residential Course

PFLP offered its 6-month (January-July) residential course at Tel Hadya research station during the 1984 cropping season. Five trainees from four countries (Syria, Libya, Tunisia, and Democratic Republic of Yemen) participated. The syllabus focused on field and laboratory techniques and lectures. Training reference materials, which included lecture notes and publications, were provided.

Each participant was assigned a small project, supervised by a senior scientist taking into consideration the previous experience and background of the trainee and his country needs. This aimed to give the trainee experience in planning, conducting, analyzing, and reporting a simple experiment. The assigned experiments are shown in Table 39.

Short Course in Hay Making

The program held a short course on hay making at Tel Hadya, 23-29 April 1984 for 12 participants from Syria. The course was designed to provide national extension officers and research assistants with a sound technical knowledge on the importance of hay as a high-quality feed, basic information on forage crops suitable for hay making in the region, and recent research findings on hay-making technology. Practical and field activities were included on the identification of the proper stage for harvesting a crop for hay.

Table 39. Experiments assigned to 1984 course participants.

Name of trainee	Country	Title of experiment
Abdallah Kasim Maghram	Democratic Republic of Yemen	Seed growth in medics
Melood Omar Alkwaldi	Libya	Plant population studies in *Vicia sativa*
Adib Mangounah	Syria	Effect of seed rate and P level on agronomic characters of forage vetches and peas
Abd El Kareem Zoltan	Syria	Palatability of vetches and forage peas at various stages of their life cycle
Abd El Aziz Ben Mohamed	Tunisia	Medic simulated grazing
		Medics germplasm evaluation

The use of different kinds of mowers, side-delivery rakes, and bailers was demonstrated, and hay was evaluated for nutritive value.

Individual Training

Two technicians from the FAO/UNDP pasture, forage, and seed multiplication project at National Agricultural Research Service, Kitale, Kenya were trained in forage germplasm evaluation and utilization for 3 months, April-June 1984.

One trainee from Morocco (GTZ-INRA) was trained for 3 weeks on forage breeding, especially on selection criteria of forage crops. This was very important in developing links with Moroccan projects.

One trainee from the Steppe, Range, and Sheep Directorate of the Syrian Ministry of Agriculture and Agrarian Reform was trained on different aspects of sheep husbandry and nutrition for 9 months (March-November 1984). His training focused on management of experimental sheep flocks (milking, weighing, feeding), keeping records, and analysis and reporting of feeding experiments. — *A. Abd El Moneim.*

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Journal Articles

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Osman, A.E. and Nersoyan, N. 1984. Forage mixtures for grazing by sheep in winter and for hay making afterwards. *In* Proceedings of the 2nd International Rangeland Congress, Adelaide, Australia.

Miscellaneous

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Genetic Resources Unit

The Genetic Resources Unit (GRU) has been established to:

- Broaden the germplasm base of ICARDA's mandate crops through plant exploration and acquisition of genetic material from other genebanks and scientific institutions.
- Multiply, characterize, and evaluate the Center's germplasm through collaboration with the scientists in the crop improvement programs.
- Document all passport and evaluation information using a computerized data management system.
- Preserve the Center's germplasm in both medium-term and long-term storage conditions.
- Distribute, on request, germplasm to scientists throughout the world.
- Conduct training courses to upgrade the technical competence of scientists and technicians involved in genetic resources work.
- Conduct genetic resources related research that would enhance the utilization of the Center's germplasm.

In 1983/84, a 5-year plan of work was developed for genetic resources activities at ICARDA. The plan outlines the direction for the development and conduct of genetic resources work; it specifies priority program elements and sets a time-frame for the achievement of specific goals. It also provides an indication of personnel and facilities requirements. During the past year germplasm rejuvenation, evaluation, documentation, and conservation continued to receive high priority. Because of constraints of personnel and other resources, the GRU relied heavily on the crop programs. Some of the activities reported here were performed in collaboration with the staff of the crop programs.

The crop program scientists participated in collecting missions in Morocco, Cyprus, and Syria. Altogether, 2558 accessions will be added to the genebank as a result of these missions. The GRU multiplied and evaluated 7880 entries of barley and 627 entries of annual *Medicago* spp. Food legume scientists also evaluated chickpeas (3341 accessions) and lentils (480 accessions). The documentation of genetic resources information has been gaining ground. All available passport information has been recorded and the evaluation data for 7880 accessions of barley, 627 entries of annual medics, and 3341 accessions of spring-sown chickpeas have been added to the information data base. A germplasm catalog of lentils has been produced with passport data on 5420 accessions and evaluation data for 19 characters on 4550 accessions. Progress has been made in the conservation of germplasm under medium-term storage conditions. Altogether 11,173 entries have been processed and stored in controlled environment. The GRU continued to provide the service of germplasm distribution to interested scientists worldwide. Together with the International Board for Plant Genetic Resources (IBPGR) and the Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD), the GRU cosponsored and participated in a 4-week training course in genetic resources.

An important achievement in 1983/84 was the use of polyacrylamide gel electrophoresis. Exploratory experiments have been initiated to determine the potential of this technique to discriminate between accessions and to determine variability within and between populations.

A collaborative study with the Pasture, Forage, and Livestock Program to investigate the natural distribution and ecology of native forage legumes in Syria is under way. This project is partly supported by IBPGR through a fellowship to a researcher who, in 1983/84, made collections of a wide range of wild annual legumes from diverse environments, utilizing an ecogeographic approach. Evaluation of germplasm and soil samples is in progress to determine the effects of environment on the spread of genetic variability.

Status of Present Collection

The total number of accessions and representative germplasm material from 66 countries for barley, lentils, chickpea, and faba beans, for which ICARDA has a global mandate, is given in Table 1. These figures indicate that there is a need to increase barley germplasm from the countries which ICARDA serves and from the Mediterranean countries in southern Europe. Urgent attention must be given to collecting valuable landraces from countries in the Arabian Peninsula, Egypt, Jordan, Lebanon, Somalia, and Sudan. There is an adequate representation of germplasm of the food legume crops from the ICARDA region, but pointed collection missions must be considered to fill both geographic and genotypic gaps in the collection.

Table 1. Origin of germplasm accessions of barley, lentil, chickpea, and faba bean at ICARDA.

Country	Barley	Lentil	Chickpea	Faba bean
Afghanistan	63	127	868	64
Albania	1	2		
Algeria	16	14	19	19
Argentina	3	6		1
Australia	7	1		1
Austria	39			1
Bangladesh		36		
Bolivia	3			
Bulgaria	27	23	14	
Canada	91	2		213
Chile	9	341	337	
China	78	1		49
Colombia	566	8	2	54
Costa Rica		1		
Cyprus	331	28	35	114
Czechoslovakia	2	18	6	28
Denmark	13			
Ecuador	7	1		105
Egypt		89	50	119
Ethiopia	2682	378	29	541
Finland	6			
France	23	8	3	13
Germany (E)		22		65
Germany (W)	864	3		224
Greece		107	12	32
Greenland	1			
Guatemala		2		
Hungary	3	27		16
India	35	1905	258	4
Indonesia				1

Contd.

Table 1. Contd.

Country	Barley	Lentil	Chickpea	Faba bean
Iran	31	913	1233	12
Iraq	19	24	30	59
Italy	16	8	25	122
Japan	68	1		
Jordan	1	310	127	13
Lebanon		70	26	35
Libya	1	1		
Malawi			1	
Mexico	21	41	55	1
Morocco	102	27	86	81
Nepal	19	12	2	
Netherlands	6	1	100	
Norway		1		
Pakistan	86	37	24	1
Palestine	1	1	33	4
Peru	9	3	3	82
Poland	8	4		6
Portugal		4	23	11
Romania	16	1		
Somalia		2		
South Africa	125			1
Soviet Union	305	102	64	62
Spain	4	155	229	241
Sudan		2	7	124
Sweden	21		10	
Switzerland			3	
Syria	580	482	959	91
Tunisia	515	10	245	52
Turkey	404	337	386	213
United Arab Emirates	7			
United Kingdom	72	1		202
United States	1011	20	44	76
Uruguay	1	1		
Venezuela	3			
Yemen		37		6
Yugoslavia	273	27	2	2
Unknown	6548	83	149	3
Total	**15145**	**5866**	**5386**	**3277**

The status of the germplasm collections for crops for which ICARDA has a regional responsibility is shown in Table 2. Additional passport information is being requested from donor institutions in order to identify suspected duplicates, particularly in the durum wheat and the *Pisum* spp. collections.

Table 2. Germplasm collection status, germplasm conserved, and accessions requiring multiplication at ICARDA.

Crop	Total no. of accessions	No. of accessions in medium-term storage	No. of accessions for multipli-cation before storage	No. of accessions in long-term storage
Cereals				
Barley	15145	*8000*	9145	
Durum wheat	16412		16412	5475
Bread wheat	1656		1656	
Food Legumes				
Lentil	5866	3566	2300	4958
Chickpea	5386	14	5372	
Faba bean	3277		3277	
Forages				
Medicago spp.	3232	250	2982	
Pisum spp.	3230	250	2980	3221
Vicia spp.	2863	479	2384	
Trifolium spp.	808		808	
Astragalus spp.	289		289	
Onobrychis spp.	731		731	
Alfalfa	858		858	
Lathyrus spp.	502	44	458	
Triticale (forage)	1565	1000	565	
Barley (forage)	1719	1190	529	
Avena	530	443	87	
Grasses	622		622	
Wild Lentils spp.	107	105	105	
Chickpea wild spp.	30	22	22	
Total	64828	13363	51582	13654

New Germplasm in 1983/84

Efforts continued during 1983/84 to collect geographically and genotypically representative germplasm of ICARDA's mandate crops. Germplasm materials were collected in Morocco, Cyprus, and Syria.

A Cereal Crops Improvement Program scientist along with an IBPGR team and national scientists from Morocco participated in a collecting expedition from 12 May to 10 June 1984. Regions in the south coast of Morocco, the High Atlas and Anti-Atlas mountain areas, and the Plaine du Sud Jibibet des Phosphates were sampled. A total of 302 entries were obtained, including barley (89), bread wheat (26), durum wheat (26), rye (3), faba beans (12), lentils (9), *Vicia* spp. (21) *Lathyrus* spp. (9), *Medicago* spp. (12) and grass species (27).

In another mission in Cyprus, which was partly supported by IBPGR, an ICARDA food legume scientist and national scientist collected 166 samples (lentils 19, *Vicia sativa* 67, *V. ervilia* 15, *Pisum sativum* 6, *Lathyrus ochrus* 12, *Lathyrus sativus* 19, and chickpeas 28). The team explored the central, southern, and western parts of the country.

In Syria, the GRU and Pasture, Forage, and Livestock Program jointly collected 2090 entries of forage species from 156 sites. The most important species included annual medics (21 species and 19 subspecies), *Trifolium* (31 species), *Onobrychis* (3 species), *Trigonella* (4 species), *Lotus, Astragalus, Hymenocarpus, Scorpiurus, Coronilla,* and *Vicia* species.

In addition to field collections, a number of accessions were obtained through direct exchange from other genebanks and scientific institutions. Altogether, 3471 samples from 83 different countries were added to the ICARDA germplasm collection (Table 3).

Germplasm Evaluation

The full potential of germplasm resources can only be realized and exploited if reliable and detailed evaluation data on individual accessions are collected through field and laboratory

Existing germplasm collections are subjected to full evaluation according to international descriptor lists.

Table 3. Germplasm distributed and received during 1984.

Crops	Distributed		Received	
	No. of accessions	No. of countries	No. of accessions	No. of countries
Barley	53	13	1005	1
Durum wheat	14	6	167	10
Bread wheat	9	3	1094	7
Triticale	831	5	34	11
Chickpea	1779	9	36	4
Lentil	1455	12	380	10
Faba bean	511	9	196	9
Medics	98	11	361	2
Pisum spp.	41	9	10	2
Vicia spp.	162	13	132	3
Other forages	166	38	56	11
Total	5119	128	3471	83

studies. In collaboration with the Cereal Improvement Program, the GRU continued work on a barley evaluation and documentation project supported by IBPGR. In 1983/84, 4885 barley accessions were evaluated in the fields at Tel Hadya and in the laboratory for 25 quantitative and qualitative traits in the IBPGR barley descriptor lists. Field observations included growth habit, growth class, plant height, days to heading, row number of lateral florets, spike density, number of spikelet groups per spike, hoodedness and awnedness, awn roughness, days to grain filling, tillering, days to maturity, awn, glume, and stem color, resistance to lodging, and agronomic score. In the laboratory, the length of rachilla hairs, kernel covering, lemma color, grain color, seed yield, 1000-kernel weight, protein percentage, and lysine/protein ratio were recorded. Evaluation of the full complement of 25 traits could not be carried out for all accessions due to the limitation of time and facilities, but is proposed to be continued in 1984/85. Considerable genetic diversity has been observed in most of the characters (Table 4). An analysis of variance by country of origin showed that genetic differences were greater between the accessions from different countries than among accessions from a particular country. The data are being further analyzed to provide a summary of statistics for each trait, a listing of elite accessions, and graphical presentation of the frequency of distribution for each character.

The GRU in collaboration with the Pasture, Forage, and Livestock Program evaluated 627 accessions of 28 annual *Medicago* species (medics) at Tel Hadya for 19 traits. The data have not yet been statistically analyzed to determine the genetic diversity between and within speices. However, the range of genetic

Table 4. Genetic diversity among barley accessions in the ICARDA germplasm collection.

Descriptors	Number of accessions	Range	Mean	Standard deviation	Variance
Growth habit	5793	1 - 3	1.959	0.657	0.432
Growth class	7869	1 - 3	2.449	0.814	0.663
Number of rows	7682	1 - 3	1.503	0.671	0.450
Spike density	7791	1 - 3	1.956	0.478	0.228
Hoodedness	7861	1 - 5	3.984	0.231	0.053
Spikelet group	7767	9.8 - 79	22.806	4.980	24.805
Days to maturity	7848	138 - 258	171.283	15.514	240.673
Awn roughness	7767	1 - 2	1.933	0.250	0.062
Plant height	7831	20 - 130	67.173	21.882	478.813
Resistance to lodging	7827	1 - 9	4.1	2.013	4.051
Kernel covering	7822	1 - 2	1.950	0.218	0.048
Grain color	7404	1 - 5	3.088	1.155	1.333
Days to heading	7850	105 - 172	133.118	9.81	96.23
Days to filling	7869	131 - 185	146.013	9.295	86.389
Stem color	7864	1 - 5	4.980	0.196	0.038
Awn color	7777	1 - 9	3.438	2.156	4.646
Tillering	7868	1 - 2	1.076	0.265	0.070
Glume color	7640	1 - 9	3.747	2.367	5.604
Length of rachilla hair	7840	1 - 3	1.405	0.492	0.242
Lemma color	7822	1 - 2	1.106	0.308	0.095
1000-seed weight	7804	14.6- 62.8	37.967	6.814	46.437
Agronomic score	7615	1 - 9	4.84	1.882	3.542

variation for each trait for accessions between species is given in Table 5. In addition, scientists of the Food Legume Improvement Program evaluated 3341 accessions of spring-planted chickpeas for 14 traits and about 500 accessions of lentils.

Table 5. Range of variation for 19 traits in 627 accessions of medic.

Characters	Range
Growth habit	2 - 3
Days to 50% flowering	97 - 175
Percentage of 2nd branch	20 - 100
Percentage of 3 rd branch	20 - 100
Number of branches/plant	1 - 9.6
Length of branch (cm)	10 - 66.08
Length of longest branch (cm)	10.7 - 70.6
Internode length (cm)	0.66 - 8.72
Number of nodes to 1st flowering	1.2 - 9.8
Number of pods/inflorescence	0.7 - 7.0
Petiole length (cm)	0.26 - 6.28
Leaf area (cm^2)	1.48 - 49.97
Vigor	1 - 4
Aphid damage	1 - 4
100-pod weight (g)	0.205 - 34.70
Seed weight/100 pods	0.027 - 11.394
Number of seeds/100 pods	106 - 1598
Seed weight/plot (g)	0.514 - 262
1000-seed weight (g)	0.416 - 20.14

Documentation

The germplasm collections can only be utilized effectively if full and accurate information is recorded, analyzed, and made readily available to scientists. A computerized data-base system for the documentation of all passport information is an effective way to identify duplicate entries and to pinpoint geographic gaps in the collections. In 1983/84, passport information for 10,207 durum wheat, 637 bread wheat, 2096 chickpea, 3149 faba bean, 3232 medic, 3220 *Pisum spp.*, and 2737 *Vicia* spp. accessions were added to the data bank (Table 6).

Germplasm accessions with specific traits are selected by computer for use by scientists.

Once all the passport information has been fully documented, duplicate entries will be eliminated and others will be rejuvenated and conserved.

Collection data (15 descriptors) for 3500 accessions, which include information about the sites which the accessions were collected, have been stored on magnetic tapes.

A sustained effort has been made to collect, collate, and record accurate and up-to-date information on the characteristics of the genetic resources samples of ICARDA crops. In 1983/84, evaluation data on 5000 barley accessions (25 descriptors), 5000 durum wheat accessions (9), 3341 chickpea entries (14), 2400 faba bean entries (6), and 625 annual *Medicago* (medics) entries (19 descriptors) were documented (Table 7). This has significantly increased the amount of evaluation data that has been added to the genetic resources data base. A preliminary barley germplasm catalog which has been produced for 3000 accessions will be expanded and finalized to include passport and evaluation data for 7780 entries. Also, the data obtained from the evaluation studies on 627 accessions of medics will be processed and analyzed for the production of another catalog. A

Table 6. Documentation status of the germplasm passport data at ICARDA.

Crops	ICARDA's holding		Documented in 1984		Documented to date	
	Number of accessions	Descriptors to be documented	Number of accessions	Descriptors/crop	Number of accessions	Descriptors/crop
Barley	15145	15			12138	6
Durum wheat	16412	15	10207	3	10207	3
Bread wheat	1656	15	637	10	637	10
Chickpea	5386	15	2096	15	5356	15
Lentil	5866	15			5420	15
Faba bean	3277	15	3149	9	3149	9
Medics	3232	15	3232	15	3232	15
Pisum spp.	3230	15	3220	7	3220	7
Vicia spp.	2863	15	2737	5	2737	5
Collection data	5000	15	3500	15	5000	15

Table 7. Documentation status of the germplasm evaluation information at ICARDA.

	ICARDA's holding		Documented in 1984		Documented to date	
	Number of accessions	Descriptors to be documented	Number of accessions	Descriptors/crop	Number of accessions	Descriptors/crop
Barley	15154	25	5000	25	8000	25
Durum wheat	16127	9	5000	9	5000	9
Chickpea (W)[1]	5386	29			3344	29
Chickpea (S)[2]	5386	14	3341	14	3341	14
Lentil	5866	26			4550	26
Faba bean	3277	6	2400	6	2400	6
Medics	3232	19	625	19	625	19

1. Winter planting.
2. Spring planting.

catalog containing the passport and evaluation data as well as other descriptive information serves as an effective means to disseminate information about the germplasm collections.

A computerized seed stock control management system is being developed. This system will be used to monitor and record seed movement and will retrieve information on existing seed stocks and the history of seed movement for any desired accessions.

Rejuvenation, Conservation, and Distribution

About 50% of ICARDA's germplasm collection is still being held by the crop programs in seed stores without temperature and humidity control. An inventory conducted during the past year revealed that seeds of a very large number of accessions (51, 307) are in short supply. The amount of seeds varies from one accession to another. Seed stock must be increased for all the crops to meet the quality and quantity standards required for conservation in medium-term storage conditions (4° C± 2°C at 15% relative humidity) and in deep-freeze chests as base collections (Table 2). Considerable effort has been made to rejuvenate the germplasm, to provide new seed stocks for conservation under controlled conditions. For many accessions (14,409 entries) it would be necessary to multiply seed in two or three successive seasons to obtain a sufficiently large stock for storage and distribution. In 1983/84 seeds of barley (6000 accessions) and medics (627 entries) were rejuvenated. Only 250 of the 627 accessions of medics met quantity requirements for conservation. In order to prevent further deterioration in seed quality of the germplasm in the breeders' collections, attention has been given to storing the entire ICARDA germplasm collection under controlled conditions. This important task is under way and already all the collections of cereal crops, those of lentils, chickpeas, a part of the faba bean collection, and germplasm of some of the pasture and forage crops have been placed in controlled environment storage.

ICARDA's germplasm collections are stored in controlled environment.

The GRU plays an important role in the distribution of the Center's germplasm. The Seed Health Laboratory (SHL) assists in the rapid and safe movement of genetic material by establishing appropriate quarantine safeguards and monitoring the seed health status (diseases and pests) of germplasm received and dispatched. In 1984, 5119 samples of more than 11 crops were distributed upon request from scientists in 128 countries (Table 3).

Training

Training of scientists and technicians in the ICARDA region in the management and use of germplasm resources needs to be strengthened and developed. Trained personnel are required to develop a regional network of germplasm scientists and technicians to promote exploration, conservation, evaluation, and utilization of diverse genetic materials. Last year the GRU supported and participated in a joint IBPGR/ACSAD/ICARDA training course. This course was designed to fill a need for persons to learn specialized skills required for genetic resources activities. The participants attended lectures and practical exercises in the fields and in laboratories; they studied methodologies relating to germplasm exploration and collection, evaluation and characterization, documentation of genetic resources information, and rejuvenation and conservation of germplasm.

The training course ran from 10 April to 7 May 1984, and had 14 participants from Syria (2), Iraq (2), Tunisia (1), Morocco (1), South Yemen (1), North Yemen (1), Jordan (1), Lebanon (1), and Algeria (2).

Present personnel and financial constraints do not permit the GRU to undertake independent training activities. However, short duration (2-3 weeks) training in specific areas related to genetic resources work for a limited number of young scientists is considered as an integral part of the genetic resources work at ICARDA.

Genetic Resources Related Research

It is contemplated that the GRU's involvement in genetic resources research would integrate some of GRU's activities with those of the crop programs and strengthen and maintain continuous and strong contacts with the scientists in the programs. Research work in the GRU is a low-key activity which is planned to provide information needed to develop effective guidelines for collecting strategies and for rationalizing the amount of germplasm to be rejuvenated and conserved. During 1983/84, studies were conducted to determine (1) the potential of electrophoretic techniques to discriminate between accessions and populations in an effort to detect duplicate entries (GRU), (2) the variation between and within lentil landraces (FLIP), and (3) the natural distribution and ecology of native forage legumes in Syria (GRU and PFLP).

Use of Electrophoresis to Discriminate Between Genotypes in ICARDA's Germplasm Collection

Conventional methods of identifying cultivars and accessions of crop plants based on studies of phenotypic characters are not entirely satisfactory. Phenotypic expressions are markedly influenced by the environment in which the plants are grown. Additional information obtained by electrophoretic studies of the plant parts can be used in conjunction with phenotypic observations to provide more reliable identification of different genetic materials.

Esterase isoenzyme electrophoresis is the most commonly used. These enzymes are relatively easy to detect, hence genetic differences in genetic materials can be identified with a reasonable degree of confidence.

Preliminary work has been started by the GRU to test the efficacy and suitability of the isoenzyme electrophoretic procedure to identify duplicates in the germplasm.

A total of 216 accessions of annual medics from six species, each with three to four subspecies, and 42 populations of barley collected from six regions (Damascus, el-Raqqa, Aleppo, Homs, Idlib, and al-Hassakeh) in Syria were selected as test materials for electrophoresis studies. The topmost leaves of medics at 4-6-leaf stage of plant growth were collected, immediately frozen, and kept in the refrigerator until assayed. Approximately 0.5 g of barley seeds and 2 to 4 leaves of medics were crushed thoroughly with 2 ml of extractant containing 20% W/V sucrose solution with 1% bromophonol blue (BPB) as a marker dye. Electrophoresis was performed at room temperature through 7% polyacrylamide gels which were then assayed for non-specific esterases. Reading was carried out twice on the same gel to avoid possible error in locating the precise position of the bands. The position of each band was calculated as an Rf-value, relative to the BPB front:

$$Rf = \frac{\text{Migration distance of the band}}{\text{Migration distance of BPB front}}$$

The medic accessions studied revealed a total of 26 bands at frequencies which differed between the 216 accessions (Fig. 1 and Table 8). The observed banding pattern by species and subspecies showed a high degree of polymorphism although some of the bands were monomorphic in some accessions. This high degree of polymorphism is a reflection of the wide genetic differences and genetic variability between the species and subspecies. The differences in banding pattern could be used for identification of duplicate samples in the germplasm collection.

The band at Rf 0.44 is monomorphic. It was present in all accessions of *M.rigidula* var. *submitis*, but was absent in all other accessions and thus it can be regarded as a good identification band for this subspecies. Also, the band at position Rf 0.35 was present in subspecies in two different species (*M.aculeata* var. *aculeata* and *M.polymorpha* var. *vulgaris*) but was absent in

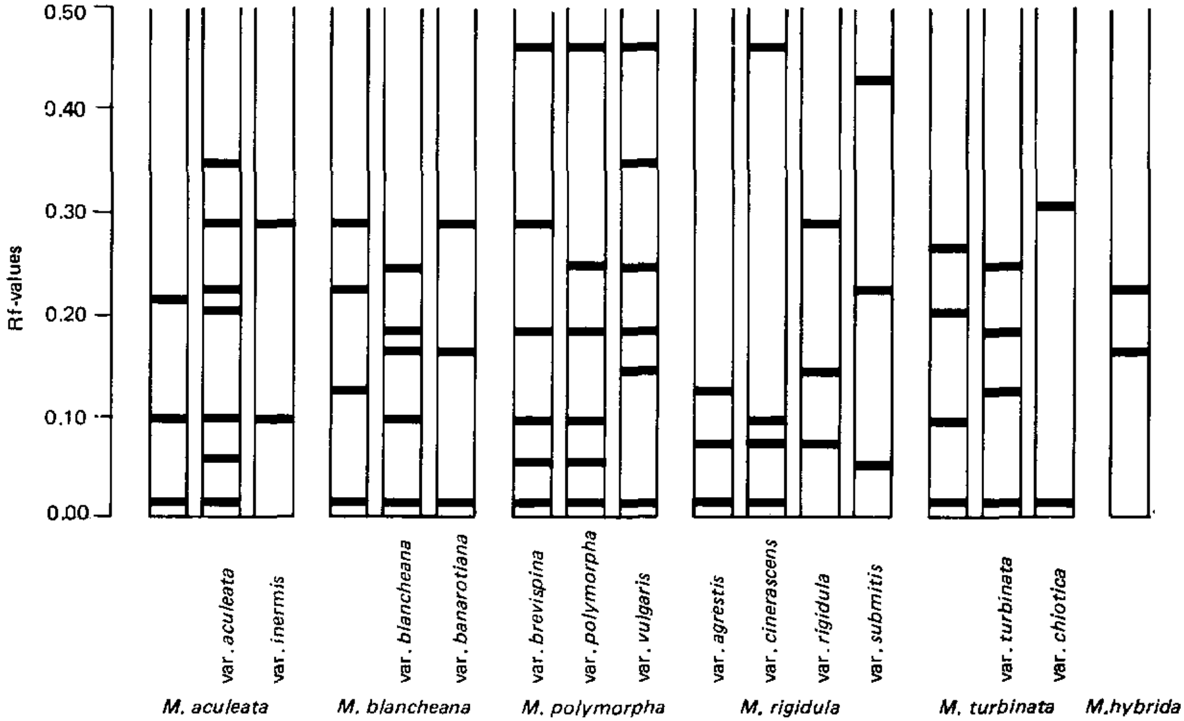

Fig. 1. Grouping banding pattern by species and subspecies in annual *Medicago* species.

the other accessions. The frequency of occurrence of the band at the Rf 0.46 position was high in all accessions of *M.polymorpha*, but low in *M.rigidula cinerascens* and was absent in other species and subspecies. Notably, a band at position Rf 0.02 was present in all the accessions of the different species and subspecies, except *M.aculeata* var. *inermis, M. rigidula* var. *rigidula, M.rigidula* var. *submitis,* and *M.hybrida.*

There are other bands which clearly differentiate the accessions. The bands shown in Fig. 1 can be used to group the germplasm accessions by species and subspecies.

The 26 bands observed in barley occurred with different frequencies in the 42 populations studied. Four of the observed bands with Rf-values of 0.54, 0.56, 0.79, and 0.83 were monomorphic. The band with Rf-value 0.56 was only found in the populations collected in the Aleppo area whereas the other three bands were observed in the populations obtained from al-Hassakeh. The band with Rf-value 0.42 was found exclusively in the population from the Damascus and ar-Raqqa regions and Rf-value 0.89 was present in populations from Aleppo and Idleb (Table 9). Other bands showed a high degree of polymorphism as indicated by the relatively high values of the polymorphic indices (PI). This degree of polymorphism reflects the genetic differences between the populations obtained from the different regions in Syria. The only exception is the low degree of polymorphism (PI = 0.067) for the Idleb populations: this low level of polymorphism is probably due to the low number of populations available for studies from that region.

The results of these electophoretic studies indicate that there is considerable genetic variability in the germplasm of both medics and barley. On the whole, a high degree of genetic variability was detected in all the accessions and populations studied. The observed variation in

Table 8. Number of observed bands and polymorphic indices for *Medicago* species and subspecies.

Species and subspecies	No. of accessions	No. of bands observed	PI
M. aculeata	10	22	0.159
M. aculeata var. *aculeata*	8	16	0.105
M. aculeata var. *inermis*	11	21	0.149
Species total	3		0.1631
M. blancheana	13	21	0.149
M. blancheana var. *blancheana*	8	25	0.160
M. blancheana var. *banarotiana*	9	24	0.159
Species total	3		0.1731
M. polymorpha var. *brevispina*	8	25	0.172
M. polymorpha var. *polymorpha*	8	23	0.154
M. polymorpha var. *vulgaris*	8	26	0.177
Species total	3		0.1789
M. rigidula var. *agrestis*	9	22	0.140
M. rigidula var. *cinerascens*	10	25	0.171
M. rigidula var. *rigidula*	11	20	0.134
M. rigidula var. *submitis*	7	18	0.124
Species total	4		0.1647
M. turbinata	14	21	0.144
M. turbinata var. *turbinata*	10	21	0.130
M. turbinata var. *chiotica*	10	22	0.149
Species total	3		0.1524
M. hybrida	7	19	0.134

banding pattern could be used to identify duplicates in the germplasm collection where morphological distinctness is lacking. — *Y. Adham and B. Somaroo.*

Variation Between and Within Lentil Landraces

This study was conducted by Dr. W.Erskine in the Food Legume Improvement Program and has been reported in the FLIP section of this report. The results underline the importance of adopting appropriate strategies for lentil germplasm exploration and management.

Ecogeographic Survey of Wild Annual Legumes in Syria

This study is a continuation of Project M2 (Ecological Study of Medics and other Annual Legumes in Syria and Jordan) of the Pasture, Forage, and Livestock Program. The objectives of this investigation are (1) to sample the genetic diversity of natural populations of annual legumes in an effort to promote their conservation and utilization and (2) to relate the distribution of legume species, their inherited characteristics, and relative population size to such variables as climate, soil type, and natural vegetation in order to obtain information relevant to the establishment of pastures and forages in Syria.

Aspects of this study already completed include:

i. A literature survey relating to ecological and climatic variability to pinpoint areas heterogeneous with respect to rainfall, altitude, soil types, and floristic composition. The information obtained in this survey was used to identify areas likely to possess diverse genetic material.

Table 9. Mean relative frequencies of the bands observed and polymorphic indices for 42 barley populations from 6 regions in Syria.

	Barley populations						
Rf value	Damas.	el-Raqqa	Aleppo	Homs	Idlib	el Hassakeh	PI
0.08	0.75	0.75	0.56	0.55	0.50	0.25	0.133
0.10	0.25	0.25	0.22		0.50	0.50	0.107
0.13	0.25		0.22	0.46		0.25	0.112
0.15	0.50	0.75	0.67	0.55	1.00	0.25	0.133
0.17	0.50	0.25	0.11	0.55		0.58	0.115
0.19	0.50	0.25	0.78	0.27	0.50	0.42	0.126
0.21		0.25		0.27		0.08	0.093
0.23	0.25	0.75	0.33	0.55		0.42	0.126
0.25	0.50		0.44			0.50	0.102
0.27		0.25	0.33		1.00	0.08	0.115
0.29	0.25	0.75	0.56	0.73		0.67	0.123
0.31	0.25		0.22	0.09	0.50	0.17	0.129
0.33	0.25		0.11	0.09		0.08	0.125
0.35	0.25		0.11	0.09	0.50	0.08	0.133
0.40	0.25	0.25	0.11	0.27		0.08	0.121
0.42	0.25	0.25					0.083
0.44		0.25		0.27		0.17	0.102
0.46	0.50		0.22	0.36	0.50	0.17	0.126
0.48		0.25	0.33	0.09		0.17	0.115
0.50	0.25		0.11			0.08	0.111
0.52		0.25	0.11			0.08	0.111
0.54						0.08	M
0.56			0.11				M
0.79						0.17	M
0.83						0.17	M
0.89			0.11		0.50		0.083
No. of Populations	4	4	9	11	2	12	42
PI	0.127	0.101	0.126	0.107	0.067	0.133	

M = monomorphic bands.

ii. A reconnaissance of the selected areas to define and map major habitats. On this basis, appropriate sampling strategies were devised for collection of annual legumes.
iii. Collection of herbarium specimens from most of the sites prior to seed ripening and maturity of the legumes.
iv. Collection of seeds from 96 sites in all.

The distribution of sites with respect to average annual rainfall and mean monthly minimum temperature is shown in Fig. 2.

Collection strategy within sites. At each site an area of approximately 0.5 ha was explored using two 40-meter strip quadrats. Estimates were made of ground cover, soil depth, and distribution of legume species within the site. In addition, a smaller area (25 m^2) typical of the site was selected for collection of a representative subsample of the total seed population of each species as well as five soil samples which were bulked for analysis at Tel Hadya. Each legume species within a site was also sampled over the

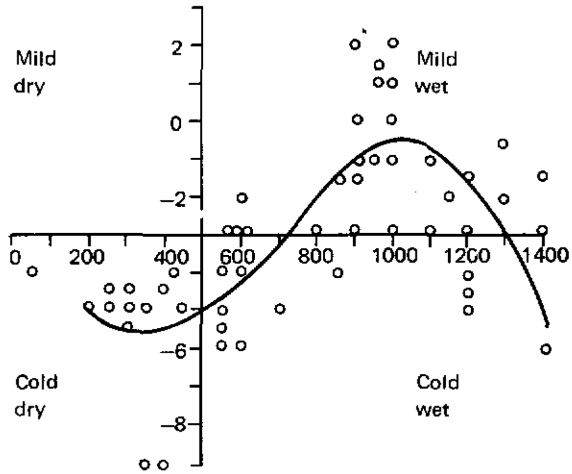

Fig. 2. Distribution of collection sites in relation to annual rainfall and average absolute minimum temperature, Syria.

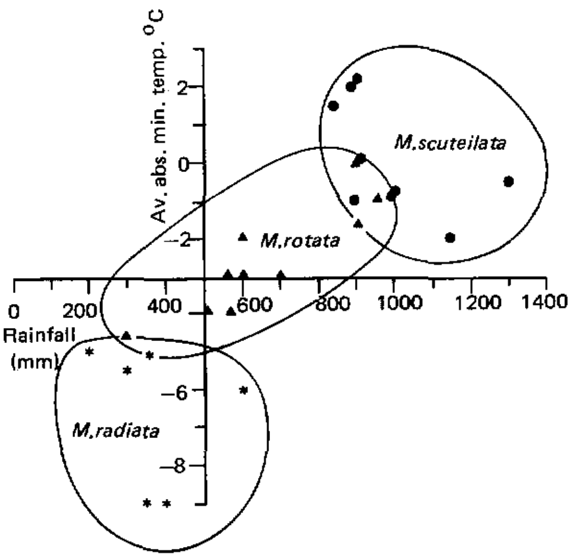

Fig. 3. Distribution of three medic species in relation to annual rainfall and average absolute minimum temperature, Syria.

total site area (0.5 ha) to obtain adequate population samples. A total of 1724 samples were collected, comprising 442 of medic species, 762 of *Trifolium* species, and 520 of 17 other legume species. Figure 3 shows the distribution of three relatively common medic species (*M.scutellata, M. rotata,* and *M. radiata*) which exhibit a pattern of clustering in relation to rainfall and minimum temperature.

Evaluation/characterization. Evaluation in 1984/85 will concern analysis of the soil samples collected from the 96 sites, and agronomic evaluation for 12 quantitative attributes of all the samples collected (Table 10). In addition, a number of morphological characters will be scored from mounted specimens, particularly those considered to be of taxonomic significance at the infraspecific level.

Table 10. Details of soil and germplasm characterization to be performed in 1984/85.

A. Soil attributes
1- Total and available P
2- Total N
3- Organic carbon
4- Available K
5- pH
6- Cu, Zn, and other trace elements
7- Texture
8- Color (Munsell color code)
9- Electrical conductivity

B. Quantitative characters for agronomic evaluation
1- Time to flowering
2- Leaf area of specific leaves
3- Petiole length
4- Internode length
5- Peduncle length
6- Flowers per inflorescence
7- Nodes to first inflorescence
8- Pods per inflorescence
9- Seeds per pod
10- Seed size
11- Hardseededness
12- Germination rate of imbibed seed

C. Morphological characters
Approximately 20 to be scored from mounted specimens.

Analysis of data. The data will be analyzed using various techniques of pattern analysis in order to cluster populations into recognizable specific and subspecific groups on the basis of the attributes recorded, and to identify specific environmental parameters influencing distribution of such groups. — *P. Cocks (PFLP) and T. Ehrman.*

Seed Health Laboratory

The Seed Health Laboratory was established in 1982 and is part of the Genetic Resources Unit. It aims to ensure that material imported does not carry potentially dangerous pests and pathogens and that the material which ICARDA distributes is healthy and complies with Phytosanitary Import Regulations of the importing countries. The Seed Health Laboratory serves all the crop improvement programs and the Genetic Resources Unit, and handles all seed exchanges.

Seed Health Testing

Approximately 800 seed consignments, comprising seed quatities between 150 g and several hundred kilograms were shipped in 1984. The seeds were inspected visually for any irregularities (insect infestations, weed seeds, soil, straw, abnormal seeds, etc.). In addition, specific test methods were used on a limited number of samples.

One major problem of seed health testing is that a sufficient sample size is required for reliable, reproducible results. Since most test methods are destructive to the seed, it is difficult to obtain the required amount of seed, especially for early generations of breeding materials. Therefore, it is generally preferred to use small samples on several different suitable test methods, e.g. agar plate with different media, filter-paper test, etc.

A brief summary of the seed health tests carried out in 1983/84 is given in Table 11. In cases where the treatment was not effective, the programs were informed accordingly.

The data in Table 11 show that the health status of the crops was generally good, which confirmed the findings of field inspections carried out during the growing season. Measures, such as improved plant protection during multiplication, more thorough cleaning process, and improved seed treatment, will be taken during next season in order to further decrease the number of cases in which pathogens presented problems.

Samples of imported material which passed through the Seed Health Lab were inspected and, where necessary, disinfected and/or treated. Special attention was given to the material to be planted other than in the isolation area.

The germplasm collection is now being evaluated for health status. These data will be stored along with passport data and information on viability.

Seed Treatment

Seed treatment is a standard procedure for all seed that ICARDA dispatches for planting purposes. Seeds required for laboratory experiments, processing, etc. are sent untreated if this is requested.

As a routine procedure, the seed treatment is monitored, and samples of treated and untreated seeds are tested for germinability.

The treatment of small samples presented some difficulties (correct dosages of the treatment chemicals, sufficient coating of seeds, avoiding health hazards to users) which had to be overcome.

Generally, using a liquid or slurry treatment helps to solve these problems. For cereals, liquid formulations of suitable chemicals and the appropriate equipment are available, but this is not the case for legumes. The use of additives with the treatment chemicals for legumes was therefore evaluated.

Table 11. Laboratory Seed Health Testing conducted on material for seed exchange, Tel Hadya, 1984.

No of samples tested	Test method	Target organisms	No. of positive samples
	BARLEY		
99	Freezing blotter test	*Helminthosporium* spp.	1
		Fusarium spp.	17
		Rhynchosporium spp.	4
7	Embryo count	*Ustilago* spp.	0
	WHEAT		
288	Washing of seeds	*Tilletia foetida*	170[a]
		Tilletia caries	17[a]
		T. caries + *T. foetida*	17
	CHICKPEA		
119	Filter paper	*Fusarium* spp., *Ascochyta* spp.	0
119	Freezing blotter test	*Fusarium* spp., *Ascochyta* spp.	0
185	Chickpea agar	*Ascochyta* spp., *Fusarium* spp.	0
185	Oxgall agar	*Fusarium* spp., *Ascochyta* spp.	0
185	Potato dextrose agar	*Ascochyta* spp., *Fusarium* spp.	0
	LENTIL		
57	Filter paper	*Fusarium* spp., *Ascochyta* spp.	3/0
44	Freezing blotter test	*Fusarium* spp., *Ascochyta* spp.	4/0
57	Potato dextrose agar	*Fusarium* spp., *Ascochyta* spp.	1/3
81	Oxgall agar	*Fusarium* spp., *Ascochyta* spp.	1/4
81	Lentil agar	*Fusarium* spp., *Ascochyta* spp	0/2
	FABA BEAN		
8	Funnel test	*Ditylenchus dipsaci*	0
48	Vis. inspection	*Orobanche* spp.	0
48	Faba bean agar	*Fusarium* spp.	4
		Ascochyta spp.	1
48	Potato dextrose agar	*Fusarium* spp.	5
	PEAS		
25	Fluorescence test	*Pseudomonas pisi*	17

a. In the washing test it cannot be distinguished between viable and nonviable spores. Spot checks were made for germination capacity of the spores in treated seeds. All the tests were negative.

Additives which do not have negative effects on chemical effectiveness and on seed viability, and which increase the adhesion of the chemical to the seed, were assessed. Sacrust, molasses (10%), Dextrine (0.2%), Citowett (0.2%), and water were used, either added to the seeds and the chemical dust or with the chemicals suspended in them. Because suspending the chemicals in the additives reduces the health hazard to operators, this method has been preferred. Water, Dextrine, and Citowett were not suitable additives, because the chemicals did not form a suspension; instead they form a "cake" at the bottom of the container after 2 hours. Molasses and Citowett both had a negative effect on germination, and both reduced plant growth. Sacrust did not have these disadvantages and gave a better control of the diseases. Thus for seed treatment, a suspension of the chemicals in Sacrust (25 ml/kg seed) is recommended. Hege applicators which allow exact dosage and avoid health hazard to a large extent, can be used for treatment of quantities in the range of 20 g to 4 kg.

Some internally seed-borne pathogens are very difficult to control. Efforts are made to identify chemicals to improve the control of these pathogens. An example is the control of bacteria in the ICARDA collection of *Pisum sativum* germplasm. Screening the material showed that 54% of 230 samples tested were infected with *Pseudomonas pisi,* which causes bacterial blight of peas. This is a quarantine organism in most countries requesting seeds from the germplasm collection; in order to comply with the phytosanitary regulations of the importing countries, infected material is not sent. Nine antibiotics were screened to evaluate their effectiveness to control bacterial blight and to investigate possible negative effects on seed viability. The results of these tests are given in Tables 12 and 13. Although there are some reservations about use of antibiotics in agriculture (selection of resistant strains of

Table 12. Number of *Pseudomonas pisi* colonies on Pseudomonas F agar after treatment (total of 5 replicates).

Chemicals (500 ppm)	Duration of treatment		
	10 min	1 hour	6 hours
Ampicillin	5	6	12
Tobramycin	23	17	5
Streptomycin	0	0	1
Kanamycin	29	37	39
Kasugamycin	4	6	6
Juglone	81	78	76
Cycloheximide	77	23	18
Tetracycline	3	1	0
Copac E (1%)	5	4	7
Check (water)	79	74	82
Check (untreated)		76	

Table 13. Effect of antibiotics on germination (%) of *Pisum sativum*..

Chemicals (500 ppm)	Duration of treatment		
	10 min	1 hour	6 hours
Ampicillin	92(79)[b]	96(73)	74(15)
Tobramycin	84(79)	87(72)	76(38)
Streptomycin	90 (73)	96(68)	73(26)
Kanamycin	91(80)	90(71)	74(48)
Kasugamycin	95(33)	74(0)	0(0)
Juglone[a]	92(60)	89(70)	82(30)
Cycloheximide	88(25)	49(48)	0(0)
Tetracycline	91(52)	87(14)	21(0)
Copac E (1%)	68 (26)	65(39)	0(0)
Check (water)	94(59)	91(69)	75(65)
Check (untreated)		93(89)	

a. Growth stimulant.

b. Figures in parentheses give the germination rate after 6 months storage.

bacteria pathogenic to humans), it is a relatively cheap and effective method for control of seed-borne bacteria. The use of Streptomycin at 500 ppm for seed soaking largely eradicated the pathogen (Table 12), as was verified in growing-on tests in the greenhouse. Streptomycin is one the antibiotics which do not affect seed viability when used for short and medium-term treatment (Table 13). It is therefore used at ICARDA to control *Pseudomonas pisi* in infected germplasm sent to countries where *Ps. pisi* is a quarantine organism.

Publications

Diekmann, M. 1983. Seedborne disease and germplasm exchange in the International Center for Agricultural Research in the Dry Areas (ICARDA). Paper presented at the Fourth International Congress of Plant Pathology, 17-24 Aug 1983, Melbourne, Australia.

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Diekmann, M. 1984. Seed treatment. *In* Seed Production Technology. ICARDA (in press).

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Computer Services

Introduction

The organizational structure of Computer Services was consolidated in 1984 under the following three main project areas:

1. General Systems Development
2. Statistics and Experiment Aids
3. Administrative Applications

The projects are not separate or isolated, but are interdependent. Such interdependence calls for a regular exchange of development schedules to enable full sharing of resources used in design and development.

Software Production

A mechanism for more rapid response in software production was implemented in 1984. This was a result of the growth in ICARDA's software, both in applications modules and in the number and diversity of the general library modules. The former enabled addressing, at times, apparently differing requirements using the same, or slightly modified, modules. The latter permitted the development of application modules from existing general library modules. The maintenance of the general format of such modules is an essential design criterion.

The ICARDA computer supports some 600 different library modules, which reside in two main libraries: ICALIB and ICAFIL. Some 420 application programs make up three packages: ICADET, ICARDA's data management system; CRISP, ICARDA's main experiment design and statistical analysis package; and MAS, the management, accounting, and information system. Miscellaneous systems management and control programs also exist to help Systems Operations make effective utilization of the computing resources.

Packages from other sources are continuously evaluated for possible acquisition. Computer Services maintains a library of information about such packages which address the requirements of research and training in agriculture. A number of these packages are in use at ICARDA (Table 1).

Table 1. General application software at the Tel Hadya Computer Center.

Name	Origin	Type
CALC	Saturn Inc., USA	Spreadsheet calculator.
CRISP	ICRISAT and ICARDA	Statistical in particular designed experiments.
CSMP	Maztek (IBM Conversion), USA	Dynamic simulation.
ICADET	ICARDA	Data management system.
GENSTAT	National Algorithmic Group, UK	Statistics - general.
MAS	ICARDA	Management, accounting, and information.
SCRIBE	Saturn Inc., USA	Wordprocessing.
SHAZAM	Dr. K. White, University of British Colombia, Canada	Advanced regression package.
SPPS-X	SPSS Inc., USA	Statistics.

A view of the Programming Area at ICARDA's Tel Hadya Computer Center.

Training

An important component of these projects is training. Continuous training schedules are set up to address user requirements. Training covers existing and new software produced at ICARDA, or procured from elsewhere.

In 1984, the training component assumed a more stable format. Computer Services is at a stage when a systematic approach to training of scientists from the national agricultural research programs in the region could be undertaken. To this end, training courses and materials were designed to address the problem of computing methods for data analysis in agricultural research, including statistics, and in data management.

Individual workstations are installed in program offices for computer users.

Systems Development

The number of terminals in the various workstations was increased to a total of 48 in 1984. The peak demand on the computing systems at the *Tel Hadya Computer* Center reaches this current maximum. To eliminate the operational stress, preparations to increase the number of users to 64 are under way. The memory capacity was increased to four million characters and the expansion of the disc space from 600 million characters is planned for May 1985.

In 1984, experiments with computer graphics were conducted. It is planned that a graphics workstation will be installed by May 1985 for central use.

Plans to upgrade the PDP-11/34A computing system at the Aleppo *Computer Center are* under way to meet the increased load on the machine. — *Khaled S. El-Bizri.*

General Systems Development

This project aims at expanding the use of data management techniques through the use of ICADET, ICARDA's data management system, in additional applications, and through continued training.

In this respect, ICADET serves as a foundation for the development of an application program or a package of programs. Such a foundation permits standard data management functions such as creation, editing, updating, sorting, and merging data files. Each standard function is expressed in a specific or mode changing command. Thirty-three such commands are in use and are listed in Table 2.

Table 2. ICADET commands.

ADD	DUPLICATE	RANK
ADD-COLUMN	EDIT-HEADER	RENAME
COMMANDS	EDT	SELECT
COMPRESS	FREE-FORM	SET-TERM
CONVERT	FREQUENCY	SHOW
COPY	HEADER	SIZE
CREATE	HELP	SORTX
CRISP	PRINT-LABEL	SORT
DELETE	PRINT	SPOOL
DIRECTORY	PRINT-COLUMN	SPSS
DISPLAY	PURGE	TRANSFORM

Packages are developed to deal with specific data acquisition, storage, access, analysis, and reporting requirements at ICARDA. Some of these are large systems, such as CERINT, the data management and analysis system for cereal breeding. Others are of lesser size, such as the meteorological data process METEOR. All these systems are subject to continual development to add new analysis or utility modules, or enhance existing ones.

Most packages use all ICADET's commands. But, in addition, each possesses specific commands which permit the performance of specific analysis (e.g. pattern recognition in reaction types in ICALAB, ICARDA's laboratory data capture and analysis system) or specific utility, such as in the production of reports (e.g. fieldbook production in LEGINT, the international nursery data processor for legumes improvement or the annual supplement production of the Chickpea Annotated Bibliography and On-Line Search System, CHABIB. Package-specific analysis and utility modules are incorporated in special routines, and form the veritcal structure of our analogy.

These modules are usually produced rapidly, as a result of the scope and diversity of ICARDA's software libraries. These libraries are used across projects, and are under continual revision.

The extent of the reliance on database management techniques may be measured by, for example, the fact that all selections made for 1984/85 cereal nurseries were directly assisted by specific selection features in CERINT. Additional features which may help the breeder and the agronomist in summarizing voluminous data and decision making, will be the central theme of the further development of such packages as CERINT, LEGINT, and METEOR.

A number of administrative packages were added in 1984 to the predominantly scientific set. These include: VISITOR, TRAVEL, RECRUIT, LEAVES, TELDIR, and MAILER, among others. On the other hand, an on-line current awareness service is available through CURAWA, of which a printed version is distributed in the region.

The design of ICADET attempts to address the specific needs of data management in agricultural research: from the viewpoint of the user, through the facilities made available; the designer, through simplified data structures; and the programmer, through intense familiarity with the inner structures and performance parameters of ICADET.

New general analysis commands are under testing and will be made available in January 1985. The PDP-11 batch processes will commonly be used in ICADET.

In this approach the concepts of relational, hierarchical, or network designs referred to in the literature (Dates 1980), are not strictly recognized in ICADET. ICADET possesses features from each of these, although it may owe more to the relational than other concepts.

ICADET version 2 will be released in May 1985. The new version will have additional facilities in the base structure, the most important of which enhances the common data dictionary and implements links and pointers to data files through redefinitions of data types. New types of data were introduced such as DATE and TIME, as well as user-defined data types, with associated user-defined verification routines. — *Basheer Bishara and Khaled S. El-Bizri.*

Statistics and Experiment Aids

This project involves the maintenance of statistical analysis services through the development of the necessary software tools, either through internal development or through procurement. CRISP (Crop Research Integrated Statistical Package), the original version of which was developed at ICRISAT, Hyderabad, India, is the main tool for breeding and agronomy. SPSS-X, SHAZAM, and GENSTAT are also used, especially for the social sciences. Advice to users on appropriate design and analysis, as well as the interpretation of results, form the second component of this project.

Software Production

New analysis or utility routines were added to address recognized requirements. Version 2.0 of CRISP currently supports 115 modules in 150 programs. Some of the routines were replacements of existing ones, others were additions:

CERBOK	Crossing block generation and printing program.
COPY	Creates a copy of a data file.
CRANDM	The routine was modified to analyze a range of variables.
CRSTAB	Two- or three-way cross tabulation.
DELETE	Deletes data files from an account.
DIRECT	Displays the directory of data files in an account.
DISTRB	Omits missing observations. The skewness and kurtoaia options were added.
DMRT	Duncan multiple range test for each of the analysis routines.
DSQUAR	Population classification analysis by Mahalanobis D2 method.
FACT2N	Analysis of variance for factorial 2^n designs.
FASTFL	Creates a CRISP data file without any descriptive information.
FILSIZ	Displays the data file size in number of blocks used.
FLDPRT	Prints randomization table either in treatment number or plot number order.
ICACRS	Converts an ICADET file into a CRISP file.
LATSQR	The routine was modified to analyze a range of variables.
MISDAT	Estimation of missing values covering all designs supported.
MODAUG	Analysis of variance for modified augmented design.
PARCOR	Partial correlation analysis.
PURGE	Purges the data files in an account.
RBDMOP	Analysis of variance for RBD design with multiple observations per plot.
RCB	The routine was modified to analyze a range of variables.
REGRES	The result from the regression analysis options, REGRES, POLR, and STPWIS may be directed to the line printer.
RENAME	Changes the file name, type, or version of an existing disc file.
SHOW	Displays the status of process, the

	system, or devices in the system.
SPOOL	Prints a list file.
STBLTY	Analyzes the stability of genotype × environment by Ebberhart and Russel (Crop Science 6:36). Automatic restructuring and pooling of variables across physical factor levels. The output result includes the F-ratios in the anova table and T-values for all the genotypes under study.
TRAN	A new program which performs the transformation of variables in an equation form. Mean and variance of variables may be used as an operand.
WIDTH	Sets terminal width either to 132 or 80 characters.

In addition to the above, the experiment aids facilities (fieldbooks, labels, etc.) have been further strengthened. All experimental designs supported by CRISP may now be linked to the experiment aids options, including those related to incomplete block designs such as the lattice design.

All fieldbooks for trials in the 1983/84 season were produced using the CRISP experimental aid modules.

The need for inclusion of multivariate analysis of variance and covariance, cluster and factor analysis, and nonparametric tests is recognized. Design work commenced in 1984, and the modules will enter the alpha-testing phase early in 1985, with a target release date set for September 1985.

A CRISP verification report was produced based on a major test run of the analysis options (CRISP Verification Tests 1984). The results confirmed a continued adherence to set standards in accuracy and efficiency.

Training

Training occupied about 30% of the resources of this project in 1984. Training was provided to 32 persons from a wide cross-section of the scientific and technical staff of the center on individual basis, to meet specific requirements. Additionally, three courses were designed to meet three identified levels of user needs. These form the structure which addresses internal requirements at ICARDA (42 registered trainees for 1985) as well as projected work with the national programs.

The second edition of the CRISP Reference Manual was issued and the first edition of CRISP Users' Guide went to press.

CRISP file handling was thoroughly studied. Work began on the conversion of the CRISP file system. The main CRISP analysis options may use ICADET-type data files. The fully converted CRISP with additional file management features should be available in September 1985. — *Bijan K. Chakraborty and Khaled S. El-Bizri.*

Administrative Applications

Administrative applications centered around the integrated management, accounting, and information system (MAS) developed by ICARDA. In 1984, the Payroll subsystem was put into active use for all staff categories; the Stock Control subsystem was put into parallel runs; and the Order Entry system is in the final stages of development. Together with the Automatic Accruals subsystem and the Personal Management subsystem, in preparation, the above represent the final stages of development of this version of MAS.

MAS now supports:

1. Multicurrency general ledger.
2. Payroll subsystem.
3. Budget development and control subsystem.
4. Manpower deployment subsystem.
5. Memorandum accounts subsystem.
6. Stock control and order entry systems.

Transactions in the above systems and subsystems are reflected in the General Ledger through manually or, more often, automatically generated vouchers destined for manual or automatic posting. Up-to-date information on ICARDA's financial status is, therefore, available for management and financial decision making.

Payroll Subsystem

This is a general subsystem providing for the two payroll types, regular and casual, under different categories and subcategories, in multiple currencies.

Payroll production follows, however, a standard procedure from updating the main files to the production of the proof-listing, the register, and the payslips. The Payroll subsystem automatically generates vouchers for posting to the relevant account of the project and responsibility center in the general ledger.

The Personnel Department at ICARDA maintains its records through the relevant section of the employee record in the Payroll subsystem. Design work on this has commenced to implement additional systems for personnel management and administration.

Budget Development and Control Subsystem

This subsystem provides a means for the preparation of budget drafts. Extensive automation of the process is implemented through the Manpower Deployment subsystem (described below), the formation of strategies for expenditure, and the monitoring of fund application.

Manpower Deployment Subsystem

The smallest financial unit in MAS is the Project. Each project is given a unique code. A group of projects form the Responsibility Center.

Accounting of personal services (salaries and overheads) is carried out by apportionment of the cost to the projects in which an employee works. The apportionment is detailed to the man/hour, and permits distribution of contribution across different projects and Responsibility Centers.

The information in the Manpower Deployment subsystem is initially used in the development of the budget. During a financial period it is used in the process of posting to the general ledger. The Manpower Reporting subsystem permits close monitoring of manpower utilization.

Memorandum Accounts

A Memorandum Account is a single-entry account reflecting a ledger entry, or the details thereof. MAS provides various accounts of this type.

MAS's Memorandum Accounts Processor permits rapid creation of such accounts. The Personal Accounts Memorandum Accounts subsystem is an example of such a facility, as is the Personal Services Memorandum Accounts subsystem. Using this facility, Summary Accounts may also be generated to accumulate the transactions in a number of detailed posting accounts in the General Ledger.

Stock Control

The primary use of the Stock Control subsystem is in the maintenance of the inventory at the Central and other stores. Stock movements are recorded instantaneously and updating the stock files is carried out automatically. Automatic notification of depletion of stock below a set level, as well as generation of purchase requests for stock items, are important components of the Stock Control subsystem.

Stocktaking is carried out partially or fully, at random or by design. A comprehensive report generator is included on all options together with self-generated reports for management.

Finally, MAS utilizes the libraries of software developed at ICARDA, notably ICALIB, ICAFIL, and MASLIB. It operates on PDP11/34A and VAX 11/780 computing systems under RSTS/E, RSX-11/M, and VMS operating systems, and requires a maximum of one million characters of disc-space storage. The size of its data files is proportional to the number of movements of accounts. Ten thousand movements require approximately five million characters of secondary storage. — *Khaled S. El-Bizri and Edward N. Sayegh (Finance).*

Reference

Dates C.J. 1980. An introduction to database system. Addison-Wesley, Reading, Mass., USA.

Communications and Documentation

Communications

The quantity and quality of publications produced by the department increased in 1984. The department staff developed working relationships with printers in Syria that enabled high quality color jobs to be done in our host country. Using in-house facilities, the department produced three issues of FABIS newsletter, one more than in previous years, and the first issue of a new Farming Systems Newsletter. The editorial and production quality of the three regular newsletters, FABIS, LENS, and RACHIS, were upgraded, with color covers on two of the newsletters for the first time. The FABIS/LENS Users' Workshop held at ICARDA commended the high quality of the newsletters.

For the first time, the Annual Report and Research Highlights were both issued in Arabic versions. Two issues of RACHIS Newsletter were translated into Arabic (to be published in 1985) with others to follow.

Other significant publications produced by the department included the workshop proceedings, germplasm catalogs, annotated bibliographies, and nursery reports.

Coverage of ICARDA in the regional and international media increased significantly over past years, with articles and broadcasts on ICARDA research in an array of magazines and newspapers and on the radio in various countries.

ICARDA's mailing list and publication distribution procedures were refined for faster and more efficient mailing.

A new science writer joined the department in 1984.

Documentation

A resident consultant for library and documentation now serves the department. The frequency of Current Awareness has increased and a Library Bulletin has been produced, the library's physical facilties were improved, and Arabic books and journals were added to the holdings.

A list of ICARDA scientists' publications, including the journal articles, was compiled.

The library now contains about 3000 books and nearly 300 journals. The emphasis in 1984 was on the purchase of journals going back to 1977.

A directory of faba bean and lentil scientists was compiled and will be published in 1985. The mailing list for Current Awareness was expanded. The library exchange list in the region and on global basis was expanded.

Documentation personnel attended the regional bookfairs and meetings with other documentalists in order to further ICARDA's documentation influence in the region.

Visitors' Services

During 1984, the Visitors' Services received and guided about 1200 visitors through the center. The visitors included scientists, government representatives, farmers, students, consultants, trainees, members of the Diplomatic Corps, and others from around the world. They came from 52 countries, and from more than 36 universities and 90 national, international, and private institutions.

The Guest of the Year was Mr. Tahir Obeid, the first Chairman of the ICARDA Board of Trustees. Mr. Obeid was Minister of Agriculture and Water in Saudi Arabia in the seventies, and helped to establish ICARDA through his distinguished accomplishments in the CGIAR.

During the year, 20 program events were held. ICARDA was honored by visits of the Minister of Agriculture and Agrarian Reform, Syria, the Governor of Aleppo Province, the Ambassadors of Japan, Saudi Arabia, The Netherlands, Turkey, India, and Australia in Syria, and the Australian Ambassador in Jordan.

Collaborative Projects with Advanced Institutions, 1984.

	Subject	Cooperating institution	Funding organization
1.	Replacement of fallow by forage crops	McGill University, Canada	CIDA
2.	Studies on rural labor	University of Western Canada, Canada	Population Council
3.	Root studies on barley and chickpeas	University of Reading, UK	ODA
4.	Phenology and productivity modelling in wheat	University of New England, Australia	UNDP
5.	Precipitation and temperature analysis	University of Reading, UK	ODA
6.	Nitrogen fertilizer efficiency using ^{15}N	International Fertilizer Development Center, USA	IFDC
7.	Nitrogen fixation studies using ^{15}N	International Atomic Energy Agency, Austria	IAEA
8.	Photothermal relations in barley, faba beans, and lentils	University of Reading, UK	ODA
9.	Collection and evaluation of barley and durum wheat germplasm	University of Saskatchewan, Canada	NSERC
10.	Cooperative project on salt tolerance of cereals	University of Munich, West Germany	GTZ
11.	Cereal, food legume, and forage quality evaluation	Canadian Grain Commision, Canada	
12.	Recurrent selection in barley, using male sterility	Montana State University, USA	
13.	Studies on nematodes affecting chickpeas, peas, and forage legumes in the Mediterranean	Institute of Nematology, Bari, Italy	CNR
14.	Resistance to bruchids in faba beans	University of Reading, UK	FF
15.	Faba bean adaptation studies	European Economic Community, Belgium	EEC
16.	Faba bean breeding methodology studies	University of Manitoba, Canada	IFAD/NVP
17.	Interspecific crossing	University of Reading, UK	ODA
18.	Studies on the resistance of faba beans to *Botrytis fabae*	Plant Breeding Institute, Cambridge, UK	
19.	Studies on ascochyta blight of faba beans	University of Manitoba, Canada	IDRC

Subject	Cooperating institution	Funding organization
20. Physiologic variation in *Ascochyta rabiei*	University of Reading, UK	ODA
21. Phosphate and iron use efficiency in chickpeas and lentils	University of Hohenheim, West Germany	GTZ
22. Measurement of out-crossing in lentil	University College of Swansea, UK	
23. Screening for cold tolerance in lentils	University of Perugia, Italy	CNR
24. Ecogeographic survey and collection of natural populations of forage legumes	International Board for Plant Genetic Resources	IBPGR
25. Nutritive value of hays and straws	Tropical Development and Research Institute, UK	ODA
26. Durum wheat yield physiology	Institut fur Pflanzenzuchtung, Saatgutforschung, und Populations-Genetik, Universitat Hohenheim, Stuttgart, West Germany,	Vater und Sohn Eiselen Stiftung
27. Performance and interaction of wheat and rye genomes in triticale	Institut fur Pflanzenbau und Pflanzenzuchtung, Gottingen, West Germany	GTZ
28. Response of barley and durum wheat to varying water supply	Birkbeck College, University of London, UK	ODA
29. Metabolic index of stress	Birkbeck College, University of London, UK	ODA
30. Use of triticale grain for poultry feed	University of Aleppo, Syria	ICARDA/Univ. of Aleppo
31. Incidence and significance of cereal root diseases in northern Syria, and their control by crop rotation	University of Bonn, West Germany	GTZ
32. Resistance to *Orobanche* spp. in *Vicia faba*	Royal Tropical Research Institute, Amsterdam, The Netherlands	EEC
33. Evaluation of independent vascular supply in *V. faba*	University of Durham, UK	EEC
34 Marginal-land improvement	University of Perugia, Italy	Italy

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* Left ICARDA during 1984.

Published by the International Center for
Agricultural Research in the Dry Areas (ICARDA)
P.O. Box 5466, Aleppo, Syria

Printed at ICARDA, Aleppo

AR-7/3000/1985