ICARDA Annual Report 1985

ICARDA
Annual Report
1985

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
Telephone: 213433; 213477; 235220; 234890

DAMASCUS OFFICE
Hamed Sultan Bldg., First Floor
Abdul Kader Ghazali Str.,
Abu Roummaneh (Next to Al-Malki Circle)
P.O. Box 5908
Damascus, Syria
Tlx 412924 ICARDA SY
Tel 420482, 420483, 331455

CAIRO OFFICE
15 G, Radwan Ibn El-Tabib Str.,
11th Floor, Giza,
P.O. Box 2416
Cairo, Egypt
Tlx 091-21741 ICARD UN
Tel 728099, 723564, 724358

BEIRUT OFFICE
Dalia Bldg., 2nd Floor,
Rue Bashir El-Kassar,
P.O. Box 114/5055
Beirut, Lebanon
Tlx 22509 LE
Tel 813303, 804071

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 ICARDA TN
Tel 230225

AMMAN OFFICE
Faculty of Agriculture,
Jordan University,
P.O. Box 5008
Amman, Jordan
Tlx 21629 UNVJ JO
Tel 843555 Extension 2579

QUETTA OFFICE
c/o Arid Zone Research Institute,
Pakistan Agriculture Res. Council,
P.O. Box 362
Quetta, Pakistan
Tlx 7836 CTO QT PK
Tel 73248

ISSN 0254-8313

Correct citation: ICARDA (International Center for Agricultural Research in the Dry Areas). 1986. Annual Report 1985. Aleppo, Syria.

Contents

Statement of Objectives

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

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

a. To serve as an international center for research into and for the improvement of barley, lentils, and faba beans (*Vicia faba*) and such other crops as may be designated by the Board of Trustees in consultation with the Consultative Group on International Agricultural Research (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 $ (x000)

Core Operations (1985)

Unrestricted and Capital

Australia	422
Canada	662
China	50
Denmark	97
Ford Foundation	175
Germany	668
IBRD (World Bank)	5,250
Italy	348
The Netherlands	343
Norway	283
Saudi Arabia	600
Spain	100
Sweden	364
United Kingdom	622
USAID	5,300

Restricted and Capital

Arab Fund	343
France	127
IDRC	
- Food Legumes (N. Africa)	132
- Farming Systems (Tunisia)	117
IFAD	
- Buildings	500
Italy	
- Buildings (GRU)	313
- Forage	240
- Durum Wheat	174
OPEC	
- Barley Improvement	162
- *Buildings*	*596*
UNDP	
- SWAN	200
USAID	
- Barley Diseases	160

Special Projects (1985)

BMZ/The Netherlands	
- Seed Production Organization	91
Ford Foundation	
- Farming Systems	75
- Factor Constraints	125
IDRC-Manitoba	
- Faba Bean Pathology	105
- Lentil Harvest Mechanization	50
- Lentil Haploid Culture	24
- Arabic Dimension Services	20
- Faba Bean Insect Pollination	13
- Survey of Forages	10
IFAD	
- Nile Valley Special Project	1,000
OPEC	
- Improved Wheat Technology/Sudan	49
USAID/AZRI	
- Baluchistan/Pakistan	492
- Cereals/Jordan	45

Arab Fund: Arab Fund for Economic and Social Development
IDRC: International Development Research Centre, Canada
IFAD: International Fund for Agricultural Development
UNDP: United Nations Development Programme
USAID: United States Agency for International Development

Board of Trustees

Acronyms and Abbreviations

ABYT	Advanced Barley Yield Trials
ACSAD	Arab Center for Studies of the Arid Zones and Dry Lands
ADYT	Advanced Durum Yield Trials
AGRIS	Agricultural Research Information System (United Nations)
AOAD	Arab Organization for Agricultural Development
ARC	Agricultural Research Center (Syrian Ministry of Agriculture and Agrarian Reform)
ARARI	Aegean Regional Agricultural Research Institute
AUB	American University of Beirut (Lebanon)
AZRI	Arid Zones Research Institute
BAREQ	Barley Grain Value Equivalent
BON	Barley Observation Nursery
CBN	Common Bunt Nursery
CIAT	Centro Internacional de Agricultura Tropical
CIDA	Canadian International Development Agency
CIMMYT	International Maize and Wheat Improvement Center (Mexico)
CP	Cereal Improvement Program
CIYT	Chickpea International Yield Trial
CNR	Consiglio Nazionale della Ricerche (National Research Council-Italy)
CRISP	Crop Research Integrated Statistical Package
DCB	Durum Crossing Block
DCH	Durum Crossing Block-High Altitude
DKL	Durum Key Location Disease Nursery
DOH	Durum Observation Nursery-High Altitude
DON	Durum Observation Nursery
DON-Rf	Durum Observation Nursery-Rainfed
DPD	Durum Preliminary Disease Nursery
DSR	Durum Stem Rust Nursery
DST	Durum Septoria Nursery
EEC	European Economic Community
ELISA	Enzyme-Linked Immunosorbent Assay

ENEA	European Nuclear Energy Agency
FAO	Food and Agriculture Organization
FBIABN	Faba Bean International Ascochyta Blight Nursery
FBICSN	Faba Bean International Chocolate Spot Nursery
FBIRN	Faba Bean International Rust Nursery
FBIYT-S	Faba Bean International Yield Trial--Small-seeded
FFVT	Farmers Field Verification Trial
FLIP	Food Legume Improvement Program
FSP	Farming Systems Program
FSR	Farming Systems Research
GRU	Genetic Resources Unit
GTZ	German Agency for Technical Cooperation
HI	Harvest Index
IBPGR	International Board for Plant Genetic Resources
IBSNAT	International Benchmark Soils Network for Agrotechnology Transfer
IBON	International Barley Observation Nursery
ICRISAT	International Crops Research Institute for the Semi Arid Tropics
IDRC	International Development Research Center
IFAD	International Fund for Agricultural Development
INA-PG	Institut National Agronomique--Paris Grignon
INAT	Institut National Agronomique de Tunisie
INRA	Institut National de le Recherche Agronomique
INRAT	Institut National de la Recherche Agronomique (Tunisie)
IPO	Research Institute for Plant Protection
IWWPN	International Winter Wheat Performance Nursery
IYT	International Yield Trial
KLDN	Key Location Disease Nursery
NARC	National Agriculture Research Council
ODA	Overseas Development Administration of the UK
OPEC	Organization of Petroleum Exporting Countries

ORSTOM	Office de la Recherche Scientifique et Technique d'Outre-Mer
PARC	Pakistan Agriculture Research Council
PBYT	Preliminary Barley Yield Trials
PFLP	Pasture, Forage and Livestock Improvement Program
PYT	Preliminary Yield Trial
RBYT	Regional Barley Yield Trial
RDYT-LR	Regional Durum Wheat Yield Trials--Low Rainfall
RDYT-MR	Regional Durum Wheat Yield Trials--Moderate Rainfall
RYT	Regional Yield Trial
SABRAO	Society for Advancement of Breeding Researches in Asia and Oceania
SAR	Syrian Arab Republic
SHL	Seed Health Laboratory
TADD	Tangential Abrasive Dehulling Device
USAID	United States Agency for International Development
USDA	United States Dept. of Agriculture
WCB	Wheat Crossing Block
WCH	Bread Wheat Crossing Block--High Altitude
WKL	Wheat Key Location Disease Nursery
WOH	Bread Wheat Observation Nursery--High Altitute
WON	Bread Wheat Observation Nursery
WPD	Wheat Preliminary Disease Nursery
WRYT, RWYT	Wheat Regional Yield Trial
WSP	Wilt-Sick Plot
WST	Wheat Septoria Nursery

INTRODUCTION

In the region that ICARDA seeks to serve, the summers are invariably hot and devoid of rain. So, except in those areas where irrigation is available, farmers must plant their crops in winter and take advantage of the precipitation that falls only in that season of the year. To grow crops in winter, in a region largely subjected to a continental climate, is hazardous at best, and it was exceptionally so in 1984/85.

Late in the growing season, during February and March, there was a severe frost, which lasted 19 days at the sites where most of ICARDA's experiments are carried out. Temperatures fell to -9.5°C at the main station at Tel Hadya and to -10.2°C at Jindiress: similar conditions were experienced at Breda and Khanasser. Meteorological statistics suggest that such a severe frost, so late in the season, is likely to occur only twice in a century. After the frost, there was a long spell that was both hot and dry. Rainfall, which had been above average at the start of the season, was below average for the remainder of it. The crops were severely damaged, and yields were well below expectations.

Such conditions are disastrous for farmers, but they can be a blessing for scientists. For eight years, ICARDA has been screening cultivars and breeding for tolerance of frost and drought. The winter of 1984/85 showed us how the germplasm responds when subjected to both of these stresses in the same season. Of all the cultivars that we planted, we found out which showed tolerance and which did not. The data from this growing season are of great value for our breeding programs and will enable us to recommend cultivars that have demonstrated a capacity to survive and to yield.

Barley is one of the most important crops in this region, and ICARDA places emphasis on the development of cultivars for use in areas with less than 300 mm of annual rainfall. Advanced breeding techniques were used to hasten the stabilization of desired characteristics, especially stress tolerance, and to gain access to the variability available in landraces and in barley's wild relative, *Hordeum spontaneum*. This research also seeks to comprehend the physiological factors that influence a plant's ability to resist different types of stress.

As in the past, ICARDA's cultivars were extensively used by national programs in 1984/85. Three new barley varieties were released in Tunisia and two durum wheat varieties in Algeria. From the food legume material, a lentil variety was released in Ethiopia, and a chickpea variety in Cyprus.

Cereal material from ICARDA was extensively used in our host country, Syria, for on-farm testing, seed multiplication, and possible release: it was similarly used in Algeria, Chile, China, Cyprus, Ecuador, Egypt, Iran, Iraq, Jordan, Lebanon, Libya, Mexico, Morocco, Pakistan, Portugal, Spain, Sudan, Thailand, Tunisia, and Turkey. In food legumes, on-farm trials with lentils, faba beans, and chickpeas were started in Syria; with chickpeas and lentils in Turkey; with chickpeas in Egypt and Morocco; and with lentils in Pakistan.

Lentil production has fallen in West Asia because of the high cost of harvesting by hand. In 1984/85, ICARDA successfully developed a mechanical harvester for lentils. The effectiveness of this machine at the research station is leading the Syrian national program to test its performance on farmers' fields in the 1984/85 season.

Evidence is accumulating that farmers can increase their profits by up to 75% by growing a forage legume in place of fallow after a barley crop. The forage legume can either be grazed, or harvested and stored for winter feed, and it allows sheep flocks to be increased by as much as 100%.

A survey in western Syria permitted ICARDA scientists to identify the medic species that occur naturally. One of these, *Medicago rigidula*, which is tolerant of frost, has been studied in pasture/cereal rotations managed by farmers at the village of Tah, near Aleppo. The land proves to be as profitable in the pasture year as it is in the cereal year, and enough of the medic seeds survive the cereal year so that the land does not need to be re-seeded to establish the pasture again.

Vetches are also interesting for use in rotation with cereals, and work was concentrated on selection and breeding. Some vetches have been identified that are resistant to root-knot nematode, to several foliar diseases, and to frost, yet they also produce a large yield of herbage and seed.

Previous research at ICARDA had shown that, when fertilizer is applied to barley, more of the available moisture is taken up by the plant and less is lost by evaporation from the soil. The better water-use efficiency leads to higher yields without calling for irrigation. In a cooperative project, ICARDA and the Soils Directorate of the government of Syria have now carried out trials fertilizing barley on farmers' fields in the northern areas of the country. These show that fertilizer, particularly phosphorus, increases profits as well as yields, and also reduces the variability of yields. As the government is offering comprehensive agricultural credit to farmers in the dry areas, there are good prospects that they will adopt the practice, once it has been demonstrated to them by the Syrian agricultural extension services.

In an average year, Syria imports barley to make up for low domestic production but, if only one quarter of the observed yield increase could be realized nation-wide, those imports would no longer be needed. Meanwhile, ICARDA continues the studies to "fine tune" its understanding of how barley responds to fertilizer: under different environmental conditions, in different crop rotations, and using various methods of placement.

Phosphorus may also be the key to improving the productivity of vast areas of marginal land that are used only for grazing. Studies have shown that the phosphorus increases plant growth to a degree that may make it profitable for livestock farmers to apply this fertilizer.

An extensive survey of wheat producers in northwestern Syria has shown that farmers base their practices, particularly with regard to fertilizer, on a careful assessment of the environment as determined by the rainfall during the season, the previous crop on the same land, and the type of soil. Thus, as improved management practices are developed, there are good prospects that the farmers will have the means to apply them.

The extreme variability of the climate in this region applies, not only from season to season, but also from place to place. Areas that are only a few kilometers from each other may experience markedly different weather in the same year. Rain and frost are often quite local phenomena and, when this is coupled with variations in soil and slope, we must acknowledge the fact that we are working under a great diversity of agroecological conditions. Cultivars and farming practices that are effective in one area may be quite unsuitable in an adjacent area.

As ICARDA further enhances its understanding of the region, it can characterize zones according to their agroecological conditions and tailor its recommendations to suit the environment of each. For example, we should be able to recommend one cultivar for a zone that is likely to suffer a prolonged drought following rain early in the season, and perhaps a quite different cultivar where there are likely to be late-season rains to promote the development of foliar diseases.

It is most unlikely that a given cultivar will ever be the best everywhere in the region, and breeders must target their development programs to particular sets of conditions. Equally, agronomists must do the same as they seek to find more effective farming systems.

However, even after homogeneous zones have been identified and research has been directed to meet the particular conditions of each of them, we are still left with an immense season-to-season variability within any one zone. Hence, much of the work of ICARDA is still focused on the maintenance of yields from season to season at the same place. The techniques available include:

- the introduction of legume crops in rotation with cereals
- more effective tillage to conserve and manage soil moisture
- irrigation with a limited amount of water to supplement inadequate rainfall.

- the management of phosphorus fertilizer, particularly to reduce its fixation in calcareous soils.

Such developments, however, require a thorough understanding and quantitative analysis of environmental variability and its effect on crops. ICARDA carries out statistical analysis of field experiments and climatic data, and it has also constructed a computer model that simulates plant growth under a range of different environmental conditions, genetic characteristics, and management practices.

It is evident, especially if research is to be targeted for particular agroclimatic environments, that an international center must work in very close cooperation with national institutions. Indeed, those national institutions are the quintessential players in any sustained effort to increase food production. ICARDA seeks always to enhance the role of national institutions, not only as partners in experiments, but as executors of the programs that will ensure that the results of research find application in farmers' fields.

In 1985, ICARDA strengthened its links with national programs, particularly in Ethiopia, Iran, Iraq, Jordan, Morocco, Tunisia, and Turkey. Details will be found elsewhere in this report, and I flag here only three of the more significant developments:

- The Nile Valley Project is entering a new phase. Ethiopia has now joined the original partners, Egypt and Sudan. All the participating countries have been impressed by the techniques that have been developed to increase the production of faba beans, and they continue to expand the area in which these techniques are applied. Together, they have asked ICARDA and CIMMYT to establish a new project, based on the same methodology, to improve their production of wheat and barley.
- The Quetta Project in Pakistan, financed by USAID, made a good start by successfully carrying out the plantings for the 1984/85 season. The project had a busy year: there was a farming-systems workshop, a meeting on chickpea breeding, an expedition to collect food legumes, and the continuation of the high-altitude cereal and legume research.
- A series of collaborative projects between ICARDA and Syria is under way–the most important being the joint on-farm trials. Farmers, scientists, and Ministry officials attended several field days and there were travelling workshops dealing with cereals and food legumes.

In keeping with the CGIAR philosophy, ICARDA is encouraging those national programs with which there has been collaboration for some years, to assume increased responsibilities. There is now a much greater involvement of national programs in the testing and evaluation of cereal and food legume material and in on-farm trials of elite cultivars. Knowing the agroclimatic conditions of some of the countries in the ICARDA region over several years, ICARDA has started offering "methodology designs" to these countries to test on their own, rather than at ICARDA headquarters. The strategy is that ICARDA gradually transfers the adaptive research to national programs and moves "upstream" by concentrating on innovative and applied research.

The other "threads" of the network with national programs are: the international nursery system, exchange of germplasm, visits by scientists, exchange of publications, workshops and seminars, and training. ICARDA sees training as one of the most important components of the network. In 1984/85, ICARDA organized three long-term residential training courses at Aleppo. Additionally, there were six short courses: two at headquarters, two in Morocco, one in Pakistan, and one in Syria. A total of 225 individuals participated in these and other more intensive individual training programs; this figure compares with 203 in 1984, and 128 in 1983.

ICARDA also collaborates with many advanced research centers in developed countries. Again, these activities are detailed in the main body of this report and, here, I will mention only the new project which, with the support of USAID, brings Montana State University into cooperation with ICARDA and the national programs. The project is aimed at developing high-yielding barley cultivars with broad-based resistance to major diseases.

A seed-production program has been established at ICARDA, and this will develop activities in research, production, and training. Indeed, the first training course was held in September 1985.

The genetic resources unit at ICARDA, as in past years, provided a useful service to researchers at the Center as well as to those in national programs. Germplasm collections were made in Egypt, Turkey, and Pakistan, and a greater effort was devoted to the evaluation, documentation, and conservation of items already in the collection. The unit distributed 15026 accessions of 20 crops to 24 countries. A virology laboratory was established and a preliminary survey was conducted to identify the principal viral diseases of food legumes and cereals in four countries of the region.

The advances made in agricultural research have brought the state of the art to an important turning-point. The resources of the earth, particularly soil and water, are finite but the demands on their use are increasing at an alarming rate. More than ever, it is realized that the degradation of the environment and the depletion of resources must be arrested if the goal of a sustainable agriculture is to be achieved.

ICARDA actively seeks to re-direct its objectives and its work, and to ensure that it will become a true center of excellence in soil and water conservation.

The completion of ICARDA's new buildings at Tel Hadya has been delayed. We now hope that these buildings will be ready by early 1987, and that their inauguration will coincide with ICARDA's 10th anniversary. In spite of our current limited laboratory and office facilities, ICARDA staff have continued to work with a deep sense of commitment to the objectives of the Center, and the progress reported here bears ample testimony. Above all, we are deeply indebted to our donors for their generous financial and moral support. Our donors have been the moving force behind our successes, and with them we share the credit for what ICARDA is today.

It is with gratitude and pleasure that I acknowledge the continuing whole-hearted cooperation of our host country, the Syrian Arab Republic: of the government for the attention and support it provides, and of the people of Aleppo who have always demonstrated a warm hospitality to the strangers in their midst.

I sincerely hope that all those concerned with improving agricultural production in the dry areas will find this Annual Report useful.

Mohamed A. Nour
Director General

The Weather During the 1984/85 Season

The outstanding meteorological event of the 1984/85 season was a prolonged period of severe frost unusually late in the season. Between 21 February and 12 March, Tel Hadya experienced 19 days of continuous frost, which was broken only by one day when the temperature did not drop below zero. The lowest temperature, -9.5°C, occurred as late as 3 March. The conditions at Jindiress, Breda, and Khanasser were very similar during this cold spell, the temperature at Jindiress falling to -10.2°C (Table 1). It is difficult to predict the probability of such an extreme condition since no such event is evident in the 25 years of temperature records available. It is unlikely that such a spell of severe frost so late in the season would occur more often than once in 50 years. Due to the occurrence of frost at such a late date, crop damage was considerable and often severe, especially to legumes.

In contrast to winter temperatures, which were lower than average, the summer of 1985 was long and hot. At Tel Hadya temperatures stayed close to 40°C from the end of July until the end of August with only few intermissions (Tables 2-5).

The moisture supply during the 1984/85 season was far better than in 1983/84. Total rainfall surpassed the long-term average at Tel Hadya and almost reached it at Breda. At Khanasser and Jindiress the totals were below the long-term average, the Jindiress total being almost as far below the mean as in 1983/84 (Table 6). Rainfall distribution was far from optimal but had compensating features. October, November, January, and, except at Khanasser, February were much wetter than average, so there was good crop development before the very cold spell started in February. From March onwards, the rainfall was much less than is normal for the end of the season. At Tel Hadya, total rainfall until the end of February was 143% of the long-term average, and at Breda 115%, but in the remainder of the season rainfall was only 38 and 61% of normal at these two sites.

Table 1. Frost events at some ICARDA research sites, 1980-85.

	1980/ 81	1981/ 82	1982/ 83	1983/ 84	1984/ 85	Mean
Khanasser	47	47	66	31	63	51
	-7.5	-7.0	-9.3	-7.0	-9.1	
Breda	37	40	62	32	43	43
	-6.5	-8.0	-9.8	-5.0	-9.6	
Tel Hadya	23	39	52	27	42	37
	-4.0	-7.8	-9.8	-4.1	-9.5	
Jindiress	19	39	51	20	38	33
	-4.0	-7.0	-8.5	-2.3	-10.2	

In each set of data, the upper row represents the number of frost days and the lower row, the absolute minimum temperature (oC).

However, because the early rains were heavy, soil moisture recharge at the end of February/early March was excellent at all sites. At Jindiress the profile was fully wetted to 2 m and some drainage occurred below that depth. This level of stored soil moisture at all sites provided some buffering against the dry conditions in March, April, and May. However, the inadequate rain at the end of the season, coupled with the damage caused by frost, resulted in mediocre crop yields in the 1984/85 season.

Table 2. Summary of monthly climatic data, Tel Hadya, 1984/85 season.

Month	Max. temp. (°C)	Min. temp. (°C)	Avr. temp. (°C)	Max. RH (%)	Min. RH (%)	Sol. rad. (MJ/m^2)	Wind run (km/d)	Evap. (mm)	Rain (mm)	No. of rainy days
SEPTEMBER										
Mean or total	34.6	17.2	25.9	72	22	21.8	332	10.9	0	0
Abs. max.	37.8	20.8	28.0	88	38	24.1	581	15.7		
Abs. min.	31.6	13.6	22.7	37	12	19.1	111	6.5		
OCTOBER										
Mean or total	28.0	10.1	19.1	63	22	15.4	169	6.0	28.2	4
Abs. max.	36.4	17.2	26.5	100	70	19.7	363	9.9	23.0	
Abs. min.	17.5	2.0	10.3	23	9	3.9	82	1.5		
NOVEMBER										
Mean or total	15.6	8.3	12.0	94	62	8.4	151	1.7	98.0	15
Abs. max.	20.8	13.5	16.4	100	93	13.4	285	4.0	30.0	
Abs. min.	9.0	-1.1	6.0	86	22	2.5	45	0.2		
DECEMBER										
Mean or total	10.7	0.0	5.3	92	49	8.6	156	1.2	22.0	10
Abs. max.	15.0	6.8	8.6	100	97	12.6	409	3.0	7.2	
Abs. min.	4.4	-6.0	2.5	63	18	2.5	23	0.2		
JANUARY										
Mean or total	11.3	3.9	7.6	96	67	6.8	145	1.2	126.3	16
Abs. max.	16.4	8.6	12.5	100	98	13.0	294	2.4	45.4	
Abs. min.	4.7	-0.8	2.9	79	30	1.8	21	0.5		
FEBRUARY										
Mean or total	9.6	1.6	5.6	87	49	10.5	287	2.3	61.3	14
Abs. max.	20.1	9.2	11.3	100	91	18.5	735	6.4	14.8	
Abs. min.	1.9	-6.8	-1.2	45	17	3.6	58	0.4		
MARCH										
Mean or total	16.9	2.1	9.5	75	28	17.9	244	4.4	24.1	6
Abs. max.	23.4	12.2	17.6	100	56	21.7	503	7.0	11.7	
Abs. min.	5.4	-9.5	-1.4	48	12	10.3	80	1.5		

APRIL										
Mean or total	24.0	8.7	16.3	88	31	21.6	288	6.7	9.6	4
Abs. max.	31.2	13.4	20.5	100	70	26.7	574	10.0	7.6	
Abs. min.	14.8	2.0	10.6	55	13	10.2	124	1.4		
MAY										
Mean or total	30.9	14.3	22.6	80	26	24.7	310	9.7	3.1	3
Abs. max.	35.6	19.6	26.7	98	38	29.1	703	14.0	2.2	
Abs. min.	23.4	5.0	16.5	43	13	13.4	117	4.3		
JUNE										
Mean or total	34.0	17.6	25.8	69	23	28.9	475	14.7	0	0
Abs. max.	39.3	20.7	28.7	87	40	31.6	704	19.0		
Abs. min.	28.9	14.0	22.2	40	0	19.8	217	9.9		
JULY										
Mean or total	36.4	19.8	28.1	67	20	28.6	486	16.1	0	0
Abs. max.	40.4	22.4	31.2	90	36	29.9	800	19.3		
Abs. min.	33.0	15.6	25.2	37	8	25.6	138	11.8		
AUGUST										
Mean or total	39.8	21.3	30.5	66	20	25.0	371	14.6	0	0
Abs. max.	44.8	26.1	34.4	91	38	28.0	719	17.7		
Abs. min.	34.0	16.8	27.4	29	9	21.9	135	11.5		
Mean or total	24.4	10.4	17.4	79	35	18.2	284	7.5	373	72
Abs. max.	44.8	26.1	34.4	100	98	31.6	800	19.3	45.4	
Abs. min.	1.9	-9.5	-1.4	23	0	1.8	21	0.2		

Table 3. *Summary of monthly climatic data, Jindiress, 1984/85 season.*

Month	Max. temp. (°C)	Min. temp. (°C)	Avr. temp. (°C)	Max. *RH* (%)	Min. *RH* (%)	Sol. *rad.* (MJ/m^2)	Wind *run* (km/d)	Evap. (mm)	Rain (mm)	No. of rainy days
SEPTEMBER										
Mean or total	33.8	18.6	26.2	75	26	22.5	281	10.4	0	0
Abs. max.	40.0	21.3	28.5	84	40	27.6	473	19.5		
Abs. min.	32.0	14.0	23.5	42	9	19.9	116	5.3		
OCTOBER										
Mean or total	28.5	11.7	20.1	62	21	15.8	152	6.1	26.4	3
Abs. max.	37.0	18.0	27.5	82	61	20.4	318	11.1	25.2	
Abs. min.	17.0	2.5	9.8	26	5	4.9	93	2.7		
NOVEMBER										
Mean or total	16.2	7.9	12.1	87	58	8.3	156	2.1	82.4	15
Abs. max.	21.0	14.0	17.5	90	85	15.7	322	6.2	15.0	
Abs. min.	9.0	-1.0	6.0	68	22	2.8	80	0.4		

DECEMBER										
Mean or total	11.4	0.3	5.9	82	41	8.7	182	1.7	44.4	7
Abs. max.	15.5	6.0	9.0	89	72	13.1	437	3.7	14.0	
Abs. min.	6.0	-5.0	2.9	47	11	2.4	68	0.7		
JANUARY										
Mean or total	11.7	4.6	8.1	85	57	6.7	163	1.7	102.0	16
Abs. max.	16.0	8.9	11.6	89	78	13.6	362	5.1	19.0	
Abs. min.	4.3	-0.8	2.7	72	28	1.2	64	0.1		
FEBRUARY										
Mean or total	8.8	0.0	4.4	83	46	10.3	246	2.3	108.0	13
Abs. max.	17.8	6.5	10.4	90	77	21.2	647	6.4	36.5	
Abs. min.	1.0	-8.5	-2.0	57	14	2.6	93	0.1		
MARCH										
Mean or total	16.6	2.8	9.7	68	30	17.9	225	4.8	30.3	7
Abs. max.	22.9	11.0	16.0	92	70	25.3	505	11.7	15.2	
Abs. min.	4.4	-10.2	-2.6	32	13	9.6	135	1.9		
APRIL										
Mean or total	22.7	8.8	15.7	86	35	23.2	257	6.0	5.6	2
Abs. max.	32.0	12.6	20.5	93	62	28.3	453	14.1	4.4	
Abs. min.	15.2	4.0	10.8	62	14	14.3	132	0.9		
MAY										
Mean or total	29.9	13.5	21.7	84	27	26.0	228	6.7	8.8	3
Abs. max.	35.0	19.2	25.6	93	60	38.2	451	11.1	3.6	
Abs. min.	23.0	7.0	16.2	63	10	8.8	51	1.0		
JUNE										
Mean or total	32.5	17.6	25.0	74	23	29.8	380	11.7	0	0
Abs. max.	37.3	21.3	28.1	88	38	33.5	547	15.6		
Abs. min.	29.0	14.0	22.4	42	7	25.5	124	6.2		
JULY										
Mean or total	34.5	19.5	27.0	71	22	29.6	385	12.5	0	0
Abs. max.	38.9	22.2	29.1	84	42	35.8	629	17.7		
Abs. min.	30.9	16.8	24.7	40	9	25.1	144	8.0		
AUGUST										
Mean or total	37.3	21.3	29.3	72	24	26.7	318	14.6	0	0
Abs. max.	44.0	26.0	33.7	83	40	31.8	607	23.9		
Abs. min.	32.0	17.5	26.2	29	6	24.7	140	9.9		
Mean or total	23.7	10.6	17.2	77	34	18.9	247	6.7	409	66
Abs. max.	44.0	26.0	33.7	93	85	38.2	647	23.9	36.5	
Abs. min.	1.0	-10.2	-2.6	26	5	1.2	51	0.1		

Table 4. Summary of monthly climatic data, Breda, 1984/85 season.

Month	Max. temp. (°C)	Min. temp. (°C)	Avr. temp. (°C)	Max. RH (%)	Min. RH (%)	Sol. rad. (MJ/m^2)	Wind run (km/d)	Evap. (mm)	Rain (mm)	No. of rainy days
SEPTEMBER										
Mean or total	33.4	14.0	23.7	66	17	22.3	249	11.4	0	0
Abs. max.	37.0	17.5	26.0	82	29	24.9	382	15.9		
Abs. min.	29.0	11.5	20.3	31	6	19.7	111	8.0		
OCTOBER										
Mean or total	26.5	7.9	17.2	57	16	16.4	162	6.1	23.2	2
Abs. max.	35.5	16.0	25.5	87	67	19.5	370	11.5	19.2	
Abs. min.	15.0	-0.2	8.5	20	5	3.7	91	1.4		
NOVEMBER										
Mean or total	15.8	7.8	11.8	92	57	8.6	191	1.9	37.0	6
Abs. max.	22.2	13.0	16.5	96	86	13.8	375	4.2	12.6	
Abs. min.	9.0	0.0	6.0	85	26	2.2	74	0.2		
DECEMBER										
Mean or total	9.4	-0.4	4.5	91	55	8.4	192	1.5	16.8	9
Abs. max.	13.7	5.0	7.9	99	97	12.5	591	4.4	4.2	
Abs. min.	5.0	-5.5	0.5	58	16	2.6	50	0.4		
JANUARY										
Mean or total	10.8	4.1	7.4	94	63	7.1	165	1.2	87.4	13
Abs. max.	15.6	9.0	12.3	100	94	12.4	376	4.2	25.4	
Abs. min.	4.7	-2.8	3.4	74	7	1.8	52	0.0		
FEBRUARY										
Mean or total	9.4	1.0	5.2	88	49	10.5	279	2.4	57.8	8
Abs. max.	20.0	7.8	11.4	99	85	19.2	749	7.2	19.0	
Abs. min.	0.5	-8.1	-1.7	45	19	3.9	110	0.4		
MARCH										
Mean or total	17.0	3.0	10.0	74	29	18.7	237	4.4	18.4	4
Abs. max.	24.2	14.3	18.4	100	44	24.0	516	8.0	9.0	
Abs. min.	4.8	-9.6	-1.9	42	17	9.5	88	2.7		
APRIL										
Mean or total	24.6	8.5	16.5	94	32	23.3	196	6.1	27.6	3
Abs. max.	31.8	15.0	20.5	100	69	29.2	341	9.7	23.6	
Abs. min.	16.3	2.9	11.8	74	12	7.1	96	1.8		

MAY										
Mean or total	31.0	13.2	22.1	86	22	26.3	226	10.2	8.4	3
Abs. max.	36.0	20.2	27.4	100	41	33.4	470	15.9	3.2	
Abs. min.	23.0	4.0	14.4	64	6	15.1	100	4.4		
JUNE										
Mean or total	34.3	16.2	25.3	73	19	31.0	331	14.1	0	0
Abs. max.	39.0	20.8	28.8	95	38	33.4	533	17.7		
Abs. min.	29.0	12.0	21.4	43	8	23.4	150	10.6		
JULY										
Mean or total	36.2	17.9	27.1	74	19	29.7	353	15.7	0	0
Abs. max.	39.9	21.5	30.7	95	43	31.5	604	18.6		
Abs. min.	32.6	13.4	23.7	37	9	27.4	161	12.4		
AUGUST										
Mean or total	38.5	19.6	29.0	68	17	25.9	304	15.6	0	0
Abs. max.	43.3	25.5	33.4	95	33	27.6	562	21.2		
Abs. min.	31.9	14.0	24.7	28	7	21.1	132	12.4		
Mean or total	24.0	9.4	16.7	80	33	19.0	240	7.6	277.0	48
Abs. max.	43.3	25.5	33.4	100	97	33.4	749	21.2	25.4	
Abs. min.	0.5	-9.6	-1.9	20	5	1.8	50	0.0		

Table 5. Summary of monthly climatic data, Khanasser, 1984/85 season.

Month	Max. temp. (°C)	Min. temp. (°C)	Avr. temp. (°C)	Max. RH (%)	Min. RH (%)	Sol. rad. (MJ/m^2)	Wind run (km/d)	Evap. (mm)	Rain (mm)	No. of rainy days
SEPTEMBER										
Mean or total	34.4	14.9	24.6	54	12	25.9	301	14.5	0	0
Abs. max.	37.5	20.0	27.5	72	21	28.5	495	19.5		
Abs. min.	30.0	11.8	21.7	22	6	23.0	126	9.7		
OCTOBER										
Mean or total	26.3	7.9	17.1	52	16	19.4	167	7.6	16.4	3
Abs. max.	36.0	15.0	25.2	84	60	22.9	373	14.1	11.0	
Abs. min.	15.0	-2.0	7.5	15	4	6.7	64	0.9		
NOVEMBER										
Mean or total	15.9	7.2	11.5	94	57	12.8	178	2.2	46.6	14
Abs. max.	22.0	12.0	16.5	99	89	17.4	353	4.6	14.2	
Abs. min.	9.0	0.0	5.6	82	24	3.5	46	0.4		

DECEMBER										
Mean or total	8.6	-1.9	3.4	97	57	12.4	173	1.2	13.0	8
Abs. max.	12.2	3.0	7.6	100	93	15.6	472	3.5	6.0	
Abs. min.	4.8	-5.6	0.6	78	20	6.4	10	0.2		
JANUARY										
Mean or total	9.7	1.9	5.8	95	60	11.8	172	1.1	58.0	22
Abs. max.	15.0	8.0	10.4	100	89	17.1	359	2.8	14.2	
Abs. min.	3.1	-4.0	0.8	80	34	5.2	33	0.1		
FEBRUARY										
Mean or total	10.2	1.5	5.8	93	45	14.6	297	2.5	35.6	8
Abs. max.	20.0	6.5	11.3	100	79	22.3	722	8.8	14.6	
Abs. min.	0.9	-5.0	-1.4	62	16	8.0	114	0.4		
MARCH										
Mean or total	16.6	1.7	9.1	82	23	22.0	255	5.2	8.6	3
Abs. max.	23.5	12.0	16.9	100	38	26.5	459	9.7	3.6	
Abs. min.	4.2	-9.1	-2.5	38	9	14.4	92	3.3		
APRIL										
Mean or total	25.0	7.4	16.2	77	24	25.8	257	8.6	9.2	4
Abs. max.	33.2	14.0	20.8	100	68	30.4	515	14.2	3.2	
Abs. min.	15.0	1.6	10.5	55	9	11.2	92	1.4		
MAY										
Mean or total	32.5	15.4	24.0	65	19	29.0	281	12.8	11.6	4
Abs. max.	40.0	22.8	29.0	82	44	33.3	552	18.6	5.6	
Abs. min.	24.4	7.0	16.5	38	7	18.1	119	3.7		
JUNE										
Mean or total	37.0	18.7	27.8	58	15	33.3	396	18.2	0	0
Abs. max.	41.2	22.6	30.9	79	26	34.3	575	23.0		
Abs. min.	32.0	14.0	24.2	35	5	32.2	162	14.1		
JULY										
Mean or total	36.3	18.1	27.2	55	16	32.8	415	20.9	0	0
Abs. max.	39.7	22.6	30.0	73	35	34.1	683	25.6		
Abs. min.	30.7	11.8	24.1	22	7	31.0	180	15.0		
AUGUST										
Mean or total	39.5	19.5	29.5	55	15	29.3	341	19.4	0	0
Abs. max.	43.4	26.8	33.9	79	30	31.5	575	24.8		
Abs. min.	34.2	13.7	26.1	21	7	27.4	143	15.0		
Mean or total	24.4	9.4	16.9	73	30	22.6	269	9.6	199	66
Abs. max.	43.4	26.8	33.9	100	93	34.3	722	25.6	14.6	
Abs. min.	0.9	-9.1	-2.5	15	4	3.5	10	0.1		

Table 6. Monthly total precipitation (mm) from September 1 till end of August.

	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sum (mm)
JINDIRESS													
1984/85	0.0	26.4	82.4	44.4	102.3	108.3	30.3	5.6	8.8	0.0	0.0	0.0	409
1983/84	1.4	21.6	127.0	22.6	51.3	39.2	60.4	68.8	0.0	0.0	0.0	0.0	392
Long-term average	1.6	25.2	51.2	99.6	89.3	76.4	59.8	46.6	19.6	2.9	0.0	0.0	472
BREDA													
1984/85	0.0	23.2	37.0	16.8	87.4	57.8	18.4	27.6	8.4	0.0	0.0	0.0	277
1983/84	0.0	8.0	45.0	14.4	43.6	14.8	42.8	35.4	0.0	0.0	0.0	0.0	204
Long-term average	1.6	13.5	32.7	59.1	48.4	38.0	35.3	35.7	16.6	1.5	0.3	0.0	283
KHANASSER													
1984/85	0.0	16.4	46.6	13.0	58.0	35.6	8.6	9.2	11.6	0.0	0.0	0.0	199
1983/84	0.0	0.2	18.8	5.8	42.4	21.2	43.6	19.6	0.0	0.0	0.0	0.0	152
Long-term average	1.0	4.7	23.7	37.6	38.5	38.3	33.0	28.9	16.7	1.1	0.2	0.0	224
TEL HADYA													
1984/85	0.0	28.2	98.0	22.0	126.3	61.3	24.1	9.6	3.1	0.0	0.0	0.0	373
1983/84	2.2	6.4	71.5	18.0	49.3	11.8	31.1	38.8	0.0	0.0	0.0	0.0	229
Long-term average	0.6	19.6	50.7	54.8	62.1	46.4	41.3	36.0	15.6	2.9	0.0	0.0	330

FARMING SYSTEMS

ICARDA
Annual Report
1985

INTERNATIONAL CENTER FOR AGRICULTURAL
RESEARCH IN THE DRY AREAS (ICARDA)
Box 5466, Aleppo, Syria

Contents

FARMING SYSTEMS

In our 1984 Annual Report, we introduced a new structure for reporting our research under the following headings: Project 1. Barley/ Livestock Systems (<350 mm annual rainfall); Project 2. Wheat-Based Systems (>350 mm annual rainfall); Project 3. Intersystems Research; and Project 4. Cereal/Livestock Systems in Tunisia.

We found that this new structure helped us to focus more clearly on our planning and reporting, and was well received by readers. This year we introduce a new concept to add to the value of the report. We present our research in the framework of "main themes reports" and 'highlight reports." Main themes represent a substantial research effort (either one or several years of work) on important project objectives. These are accompanied by shorter "highlight reports" which summarize specific research results relevant to the discussion and conclusions of the main themes. In this way, we make important new information available to our readers, but would stress that in some "highlight reports" further research will be required before firm conclusions can be drawn. This year, we report results from Projects 1, 2, and 3 only. Our collaborative research with the Tunisian National Program (Project 4) made good progress in 1984/85 in on-farm trials, follow up surveys, and livestock studies on representative farms of the target groups outlined in our 1983/84 Annual Report. The results of these studies are still being evaluated, and will be reported separately in early 1986.

Staff Changes

Dr Dyno Keatinge, barley/livestock systems agronomist was transferred to Quetta in Baluchistan Province of Pakistan to lead the ICARDA/AZRI/USAID high-elevation farming systems project. Dr. Seweryn Kukula, after 4 years of his research at ICARDA on weed control in food legumes and cereals, returned to Poland and Dr. Joseph Stephens, microbiologist, after his 3 years at ICARDA, returned to Canada. These positions will be filled in 1986, but the microbiologist position will be transferred to the Food Legume Improvement Program, and the weed scientist position will be filled by an agronomist with a broader responsibility for the wheat-based farming systems of the region.

Dr Ronald Jaubert, after 3 years of postdoctoral research on village-level studies of crop/livestock interactions in barley/livestock farming systems, returned to France. The work he initiated will be continued in collaboration with the Pasture, Forage, and Livestock Improvement Program.

Dr. Awad el-Karim (agricultural economist) returned to Sudan after a year's postdoctoral research. Mr. Salah A. Magid (agricultural economist) who spent 9 months with us completing his MSc thesis also returned to Sudan. Two PhD students, Mohamed A. S. Abdul Moneim (nitrogen fertilizer dynamics) and Yousef Sabet (rainfall/soil erosion studies) completed their field studies and returned.

In early 1985, Dr. Mohamed Bakheit Said from the Sudan joined the program as Senior

Training Officer. In 1986, FSP will offer an innovative 6-week residential training course. Four new postgraduate students joined the program: Mr. Noureddin Mona (PhD, agricultural economist) from Syria, Mr. Omar Salem Bin Shoib (MSc, wheat agronomy) from S. Yemen, and Mr. Taiseer el-Masri (*BNF in forage legumes*) and Mr. Ghazi el-Karaki (BNF in food legumes) from Jordan.

Towards the end of 1985, Dr. Peter Cooper (program leader) will begin a 9 months sabbatical leave at Reading University in England. Much of his time will be spent on writing up aspects of 6 years' work on crop management and water-use research. During his absence, Dr. Kutlu Somel (economist) will coordinate the program's activities.

1984/85 Meteorological Summary

Two main features of the weather during the 1984/85 season influenced the trials at all our stations. First, in the 22 days from 17 February, subzero night temperatures were recorded on all but 2 or 3 days at all sites (extremes ≤-9°C at all sites, Table 1) and daily mean temperature was less than 0°C on several days. This was accompanied by minimum relative humidities below 25% on most days. The cereal crops, which had commenced stem elongation at that time, suffered severe damage, especially at Jindiress, with a total loss of expanded leaves and death of main tillers. Legumes also were severely affected, especially peas which suffered a total loss of the above-ground dry matter.

Table 1. Frost events during 1980-85 at some ICARDA research sites in Syria.

		Khanasser		Breda		Tel Hadya		Jindiress	
Month		No. of frost days	Min. abs. temp. (°C)	No. of frost days	Min. abs. temp. (°C)	No. of frost days	Min. abs. temp. (°C)	No. of frost days	Min. abs. temp. (°C)
October	1980	2	– 3.0						
	1981								
	1982								
	1983								
	1984	4	– 2.0	1	– 0.2				
November	1980	8	– 7.5	8	– 6.5	2	– 4.0	3	– 2.5
	1981	5	– 6.0	4	– 3.0	4	– 4.2	4	– 2.8
	1982	15	– 5.5	11	– 4.2	4	– 4.4	9	– 5.0
	1983								
	1984	1	0.0	1	0.0	1	– 1.1	1	– 1.0
December	1980	17	– 5.0	14	– 4.5	6	– 3.6	7	– 4.0
	1981								
	1982	16	– 6.0	14	– 4.2	15	– 6.4	16	– 4.3
	1983	11	– 5.5	10	– 5.0	10	– 3.9	9	– 2.2
	1984	24	– 5.6	16	– 5.5	16	– 6.0	14	– 5.0

Cont'd

January	1981	7	– 3.0	6	– 5.0	3	– 2.4	2	– 2.5
	1982	8	– 4.0	9	– 6.0	11	– 0.6	9	– 5.0
	1983	17	– 9.3	16	– 9.8	18	– 9.8	18	– 8.5
	1984	8	– 3.9	9	– 3.0	5	– 2.4	4	– 1.8
	1985	10	– 4.0	3	– 2.8	3	– 0.8	2	– 0.8
February	1981	10	– 3.0	6	– 2.0	7	– 3.0	6	– 2.0
	1982	18	– 6.0	17	– 8.0	17	– 7.8	16	– 7.0
	1983	13	– 3.0	15	– 4.5	11	– 3.6	4	– 5.0
	1984	11	– 4.3	11	– 4.3	9	– 3.9	6	– 2.3
	1985	12	– 5.0	12	– 8.1	10	– 6.8	11	– 8.5
March	1981	1	0.0			2	– 0.4		
	1982	16	– 7.0	9	– 4.8	7	– 4.2	10	– 5.0
	1983	4	– 3.7	6	– 7.2	4	– 5.6	4	– 5.4
	1984	1	– 0.6	2	– 1.0	1	– 0.5	1	– 0.4
	1985	12	– 9.1	10	– 9.6	12	– 9.5	10	– 10.2
April	1981	2	– 2.0	3	– 2.2	3	– 2.5	1	– 1.5
	1982			1	– 1.2				
	1983	1	– 2.2						
	1984								
	1985								
Seasonal Total	1980/81	47	– 7.5	37	– 6.5	23	– 4.0	19	– 4.0
	1981/82	47	– 7.0	40	– 8.0	39	– 7.8	39	– 7.0
	1982/83	66	– 9.3	62	– 9.8	52	– 9.8	51	– 8.5
	1983/84	31	– 7.0	32	– 5.0	25	– 3.9	20	– 2.3
	1984/85	63	– 9.1	43	– 9.6	42	– 9.5	38	– 10.2

Table 2. Monthly precipitation during the 1984/85 season as percentage of the long-term averages.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Season
Tel Hadya	144	193	40	203	132	58	27	20	113
Jindiress	105	161	45	115	142	51	12	45	87
Breda	172	113	28	181	152	52	77	51	98
Khanasser	349	197	35	151	93	26	32	69	89

The second feature was related to rainfall (Table 2). Early rains were excellent and to the end of February were 20 to 60% above average at all sites except Jindiress. Soil water recharge was particularly high, even at Jindiress, because of the good rainfall distribution. However, in the second half of the season, rainfall was low. Less than 40%

of average rain in March, April, and May fell at Jindiress, Tel Hadya, and Khanasser, and only 60% at Breda. Crops suffered a severe stress in later growth stages, although this was buffered to some degree by the stored water.

Temperature and rainfall records for the four sites are summarized in Figs 1 and 2.

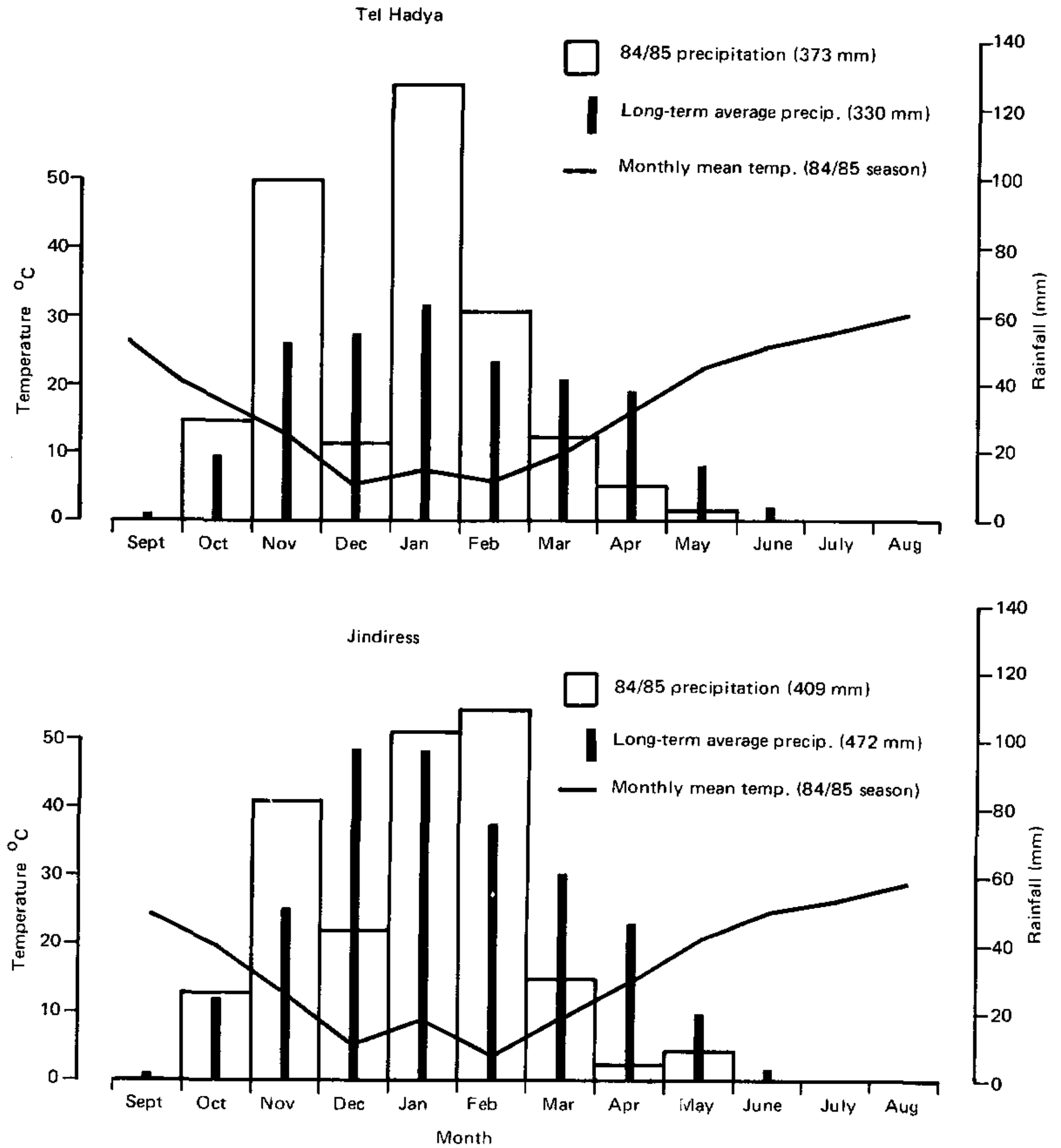


Fig. 1. Rainfall and temperature records for Tel Hadya and Jindiress, northwestern Syria.

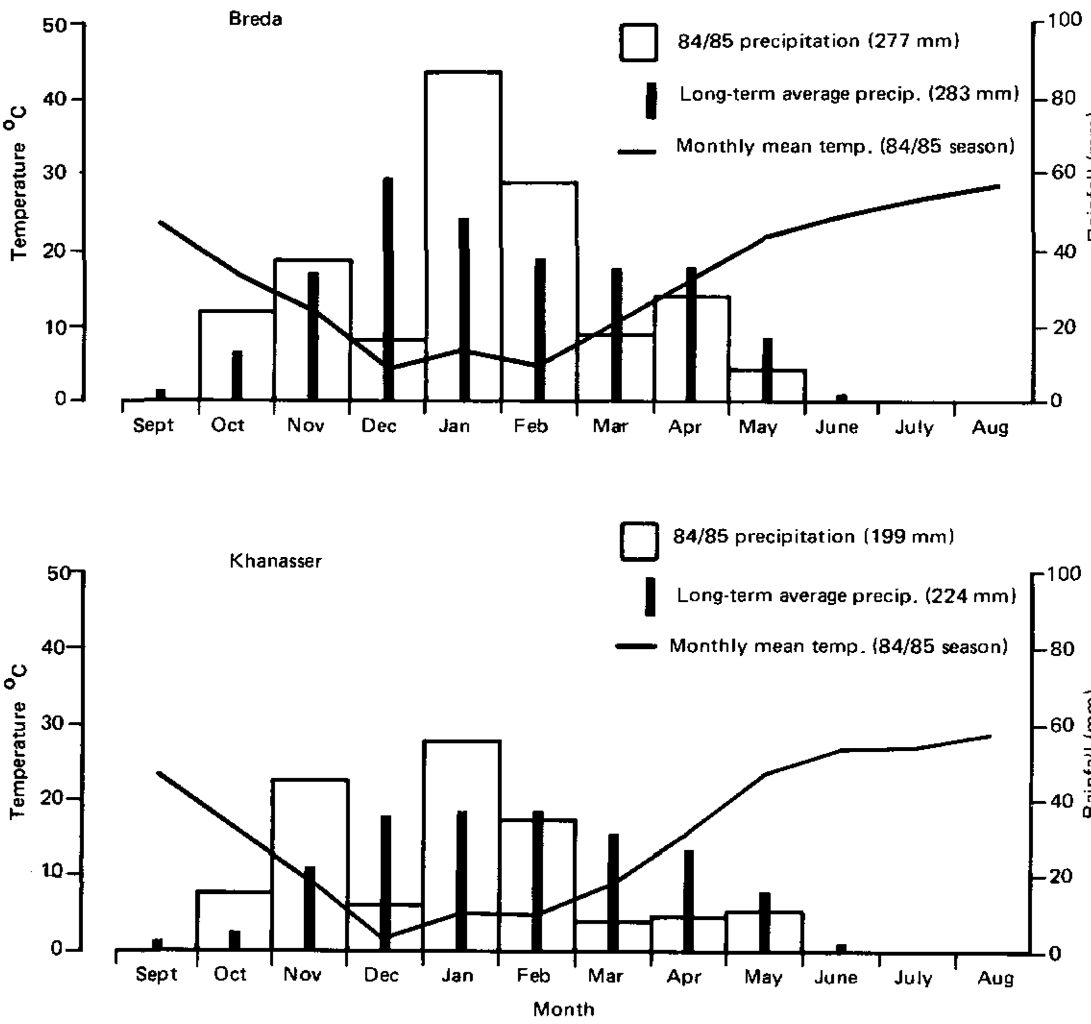


Fig. 2. Rainfall and temperature for Breda and Khanasser, northwestern Syria.

Research Highlights

Some interesting highlights from our Barley/Livestock Systems Research are listed below:

- in collaboration with the Syrian Soils Directorate, we demonstrated a widespread and highly economic response of barley to fertilizer throughout the drier areas of Syria in on-farm trials.
- important effects of year, crop rotation, and residual fertilizer on barley were observed, and economics of N and P fertilizer use was assessed.
- in cooperation with PFLP, we demonstrated that forage legumes can be economically incorporated into the existing crop rotations, either for grazing or for harvesting and storing as winter feed.

In 1984/85, we expanded the Wheat-Based Systems Research by conducting an extensive survey of wheat production practices in Syria to provide a sound basis upon which to build ICARDA's on-station and on-farm research. The initial analyses of these data highlighted:

- the relatively recent, but extensive, adoption of improved production practices by farmers (N and P, herbicides),
- farmers' judgement about how much nitrogen should be topdressed according to rainfall conditions,
- farmers' evaluation of the effect of "previous crop" on fertilizer requirements of wheat,
- farmers' attitude to the use of herbicides compared to utilizing weeds as livestock feed through hand weeding, and
- the variability in tillage practices, seeding rates, preferred varieties, fertilizer rates, weed control measures, crop rotations, yield expectations, and straw disposal methods associated with wheat production.

In the Intersystems Research Project, which focuses on a variety of topics relevant to all farming systems in the ICARDA region, we:

- conducted detailed surveys, both technical and socioeconomic, to assess the importance and implications of supplemental irrigation on production of winter crops in Syria.
- investigated the effect of method of phosphate fertilizer application on crop response and phosphate fixation and demonstrated the effect of long-term applications of fertilizer on the phosphate status of the soil and its effect on responses to applied triple superphosphate.
- utilized a wheat growth simulation model (SIMTAG) to demonstrate the effects of soil-water holding capacity, seasonal variability of rainfall distribution, and genotypic characteristics on the long-term probability of wheat yields at six locations in Syria.
- demonstrated the effect of contrasting tillage practices on potential rainfall runoff and soil erosion.

In summary, in 1984/85 we placed an increased emphasis on on-farm evaluation of improved and innovative production practices, initiated some new research activities, and further strengthened our collaboration with the Syrian National Program in all these activities.

During the year, FSP scientists visited national program scientists in Pakistan, India, Jordan, Egypt, Sudan, Morocco, Tunisia, Cyprus, Spain, Italy, France, Great Britain, Australia, and the USA to strengthen our ties and cooperative research programs. Such links are vital to our efforts to fulfill not only our obligations to our host country Syria but to all countries that ICARDA serves. More and more emphasis is being placed on such outreach activities and this is reflected in our much expanded training program presented in this report.

Barley/Livestock Systems Research

In the dry areas of Syria receiving 200-350 mm of annual rainfall, barley is the principal crop grown for feed for sheep. Our surveys during the last 4 years have identified several constraints currently preventing farmers from adopting improved production practices (ICARDA 1984a, 1985). Resulting from this work, the Farming Systems Program, in close cooperation with the Pasture, Forage and Livestock Program (PFLP), has developed two major research objectives which are reported here.

First, we are evaluating the biological and economic potential for fertilizer use on barley. Barley yields are very poor and soil nutrient deficiencies are widespread and yet farmers do not apply fertilizer to barley, and the Syrian Ministry of Agriculture and Agrarian Reform has not yet developed any fertilizer recommendations for these areas.

Our 5 years' research, both on station and in farmers' fields, has demonstrated consistent and highly economic responses to phosphate and nitrogen fertilizer without corresponding increases in crop water use (Cooper 1983). This work was reviewed in a joint Syrian Soils Directorate/ICARDA workshop in 1984, and a cooperative research program was initiated in the 1984/85 season to evaluate the potential for fertilizer use in farmers' fields throughout Syria. The results of this first year's cooperation are reported in some detail. This on-farm work continues to be supported by on-station research, and two topics of special interest are reported as research highlights. The first investigates the implications of year, crop rotation, and residual fertilizer effects on fertilizer responses of barley, and the second reports the results of an ICARDA/Reading University research project which is evaluating barley varietal differences in root production, and their implications for water use and water-use efficiency.

The second area, in which scientists from FSP and PFLP are working together, is to evaluate the potential for introducing annual-sown forage legumes into these farming systems. Studies on the sheep feeding cycle of these systems (ICARDA 1985) have shown that seasonal shortages of feed are common (in winter and spring), and that these can have disastrous effects in dry years when farmers are forced not only to graze their immature barley crops, but to sell and slaughter a large proportion of their flocks. Our surveys (Somel *et al.* 1984b) have shown that two dominant rotations are used by farmers: a 2-year fallow/barley rotation and continuous barley. Forage legumes can be grown, either as a replacement for fallow, which conserves little, if any, moisture for subsequent crops, or as a break in continuous barley cropping which leads to substantial yield reduction. These forage legumes can be used either for grazing in the spring, or for harvest as a mature crop for subsequent use during the critical winter months when feed shortages are most severe. Both these options were investigated in farmers' fields in the 1984/85 season, and the results are reported here.

A third option for forage legume utilization, that of hay making, is being investigated in long-term rotation trials established in 1982. Preliminary results were reported last year (ICARDA 1985), and a full analysis will be presented in 1986 after two full cycles of rotation.

Other research on the effects of seed rate and planting method on forage legume productivity is also reported this year, and the results of village surveys on winter supplementary feeding of sheep are highlighted.

Our research continues to demonstrate feasible solutions to the problems of poor yields, low incomes, and gradual resource degradation in the barley-producing dry areas of Syria. The focus of this research has shifted from on-station experimentation to testing solutions in farmers' fields, and we are now working in closer collaboration with the Syrian National Program.

Fertilizer Use on Barley

A collaborative project between the Soils Directorate of the Syrian Ministry of Agriculture and Agrarian Reform and the Farming Systems Program was developed in 1984/85 to assess the biological and economic effect of phosphorus and nitrogen fertilizer on barley in barley/livestock systems across a wide area in northern Syria. Multiple location - multiple season trials are being carried out in farmers' fields. On-farm experimentation of this nature allows farmers' reactions and evaluation of the trials to be gauged, thus providing a means of assessing the potential adoption of new technology.

Trial Details

In this first year of the project, trials were conducted in farmers' fields at 15 locations in the Provinces of Hama, Aleppo, Raqqa, and Hassakeh. These Provinces span important barley-growing areas and reflect conditions in which 60% of the total barley-producing areas of Syria are located. The trial was also planted at our permanent site at Breda. The sites were chosen on the following criteria: (I) should be level with deep, relatively stone-free soil to permit installation of neutron-probe access tubes at some sites to monitor changes in soil moisture during the growing season, (II) should have been preceded by fallow in the 1983/84 season, and (III) should be distributed in agricultural stability zones 2 and 3.*

Prior to sowing, soil samples were taken from various horizons to a depth of 100 cm at each site to characterize soil conditions. Analysis for available phosphorus (P-Olsen test) showed generally low values, with all but four sites having less than 6 ppm of P in the top 20 cm of the profile. The remaining sites had less than 10 ppm. Total mineral nitrogen (NO_3^- and NH_4^+) contents in the top 60 cm were also low (<50 kg/ha) at the majority of sites, but there were exceptions, particularly amongst the drier sites. Most soils had organic matter contents less than 1% by weight in the top 20 cm, and the maximum value recorded was 1.4%.

All of the soils had pH values $\geqslant$ 8 throughout the profile; all but one were calcareous, but electrical conductivity values showed no evidence of salinity. Profile clay contents ranged from 47 to 72%, with little evidence of textural change within the profile.

At each site the trial was laid out in a replicated (2) randomized complete block design with four levels of nitrogen fertilizer (0, 20, 40, 60 kg N/ha) and four levels of phosphorus (0, 30, 60, 90 kg P_2O_5/ha). Seed bed preparation was carried out using implements hired in the villages. Plots, which were 2.1 x 12.5 m in size, were sown to barley (variety Arabi Aswad) at 100 kg/ha using an Oyjord planter. All of the phosphorus and half of the nitrogen was drilled with the seed; the remaining N was topdressed at the tillering stage. Weeds were controlled by a single application of Brominal Plus, and the seed was treated with Vitavax.

Plant and soil samples were taken at three stages during the season: tillering, anthesis, and harvest maturity. Only selected treatments were sampled at tillering and anthesis and the results are not reported. At harvest all plots were sampled for total biomass and grain yields, and yield components were derived. Selected treatments were again sampled for soil-available P and mineral N.

Crop Responses to Fertilizer

Rainfall was recorded weekly at each location. Seasonal rainfall was excellent at all sites until the end of February and in Hassakeh Province throughout the season. However, from the beginning of March, Hama Province received no effective rain, and in Aleppo and Raqqa Provinces rainfall was approximately only 50% of "normal." Cold and frost at the end of February and early March caused extensive crop damage especially in Raqqa and Hassakeh Provinces. Temperatures were lower than any recorded at that stage of the season in the past 25 years. Frost damage was less severe in the plots to which phosphorus had been applied, but damage was apparently increased by herbicide application.

Trials at two sites failed to establish satisfactorily; at one due to soil crusting and at the second due to inadequate seed bed preparation where the only implement available for this purpose was a disc plow. Two other sites were harvested before they could be

* Zone 2: 250-350 mm mean annual rainfall with $\geqslant$250 mm in two-thirds of years.

* Zone 3: >250 mm mean annual rainfall with $\geqslant$250 mm in half of years.

sampled at maturity. Data from a fifth site could not be used due to an apparent nutrient gradient across the trial which caused major yield differences within and between replicates. Thus data from 11 sites (including Breda) only were available and are reported here.

There were significant ($p<0.1$) increases in total dry-matter production (TDM) in response to phosphorus at 9 of 11 sites (Table 3), principally at the P_{30} or P_{60} application level. Soil-extractable P levels at the nonresponsive sites were 5.8 and 9.9 ppm. Elsewhere, the TDM increase was about 20-40%, but ranged from 7% at Khashouka to 135% at Skiro (Table 3).

Responses of grain yield to P application largely paralleled those for total dry matter. However, the effect was significant ($p<0.1$) at only six sites (Table 4). There was a general trend for 1000-grain weights to decrease with increasing fertilizer levels; the effect was significant at 9 of 11 sites for each of P and N (Table 5). The only exception was at Skiro where increased grain size with P application confirmed the severe P deficiency.

Application of up to 40 kg N/ha increased total dry-matter yields at 7 of 11 sites. Proportional increases ranged from approximately 20% at Hobar and Maboujeh to 95% at Mariamine, but most were about 30-60% (Table 3). There was a clear relationship between mineral N at sowing and the presence or absence of a response. There were increased grain yields at seven sites in response to N application, and the proportional response to N was similar to that for dry matter (Table 4).

There were substantial differences in 1000-grain weight between sites at any level of N or P. Highest weights were recorded for the sites in Hassakeh Province (Khashouka and Jesaah) where late rains were received (Table 5). The reduced grain size at other sites was partly due to water stress during grain filling. With fertilizer, the smaller grain size was more than offset by increased grain numbers as reflected in yield increases.

Significant ($p<0.1$) P x N interactions (data not presented here) in total dry-matter production occurred at five sites and at three sites in grain yield, with, in most cases,

Table 3. Mean total dry-matter yield (t/ha) of phosphorus and nitrogen fertilizer treatments on barley (var. Arabi Aswad) at 11 sites in northern Syria, 1984/85.

	Phosphorus					Nitrogen				
Site	P_0	P_{30}	P_{60}	P_{90}	Sig. level	N_0	N_{20}	N_{40}	N_{60}	Sig. level
Ibtin	5.21	5.14	5.51	5.42	ns	4.2	5.06	5.72	6.22	xx
Mariamine	3.70	3.79	4.21	4.27	ns	2.51	3.53	4.89	5.04	xx
Hobar	5.20	6.06	6.13	6.61	x	4.98	5.88	6.41	6.73	xx
Breda	3.68	4.85	5.60	5.94	xx	4.12	4.87	5.65	5.43	xx
Jifr Mansour	3.35	3.72	4.09	4.04	x	3.71	3.62	3.90	3.97	ns
Ghrerifeh	1.52	2.15	2.45	2.79	xx	1.61	2.13	2.54	2.62	xx
Maar Shahour	2.09	2.89	3.11	3.75	xx	2.06	2.81	3.31	3.64	xx
Maboujeh	4.74	6.17	6.10	5.95	x	4.96	5.82	6.37	5.81	ns
Skiro	1.58	3.11	3.73	4.01	xx	3.10	3.96	3.06	3.29	ns
Khashouka	5.02	5.43	5.39	5.68	x	3.86	5.03	6.21	6.42	xx
Jesaah	6.39	7.29	7.74	7.50	x	6.89	6.87	7.51	7.65	ns

x=$p<0.05$; xx=$p<0.01$
ns = not significant.

Table 4. Mean grain yields (t/ha) of phosphorus and nitrogen fertilizer treatments on barley (var. Arabi Aswad) at 11 sites in northern Syria, 1984/85.

	Phosphorus					Nitrogen				
Site	P_0	P_{30}	P_{60}	P_{90}	Sig. level	N_0	N_{20}	N_{40}	N_{60}	Sig. level
Ibtin	2.38	2.26	2.31	2.22	ns	2.05	2.18	2.83	2.55	xx
Mariamine	1.66	1.76	1.92	1.92	ns	1.29	1.60	2.18	2.20	xx
Hobar	2.35	2.61	2.65	2.72	ns	2.29	2.64	2.60	2.79	x
Breda	1.78	2.29	2.53	2.65	xx	2.01	2.26	2.55	2.43	xx
Jifr Mansour	1.38	1.56	1.49	1.59	x	1.59	1.57	1.49	1.51	ns
Ghrerifeh	0.69	0.86	0.93	1.01	xx	0.70	0.85	0.98	0.95	xx
Maar Shahour	1.01	1.29	1.33	1.56	xx	1.01	1.25	1.42	1.52	xx
Maboujeh	1.98	2.55	2.46	2.41	ns	2.14	2.38	2.59	2.30	ns
Skiro	0.66	1.38	1.64	1.85	xx	1.40	1.31	1.39	1.43	ns
Khashouka	2.29	2.46	2.40	2.51	ns	1.74	2.24	2.78	2.90	xx
Jesaah	2.92	3.34	3.56	3.52	x	3.22	3.17	3.46	3.49	ns

x=$p < 0.05$; xx=$p < 0.01$

ns = not significant.

maximum values recorded in the $N_{40}P_{60}$ treatment. The nature of the interaction varied. At two sites there was a dry-matter response to N in the absence of P but no effect of P without N. P in the absence of N increased total dry matter at a third site, whilst at the other two locations both N and P were required for a dry-matter yield increase. The pattern for significant interactions on grain yield was similar to TDM where such interactions occurred.

The data were pooled within agricultural zones and subjected to analysis of covariance using three rainfall terms-rain from the start of the season to tillering, from tillering to anthesis, and from anthesis to maturity- and initial Olsen extractable P and mineral N as covariates. Adjusted mean total dry-matter yields, grain yields, and 1000-grain weights were calculated (Figs 3 and 4). In zone 2 the major and significant ($p \leq 0.05$) response was to nitrogen-48 and 36% for TDM and grain, respectively, on adjusted means. Phosphorus application increased TDM by 19% and grain yield by 14% on adjusted means (Fig. 3). However, in zone 3, the major response ($p \leq 0.01$) was to phosphorus (53% in TDM; 44% in grain yield) but nitrogen also caused significant ($p \leq 0.01$) yield increases-26% in TDM and 14% in grain yield (Fig. 4). These proportional increases were calculated on adjusted means.

There were similar trends for 1000-grain weights in both zones (Figs 3 and 4), but weights were consistently smaller in zone 3 than in zone 2. In both zones minimum grain weights occurred at 60 kg P_2O_5/ha, but there was a continued negative response to N at the highest application level (60 kg N/ha).

These results show that there can be substantial yield increases with fertilizer application, though they are based only on one season's data. Maximum TDM was not achieved (Figs. 3 and 4), but grain yields were probably close to the maximum achievable under 1984/85 conditions.

Table 5. Mean 1000-grain weight (g) of phosphorus and nitrogen fertilizer treatments on barley (var. Arabi Aswad) at 11 sites in northern Syria.

	Phosphorus					Nitrogen				
Site	P_0	P_{30}	P_{60}	P_{90}	Sig. level	N_0	N_{20}	N_{40}	N_{60}	Sig. level
Ibtin	32.5	30.7	30.8	30.4	xx	32.6	31.2	30.7	29.8	xx
Mariamine	32.1	32.3	31.9	33.8	ns	35.5	32.7	32.1	29.8	x
Hobar	30.7	28.5	28.4	28.1	ns	31.0	29.7	27.1	27.9	x
Breda	37.5	34.7	33.2	32.8	xx	36.1	34.7	34.0	33.2	xx
Jifr Mansour	28.4	26.4	25.1	24.8	xx	27.8	27.4	24.8	24.7	xx
Ghrerifeh	29.8	25.7	24.8	24.7	xx	27.6	26.3	26.3	24.8	xx
Maar Shahour	33.9	33.0	31.4	31.1	xx	33.7	32.6	31.7	31.4	x
Maboujeh	30.6	30.7	29.2	28.6	ns	31.1	29.3	29.6	29.0	ns
Skiro	28.8	32.4	31.7	33.3	xx	31.8	31.5	32.0	30.9	ns
Khashouka	36.7	36.2	35.8	34.7	x	36.0	35.2	35.9	36.4	x
Jesaah	38.7	39.8	37.3	37.5	xx	39.0	38.1	38.8	37.3	x

x=$p < 0.05$; xx=$p < 0.01$

ns = not significant.

Economic Evaluation

It is not sufficient to consider only biological responses. If fertilizer use is to be implemented in drier areas it must increase the financial returns to farmers, so an economic analysis of the results was carried out.

The adjusted values for TDM and grain yields, within each agricultural zone, were used to evaluate the economic feasibility of fertilizer application.

The principal assumptions used in the analyses were: (i) government prices were used for barley while farm gate costs were used for fertilizer, (ii) TDM was converted to an economically meaningful quantity of barley grain value equivalent (BAREQ), (iii) harvest costs were assumed to be 10% of the value of BAREQ, and (iv) fertilizer application costs were assumed to be 20 SL/ha, totalling 40 SL/ha for the two applications.

With these assumptions, fertilizer application consistently gave increases in net revenue in zones 2 and 3, indicating the profitability of fertilizer use on barley (Table 6).

The derived marginal net benefit/cost ratios (Table 6) imply that marginal profit rates of over 100% can be achieved with fertilizer use. The large increases in net revenue per hectare (max. 1054 SL/ha at $N_{60}P_{60}$ in zone 2 and max. 911 SL/ha at $N_{40}P_{90}$ in zone 3) are sufficient to allow for costs which may have been overlooked (Fig 5). These preliminary results confirm that fertilizer can be profitably used to increase barley production in drier areas. However, some caution is necessary in interpreting data from only one season. More detailed analyses using pooled regression techniques will be reported in near future. --*Soils Directorate of Syria: J. Abdul Karim, K. El Hajj/ICARDA: P. Cooper, K. Somel, A. Matar, H. Harris, D. Keatinge.*

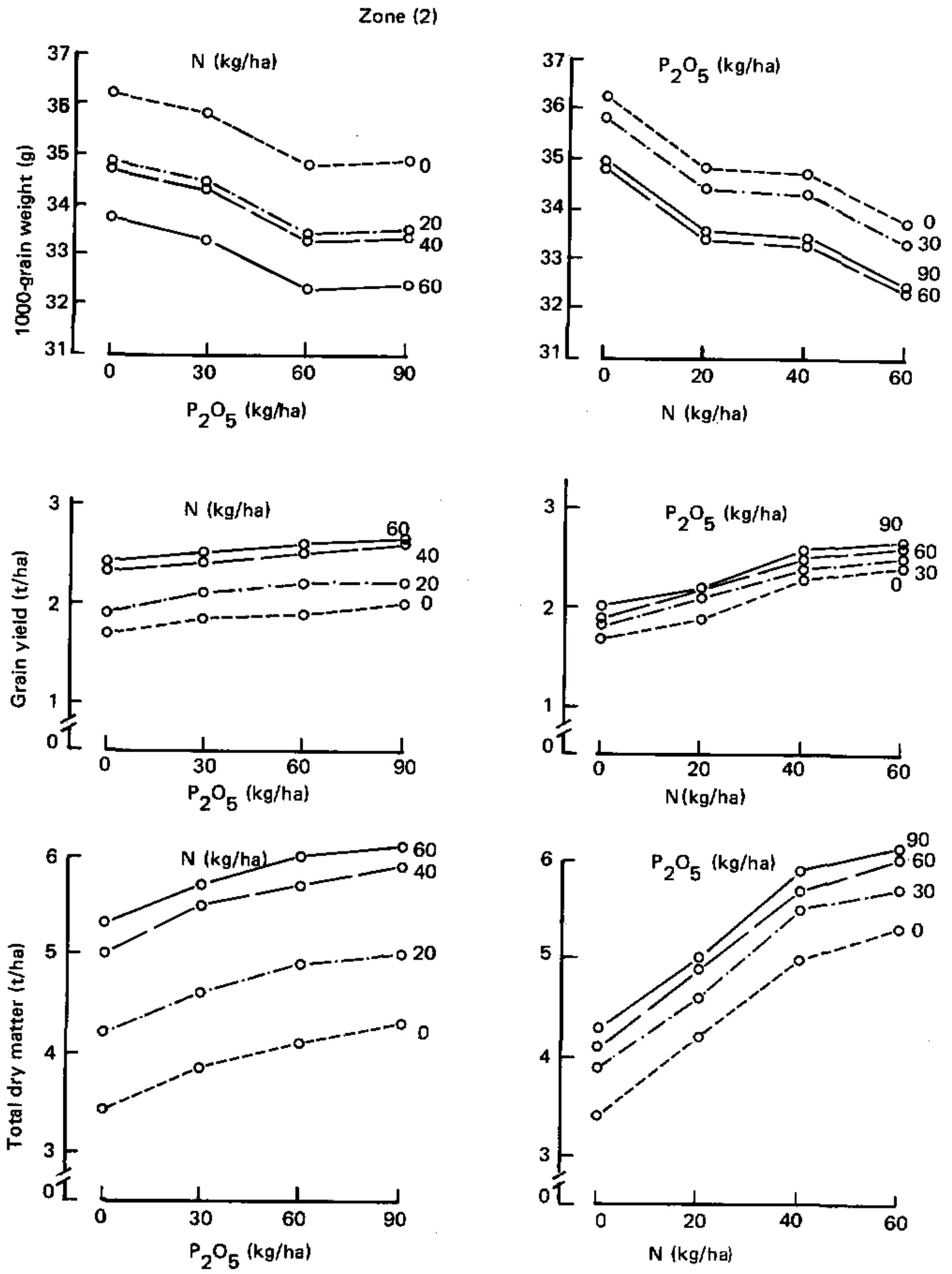


Fig. 3. The response to N and P in zone 2 after adjustment for the effects of rainfall and initial P and N fertilizers.

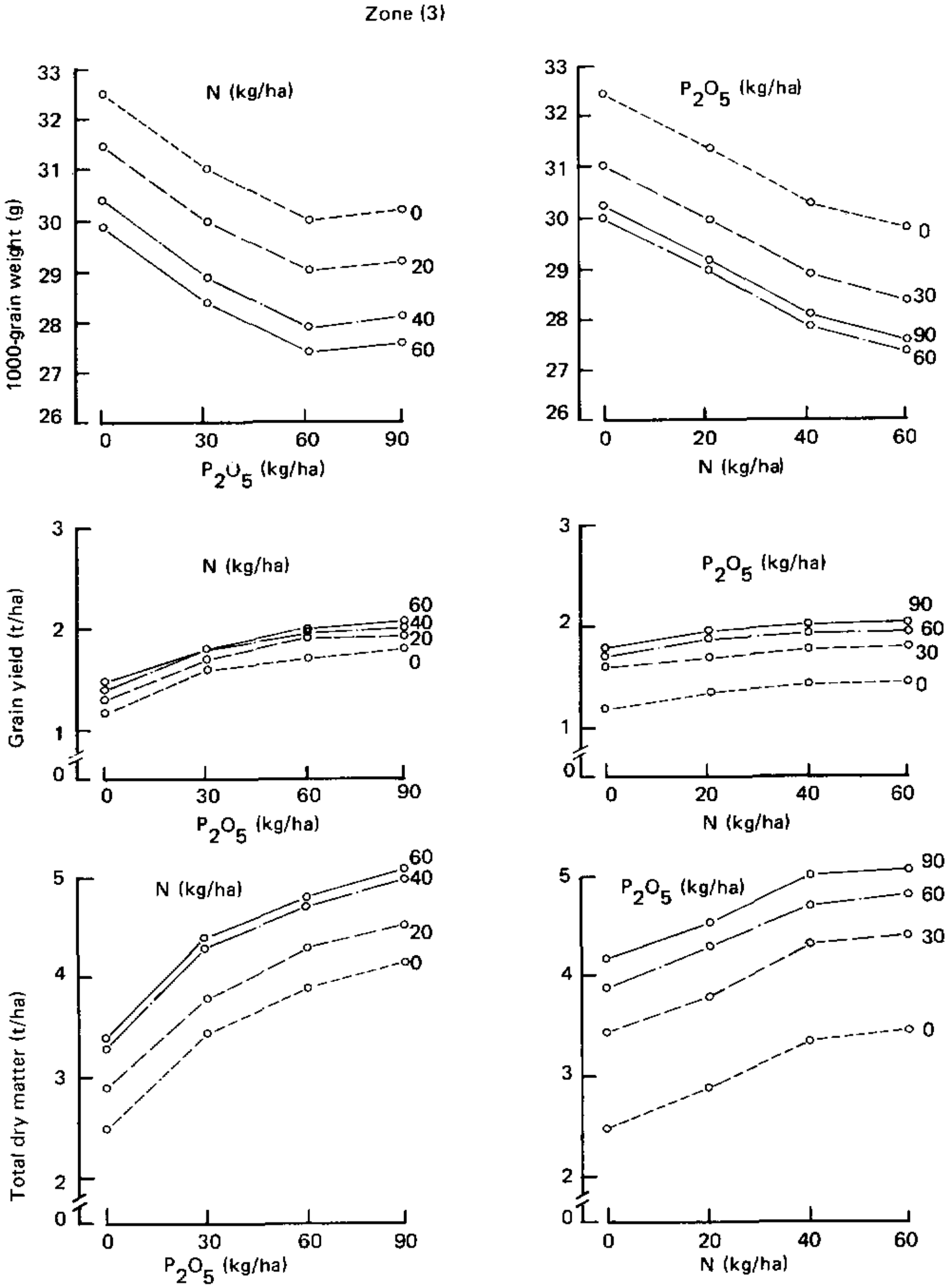


Fig. 4. The response to N and P in zone 3 after adjustment for the effects of rainfall and initial P and N fertilizers.

Table 6. Costs and benefits of fertilizer use.*

Zone 2	N_0P_0	N_0P_{30}	N_0P_{60}	N_0P_{90}	$N_{20}P_0$	$N_{20}P_{30}$	$N_{20}P_{60}$	$N_{20}P_{90}$	$N_{40}P_0$	$N_{40}P_{30}$	$N_{40}P_{60}$	$N_{40}P_{90}$	$N_{60}P_0$	$N_{60}P_{30}$	$N_{60}P_{60}$	$N_{60}P_{90}$
Total dry matter (kg/ha)	3424	3853	4136	4268	4165	4594	4877	5009	5032	5461	5744	5876	5298	5727	6010	6142
Grain yield (kg/ha)	1682	1853	1932	1977	1908	2080	2159	2203	2263	2434	2514	2558	2350	2521	2601	2645
Barley equivalent of TDM (kg/ha)	2292	2553	2704	2779	2698	2690	3110	3185	3232	3494	3644	3719	3382	3643	3794	3869
Gross revenues (SL/ha)	2521	2808	2974	3057	2968	3256	3421	3504	3555	3843	4008	4091	3720	4007	4173	4256
Increase in gross revenues due to fertilizer use (SL/ha)		287	433	536	447	735	900	983	1034	1322	1487	1570	1199	1486	1652	1735
Cost increases (SL/ha)																
Fertilizer		86	171	257	74	160	245	331	148	234	319	405	222	308	393	479
Fertilizer application		20	20	20	40	40	40	40	40	40	40	40	40	40	40	40
Harvesting		29	43	54	45	74	90	98	103	132	149	157	120	149	165	174
Total cost increases		135	234	331	159	274	385	469	291	406	516	602	382	497	598	693
Net returns due to fertilizer use (SL/ha)		152	199	205	288	461	515	514	743	916	971	968	817	989	1054	1042
Marginal net benefit/ cost ratio		1.13	0.85	0.62	1.81	1.68	1.34	1.10	2.55	2.26	1.88	1.61	2.14	1.99	1.76	1.50

Table 6 (Cont). Costs and benefits of fertilizer use.

Zone 3	N_0P_0	N_0P_{30}	N_0P_{60}	N_0P_{90}	$N_{20}P_0$	$N_{20}P_{30}$	$N_{20}P_{60}$	$N_{20}P_{90}$	$N_{40}P_0$	$N_{40}P_{30}$	$N_{40}P_{60}$	$N_{40}P_{90}$	$N_{60}P_0$	$N_{60}P_{30}$	$N_{60}P_{60}$	$N_{60}P_{90}$
Total dry matter (kg/ha)	2538	3450	3872	4152	2927	3839	4262	4541	3348	4261	4683	4962	3444	4356	4779	5058
Grain yield (kg/ha)	1229	1599	1734	1825	1356	1727	1863	1953	1435	1805	1941	2029	1455	1825	1960	2051
Barley equivalent of TDM (kg/ha)	1687	2247	2483	2639	1906	2466	2702	2859	2105	2665	2901	3057	2151	2711	2947	3103
Gross revenues (SL/ha)	1856	2472	2731	2903	2097	2713	2972	3145	2316	2932	3191	3363	2366	2982	3242	3413
Increase in gross revenues due to fertilizer use (SL/ha)		616	875	1047	241	857	1116	1289	460	1076	1331	1507	510	1126	1386	1557
Cost increases (SL/ha)																
Fertilizer		86	171	257	74	160	245	331	148	234	319	405	222	308	393	479
Fertilizer application		20	20	20	40	40	40	40	40	40	40	40	40	40	40	40
Harvesting		62	88	105	24	86	112	129	46	108	133	151	51	113	139	156
Total cost increases (SL/ha)		168	279	382	138	286	397	500	234	382	492	596	313	461	572	675
Net revenues due to fertilizer use (SL/ha)		448	596	665	103	571	719	789	226	694	839	911	197	665	814	882
Marginal net benefit/ cost ratio		2.67	2.14	1.74	0.75	2.00	1.81	1.58	0.97	1.82	1.71	1.53	0.63	1.44	1.42	1.31

* The yield figures are derived from the pooled analysis of covariance.

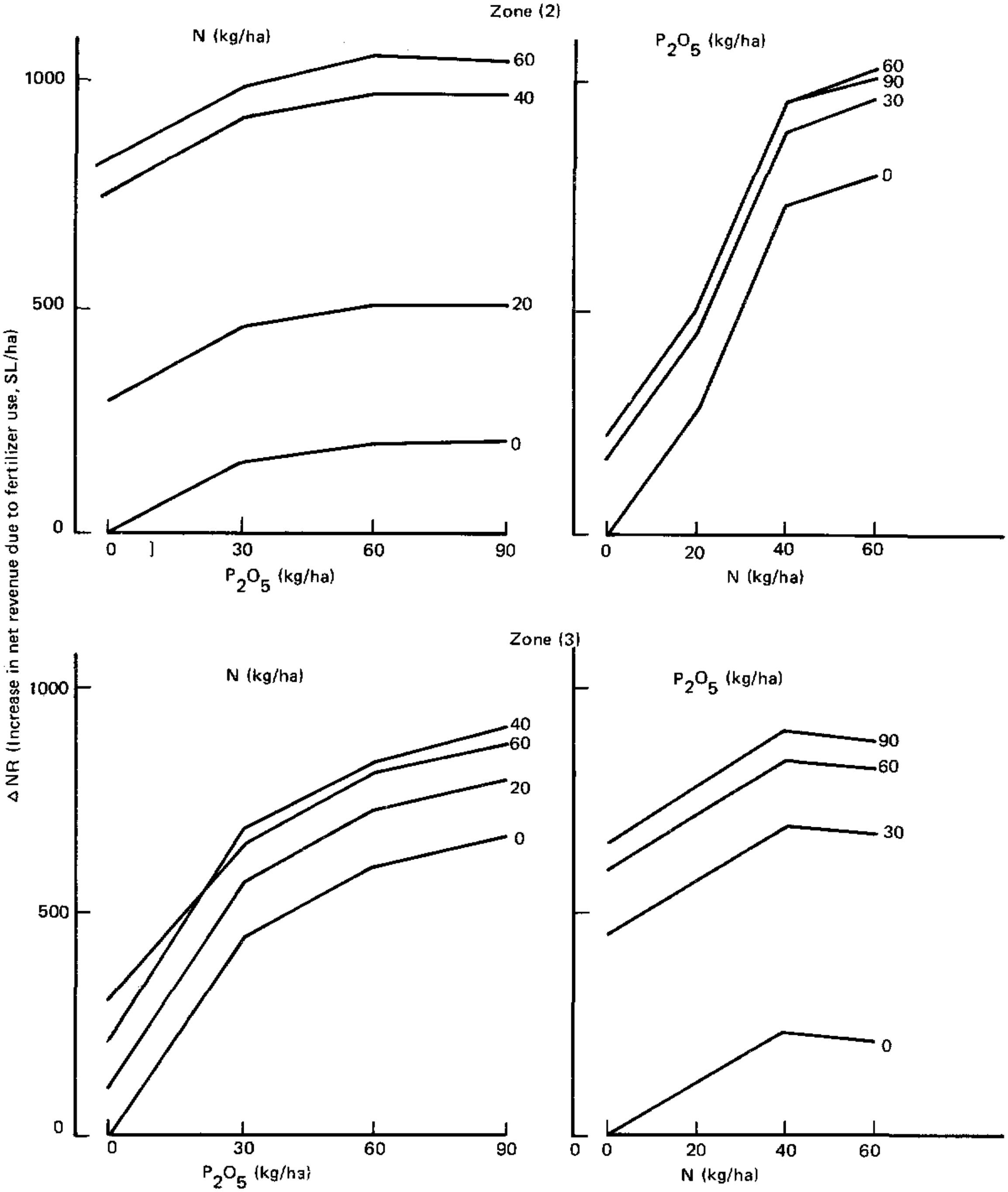


Fig. 5. Increases in net revenues due to fertilizer use.

Structure and Price Responsiveness of Barley Production in Syria

ICARDA is paying attention to many aspects of the barley-livestock sector. This study considers the impact of government programs on barley production at the macroeconomic level.

Changes in the acreage, production, and yields of the crops for which ICARDA is responsible can influence ICARDA research priorities. In such cases the success of technological developments can be enhanced by utilizing the knowledge gained.

The objectives of the study were to: (i) describe the sheep-barley subsector in Syrian agriculture, (ii) apply dynamic models of producer behavior to obtain estimates of short-run and long-run supply elasticities for barley, (iii) analyze the response in barley area and production in Syria to variation in prices, the environment, and the international market, and (iv) examine the implications of the results for policy purposes.

Nerlovian Supply Response and Vector Autoregression (VAR) models were applied to Syrian data for the barley-livestock sector during 1951-82. The derived supply elasticities will be useful for policy purposes. The VAR model is useful for studying the cyclical changes in area, sheep numbers, and other factors in response to variations in prices and rain.

The supply response approach is useful to study the effects of government programs on area through the price mechanism. An innovative methodology was first used for agriculture by Nerlove (1958) and is appropriately called Nerlovian Supply Response analysis.

The basic Nerlovian model postulates that farmers' price expectations change from year to year and that this change is related to differences between actual and expected prices in the past. Adjustment in area, i.e., actual area planted, is a function of expected prices.

This study incorporates the effect of government programs (announced prices) which influence price expectations, the structural changes such as land reform, the influence of the mutton market on barley area, and the effects of annual rainfall.

Preliminary Results

Using a Nerlovian Supply Response approach with price expectations, the long-run and short-run supply elasticities were derived. With this approach, the desired barley area (A_t) is a function of the expected price:

$$A_t = a + bP_t^* + u_t \qquad (1)$$

where P_t^* is the expected price of barley in SL/t, and u_t is the error term.

Price expectations are hypothesized to be formed through an "adaptive expectations" process. Hence, the change in expected price is proportional to what was expected and what was realized in the previous period:

$$P_t^* - P_{t-1}^* = c\,(P_{t-1} - P_{t-1}^*), \qquad (2)$$

$$0 < c < 1$$

where P_{t-1} is the actual price of barley.

The system of equations in (1) and (2) can be reduced to:

$$A_t = ac + (1-c)\,A_{t-1} + bcP_{t-1} + w_t \qquad (3)$$

where $w_t = u_t - (1-c)\,u_{t-1}$.

Preliminary results for barley area in Syria for the period 1952-82, are as follows:

i) Current price SL/t

$$A_t = \underset{(2\%)}{286.4} + \underset{(5\%)}{0.40}\,A_{t-1} + \underset{(1\%)}{0.73}\,P_{t-1}$$

where Adj $R^2 = 0.62$ $\quad F(2,27) = 24.8$ (0.1%)

ii) US dollar price per ton

$$A_t = 195.2 + 0.59\, A_{t-1} + 2.02\, P_{t-1}$$
$$\quad (10\%) \quad (1\%) \qquad (5\%)$$

where Adj $R^2 = 0.57$ $F(2,27) = 19.9$ (0.1%)

iii) Constant price SL/t (1975 prices)

$$A_t = 178.8 + 0.82\, A_{t-1} + 0.01\, P_{t-1}$$
$$\quad (0.1\%)$$

where Adj $R^2 = 0.49$ $F(2,27) = 15.1$ (0.1%)

Figures in parentheses indicate the significance level.

When current or constant prices (1975 prices) were used the price expectation coefficient was not significantly different from zero at 5% significance.

The implied area elasticities to price were 0.1-0.3 for the short run and 0.3-0.5 for the long run. Hence, large price increases would be required to induce changes in barley areas.

When the reduced equation was reestimated using the relative barley price with respect to the price of mutton, there was a significant influence of meat price on barley area as follows:

$$A_t = 760.24 - 8532.98\, RMP_{t-1} + 0.51\, A_{t-1}$$
$$\quad (2\%) \qquad (1\%)$$

where Adj $R^2 = 0.58$, $F(2,27) = 21.08$ (0.1%)

RMP_t is the current domestic barley price divided by the current domestic mutton price, both in SL/t.

The derived short-run area elasticity to price is -0.42 while the long-run elasticity is -0.86, implying that increases in mutton price strongly influence barley area.

Another exercise was conducted to incorporate structural change (land reform). In the basic Nerlovian models no structural change was observed between 1952-65 and 1966-82 implying that behavioral patterns of supply response did not change between those periods.

Policy Implications

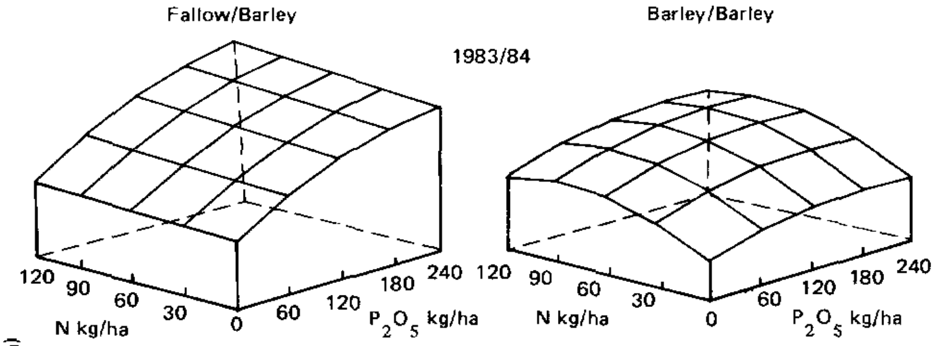
The results showed that Syrian farmers respond to price changes and there was a highly significant influence of mutton price on the barley area in Syria. These results are supported by the vector autoregression model where mutton price was a dominant factor in barley production. Continuing research on alternative models will show the dynamic macroeconomic relations between the barley and livestock sectors. However, the planning of barley production must consider the livestock sector because it is the driving element of the system. --*N. Mona and K. Somel.*

Implications of Crop Rotation, Year, and Residual Effects on Fertilizer Responses of Barley

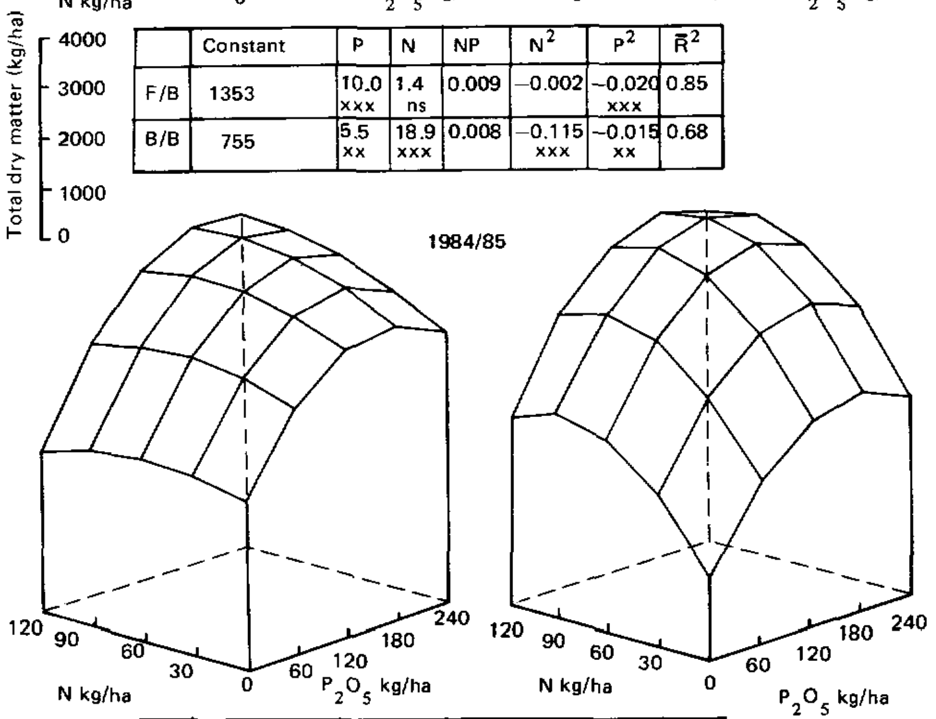
In Syria, barley is grown in two principal rotations; as a two-course fallow-barley rotation or as a continuous barley crop. ICARDA is cooperating with the Syrian Soils Directorate to evaluate, on a national basis, the potential for fertilizer use in these dry barley/livestock farming systems. To date, these trials have been conducted on fields preceded by fallow, and a single season's barley grain and straw yield data have been used for economic analysis (see "Fertilizer Use on Barley"). Other research at ICARDA and elsewhere has shown that fertilizer responses are affected by previous cropping history and so residual responses to applied fertilizer in subsequent years must be considered in any economic evaluation. These aspects were investigated in detail at a single location in northwest Syria.

Trial Details

In 1983/84 and 1984/85, a 5 x 5 factorial trial with 25 treatment combinations of nitrogen and phosphate (see Fig. 6 for treatment level) was sown at Breda in adjacent blocks of uniform land, one under continuous barley and the other preceded by fallow. In



	Constant	P	N	NP	N^2	P^2	$\bar{R}^2$
F/B	1353	10.0 xxx	1.4 ns	0.009	−0.002	−0.020 xxx	0.85
B/B	755	5.5 xx	18.9 xxx	0.008	−0.115 xxx	−0.015 xx	0.68



	Constant	P	N	NP	N^2	P^2	$\bar{R}^2$
F/B	3320 xxx	29.6 xxx	11.5 ns	0.06 x	−0.11 ns	−0.09 xxx	0.81
B/B	1615 xxx	30.5 xxx	54.0 xxx	0.03 ns	−0.31 xxx	−0.09 xxx	0.79

Fig. 6. Effect of year and rotation on the response surface of total dry-matter production of barley to applied N and P fertilizer, Breda, northwestern Syria.

both years, treatments were replicated twice in each rotation. Phosphate fertilizer was drilled with the seed (17.5 cm row spacing, 100 kg/ha seeding rate) and 20 kg N/ha was topdressed where applicable at sowing. The remainder was topdressed at the start of stem elongation. In addition, in 1984/85 the previous season's trial site in both rotations was sown with an unfertilized barley crop, and the plots relocated to measure the residual effects of the 1983/84 fertilizer application. At harvest, all yield components were recorded in both years.

The results are presented briefly, with reference to total dry-matter production only, since trends were the same for grain and straw yields.

The response surfaces of barley total dry matter to N and P fertilizer in both years, with their respective regression equations, are presented in Fig 6. The 1983/84 was a dry year (204 mm rainfall), but there were significant responses in both rotations. In the fallow/barley rotation, the response was entirely to phosphate with no significant response to nitrogen. In the continuous barley rotation, there were responses to both nitrogen and phosphate, although the response to phosphate was reduced. Rotation had a highly significant effect on production, as did nitrogen and phosphate fertilizer (Table 7). The effect of rotation on these responses is clear in the significant rotation x nitrogen and rotation x phosphate interactions.

The 1984/85 was a year of average, but fairly well distributed rainfall (276 mm), and production levels were more than doubled. Nevertheless, similar trends to those in 1983/84 were observed. In the fallow/barley rotation, there were very large responses to phosphate, with responses to nitrogen only at high phosphate levels (note the N x P interaction in the regression equation). In contrast, in the continuous barley rotation, large responses to both nitrogen and phosphate were measured. The analysis of variance of

Table 7. Levels of significance of main effects and interactions from an ANOVA of pooled data sets of two rotations (fallow/barley and barley/barley).

Source	1983/84[a]	1984/85[a]	Residual effects of fertilizer applied in 1983/84 measured in 1984/85
Rotation	xx	xx	xx
Nitrogen	xx	xx	ns
Phosphate	xx	xx	xx
Rot x N	xx	xx	ns
Rot x P	xx	ns	xx
N x P	ns	x	ns

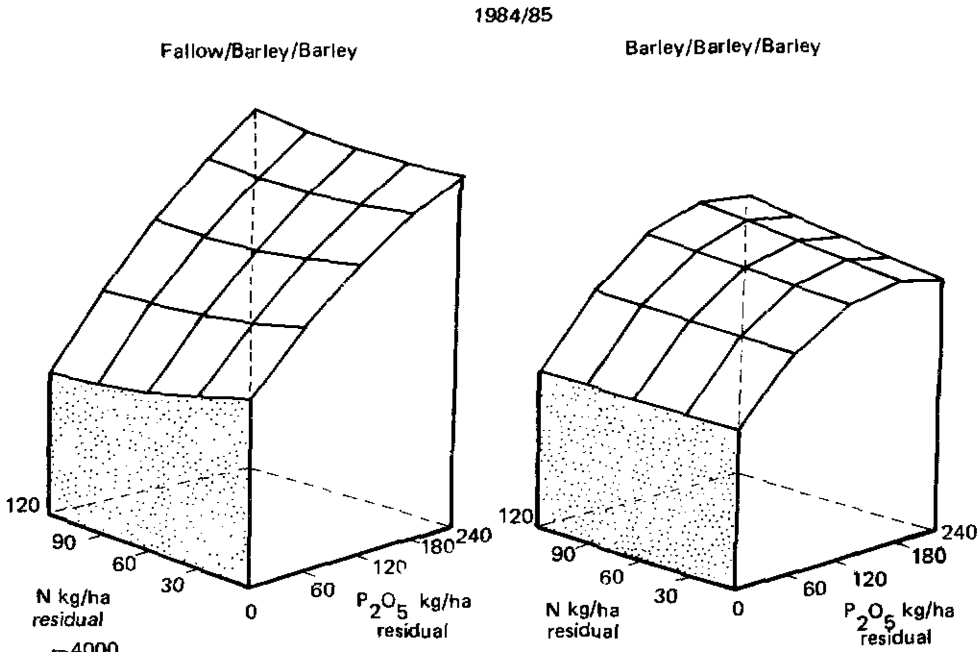
xx=$p<0.01$ x=$p\leqslant 0.05$

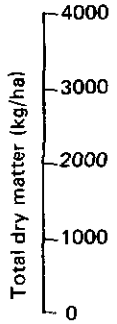
ns = not significant.

a. fertilizer applied.

the pooled data set again shows the same trends as in 1983/84, but in 1984/85 there was no rotation x phosphate interaction.

The residual effects of fertilizer applied in 1983/84 on total dry-matter production of a second barley crop in 1984/85 are presented in Fig 7. In these residual data sets, both crops of barley were preceded by barley in 1984/85, thus we compare barley/barley/barley with fallow/barley/barley. There were very substantial responses to the residual effect of phosphate fertilizer in both barley/barley/barley and fallow/barley/barley rotations, but these were much less in the former than in the latter. There was no response to residual nitrogen in either rotation even though there were substantial responses to nitrogen applied in 1984/85 (Table 7). Immobilization of the available residual nitrogen into organic forms through microbial breakdown of barley residues and roots is likely to be the principal mechanism involved. The effect of a fallow break on fertilizer responses persists for more than





	Constant	P	N	NP	N^2	P^2	R^2
F/B/B	3640	20.5 xxx	−11.0 ns	0.04 ns	0.04 ns	−0.03 xx	0.82
B/B/B	3085	24.3 xxx	−0.2 ns	0.02 ns	−0.01 ns	−0.07 xxx	0.75

Fig. 7. The effect of rotation on the response surface of total dry-matter production of barley to residual fertilizer effects from the preceding season, Breda, northwestern Syria.

one year and is reflected in the analysis of variance of the pooled data set for the residual trial in Table 7.

In evaluating fertilizer responses of barley in these dry areas, year, rotation, and residual effects of fertilizer all must be considered in calculating the economically optimum recommendation to farmers. Economic evaluation of the data set presented here is currently under way.--*P. Cooper.*

Root Growth and Water Use of Different Barley Varieties

Previous experiments in controlled environment glasshouses at Reading University, U.K., have shown substantial differences in root growth between varieties of barley grown until the 3-4 leaf stage. Field experiments were conducted in northern Syria during 1984/85 to determine whether similar differences occur in

Table 8. Grain, straw, and total dry-matter production (kg/ha) at maturity.

	Tel Hadya (373)[a]			Breda (277)[a]			Ghrerifeh (245)[a]			Khanasser (199)[a]		
Variety	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
Arabi Abiad	4140	5150	9290	2800	2790	5580	1450	1710	3150	930	1140	2070
Beecher	4320	6020	10340	2620	2940	5560	1050	1650	2700	880	1230	2120
Cytris	3440	5260	8700	2120	2690	4810	880	1580	2460	370	1300	1660
Rihane 'S'	4100	5170	9270	2260	2750	5350	1120	1530	2650	760	1140	1890
Swanneck	3390	5430	8830	2140	2720	4860	890	1350	2240	660	1090	1660
Mean	3880	5410	9290	2460	2780	5200	1080	1570	2640	720	1180	1880
LSD (0.05)	584	813	1314	229	271	479	167	250	417	125	209	313

a. Total rainfall (mm).

the field, whether they are retained throughout growth and, if they occur, whether they affect water use and grain yield.

Five varieties of barley (Arabi Abiad, Beecher, Cytris, Rihane - 'S', and Swanneck) were sown at four sites in northern Syria following fallow. The sites, at Tel Hadya, Breda, Grerifeh, and Khanasser, were selected to represent a range of soil types and rainfall. Seeds were treated with fungicide and sown at a rate of 90 kg/ha in rows 17.5 cm apart in plots 12.5 m long x 2.1 m wide. Fertilizer was drilled with the seed at 20 kg N/ha and 60 kg P_2O_5/ha and in March crops were further topdressed with nitrogen at 20 kg/ha at Breda and Grerifeh and 40 kg/ha at Tel Hadya. The plots were arranged in a randomized block design replicated six times at all sites.

Intensive measurements of shoot development, shoot growth, root growth, and water use were made at Breda and Grerifeh. Fewer measurements were made at Tel Hadya and Khanasser but shoot and root growth were assessed at anthesis and final yields recorded.

Arabi Abiad and Beecher consistently produced more dry matter than the other varieties at maturity (Table 8). With the exception of the wettest site (Tel Hadya), Arabi Abiad produced heavier grain yields than all other varieties; its harvest index (ratio of grain weight : total shoot weight) is greater than that of Beecher. However, as in previous studies, the total amount of water used by each variety at each site was similar, resulting in varietal differences in water-use efficiency of dry-matter and grain- yield production (Table 9).

Table 9. Total water use and water-use efficiency (WUE) of grain yield at Breda and Ghrerifeh.

	Water use (mm)		WUE (kg/ha/mm)	
Variety	Breda	Ghrerifeh	Breda	Ghrerifeh
Arabi Abiad	241	200	11.6	7.3
Beecher	240	199	10.9	5.3
Cytris	232	198	9.1	4.4
Rihane 'S'	239	200	10.9	5.6
Swanneck	240	198	8.9	4.5

The distribution of root length within the

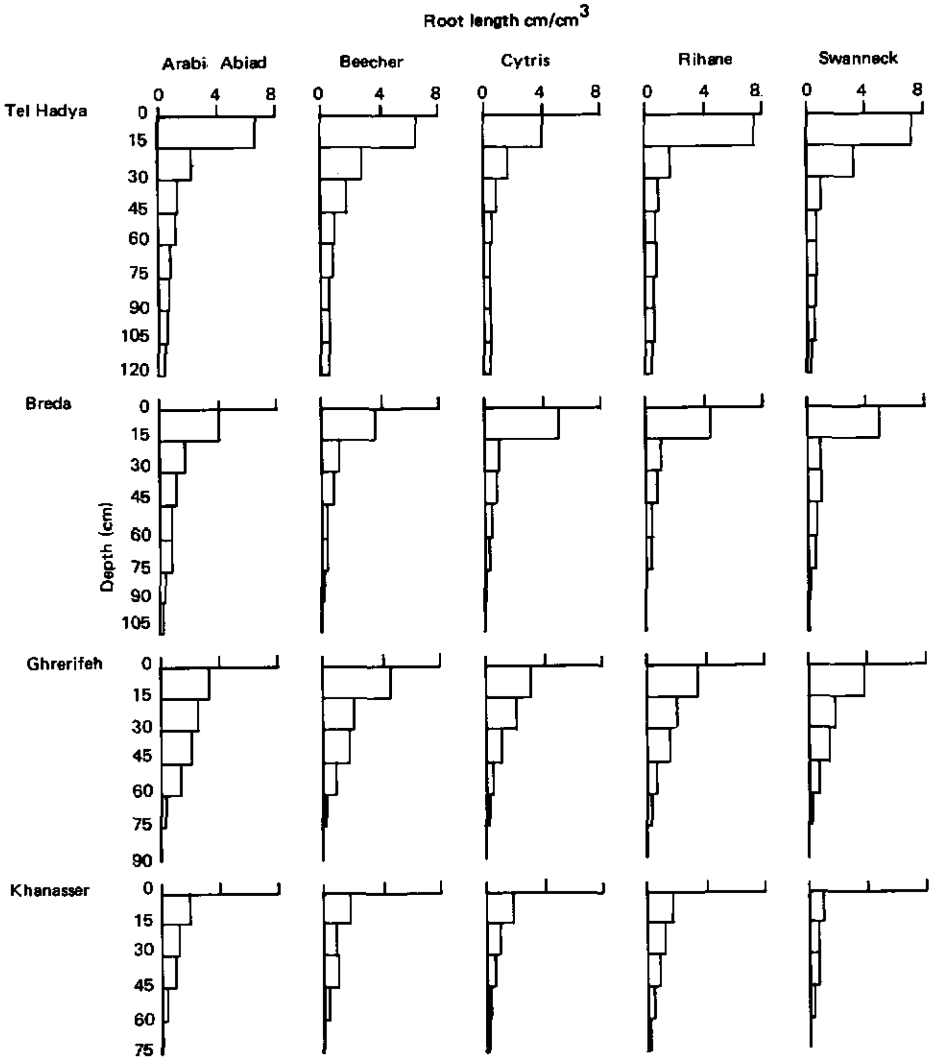


Fig. 8. Root length of five barley varieties at anthesis.

soil profile was measured for all varieties at all sites at anthesis. There were marked differences between sites in both the total root length and the depth of rooting (Fig. 8) and both of these measures decreased as the sites became drier. The root length at any particular depth is highly variable but statistical analysis showed that Arabi Abiad had more root length in all layers deeper than 30 cm than other varieties at all sites except the wettest, Tel Hadya. This result is consistent with results obtained in 1983. Further analysis of the results will be undertaken to determine whether there were differences between varieties in the timing of water use and the changes in dry matter per unit of water used during the season. The significance of the differences in rooting patterns will also be assessed. --*P. Gregory, A. Wehbe, S. Brown, and H. Harris.*

Feasibility of Rotations with Legumes: The Mature Crop Option

In Syria, the high-rainfall areas are associated with intensive cultivation of wheat, legumes, summer crops, and tree crops, while much of the steppe is permanent grazing land. Between these areas lie the dry cultivated areas of Syria, with average rainfall between 200 and 350 mm. Soils are frequently low in available phosphate (FSP 1982; Harmsen 1984) and are often shallow or stony.

In these dry cultivated areas, the primary agricultural activity of the rural population is barley production integrated with raising sheep. The predominant crop rotation is cereal/fallow, but a secondary practice is continuous or nearly continuous cereal cultivation (FSP 1982; Tully 1984). From the point of view of total agricultural output, both systems may be improved by using alternative crop rotations. Legume crops which replace fallow produce a source of food, feed, or income at little cost to the subsequent cereal crop, according to on-station research (ICARDA 1985). Alternatively, legumes act as a break-crop in continuous cereal cultivation, inhibiting soil diseases and contributing to soil fertility.

In spite of these advantages, economic analysis of previous on-station trials suggests that rotations of barley with vetch are less profitable than either a barley-fallow rotation or continuous barley with fertilizer (ICARDA 1985). The main problem appears to be the low profitability of the legume crops themselves. The purpose of the current research is to evaluate the potential of legume crops in farmers' fields in the dry area, and to test some factors which may be limiting their productivity.

Survey research suggests that in northwestern Syria, legume cultivation decreases rapidly below the 350 mm isohyet (Fig. 9). Legumes are mostly grown in wetter areas and on better soils, while fallowed land

Table 10. Mean percentage crop areas in the 250-350 mm rainfall zone, NW Syria (Tully 1985).

	Cereals[1]	Legumes[2]	Summer crops[3]	Fallow[3]
Rainfall group				
Wet (350 mm)	45	20	23	12
Medium Wet	50	12	11	27
Medium Dry	56	1	2	41
Dry (250 mm)	60	1	3	36
Soil type				
Good	55	13	16	16
Medium	47	13	16	24
Poor	54	3	0	43
Total	52	8	10	30

1. Effects of rainfall, significant at $P < 0.01$.
2. Effects of rainfall, soil significant at $P < 0.01$.
3. Effects of rainfall, soil significant at $P < 0.01$; interaction significant at $P < 0.05$.

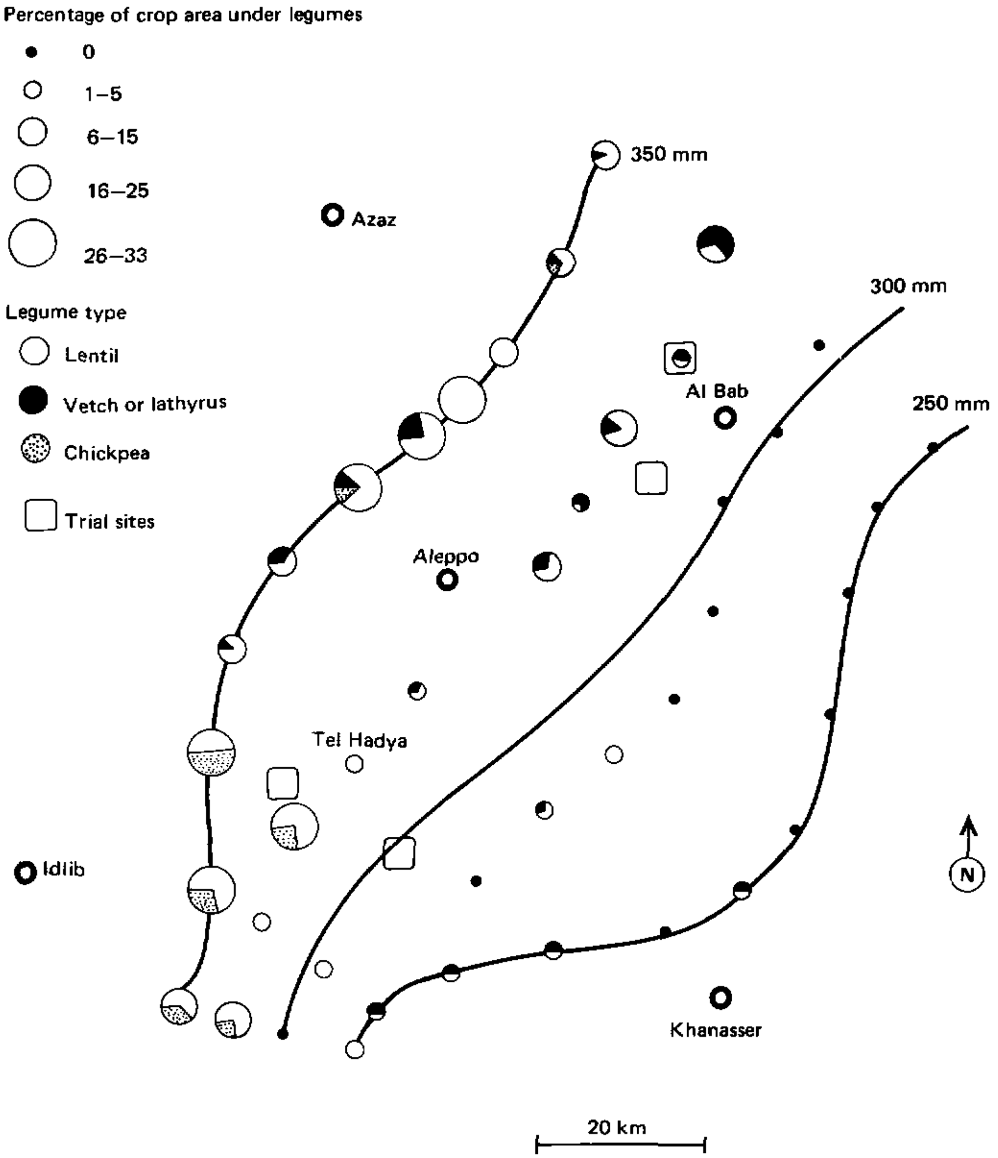


Fig. 9. Legumes as a percentage of crop area in the 250-350 mm rainfall zone.

is more common in drier areas and on lower quality soils (Table 10). Therefore, to expand legume cultivation their potential in these more difficult conditions must be demonstrated. On-farm trial sites were situated in three villages in the 250-350 mm rainfall zone, on fields of diverse quality. Two replicates were also planted at Tel Hadya for comparison.

In wetter parts of Syria, legume profitability is limited by high harvest costs. In areas below 350 mm rainfall,

Table 11. Farmer evaluation of the importance of factors limiting legume cultivation[1] (Tully, unpublished).

Rainfall group / Factor: Importance:	Low yield[2]			Startup cost			Harvest cost[3]		
	Much	Some	None	Much	Some	None	Much	Some	None
Wet (350 mm)	1	5	5	1	3	7	11	0	0
Medium Wet	6	1	2	1	3	4	5	0	5
Medium Dry	8	1	1	2	3	2	3	1	3
Dry (250 mm)	6	1	0	4	0	2	2	1	3
Total	21	8	8	8	9	15	21	2	11

1. Figures are number of respondents.
2. Chi-square significant at $P < 0.01$.
3. Chi-square significant at $P < 0.05$.

however, the major factor limiting legume cultivation appears to be low yields (Table 11). Thus, it is necessary to determine if it is possible to use existing technologies to raise the yield and profitability of legume crops.

Previous research has suggested that legume yields are often improved with phosphate fertilizer. In addition, research on lentils and vetch has indicated that damage to root nodules by sitona weevil larvae has a substantial effect on nitrogen fixation and grain yields; this damage can be controlled with Carbofuran (ICARDA 1984, 1985). Phosphate and Carbofuran treatments were included in a simple design with the three legume species most common in dry areas of Syria: vetch, lathyrus, and lentil (*Vicia sativa, Lathyrus sativus,* and *Lens culinaris*) (Table 12).[1]

In addition, the trial was designed to compare barley-legume rotations with the most common local rotations: barley-fallow, unfertilized continuous barley, and fertilized continuous barley. Thus plots of fallow land, barley, and barley with nitrogen were also treated with phosphate and Carbofuran. All plots will be planted with barley in the subsequent season to determine residual effects of crops and treatments.

Yield measurements were taken at maturity,

1. Details of site selection, trial design, and logistics are reported in Tully et al. 1985.

Table 12. Trial design.

Treatments 6 rotations	1983/84	1984/85	1985/86
	Barley	Vetch	Barley
	Barley	Lathyrus	Barley
	Barley	Lentil	Barley
	Barley	Fallow	Barley
	Barley	Barley	Barley
	Barley	Barley+N	Barley+N

2 levels of phosphate: 0, 46 kg/ha (100 kg TSP)
2 levels of carbofuran 5G: 0, 30 kg/ha
2 levels of nitrogen on barley: 0, 60 kg/ha (20 kg with seed and 40 kg top dressing in March)
Split-strip design: rotations as main plots split by carbofuran, P_2O_5 in a strip.
One replicate per farm on four farms in each of three villages; two replicates at Tel Hadya; 200 m^2 plots.
Legumes inoculated; barley treated with fungicide.
Local cultivation and planting practices.
Previous crop: unfertilized cereal.

when farmers usually harvest, for all crops. In addition, one possibility for improving the profitability of legume crops is grazing them *rather than harvesting them.* Therefore, samples were taken in mid-April to assess the dry matter available for grazing. A direct test of the grazing option was carried out in a set of associated trials, reported in the next section. Biological nitrogen fixation was assessed using the acetylene reductase activity (ARA) technique, and nodule damage by sitona larvae was assessed monthly from root samples.[1]

Legume Results

In reviewing the results the climate in 1984/85 should be considered (see "1984/85 Meteorological Summary"). The low temperatures in late winter had a depressing effect on both crops and insects, especially sitona weevil. Seasonal rainfall was not far from average, but spring rains (in the period of seed filling) were poor. This could be expected to have a substantial effect in those farmers' fields which have a low capacity for moisture storage due to limited soil depth.

As expected, inter-farm variability was high (Fig. 10). Seasonal rainfall in the three trial areas totalled 234, 277, and 301 mm, but these differences showed no relationship to yield. Yields were closely associated with soil depth and stoniness, and frost also clearly affected one field. In spite of this variability, treatments had a significant effect (Table 13), although Carbofuran appeared to have less of an effect in high-yielding sites than in low-yielding ones.

The three legumes showed different growth patterns. At the grazing stage, vetch was more productive than lathyrus and lentils.

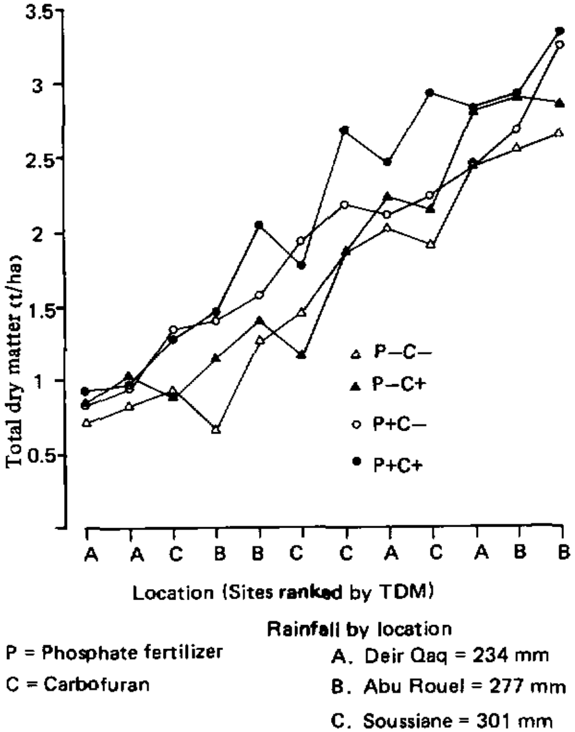


Fig. 10. Biological yield by site and treatment.

However, by the end of the season lathyrus had nearly caught up with vetch in total biological yield, and far exceeded vetch in seed production. Since the seeds of these legumes are quite high in protein, the high harvest index of lathyrus also indicates high protein production compared to the other species. Lentil growth was similar to lathyrus at the grazing stage, but there was no late surge in growth as with lathyrus. These results are consistent with other research reported this year (see "Forage Legumes: The Grazing Option"). They will be checked next season, since they may only reflect the relative adaptation of these legume species to spring drought or late frost.

The different species exhibited significant differences in biological nitrogen fixation as assessed by ARA and sitona damage.

1. ARA and nodule damage were not monitored in Tel Hadya experiments.

Table 13. Legume results from on-farm sites.

	Grain (kg/ha)	Straw (kg/ha)	Total dry matter	Harvest index	Grazing[1] (kg/ha)	ARA[2]	Nodule damage[3] (%)
ANOVA Levels of Significance							
Species	xx	xx	xx	xx	x	xx	xx
Phosphate	xx	xx	xx	ns	x	xx	ns
Carbofuran	xx	xx	xx	ns	xx	xx	xx
SP X P_2O_5	ns	ns	ns	ns	ns	xx	ns
SP X Carb.	x	ns	x	ns	ns	ns	xx
Main Effect Means							
Species							
Vetch	731	1322	2054	0.34	573	565	18.4
Lathyrus	866	1018	1884	0.46	432	773	3.1
Lentil	600	1041	1641	0.36	434	299	26.5
Phosphate							
With	802	1221	2024	0.39	507	604	15.1
Without	657	1035	1692	0.38	455	488	17.0
Carbofuran							
With	769	1196	1965	0.39	516	605	27.6
Without	691	1062	1753	0.39	446	487	4.5

Selected Species x Carbofuran Interactions

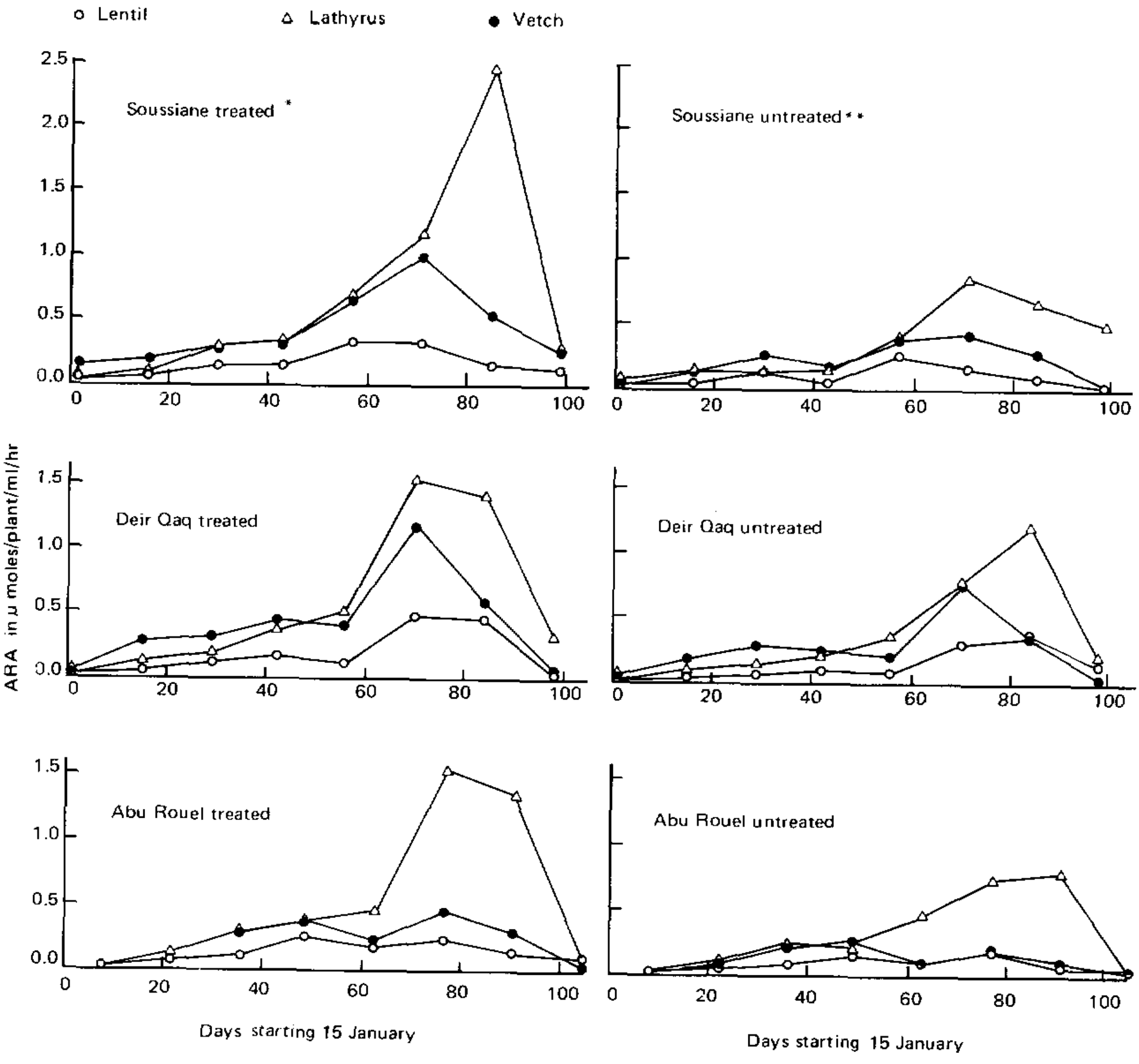
	Grain		Straw		TDM		BNF		Nod. damage	
Carbofuran	+	–	+	–	+	–	+	–	+	–
Vetch	820	647	1448	1202	2253	1862	651	479	5.7	31.3
Lathyrus	866	866	1092	940	1903	1866	828	718	1.0	5.3
Lentil	633	566	1128	954	1747	1535	335	264	6.8	46.3

x=$p<0.05$; xx=$p<0.01$.

1. Total dry matter (kg/ha) of samples taken in the first half of April.
2. ARA figures are the product of seasonal mean ARA (moles/ml/plant/hour) by thousands of observed plants/ha. They are relative values only.
3. Maximum observed levels.

For all species, ARA activity was slow to develop due to low temperatures and sitona damage occurred about one month later in the season than usual (Fig. 11) (ICARDA 1985, ICARDA 1984). It is clear that lathyrus is superior to vetch and lentils in nitrogen fixation, irrespective of treatment. Thus, although lathyrus produced more seed, with a large content of nitrogen, this was not at the expense of soil nitrogen. In addition, lathyrus appears to be relatively unaffected by sitona weevil, which may partially account for the differences noted above.

The differential effect of sitona weevil on the three species is clear in their responses to Carbofuran. Nodule survival and BNF were improved by Carbofuran in all species, but the effect on lathyrus was small.



*Treated = P^+C^+
**Untreated = P^-C^-

Fig. 11. ARA activity over time, 1984/85 season. (Results are mean activities observed at the four farms in each of the three villages.)

Lentil and vetch without Carbofuran suffered considerable nodule damage, but even these levels were low compared to other years and locations. Damage levels of 94-96% have been reported at Tel Hadya in the last two years (ICARDA 1984, 1985), and a survey of farmers' fields in 1980 found average damage of 68% (Tahhan and Hariri 1982). This season, spot checks in farmers' fields in five legume-growing villages showed mean nodule damage of 57-88%. Percent nodule damage was the only variable which showed no significant variance across trial fields, indicating that the insect responsible is very widely distributed.

As a result of the species' differences in susceptibility to sitona damage, Carbofuran had different yield effects on the three legumes. There was no response in grain yield in lathyrus and only a 2% increase in total biological yield. On the other hand, total biological yields of lentil increased by 14% and vetch by 21%.

The effect of Carbofuran may be questioned, because the chemical has also been reported to have nematocidal and quasi-hormonal effects. However, both pot experiments and on-farm trials with lentils comparing Carbofuran to Heptachlor (which has not been reported to have nematocidal or hormonal effects), have failed to show any difference between them (ICARDA 1984, 1985). This suggests that the main effect of Carbofuran, on lentils at least, is as an insecticide. Furthermore, over all three legumes, when nodule damage is used as a covariate in the analysis of variance, the significance of the Carbofuran effect on both yield and ARA is eliminated. This suggests that the major effect of carbofuran on legumes is to protect root nodules from sitona damage.

Phosphate fertilizer increased mean legume yields by 20%, with no significant differences among species in yield variables. The only significant species-phosphate interaction was found in ARA activity, where phosphate increased ARA in vetch and lathyrus more than in lentils.

In Tel Hadya, the main effects were all significant and similar to those observed in farmers' fields, but yields were approximately twice as high. These will be discussed in the economic analysis.

Barley Results

In on-station work, barley crops following cereals show substantial responses to both nitrogen and phosphate (see "Implications of Crop Rotation, Year, and Residual Effects on Fertilizer Responses of Barley"). This was confirmed on farm in this trial (Table 14). In addition, the barley showed an unexpected and significant response to Carbofuran, which was applied to the barley and fallow only to maintain consistency of treatments across species. This suggests that Carbofuran has a quasi-hormonal effect on barley, although nematode control may also be partially involved.

Production of Spring Grazing

One possibility for reducing legume production costs is through grazing the crop in spring rather than harvesting it. Samples were taken in mid-April to evaluate the grazing potential of the various crops. Vetch was clearly superior at the grazing stage, with total dry-matter of 573 kg/ha compared to 432 and 434 for lathyrus and vetch. However, barley dry - matter production was substantially greater than all legumes with a mean of 807 kg/ha over all treatments. A number of farmers are growing continuous barley for grazing because of this high productivity. This raises the question of whether continuous barley as a spring grazing crop has the same negative effects that are associated with continuous barley as a harvested crop. If not, barley would be a better choice for a grazing crop.

Economics of Crops and Practices

Yield responses to treatment are apparent in these experiments, but whether the treatments, or the crops themselves, can be used profitably is still to be considered. The costs and returns to the various production

Table 14. Barley results from on-farm sites[1].

	Grain (kg/ha)	Straw (kg/ha)	Total dry matter	Grazing (kg/ha)
ANOVA Levels of Significance				
Nitrogen	x	x	x	ns
Phosphate	xx	xx	xx	xx
Carbofuran	x	xx	xx	xx
Main Effect Means				
Nitrogen				
With	1446	2628	4074	879
Without	1072	2017	3089	735
Phosphate				
With	1440	2610	4050	922
Without	1077	2034	3111	702
Carbofuran				
With	1378	2589	3967	900
Without	1127	2037	3164	715

x=$p<0.05$; xx=$p<0.01$.

1. Grain, straw, and TDM are based on eight sites; four were damaged by grazing before samples were taken.

practices are estimated in Table 15. Legumes are treated as a group, pending confirmation of inter-species differences in other seasons. In this season, lathyrus was the best producer and lentil the worst. The assumed cost of Carbofuran is two-thirds of the actual cost, because equal control can be achieved with 10-20 kg/ha, rather than the 30 kg used in this experiment. Barley yields are given for nonCarbofuran treatments because Carbofuran is not being considered as a barley treatment.

The feasibility of crops and treatments varies with the yield potential of the field. Therefore trial results have been grouped *post-hoc* into low- and high-yielding farms, based on the total biological yield of the legumes. Tel Hadya results are shown as a separate category.

In the low-yielding fields, mean income across all treatments was 405 SL/ha, the equivalent of about 6 days' wages in off-farm work. Rates of profit were also relatively low. Thus it is not surprising that most farmers fallow their poorer fields after cereals. Furthermore, legume income was half that of barley. Phosphate improved profitability and net income figures for both legumes and barley but Carbofuran application was unprofitable at this yield level.

These findings are relevant to the feasibility of legume rotations on these fields. At these income levels, it is doubtful that farmers will plant fertilized legume crops after cereal on low-quality fields under current economic conditions. However, phosphate application on cereal crops could have a residual effect on subsequent crops (see "Phosphate Fixation and Management in Calcareous Soils"). Thus if the use of phosphate on cereal crops becomes more common on low-yielding fields, it may increase the feasibility of legumes as rotation crops.

Table 15. Economic returns to crops and treatments (per ha).

	Grain yield (kg/ha)	Straw yield (kg/ha)	Total revenue (SL/ha)	Basic costs (SL/ha)	Treatment costs (SL/ha)	Net income (SL/ha)	Profit on total costs (%)	Profit on treatment costs (%)
				Low-Yielding Farms				
Legumes								
P– C–	347	605	1117	801	0	316	39	NA
P– C+	390	666	1243	822	400	21	2	–74
P+ C–	476	847	1548	868	134	545	54	171
P+ C+	522	864	1639	887	534	218	15	–18
Barley[1]								
P– N–	341	671	796	649	0	147	23	NA
P– N+	689	1414	1637	794	254	589	56	174
P+ N–	468	941	1102	702	134	266	32	89
P+ N+	1128	1927	2486	956	388	1142	85	257
				High-Yielding Farms				
Legumes								
P– C–	889	1335	2668	1061	0	1607	151	NA
P– C+	968	1489	2937	1103	400	1434	95	–43
P+ C–	1032	1436	2995	1123	134	1738	138	98
P+ C+	1148	1698	3422	1187	534	1701	99	18
Barley[1]								
P– N–	1300	2247	2429	593	0	1836	309	NA
P– N+	1531	2841	2919	640	254	2025	227	75
P+ N–	1665	3002	3148	667	134	2347	293	382
P+ N+	1881	3185	3495	711	388	2396	218	144
				Tel Hadya				
Legumes								
P– C–	1463	2004	4218	1329	0	2889	217	NA
P– C+	1810	2249	5011	1478	400	3133	167	61
P+ C–	1632	1928	4428	1386	134	2908	191	15
P+ C+	2071	2440	5613	1591	534	3488	164	112
Barley								
P– N–	2048	2939	3646	745	0	2902	390	NA
P– N+	2324	3422	4164	801	254	3109	295	82
P+ N–	2474	3142	4282	831	134	3318	344	310
P+ N+	2677	3678	4717	872	388	3457	274	143

Assumptions:

Seed value: barley 1.35, legumes 1.65. Straw value: barley 0.5, legumes 0.9.

Cost of cultivation, seed, broadcasting: barley 230, legumes 343.

Harvest and postharvest costs:

Barley on low-yield farms (hand harvest): 7 + (TDM/800) harvest days @ SL 40/day; SL 26/100 kg seed for transport, threshing, winnowing.

Other barley (combine harvested): 15% of seed for harvest, transport, winnowing; 60% straw recovery at a cost of SL 100 for labor.

Legumes: 7 + (TDM/500) harvest days @ SL 40/day; SL 44/150 kg seed for transport, threshing, winnowing.

Treatment costs: phosphate 134, nitrogen 254, carbofuran 400.

1. Based on four sites. Two in each group were damaged by grazing before samples were taken.

On the high-yielding fields, income figures were better. Legume income increased to about 75% that of barley, but it required more cash outlay, and thus produced lower rates of return on money invested. Carbofuran was not profitable on legumes and decreased net income. Phosphate increased net income on legumes by 8% at a slightly reduced rate of profit, but it increased barley income by 28%.

At Tel Hadya the legumes produced as much net income as barley. Carbofuran was profitable on legumes, while phosphate gave reasonable profits only in the presence of carbofuran. Barley has lower costs than legumes and thus is more profitable.

Conclusions

Our figures represent a single year's production after a cereal crop but most farmers look beyond a single year, and take the long-term crop rotation into account. Therefore, growing a crop instead of fallowing the land has a cost which is not counted here: possible reduced yields on the subsequent crop. Thus the fact that income from legume crops approaches that of barley on better fields is positive for legumes, because a cereal crop following legumes should produce a substantially higher yield than one following barley. The residual effect of the current season's practices will be tested in the coming season on a uniform barley crop.

In better fields, net income from legumes can approach or equal that of barley, but the legume crops require a higher investment. Thus many farmers who grow continuous barley explain that they do so because they are poor. This is an area where the Cooperatives and the Agricultural Bank could act to enhance the attractiveness of legumes through credit arrangements to reduce seed cost. A greater problem is the harvest cost, which accounts for most of the difference between legumes and barley in net income and profitability (Table 15). Short-term credit for hiring harvest labor could make it easier for poor farmers to grow legume crops. In the long run, mechanical harvesting techniques would have the same effect.

Phosphate was consistently profitable, but at lower levels with legumes than with the cereals. Therefore, if phosphate or cash is limited, it might best be applied to the cereal course of a rotation, allowing the legumes to use residual phosphate.

Carbofuran was only profitable at Tel Hadya, and while it produced a good percentage yield response on farmers' fields, increased revenues were too low to pay for it. However, if application rates can be reduced to 10 kg/ha or less, carbofuran would be more profitable than it appears in these results. It would be most economic on specific crops, such as vetch, which are susceptible to sitona attack. If treated plots produce a better barley crop in the next year, due to greater nitrogen fixation, this would increase the profitability of Carbofuran in the longer term.

Rotations with legume crops appear to have potential for better yields in the barley-growing areas of Syria, and to be more profitable than on-station work has so far indicated. Legumes produce revenue approaching that of barley after a cereal crop, and should have a better effect than barley on a subsequent cereal crop. Treatments with phosphate and Carbofuran improve crop yields substantially but have a lesser effect on income; additional research is required to determine economically optimal rates for these treatments.

Forage Legumes: The Grazing Option

Sheep milk and meat are the major outputs of the barley/livestock system in the Breda/Bueda area and forage legumes are being evaluated as an alternative to fallowing land or growing continuous barley. The trials integrated livestock and agronomy in individual on-farm studies which assessed the meat/milk production potential of forages and their effect on the subsequent barley crop. Farmers may then apply these methods and provide feedback to researchers on possible factors hindering adoption of the practice.

The on-farm grazing trials in 1984/85 had the following objectives: (i) to assess the dry-matter yields of vetch and lathyrus, with and without phosphate fertilizer, and (ii) to measure the milk yield potential of sheep grazing vetch, lathyrus, and communal village grazing lands using separate flocks of Awassi ewes.

Details of the methodologies and results of the trials are presented by Tully *et al*, (1985), and Thomson *et al.* (1985), respectively.

Methodology

Trials were conducted on eight farms. Vetch (*Vicia sativa*, local cultivar) and lathyrus (*Lathyrus sativus*, local cultivar) were planted, using farmer practices, on plots of 0.7 to 1.0 hectare separated by a fallow strip at least 10 m wide. Half the area of each forage received 50 kg/ha of P_2O_5. Plots were fenced to assist in grazing management and to keep out stray animals.

Sheep flocks on the eight farms were divided into three groups; a control, grazing communal lands according to traditional practices, and separate flocks grazing either vetch or lathyrus. Each group had at least five lactating ewes, generally without lambs. Before grazing started, groups were balanced for liveweight and milk yield using information from the pregrazing period when all three groups were herded together. Grazing of the appropriate treatments started when sufficient herbage became available in early April. When forage pastures were exhausted the three groups were herded together for a 7- to 14-day postgrazing period.

Samples were taken from the grazing trials for dry-matter determination at the hay (mid-flowering) stage, corresponding to the start of grazing, and the mature stage, on April 3 and April 29, respectively. Herbage sampled at the mature stage was protected from grazing with cages.

Milk yield and liveweight of at least five ewes per treatment were measured once or twice during the pregrazing and postgrazing periods. During grazing milk yield was measured every 7 days and liveweight every 14 days.

Results

Unfertilized and fertilized vetch yielded more hay ($p<0.05$) than the corresponding lathyrus treatments (Table 16). However, by the mature stage, unfertilized lathyrus yielded more straw plus grain than unfertilized vetch ($p<0.05$) because lathyrus accumulated dry matter at twice the rate of vetch. Yields in the fertilized treatments were similar. This may indicate that lathyrus can fix more nitrogen (see "Feasibility of Rotations with Legumes: The Mature Crop Option"), and extract more soil nutrients and moisture under low-fertility conditions than vetch. Farmers in the area appear to be aware of this difference since lathyrus is grown on small areas, whereas vetch crops are very uncommon.

At the hay stage there was a similar response to phosphate application by both species. However, at the mature stage the response of vetch was greater than lathyrus. Other studies at ICARDA showed this species difference at the hay stage, but no yield measurements were made at the mature stage (ICARDA 1982, 1983).

Although the yield potential of vetch and lathyrus may be similar, the higher harvest index of lathyrus (Table 16) gives it a considerable advantage over vetch. With the grazing option, 16-22% of the lathyrus crop area would be needed for seed production

Milk yields of Awassi sheep are recorded in on-farm trials evaluating the potential of forage legumes.

Table 16. Dry-matter yields (kg/ha) of vetch and lathyrus, with and without phosphate fertilizer application, harvested at the hay and mature stages.

	Crop rotation				LSD
	Bo/Vo[1]	Bo/V+	Bo/Lo	Bo/L+	(0.05)
Forage yields:					
Hay (n=6)[2]	765	1288	489	835	239.9
Mature crop (n=8)	1258	2063	1544	1863	367.6
Straw (n=8)	908	1404	810	888	223.7
Grain (n=8)	350	659	734	975	139.1
Harvest index (n=8)	28	32	47	42	11.1

1. See text for explanation of symbols.
2. Number of observations in each mean.

compared with 24-46% for vetch. This is important if farmers want to maximize grazable area and minimize high harvest costs.

If the crops are harvested at the mature stage, lathyrus could yield 9-35% more metabolizable energy and protein per hectare because of its higher harvest index. Also, the mature crop would yield up to 50% more metabolizable energy than hay. The extra costs of harvesting the mature crop would be small compared with this yield advantage.

Unadjusted and adjusted milk yields are shown in Table 17. Milk yield measured during the pregrazing period was used to adjust milk yields measured during grazing. This adjustment was necessary since differences in initial milk yields across treatments were sometimes large, even though attempts were made to remove this source of bias when allocating ewes to treatments. Before adjustment, milk yields of ewes grazing forages were slightly higher than ewes grazing communal land ($p<0.05$). However, after adjustment, milk yields across treatments were similar.

During the first 21 days of the grazing period, ewes grazing vetch and lathyrus gained more liveweight than ewes grazing communal lands (Table 17). The nutrients supplied by forages exceeded the needs of these unimproved Awassi ewes, with a modest milk yield

Table 17. Daily milk yields, liveweight, and liveweight changes of ewes grazing common lands, vetch, and lathyrus during three experimental phases.

	Grazing treatment			Standard error of difference
	Common land	Vetch	Lathyrus	
Milk yield (g/ewe)				
Pregrazing	512	465	568	55.0
Grazing	542	594	582	32.2
Postgrazing	377 [a]	425 [b]	368 [a1]	18.3
Adjusted milk yield (g/ewe)				
Grazing	542	543	526	44.0
Postgrazing	377	370	333	34.4
Liveweights (kg)				
Pregrazing	42.6	42.9	42.6	1.09
Grazing	48.1	49.0	49.5	1.13
Postgrazing	49.6	50.8	50.6	1.23
Liveweight Changes (g)				
Day 0-7	259 [a]	300 [ab]	356 [b]	29.64
Day 7-21	211 [a]	240 [ab]	272 [b]	20.90
Day 21-35	143	161	160	11.73
Day 35-56	59 [a]	60 [a]	21 [b]	13.93

1. Means followed by different superscripts are significantly different ($P < 0.05$).

potential in mid-lactation. The excess nutrients were partitioned to body tissue synthesis.

The similarity of the milk production and liveweight gains of ewes grazing forages and communal lands probably occurred because ewes *in the control group compensated for the lower* herbage availability on communal lands by spending more time grazing each day. *Furthermore,* the nutritive value of the forages and natural herbage were similar. In villages where communal grazing is limited, forages could provide lactating ewes with spring grazing. Where communal village grazing is available, forages could be used to fatten lambs which has been shown to be very profitable. In either case, the option to grow crops for seed and straw remains.

The productivity of the vetch and lathyrus forages is shown in Table 18. The average number of sheep per group was higher and the plot area was lower than originally planned. Furthermore, the cold spring weather delayed the start of grazing. The short growing season and the high stocking rate of about 20 ewes per hectare led to a short grazing season. The dry-matter yield, the dry-matter available to ewes, milk yields, and live weight gains per hectare were similar for each treatment. The dry-matter availabilities and milk yields were double those reported for the previous year.

Dry-matter yields and meat and milk outputs from the forages were sufficient to make them economically attractive. The choice between lathyrus and vetch appears to depend on the method of using the crop, and the adoption of forages will depend on phosphate

Table 18. Productivity of vetch and lathyrus pastures.

	Vetch	Lathyrus	Standard error of difference
Number of flocks	5	5	
Number of sheep	10.8	10.8	
Plot area (ha)	0.51	0.56	
Duration of grazing (days)	31.2	31.2	
Stocking rate (sheep/ha)	20.6	19.6	
Dry-matter yield (kg/ha)[1]	1681	1845	81.1
Herbage availability [2] (kg DM/sheep/day)	2.9	3.6	0.42
Milk yield (kg/ha)	365	333	28.9
Liveweight gain (kg/ha)	93.4	88.8	11.0

1.Mean from second sampling, fertilized+unfertilized plots.
2. Six of 8 legume sites were grazed.

fertilizer application. The use of forages would depend less on the availability of seed as this can be produced by farmers themselves.

Future Research

These on-farm trials provide yield data which represent what the farmer would expect if he adopted the practice. The trials also provided valuable experience into the problems associated with on-farm trials involving livestock. In the next step of these on-farm grazing trials the farmer will make all the major decisions on crop management and utilization. He may decide to use it for grazing by lactating ewes or fattening lambs, or to let it mature to produce seed for the next season. ICARDA will provide only seed and fertilizer in 1985/86 and monitor how the farmer uses the crop. The national program will be increasingly involved in this research.--*E. Thomson, R. Jaubert, and M. Oglah.*

Forage Agronomy: Effects of Seed Rate, Species, and Sowing Method on Legume Yields

Surveys have indicated that legume crop areas are being reduced in northwestern Syria, primarily because of declining profitability. One factor contributing to high costs is the use of high rates of expensive seed (150-225 kg/ha). A trial was undertaken to determine whether seed rates could be reduced in vetch, lathyrus, and lentil and whether sowing method had an effect on optimal seed rate. The trial was factorial, with species and sowing method as main plots, split by seed rate and there were three replicates. All plots were inoculated and treated with 60 kg/ha phosphate and 20 kg/ha Carbofuran 5G.

Results

Seed rate had a substantial effect on hay yield but by the mature stage, when most farmers harvest, there were no significant differences between the 125, 175, and 225 kg/ha rates (Table 19). This suggests that farmers could reduce their seed rates to as low as 125 kg/ha without reducing yields. At 75 kg/ha, however, yields at Tel Hadya were significantly lower. Interactions with sowing method and species were not significant.

There were few differences among species. Lathyrus produced the highest quantities of seed, which agrees with on-farm trial results. Total biological yields of lentil were significantly lower than vetch and lathyrus at Tel Hadya.

Drilling significantly increased yields in four out of six measures, including a 33% increase in hay and a 24% increase in total biological yield at Breda. At Tel Hadya, responses were smaller. Drilling provides improved crop geometry and fertilizer placement, which has increased cereal yields by approximately 10% (Cooper *et al.* 1981).

Table 19. Effects of seed rate, species, and sowing method on legume yields (kg/ha).

	Hay yield[1]	Seed at maturity	TDM at maturity	Hay yield	Seed at maturity	TDM at maturity
		Breda			Tel Hadya	
Seed rate (kg/ha)						
75	2160	1980	4370	2220	2020	4260
125	3390	2080	4650	3280	2330	5020
175	3490	2070	4780	4060	2280	5060
225	4120	2010	4800	4060	2290	5090
LSD (0.05)	530	305	720	454	347	630
Species						
Vetch	3440	1990	4960	3660	2350	5550
Lathyrus	3140	2370	4630	3140	2640	5200
Lentil	3300	1740	4360	3410	1710	3830
LSD (0.05)	373	183	452	321	234	566
Sowing method[2]						
Drill	3750	2280	5140	3680	2232	5090
Broadcast	2830	1780	4160	3130	2150	4610
LSD (0.05)	305	149	369	262	191	461

1. Flat pod stage.
2. Drill at 17.5 cm row spacing; broadcast at 48 cm and covered by tabban.

This trial suggests that these legumes may also be responsive to improved sowing methods.

Hay yields were on average 71% of mature TDM yields, indicating that legumes produce much of their yield late in the season. This is probably why farmers harvest legume crops as late as possible, even though this creates a labor bottleneck. It also suggests that trials with legumes harvested at the hay stage will show substantially lower profitability than farmer practices since the increased production at maturity (and its value) will more than offset the slightly increased harvest cost.

The first year's results suggest that there is a potential for increased profitability of legume crops through reduced seeding rates and improved sowing methods. Lathyrus and vetch can be more profitable than lentils but factors such as seed availability and crop marketing may make lentils more attractive to farmers even if yields are lower. These are preliminary results and the trial will be repeated in 1985/86.--*D. Keatinge, D. Tully, and H. Harris.*

Supplementary Feeding and Efficiency of Feed Use at Bueda

A village survey based on 19 farms in the Bueda area was continued for a second and final year. Special attention was given in 1984/85 to investigating supplementary feeding strategies since they represent one of the most significant costs in livestock production. The survey aimed to identify ways of improving the efficiency of supplementary feed use. It also provided a unique opportunity to monitor management strategies of farmers during and following the drought year of 1983/84.

Levels and Composition of Supplementary Feeds

The high levels of supplementary feeding reported in earlier surveys in Aleppo Province were confirmed (Table 20) even following a drought year marked by a total crop failure. These levels may exceed the metabolizable energy (ME) needs of ewes by up to 40%. Farmers maintained feeding levels in 1984/85 by purchasing 90% of the feed since feed reserves were depleted following the preceding drought year.

There was evidence from the 1984/85 data that farmers vary feed ingredients from year to year to minimize costs. For example, wheat grain, being 7% cheaper, replaced some of the barley grain. However, the amount of cereal grain was 50% lower in 1984/85 compared with 1983/84 (Table 21) and this was compensated for by an increase in the proportion of industrial by-products. These changes

Table 20. Levels of supplements offered to sample flocks in terms of dry matter (DM), metabolizable energy (ME) and crude protein (CP), (± = SD).

	November	December	January	February	Mean
DM (kg/ewe/day)					
1983/84	1.9 ± 0.4	1.9 ± 0.4	1.9 ± 0.5	1.5 ± 0.6	1.8 ± 0.5
1984/85		1.5 ± 0.7	2.0 ± 0.6	1.8 ± 0.6	1.8 ± 0.6
ME (MJ/ewe/day)					
1983/84	17 ± 4	17 ± 4	19 ± 5	19 ± 6	18 ± 5
1984/85		15 ± 4	18 ± 4	16 ± 5	16 ± 5
CP (g/ewe/day)					
1983/84	163 ± 33	163 ± 33	190 ± 52	182 ± 68	174 ± 49
1984/85		160 ± 73	207 ± 61	147 ± 46	171 ± 59

Table 21. Contribution of feedstuffs in percentage of dry matter (DM), metabolizable energy (ME), and crude protein (CP), (1983/84, Nov - Feb; 1984/85, Dec - Feb).

	DM		ME		CP	
	1983/84	1984/85	1983/84	1984/85	1983/84	1984/85
Grain	36.5	15.8	48.5	22.1	44.5	22.2
Straw	49.7	53.5	33.3	43.2	22.3	24.1
Industrial by-products	13.8	30.7	18.2	34.7	33.2	53.7

Grain: Barley + wheat + lathyrus.
Straw: Barley + wheat + lathyrus.
Industrial by-products: Wheat bran, cotton-seed cake and hull, cotton seed, sugar beet pulp.

occurred due to an increase in cereal grain prices in 1984, whereas industrial by-products are provided by the General Organization for Feed at subsidized prices. Overall, the ME offered to flocks, and feed costs were similar in both years.

Efficiency of Feed Use

In spite of high levels of supplementation, growth rates of lambs in sample flocks were well below those of experimental flocks at Tel Hadya (Fig. 12). Several factors may be responsible for the low efficiency of feed use. First, on-station research has shown that ewe liveweight before lambing has a marked effect on lamb growth performance and in this survey ewe liveweight before lambing was about 20% below optimum. This suggests that low feed efficiency is partly related to inadequate feeding during pregnancy in autumn and early winter. Second, supplements are fed when there is insufficient grazing available in winter and the availability of communal grazing in the spring is uncertain (Jaubert and Oglah 1985). A third factor, which has not been adequately studied, is the detrimental effect of internal parasites on sheep productivity.

Supplementary feeds could be used more efficiently if sheep were penned when communal grazing is poor. A slight reduction in supplementary feeding levels might lead to further savings, even if ewes lost some liveweight. On-farm grazing trials showed that these losses could be replaced in the spring if ewes were to graze annual forage pastures.--*R. Jaubert.*

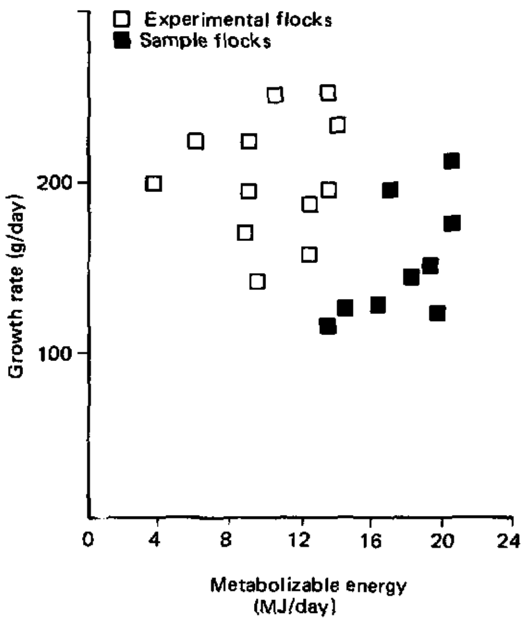


Fig. 12. Growth rates of lambs and levels of supplementary feeding of ewes in early lactation in experimental and sample flocks.

Wheat-Based Systems Research

In the ICARDA region, national programs have focused their research on the higher potential wheat-based farming systems. This research has produced successful recommendations for improved wheat production and farmers are adopting these new technologies. Wheat production in many countries has increased substantially in the last 15-20 years. Nevertheless, production can and must be increased further as wheat is a principal staple food crop.

A survey of current production practices of wheat farmers in Syria was conducted to assess how our research can most usefully complement that of the national program.

The initial results of this survey are reported in some detail, together with a summary of parallel on-farm trials which focused on the important effects of fertilizer and herbicide in farmers' fields. The results from this survey have provided information which has been utilized in planning on-farm wheat and food legume research for 1985/86.

A summary of results obtained in a global cooperative program (IBSNAT), in which we are partners, is also reported. IBSNAT aims to improve the efficiency of transfer of improved production technologies for many crops, and we are assisting in this activity for wheat.

Wheat Production Practices in Northwestern Syria

Wheat is arguably the most important food crop grown in West Asia and North Africa. In Syria, as in other countries of the region, wheat is the most important source of calories and protein in the national diet (FAO 1984). Wheat is second only to barley in crop area in Syria, and because it is grown under more productive conditions, it ranks first of all crops in overall output (SAR 1983).

Syria, like many other countries of the ICARDA mandate area, is pursuing a policy of self-sufficiency in basic food crops, especially wheat (SAR 1981). However, the country has imported a yearly average of 345,000 metric tons of wheat and wheat flour, worth $36 million, during 1977-82 (FAO 1980, 1983). Furthermore, population growth is expected to increase wheat demand for the foreseeable future, emphasizing the need for greater yields in the future.

ICARDA has a regional responsibility for research on wheat, and has been engaged in wheat breeding and agronomy research since 1977. Within the Farming Systems Program, research on wheat has involved fertilization, weed control, tillage systems, and rotations with nitrogen-fixing legumes. Results have been encouraging, with substantial responses to earlier planting date, improved weed control, and fertilization with nitrogen and phosphate (FSP 1984, ICARDA 1984a). However, these responses show large interactions; improved yields from one innovation may depend upon the adoption of a set of associated practices.

The feasibility of new technologies depends in part on the existing farming systems. A survey of wheat producers in northwestern Syria was undertaken to determine the relevance of current research results and to provide direction for new research. The survey was designed to answer the following general questions:

How is wheat grown? To what extent can ICARDA recommendations improve farmer practices? How much room for improvement is there with available technologies?

What problems do farmers have which might be addressed in new research?

What role does wheat play in the farming system? Are wheat production practices constrained by other aspects of the system?

Wheat-Dominated Areas of Syria

Wheat is grown from the wettest to the dryest areas of Syria. In areas where barley predominates, wheat is grown for subsistence, even at the edge of the steppe (Thomson *et al*; Tully 1985, unpublished). In wetter areas (over 325 mm mean annual rainfall), wheat is grown in sufficient quantities to produce a marketable surplus. Barley is also grown in wetter areas but in contrast to the barley-livestock system, it is grown as a marketable alternative to wheat, and not usually for on-farm livestock feeding. Wheat is the yardstick by which other crops are measured.

Irrespective of cereal choice, there is a fairly complex mix of crops, rotations, and input uses in wetter areas. Livestock are also diversified, including both cattle and small ruminants. Many farmers are members of cooperatives, and receive government assistance and advice on seed, fertilizer, and herbicide application.

The most productive rainfed wheat-growing areas are in the wetter parts of the country, and of these, the largest is in the northwest while the second largest, and possibly more productive, is in the northeast. Most market production of wheat is in these regions. The current survey is restricted to northwestern Syria and focuses on rainfed wheat production.

Sampling

Sampling was done as follows:

1. The sampling universe was limited to four provinces: Idlib, Aleppo, Homs, and Hama. Because the survey was concerned with weed control and fertilization, which are more common in the wetter areas, an arbitrary limit was drawn at the 325 mm mean annual rainfall isohyte, as estimated from the Climatic Atlas of Syria (Tully 1985, unpublished). The line followed district boundaries where convenient; where districts were inevitably cut, lists of villages within the imaginary line were compiled.
2. Within the sampling universe, wheat area was approximately 176,000 ha. The smallest administrative units (*nawahi*) were grouped into seven sampling units of similar environmental conditions, each with approximately equal area (25,000 ha) of rainfed wheat (Fig. 13).

3. Within each sampling unit, one subdistrict (*nahiya*) was randomly chosen to allow visits to a larger sample with available resources.

4. Three villages were randomly selected in each subdistrict using the probability proportionate to size (PPS) technique of Lahiri (1951), described in Cochran (1977) and proportionate to the number of families shown in the 1970 census (SAR, n.d.). Urban centers were excluded.

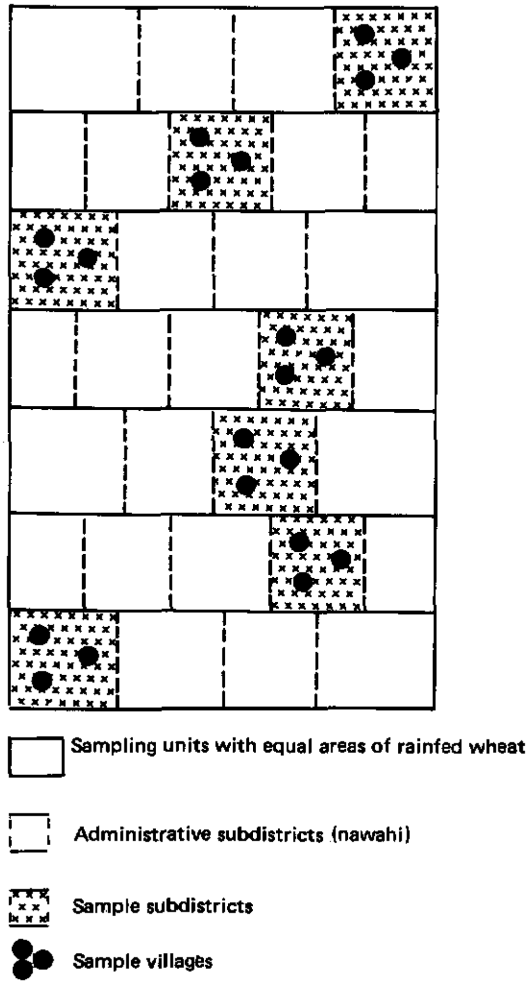


Fig. 13. Sampling design for wheat survey, 1984/85.

Alternative villages were similarly selected in each subdistrict in the event that selected villages did not grow rainfed wheat; alternative villages were used on six occasions. Thus 21 villages were selected.

5. Within each village, lists of farmers growing rainfed wheat this year were compiled and from these, three were randomly selected for interviews. This resulted in a sample of 63 wheat farmers.

Table 22. Soil characteristics of sample wheat plots (% of plots).

Depth	(cm)	Stoniness		Texture		Color		Topography	
0-25	10	Clean	53	Clay	42	Lt brn	22	Plain	63
25-50	14	Moderate	22	Clay loam	20	Yel brn	5	Rolling	19
50-100	19	Severe	22	Silt loam	32	Med brn	22	Sloping	19
>100	58	Mixed	3	Sandy loam	5	DK brn	17		
						Reddish	34		

A bias was introduced in steps 3 and 4 by the exclusion of villages and farmers who do not grow rainfed wheat. Therefore, wheat area is somewhat higher and irrigation less than for the general population. This was not a sample of all farmers of the wheat-based system; it is explicitly a sample of farmers producing rainfed wheat in the area described.

Farmers were visited on three occasions; late winter, spring, and summer. There were some changes during the season. Five farmers plowed their crop under in spring because it had failed due to frost so some crop observations were not possible. Eight farmers irrigated their crop once or twice in spring because they considered the rain insufficient, although they had not originally expected to irrigate.[1] However, their production practices, including this irrigation, are still representative of rainfed wheat production.

Basic Information

Information was collected concerning the largest wheat plot which covered approximately 94% of the sample wheat area. Mean size of the wheat plot was 2.4 ha (SD 2.1) and ranged from 0.15 to 10 ha.

1. Supplementary irrigation as a back-up to rainfall is common in Hama; see Bailey (1982). In that study; irrigated crops in a dry year yielded less than crops produced with rainfall alone under wet conditions.

Soil characteristics are presented in Table 22. Most commonly the soils were deep, dark, clean, and flat, but many soils were less than ideal. For simplicity in subsequent analyses, soils were classified into three types based on stoniness and depth. "Good" soils were those which were clean and deeper than 50 cm "poor", those which were very stony and usually quite shallow; and "medium," those falling in-between.

Tillage

Farmers use a range of methods and intensity in soil cultivation. The mean number of cultivations (including seed covering) is 2.4, but ranges from 1 to 7 (Table 23). The basic system includes two passes, i.e. ridging up, broadcasting over the ridges, and splitting the ridges to cover the seed. A few farmers omit the first step, while others make one or more additional cultivations before planting. Farmers who fallowed the preceding year may make a number of spring or summer cultivations; however, only 12% of cultivations took place before 1 September. Farmers sometimes grow summer crops immediately before wheat. Cultivations for weed control in these crops may affect wheat, but are not included.

Equipment is varied but the duckfoot cultivator is the most widespread. Plows were slightly more common in preliminary cultivations but were also used before seeding

Table 23. Cultivations and equipment.

Number of cultivations	Percent of farms	No. of deep cultivations	Percent of farms	Equipment used	Percent of cultivations
1	13	0	41	Cultivator	53
2	52	1	37	Disc plow	11
3	22	2	19	Moldboard plow	11
4	10	≥3	3	Feddan plow	14
>4	3			Disk harrow	6
				Tabban	3

Table 24. Wheat varieties used.

	Users		Percent with problems	Source	
	Number	Percent		Own or market	Coop. or Ag. Bank
Durum Wheat					
Jouri 69	19	30	42	53	47
Bayadi	14	22	29	79	21
Jezira 17	10	16	56	80	20
Hammari	6	10	100	100	0
Stork	4	6	50	100	0
Bread Wheat					
Mexipak	10	16	40	50	50

or to cover seed. Over half of the wheat fields were plowed deeply at least once.

Farmers consider tillage to be a very important factor affecting yield, and it absorbs 22% of the preharvest costs of wheat production. Farmers within the same village usually follow the same cultivation practices. This may be a result of equipment availability or simply local agreement on appropriate practices and equipment. Farmers are unlikely to have extensively compared tillage practices, and cheaper or more productive alternatives could probably be found. Experimentation with different cultivation practices in on-farm trials would interest farmers considerably.

Seed and Planting

Most of the wheat grown was durum (Table 24). Approximately half the farmers found no problem with the variety they were using. There was no systematic relationship between problems and variety, except that five of six farmers growing Hammari complained of disease. The government, through Cooperatives and the Agricultural Bank, is mostly providing the seed of varieties preferred by farmers.

Although some farmers prefer their own seed, 54% of them using their own seed had complaints compared to 24% of those using seed from Cooperatives or the Agricultural Bank (Table 25), suggesting that government efforts

Table 25. Cultivar problems as related to source of seed.

	Seed source							
	Own		Market		Coop. or Ag. Bank		Total	
	N	%*	N	%	N	%	N	%
No problem	15	50	5	45	13	76	33	57
Disease	7	23	2	18	0	0	9	16
Low drought tolerance	3	10	3	27	1	6	7	12
Not pure seed	3	10	0	0	1	6	4	7
Other	2	7	1	9	2	12	5	9
First time using	0		2		2		4	

* Excluding first time users.

to provide high quality seed are appreciated by farmers. However, only 8% of farmers travel more than 1 km to get seed. To encourage the use of government-provided seed, distribution might be expanded to make seed more easily available.

Asked what they would like to see in a new variety, 87% *farmers mentioned higher yield*, 14%, resistance to shattering, and 8% resistance to smut. Lodging, straw production, tillering, drought tolerance, and food quality were occasionally mentioned.

Broadcasting of seed was used by 84%, spinners by 11%, and drills by 5% of farmers. Mean seed rate was 182 kg/ha, with a standard deviation of 65 kg/ha. Distribution of seed rate is shown in Fig. 14. Most farmers used moderate seeding rates (77% used 200 kg/ha or less), but the rates were as high as 350 kg/ha. Farmers were not asked to explain their choice of seed rates.

Very little wheat was planted after the second week of December (Fig. 15). One-third of farmers said they planted at the same time every year, while 56% cited rainfall and 18% cited seed emergence as factors affecting planting date. Three farmers cited equipment availability and only one cited time conflicts as factors. Some farmers cited combinations of factors.

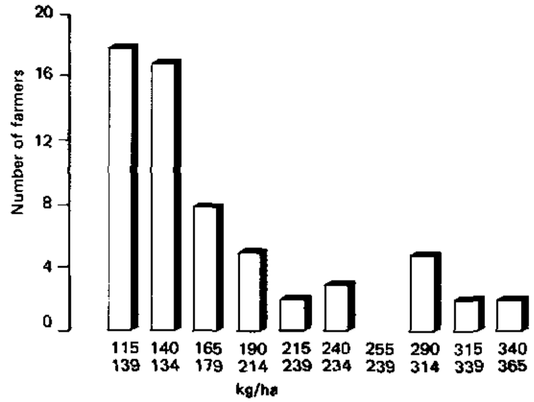


Fig. 14. Seed rates of wheat as used by farmers during the 1984/85 season.

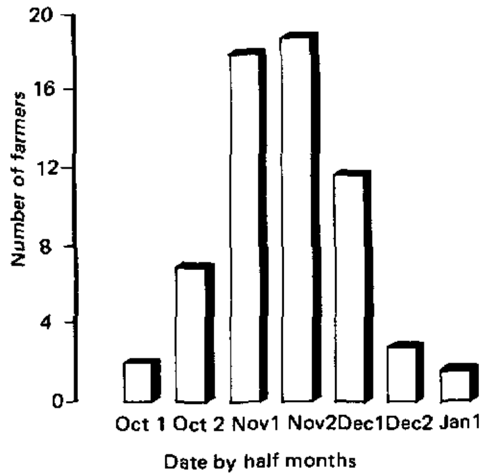


Fig. 15. Planting dates of wheat as used by farmers during 1984/85.

Although some farmers plant quite late, most planting takes place between the early and late dates used in our on-station trials (FSP 1984). Weed emergence is not a dominant factor determining planting date so it may be unnecessary to examine the herbicide-planting date interaction in on-farm trials.

Fertilization

Rates of phosphate and nitrogen applied are shown in Figs. 16 and 17. Phosphate and nitrogen application rates are significantly related to soil type, in that less fertilizers are used on poorer soils. Nitrogen use is also significantly related to the previous crop for example more nitrogen is applied to wheat following summer crops regardless of soil type (Table 26). Bailey (1982) reported that farmers in two Hama villages believed that irrigated summer crops deplete the soil of nutrients so that a subsequent wheat crop requires more fertilizer. Phosphate application as a function of the preceding crop is not significant at the 0.05 level. There also appears to be a regional effect;

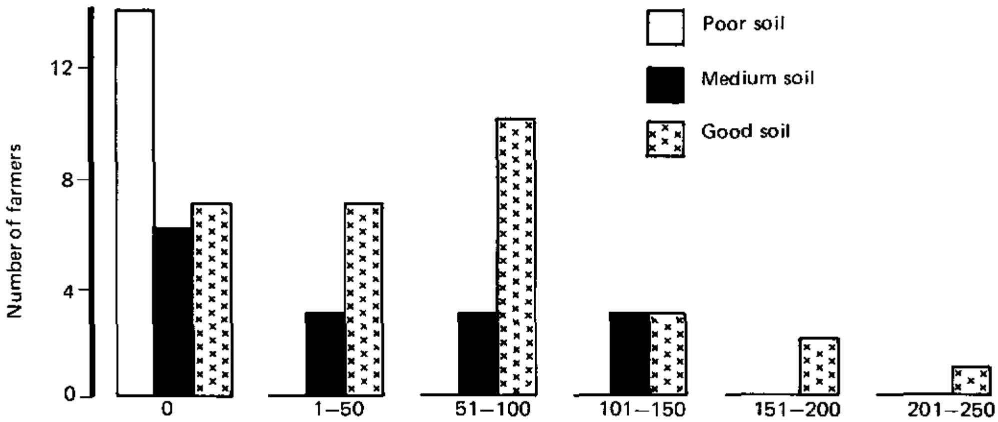


Fig. 16. Phosphate rates applied to wheat crops grown during 1984/85.

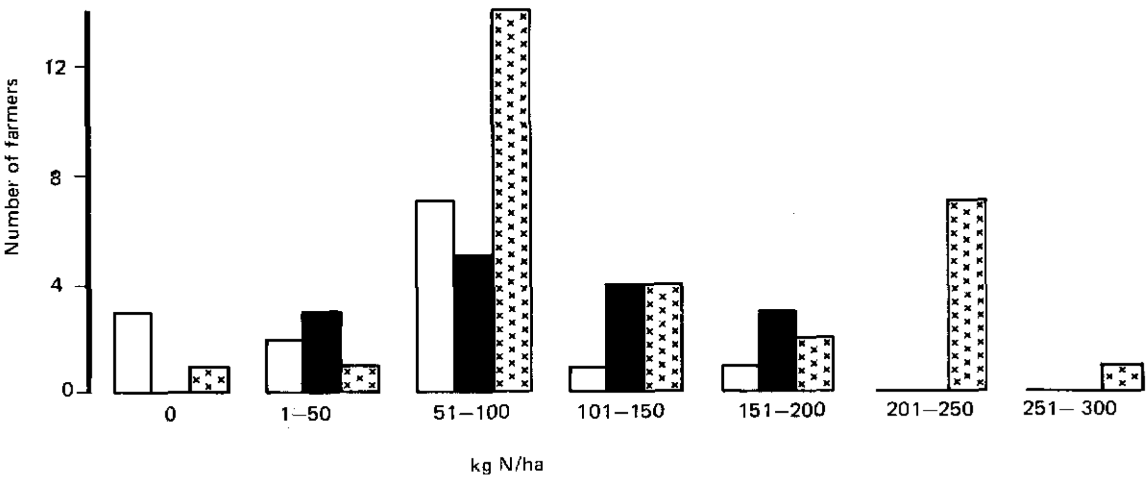


Fig. 17. Nitrogen rates applied to wheat grown during 1984/85.

Table 26. Fertilizer rates by soil type and previous crop.

Soil type	After irrigated summer crops Mean	SD	N	After other crops Mean	SD	N
	Nitrogen (kg/ha)					
Good	222	76	10	88	51	20
Medium	144	27	5	74	39	10
Poor	118		1	51	52	12
	Phosphate (kg/ha)					
Good	71	72	10	64	50	20
Medium	87	50	5	25	28	10
Poor	0		1	0	0	12

all eight farmers applying more than 200 kg N/ha were located in the Ghab valley. This may be due to the area's higher rainfall and different soils. In an analysis of variance of nitrogen rate, sampling district was significant even after the affects of soil type and previous crop were taken into account.

Every farmer using phosphate applied it with the seed, by drill or by broadcasting over the ridges before seed covering. Only 24% of farmers applied nitrogen with the seed and the amounts used were small. Ninety-two percent of all nitrogen was applied in February or March (Fig. 18). Most farmers prefer to see how wet the season is before deciding on the amount of nitrogen to use.

Table 27 shows farmers' estimates (fertilizer users only) of suitable rates of phosphate and nitrogen in wet, average, and dry years, and what they actually applied this year. For nitrogen, 62% of farmers changed their rate according to rainfall, while only 29% change their rate of phosphate. For phosphate, the seasonal rainfall estimate is based on the early rains, and the risk of not getting an economic return in the same year is greater than with nitrogen.

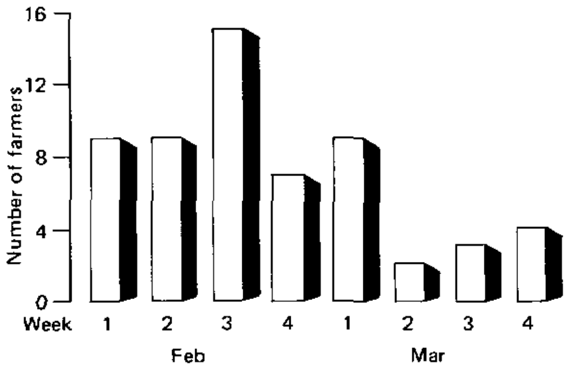


Fig. 18. Date of topdressing nitrogen to wheat during 1984/85.

Nitrogen and phosphate application rates varied significantly as a function of weed infestation (Table 28). This effect was not eliminated by controlling for soil type or previous crop which may indicate that farmers reduce fertilizer levels on fields with weed problems because fertilizer stimulates weed growth. Thus the weed control-fertilization interaction is significant and should continue to be studied in on-farm trials.

The dominant nitrogen source was urea, representing 78% of N applied, which follows the Syrian Soils Directorate recommendations for wet areas. Calnitro and ammonium nitrate

Table 27. Fertilization rates according to rainfall (nonusers excluded).

	Phosphate (kg/ha)			Nitrogen (kg/ha)		
	Mean	SD	N	Mean	SD	N
Rainfall						
Wet	91	42	29	164	124	55
Average	83	38	29	118	63	55
Dry	67	44	29	74	54	55
This year	83	46	36	109	73	59

Table 28. Farm practices related to weeds (means).

	N	Weed cover[1] (%)	Yield loss if unweeded[2] (%)	Cultivation costs (SL/ha)	Seed rate (kg/ha)	Planting date	N (kg/ha)	P_2O_5 (kg/ha)
Weed Level[1]								
High	16	56	35 * @@	365	171 @	14 Nov	78 **@	19 **
Moderate	19	33	29	244	176	16 Nov	93	48
Low	23	14	22	234	207	25 Nov	140	62
Control Method								
Manual	18	32	35 **	329	169	17 Nov	88 **	35 **
Herbicide	19	30	34	288	213	23 Nov	152	79
Herbicide some years	9	39	25	218	184	14 Nov	112	20
None	12	27	12	209	175	20 Nov	63	28

1. Observations were made of sub-plots without weed control.
2. Farmers' estimates.

* = F significant at $P < 0.1$
** = F significant at $P < 0.05$
@ = r with % weed cover significant at $P < 0.1$.
@@ = r with % weed cover significant at $P < 0.05$.

were also used. Eighty-four percent of farmers get some or all of their fertilizer from their Cooperative or the Agricultural Bank, while only 16% rely entirely on the market. Sixty-five percent say they have no problem getting fertilizer. Most farmers get fertilizer within their village or in a nearby village but 22% go more than 18 km for it.

Farmers began using fertilizers, on average, 13 years ago and only 7% have begun in the last 5 years. Fifty-two percent learned about fertilizer through the extension service or their Cooperative, 13% from traders, and 36% from other farmers or the landowner. Farmers use nitrogen fertilizers more than phosphate; 38% of the sample never use phosphate compared to only 7% for nitrogen. This may be a result of longer exposure to nitrogen fertilizers and more extension. However, given that low phosphate application rates are closely associated with soil type, farmers may be as well informed about phosphate, but do not consider its use to be worthwhile on poor soils.

In general, wheat growers show a high awareness of fertilizers, have access to them and have been using them for some time. Survey results show that fertilizer use is variable, but is a response to certain factors, particularly soil type, previous crop, rainfall, and possibly weed infestation. Clearly, farmers will adjust their fertilizer use in response to field conditions. The Farming Systems Program is undertaking research in 1985/86 to calibrate fertilizer recommendations to soil qualities, rainfall, and rotation.

Weed Control

Sixty percent of farmers had moderate or severe weed infestation in uncontrolled areas of their wheat crops, based on observations made in late April. Broadleaf weeds, notably *Sinapis arvenis* and *Gallium spp.*, were the major problem, but grasses were an important weed in 14% of fields. Severe weed levels were significantly associated with low rates of fertilizer, suggesting that farmers reduce fertilization on badly infested fields (Table 28). Weedy fields also received more intensive cultivation, but the effect was not significant.

Most farmers used herbicides in some years, but some farmers did not consider weeds a serious problem in 1984/85. A sizable minority used hand weeding and 21% used no weed control. These figures only concern wheat; 36% of farmers using herbicides on wheat and 22% of those using no weed control were weeding other fields at this time.

Farmers who do not control weeds estimate their yield loss from weeds to be small compared to farmers who control weeds by hand or herbicide. However, there is only a small difference among groups in the observed level of weed infestation (Table 28), suggesting that some farmers may have more of a weed problem than they think. Farmers' estimates of yield losses caused by weeds agreed substantially with those found in on-farm trials.

Of the eighteen families controlling weeds by hand, only one hired labor. The task required a mean of 69 hours per hectare, but was quite variable (SD = 54). Of the time spent on weeding, 76% was by women and 17% by men aged 13 and over. There was no significant relationship between weed control technique and any demographic measure such as household size, dependency ratio, and adult females as a proportion of family, nor were herbicide users more involved with off-farm employment or other competing activities. Nevertheless, farmers often cite lack of labor as a reason to use herbicide so other factors must determine the availability of family labor which were not discovered in this survey.

If labor is valued at 25 SL/day, the mean cost of hand weeding is 216 SL, compared to 59 SL for herbicide. However, if the labor of the farmer and his family is valued at a rate well below the market price, hand weeding is less costly.

All farmers stated that better yields were an important reason for controlling weeds as they do although there are differences among herbicide users and hand weeders on other major reasons for choosing a particular method (Table 29). Herbicide users were more likely to cite low cost and intensity of weed infestation as reasons to use herbicide while 22% of hand weeders considered the provision of livestock feed an important reason to pull weeds.

These differences were confirmed in other questions about the choice of weed control method. A combination of cost and labor availability was given by 89% of herbicide users to explain why they did not use more manual weeding. Hand weeders gave a variety of reasons for not using herbicide including cost, need for weeds as feed, and low infestation levels. However, over half said they were unfamiliar with herbicides, they

Table 29. Main reasons for choice of weed control method.

	Percentage of farmers using	
	Manual weeding	Herbicide
Better yield	100	100
Lower cost	44	95
Intensity of weeds	11	68
Reduce trespassing[1]	11	22
Feed animals	22	0
N	18	19

1. To prevent other farmers gathering weeds.

were unavailable, or they did not find them effective, which may be a result of poor application. Oglah (1984) found improper application to be a common problem in Jordan. If they had less family labor, only 12% said they would use herbicide while 71% said they would hire labor. Since hired labor would be more costly than herbicide, this indicates that these farmers are unfamiliar with herbicides or they are unavailable.

There was no significant difference between hand weeding and herbicide use in the level of weed infestation in estimates of yield losses from weeds if no weeding is done, seed rates, or planting dates. However, herbicide use is associated more with use of fertilizer than hand weeding.

Nearly all herbicide users have applied them for more than 3 years. Approximately half learned about them through extension officers or their cooperative, and the rest from other farmers. The most common type was U-46 combi or equivalent (2,4-D + MCPA), but smaller amounts of pure 2,4-D were also in use. This product gave good weed control at Tel Hadya, but was not as effective as Brominal/Illoxan and other preparations. These latter products are more expensive than 2,4-D but they are still profitable on farmers' fields.

The main source of herbicide was the market, at a mean distance of 11 km. Only 37% of farmers purchased it in their village. Knapsack sprayers and tractors were used for application, and labor is hired for the job in two-thirds of all cases. Mean costs per hectare were SL 31 for the chemical and SL 28 for labor.

Because weeds are used to feed animals, farmers with animals were asked to rate the importance of weeds and other feed sources (Table 30). Few farmers rated weeds as an important feed source and they are commonly used as supplementary feed. Green barley and communal grazing areas were the most important feed sources in spring.

Table 30. Farmers' ranking of the importance of spring feed sources as a percentage of farmers with livestock, *n*=48.

	Importance		
Feed source	Major	Minor	None
Range	61	16	22
Fallow	29	14	57
Steppe	6	0	94
Green barley	51	8	41
Weeds	6	31	63
Stores	20	4	76
Purchase	19	0	81

Sample farmers owned 1346 sheep, 123 goats, and 54 cattle. Twenty-nine percent of farmers with animals used weeds as a supplement, providing an average estimated 28% of feed. Green barley and conserved feeds were most important to cattle owners in spring, while shepherds more commonly grazed their sheep on the range (Table 31).

A substantial minority of farmers will continue to weed by hand, either because they are able to control weeds with lower cash outlay or to provide livestock feed. Our on-station research (ICARDA 1984a) and this survey suggest that there is little difference between manual weeding and herbicide. Therefore, there is no reason to attempt to "convert" those farmers who are happy with manual techniques. However, the surveys suggest that many farmers, both nonweeders and hand weeders, are unfamiliar with herbicides. With increased availability and education, they might find a yield-increasing economic role for herbicides in the near future. Herbicides are cheap so even those farmers who estimate little loss to weeds might profit from herbicide application.

Harvesting

Wheat harvesting is extensively mechanized (Table 32). Only 18% of sample farmers harvested their wheat by hand; usually in stony fields or inaccessible areas. After mechanical harvesting, most straw was collected for winter feed or grazed *in situ*. However, a substantial amount of straw and crop residues were burned possibly because farmers prefer to destroy the straw to facilitate plowing their fields. Sixty-two percent of farmers rate tillage as a major factor in determining yields (Table 33) and thus stubble management and tillage warrant further study at ICARDA.

Yields

Farmers expect to harvest an average of 2 t grain/ha; about 1 t in a bad year and 3 t in a good year (Table 34). This yield level is well above estimates for unimproved wheat production and substantially exceeds mean yields of other developing countries (Hanson *et al.* 1982) which suggests that a "wheat revolution" is well under way in this part of Syria.

In the last two seasons, sample farmers had mean yields of about 2 t. They rated the 1984/85 season slightly below average, mainly due to cold weather, while 1983/84 was

Table 31. Distribution of livestock holdings and main feed sources.

Livestock owned	Farms (%)	Main feed sources
None	17	
1-15		
sheep and goats	24	Range, Green barley, Fallow
>15		
sheep and goats	19	(Same)
Cattle only	29	Green barley, range, stores, purchase
Cattle and small stock	10	(Same)

Table 32. Harvest techniques and disposition of straw (% of farmers).

Hand harvest; all straw collected	18
Machine[1]; cut straw collected, rest grazed	20
Machine; cut straw collected, rest burned	14
Machine; cut straw collected, rest plowed	2
Machine; all straw grazed	23
Machine; all straw burned	19
Machine; all straw sold for grazing	5

1. Machines used: 89% combine, 11% binder.

Table 33. Farmers' rating of factors affecting yields (% of farmers).

	Importance		
Factor	Major	Minor	None
Nitrogen	74	23	3
Phosphate	53	23	25
Tillage	62	34	3
Weed control	20	54	26
Variety	20	31	49
Planting date	10	15	75
Seed rate	0	21	79

Table 34. Grain yields (kg/ha).

Estimated	Mean	SD
Good year	3262	1442
Average year	1973	950
Bad year	946	648
1983/84	2222	1468
1984/85	1914	1320
Farmers' rating of: (% of farmers)	1983/84	1984/85
Good	42	19
Average	30	43
Bad	28	38

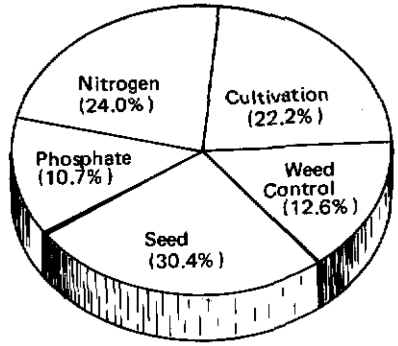


Fig. 19. Preharvest costs for wheat during 1984/85.

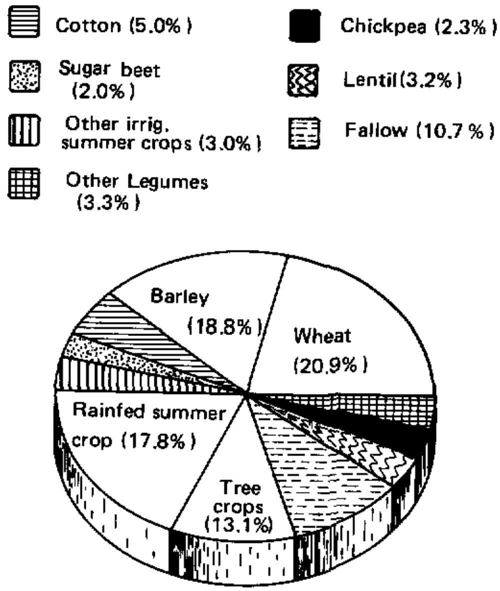


Fig. 20. Land use by crop during 1984/85.

slightly above average. This contrasts with barley-growing areas, where 1983/84 was a bad year because of low rainfall. Wheat-producing areas can endure some shortage of rainfall, although they are vulnerable to many other factors which are not significant in drier areas.

Fertilization and tillage were considered the most important practices affecting yields (Table 33). Weed control is second in importance while variety, planting date, and seed rate were of minor importance.

In general, farmers invest in those practices that they consider important. The distribution of preharvest costs for wheat is shown in Fig. 19. The cost of weed control is minor compared to other inputs and there should be a high potential for increased herbicide use.

Wheat in the Farming System

Wheat is grown alongside many other crops, including legumes, melons, cotton, and trees. The crop mix observed among the sample in the current year (Fig. 20) was biased towards wheat production by the sampling technique, which excluded those who do not grow wheat and was restricted to farmers growing wheat in this year. Therefore, the proportionate area of wheat is exaggerated compared to the area as a whole and compared to crops grown in rotation with wheat. However, barley occupied nearly as much area as wheat, in spite of the sampling bias. This is due to the substantial demand for winter feed. Forty-one percent of farmers said they have decreased their area planted to wheat since 1980, usually because

Table 35. Rotations and previous crops.

Rotation	Farmers (%)	Previous crop	Farmers (%)
Cereal/legume/winter fallow*	27	Chickpea	21
Cereal/irrigated summer crop	30	Other legumes	3
Cereal/rainfed summer crop	16	Rainfed summer crop	23
Cereal/legumes	13	Cotton	15
Cereal/fallow	10	Sugar beet	8
Varying rainfed 2-course	5	Other irrigated summer crop	3
		Fallow	15
		Barley	6
		Other	6

*Winter fallow is followed by a rainfed summer crop, spring chickpea, or summer fallow.

they find barley more profitable. This emphasizes the importance of increasing barley production in the dry areas, where wheat cannot be profitably grown, to allow a rational allocation of the land and climatic resources of the higher potential areas for wheat production.

Trees occupy 13% of the land, while rainfed summer crops, legumes, and irrigated summer crops occupy approximately as much area as cereals. Thus wheat, while possibly the most important crop, is likely to be less important than the others in combination.

Information on land use in the current year is complemented by data on rotations. The majority of farmers state that they follow some kind of two-course rotation, and of these, most rotate wheat with cotton or other irrigated summer crops. There are three-course rotations on approximately 27% of farms.

In 1984 wheat was most commonly planted after irrigated summer crops (26%), legumes (24%) and rainfed summer crops (23%) (Table 35). This suggests a greater role for irrigated summer crops and legumes than indicated by 1984/85 land use, since these crops are regularly grown on large areas of land which were planted to wheat in the survey year.

The legume planted in the second year of a three-course rotation is usually lentil while the legume preceding cereal is usually chickpea. Chickpea is commonly grown in a two-course rotation with cereal, but may also be grown in the third year of a three-course rotation.

Wheat, therefore, is part of a complex farming system and occurs in a wide variety of rotations. Legumes, irrigated summer crops, rainfed summer crops, and trees are also important. Activities other than crop production are significant elements in the rural economy. The proportion of income contributed by various activities, as estimated by farmers, is shown in Fig. 21. Wheat is a major contributor, but other crops in combination are worth twice as much and almost 40% of family income comes from noncrop sources.

Continuing Research

The farmers in this survey will be visited at least once more. In this visit, the economics of wheat and other crops in the wheat-growing system, the reasons behind crop choices and production practices, and the role of livestock in the farming system will be

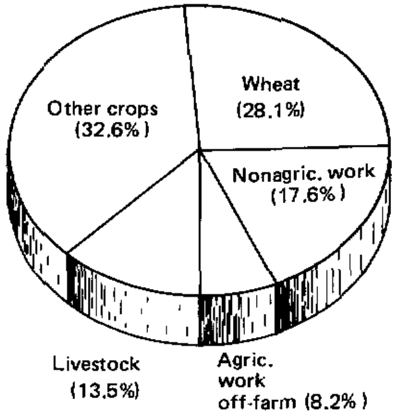


Fig. 21. Sources of income as represented by various activities of farmers, 1984/85.

studied. In addition, existing data will be further analyzed to explain the observed variance in practices. It is hoped that the sample data can suggest subsystems of practices within the wheat-growing area, or recommendation domains which would help to focus future research.

Wheat On-Farm Trials

In 1984/85, unreplicated 2 x 2 factorial trials were sown in 18 farmers' fields in the main wheat-growing region of northwestern Syria. These trials were in the same areas as the surveys described in the previous section. There were four treatment combinations of ± weed control (bromoxyril + diclopmethyl, 0.5 kg ai/ha + 1.0 kg ai/ha applied at the 4-leaf stage) and ± fertilizer (60 kg P_2O_5/ha with seed, 80 kg N/ha, half at planting, half as top dressing). These were superimposed on wheat crops managed according to the farmer's own tillage and planting methods, i.e., broadcasting seed and fertilizer over ridged land and splitting the ridges to cover them. Weed dry-matter production and grain and straw yields were measured in all plots. The locations were divided into severe weed infestation sites (8) and moderate weed infestation sites (10) for separate analyses, with replication by location. The results and an economic evaluation of treatment effects are presented in Table 36.

At the moderate infestation locations, there was a significant response to fertilizer with and without weed control. However, herbicide only gave significant responses ($p<0.05$) in the presence of fertilizer, which stimulated weed growth as indicated by a significant fertilizer-weed control interaction. At the severe weed infestation locations, there was a significant main effect response to both weed control and fertilizer and a significant interaction indicated that yields were largest when both were used.

The greatest increase in net income occurred where both treatments were applied. Fertilizer application without weed control barely paid for itself and although weed control alone was profitable in severely infested fields, it was not so in less infested. Therefore fertilizer must be used with weed control if large rates of return are expected. Also, selective use of different herbicides and application rates could assist in reducing cost and increasing profitability.--*S. Kukula and A. Dakermanji.*

IBSNAT: Wheat Response to Nitrogen

The International Benchmark Soils Network for Agrotechnology Transfer (IBSNAT) project has two main objectives: (i) to accelerate the flow of agrotechnology developed at one site to other locations, and (ii) to increase the possible success of that transfer. Soil-crop-weather simulation models are used and existing models are being calibrated and validated by IBSNAT.

Wheat is an important crop of the ICARDA mandate and considerable work on the dynamics of wheat response to nitrogen fertilizer has been carried out by ICARDA in northern Syria.

Table 36. Effects of fertilizer and herbicide on wheat production in farmers' fields.

Treatment		Kg/ha			SL/ha			
Fertilizer	Weed control	Grain yield	Straw yield	Weeds (TDM)	Increased crop value	Increased costs	Change in net income	% profit
				10 moderate infestation fields				
–	–	1397	2210	242				
+	–	1631	2821	422	586	574	12	2
–	+	1463	2351	42	153	287	– 134	– 46
+	+	1872	3192	20	1090	896	194	22
				8 severe infestation fields				
–	–	955	1558	1244				
+	–	1227	2058	1530	600	575	25	4
–	+	1270	1862	108	589	331	258	78
+	+	1601	2502	195	1332	920	412	45

Economic assumptions: Crop value: seed 1.5 SL/kg, straw 0.38 SL/kg.
Herbicide costs: 272 SL/ha (chemical + application).
Fertilizer costs: P_2O_5 215 SL/ha, N: 340 SL/ha (fertilizer + application).
Harvest + postharvest costs: 10% of total crop value.

One simulation model, used by IBSNAT, is CERES wheat-N, to predict the response to N fertilizer and fertilizer-use efficiency. This model may be useful to transfer ICARDA technology from Syria to other areas, provided it is well calibrated for Mediterranean regions. Therefore wheat response to nitrogen was tested in three environments to collect a full data set for IBSNAT calibration of CERES-N.

Durum wheat (Sham-1) was planted at three sites, Breda, Tel Hadya, and Jindiress, using four levels of N (0, 30, 60, and 90 kg N/ha). One third of the N was applied at sowing, the remainder was topdressed at tillering. Data on soils (fertility level to 150 cm and soil water dynamics), plants (development rate, chemical composition, nutrient uptake, biomass production at three physiological growth stages, and final grain yield), and weather were recorded at each site.

The results showed:

1. The levels of mineral N at all sites at sowing were quite high, ranging at 0-150 cm from 83 to 111 kg/ha. However, at harvest the levels were much lower, even for soils which had received 90 kg N/ha. The range in levels at this time for N_{90} treatments was from 26 kg/ha to 60 kg/ha.

2. Maximum soil water storage occurred at about the end of February at all locations (Fig. 22). At Jindiress there was possibly drainage below the depth of measurement (180 cm) in treatments N_0 and N_{30} during March. Overall, however, there were no detectable differences in water use between N treatments during the growing season. Severe cold at Jindiress in early March caused loss of most of the expanded leaf area in all treatments which may have influenced water use.

3. Despite the high initial levels of mineral

Table 37. Effect of level of N added (kg/ha) on wheat yields and N content in total dry matter (TDM) produced at tillering, anthesis, and maturity at three experimental stations with various effective rainfall.

Site	Physiological stage	Nitrogen treatment								LSD (0.5)	
		N_0		N_{30}		N_{60}		N_{90}			
		t/ha	N%	t/ha	N%	t/ha	N%	t/ha	N%	t/ha	In % of N
Jindiress (400 mm rainfall)	Tillering	0.17	4.95	0.24	5.23	0.24	5.26	0.20	5.26	0.093	0.242
	Anthesis	5.54	1.39	6.23	1.54	7.16	1.61	6.70	1.62	2.036	0.258
	TDM at harvest	7.77		9.11		8.96		9.52			
	Straw	4.78	0.26	5.62	0.35	5.52	0.32	5.84	0.34	0.698	0.105
	Grain	2.99	1.82	3.49	1.97	3.44	2.23	3.68	2.25	0.327	0.149
Tel Hadya (370 mm rainfall)	Tillering	0.12	5.38	0.17	5.55	0.17	5.52	0.20	5.36	0.105	0.363
	Anthesis	7.71	1.44	7.67	1.58	7.20	1.66	7.86	1.59	2.224	0.141
	TDM at harvest	8.62		8.22		8.76		8.34			
	Straw	5.44	0.37	5.42	0.46	5.78	0.52	5.58	0.61	1.055	0.122
	Grain	3.18	2.45	2.80	2.74	2.98	3.02	2.76	3.09	0.581	0.309
Breda (268 mm rainfall)	Tillering	0.11	4.50	0.15	4.83	0.16	5.14	0.13	5.23	0.064	0.272
	Anthesis	3.32	1.11	4.51	1.39	2.85	1.48	4.17	1.59	1.024	0.117
	TDM at harvest	4.27		4.16		5.03		4.88			
	Straw	2.76	0.32	2.72	0.32	3.36	0.42	3.34	0.49	0.413	0.163
	Grain	1.51	2.02	1.44	2.23	1.67	2.68	1.54	3.04	0.234	0.348

N, there were responses to applied N. There were significant ($p<0.01$) grain yield responses at Jindiress (Table 37) with 30 kg/ha of applied N, but there was no effect of additional fertilizer. At Breda, there was a significant straw yield response to N ($p<0.05$) but no effect on grain yield, whilst at Tel Hadya there was no response (Table 37).

4. There were highly significant ($p<0.01$) increases in grain N content with nitrogen application at all three sites (Table 37). The straw N content was increased significantly ($p<0.05$) at both Breda and Tel Hadya. The level of N to which there was a response varied with both the site and the time of sampling. In most cases the response was to the first 30 kg, but grain N continued to increase up to 60 kg/ha at all sites and to 90 kg/ha at Breda (Table 37).

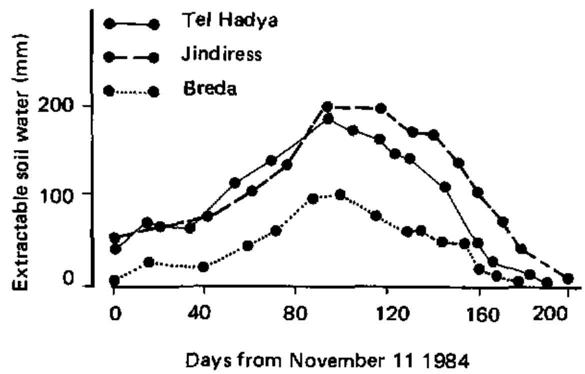


Fig. 22. Extractable soil water in the soil profile during the growing season 1984/85 at three sites in northern Syria.

These results for N content agree with those for dry-matter and grain production, and with the pattern of soil water availability. At Jindiress, with most water, the highest yields and the lowest N contents were recorded. At the other sites high plant N levels were due to reduced assimilation caused by increased water stress in the later growth stages. (Fig. 22).--*A. Matar, H. Harris, and W. Goebel.*

Intersystems Research

Phosphate Fixation and Management in Rainfed Calcareous Soils

In ICARDA region, there are large deposits of rock phosphate, and several countries (Morocco, Tunisia, and Syria) are exporters of rock phosphate and producers and consumers of locally-manufactured phosphate fertilizer. Phosphate deficiency is common in the widespread calcareous soils of the region, and there are large and economic responses to phosphate fertilizer application (Soils Directorate/ICARDA 1985).

Specific management techniques are required to maximize the efficiency of phosphate fertilizers because of the gradual chemical transformation of phosphates into unavailable forms through reaction with free calcium salts and the limited mobility of phosphates in calcareous soils. Most farmers using phosphate on cereal crops broadcast and incorporate the fertilizer sometimes several months before seeding. They do not assess the amount they should apply relative to the previous history of phosphate use, the current soil fertility status, or to the expected crop yield. Information on these factors is scarce for the calcareous soils of ICARDA's region.

In 1984/85, research was started to provide more detailed information on these topics. The first results are reported here under three headings; (a) effect of banding versus broadcasting triple superphosphate on P uptake and growth of wheat, (b) effect of banding versus broadcasting on rates of phosphate fixation, and (c) residual effect of previous phosphate application on soil available P levels and barley responses to applied P.

Banding Versus Broadcasting Phosphate and Wheat Responses

Triple superphosphate was applied at four rates (0, 40, 80, 120 kg P_2O_5/ha) to a wheat crop which was drilled at a rate of 100 kg/ha with 17.5 cm between rows. The phosphate was either broadcast and incorporated in the plough layer just before seeding, or banded with the seed at sowing. The trial was conducted at three locations representing the major soil types of the region; Jindiress (*Chromic Vertisol*, FAO, long-term average rainfall 475 mm/year), Tel Hadya (*Vertic Luvisol*, 350 mm), and Breda (*Calcic Xerosol*, 275 mm). The eight treatment combinations were replicated three times at each location. Nitrogen was applied as a uniform dressing across all treatments (20 kg N/ha at sowing and 40 kg/ha topdressed at tillering). The crops were sampled at several growth stages and P uptake and dry-matter production were recorded. The results from Tel Hadya and Breda only are presented as severe frost damage at Jindiress in March affected the growth and P uptake patterns resulting in inconclusive results. The trial will be repeated at the three locations in 1985/86.

Dry-matter production at tillering and harvest are presented in Figs. 23 and 24. At Tel Hadya and Breda, there were larger growth rates at tillering where phosphate was banded rather than broadcast. This was also evident at Jindiress before the severe frost damage. These differences were significant at $p<0.5$ at Breda and Jindiress, but not at Tel Hadya although the pattern was the same at all three locations. By harvest, there was a different pattern. At the lowest level of 40 kg P_2O_5/ha, there were no differences in final yield between the two application methods, but banding was superior at the two higher rates. These trends in dry-matter production are reflected in the P uptake data (Fig. 25).

P uptake from applied fertilizer can be estimated by subtracting uptake in treatments

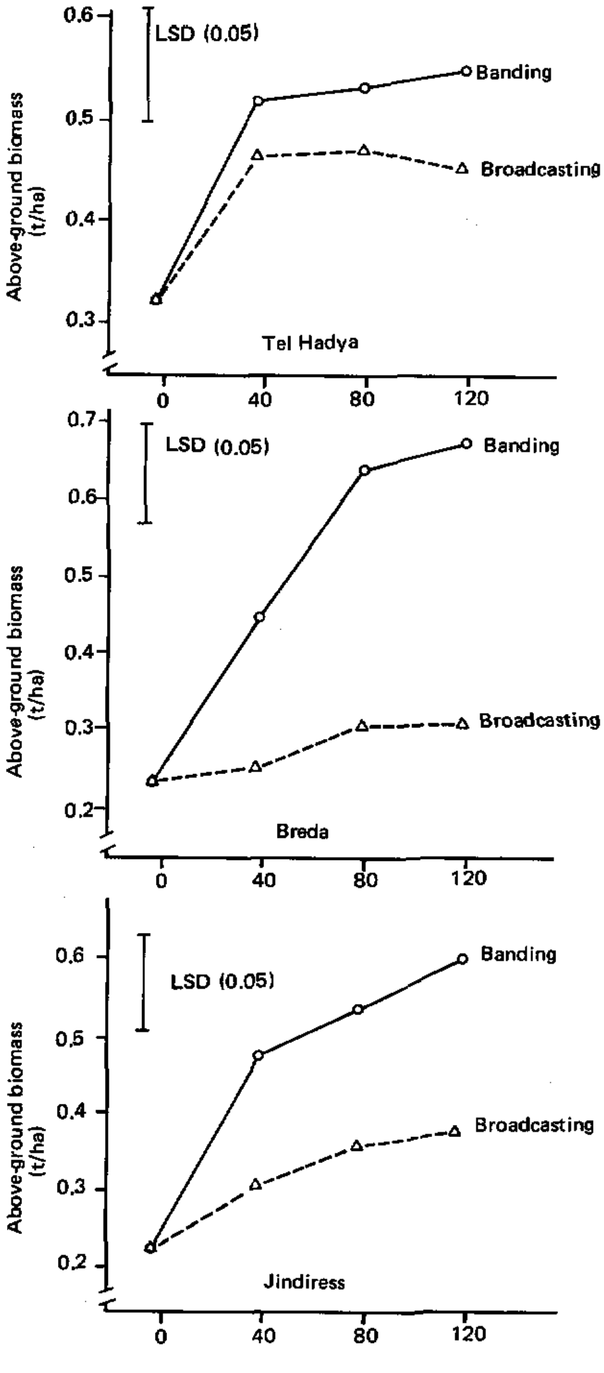


Fig. 23. Above-ground biomass of wheat at tillering as a function of rate and method of phosphate application at the three experimental sites of Tel Hadya, Breda, and Jindiress.

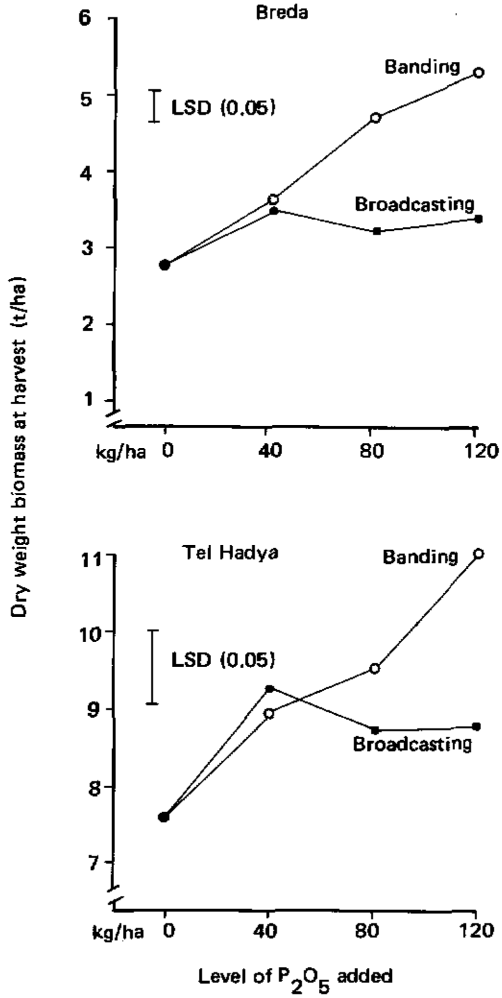


Fig. 24. Effect of rate and placement of phosphate added to soils on dry weight biomass at harvest at both Breda and Tel Hadya experimental stations, 1984/85.

without fertilizer from those in which fertilizer was applied (Table 38). At tillering, when the root systems are relatively small, a very high percent of P uptake was derived from the fertilizer when it was banded, and the proportion increased with increasing application rate. Where fertilizer was broadcast, a much smaller fraction of the P taken up was from the fertilizer and there was less difference between application rates.

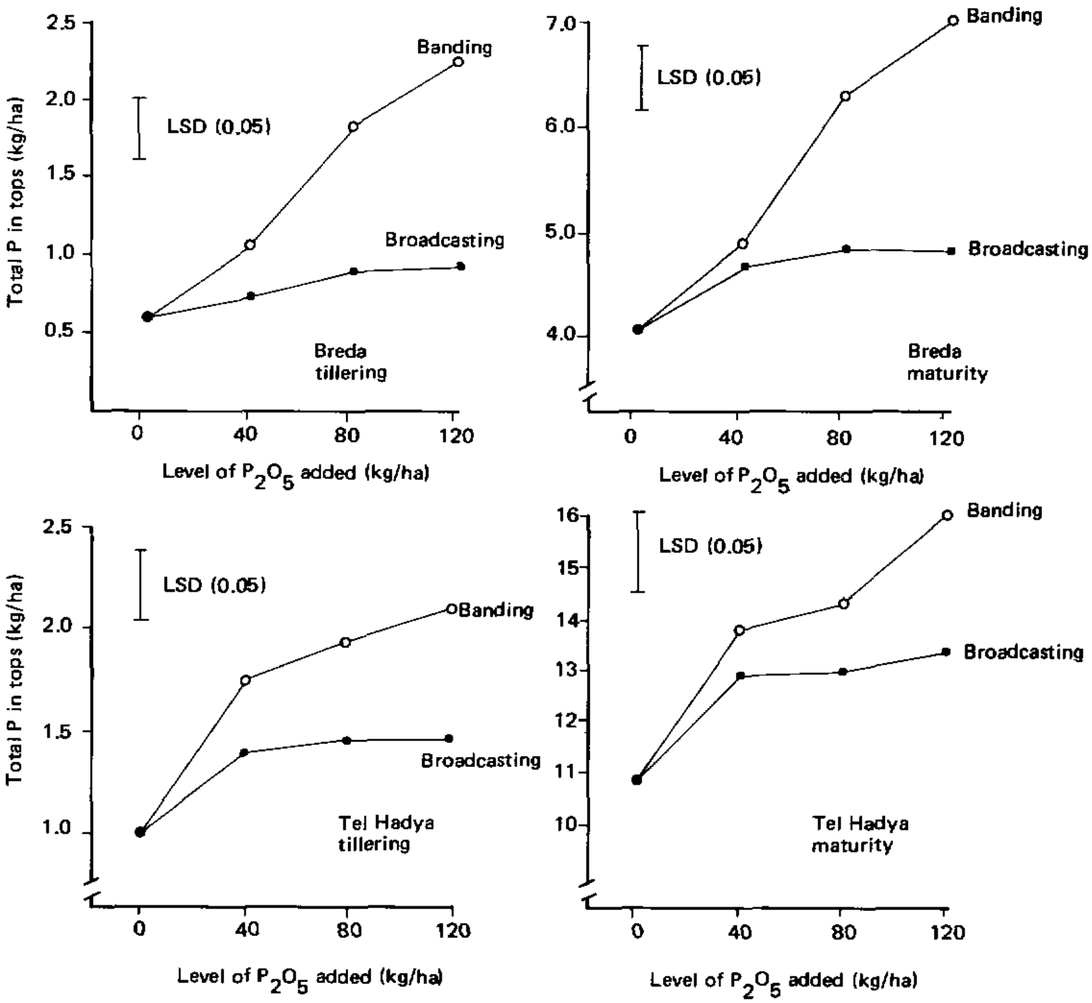


Fig. 25. Effect of rate and placement of superphosphates on total P uptake by above-ground total dry matter produced at tillering and maturity.

As root systems developed and expanded into a greater soil volume, the proportion of P uptake derived from fertilizer decreased. Native available soil phosphate was an increasingly important source at both locations, and differences in the method of fertilizer application were less pronounced. By harvest, between 14 and 41% of phosphate uptake was estimated to have come from applied fertilizer. The results from this and other studies (Shepherd 1985) confirm that one of the most important results of banded phosphate is to promote early vigorous growth and, in cereals, this is closely associated with final yield potential. Studies at ICARDA have also shown (Gregory *et al.* 1984) that banded phosphate promotes root growth, and thus increases the plant's ability to utilize native available phosphate. Therefore data in Table 38 may overestimate the percent phosphate uptake derived from the applied fertilizer and the estimation of percent recovery of applied fertilizer. Even if these latter figures are overestimated, the percent

Table 38. Effect of location, method, and level of P application on percent P uptake derived from applied fertilizer.

Location/level (kg P_2O_5/ha)		Percent P-uptake by wheat from applied fertilizer					
		Tillering		Anthesis		Harvest	
		Banded	Broadcast	Banded	Broadcast	Banded	Broadcast
Breda	40	44	21	31	28	16 (4.5)[a]	14 (3.8)
	80	68	34	44	30	36 (6.5)	17 (2.3)
	120	73	35	48	35	41 (5.3)	16 (1.3)
Tel Hadya	40	43	28	15	16	21 (16.9)	16 (12.1)
	80	47	33	23	11	24 (9.7)	16 (6.0)
	120	53	32	31	37	32 (9.7)	18 (4.7)

a. Figures in parentheses represent percent of applied fertilizer recovered by the crop at harvest.

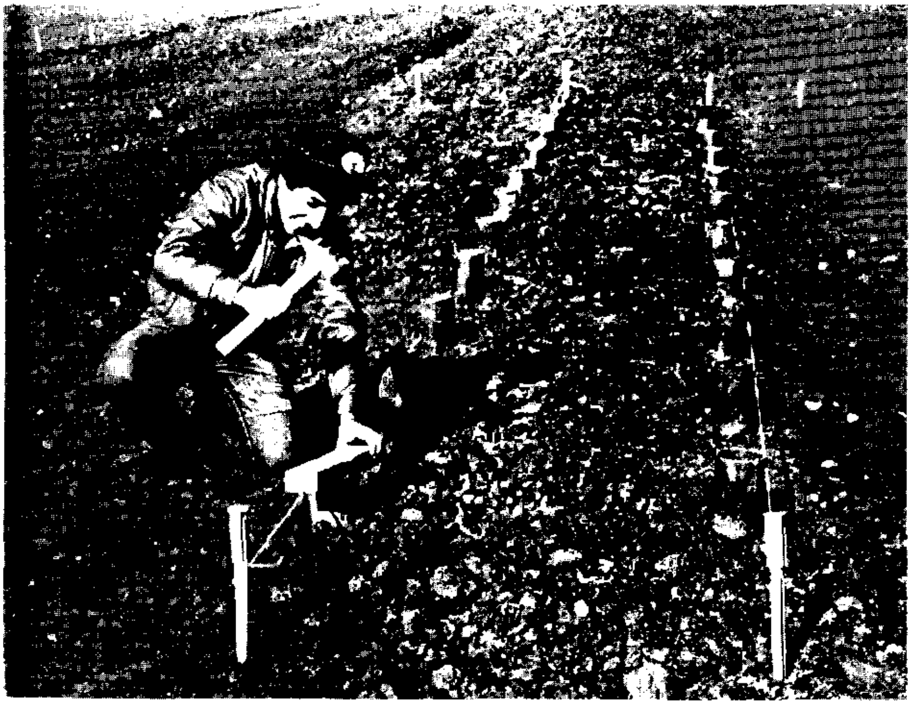
recovery of applied phosphate is very low; from 4.5 to 16.9% for banded fertilizer and 1.3 to 6.0% for broadcast fertilizer.

Banding of P fertilizer appears to lead to greater P uptake and thus greater efficiency of fertilizer use and larger wheat yields compared to broadcasting and incorporation. This effect may be greater when farmers broadcast and incorporate their fertilizer several weeks before sowing as seen, for example, in Tunisia. Other studies indicate that phosphate fixation is rapid during the first months after application, so the nearer to seeding the phosphate is applied, the greater will be the availability of that fertilizer to the growing crop. The results obtained when 40 kg P_2O_5/ha was applied are anomolous, and it is unclear why the early benefit from banding was not evident at final harvest, although the effect was consistent at both locations. The work will be repeated next year to assess the effect of method and level of P application on root growth and establish if it was specific to this year's trial or whether it is a genuine "method of application" x "level of application" interaction.

Banding Versus Broadcasting and P Fixation

Parallel to the studies reported in the previous section, the change in the status of soil available P was monitored monthly for 10 months following application in November 1984. The same eight treatment combinations were used, but a special technique was utilized to reduce the inherent variability in P analyses associated with sampling plots to which P fertilizer was applied.

Metal cylinders (10 cm diameter, 20 cm deep) were pressed into the soil and carefully weighed amounts of triple superphosphate, corresponding to rates of 40, 80, and 120 kg P_2O_5/ha, were either banded or incorporated with the soil in the cylinders. At each sampling, the complete bulk of the soil within the cylinders was sampled and carefully mixed *prior* to analyses. Analyses of soil samples taken just below the base of the cylinder confirmed that the applied phosphate had not leached out of the cylinder. This study focused on the transformation of monocalcium phosphate (the dominant salt in triple superphosphate) into less soluble forms



Application of phosphate inside steel cylinders forced into the soil has been found to be an accurate method to monitor the change in available P with time.

through soil reaction; plants were not grown in the cylinders. The change in levels of Olsen-extractable phosphate was expressed in mg/kg soil (ppm). The available phosphate levels in unfertilized soils remained more or less constant throughout the season, and these values were subtracted from those found in fertilized soils. The results given in Figs. 26 and 27 thus represent the change in availability of applied triple superphosphate.

These results should be interpreted with caution because even when pure triple superphosphate was subjected to Olsen extraction, only 60-65% of the phosphate was recovered due to slow dissolution of the fertilizer granules. Also, when soil and fertilizer granules are shaken together with the sodium bicarbonate extracting solution, there will be slight, but unmeasurable, rapid fixation of phosphate. Therefore the results probably underestimate the availability of applied fertilizer in undisturbed soil samples.

Fig 26 shows the effect of phosphate application method (mean of all application levels) on the rate of fertilizer fixation. There was little practical difference between the two methods across all three locations, although there was a significant trend for broadcast phosphate to be fixed at a slightly greater rate than banded phosphate.

Phosphate fixation depends upon fertilizer/soil contact, and broadcast and incorporated fertilizer may have greater fertilizer/soil contact and thus be more rapidly fixed than banded fertilizer. However, detailed examination of the banded fertilizer distribution in the soil showed that, even at 120 kg P_2O_5/ha, granules were invariably completely surrounded by soil particles, and only occasionally were they in contact with each other. In practice, there was little difference in fertilizer/soil contact between the two application methods. Therefore the greater efficiency of P uptake from banded phosphate observed in the previous

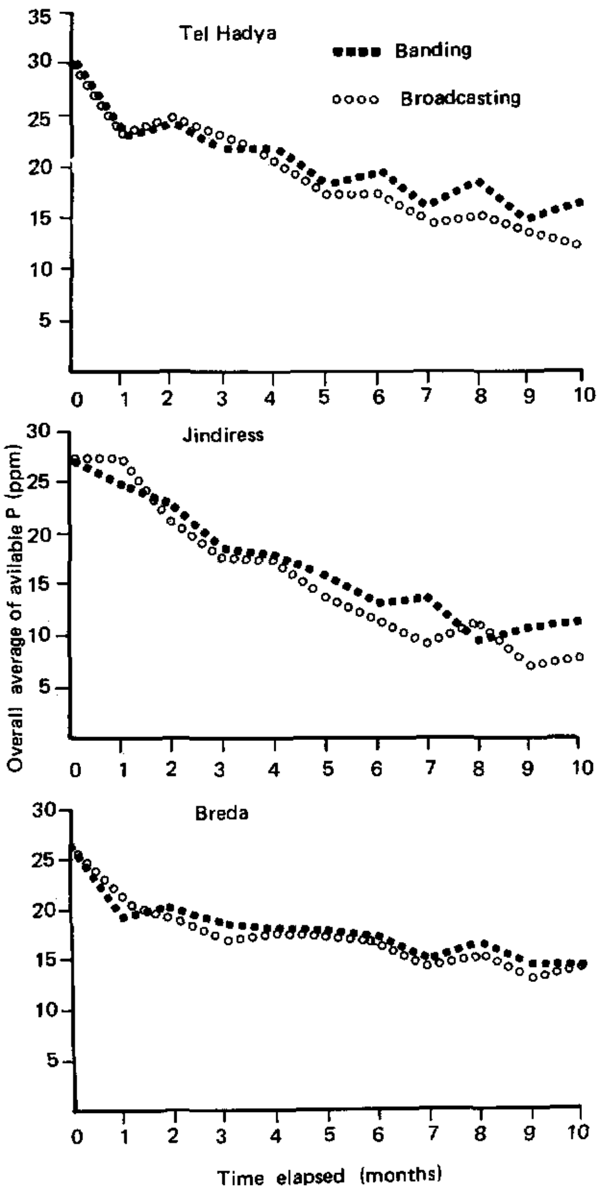


Fig. 26. Effect of banding and broadcasting phosphate fertilizer on the change in its availability (mean of all levels of application).

section results from improved root/fertilizer granule contact during early growth rather than a slower decline in availability of banded fertilizer.

Fig. 27 shows the decline in availability of banded fertilizer phosphate with time at the three locations. Exponential curves were fitted to these data in the form:

$$P = ke^{-aT}$$

where, P = available Olsen-extractable phosphate (ppm)

k = intercept at time zero,

a = constant describing rate of fixation, and

T = *time in months after application.*

From these curves, two variables were calculated: the fertilizer half-life, or the time for fertilizer availability to be halved due to fixation, and the equilibrium time, or the time taken for the added fertilizer availability to reach zero (Table 39). The fertilizer half-life is useful to evaluate fixation during the year of application, whereas the equilibrium time is useful to evaluate the number of seasons during which residual effects of phosphate fertilizer may be expected. Applied fertilizer fixation was proportional to application level; faster rates were associated with higher levels. This is reflected in the fact that the half-life of available fertilizer P is more or less unaffected by the different levels of application. Fixation proceeded faster at Jindiress (mean half-life 5.5 months) than at Tel Hadya or Breda (mean half-lives 9.8 and 11.8 months). The equilibrium time data show that responses to residual phosphate would be expected for at least the two following seasons at Breda, but possibly for only one season at Jindiress. This was also shown in field studies (ICARDA 1983) where there were significant responses to a single application of 60 kg P_2O_5/ha for 3 years at Breda, but at Jindiress, there was a response only in the second year following application. Further studies are required on the soil type/climate interaction causing these differences and a collaborative research project with the University of Reading, UK, is being developed. A knowledge of applied phosphate fertilizer dynamics in calcareous soils is essential for optimum fertilizer strategies and economic evaluation of fertilizer use.

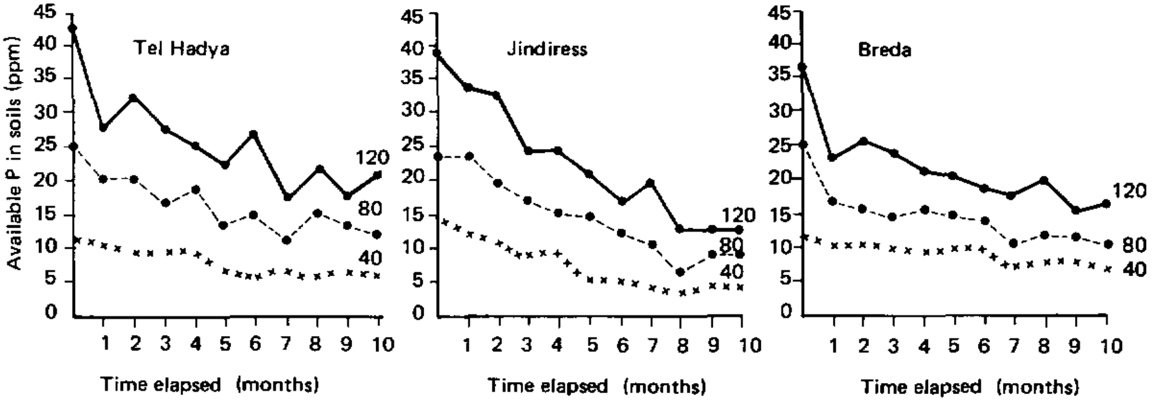


Fig. 27. Change in available banded fertilizer P at three locations in northwestern Syria.

Table 39. The half-life and time to reach equilibrium of banded phosphate fertilizer as affected by location and application rate.

Application rate (kg P_2O_5/ha	Half-life (months after application)			Time to reach equilibrium (months after application)		
	Jindiress	Tel Hadya	Breda	Jindiress	Tel Hadya	Breda
40	4.8	10.9	15.2	19	39	53
80	5.9	8.3	10.2	32	39	45
120	5.9	10.3	10.1	32	54	51

Residual Effect of Previous Phosphate Application

In 1980, a phased entry long-term rotation trial was established at Khanasser (*Calcic Xerosol*, 220 mm) to compare three crop rotation systems of fallow/barley, vetch/barley, and barley/barley. Within these rotations, different phosphate levels were applied; 0, 60, and 120 kg P_2O_5/ha per 2-year period.

Severe and persistent bird damage to young vetch plants caused almost total failure of the crop at Khanasser in all years, and in 1984 the trial was abandoned. However, there were sufficient plots in the barley phase to examine the effect of previous fertilizer history on soil fertility and the response to different levels of P fertilizer applied in 1984/85. Using the two rotations, there were nine replicates which received 0, 120, and 240 kg P_2O_5/ha during the previous 4 years. Available soil P (Olsen-extractable) was determined in all plots which were then split three ways and drill sown with barley (Arabi Aswad, 100 kg/ha seeding rate) with three application rates of banded phosphate; 0, 60, and 120 kg/ha. These nine treatment combinations were sampled for dry-matter

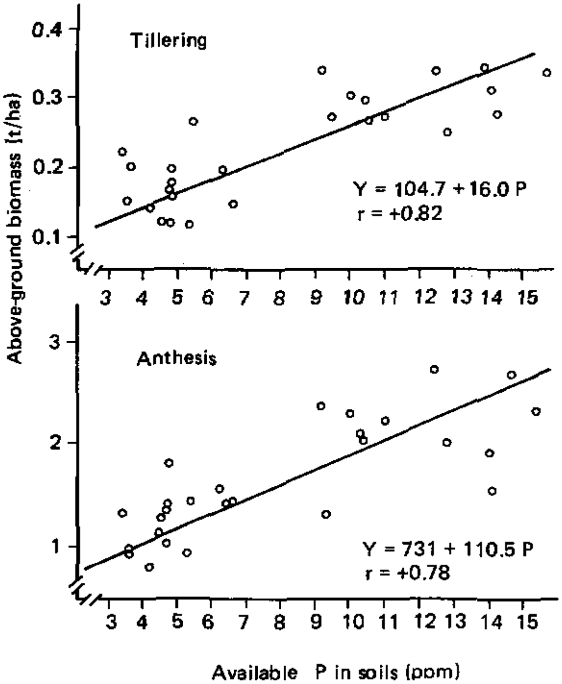


Fig. 28. The above-ground biomass of barley, at both tillering and anthesis stages, as related to level of available P in soils at sowing, at Khanasser experimental station, 1984/85.

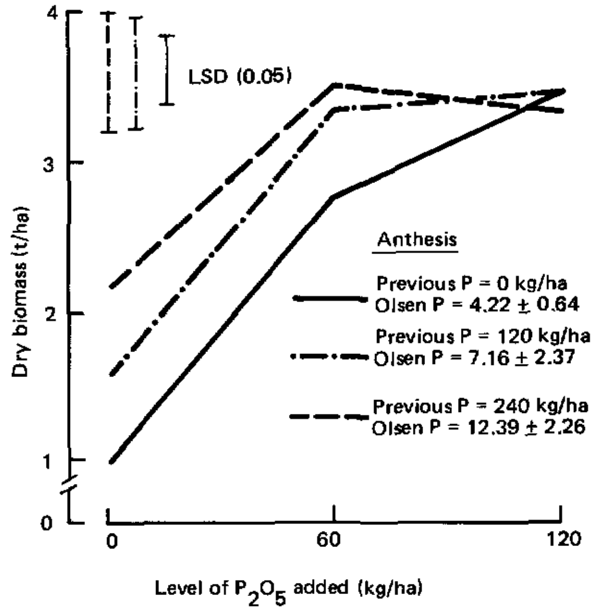


Fig. 29. The residual effect of previous P added in the last 4 years and direct application of P on dry weight biomass of barley at anthesis, at Khanasser experimental station, 1984/85.

production and P uptake during growth up to anthesis. Yield components were measured at harvest, but bird damage during grain formation again resulted in unreliable yield data.

Fertilizer application over the preceding 4 years had a pronounced effect on the Olsen-extractable phosphate levels at the start of the season, ranging from a mean for previously unfertilized plots of 4.22 ppm (± 0.64) to 12.39 ppm (±2.26) for plots which received 240 kg P_2O_5/ha. The dry matter produced at tillering and at anthesis in plots receiving no fertilizer in the current season was linearly related to the initial soil P status (Fig. 28). However, the effect of fertilizer application in the current year was dominant (Fig. 29). Analysis of variance confirmed that initial phosphate status had a significant effect on barley production, current levels of application of fertilizer gave rise to large responses, and there was a significant interaction between initial P status and response to applied phosphate (Table 40).

These results from Khanasser, which has the same soil type as Breda, confirm the importance of the effect of applied fertilizer on residual effects in subsequent years, and the implications of those residual effects on the long-term strategy of phosphate fertilizer use. Such effects must be considered in the economic evaluation of fertilizer use.--*A. Matar.*

Table 40. Analysis of variance of barley dry-matter production at anthesis as a function of residual and direct phosphate application (1984/85).

Source of variation	DF	SS	MS	F
Total	26	20.915		
Replicates	2	0.0208		
Direct P	2	17.2557	8.6278	146.11 **
Residual P	2	1.6575	0.8287	14.03 **
Direct x residual interaction	4	1.0363	0.2591	4.39 *
Error	16	0.9448	0.0590	

* = significant at $P < 0.1$.
** = significant at $P < 0.05$.

Impact and Potential of Supplemental Irrigation within Rainfed Areas

Past and current trends of food and agricultural production in the ICARDA region are unsatisfactory despite considerable achievements. Fifty percent of the region's food requirement is imported and by 1990, there will be a 30-34 million tonne food deficit. The goal of this project is to economically improve productivity of basic food crops in rainfed areas using supplemental irrigation, with emphasis on wheat, barley, faba beans, chickpeas, lentils, and forages.

Of the total cultivated area in the ICARDA region, 70% is rainfed, with a cropping intensity of 55% and a yield gap ratio of 2.5:1 (research station:farmer). Of the total agricultural production, 75% is grown on 20% of the total cultivated area under irrigation, and irrigation efficiency is only 30%. Food production can be increased by: (i) introducing supplemental irrigation, (ii) expanding areas for rainfed and irrigated farming, (iii) decreasing yield gap ratio, and, (iv) increasing irrigation efficiency.

In an area where a crop can be grown by natural rainfall alone but additional water improves yields, irrigation is **supplemental.** Supplemental irrigation can increase and stabilize yields and provide suitable conditions for using high inputs, i.e. high-yielding varieties, more fertilizer, and more intensive cropping. Supplemental irrigation is an improvement on existing farm practices and the decision to irrigate is based purely on the estimated profitability of doing so.

Supplemental irrigation interrupts the cycle of decreasing productivity and increasing migration currently observed in small-scale farming communities. The characteristics of rainfed areas with unstable yields and low-cropping intensity (Fig. 30), and increasing population and basic needs result in the degradation of natural resources. This contributes to lower yields, inadequate earnings, and increased migration. Introducing supplemental irrigation into

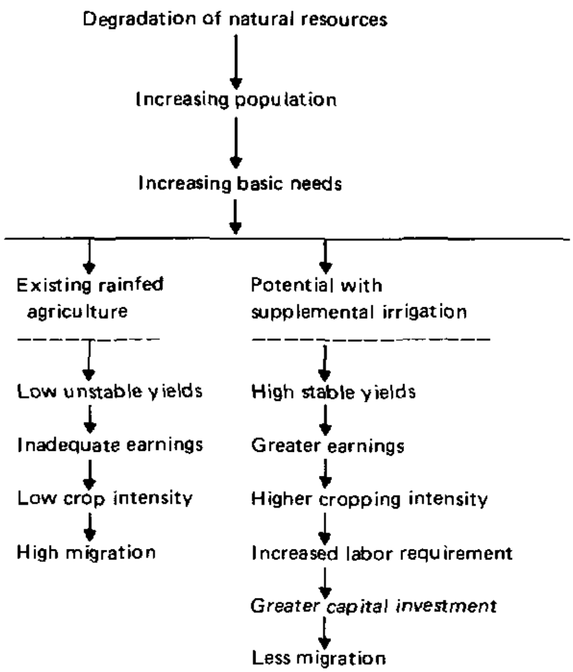


Fig. 30. Impact of supplemental irrigation on productivity and migration.

rainfed areas can lead to greater capital and labor investment and consequently, reduce migration.

Supplemental irrigation research at ICARDA aims to improve farming practices with farmers actively participating in any improvements made. Small-scale supplemental irrigation systems are being examined technically, agronomically, socially, and economically to identify potential areas for improvement and development.

The project methodology includes:

(1) Diagnosis: Farming systems are assessed and constraints identified and prioritized.

(2) *Design:Feasible technological alternatives* are developed to solve farmer's problems. Improvements which can be implemented on existing systems are the main feature of the approach.

(3) Test: Farmer acceptance of these solutions is assessed with on-farm trials.

(4) Extension: Field demonstration of technological solutions are expanded to a larger scale.

The specific elements of supplemental irrigation being examined are land, water sources, production costs, capital investment, irrigation equipment, machine operators, labor requirements, improved cultivars, insects and disease, weed and other pest controls, culture and management (fertilization, spacing, cultivating, irrigating, etc.), harvesting, processing, waste management, transportation to market, market development and promotion, supply and demand, price analysis, profitability and income, and government policies, laws, and regulations. To achieve the maximum socioeconomic benefits of supplemental irrigation, implementation of results will include systems which consider the needs of small farmers, herders, and the rural poor.

Site Selection

Agricultural land suitable for supplemental irrigation studies must have four basic features:(i) irrigable terrain, (ii) potentially fertile soils, (iii) a climate in which the crop can thrive, and (iv) a source of water of consistent quality.

In selecting sites, locations were chosen for which climatological data were available and for which there was potential for socioeconomic development. The following four sites were selected:

(1) Aleppo Province, northwest Syria.

(a) Tel Dhaman subdistrict (Breda), zones *2 and 3, 45 km southeast of Aleppo.*

(b) Mare'a subdistrict (Shahba Reservoir), zones 1 and 2, 45 km northeast of Aleppo.

(2) El Hassakeh Province, northeast Syria.

(a) Kamishly, zones 1 and 2, 60 km north of Hassakeh.

(b) Tel Hamis, zones 2 and 3, 40 km northeast of Hassakeh.

The plateaus of Aleppo have continental characteristics. Rainfall is greater than 250 mm, with the gradient decreasing easterly from the foothills inland. The "dry" season is 5-7 months. The temperature is cool in winter with 10-30 days of temporary frost depending on elevation. Summers are hot with temperatures of 40°C and large diurnal variation.

In the central plateaus at El Hassakeh and Kamishly sites, the rainfall gradient rapidly declines from 450 mm to 200 mm or less and the dry season lasts 8-10 months. Winter temperatures are cool in the plateaus and plains, but there are 10-30 days with temporary frost depending on elevation. The region lies in a plain formed from thick alluvial and colluvial quaternary deposits originating in the Taurus mountains and, to a lesser extent, from the mountains to the south. The plain slopes from north to south in the northern part and from south to north in the southern part. The surface of the plateau is slightly rolling and is cut by many wadis (dry washes or gullies) which are mostly tributaries of the Khabour River.

Site Characteristics of Tel Dhaman and Mare'a (Aleppo)

The subdistrict of Tel Dhaman lies 45 km southeast of Aleppo and the subdistrict of Mare'a lies 40 km north of Aleppo. The total area of the Tel Dhaman is 106,000 ha (Table 41) of which 84% is cultivated, 15% uncultivated, and 1% pasture. Of the cultivated land, 8% has supplemental irrigation and 92% is rainfed. One third of this land area is fallow. The total area of Mare'a is 32,070 ha, of which 56% is cultivated, 43% uncultivated, and 1% natural pasture. Of the cultivated land, 16% is under supplemental irrigation and 84% is rainfed.

Tel Dhaman has a total of 2558 agricultural land holdings with an average farm size of 20 ha for irrigated lands and 30 ha for rainfed lands. In Mare'a, there are 1556 agricultural land holdings with an average size of 5 ha for irrigated lands and 9 ha for rainfed farms. In Mare'a, 90% of the holdings are fragmented; each farm has several plots; some widely separated from each other. The population of Tel Dhaman is 23,910 with a sex ratio of 50:50 (male:female) and Mare'a has a population of 18,167 and a sex ratio of 53:47. Of the 114 villages in Tel Dhaman, 62 have rainfed agriculture with no potential for supplemental irrigation, 43 have irrigation from tube wells, 4 have limited irrigation water from the Kwiak River, and 5 have irrigation water from the Kwiak River and tube wells. Of the 19 villages in Mare'a, 4 have rainfed agriculture with no potential for supplemental irrigation, 11 have irrigation from tube wells, and 4 have a limited supply of groundwater.

Table 41. Land use parameters for the study sites in Aleppo province.

Parameter	Subdistricts: Tel Dhaman (ha)	Subdistricts: Mare'a (ha)
Total area	106,000	32,070
Cultivated	88,800	17,698
Rainfed	81,800	14,866
Irrigated	7,000	2,832
Uncultivated	16,200	13,924
Pastures	1,000	448

Tel Dhaman has 18 cooperative societies. There is one agricultural extension center at Aatshanah Sharkyeh village, one veterinary center at Breda, and one medical center at Tel Dhaman. In Mare'a, there are 10 cooperative societies, one agricultural extension center at Um Housh village, and one medical center and one veterinary center at Mare'a village. Schooling and educational services are available throughout the Tel Dhaman subdistrict with primary schools in all villages. Some villages have intermediary schools and two villages have secondary school. Primary, intermediate, and secondary schooling is available in the Mare'a subdistrict.

Electrical power networks have been established in more than 60% of the villages in Tel Dhaman with plans to supply the entire subdistrict with electricity within the next few years. Electrical power networks have already been established in about 90% of the villages of the Mare'a subdistrict; the other 10% should have electricity soon.

The domestic water in the Tel Dhaman subdistrict is taken from wells some of which are polluted and the water is not tasty. Only four villages in the Mare'a subdistrict have potable domestic water under pressure, the remainder use water from wells which is considered clean, tasty, and drinkable. The government plans to provide all villages in both subdistricts with potable water under pressure and some of these projects are currently under construction.

The villages of the Tel Dhaman subdistrict are interconnected by dirt roads although some villages have asphalt roads which connect with Aleppo, Khanasser, Abou D'hour, and other neighboring towns. In the subdistrict of Mare'a, there are no transportation problems; vehicles are available, and most villages in the subdistrict are interconnected with each other and Aleppo by asphalt roads. The main market for the Tel Dhaman subdistrict is Aleppo and there is a bazaar every Monday at Abou D'hour, 35 km from Breda and 18 km from Tel Dhaman. The main market for agricultural products from Mare'a is Aleppo and, for agricultural production inputs, Azaz, which is 23 km north of Mare'a.

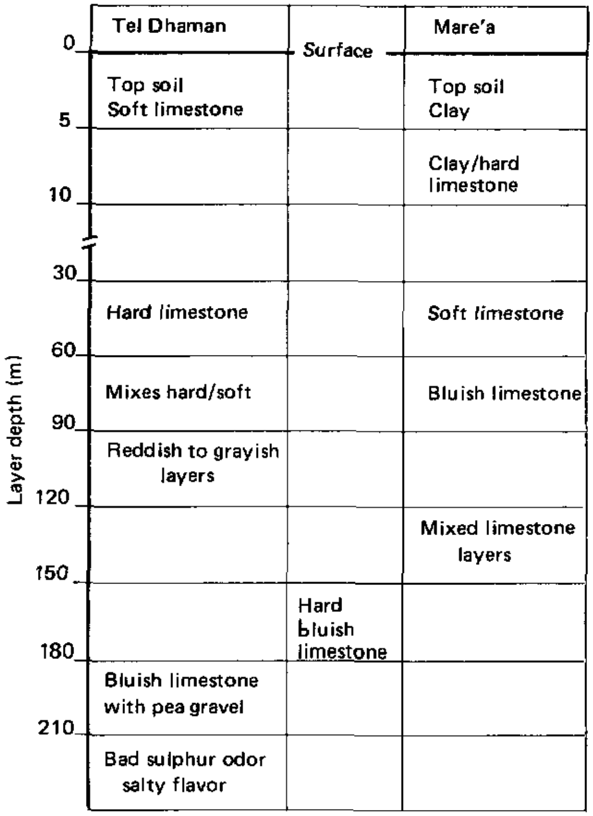


Fig. 31. Lithological cross-sections at the study areas.

Agronomic Characteristics

Groundwater is precipitation (dew, snow, or rain) that has percolated through porous rock and collected in sponge-like layers of rock, sand, and gravel called aquifers. These are sometimes only a few meters below the soil surface, but may be a kilometer deep. The depth of the principal aquifer was not determined for the two study sites. The amount of groundwater stored in an aquifer and which can be extracted from it, depends on the material of the aquifer. The lithological cross-sections delineating the character, thickness, and boundaries of the soil or rock beds overlying and underlying the aquifers at the two study sites are shown in Fig. 31.

The depth of clay in the top 30 m is greater in the Mare'a region than the Tel Dhaman region. Some of these clays can store enormous volumes of water but these clays are unproductive as aquifers because they do not yield their water, i.e., they have a low permeability. Below 180 m, the wells in Tel Dhaman produced sulfurous water of high salinity. Cross-sections of these clay and rock materials indicate that recharge by direct precipitation would be restricted by these low-permeable materials. If recharge occurs by precipitation, it must flow through fissures and cracks in the vertical planes of these rocks.

Wells are dug using the impact or percussion technique in which a 40-cm diameter borehole is dug at 10-15 m/day in clay or soft limestone but only 2-3 m/day in hard limestone. Most wells have protective metal screens down to the groundwater with gravel packs. In some locations in Tel Dhaman, 20% of the newly-dug wells do not provide an adequate water supply. In Mare'a, the thickest strata of the cross-section are clay or soft limestone and digging costs are 30-35 SL/m, compared to 60-70 SL/m in Tel Dhaman.

Storm water runoff from surrounding hills, wadis, and rivers is a primary source of groundwater recharge. During the last 3 years the water table has fallen due to low rainfall, and consequently, low groundwater recharge and a large number of new wells. Because of the increased depth to the water table, pumping costs are going higher.

In Tel Dhaman exploitation of the groundwater started 15 years ago; but in Mare'a exploitation started 25 years ago, with increased well digging in both subdistricts especially in the last 5 years. Tel Dhaman has about 150 wells and Mare'a, 549.

In the Tel Dhaman subdistrict, the depth to the water table is 50-60 m with a pumping depth of 70-80 m. Average depth to water table in the Mare'a subdistrict varies from 60 to 120 m. Sometimes wells must be dug to 200 m for adequate water but in some villages water is not available even at 360 m. The water flow capacity is 30-40 m^3/hr for irrigation pumps in Tel Dhaman and 30-50 m^3/hr for pumps in Mare'a with 7.5-10 cm outlets.

A detailed estimate of the cost of production of underground water is shown in Table 42. The cost of supplemental irrigation water is influenced by the source of water (surface or underground), distance of conveyance, and height of pumping. The average cost of digging a well in Tel Dhaman is 6,000 SL while in Mare'a it is about 3,000 SL. The cost for the engine and pump is 25,000-30,000 SL. The plastic pipe to convey water from the well to the field costs 22 SL/m at Tel Dhaman and 15-20 SL/m at Mare'a. Digging a well is a risky investment because (i) there is no guarantee that an adequate supply of water will be found at an economic depth; and (ii) credit from the Agricultural Bank for pumping equipment is not available until a well has been dug and water is available.

Wells in both subdistricts are all individually owned. At Tel Dhaman water is exclusively used by the well-owner, although a few well-owners help each other when water supplies are low. In Mare'a, water is usually used by the well-owner and farmers with good wells occasionally sell water to neighbors at 40 SL/hr for wells of 10 cm flow, and 25-30 SL/hr for wells of 7.5 cm flow. Alternatively, well-owners of Mare'a may receive one-third of the produce in payment for a season's irrigation of a neighbor's plot.

The topography of the two subdistricts is rolling and uneven which makes water conveyance and distribution difficult for irrigation. Since land-levellers are not used, fields must be subdivided into small plots to simplify irrigation of the entire field. Normally, one irrigation is applied during December before planting winter crops, with a second irrigation between March and April. Farmers in Mare'a do not usually apply a presowing irrigation for winter crops but wait until the first rains to sow them when the first 40-60 cm of the soil surface are at field capacity.

Surface irrigation is the principal method of applying water but sprinklers were introduced a few years ago and are increasingly used. About 10% of the total irrigated area is irrigated with sprinklers.

At Tel Dhaman, barley and wheat are the major winter crops, with faba beans on 1% of the cultivated area. Wheat is the major crop receiving supplemental irrigation in both subdistricts. Gezira 17, planted in zone 2 of Tel Dhaman, receives three to four irrigations in normal rainfall years. Siete Cerros and Mexipak varieties usually receive one irrigation less than Gezira 17. Wheat grown in zone 3 usually receives four to five irrigations.

In Tel Dhaman, barley usually receives supplemental irrigation twice per season from

Table 42. Estimated production costs (SL) for underground water in Aleppo province.

Parameter		Tel Dhaman		Mare'a	
Well - 150 m deep					
Drilling		@70 SL/m,	10,500	@35 SL/m,	5,250
Casing		@20 SL/m,	3,000	@20 SL/m,	3,000
Pump shaft		@25 SL/m,	3,750	@25 SL/m,	3,750
Total			17,250		12,000
Pumping units					
Pump	16,000				
Motor	14,000				
Total	30,000				
Fuel + oil + labor	10,800				
Maintenance	3,500				
Total	14,300				
Water pumped/year					
3740 hrs of pumping/year x 96 m^3/hr = 359,000 m^3/year					
(3740 hrs = 170 days x 22 hrs/day)					
Total annual cost[1]					
Interest and depreciation on well			2,122		1,476
Interest and depreciation on pumping unit			3,402		3,402
Operation and maintenance including labor			14,300		14,300
Total			19,824		19,178
Cost/m^3 of water[2]			0.0552 SL/m^3		0.0534 SL/m^3

1. Assuming: Life of well = 25 years
Life of pumping units = 10 years
8% interest
2. @3.9 SL = $1.00

the Kwiak River. In zone 2, barley is occasionally irrigated by the well system one or two times. Although barley is grown in rainfed conditions in Mare'a, some fields may receive supplemental irrigation in exceptionally dry seasons.

In Tel Dhaman, faba beans are irrigated two or three times in zone 3 and one or two times in zone 2 during normal rainfall years. Faba beans usually receive five to six irrigations in zone 2 at Mare'a.

Agricultural mechanization was introduced to Tel Dhaman nearly 20 years ago and 25 years ago to Mare'a (Table 43). However, acquisition of equipment has accelerated where the level of mechanization is related to increased supplemental irrigation and higher prices for agricultural products.

In Tel Dhaman, some operations such as cultivation, irrigation, and cereal harvesting have enough equipment, whereas equipment for seeding, fertilization, and pesticide application are in short supply. In Mare'a, only cultivation and irrigation equipment are readily available. Tractors are in adequate supply in the Tel Dhaman subdistrict but both

Table 43. Estimated time agricultural equipment was introduced.

	Years in use	
Equipment	**Tel Dhaman**	**Mare'a**
Tractors	20	25
Combine harvesters	10	15
Transport vehicles	20	30
Water pumps	15	25
Seed drills	10-12	1
Fertilizer spinners	2	2
Pesticide applicators	8	10

subdistricts lack sufficient combine harvesters and seed drills, which must be hired from neighboring districts. Some operations, such as weeding and harvesting of summer crops and legumes remain manual.

Equipment is usually owned by individual farmers in Tel Dhaman. Farmers who do not own equipment can hire it at the following rates: plowing by moldboard on irrigated fields @120 SL/ha, cultivation by duckfoot harrow @70 SL/ha, and harvesting wheat and barley @7-15% of the harvest (percentage decreases as the yield increases). Agricultural equipment in Mare'a is either individually owned or government owned.

The seed variety, seeding rate, sowing method, and planting dates for cereals are shown in Table 44. In both subdistricts, farmers use their own seed supplies of local varieties or purchase it from local markets. Seeds of improved high-yielding varieties, especially of major crops, are distributed by the government.

In Tel Dhaman, rainfed crops are usually sown a month earlier than crops for supplemental irrigation. Wheat is planted in December for rainfed conditions and in January under supplemental irrigation. Barley is planted during November under rainfed conditions and in December when supplemental irrigation is used. Delays in planting can occur with supplemental irrigation if cereals follow cotton or if field preparation is delayed due to rain.

Table 44. Seed variety, date, and method of planting, and seeding rate.

	Supplemental irrigation	**Rainfed**
Variety	Improved	Local
Planting date		
Tel Dhaman		
wheat	Jan	Dec-Jan
barley	Dec	Nov
Mare'a		
wheat	Nov-Dec	Nov-Dec
barley	Nov	Nov
Planting method	Mechanical	Manual
Planting rate (kg/ha)		
Tel Dhaman	150-180	100-120
Mare'a	120-150	100-120
Planting depth (cm)	5-7	Surface/furrowed

Since most of the cultivated area in Mare'a is in zone 1, there are no differences in sowing date for cereals between supplemental irrigation and rainfed conditions. Wheat is sown in November and December and barley a few days earlier (Table 44). Farmers prefer to plant cereal crops in November, but planting can be delayed until December if there is low rainfall, equipment or other agronomic inputs are unavailable, or field preparations are delayed.

In Tel Dhaman, high-yielding wheat varieties are grown with supplemental irrigation,whereas local varieties are grown in rainfed conditions. Cereals are planted by seed drills with supplemental irrigation and are broadcast by hand under rainfed conditions.

In Mare'a, high-yielding wheat varieties are grown with supplemental irrigation and on most rainfed soils in agroclimatic zone 1. Local varieties are grown on rainfed soil in zone 2. Seeds are broadcast by hand but seed drills have been introduced recently with supplemental irrigation. In both subdistricts seeding rates vary by rainfall zone, soil type, and whether supplemental irrigation is used.

The *methods of seedbed preparation* are different for rainfed and supplemental irrigation conditions. Two cultivations under rainfed conditions: a presowing cultivation (Ayar) and a seed covering cultivation (Rdad), are both done with a *duckfoot cultivator*. There are four cultivations for crops under supplemental irrigation: the first is deep plowing with a moldboard during November after removing crop residues (usually cotton); the second is before Ayar and is done with the duckfoot cultivator;and, the third and fourth are the Ayar and Rdad.

In some villages of Tel Dhaman, salinity is a limiting factor of the cropping system and must be considered in seedbed preparation. Soil surface crusting occurs frequently, which hinders seedling emergence.

In the river system of the Tel Dhaman subdistrict, only winter crops are fertilized with nitrogen (urea) and phosphorus (triple superphosphate) and at lower application rates than those of the well system (Table 45). In the well system, all winter and summer crops are fertilized with nitrogen and phosphorus except on saline soils where manure is applied. In the rainfed system, only winter crops which are grown in zone 2 are fertilized with nitrogen (calcium nitrate) and phosphorus (TSP). Fertilizer is not applied in zone 3.

Table 45. Average fertilizer application rates (kg N and P_2O_5/ha) at the two study sites.

	Tel Dhaman		Mare'a	
	SI	Rainfed	SI	Rainfed
Winter crops				
N	160	30	150	100
P	105	45	100	80
Summer crops*				
N	160	0	150	0
P	105	0	100	0

* Only summer crops are irrigated.

Table 46 shows the land and crop allocation for the two study sites. Wheat is the number one crop considered for

Table 46. Percentage of land and crop allocation for the two study sites.

Crop		Tel Dhaman			Mare'a		
		SI	Rainfed	Total	SI	Rainfed	Total
Wheat:	Improved	19.3	0.3	3.8	38.2	24.7	27.1
	Local	23.7	19.0	19.8		9.8	8.0
Barley		12.3	79.8	68.5		4.3	3.6
Lentils						24.5	20.2
Chickpeas						2.6	2.1
Faba beans					1.7		0.3
Melons*		18.5	0.2	3.3	0.3	14.3	11.8
Cotton*		15.4		2.6	13.7		2.4
S. vegetables*		5.5	0.3	1.2	8.6	9.7	9.5
Sugar beet*		3.0		0.5	29.5		5.2
Other crops		2.3	0.4	0.3	8.0	10.1	9.8

* Only summer crops are irrigated.

supplemental irrigation followed by barley and faba beans. Cropping intensity under the river system in Tel Dhaman is 100%, of which 54% is attributed to supplemental irrigation of wheat and barley and 46% to irrigation of cotton, melons, and vegetables. Cropping intensity under the well system is 105%; 50% is from supplemental irrigation of winter crops, of which 95% is planted to wheat and 5% is planted to faba beans and spring potatoes; 50% is from irrigation of summer crops predominantly cotton, followed by sugar beets, melons, and vegetables, and 5% is attributed to irrigation of sesame and maize plantings. The cropping intensity under supplemental irrigation in Mare'a is 105% distributed as 50% winter crops, 50% summer crops, and 5% maize and sesame.

The cropping intensity in rainfed conditions in Tel Dhaman varies according to agroclimatic zones. In zone 2, with above-average soils and rainfall, 65% of the cropping intensity is from wheat and barley with the remainder in fallow and, with average soils and rainfall, 50% is from barley and the remainder in fallow. In zone 3, 60% is from barley and wheat with 40% in fallow, and in zone 4, 40% is from barley with the remainder in fallow. In Mare'a, in rainfed conditions, the cropping intensity is 100% in zone 1 with 33% cereals, 33% legumes, and 33% summer crops, mainly melons. The cropping intensity in rainfed zone 2 is 75%, of which 50% is from cereals, 15% from legumes, and 10% from summer crops.

Table 47 shows the common weed species found at both sites. Winter crops are not always hand-weeded; herbicide is applied on 60% of the fields under supplemental irrigation and on 20% of the rainfed lands. The areas sprayed can vary in size from year to year depending on the incidence of weeds. Presowing or preemergence herbicides are used on 100% of the area allotted to irrigated cotton or sugar beets.

Table 47. Common weed species found in both study sites.

Local name	Scientific name
Winter crops	
Suffaira	*Sinapis arvensis*
Shufan Barri	*Avena sterilis*
Najeel	*Cynodon dactylon*
Hulyyan	*Sorghum halepense*
Summer crops	
Maddadeh	*Convolvulus althacoides*
Aenab el-dubbeh	*Solanum nigrum*
Thullaigeh*	*Stochya nivea*
Orf ed-deek**	*Amaranthus* spp.

* In Tel Dhaman subdistrict only.

** In Mare'a subdistrict only.

Pest infestation is more serious on irrigated crops than under rainfed conditions, especially summer crops. Major economically important insects found at both sites are the suni bug (*Eurygaster integriceps*) on wheat and barley, the boll worm (*Heliothis armigera*) on cotton, aphids (*Aphis* spp.) and red spider mites (*Tetranychus* spp.) on vegetables, beet flea beetle (*Chaetocnema tibialis*) on sugar beet, and the cutworm (*Agrotis* spp.) on summer crops and vegetables. No major insect infestations have been observed on winter crops for either supplemental irrigation or rainfed conditions. Areas sprayed for pest control vary by crop type and level and severity of pest infestation. In Mare'a, 10-50% of the wheat fields are normally sprayed to control suni bug.

Plant diseases are not considered a problem. Smut and rust can occur on wheat grown under supplemental irrigation and, to a lesser extent, on rainfed wheat in zone 1.

There are higher average yields for wheat and barley with supplemental irrigation than under rainfed agriculture in both subdistricts. High-yielding wheat varieties produce, on average, 5 t/ha with supplemental irrigation compared to 2 t/ha in zone 1 and

1.5 t/ha in zone 2 under rainfed conditions. Rainfed crops mature and are harvested 10-20 days before crops grown under supplemental irrigation. Harvest date varies by crop, soil type, and climate.

Harvesting costs are usually higher for cereals grown under supplemental irrigation, since the net cost of harvesting cereals is based on yield, i.e., cost ranges from 5 to 12% of the total harvest. These rates are for combine harvesting.

Livestock are more important in rainfed agriculture than in supplemental irrigation systems. In Mare'a, 83% of the cultivated land is located in zone 1 under rainfed conditions but livestock are unimportant in farm income because the land is too valuable for grazing.

There are about 100,000 sheep in Tel Dhaman where they are an integral part of the farming system, particularly in zones 3 and 4. Flock size per family or household decreases from zone 4 to 3 to 2 and is minimal where supplemental irrigation is used except where limited numbers of dairy cattle (Fresian) are integrated exclusively with irrigation. In Mare'a about 12,000 sheep are incorporated into rainfed agriculture and 180 dairy cattle are integrated with supplemental irrigation. The total number of livestock has been increasing in both subdistricts.

Flocks are moved twice per year in Tel Dhaman: once to the steppe during spring, returning for the summer and once to the western, wetter region after the harvest of summer crops, returning during winter. Average charges for grazing crop residues in 1984 were 250-300 SL/ha for cereals and 450-550 SL/ha for cotton or sugar beets.

In Mare'a, flocks are moved once to the steppe during spring, returning in summer to graze winter crop residues. There is no move to the wetter regions in the west. Flocks from the subdistrict and elsewhere can graze crop residues either free, or at a token charge (100 SL/ha). Green barley grazing is also available but at 4,000 SL/ha.

Social and Economic Characteristics

With rainfed agriculture in Tel Dhaman, 90% of the total labor requirement is provided by the family, whereas, with supplemental irrigation, only 10% of the labor requirement is provided by the family; 70% is hired labor and 20% sharecroppers. Operation of the irrigation system is done solely by family labor, harvesting is done partly by family labor, and other farming operations are done by hired labor. With rainfed agriculture, in the Mare'a subdistrict, 70% of farmers rely on family labor and 30% on hired labor. With supplemental irrigation, only 10% of total labor is provided by the family, 20% by sharecroppers, and 70% by hired labor. Relatives and neighbors no longer contribute free labor.

Hired labor for farms in Tel Dhaman with supplemental irrigation is provided primarily by the farmers of rainfed farms within the same village or from neighboring villages, and occasionally, from outside the subdistrict. In Mare'a, about 65% of the hired labor is from rainfed farms within the village, 10% from neighboring villages, and 25% from outside the subdistrict. There is labor scarcity at peak-demand periods; for example, harvesting winter and summer crops, seeding, fertilizer application, and weeding of summer crops.

Daily wages of hired labor have doubled and even tripled during the last 5 years in both subdistricts.

In Tel Dhaman, 60% of the total migration from rainfed areas is permanent, i.e., farmers migrate to neighboring cities or abroad. Temporary migration occurs when labor is not needed for rainfed agriculture and many farmers migrate to irrigated areas for employment. Farmers from Mare'a do not migrate permanently, neither from rainfed nor irrigated farms. About 35% of the farmers from rainfed agriculture migrate temporarily to Aleppo during the off-season and return when their labor is needed.

Most agricultural products are transported from both subdistricts to Aleppo for marketing. Sugar beet goes to Meskeneh. The commodity market is regulated by the government and there are complicated formal procedures for marketing crops. Regulated crops include wheat, barley, lentils, cotton, sugar beet, and maize. Sesame, fruit products, and vegetables can be sold either to the government or directly to individual traders.

Vegetables, wheat, and cotton, are the most profitable crops for farmers with irrigation systems. Under rainfed conditions, melons, wheat, and barley, are the most profitable crops in zone 2, while barley and livestock are the most profitable in zones 3 and 4.

Net income per hectare with supplemental irrigation in Tel Dhaman is five to six times that of rainfed agriculture and in Mare'a about 10 times. With supplemental irrigation, nearly all households in Tel Dhaman and more than 70% of households in Mare'a receive all earnings from the farm, whereas, under rainfed agriculture, only 30% of the households in Tel Dhaman and less than 50% in Mare'a can rely on their farms for their total income.

Thus off-farm income contributes a major portion of the household's total income in rainfed areas. The income differences between farmers of irrigated and rainfed agriculture are reflected in the diverse social status and life styles of the two groups. An increased quantity and quality of food, improved housing, clothing, cars, TV sets, and other facilities are observed where irrigated farming exists.--*E. Perrier and A. B. Salkini.*

Simulation with SIMTAG

Climatic variability, within and between seasons, is possibly the most characteristic environmental quality of the ICARDA region. This is most evident in the widely different rainfall amounts and distributions, but also applies to temperature and other climatic elements. The implications of this variability for agriculture have been analyzed by Keatinge *et al.* 1985. The consequence of the highly variable weather from season to season is even more variable crop yields. Table 48 shows simulated grain yields for two wheat cultivars compared with seasonal rainfall for 1960/61 to 1984/85. The ratio of rainfall in the driest to the wettest years is appproximately 1:3, while the ratio of yields is much wider. Perhaps even more important is that in different seasons the relative yield of the cultivars changes. This illustrates some of the difficulties attached to the interpretation of experimental data from such environments.

Not only are seasons, and therefore crop yields, variable. Time sequences may occur which could lead to misinterpretation of crop-environment interactions. For example, the data presented for Muslimieh (Table 48) show that the cultivar Sonalika outyielded Novi Sad in 14 years out of 25, but in the last 6-years the reverse was true in four out of six instances. Thus a 6-year experimental program would be insufficient to ensure correct interpretation. Longer experimental programs would be time consuming and costly. It has been suggested that the judicious use of weather-driven computer simulation models could help improve the efficiency of quantification of variability (Harris *et al.* 1985). This in turn should help in understanding crop-time-environment interactions and facilitate targeted development of adapted genotypes and cropping strategies.

The Tool

The SIMTAG (*SIM*ulation of *T*riticum *A*estivum *G*enotypes) wheat model (Stapper 1984) was presented in a previous report (ICARDA 1985). It was developed at ICARDA in collaboration with the University of New England, Armidale,

Table 48. Seasonal precipitation and simulated grain yield for two wheat varieties at Muslimieh, northern Syria.

Seasons	Precipitation (mm)	Grain yield Sonalika (kg/ha)	Grain yield Novi Sad (kg/ha)
1960/61	213.5	1250	910
1961/62	421.8	4210	5580
1962/63	442.0	4760	5450
1963/64	332.9	3310	1820
1964/65	366.6	4180	4420
1965/66	195.7	800	690
1966/67	589.1	5560	5870
1967/68	439.8	2800	2940
1968/69	525.8	4980	5820
1969/70	168.9	760	600
1970/71	293.3	2050	1490
1971/72	417.7	3580	4370
1972/73	164.7	450	360
1973/74	351.9	3620	3930
1974/75	304.0	1910	2140
1975/76	457.6	3470	3510
1976/77	295.5	1010	950
1977/78	342.0	3200	3410
1978/79	248.0	880	950
1979/80	400.5	3260	2590
1980/81	310.9	1280	1250
1981/82	290.7	710	510
1982/83	277.9	1060	1090
1983/84	232.6	930	970
1984/85	345.2	3050	2680

NSW, Australia. Developed from an early version of the CERES model (Ritchie, personal communication), SIMTAG was calibrated using crop data from ICARDA's permanent sites in northern Syria. Predictions from the model agree closely with experimental data from semiarid regions in Syria, Morocco, Mexico, South Africa, and Australia.

Inputs required for the model are: daily rainfall, maximum and minimum temperatures and short wave radiation; a description of the hydraulic properties of the soil profile, soil depth and soil albedo; crop genetic parameters describing photoperiodic response, photothermal development, kernel carrying capacity and filling rate; and management factors (sowing date and rate, irrigation amounts and dates, etc.). From these, the model computes derived climatic variables (e.g., evaporation, photothermal time), water balance, phasic development, vegetative development, and plant growth and final yield (Fig 32).

Comparison of Two Contrasting Genotypes in Syria

In this study SIMTAG was used to examine several aspects of crop-environment interactions for six sites in Syria: Kamishly, Muslimieh, Aleppo, Hama, Izra'a, and Sweida.

Daily rainfall and temperature data from 1960/61 to 1984/85 were supplied by the Meteorological Department of the Syrian Ministry of Defence, Damascus. Monthly and seasonal averages for the period are shown in Table 49. Daily shortwave radiation was derived from maximum clear day radiation at ground level converted to actual radiation values using temperature dependent relationships established from data collected at four permanent recording sites by the Farming Systems Program in the past 6 years.

For each site, the same three contrasting soil profiles were used. These were based on the hydraulic characteristics of soils in the Aleppo Province and were chosen to represent a range in plant extractable water due to soil depth and soil hydraulic properties.

These weather and soil data were used to "run" SIMTAG and to "grow," on the computer, 25 wheat crops -- one for each year of weather record.

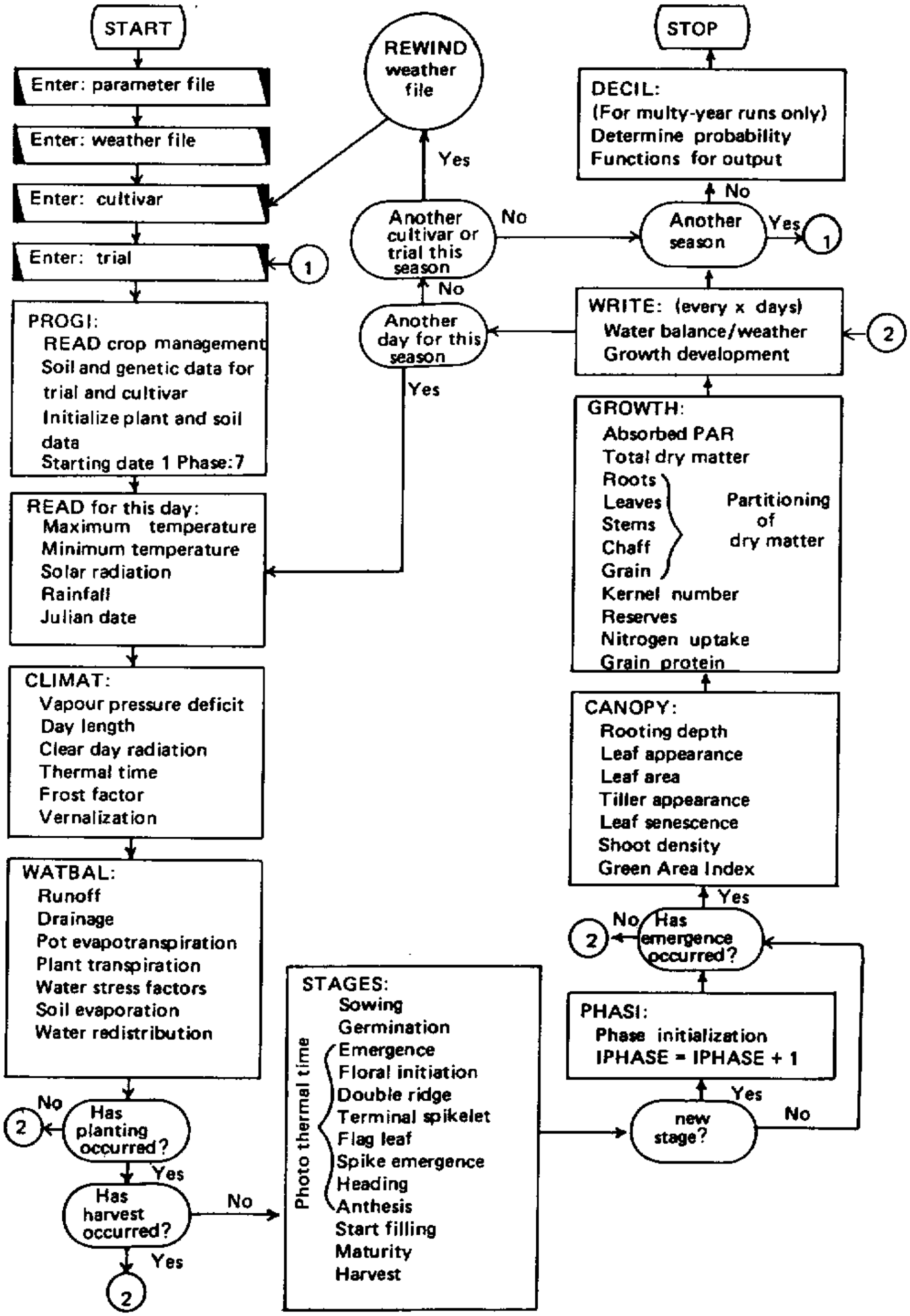


Fig. 32. Flow chart for the wheat model SIMTAG (Stapper 1984).

On all runs a uniform sowing depth, date, and rate were assumed. The sowing date (15 November) coincides with the most common period in northern Syria, but germination date is predicted by the model according to the available soil water at the sowing depth which is calculated by the water balance routine. Thus when rains at the start of the season are delayed after 15 November (in this case) the model will take account of the fact, and the start of crop growth and development will be delayed. The two cultivars used in the analysis were selected to show maximum contrasts of development rate. The first cultivar equates to Sonalika with early maturity, a small number of kernels per spike, but a fast rate of kernel filling, resulting in potentially high 1000-kernel weights. The second cultivar is a late maturity type, equivalent to Novi Sad, with large kernel carrying capacity but slower kernel filling rate and potentially smaller kernels (based on Mexipak).

The grain yields predicted by the model reflect the climatic variability during 1960/61-1984/85. They were plotted (Fig. 33) as the cumulative probability that the yield will be less than or equal to the amount specified on the x-axis. For example, at Kamishly on a Luvisol, the predicted yield of both cultivars is less than or equal to approximately 3 t/ha in 2 years ($p=0.2$) out of 10. However, for any level of cumulative probability greater than 0.2 the yield predicted for the late cultivar exceeds that for the early one. Thus the use of a late cultivar would increase overall production on this soil type at Kamishly. Where less water is available to the crop the early cultivar outperforms the late one in 5 years out of 10 ($p=0.5$) (Vertisol) or virtually always (Xerosol soil).

Fig. 33 also shows the cumulative probabilities of grain yield for the six locations and three selected soil types. At all locations, the model predicts that in years when seasonal conditions cause small yields the early maturing cultivar will have a yield advantage, whereas in the most favorable seasons the late cultivar could be expected to give the greater yield. This is a consequence of differences in maturity type and kernel type which both influence yield in a similar way. In optimum growth conditions, early cultivars usually yield less than late ones. However, where drought in the terminal growth stage may be a problem, as in the winter rainfall areas under consideration, late maturing cultivars are more affected by stress and early cultivars tend to show a yield advantage. Seasons with good rainfall also tend to be longer, due to better rainfall distribution and more available soil moisture at the end of the season, which gives late maturing cultivars a relative advantage.

Kernel type is equally important. Fig 34 shows the basis on which kernel type, kernel filling rate, and interactions with dry matter at anthesis are modelled (Stapper 1984). Cultivars are placed into a group, determined by the phenotypic expression of their genotype. Various combinations of potential kernel-carrying capacity (high, medium, or low), potential kernel size (large, medium, or small) can be specified. The upper bounds of the group into which they fall determines maximum kernel numbers whilst stress around anthesis reduces the number towards the lower boundary. In conditions where yields are small (<300 g/m^2 dry weight at anthesis), all cultivars tend to have similar kernel numbers (22.6 kernels per gram of dry weight at anthesis). This gives a relative yield advantage to the earlier cultivar which has a higher rate of kernel filling. In contrast, when postanthesis stress is not severe the larger kernel size of the early cultivar cannot compensate for the greater number of smaller kernels in the late cultivar, and the yield advantage lies with the latter.

These relationships are reflected in the predicted cumulative probability distribution functions (CDF's) of yield shown in Fig 33. On deep soil with a large water-holding

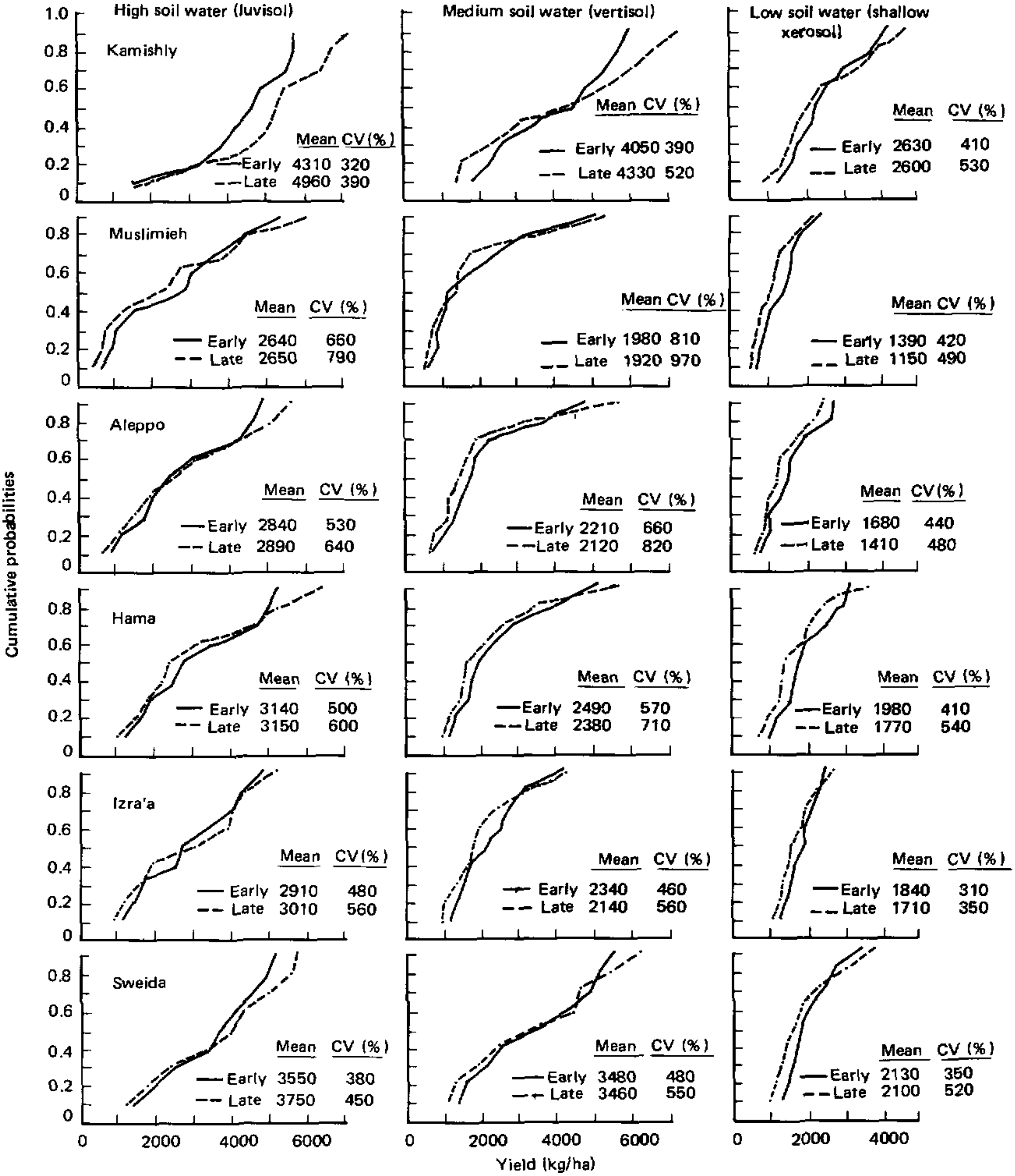


Fig. 33. Cumulative probabilities of simulated grain yield for two cultivars of wheat and three soil water storage capacities.

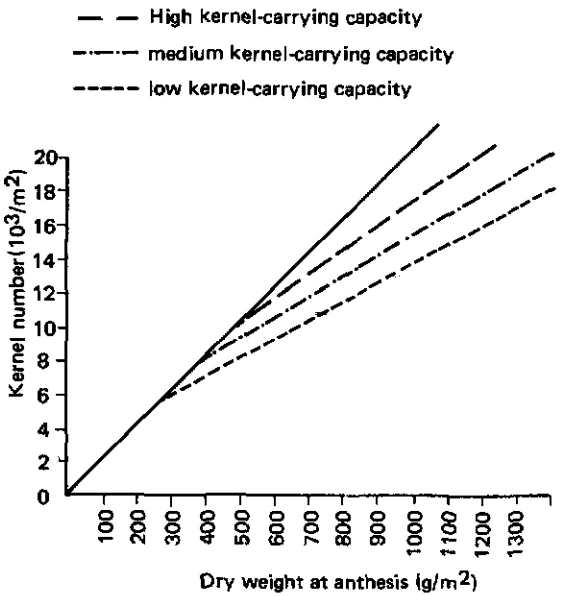


Fig. 34. Relationships between kernel number and dry weight at anthesis for cultivars with differing kernel-carrying capacity (Stapper 1984).

capacity the early cultivar can be expected to outyield the late one in most years at Muslimieh, Aleppo, and Hama, but at the wetter and/or colder sites of Sweida and Kamishly the reverse holds. At Izra'a the results are inconclusive, with each cultivar returning the highest yields in about 50% of years. As yield stability in seasons of less growth potential is important, however, the early cultivar would be the preferred one. These CDF's reflect the degree of environmental risk, the line lying predominantly to the right normally representing the least risk *option.*

On a soil type with a smaller extractable water-holding capacity (the Vertisol type) the late cultivar would represent the preferred option only at Kamishly (Fig 33). Where the water storage capacity is even less (shallow Xerosol) the early cultivar should outyield the late one at all sites.

The positive correlation between grain yield and cumulative evapotranspiration (CET) during crop development is illustrated in Fig 35. This is amplified by the fact that water-use efficiency (WUE) for grain increases with available water and yield. When yields are poor, there is a negative correlation between extractable water and soil evaporation and low WUE results. This can be expected to be due to rain distribution and intensity, and to the crop's ground cover, particularly early in growth (Cooper 1983). Where there was more rainfall, greater soil moisture storage occurred, crop growth, and thus ground cover, was better and soil evaporation was a smaller proportion of seasonal water use. Stress at the late stages of crop growth was less severe as a consequence and water-use efficiency for grain yield was higher.

Crops at Kamishly, where rainfall was greatest, gave the best yields and had the largest WUE's. Muslimieh and Izra'a (Fig. 35) as well as Aleppo and Hama have similar *distribution of extractable moisture,* WUE, and grain yield, all of which were considerably lower than for Kamishly. The distribution at Sweida, which has the *second largest yield* potential is different. The reasons for this are more complex and involve a rainfall and temperature interaction. Because of its higher altitude, (Table 49) and associated cooler temperatures, evaporative demand is less. This results in better profile water recharge during winter and a better water supply and less stress at critical periods at the end of the season. Maturity occurs 2-3 weeks later than at Izra'a which is at the same latitude. Sweida is sited on the windward side of Jebel al Arab, and the better *performance of crops on shallow soils at this* site may be due to more frequent rain.

"Best Bet" Maturity and Kernel Types

SIMTAG allows the creation of artificial cultivars with various combinations of

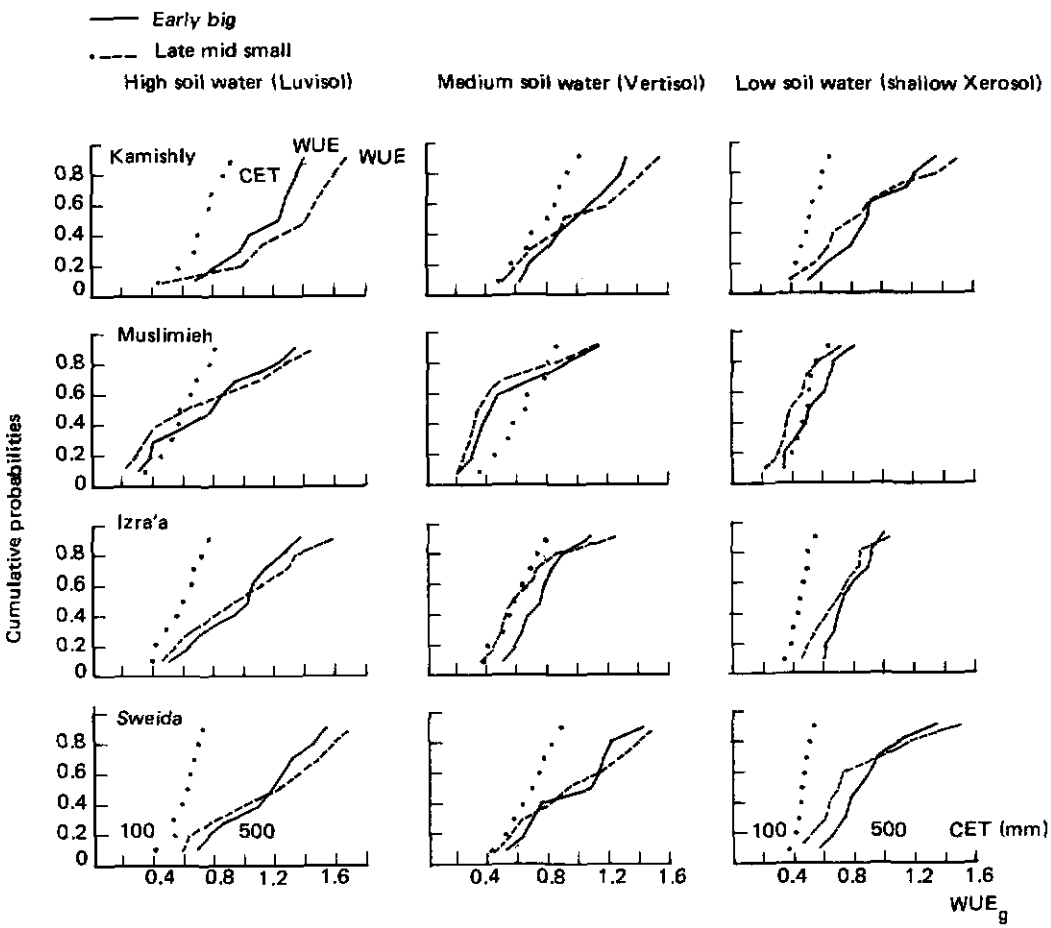


Fig. 35. Cumulative probabilities for simulated water-use efficiency (WUE_g) and cumulative evapotranspiration (CET) (mm).

phenotypic characters. This can help to identify germplasm material for field testing. Hypothetical cultivars with four different maturity characteristics (early, semi-early, mid-season, and late) and three different kernel types (small, medium, and large) were "grown" at the same six sites, using the same three soil types and 25 years of climatic data. The CDF's were determined for each and summarized (Table 50) as the "cultivar" giving the greatest yield at each decile level, on each soil type.

Assuming that the "cultivar" most frequently producing the greatest yield, irrespective of probability level, is best, then a mid-season cultivar with large kernels is outstandingly the "best bet" type (Table 50). It is only in the environments with large yield potentials that late and/or small-seeded cultivars are more productive, with the exception of the ambiguous result for the medium water-holding soil at Muslimieh.

These results suggest that there are sufficient differences in the interactions of

Table 49. Monthly mean precipitation for six locations (1960-1985).

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Kamishly	81.0	67.0	68.0	68.0	32.0	1.0	0.3	0.0	0.3	17.9	37.9	66.1	439.5
Latitude $37^\circ 03'$													
Longitude $41^\circ 13'$													
Elevation 452 m													
Muslimieh	74.9	49.5	46.3	35.7	17.6	2.2	0.0	0.4	1.8	19.9	36.6	66.6	351.6
Latitude $36^\circ 20'$													
Longitude $37^\circ 13'$													
Elevation 425 m													
Aleppo	60.6	49.8	46.2	37.5	21.4	1.0	0.0	0.1	1.5	10.7	33.2	61.7	333.1
Latitude $36^\circ 11'$													
Longitude $37^\circ 13'$													
Elevation 390 m													
Hama	72.1	54.8	47.9	35.3	10.3	1.5	0.4	0.1	2.0	24.3	36.8	65.1	350.6
Latitude $35^\circ 08'$													
Longitude $36^\circ 45'$													
Elevation 307 m													
Izra'a	69.8	56.0	53.0	23.4	2.7	0.0	0.0	0.0	0.1	6.2	17.6	51.9	280.7
Latitude $32^\circ 51'$													
Longitude $36^\circ 15'$													
Elevation 575 m													
Sweida	76.4	73.6	63.3	31.0	6.2	0.0	0.0	0.0	0.4	15.0	31.0	59.7	356.6
Latitude $32^\circ 42'$													
Longitude $36^\circ 35'$													
Elevation 997 m													

these simple characters to warrant monitoring in the field. Cultivar testing with these characters would provide a test of the hypothesis and of the truth of the model predictions.

The Outlook

Field studies of a set of cultivars, thought to differ in drought tolerance, were undertaken in 1984/85. However, because of severe frost, the results were inconclusive, and the work will be repeated in a modified form in 1985/86. The objective of these studies is to sharpen our perception of the most appropriate characters for drought tolerant cultivars, and to provide data on which to model the identified characters. Additional parameters relating to growth and development prediction could then be specified as genetic input parameters and the model used to test their efficacy in increasing yield and yield stability in a range of environments. This work will continue in collaboration with the Cereals Program.--*W. Goebel, H. Harris, G. Ortiz Ferrara, and D. Mulitze.*

Table 50. "Best bet" varieties for six locations and three soil types.

	Deciles										
	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	Best variety	Soil type
Kamishly	Ls	Ls	Ls	Ls,Ms	Ls	Ls	LB	Ss	MB	Ls	Luvisol
	Ls	Ls	Ms	Ls	Ms	Ms	Ms	EB	EB	Ms	Vertisol
	Ls	Ms	Ls	MB	MB	MB	MB	SB	EB	MB	Shallow Xerosol
Muslimieh	Ms	Ms	Ls	MB	EB	MB	MB	MB	MB	MB	Luvisol
	MB	Ls	EB	LB	LB	LB	MB	MB	SB	LB,MB	Vertisol
	EB	MB	MB	MB	EB	MB	LB	EB,SB,MB	SB	MB	Shallow Xerosol
Aleppo	Ms	Ms	Ms	MB	MB	MB	LB	MB	MB	MB	Luvisol
	Ms	Ss,MB	Ss,SB	LB	LB	MB	MB	MB	MB	MB	Vertisol
	Es,MM	Es	MB	MB	EB	MB	MB	MB	LB	MB	Shallow Xerosol
Hama	Ls	Ms	Ss	Es	EB	EB	MB	MB	MB	MB	Luvisol
	Ms	Ls	Ms	Ss	LB	MB	LB	MB	MB	MB	Vertisol
	Ls	EM	EB	MB	SB	MB	MB	MB	MB,EB	MB	Shallow Xerosol
Izra'a	Ms	Ms	Ms	Ls	Ms	SB	LB	LB	MB	Ms	Luvisol
	Ls	Ms	Ms	Es	MB	MB	MB	MB	MB	MB	Vertisol
	MB	EM	LB	LB	MB	MB	MB	MB	LB	MB	Shallow Xerosol
Sweida	Ms	Ls	Ls	Ms	Ls	Ms	Ss,SB,MB	MB	MB,LB	Ms,MB,Ls	Luvisol
	Ls	MB	Ss	Ms	Es	Ms	MB	MB	MB	MB	Vertisol
	Ls	Ls	EB	MB	MB	MB	MB	Es,EM,EB	EB	MB	Shallow Xerosol

Maturity group	Kernel type
E: Early	s: Small
S: Semiearly	M: Medium
M: Medium	B:Big.
L: Late.	

Infiltration and Runoff Studies by Using a Rainfall Simulation Type ORSTOM

Although ICARDA is sited in the dry areas, occasional intense, localized rain storms are a feature of much of the region. Rainfall and rainfall intensity records for the Aleppo airport meteorological station of the Meterological Section of the Syrian Ministry of Defence show that intense storms occur predominantly at the start (October and November) and end (April and May) of the rainfall season (Table 51).

At the beginning of the season most land is devoid of vegetation following grazing during long dry summer. Towards the end of the rainy season, land fallowed during winter will have relatively large water contents in the surface horizons. In both circumstances, heavy rainfall is likely to cause runoff, which may in turn cause soil erosion. Studies on the frequency of high intensity rain events, and of infiltration and runoff have therefore started.

Table 51. Number of rain events of 15 minutes for different amounts of rain (<5 mm - >15 mm), Aleppo airport, 1967-81.

Month	Amount of rain (mm) <5	%	5-10	%	10-15	%	>15	%	Mean maximum rainfall intensity during the same period mm/hr
Jan	14	93.3	1	6.7					8.24
Feb	14	93.3	1	6.7					11.6
Mar	13	86.7	2	13.3					11.1
Apr	10	66.7	4	26.7	1	6.7			16.1
May	6	40.0	7	46.7			2	13.3	27.8
June	1	6.7	1	6.7					0.7
Sept	14	93.3	1	6.7					2.2
Oct	10	66.7	3	20	2	13.3			19.7
Nov	12	80.0	2	13.3	1	6.7			14.9
Dec	15	100							10.7

A rainfall simulator (Asseline and Valentin 1977) was used to study the infiltration capacity of soils at Tel Hadya and on the off-station site at Breda. At Tel Hadya the infiltration rate on dry soil is relatively rapid. Using a range of simulated constant intensities on an essentially flat area (slope *ca* 2%) it was shown that, when the soil is air dry during summer, an infiltration rate of approximately 50 mm/hr can be maintained for 1 hour before runoff commences. However, at Breda where the soil contains a large silt fraction, (*ca* 40%) surface dispersion occurs and infiltration rates are much slower.

The pattern of rain intensity distribution during thunderstorms was studied from intensity records taken at Tel Hadya in the past 6 years. These showed a period of several minutes of relatively low intensity rain (up to *ca* 30-40 mm/hr) followed by a few minutes of greater intensity (90-150 mm/hr). This pattern was simulated by simulating rain at 30 mm/h for 15 minutes followed by 5 minutes at 95 mm/h. Runoff was markedly increased and soil water storage decreased, illustrating the potential problem at each end of the rainfall season.

An important feature of land tenure in the region is the fragmentation of individually-owned land holdings. Small parcels of land are usually subdivided in narrow strips up and down hillsides so that good and poor land is evenly distributed amongst farmers. As a result, farmers are often forced to cultivate their land up and down the slope, a practice that could exacerbate runoff and erosion.

To assess the potential danger, three types of tillage were carried out both with and across the slope (5%) of land at Tel Hadya, and 50 mm/hr of rain was applied for 1 hour. Tillage was carried out with the commonly used duckfoot cultivator and disc plough and a chisel plough although the latter is not normally used in the region.

Either a disc or chisel plough was superior to the cultivator when the direction of working was up and down the slope (Fig. 36). It is unclear whether increased working depth or increased surface roughness was the major factor reducing runoff. When the

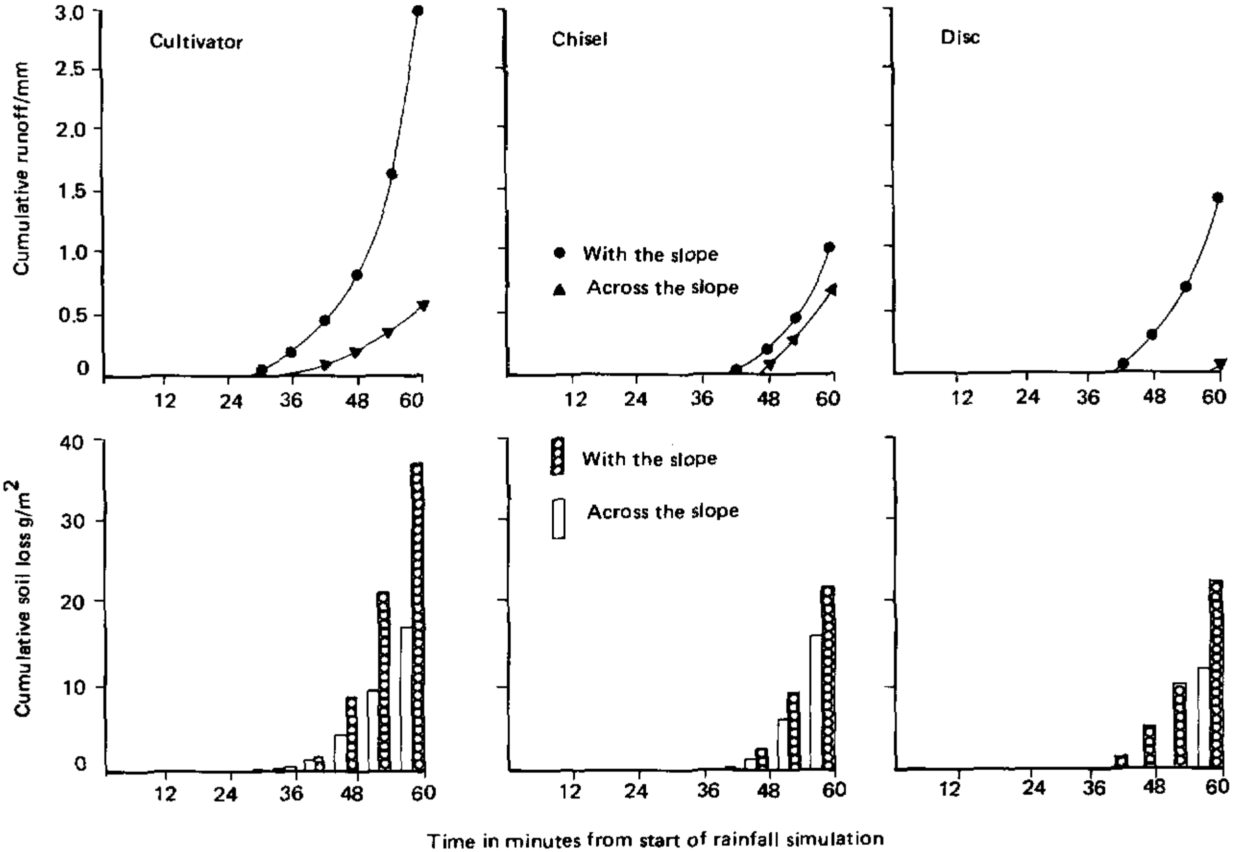


Fig. 36. Effect of tillage practices on runoff and soil loss following simulation of 50 mm rainfall at an intensity of 50 mm/h.

direction of working was across the slope runoff was markedly reduced in all treatments.

Rainfall of this intensity and duration only occurs very rarely, but however infrequent, soil loss due to erosion is permanent and irreplacable. The implications of this study are that the only one of these tillage practices which would cause concern is the use of a duckfoot cultivator with the direction of the slope. Unfortunately, this practice is common, and, given the current land holding pattern and equipment availability, is likely to remain so.--*Y. Sabet and H. Harris.*

Single-Pass Seeder

Major crops in Syria (i.e., wheat, lentils, barley) are currently hand-broadcast over ridges (sometimes followed by hand-broadcast phosphate fertilizer) and then covered by ridge splitting or with a tabban (a heavy bar pulled by tractor). This procedure may require four passes over the land: (1) tractor plus duckfoot cultivator to ridge the soil (2) hand broadcasting of seed, (3) hand broadcasting of fertilizer, and (4) tractor (plus cultivator or tabban) to cover seed and fertilizer.

We have developed (with the help of Station Operations) a simple Single Pass Seeder which incorporates the commonly used duckfoot cultivator, locally made driving wheels for depth control, two boxes (one for seed and one for phosphate fertilizer with rate controls), and a fixed tabban. This seeder can work directly into moist or dry uncultivated soil and in a single operation: opens ridges, places the phosphate fertilizer, drops the seed and covers both seed and fertilizer.

A prototype of the seeder was compared to hand broadcasting and drill seeding at Breda, northwestern Syria, with and without phosphate fertilizer. Phosphate gave significant yield increases in all sowing methods (Table 52). Without fertilizer, grain and straw yields were low, and there were no significant differences between sowing methods. However, in fertilized plots, both drill seeding and the Single Pass Seeder significantly outyielded hand broadcasting.

Economic evaluation of the Single Pass Seeder depends on several cost estimates based on custom farming charges in 1985. Hand harvesting is assumed in each case to simplify valuation of straw yields; with combine harvesting the values of collected straw and stubble grazing must be calculated.

Total costs for barley crops sown with and without fertilizer by hand broadcasting and by the Single Pass Seeder are similar. The significant yield increase obtained by the Single Pass Seeder when phosphate is applied is reflected by a considerable increase in net revenue. Highest net revenues were calculated for drill seeding with fertilizer. Good fertilizer placement appears to be responsible for the excellent economic results obtained with sowing by drill or by the Single Pass Seeder. The high marginal rates of return calculated for the Single Pass Seeder and the drill without fertilizer are based on yield increases which are not significant at the 5% level.

An important advantage of the Single Pass Seeder which cannot be evaluated by the simple measures of significance and straight-forward budgets of Table 52, is timeliness. The seedbed preparation required by the drill and the extra operations required by hand sowing all take time and often cannot be completed on the same day. By temporarily bolting the "single pass" boxes and drive wheels to the cultivator he uses for other jobs during the year, the farmer may have more control over sowing operations.--*P. Cooper, J. Diekmann, and T. Nordblom.*

Training and Agrotechnology Transfer

During 1984/85, a number of training activities were carried out by FSP staff. These included contributions to other programs' residential training courses, development of curricula and schedules for new training courses, organization of workshops on topics of interest to FSR, organization of short training courses, supervision of individual trainees and other miscellaneous activities.

Contribution to Residential Courses

These courses were offered by FLIP, CP, and PFLP. As in previous years, FSP staff contributed to these courses through: (i) lectures on approaches to FSR, (ii) lectures and practicals on weed control principles and methodology, (iii) lectures on the microbiology of rhizobia and inoculum production, and (iv) a lecture and a practical on soils and fertilizers in rainfed agriculture.

Table 52. Economic comparison of the single-pass planter with hand broadcast and drill seeding of Arabi Abiad barley, 1985.

Sowing method	Drill		Hand broadcast		Single pass	
Fertilizer (60 kg P_2O_5/ha)	With P	Without P	With P	Without P	With P	Without P
Grain yield (kg/ha)	1774	1034	1392	798	1674	1012
LSD (0.05) = 242 kg						
Straw yield (kg/ha)	1922	844	1374	726	1580	876
LSD (0.05) = 313 kg						
Grain value (SL 1.43/kg)	2537	1479	1991	1141	2394	1447
Straw value (SL 0.54/kg)	1038	456	742	392	835	473
Total crop value (SL/ha)	3575	1935	2733	1533	3229	1920
Costs*						
Seed (100 kg x SL 1.5)	150	150	150	150	150	150
Fertilizer (SL 2.17/kg)	130		130		130	
Fertilizer transport	45		45		45	
Cultivation (opening)	55	55	55	55		
Hand broadcast seeding			37	37		
Hand broadcast fertilizer			20			
Disk harrowing (pre-drill)	36	36				
Drill seeding	46	36				
Single-pass planter					83	73
Cultivation (closing)			55	55		
Hand harvest costs	687	450	565	375	656	444
Total costs	1149	727	1057	672	1064	667
Net revenue						
Crop value minus costs	2426	1208	1676	861	2165	1253
Compared to hand broadcast, without P						
A= Increase in net revenue	+ 1565	+ 347	+ 815	0	+ 1304	+ 392
B= Increase in total costs	+ 477	+ 55	+ 385	0	+ 392	− 5
A/B= Marginal rate of return	3.28	6.31	2.12		3.33	− 78.4

* Custom farming charges in 1985 were approximately 55, 36, and 37 SL/ha for single cultivation, drill seeding, and hand-broadcast seeding operations, respectively. Costs of the new Single-pass planter are estimated to be no more than SL 73/ha; this includes the cost of the "ducksfoot" cultivator operation, plus half the cost of drill seeding. Additional costs of SL 10/ha are assumed for seeding equipment capable of simultaneous fertilizer application. The cost of disk harrowing is assumed the same as drill seeding. Hand harvest costs (SL/ha) were computed as: 120 + 0.32 x kg grain yield/ha (Mazid and Hallajian 1983).

Table 53. Postgraduate students in FSP, 1984/85.

Name	Degree	Cooperating University	Thesis topic
E. Rashed	PhD	McGill, Canada	Crop rotation (barley)
M. Mokbel	PhD	Massachusetts, USA	Nutritional and dietary patterns
A. Wehbe	PhD	Reading, UK	Barley root development
Y. Sabet	PhD	Paris, France	Rainfall intensity/soil erosion
M.A. Moneim	PhD	Colorado State, USA	N dynamic of area fertilizer
N. Mona	PhD	Texas A & M, USA/Aleppo, Syria	Structure and price responsiveness (barley)
S. Dozom	MSc	Aleppo, Syria	Tillage, weed control and fertilization effects
S.A. Magid	MSc	Gezira, Sudan	Economical analysis of milk enterprises at Rahad
O.B. Shoib	MSc	Aleppo, Syria	Herbicide and fertilizer effect on wheat
T. El-Masri	MSc	Jordan	Evaluation of cultural practices on forage legumes
G.A. Karaki	MSc	Jordan	Response of lentil to drought

Development of FSP 6-Week Course

One of the major activities during the season was the development of the FSP annual residential training course. A curriculum and schedule for the course were completed and invitations were sent to national agricultural reserach programs in the region to nominate suitable junior level researchers for the course. Approximately, 20 participants will be selected on a competitive basis.

The annual residential training course is one of the major components of the training and agrotechnology transfer program at ICARDA. It will be held at ICARDA headquarters in Aleppo during 15 February-5 April 1986. The course has three objectives:

1. To introduce personnel from the region's national agricultural research programs to FSR approach.

2. To provide participants with a sound technical knowledge in their chosen fields of agricultural research.

3. To promote contacts and information exchange between ICARDA and national programs.

The General Course is structured on the four stages of FSR: diagnostic, experimental, testing, and extension. There will be specialist courses after the general course which will cover crop agronomy, on-farm livestock trials, soil moisture, soil fertility, socioeconomics, and supplemental irrigation. Training will include lectures, practical field/laboratory work, and informal discussions.

Workshops

Three workshops were held during the season. The first one, ICARDA Second Regional Farming Systems Research workshop, was held in Damascus, 9-11 December 1984. The theme was Crop and Livestock Husbandry Systems in Dryland Areas: The Scope for Improved

Profitability. The objective of the workshop was to discuss ongoing research activities in the region, seek venues to apply the FS perspective and experience, and learn from other scientists' experiences. The workshop was jointly funded by ICARDA and the Ford Foundation and was attended by 40 participants from the region, Syria, and ICARDA.

The second workshop "Methodology, Statistical Analysis and Economic Interpretation of Crop Rotation Trials" was held at ACSAD headquarters, Duma, Syria, 10-12 March 1985. This workshop was funded by ICARDA, ACSAD, and IDRC, and was attended by 35 participants from the region, Syria, ICARDA, ACSAD, UK, and USA.

The third workshop was on Research Methodology for Livestock On-farm Trials. The objectives of this workshop were (1) to facilitate professional contact among scientists in the region who are conducting on-farm livestock trials, (2) to critically evaluate methods used in the design and on-farm testing of improved management practices for livestock and livestock-crop systems, and (3) to formulate a clear set of statements on the strengths and weaknesses of different approaches to livestock on-farm trials. The workshop, held at ICARDA headquarters in Aleppo, 25-28 March 1985, was funded by ICARDA and IDRC and attended by 25 participants from countries of the region and elsewhere. The proceedings of the workshop were published in English with Arabic and French translations of the summary discussions. The full text will be published later in both Arabic and French.

Short Courses

Four senior research assistants from the Syrian Soils Directorate received intensive laboratory instruction on soil analysis methods, during 16-22 February 1985. The curricula and schedule were developed for a short training course in soil and plant analyses which is planned for January 1986.

Individual Training

The FSP continues to attract postgraduate students who carry out research in line with ICARDA's mandated research areas and related to regional and national priorities. During 1984/85 FSP staff supervised 11 postgraduate students (Table 53). The FSP plans to attract at least two more postgraduate students in the coming season.

A number of nondegree-related individual training programs were conducted during 1984/85. A Tunisian from INAT received training on microbiology, particularly related to rhizobium and legume interactions. Another Tunisian spent 2 weeks with the FSP and became acquainted with the methodology and implementation of the FSR. A research assistant from AUB spent 2 weeks in the soil laboratory and was trained on the use of the atomic absorption spectrometer. A Sudanese assistant received a joint FLIP/FSP 1-month course on the theory and practice of gas chromotography. Two trainees from IMA-PG, Paris, took an overall view of the FSP's research activities with particular emphasis on work in the Bueda-Breda area and conducted a small study on the physical properties of some soils in Bueda area.

Miscellaneous Activities

In addition to the above a number of scientists from countries in the region and elsewhere visited the FSP for periods of 1-7 days. Staff also participated in presentation days at Tel Hadya.--*M.B. Said.*

References

Askari, H. and Cummings, J. 1976. Agricultural supply response: a survey of the econometric evidence, New York, Praeger.

Asseline, Y. and Valentin, C. 1977. Construction et mise au point d'un infiltromètre à aspersion. Series Hydrologie 15(4):321-344.

Bailey, E. 1982. Wheat production with supplementary irrigation in two Hama villages. ICARDA Discussion paper No. 8: ICARDA, Aleppo, Syria.

Cochran, W.G. 1977. Sampling techniques. (Third edition). Wiley and Sons, New York, USA.

Colwell, J.D. 1973. The derivation of fertilizer recommendations for crops in a non-uniform environment, Pont. Acad. Sci. Scr. Var. No. 38.

Colwell, J.D. and Morton, R. 1984. *Development and evaluation of general or* transfer models of relationships between wheat yields and fertilizer rates in southern Australia. Australian Journal of *Soil Research 22:191-205.*

Cooper, P. *et al.* 1981. Soil water and nutrient research 1979/1980. ICARDA, Project Report No. 3.

Cooper, P. 1983. Crop management in rainfed agriculture with special reference to water use efficiency. Proc. 17th Coll. Int. Potash Inst., Berm.

El-Hajj, K. 1984. The relationship between soil content of phosphorus and the response of wheat to phosphate in rainfed agriculture. Pages 138-150 *in* proceedings of Soils Directorate/ICARDA Workshop on Fertilizer Use in the Dry Areas.

FAO (Food and Agriculture Organization). 1980. FAO 1979 Trade Yearbook, Vol. 33, Rome, Italy.

FAO (Food and Agriculture Organization). 1983. FAO 1982 Trade Yearbook, Vol. 36, Rome, Italy.

FAO (Food and Agriculture Organization). 1984. Food Balance Sheets, 1979-81 Average. FAO, Rome, Italy.

FSP 1982. Crop productivity within rotational systems. Research Report 1982, Project III. ICARDA, Aleppo, Syria.

FSP 1984. Draft Annual Report 1983/84, Appendix. Project 2 Wheat-Based Systems. ICARDA, Aleppo, Syria.

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

Hanson, H., Borlaug, N.E., and Anderson, R.G. 1982. Wheat in the Third World. Boulder, Colorado: Westview.

Harmsen, K. 1984. Dryland barley production in northwest Syria: I. Soil conditions. Pages 12-67 *in* Proceedings of the Soils Directorate/ICARDA workshop on Fertilizer Use in the Dry Areas.

Harris, H.C., Goebel, W., and Cooper, P.J.M. 1985. Crop genotype-environment interaction. CNR/ICARDA Seminar on Developing Improved Winter Cereals for Moisture Limiting Environments. Capri, *Italy, 27-31 October 1985. (In press).*

ICARDA (International Center for Agricultural Research in the Dry Areas). 1982. Annual Report 1981. ICARDA, Aleppo, Syria.

ICARDA (International Center for Agricultural Research in the Dry Areas).1983. Annual Report 1982. ICARDA, Aleppo, Syria.

ICARDA (International Center for Agricultural Research in the Dry Areas). 1984a. Annual Report 1983. ICARDA, Aleppo, Syria.

ICARDA (International Center for Agricultural Research in the Dry Areas). 1984b. Research Highlights 1983. ICARDA, Aleppo, Syria.

ICARDA (International Center for Agricultural Research in the Dry Areas). 1985. Annual Report 1984. ICARDA, Aleppo, Syria. 344 pp.

Jaubert, R. and Oglah, M. 1985. Supplementary feeding of Awassi ewes in the barley zone of northwest Syria. Proceedings of the ACSAD International Conference on Animal Production in Arid Zones. Sept 1985 ACSAD, Damascus, Syria. (In press).

Keatinge, J., Dennet, M., and Rodgers, J. 1985. The influence of precipitation regime on the management of three course crop rotations in N. Syria. Journal of *Agricultural* Science, Cambridge 104: 281-287.

Lahiri, D.B. 1951. A method for sample selection providing unbiased ratio estimates. Bulletin of the International Statistical Institute 33(2):133-140.

Laird, R.J. and Cady, F.B. 1969. Combined analysis of yield data from fertilizer experiments. Agronomy Journal 61: 829-834.

Maddala, G.S. 1977. Econometrics. Tokyo, McGraw Hill, Kogakusha.

Matar, A. 1984. Barley productivity of rainfed soils as related to soil, precipitation and fertilization in a pilot area of Syria. Pages 121-137 *in* Proceedings of Soils Directorate/ICARDA workshop on Fertilizer Use in the Dry Areas.

Nerlove, M. 1958. The dynamics of supply: estimation of farmers' response to price. John Hopkins, Baltimore, USA.

Oglah, M.A. 1984. Infrastructural constraints to technological change in wheat production in Jordan. Report of Jordan Collaborative Project.

Ryan, J.G. and Perrin, R.K. 1973. The estimation and use of a generalized response function for potatoes in the Sierra of Peru. North Carolina Agricultural Experimental Station. Technical Bulletin 214.

Ryan, J.G. and Perrin, R.K. 1974. Fertilizer *response information and income gains: the* case of potatoes in Peru. American Journal of Agricultural Economics 337-343.

SAR (Syrian Arab Republic). 1969. Administrative divisions, Syria and Lebanon, 1/750,000. Damascus, Military Bureau of Mapping.

SAR (Syrian Arab Republic). 1977. Climatic atlas of Syria. Damascus, Ministry of Defence, Meteorological Department.

SAR (Syrian Arab Republic). 1981. Fifth five-year economic and social development plan of the Syrian Arab Republic 1981-1985. Damascus, Arab Office for Press and Documentation.

SAR (Syrian Arab Republic). 1983. Statistical abstract. Central Bureau of Statistics. Damascus, Syria.

SAR (Syrian Arab Republic).(N.D.). Population Census in Syrian Arab Republic, 1970. Central Bureau of Statistics, Damascus, Syria.

Shepherd, K. 1985. Growth and yield of barley in Mediterranean-type environments. PhD thesis. University of Reading, UK.

Smith, J. and Umali, G. 1984. Fertilizer recommendations based on soil nitrogen levels: a total nutrient model. Journal of Agricultural Economics 35: 231-241.

Soils Directorate/ICARDA. 1985. Fertilizer use on barley, collaborative project report. Sept 1985. SD/MAAR/SAR and FSP/ICARDA, Syria.

Somel, K. 1984a. Environmental variability and multiple site-multiple season trials. Discussion Paper No. 14, ICARDA, Aleppo, Syria.

Somel, K. 1984b. Rotations and yield expectations in barley production in Syria. *In* Proceedings of Soils Directorate/ICARDA workshop on Fertilizer Use in the Dry Areas. ICARDA, Aleppo, Syria.

Stapper, M. 1984. Simulations assessing the productivity of wheat maturity types in a Mediterranean climate. PhD thesis. University of New England, Australia.

Tahhan, O. and Hariri, G. 1982. Survey of lentil insects in northern and northeastern Syria. Lens 9:34-37.

Thomson, E.F., Jaubert, R., and Oglah, M. 1985. On-farm comparisons of milk yield of Awassi ewes grazing introduced forages and common village lands in the barley zone of NW Syria. *In* Proceedings of the ACSAD International Conference on Animal Production in Arid Zones, Sept 1985. ACSAD, Damascus, Syria. (In press).

Thomson, E.F., Bahhady, F., and Termanini, A. 1985. Production practices and grain yields of barley and wheat at the cultivated margin of the NW Syrian steppe.

Tully, D. 1984. Land use and farmer strategies in al-Bab: The feasibility of forage legumes in place of fallow. ICARDA Research Report No. 13. ICARDA, Aleppo, Syria.

Tully, D. 1985. Environment and farmer practices in northwestern Syria: An application of rapid survey techniques. ICARDA Research Report. (In press).

Tully, D., Thomson, E.F., Jaubert, R., and Nordblom, T.L. 1985. On-farm trials in northwestern Syria: testing the feasibility of annual forage legumes as grazing and as conserved feed. *In* Proceedings of a workshop on Research Methodology for Livestock On-Farm Trials (Nordblom, T.L., Awad El K.H. Ahmed, and Potts, G.R., eds). 25-29 March 1985 Aleppo, Syria. IDRC, Ottawa, Canada.

Voss, R.E., Hanway, J.J., and Fuller, W.A. 1970. Influence of soil, management, and climatic factors on the yield response by corn (*Zea mays* L.) to N, P and K fertilizer. Agronomy Journal 62: 736-740.

Publications

Journal Articles

Keatinge, J.D.H., Dennett, M.D., and Rodgers, J.A. 1985. The influence of precipitation regime on the management of three-course crop rotations in northern Syria. Journal of Agricultural Science (Cambridge). 104: 281-287.

Keatinge, J.D.H., Neate, P.J.H., and Shepherd, K.D. 1985. The role of fertilizer management in the development and expression of crop drought stress in cereals under Mediterranean environmental conditions. Experimental Agriculture 21: 209-222.

Keatinge, J.D.H., Dennett, M.D., and Rodgers, J.A. 1986. The influence of precipitation regime on the crop management of dry areas in northern Syria. Field Crops Research (in press).

Nordblom, T.L., Ahmed, A.H., Miller, S.F., and Glenn, D.M. 1985. Long-run evaluation of fertilization strategies for dryland wheat in northcentral Oregon: simulation analysis. Agricultural Systems 18(3): 133-153.

Conference Papers

Cooper, P.J.M., Keatinge, D., and Kukula, S. 1985. The management of vertisols in Mediterranean environments. A case study from N.W. Syria. *In* Proceeding of IBSRAM Conference on Vertisol Management. February 1985, ICRISAT, Hyderabad, India.

Cooper, P.J.M., Somel, K., Matar, A., Harris, H., Keatinge, D., Abdul Karim, J., and El Hajj, K. 1985. The effect of fertilizer on barley yield, water use and water use efficiency in the barley-livestock farming systems of Syria. Paper Presented at the 25th Science Week, 2-7 November 1985, Damascus, Syria.

Harris, H., Goebel, W., and Cooper, P.J.M. 1985. Crop genotype-environment interactions. *In* CNR/ICARDA Seminar on Developing Improved Winter Cereals for Moisture Limiting Environments. 27-31 October 1985, Capri, Italy.

Jaubert, R., Oglah, M., and Thomson, E. 1985. On-farm coparisons of milk yield of Awassi ewes grazing introduced forages and common village lands in the barley zone of northwest Syria. Paper presented at the International Conference on Animal

Production in Arid Zones, September 1985, ACSAD, Damascus, Syria.

Jaubert, R. and Oglah, M. 1985. Supplementary feeding of Awassi ewes in the dry cultivated areas of northwest Syria. *In* Proceedings of the International Conference on Animal Production in Arid Zones. 1985, ACSAD, Damascus, Syria.

Keatinge, J.D.H., Cooper, P.J.M., and Hughes, G. 1985. The potential of peas as a forage crop in the dryland cropping rotations of W. Asia. Pages 185-191 *in* Proceedings of the 1984 Nottingham School of Agriculture, The Pea Crop - The Basis for Improvement. 1985, Butterworths, London, UK.

Kukula, S. Weed management in dryland cereals production in the Middle East. FAO Expert Consultation on Improved Weed Management in the Near East, 30 October - 1 November 1985, Nicosia, Cyprus.

Matar, A. and Abdul Karim, J. 1985. Response of barley to fertilization in arid areas. Paper presented at the Arab Conference for Agricultural Research for Basic Food Crops, a Joint AFESD/ICARDA Conference, 31 March - 5 April 1985, Aleppo, Syria.

Narayana, V.V. and Cooper, P.J.M. 1984. Management of terrain, soil and water in seasonably arid environments. *In* Advancing Agricultural Production in Africa. Proceedings of the CAB Conference, 1984, Tanzania.

Nordblom, T.L., Nygaard, D.F., and Salkini, A.B. 1985. Economics in the design, execution and analysis of on-farm trials. Pages 291-295 *in* Proceedings of an International Workshop at ICARDA on Faba Beans, Kabuli Chickpeas and Lentils in the 1980s (Saxena, M.A. and Varma, S. eds.), 16-20 May 1983, ICARDA, Aleppo, Syria.

Nordblom, T.L., Ahmed, A.H., and Potts, G.R. (eds), 1985. Research methodology for livestock on-farm trials: Proceedings of a workshop held at ICARDA, Aleppo, Syria, 25-28 March 1985, IDRC, Ottawa, Ontario, Canada, 313 pp.

SD/FSP, Fertilizer use on barley in northern Syria, 1984/85. Collaborative Research Project Report, September 1985. Soils Directorate, Ministry of Agriculture and Agrarian Reform, Syrian Arab Republic, and Farming Systems Program, ICARDA, pp.

Somel, K. 1986. Agricultural policy in Turkey: 1950-1980. Presented at the Workshop on Food Problems and State Policies in the Middle East and North Africa, September 1984, SSRC/IFAD, Rome, Italy. (In press).

Somel, K. and Mazid, A. 1985. Macroeconomic perspectives to crop-livestock systems. Paper presented at the Second ICARDA Regional Farming Systems Research Workshop on Crop and Livestock Husbandry Systems in the Dryland Areas: The Scope for Improved Profitability. December 1984, Damascus, Syria, ICARDA, Aleppo, Syria.

Somel, K., Keatinge, D., Cooper, P., and Tully, D. 1985. Experimental design of small plot crop rotation trials in the dry areas of N. Syria: (i) the influence of agronomic management and (ii) implications for analytical methodology and economic interpretation. Presented at the ICARDA/ACSAD/IDRC Workshop on Crop Rotation in the Middle East and North Africa, February 1985, Damascus, Syria.

Tully, D. 1985. Labour migration in the economy and society of Dar Masalit. Pages 159-169 *in* Sudan Studies Association Selected Conference Papers, 1982-1984. (El Bedawi, M. and Sconyers, D. eds.), Baltimore, Sudan Studies Association, Sudan.

Tully, D., Thomson, E.F., Jaubert, R., and Nordblom, T.L. 1985. On-farm trials in northwestern Syria: testing the feasibility of annual forage legumes as grazing and as conserved feed. *In* Proceedings of a workshop on Research Methodology for Livestock On-Farm Trials (Nordblom, T.L., Awad El K.H. Ahmed, and Potts, G.R., eds). 25-29 March 1985 Aleppo, Syria. IDRC, Ottawa, Canada.

Miscellaneous

Abdelmagid, S.A., 1985. An economic analysis of dairy/forage enterprises in the Rahad agricultural project, Sudan. Unpublished MSc thesis, Faculty of Economics and Rural Development, University of Gezira, Wad Medani, Sudan. 163 pp.

Ahmed, A.H. and Abdelmagid, S.A. 1985. Dairy production systems in the Rahad scheme (Sudan): survey results 1984. Faculty of Economics and Rural Development, University of Gezira, Wad Medani, Sudan, 50 pp.

Jaubert, R. and Oglah, M. 1985. Farming systems management in the Bueda/Breda sub-area, 1983/84. Farming Systems Program, Research Report No. 13. ICARDA, Aleppo, Syria.

Matar, A. 1985. Report of the group mission to the Arab Kuwaiti bank on the Khabour valley project in Syria. A study conducted by the Arab Fund for Economic and Social Development, February 1985, Kuwait.

Matar, A. 1985. Standardization of the $NaHCO_3$-extractable P in soils of the ICARDA region. Research Report No. 13, November 1985, ICARDA, Aleppo, Syria. 17 pp.

Matar, A. 1985. Gypsiferous soils, FAO Monograph. (In press).

Modawi, R.S., Nour, A.Y.M., Ahmed, A.H., Mohamed, A.B. and Ibrahim, A.E.S. 1985. Irrigated summer forages for small dairy farms in the Rahad agricultural scheme (Sudan): on-farm trials. Pages 191-208 *in* Proceedings of the Research Methodology for Livestock On-Farm Trial workshop. (Nordblom, T.L., Ahmed, A.H., and Potts, G.R., eds.), 25-28 Mar 1985, ICARDA, Aleppo, Syria. IDRC, Ottawa, Canada.

Mokbel, M. 1985. Evaluation of nutritionally relevant indicators in villages in Aleppo province, Syria, and their relation to agricultural development. Unpublished PhD dissertation submitted to the Department of Food Science and Nutrition, University of Massachusetts, Amherst, 1985.

Shepherd, K. 1985. Growth and yield of barley in Mediterranean-type environments. Unpublished PhD thesis, Department of Agricultural Botany, Reading University, UK.

Somel, K. 1985. Cereal improvement in the dry areas: a report on the Jordan cooperative cereal improvement project, 1978/79 to 1982/83, University of Jordan, Jordanian Ministry of Agriculture and ICARDA, December 1984. (In press).

Somel, K. and Amamou, H. 1985. Jordan wheat follow-up survey, 1982. Jordan Collaborative Research Project, ICARDA, Aleppo, Syria.

Tully, D. 1985. Anthropology and Farming Systems Research. Farming Systems Research News 3(1): 1, ICARDA, Aleppo, Syria.

CEREAL CROPS IMPROVEMENT

ICARDA Annual Report 1985

INTERNATIONAL CENTER FOR AGRICULTURAL RESEARCH IN THE DRY AREAS (ICARDA)
Box 5466, Aleppo, Syria

Contents

CEREAL CROPS IMPROVEMENT

The 1984/85 season was of great significance as farmers in Tunisia, Qatar, Peoples Democratic Republic of Yemen, Syria, and Portugal planted new barley and wheat varieties released through the partnership of their respective national programs with ICARDA and CIMMYT. The national programs of Pakistan, Iran, Turkey, Jordan, Syria, Lebanon, Sudan, Egypt, Libya, Tunisia, Morocco, Portugal, Spain, Thailand, Mexico, Ecuador, and Chile identified several new lines for large-scale on-farm testing, seed increase, and possible release (Table 1).

The program continued to emphasize the development of new technology for stress environments. During 1984/85 work on agronomy/physiology was reviewed to integrate physiological concepts into analytical breeding. The main activities focused on improving water-use efficiency for low-rainfall areas, identifying desirable traits for barley and wheat grown under water and temperature stress, and studying the physiological characteristics of barley and durum wheat landraces. The effect of crop management on parameters favoring early growth and water-use efficiency was studied.

Work on dual-purpose barley was reduced, while additional resources were allocated to barley improvement research. A senior barley breeder worked full-time on developing barley varieties and appropriate breeding methodologies for harsher environments (<300 mm rainfall and temperature stresses) with emphasis on yield stability. Multilocation testing of early segregating populations and a modified bulk population method were used for more efficient selection for higher yields in dry areas. Selection for total above-ground biological yield was started.

Barley landraces were assessed for their adaptation and variability to different stresses and lines capable of producing larger yields than existing cultivars under moisture, nutrient, and temperature stress were identified. The use of mixed cultivars for dry areas produced interesting results. A number of useful accessions were identified from the *Hordeum spontaneum* germplasm. Crosses between *H. spontaneum* and *H. vulgare* producing excellent above-ground biomass under very dry conditions (<200 mm) were identified and these will be further improved through backcrossing.

In the ICARDA/CIMMYT durum improvement project our emphasis continued on developing germplasm and production technologies to increase yield dependability in poor crop growing years, but allow full use to be made of the environment in good years. It included a study of parental materials for tolerance to specific yield-limiting stresses; hybridization of superior genotypes with locally adapted cultivars and landraces, and selection of desirable genotypes for stress tolerance. The material was evaluated in a range of stress environments with carefully selected sites and management.

Several durum lines, from crosses between improved genotypes and locally adapted cultivars and selected under low- to moderate-rainfall and nutrients, performed

Table 1. Barley and wheat varieties released through partnership of national programs, ICARDA, and CIMMYT.

Crop/country	Variety	Year of release
Barley		
Cyprus	Kantara (Roho)	
Iran	Val Fajr	
Morocco	Asni (Orge 1579)	1984
	Tamellalt (Orge 1703)	1984
	Tissa (Orge 1580)	
Qatar	Gulf (Avt/Ath)	1982
	Harma	1983
Tunisia	Roho	1985
	Taj (WI 2198)	1985
	Faiz (ER/Apam)	1985
Durum wheat		
Cyprus	Mesaoria	1982
	Karpasia (Sham 1)	1984
Egypt	Sohag (Stork'S')	1979
Morocco	Marzak	1984
Libya	Marjawi	1984
	Baraka	1984
	Zorda	1984
	Fazan	1984
	Dara	1983
Portugal	Celta (Sham 1)	1983
Syria	Sham 1	1984
Spain	Penaflor	1984
Bread wheat		
Iran	Azadi	
Libya	Zellaf	1984
	Sebha	1984
	Germa	1984
Morocco	Jouda	1984
	Merchouche	1984
Pakistan	Zargon	1982
Peoples Dem. Republic of Yemen	Ahgaf	1982/83
Sudan	Debeira	1982
Syria	Sham 2	1983

better than national checks. A new collaborative project to evaluate, document, and utilize landraces of durum wheat was funded by the Italian Government, which will strengthen existing effort in this area.

In the ICARDA/CIMMYT bread wheat improvement project, which has a special responsibility to develop suitable varieties for moderate-rainfall areas, our emphasis continued on incorporation of disease resistance, especially to foliar diseases (rust, septoria, etc.) and the seed-borne diseases such as bunt and loose smut, and tolerance to drought, cold, and heat.

The triticale improvement project focused on developing germplasm for the lower rainfall areas of West Asia and North Africa with emphasis on total biological yield, drought and cold tolerance, grain appearance, and industrial and nutritional quality. ICARDA triticale germplasm often outyielded wheat. The triticale project will, however, be phased out due to financial constraints.

Germplasm developed through the *high-elevation cereal research* was very useful in Iran, Morocco, Pakistan, and Turkey. The ICARDA/FAO/PARC project in Pakistan was jointly reviewed and research strategies developed for future.

More attention was paid to disease resistance, particularly scald, stripe rust, common bunt, and *Septoria tritici* blotch. National centers were encouraged to undertake specific responsibilities for themselves and for adjoining countries, e.g., virulence analysis of stem rust in Egypt, yellow rust in Pakistan, septoria in Morocco, and scald in Tunisia. A collaborative project with Montana State University, funded by USAID, started with emphasis on strengthening the research capabilities of national programs in improving disease resistance in barley. Screening for aphid resistance was initiated in Egypt and Sudan. Entomology research at the base program in Aleppo will be strengthened with the appointment of a senior entomologist in 1986.

During 1984/85, new collaborative research projects were established with Turkey, Iran, Ethiopia, Egypt, and Sudan, and with institutions in developed countries, such as Britain, Canada, Italy, the Netherlands, and USA. Work with Syria, Jordan, Libya, Yemen Arab Republic, Peoples Democratic Republic of Yemen, Pakistan, Portugal, Spain, and Italy was strengthened. Central and South America were covered through the joint CIMMYT/ICARDA barley project based in Mexico.

The International Nursery System provided more targeted and "specific need" germplasm to the national programs. The data feedback system was improved and the preliminary report on 1984/85 international nurseries was provided to national program scientists for use before the planting season.

Residential courses, in-country courses, short specialized courses, and individual tailor-made courses were offered by the program. Two doctoral and three masters students were supported and national scientists worked in the program for periods of 1 week to 3 months. Over 150 scientists from the region and elsewhere visited the program.

The program organized two travelling workshops and an international seminar, jointly sponsored by CNR (Italy) and ICARDA, on improving winter cereals in moisture-limiting areas. Several scientific papers, reports, and training manuals were published. In 1985, two issues of RACHIS were published in English and Arabic.

Staff Changes

During 1984/85, Dr. Edmundo Acevedo joined as agronomist/physiologist. Dr. M.S. Mekni, barley breeder, went on study leave to France. Messrs Munzer Naimi and Riad Saccal went to the Netherlands for professional training.

Research Highlights

Barley

* Three barley varieties, Roho, Taj, and Faiz, were released in Tunisia from ICARDA's International Nursery System material distributed under the names of Roho, WI 2198, and ER/Apam, respectively. Roho and Taj are adapted to low-rainfall, and Faiz to moderate-rainfall areas. Tunisia may release a sister line of Rihane in 1986.

* In the 1983/84 regional trials, Soufara'S', a new line, had the highest mean yield and outyielded the previously highest yielding lines such as Rihane and Mari/CM67 across 22 locations.

* The modified bulk method was applied for the first time in areas receiving less than 300 mm rainfall, so as to conduct selection for stress environments in the target environment. Even at dry sites, there is enough genetic variability to allow significant genetic advance.

* From landraces, a line, Tadmor, was identified which outyielded the best local barley cultivars by 49% at Bouider (177 mm rainfall), by 25% at Breda (277 mm rainfall), and by 4% at Tel Hadya (373 mm rainfall).

* Work on less conventional germplasm, such as landraces and *H. spontaneum*, indicated that: (i) landraces are genetically diverse and can be rapidly exploited to generate improved strains for stress environments, and (ii) some *H. spontaneum* accessions have combined cold and drought tolerance, good height under dry conditions, and acceptable plant type. A small program of hybridization with *H. vulgare* will be started in 1985/86.

Durum Wheat

* A number of countries are testing several new promising entries of durum wheat. Sham 1, Korifla, Sebou, Kabir, Omrabi, Belikh, Quadalete, and Marjawi are under large-scale yield testing in Syria, Jordan, Turkey, Cyprus, Libya, Morocco, Portugal, and Spain.

* Sebou and Korifla outyielded improved commercial varieties in Syria for the last 3 years in on-farm trials and may be released as new varieties. The grain quality of Korifla is better than that of Haurani, which is considered excellent in West Asia. Korifla also gave large grain yields in on-farm trials in Jordan, Cyprus, and Turkey.

* Plants from crosses between locally-adapted landraces and high-yielding varieties are now under advanced yield testing and the results indicate that several desirable traits are combined, e.g. drought and frost tolerance, earliness, and large yield potential in moderate- to low-rainfall areas.

* Two-layered bread baking and preliminary spaghetti preparation from strong and weak durum lines verified that durum wheats selected for protein strength suitable for flat bread baking are equally suitable for pasta.

* Two years' data indicated that there is considerable genetic variability for total biomass production in durum wheat landraces.

Bread Wheat

* Several lines were identified which combine high yield potential with drought and cold tolerance. These were superior to the local check, Mexipak 65, and to the improved check, Sham 2, for two consecutive years of testing. The identified lines outyielded the checks by as much as 14-46 % and had high drought and cold tolerance levels.

* Six bread wheat lines, highly responsive to a range of moisture regimes (280 and 600 mm), were identified. Four of these came from the winter x spring crosses. All six lines significantly outyielded the local and improved checks by 12-69 %.
* Five bread wheat lines with superior yield and drought tolerance were identified after two consecutive years of testing in rainfed conditions at Breda and Tel Hadya. Average yield was 3.1-4.3 t/ha; one line yielded 49% more than the check.

* The cultivar Flk'S'/Hork'S' performed very well in Syria, Turkey, and Morocco where it is being considered for release.

* Several bread wheat lines combining high protein percentage and 1000-kernel weight were identified. These lines were selected by 12 or more national programs in the region for further testing and possible release as commercial varieties.

High-Elevation Cereal Research

* For the third year, three durum and bread wheat lines had improved yields at Quetta and Annoceur and this season at the Anatolean plateau in Turkey. They were also resistant to tan spot and yellow rust.

* Frost tolerance and high protein content of *T. dicoccoides* was transferred into *T. durum* without losing the high 1000-kernel weight.

* A number of durum wheat lines with high 1000-kernel weight (57.9-63.5 g), high

protein content (15.7-18.2%), and other desirable agronomic characteristics were identified from crosses between spring and winter types of landraces.

Triticale

* Two-layered bread baked from triticale indicated that, provided triticale flours have adequate dough strength, they behave in a similar manner to bread wheat flours during baking. This makes them suitable for commercial production for human food in areas where flat breads are a staple.

International Nurseries

* The 1984/85 Preliminary Report for the regional nurseries was distributed in October 1985.

* The international nurseries were further diversified with the subdivision and targeting of nurseries for low-rainfall areas, moderate-rainfall areas, and areas requiring cold tolerance.

Training

* Fifteen researchers from 12 countries participated in a 3-month residential training course which focused on breeding techniques for cereal crops in rainfed areas, agronomy/physiology, disease and insect resistance, grain quality, and field verification trials.

* Twenty-one researchers from Pakistan participated in an in-country training course on analysis and interpretation of cereal research data.

* Twenty-six research assistants and extension agents participated in the first part of a 'hands-on' course on cereal on-farm verification and demonstration trials' in Morocco, sponsored jointly by INRA, FAO, and ICARDA. The second part of the course will take place at crop maturity.

* In cooperation with other programs, the Program provided short training courses for 49 scientists from the region. Thirty-one researchers from Syria were trained at ICARDA; 15 on disease methodology and 16 on experimental design. Eighteen scientists from nine Arab countries were trained on seed technology in a 3-week course cosponsored by AOAD.

* Eight researchers from five countries (Iran, Morocco, Syria, Tunisia, and Cyprus) received individual training on cereal breeding, disease and insect resistance, germplasm evaluation and grain quality.

International Cooperation

* Collaborative research was established with Montana State University (USA), University of Tuscia (Italy), the Plant Breeding Institute (Cambridge, UK), and with Sudan, Egypt, Iran, Ethiopia, and Turkey.

* An International Seminar was organized jointly with CNR, Italy, on improving winter cereals in water-limiting areas.

General

* Barley and wheat germplasm was developed with multiple disease resistance and genetic stocks were identified with resistance to specific diseases, e.g. yellow rust, common bunt and *Septoria tritici* blotch. There are 23 lines resistant to barley yellow rust, 22 to durum wheat yellow rust, 22 to common bunt

in durum and bread wheat, and 7 to septoria blotch in durum and bread wheat.

* *The NIR analyzer was calibrated for protein* determination in cereal straws.

* The following lines had excellent resistance to wheat stem sawfly in 4 years of testing in Syria: (a) barley, Th.U.48, Th.U. 32, 80/5116, (b) bread wheat, Law and Limpopo, and (c) durum wheat, H 95, Bari 81-147, PI 191741, Barada.

* On-farm trials in zones A and B showed that even though farmers are adopting some improved practices there is still scope for cereal yield improvement by using newly-released cultivars and recommended cultural practices.

* In durum and bread wheat, *the variation in* nitrogen-use efficiency among years was highly related to soil-nitrogen content and other environmental constraints. The *nitrogen uptake-grain yield curve was* unique for bread and durum wheat and neither the harvest index nor the nitrogen harvest index seemed to be affected by nitrogen rates in a given cultivar.

* In barley in which awn stomata remain open at very low plant water potentials, nitrate reductase activity did not decrease under field conditions and moderate to high water stress. However, the metabolite concentration of grains seemed to integrate stresses during grain filling period.--*J.P. Srivastava.*

Project I : Barley Improvement

Barley is a widely adapted crop and, next to wheat, is the most important cereal crop in the Near East and North Africa where it is grown principally as animal feed. It is also widely grown in Latin America, Central Africa, and the Far East mainly for human consumption. Among cereals, barley is predominant where wheat performs poorly or fails to grow, *because of low soil fertility or moisture* stress, or both.

During 1984/85, ICARDA implemented a workplan, agreed with CIMMYT in summer 1984, in which the Mexico-based component of the project will develop barley germplasm (i) specifically for Latin America, particularly for the Andean region; (ii) adapted to warm winter, short-season environments; and (iii) resistant to BYDV and other important diseases in the region. National programs will be encouraged to develop appropriate agronomic practices to improve barley production in Latin America. Research activities *will* be coordinated by ICARDA by developing germplasm and agronomic practices to improve barley production in the Middle East and North *Africa.*

During 1985 the Program established active cooperation with Ethiopia, one of the major barley-producing countries in Central Africa and, within the Middle East and North Africa, there was more emphasis on breeding for low-rainfall areas (<300 mm annual rainfall).

Dry areas, where barley with sheep is often the only farming activity, are characterized by unpredictable environmental conditions. Cold, drought, and heat are common, but their intensity and timing are variable. The development of successful genotypes for such conditions requires adequate levels of resistance/tolerance to a number of stresses. Suitable genotypes can be developed by testing both segregating populations and finished lines over a number of locations and years.

During 1984/85 the structure and overall objectives of the barley project were the same as in previous years. The following areas of research were either initiated or strengthened:

a) Evaluation of total biological yield (grain + straw) was initiated because barley straw, together with the grain is widely used as animal feed. Evaluations were done in some segregating populations and yield trials. The Program has a collaborative project with the Pasture, Forage, and Livestock Improvement Program to evaluate straw quality.

b) A modified bulk method was used to improve the efficiency of selection in low-rainfall areas (<300 mm rainfall).

c) Multilocation testing and selection of early segregating populations was done at Tel Hadya and Breda, and at a new site, Bouider, with a long-term average rainfall of 175 mm.

d) Landraces were evaluated for their adaptation to dry areas and to quantify and utilize the available genetic diversity within these populations.

e) *H. spontaneum* was evaluated as a source of resistance/tolerance to very dry conditions.

Component 1: Breeding

The barley breeding program aims to (1) develop and distribute genetically diverse germplasm so that national programs can select the material best suited to their needs, and (2) develop barley genotypes adapted to dry areas and responsive to moderate rainfall and/or improved agronomic practices. In the short term, selection for specific adaptation is also being practiced.

A modified pedigree system is used for moderate-rainfall areas and a modified bulk method for dry areas. The backcross method is also used to transfer single characters into improved germplasm.

During 1984/85, nitrogen (20 kg/ha) and phosphate (40 kg/ha) were applied in the fields used for evaluating breeding material at low-rainfall testing sites. This was done because yield and yield stability can be increased in climatically unfavorable environments by adopting both genetically improved plant material and better agronomic practices.

Before distribution to national programs, the most promising bulks and lines are tested in small (3 m^2) plots over 2 years at three locations in Syria (Bouider, Breda, and Tel Hadya) with average annual rainfall of 175-350 mm. Advanced yield trials are then carried out on promising material at seven locations for 1 or 2 years, the additional four locations being Ousseltia (200 mm) and El Kef (450 mm) in Tunisia; Terbol (650 mm) in Lebanon; and Athalassa (250 mm), in Cyprus.

Information on disease resistance is collected from a number of locations in the Key Location Disease Nursery (KLDN) when lines are bulked for preliminary yield trials, and again at the stage of advanced yield trials.

Evaluation of Segregating Populations

During 1984/85, 15,846 F_2 and later-generation segregating populations were evaluated by the modified pedigree system. Except for the F_2 families, which were sown at Bouider, Breda, and Tel Hadya, the other segregating populations were sown only at Tel Hadya with an unreplicated experimental design and systematic checks. Crop growth as well as competition with weeds was poor at Breda and Bouider, so segregating populations were visually selected only at Tel Hadya. With the pedigree method, 4525 single head and single plants were selected and 2826 populations were bulk harvested for the modified bulk method.

A total of 729 F_3 families and 219 F_4 families were evaluated at three locations (Bouider, Breda, and Tel Hadya) by the modified bulk method. Days to heading, days to maturity, plant height, grain yield, and, only in the F_4 families, straw yield were recorded and the drought susceptibility index, S, proposed by Fischer and Maurer (1978) was calculated for all segregating populations. Low values of S indicated higher levels of drought resistance.

Table 2. Average grain yield (kg/ha), plant height, cold tolerance, early growth vigor, and drought susceptibility index (S) of F_3 families selected for grain yield in favorable and unfavorable environments.

Character	Selection at Bouider			Selection at Tel Hadya		
	Top 5%	Bottom 5%	Diff.	Top 5%	Bottom 5%	Diff.
Grain yield at Bouider	1686	274	1412***	929	758	171
Tel Hadya	3935	3565	370*	5367	2508	2859***
Plant height at Bouider	53.2	38.3	14.9***	43.8	44.6	-0.8
Tel Hadya	72.8	73.8	-1.0	79.5	63.6	15.9**
Cold tolerance+	2.7	3.6	-0.9***	3.0	3.3	-0.3***
Early growth vigor+	2.7	3.5	-0.8***	2.4	3.3	-0.9***
Days to head(Bouider)	148.4	153.1	4.7**	141.1	142.3	1.2
Drought susc. index	0.83	1.17	-0.34***	1.05	0.97	0.08*

* $P<0.05$;** $P<0.01$;*** $P<0.001$.

+ Average of three locations.

Selection for high grain yield at Tel Hadya is expected to increase drought susceptibility (Table 2), whereas selection for high grain yield at Bouider is expected to increase drought resistance. At both locations the F_3 families with highest grain yields were significantly more cold tolerant and more vigorous in the early stages of growth than the F_3 families with lowest grain yield. At Bouider the F_3 families with higher grain yields were significantly earlier in heading than the F_3 with lowest grain yield, while selection for grain yield at Tel Hadya is not expected to affect days to heading. Material selected for high and low grain yield at Bouider is expected to give a correlated response when grown at Tel Hadya (3935 kg/ha vs 3565 kg/ha). However, selection for high and low grain yields at Tel Hadya is expected to produce insignificant effects when the material is grown at Bouider.

These data indicate that direct selection under stress is more efficient than selection in favorable environments, i.e. high yield potential under favorable environments is not a useful selection criterion to identify superior genotypes for dry areas. In the top 5% of the F_3 families with high grain yield at Tel Hadya there were only three families which were also in the top 5% for grain yield at Bouider.

To test whether selection at one given location was independent of selection at a different location a χ^2 analysis was done on a set of three 2 x 2 contingency tables (Table 3).

Selection at Bouider was independent of selection at Tel Hadya, but the number of families selected at Breda and Tel Hadya and at Bouider and Breda was significantly ($P<0.001$) higher than expected on the basis of independence.

Table 3. Observed and expected number of selected or rejected F_3 families at two different sites and χ^2 for independence.

1st location		2nd location		Observed	Expected
Bouider	selected	Tel Hadya	selected	41	41.4
"	"	"	rejected	70	69.6
"	rejected	"	selected	231	230.6
"	"	"	rejected	387	387.4
				χ^2=0.008 P>0.90*	
Breda	selected	Tel Hadya	selected	78	45.5
"	"	"	rejected	44	76.5
"	rejected	"	selected	194	226.5
"	"	"	rejected	413	380.5
				χ^2=44.46 P<0.001	
Bouider	selected	Breda	selected	32	18.6
"	"	"	rejected	79	92.4
"	rejected	"	selected	90	103.4
"	"	"	rejected	528	514.6
				χ^2=13.13 P<0.01	

*P = Probability that selection at one location is independent of selection at another location.

The criteria used to select F_3 bulk families for further testing in 1985/86 were (i) average grain yield across locations, and (ii) grain yield at the driest site (Bouider). Similar criteria were used for the F_4 bulk families which were promoted or discarded depending on grain yield or total biological yield. Selection of F_3 and F_4 families performing well at Bouider should generate material specifically adapted to dry conditions. Such material will be used with high-yielding parents in the crossing program.

The number of F_3 and F_4 bulk families significantly outyielding ($P < 0.05$) the best local cultivar (Arabi Abiad) was small due to environmental variability. Only five F_3 families significantly outyielded the best local cultivar (one at Bouider and four at Tel Hadya). One F_4 significantly outyielded Arabi Abiad at both locations and one at Bouider for total biological yield but not for grain yield. This shows that both grain and straw yields are necessary for a proper assessment of the potential of segregating populations. A pure line, Tadmor isolated from locally grown barley collected at Taibe, 90 km NE of Palmyra, also significantly outyielded Arabi Abiad at Bouider and across locations.

Yield Trials of Advanced Lines

Preliminary Yield Trial. Table 4 summarizes the results on grain yield of the PBYT at Tel Hadya and Breda. At both locations, a number of lines yielded significantly ($P<0.05$) better than the checks. The number of lines outyielding the local check was much higher at Tel Hadya (9.8%) than at Breda (4.7%) as Arabi Abiad performed better at Breda. Apparently, the local check had a high level of cold tolerance and/or cold resistance and was not affected by the severe cold during this season. The improved checks performed better at Tel Hadya than at Breda, as expected

Table 4. Grain yields in the preliminary yield trial at Tel Hadya and Breda (Syria), 1984/85.

PYT	Tel Hadya	Breda
No. of lines tested	693	613
No. of lines outyielding the		
improved check+	62(8.9)*	152(24.8)
long-term check+	123(17.7)	157(25.6)
local check+	68(9.8)	29(4.7)
No. of lines significantly outyielding the		
improved check+	8(1.2)	15(2.4)
long-term check+	13(1.9)	8(1.3)
local check+	3(0.4)	6(1.0)
Mean yield (kg/ha) of		
improved checks	5161	862
long-term checks	4641	834
local check	5054	1071
Site mean yield (kg/ha)	4458	718

+ Improved checks: Rihane'S'03 (6 row) or ER/Apm (2 row)
- Long-term checks: Beecher (6 row) or Harmal (2 row)
- Local check: Arabi Abiad.
* Expressed as % of total number of lines tested.

because they were bred, evaluated, and selected under the more favorable environment of Tel Hadya. Six lines significantly outyielded Arabi Abiad at Breda (Table 5).

Advanced Yield Trial. Pooled analysis of variance for grain yield across the five locations (Breda, Bouider, Tel Hadya in Syria; Terbol in Lebanon; and El Kef in Tunisia); showed that genotype x location interactions as well as differences among locations were highly significant. Significant differences among genotypes, however, were largely due to the interaction effect. The mean linear coefficients of correlation for grain yield between the five different locations were generally low, ranging from -0.15 between El Kef and Terbol to 0.37 between Bouider and Breda, indicating the importance of multilocation testing.

Fig. 1 shows the number of lines which significantly outyielded the checks in the ABYT at the five locations and illustrates the magnitude of the genotype x location interaction. The improved checks performed poorly at Breda, where yield was lowest (due to herbicide and cold damage), and was significantly outyielded by a number of lines at that location. Its performance was better at the highest yielding locations, Tel Hadya, Terbol, and El Kef. The Syrian local cultivar performed well at Breda and Bouider and was significantly outyielded ($P<0.05$) by only one test entry. It did not yield well at Terbol or at El Kef where it was significantly outyielded by two-thirds of the tested lines. The fact that it performed well at Tel Hadya, a high-yielding site, but not at the other high-yielding sites, indicates that productivity of the locations did not cause its differential performance. Accumulated data indicate that the Syrian local cultivar possesses a high level of cold tolerance and/or resistance which is necessary for the

Table 5. Lines significantly outyielding ($P < 0.05$, 1-sided) the local check, Arabi Abiad, in preliminary yield trials.

Cross and pedigree	Grain yield (kg/ha)	% of Arabi Abiad
Roho//Alger/Ceres 362-1-1 ICB77-0187-2AP-2AP-2AP-2AP-3AP-0AP	1290	134
Roho//Alger/Ceres 362-1-1 ICB77-0187-1AP-2AP-3AP-4AP-1AP-0AP	1216	126
Cr.366-13-2/Iris ICB79-0447-1AP-1AP-2AP-3AP-0AP	814	133
Impala/Julia//Api ICB78-1085-2AP-2AP-1AP-1AP-0AP	1024	138
Cm/3/Api/CM67//Mona CMB77A-0125-2AP-1AP-1AP-1AP-4AP-0AP	950	138
ROD589/11012-2//M1101/Aths/3/Cel//Mzq/Gva CMB80-0688-3Y-1B-1Y-3H-OAP(A)	783	141

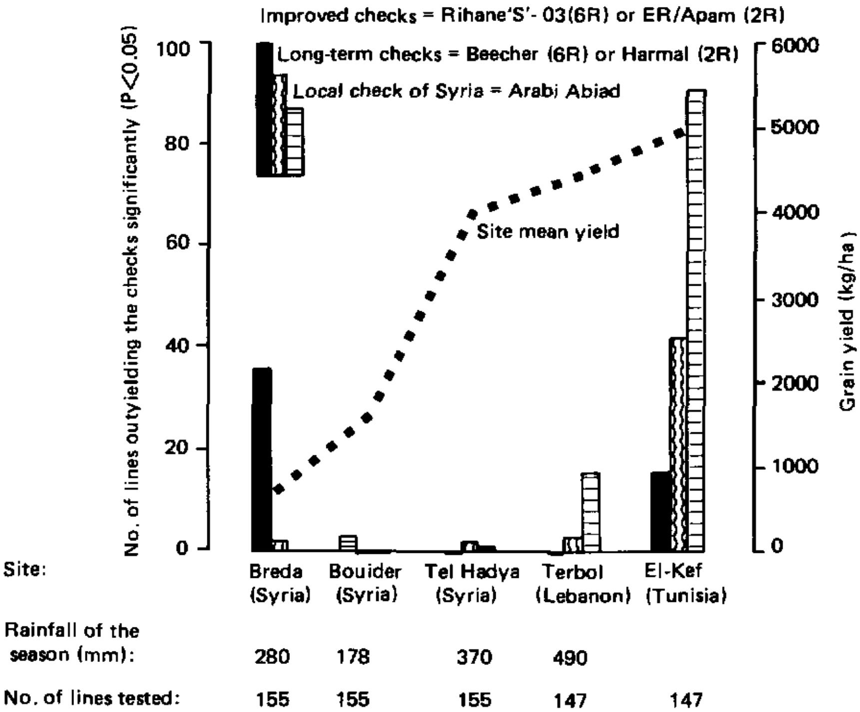


Fig.1. Number of lines significantly ($P < 0.05$) outyielding the checks in the 1984/85 advanced yield trials at five different locations.

Table 6. Performance of a number of entries in the ABYT with good yields at each of five locations (Tel Hadya, Breda, Bouider, Terbol, and El Kef) in 1984/85. (Upper row: grain yield; lower row: biological yield; both in kg/ha).

Name or cross and pedigree	Location				
	Tel Hadya	Bouider	Breda	Terbol	El Kef
WI 2291/Roho	4441	1586	972	4677	6093**
ICB 78-0643-2AP-1AP-1AP-0AP	7682	2604	1706		
WI 2291/WI 2269	4500	1237	1194	4816	5947
ICB 78-0594-8AP-1AP-0AP	7555	1947	1953		
WI 2291	4546	1577	1098	4716	5733*
	8188	3154	1870		
Aurore/Esp//Alger/Ceres,362-1-1	4250	1984	1141	4294	6000*
LB 2L-9L-6AP-0AP	7675	3311	2024		
25-84/Attiki	4135	1496	1021*	5333	6053**
CYB 165-14A-2A-1A-0A	6697	2330	1743*		
Harrison/Nopal	4114	1993	913*	5111	5560
CMSWB 78A-0043-4AP-4AP-0AP	7416	3444	2006*		
M 69.77/Shi-r-kci N087/4/Pro/	4154	1558	1123*	5244	5587
Tol 1//Cer*2/Tol 1/3/5106	6808	2268	2030		
CMB/76A-0096-500H-501Y-0B-500Y-0B					
Mean of improved check	4691	1439	708	5038	4867
	8090	2423	1423		
Mean of long-term check	4115	1649	1069	4623	4391
	6927	2762	1880		
Mean of Arabi Abiad	4582	1852	1484	4345	3606
	7742	3385	2433		

-* Significantly ($P < 0.05$) higher yield than the improved check.

** Significantly ($P < .05$) higher yielding than the best check.

cold winters of Syria. However, these results on genotype x location interaction highlight the difficulties in developing high-yielding germplasm suited to the whole region.

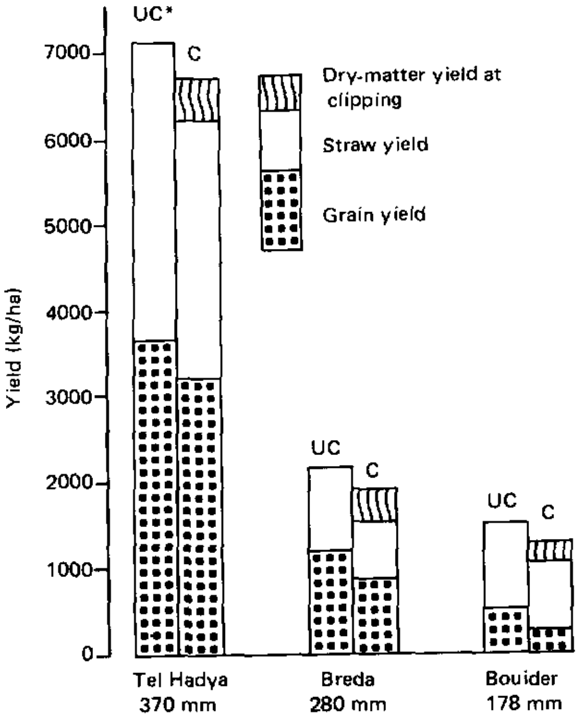
Although the genotype x location interaction was large, a number of lines yielded well at each of the five locations (Table 6).

The full set of ABYT was planted at Tel Hadya in February (late planting) as in previous years. Planting was done late to assess the tolerance of these lines to severe heat and drought stress during kernel filling. Linear correlation coefficients in grain yield between the normal and late plantings were -0.21 - 0.57, with a mean of 0.23 across experiments, which was lower than those of the previous 2 years. Therefore, late planting exposed the genotypes to different environmental stresses which resulted in substantial differences in performance compared with normal planting.

Dual-Purpose Barley Yield Trial. During 1984/85, 160 barley lines were evaluated for dual-purpose potential, i.e., forage for grazing at the tillering stage plus grain at maturity. The trial was carried out at Tel Hadya and Breda, and a small subset was evaluated at Bouider. A split-plot design with two replications was used in which the treatments (with or without mowing) were the main plots and the genotypes (24 in each experiment) were the subplots. Lines with more vigorous vegetative growth were sampled and mown earlier than the others.

Simulated grazing (mowing) did not significantly reduce the total above-ground biological yield at all three sites (Fig. 2) and there was no significant reduction in grain yield after grazing at Tel Hadya and Bouider. At Bouider, grain yield had a large coefficient of variation, which probably accounted for the nonsignificant differences between the two treatments. At Breda, grain yield was not significantly decreased after grazing for five out of the eight experiments.

In all experiments, there were highly significant differences in grain and biological yield among entries. For grain yield, the entry x treatment interaction was significant for 13 of the 17 experiments. This, together with the previous season's results (ICARDA Annual Report 1984) indicates that entries giving the best grain yield when



* UC = unclipped, C = clipped, difference between the two treatments is nonsignificant (P <0.05) at all three sites.

Fig. 2. Mean dry-matter yield at clipping and straw and grain yield with and without clipping at three locations.

not mown do not necessarily give the best grain yield when mown.

Twenty-eight entries at Tel Hadya and seven at Breda produced significantly more dry matter at mowing than Arabi Abiad (which yielded more than Arabi Aswad). At Tel Hadya, two entries produced significantly more total biological yield than Arabi Abiad but, for grain yield, no entries performed significantly better than the local checks.

International Nurseries

Targeting germplasm for different environmental zones continues to receive priority. In 1982, three diverse sets of segregating populations; one for dry areas,

Table 7. Names, pedigrees, and agronomic performance of the lines most frequently selected by national programs from the Barley Observation Nursery, 1983/84.

Name/cross	Pedigree	No.of locations where line selected	Grain yield* (kg/ha)	Days to heading	Days to maturity*	Plant height** (cm)
Deir Alla 106/Celaya	ICB 77-0091-4AP-0AP	8	5108	110	147	88
Rihane'S'-01	SEL. 2L-1AP-1AP-0AP	6	4354	111	148	89
Rihane'S'-08	SEL. 12L-2AP-0AP	6	4957	110	148	92
IFB 974		6	4292	119	159	84
WI 2291/Bgs	ICB 78-0672-6AP-0AP	6	4749	108	146	85
Comun/3/Api/CM67//Mona	CMB 77A-0125-2AP-2AP -2AP-1AP-0AP	6	4432	110	147	78
Rihane (improved check)		6	5058	111	148	86

* Average of 16 locations.

** Average of 19 locations.

one for moderate-rainfall areas and one for high-elevation areas, were offered to national programs. From 1984, three different observation nurseries have also been distributed. Three different sets of regional yield trials were distributed in 1985 for the first time.

Observation Nursery

The Barley Observation Nursery (BON) provides promising advanced lines, developed at ICARDA, to national programs for preliminary screening. There were 150 entries in the 1983/84 nursery, with Rihane as a check. Eight triticale lines were included to compare their performance with barley in different environments. Six entries were selected at six or more locations out of a total of 18 (Table 7). The agronomic traits and disease reactions of the nursery are described in the 1983/84 Regional Yield Trials and Observation Nurseries - Final Report.

Regional Yield Trial

From the BON, outstanding lines are promoted to the Regional Barley Yield Trial (RBYT). There were 21 improved barley lines in the 1983/84 RBYT, one national check, one triticale line, and one durum wheat line. It had a randomized complete block design with four replications. Soufara'S', a new entry, had the highest mean yield across 22 locations (Table 8), while Rihane'S'-03, Rihane, and Mari/CM 67, which ranked first, second, and third in 1982/83, were second, fifth, and seventh, respectively, in 1983/84. Though Soufara'S' had the highest mean yield, it was not as widely adapted as Rihane'S'-03. Details of the RBYT results are available in the 1983/84 Regional Yield Trials and Observation Nurseries-Final Report.

The total number of lines in the RBYT which significantly outyielded local checks in some of the countries of the ICARDA region, is shown in Fig. 3.

Evaluation of Landraces

This research aimed to determine whether locally-adapted germplasm could improve barley yields under harsh conditions. The landraces presently grown in Syria are genetically variable, and it should be possible to generate, in a relatively short time, lines and/or populations with improved yield and

Table 8. Performance of the highest yielding entries in the 1983/84 Regional Yield Trial.

Cross	Pedigree	Grain* yield(kg/ha)	Rank*	CKH**	SEL**
Soufara'S'	Sel, 5AP-0AP	5223	1	5	12
Rihane'S'-03	Sel. 2L-1AP-3AP-0AP	5149	2	10	18
CI 7118-9/Deir Alla 106	ICB 773423-2AP-2AP-0AP	4866	6	3	9
Mari/CM 67	CMB 72-140-8Y-1B-3Y-3M-0Y	4801	7	6	6
Rihane'S'-05	Sel, 2L-1AP-4AP-0AP	4796	8	5	5
Rihane (improved check)		4882	5	5	9
Beecher (long-term check)		4484	18	4	9
Drira/M2A (triticale)	X - 15893-0AP	4935	4	8	12
Sahl (durum wheat)		4396	20	6	7

* Average of 22 locations.
** CHK No. of locations significantly outyielding the national check.
SEL No. of locations among the top five entries.
Based on data from 34 locations.

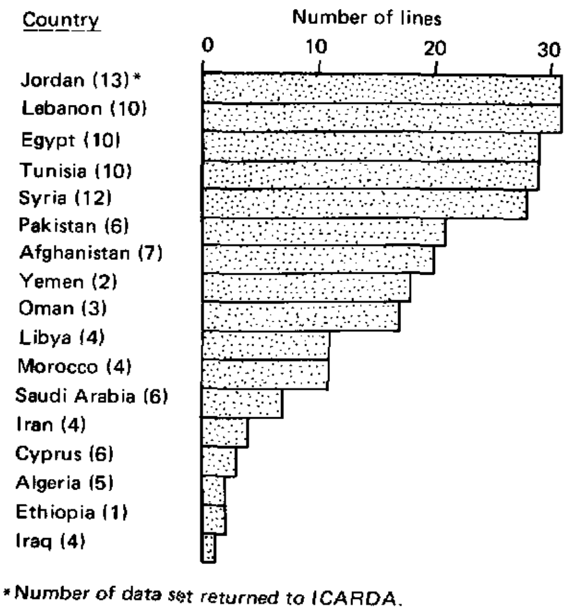


Fig. 3. Number of lines in the Regional Barley Yield Trials from 1977/78 to 1983/84 (1982/83 not included) which significantly outyielded the national check.

stability for release as varieties and for use in the crossing program to combine higher levels of stress resistance/tolerance with larger yield potential. These studies should also clarify whether "pure line breeding" is the correct approach for dry areas.

The variability between and within samples of local cultivars collected from different areas of Syria and Jordan was measured in three experiments. Because seed was limited, the experiments were sown only at Breda. The first two experiments contained 10 single-head progenies for each of 14 collection sites and four checks (Arabi Abiad, Arabi Aswad, Harmal, and Rihane 'S'). There were 144 genotypes in a 12 x 12 simple lattice design with two replications and a 2-row x 2.5m plot size. The 14 collection sites in the first experiment were different from those represented in the second. The third experiment had the same structure and layout as the first two, but 70 single-head progenies from each of two collection sites were studied and the plot size was 4 rows x 2.5 m.

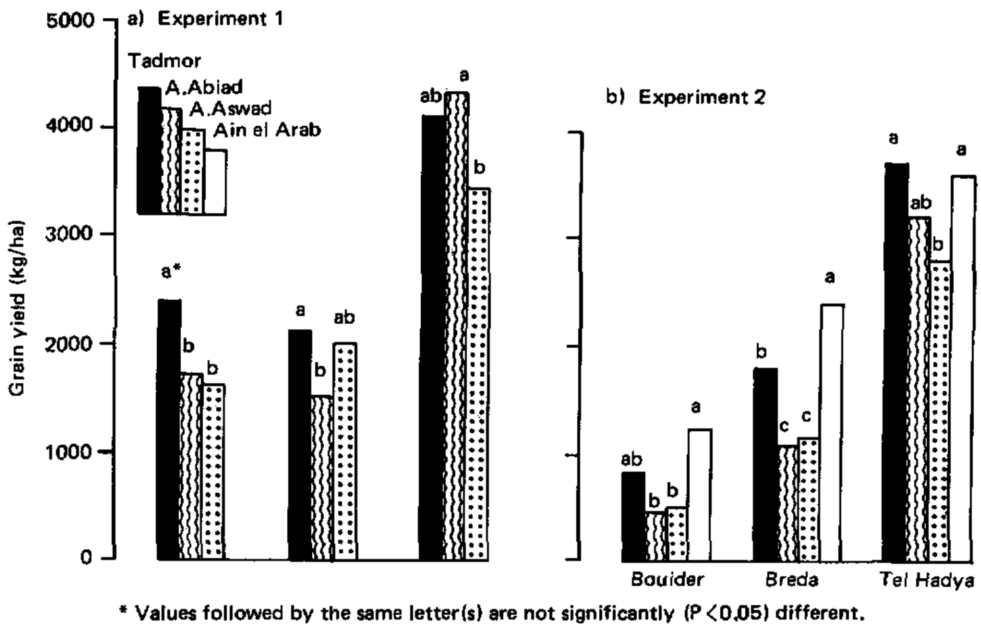


Fig.4. Grain yield of Tadmor, a pure line selected from a collection at Taibe, near Palmyra, and of a sample collected at Ain el Arab.

Growth class (erect or prostrate), cold tolerance, plant height, days to heading, days to maturity, grain-filling period, grain yield, 1000-kernel weight, and protein and lysine content were recorded. In the third experiment growth class was omitted and a score for early growth vigor made. Disease reaction was scored at Tel Hadya with artificial inoculation for yellow rust and scald and natural infection for powdery mildew. Reaction to yellow rust was scored in all three trials, but reactions to scald and powdery mildew were scored only in the first trial.

The results for 1984/85 showed that the two landraces grown in Syria are diverse for characters such as cold tolerance, days to heading, plant height, grain yield, disease resistance, 1000-kernel weight, and protein and lysine content. This diversity was found between samples of landraces collected at different sites and between single-head progenies within the same collection site.

In most cases this variability is useful and a number of lines and/or populations were identified with better expression of certain characters than Arabi Abiad and/or Arabi Aswad. For example, Tadmor, a pure line selected from a sample collected at Taibe, near Palmyra, outyielded both Arabi Abiad and Arabi Aswad, especially under dry conditions (Fig. 4). Tadmor also has a higher 1000-kernel weight (36.4g) than Arabi Aswad (31.8g), a protein content of 10.7% and a lysine content of 0.43%. In one of the trials where Tadmor was evaluated, a sample collected at Ain El Arab significantly outyielded both local cultivars at Bouider and Breda.

Table 9. Preliminary observations on F_3 families (*H. vulgare* x *H. spontaneum*) grown at Bouider (178 mm rainfall).

Entries	Cold tolerance*		Days to heading		Plant height(cm)	
	Mean	Range	Mean	Range	Mean	Range
F_3-19	3.6	2-5	126.9	121-145	86.4	69-103
F_3-17	2.5	2-3	125.0	121-129	74.5	69- 80
F_3-20	2.7	1-5	130.1	122-145	75.6	52- 97
F_3-21	2.9	1-5	133.1	125-145	83.0	61-100
F_3-22	1.9	1-3	129.5	115-144	79.6	60-102
F_3-23	1.0		137.6	130-144	78.0	55- 88
F_3-24	2.9	2-4	132.5	126-142	69.8	55- 96
F_3-25	1.3	1-3	132.3	126-144	74.0	61- 80
F_3-27	2.3	1-5	133.5	126-145	78.9	65- 99
F_3-28	1.8	1-4	132.1	123-145	84.4	75- 97
Arar	4.5		129.6		58.6	
Harmal	3.2		128.5		57.2	
A. Aswad	1.3		129.6		68.2	

* Scale 1-5: 1, good; 5, poor.

Evaluation of *Hordeum spontaneum*

This research started in 1985. The wild progenitor of cultivated barley is widespread along the Fertile Crescent and because it grows in very harsh environments it is a possible source of resistance/tolerance to extremely dry conditions.

The objectives of the first year of research were to: (a) screen for resistance/tolerance to very dry conditions, (b) evaluate the diversity for agronomic characteristics, (c) select accessions to start a small hybridization program with cultivated barley, (d) evaluate F_3 families between *H. spontaneum* and cultivated barley derived from F_2 plants with nonbrittle rachis, from the Plant Breeding Department of the University of Perugia (Italy).

The material (1387 accessions of *H. spontaneum*; 1180 from the USDA collection, 207 collected from Syria, and 168 F_3 families of *H. spontaneum* x *H. vulgare*) was evaluated only at Bouider. There was too much rain (178 mm) to screen for tolerance/resistance to very dry conditions and so evaluation was restricted to the last three objectives.

The accessions of *H. spontaneum* were evaluated using a modified augmented design by dividing the accessions into three sets. Arabi Aswad was used as a check and some improved cultivars and pure lines selected from landraces were included for comparison. The F_3 families were grown in an augmented design with Harmal, Arar, and Arabi Aswad as systematic checks.

The *H. spontaneum* collection was diverse for growth habit, cold resistance, and days to heading. Accessions with relatively good plant type were identified and these will be used in crosses with landraces and improved cultivars.

Some of the F_3 families between *H. spontaneum* and cultivated barley were very tolerant to cold and headed up to 2 weeks earlier than the early cultivar Harmal (Table 9). Some families were more than 30 cm taller than the local landrace, Arabi Aswad, which is characterized by tall plants even when grown in dry areas.--*M.S. Mekni, S. Ceccarelli, and S.K. Yau.*

Mexico-Based Project

The results from two generations of breeding work since the shift of the world mandate for barley improvement from CIMMYT to ICARDA are reported. The summer cycle (May-October) is conducted in central Mexico at three sites: El Batan, Toluca, and Lagunilla. The winter cycle (November-May) is conducted in the northwestern part of Mexico at CIANO's Experimental Station in the Yaqui Valley.

The CIMMYT/ICARDA barley breeding program based in Mexico emphasizes the incorporation of disease resistance into barley germplasm with good agronomic traits. The most important diseases in Latin America are: leaf rust (*Puccinia hordei*), scald (*Rhynchosporium secalis*), stripe rust (*P. striiformis* f.ssp. *hordei*), BYDV, and net blotch (*Helminthosporium teres*). Since different resistance genes cannot be incorporated into the germplasm base at the same time, a step-wise approach is used. First, a template of resistance to leaf rust and scald was built across the entire germplasm base and advanced lines resistant to both diseases were yield-tested during the 1984/85 winter cycle. Stripe rust resistance is being incorporated and the incoporation of BYDV resistance across the entire germplasm base has just begun.

Summer Season 1984

Screening for scald resistance. Breeding materials were screened for resistance to scald under artificial inoculation at El Batan and Toluca. The latter is ideal for scald screening due to the moist climate. Materials were also planted at Lagunilla, a site with high natural scald infestation.

F3 material from Chile was inoculated with scald and selections made. This F3 population was planted for the first time as part of a shuttle breeding program between Mexico and Chile. Resistant selections were advanced as F4 in the Yaqui Valley and returned to Chile as F5.

Screening for leaf rust resistance. A severe artifical epidemic of leaf rust was established at El Batan and some advanced lines selected as resistant during the previous cycle became susceptible. The production of fresh leaf rust spores in the greenhouse and the increased number of susceptible spreader rows throughout the fields was important in creating a successful epidemic. Races of barley leaf rust present in Mexico are being continuously monitored by the USDA Rust Laboratory in Minnesota. Race 19 is clearly predominant but races 12 and 30 are also present.

At Toluca, segregants susceptible to leaf rust were discarded although the disease was not present at a high level.

Leaf rust and scald resistance, straw strength, and good insertion of spike in the peduncle (i.e. strong neck) were the most important criteria applied in the pre- and final selections. Artificial inoculations were used in selecting resistant material, and many susceptible lines were discarded in all segregating generations.

Screening for net blotch resistance. At El Batan, seedlings of segregating populations were inoculated with an aqueous spore suspension of *Helminthosporium teres* using a "rag-doll" technique in the greenhouse. Some basic nurseries such as CB, LO, Miscellaneous, Winter CB, and LO, were also tested to identify reaction of the component lines. This system was used to determine whether or not net blotch resistance in F2 seedlings matched that in adult plants in the field. Seedlings resistant in the greenhouse were transplanted in the field among susceptible check lines and after several inoculations following late afternoon rains, a severe net blotch epidemic was produced that killed the checks. However, many greenhouse-selected transplants remained resistant as adults and were advanced as F3 material.

Screening for Barley Yellow Dwarf Virus (BYDV) resistance. Planting in late June at Toluca provided a favorable environment for BYDV selection, thus confirming our earlier observations. Symptoms were clearly identifiable as BYDV, especially in the F6 nursery. Resistant sources to BYDV from the crossing block were planted in two replications surrounded by wheat borders heavily infected with BYDV. The resistant lines were MCU33/FZA/TIB/3/PI356456, ESCII-72-83-3E-7E-5E-1E, CM72, Sutter, UC566, 79 W 40762, 79 W 41762, PI 382406, Ojillo"S", and Palo Santo.

Winter Season 1984/85

Screening for leaf rust resistance. Breeding for leaf rust resistance became a major objective of the program due to a sudden increase in this disease in South America. National breeding programs have concentrated on incorporating stripe rust resistance into their germplasm, while the potential hazards of leaf rust have been relatively ignored.

An unusually rainy season in the Yaqui Valley provided ideal environmental conditions for leaf rust development after artificial inoculation. Resistant plants were selected and large numbers of susceptible plants were eliminated in all the segregating generations. To ensure leaf rust infection in early barleys, nurseries were surrounded by dense, susceptible borders, planted 1 month in advance and inoculated heavily. This produced a severe epidemic in the early material and helped eliminate a large number of lines previously thought to be resistant.

Of 11,087 accessions from the USDA World Barley Collection, only 285 remained resistant to leaf rust after two selection cycles in the Yaqui Valley. These entries were sent to Ecuador and Peru for further testing. Leaf rust evaluation was impossible during the summer of 1985 at the Santa Catalina Experimental Station in Ecuador, due to acid soils and heavy stripe rust and BYDV infections. In Peru, the leaf rust-resistant entries were planted in the coastal region where stripe rust intensity is much lower, so good results are expected.

Screening for stripe rust resistance. Stripe rust is the principal barley disease in the Andean region. Therefore, incorporating stripe rust resistance into the ICARDA-CIMMYT germplasm is crucial and must be combined with other desirable characters for the South American region.

Most of the national programs in South America use a very small gene pool for stripe rust resistance, which must be diversified. New resistance has been identified in European germplasm sent for testing in South America (Table 10).

Early segregating populations up to F3 were sent from Mexico for testing in South America and plants resistant to leaf rust, stripe rust, and scald were selected in Bolivia and Ecuador.

Yield trials Eleven yield experiments were conducted in the Yaqui Valley under irrigated conditions. Each experiment had 25 lines of similar maturity and five checks which were chosen for their high yield potential.

Yields were very high during this growing cycle; some lines produced 8.3 t/ha, the highest ever recorded in the program.

Most of the new lines with high yields were from two crosses: Gloria/Come and Gloria/Copal. These lines have stiff straw, resist shattering, and resist leaf rust and scald under Mexican conditions. The 100 lines with highest yields were put into the 13th IBON for testing by national programs around the world.

Table 10. Lines resistant to stripe rust, *P. striiformis* (race 24), in Bolivia and Ecuador.

	1984		1985
Line	**Bolivia**	**Ecuador**	**Ecuador**
"Emir" as common parent			
Hassan	5MS*	TR	10S
Mirena	TMR	TR	TS
Tirtern	TMS	TR	TS
Atem/Egmont	10MS	TR	TS
Atem/Flare	5MS	TR	10S
Athos/Goldin	TMR	TR	TR
Athos/Hood	10MS-S	TR	10S
Mink/Akka//Hassan/Minak	TMR	TR	TR
"Abed" as commom parent			
Universe	5MS	TR	TS
Soverring	5MS	TR	TS
"Midas" as common parent			
Gold Marker	10MS-S	TR	TR
BH4'200'5'90//Gold marker/Ambre	5MS	TR	10S
Gold marker//Ark Royal/G. Promise	TMR	TR	10S
Triumph derivations			
Triumph/Hra 4.1045	TMR	TR	5S
Triumph/Tyra	TMS	TR	TS
Other lines			
Zgmont	TMS	TR	10S
Chevalier	TMS	TR	TS
Russian 81	10MS-S	TR	TS
MC 20	0	TR	TR
Arrow	TMS	TR	5S
Fingal/F784.70	TMS	TR	TS
F784.70/HW46.58.1	0	TR	10S

* S = susceptible; R = resistant; M = moderate; T = trace.
The figure is % infection; the letter is reaction type.

Yield potential of early barley. The CIMMYT Agronomy Program planted two advanced early lines, Mona//Mzq/B1 and Mona/Gtwy/D1 after soybean (the first week of November) and harvested in February. Although previous soil treatments under soybean affected some plants, the trial proved that these genotypes could grow between the soybean harvest and cotton planting. Seed increases of these two advanced early lines were planted at El Batan for large-scale testing on farms next season.--*H. Vivar.*

Component 2: Pathology

Screening for Resistance to Yellow Rust

The Barley Yellow Rust Nursery (BYR-85) is sent to a few sites to confirm the resistance of its material to the disease. Lines in this nursery have undergone several screening procedures for resistance to yellow rust. Of the 175 lines in this year's nursery, 56 were tested in the seedling stage against six isolates and all were tested against one isolate in the adult stage at Research Institute for Plant Protection (IPO), Wageningen. Results from this work will be published separately.

Multilocation Testing for Disease Resistance

The Key Location Diseases Nursery (KLDN) contains lines of the Advanced Yield Trials and lines selected for resistance to one specific disease. This nursery is sent to several 'hot-spots' in the region and elsewhere to be screened for resistance to the prevailing diseases.

The disease data of the KLDN-84 are shown in Table 11. Of the lines tested 7, 23, 42, and 51 were resistant to yellow rust, leaf rust, powdery mildew, and scald, respectively. The names or crosses/pedigrees of the lines resistant to two diseases are given in Table 12. For yellow rust and scald, no line was resistant to both diseases, but four were resistant to leaf rust and scald. Three lines were resistant to yellow rust and powdery mildew, but only one line was resistant to both leaf rust and powdery mildew. Seven lines were resistant to both powdery mildew and scald.--*J. van Leur and O. Mamluk.*

Component 3: Agronomy

During 1984/85 the performance of barley was compared with triticale at a dry site. The experiments evaluated the response to grazing, compared improved agronomic practices with traditional ones, and determined the nitrogen efficiency of barley genotypes. Results of the last experiment will be reported later and the results on improved vs traditional practices are presented under the agronomy component of Durum Wheat Improvement in this report.

Table 11. Number[1] of barley lines resistant[2] to yellow rust, leaf rust, powdery mildew, and scald at different locations (KLDN-84).

Disease	Location codes[3]	No.of lines
Yellow rust	SYR 01, SYR 53, LEB 01, PAK 01, ECU 01	7
Leaf rust	SYR 51, TUN 01, POR 01, MEX 01, ECU 01	23
Powdery mildew	SYR 52, TUN 01, MOR 01, POR 01	42
Scald	SYR 02, TUN 01, MEX 02, ECU 01	51

1. Number of lines tested = 360, excluding the checks.
2. Selection criteria: rusts <5% severity; powdery mildew < 5; and scald < 3 on 0-9 scale.
3. Syria = SYR 01 and 02 screening sites Tel Hadya; SYR 51 Lattakia; SYR 52 Mareh; SYR 53 Al Ghab. Lebanon = LEB 01 Terbol. Pakistan = PAK 01 Islamabad. Ecuador = ECU 01 Quetta. Tunisia = TUN 01 Beja. Portugal = POR 01 Elvas. Mexico = MEX 01 Obregon; MEX 02 El Batan. Morocco = MOR 01 Rabat.

Table 12. Barley lines of KLDN-84 resistant to more than one disease.

Name or cross	Source KLDN-84
Leaf rust and scald	
Matnan'S'	25
TH.UNK.23	67
Comp.Cr.299/Apm	171
NACC 4000-123-80	186
Yellow rust and powdery mildew	
Jerusalem a barbes lisses/CI 10836	239
Patty(A)	290
Jerusalem a barbes lisses/CI 10836	317
Leaf rust and powdery mildew	
Jerusalem a barbes lisses/CI 10836	239
Powdery mildew and scald	
Rihane'S'-1	123
Roho//Alger/Ceres, 362-1-1	294
Cossack	309
Alpha	310
Espe	353
Arma(B)	365
WI 2197/A. Hor 346.70	394

Comparison of Barley with Triticale

Two high-yielding triticale lines, Bgl'S' and DOC 6, were compared with two barley genotypes, Arabi Abiad (a local landrace) and Rihane'S' (a high-yielding line) at Breda, a dry site with a long-term average rainfall of 283 mm. The experimental design was a randomized complete block with four replications and 3.24 x 5 m ($16.2m^2$, 12 rows) plot size. The seed rate was 120 kg/ha and plots were fertilized with 20 kg N/ha and 60 kg P_2O_5/ha. The trial was sown on 11 December 1984 and harvested on 21 May (barley) and 14 June (triticale). Weeds were controlled by hand rather than herbicides. The total biological yield was obtained by hand harvesting the middle eight rows of each plot; plants were then threshed to measure grain yield.

The barley genotypes significantly outyielded the triticale lines in grain production (2963 kg/ha vs 1714 kg/ha) (Table 13). This difference was partly caused by kernel shrivelling and fewer fertile tillers in triticale. However, the triticale lines yielded significantly more straw (54%) which was thicker and stronger than in the barley. The 1000-kernel weight and harvest index were higher in the barley genotypes (Table 13).

Therefore, barley with a shorter growing period had more reliable grain production than triticale in dry environments due to better establishment, faster growth, earlier maturity, and a more suitable phenology.

Response to Grazing

The effect of grazing on barley-yields was studied at Tel Hadya using a split-plot design with three replicates. The main plots were three grazing treatments; ungrazed (G_0), grazed at mid-tillering stage (G_1), and grazed at the beginning of jointing stage (G_2). Twenty barley genotypes tested the previous season constituted the subplots. The seed rate was 100 kg/ha, the fertilizer rate was 80 kg N/ha and 40 kg P_2O_5/ha, and plots were 1.6 m x 10 m. Before grazing, an area of 1 m^2 was hand-clipped for dry-matter assessment. After grazing, plots were allowed to recover and grain and straw yield determined at maturity.

Fig. 5 shows the effects of the different grazing treatments on yields. Delaying grazing until the jointing stage more than doubled, the amount of dry-matter accumulated for grazing. However, grazing at jointing and at tillering significantly decreased grain,

Table 13. Performance of two barley and two triticale genotypes at Breda, 1984/85.

Genotype	Grain yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)	Fertile tillers (no./m^2)	1000-kernel wt.(g)
Barley						
Rihane'S'	2881	2740	5621	52	358	36
A. Abiad	3044	2890	5934	51	563	37
Mean	2963	2815	5778	51	461	36.5
Triticale						
Bgl'S'	1633	4320	5953	29	289	26
Doc 6	1794	4340	6134	28	278	30
Mean	1714	4330	6044	28	284	28.0
CV (%)	11.9	12.7	11.4	5.1	16.0	9.6
LSD (0.05)	299	473	N.S	21	64	3.2

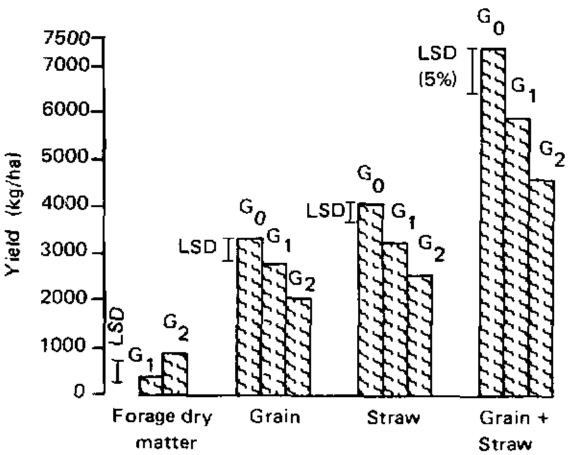


Fig. 5. Mean effects of the different grazing treatments on forage, grain, straw, and biological yield of 20 barley genotypes. (G_0 = No grazing; G_1 = grazed at mid-tillering stage; G_2 = grazed at beginning of jointing stage.

straw, and biological yields at maturity. The effects of the different treatments on other characters are given in Table 14. Grazing delayed heading and maturity, but did not affect the number of fertile tillers and harvest index.

There were significant differences in performance among genotypes within each treatment. Arabi Abiad, Rihane'S', and Saida had high dry-matter yields at grazing and high grain yields after grazing. Therefore, they appeared to be the best as dual-purpose types.--*I. Naji.*

Component 4: Grain Quality

In 1984/85, 9632 tests on barley lines were carried out and material was identified with good malting potential and with higher lysine levels which are suitable for food and feed. A near-infrared analyzer was calibrated for protein content determination of barley straws. Every tenth sample was verified by the Kjeldahl process and the coefficient of correlation between the two methods was 0.92.

Table 14. Effects of grazing treatments on days to heading, days to maturity, number of fertile tillers, and harvest index at Tel Hadya, 1984/85.

Treatment	Fertile tiller (no./m^2)	Days to head	Days to mature	Harvest index
No grazing (G_0)	932	116	147	0.44
Grazed at mid-tillering(G_1)	845	120	150	0.45
Grazed at beginning of jointing (G_2)	926	126	156	0.45
LSD (5%)	81	2.3	1.5	NS

Table 15. ***Performance of six promising*** **barley lines for malting from the 1983/84 yield trials at Tel Hadya.**

	Yield (kg/ha)	Size >2.8mm (%)	Size >2.5mm (%)	1000-kernel weight (g)	Protein (%)	Diastatic potential
Mean	3627	44.8	86.2	43.8	9.3	198
Minimum	3427	29.2	76.6	36.3	7.3	183
Maximum	4022	89.0	98.8	47.0	10.3	230

There have been increasing requests for malting barley lines in the ICARDA region so barley is screened for malting potential. Selection is based on a high proportion of plump kernels with high diastatic potential. Table 15 summarizes the characteristics of six barley genotypes.

In some countries of the region, significant quantities of barley are consumed as human food. The NIR (near-infrared) testing of barley for lysine has enabled the identification of several genotypes with plump kernels, high test weight, and above-average lysine content which is suitable for both food and feed.--*P. Williams and F.J. El Haramein.*

Component 5 : Entomology

In 1984/85, screening for sources of resistance to aphids and wheat stem sawfly was emphasized. From the 1983/84 advanced yield trial, 270 lines were screened for aphid resistance at Tel Hadya under natural infestation and at two locations (Tel Hadya under artificial infestation and Suran under natural infestation) for resistance to wheat stem sawfly. In both screenings, lines were identified with no insect damage. However, it is not possible at this stage to discriminate between true resistance or escape.--C. *Cardona and A. Rashwani.*

Project II: Durum Wheat Improvement

Durum wheat (*Triticum turgidum* var. *durum*) is one of the most important food crops in the moderate- and low-rainfall areas in the Mediterranean region.

During 1984/85, the ICARDA/CIMMYT joint durum wheat project strengthened the: (i) identification and distribution of superior genetic stocks for specific traits, (ii) use of multilocation testing for early segregating populations, (iii) evaluation of advanced durum lines for resistance to common bunt and septoria leaf blotch, (iv) evaluation of advanced durum wheat lines for adaptation to the major durum wheat-growing countries, and (v) evaluation for drought, heat, and frost resistance.

Component 1: Breeding

Germplasm Development and Testing

The breeding strategy for the development of genotypes adapted to the Mediterranean rainfed areas involves: (i) using stress- specific sites, (ii) combining desirable traits, and (iii) evaluating segregating populations and bulked lines from F_5, F_6, and F_7 in different environments. The environments are chosen to represent different ranges of rainfall, temperatures, and different biotic and abiotic constraints.

Identification of Genetic Stocks for Hybridization

One hundred and eleven parental lines were identified for tolerance to drought, heat, cold, and salt, 96 for disease resistance, 56 for insect resistance, and 259 for good grain quality. Crosses in the durum wheat project are designed for the various agroclimatic conditions under which durum wheat is primarily grown. Special emphasis is placed on rainfed areas with mild and cool winters.

Evaluating Segregating Populations

Segregating populations were planted at three sites under the following conditions:

(a) Breda rainfed (277 mm) with 30 kg N and 30 kg P_2O_5/ha,

(b) rainfed at Tel Hadya (373 mm) with 60 kg N and 60 kg P_2O_5/ha,

(c) late planting (15 February) under rainfed conditions (300 mm),

(d) high input conditions at Tel Hadya, early planting (15 October) with supplementary irrigation (450 mm) and 120 kg N + 60 kg P/ha, and

(e) Lattakia, to screen for disease resistance particulary septoria leaf blotch and leaf rust (800 mm).

Thus, the early segregating populations were exposed to a gradient of moisture stress, from 277 mm at Breda to 800 mm at Lattakia. In the dry environments and at Lattakia the modified bulk procedure was used. Selections were bulked in each of the F_2 and F_3 generations and individual plant selection started in the F_4 generation.

The severe cold at Tel Hadya and Breda this season allowed germplasm screening for cold resistance. The highest selection was made from crosses between frost-resistant and high-yielding entries and landraces, followed by crosses between entries with high yield and drought tolerance. The crosses for earliness, multiple resistance, and common bunt resistance were also largely selected.

The major selection for low rainfall and fertility came from crosses between high-yielding and adapted landraces and from crosses between high-yielding and drought-tolerant lines.

Table 16. Entries of durum wheat combining high grain yield across environments, drought and frost tolerance, and earliness, 1984/85.

Nursery and entry no.	Entry name and pedigree	Yield (kg/ha)	S	Cold tolerance	Days to heading
ADYT 117	Omrabi L0400-1L-1AP-3AP-3AP-0AP	4210	0.82	7	171
ADYT 118	Omrabi L0400-1L-1AP-3AP-6AP-0AP	4381	0.79	8	171
ADYT 119	Omrabi L0400-1L-1AP-3AP-4AP-0AP	4175	0.92	7	171
ADYT 207	GdoVZ 385/Gs ICD 77-0134,AP OSH	4012	1.04	7	173
ADYT 215	Pin/Gre//Trob ICD-Sel-1AP-4AP-0AP	4160	0.81	7	172
ADYT 516	Gdovz 578/Swan ICD-Sel-3AP-1AP-2AP-0AP	4166	0.97	6	177
Checks	Stork	3572$\pm$178	1.18	3	174
	Sham 1	3574$\pm$114	1.16	3	177
	Haurani	3419$\pm$ 90	0.98	8	179

*Cold tolerance scale 1-9: 1 = susceptible, 9 = resistant.
S = Drought susceptibility index (Fischer and Maurer 1978).

Selected F_3, F_4, and F_5 are further evaluated in different agroenvironmental conditions with 250 - 600 mm annual rainfall. They are also evaluated in Cyprus for mild winters, as well as Tunisia and other locations. The best homogeneous lines are promoted to replicated yield trials

Advanced Testing

Yield. Promising entries in the F_5, F_6, or F_7 generations with high-yielding ability, and important desirable traits are included in preliminary yield trials, are evaluated in replicated trials at three locations and as observation nurseries at 10 locations. They are also evaluated in the initial disease screening nurseries for disease resistance and for grain quality. Based on these evaluations the more promising lines are promoted to advanced yield trials where they are evaluated for 1-2 years in five different environments and at 15 locations as observation nurseries. They are also further screened in Key Location Disease Nurseries (KLDN) for stem sawfly and aphid resistance, and for nutritional and industrial grain quality.

Yield performance and moisture stress. Lines with high yield potential were identified in different environments (Table 16).

Omrabi lines in particular were also early, cold tolerant, and maintained their yield in the drier sites (smaller drought *susceptibility index* (S). *For any genotype,* S measures its relative susceptibility to drought; the higher the S the lower the drought tolerance. Fig. 6 shows the distribution of S values for the 210 ADYT entries. The lines with small S and those with large S will be further tested under different stress conditions in 1985/86.

Table 17. Correlation coefficients among drought susceptibility index (S) and grain yield for different moisture stresses in durum wheat.

Environment	Rainfall (mm)	Correlation coefficient between yield and S
Breda (dry)	270	- 0.713 **
Tel Hadya (late planting)	300	- 0.314 **
Tel Hadya (rainfed)	342	- 0.327 **
Tel Hadya (early rainfed)	450	- 0.182 *
Terbol	550	+ 0.761 **

n = 210.

* P < 0.05; ** P < 0.01.

Table 18. Mean yields of the highest and lowest 5% yielding entries under rainfed conditions at Tel Hadya, 1984/85.

Entry group	Yield (kg/ha)	Mean yield (kg/ha)	Regression coefficient	Coefficient of determination
5% Highest	2957	4077	0.96	0.97
5% Lowest	1677	3408	1.19	0.95
Difference	1280***	669***	-0.23**	

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

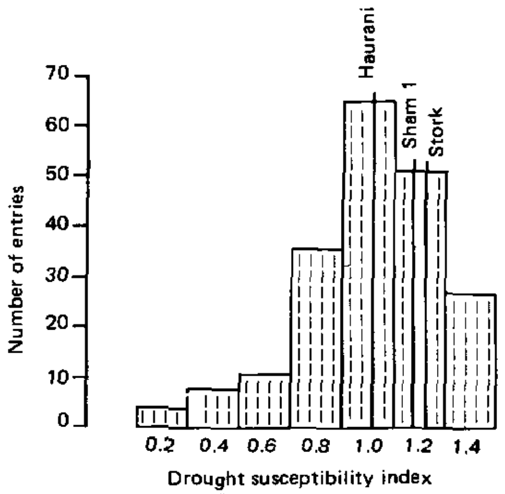


Fig. 6. Distribution of drought susceptibility index(S) for ADYT entries. S values were calculated using yields at Breda as stress environment and at Terbol as favorable environment.

There *was a negative and high correlation* between drought susceptibility index (S) and grain yield at Breda (Table 17), indicating that higher grain yields in durum wheat are related to greater drought tolerance. At Terbol there was a positive correlation between S and grain yield. The correlation between drought susceptibility index and grain yield was strongly related to the amount of rainfall.

Yield potential and stability. The grain yield *and stability results (Table 18) indicate that* high grain yield under Mediterranean rainfed conditions and good yield stability can be successfully combined when appropriate breeding and testing procedures are adopted.

Table 19. Average grain yield (kg/ha) of durum wheat selected for grain yield in areas with limited (Breda) and adequate (Tel Hadya, early planting) rainfall.

Character	Testing environments					
	Breda			Tel Hadya		
	Top 5%	Bottom 5%	Difference	Top 5%	Bottom 5%	Difference
Grain yield						
Breda	1419	699	720 ***	986	1205	-219 ns
Tel Hadya	4361	4083	278 ns	5125	2836	2289 ***
Plant height						
Breda	65	59	6 *	58	60	-2 ns
Tel Hadya	70	68	2 ns	76	65	11 **
Cold tolerance	5.0	3.8	1.2 *	6.3	3.7	2.6 ***
Days to heading	170	174	- 4 *	173	175	-2 ns
Drought susceptibility index	0.91	1.14	-0.23 ***	1.04	0.92	0.12 **

* $P<0.05$, ** $P<0.01$, *** $P<0.001$.
ns = not significant.

Selection strategy. When the performance of ADYT entries was compared for two different environments (Table 19), the 5% top and 5% lowest yielding entries at Breda were not significantly different at Tel Hadya. The 5% top and the 5% lowest yielders at Tel Hadya were not significantly different at Breda. These results suggest that selection should be done in the environment for which the crop is intended.

Plant height, earliness, and cold and drought resistance are also important traits for final grain yield in the areas where there are environmental stresses.

Cold tolerance. Cold damage was severe in 1984/85 and is reflected in the strong relationship between grain yield and cold tolerance. Early lines were affected by cold but several entries were found combining with earliness and frost tolerance.

Heat and terminal drought. The 210 ADYT entries of durum were planted mid-February and harvested at the end of June to subject the plants to severe dry and hot weather during grain filling.

The checks Stork and Sham 1 are high-yielding varieties widely adapted to the Mediterranean region, particularly in areas with mild winters and moderate to high rainfall. Haurani is a local variety cultivated in the rainfed areas of the Middle East with cooler winters. Table 20 shows a number of promising entries compared with the checks.

Table 20. Durum wheat entries significantly outyielding the checks at late planting, Tel Hadya, 1984/85.

Entry		Yield (kg/ha)	Days to heading	Plant height (cm)
202	Omrabi ICD 058-3L-1AP-2AP-1AP-0SH	2616	91	90
205	Ruff//Jo/Cr/3/Fg.9 ICD 079-0401-1AP-1AP-0AP	2566	97	80
210	Shwa//Jo /AA/3/Bit CD 27672-4AP-1AP-4AP-0SH	2438	93	75
221	Can 2101/Magh//Stk/3/Wlls/65150 L15111-35-2AP-3AP-0AP	2416	94	80
Checks				
Stork		2083	91	75
Sham 1		1966	97	75
Haurani		1850	100	90
LSD (0.05)		321		
CV (%)		8.97		

International Testing

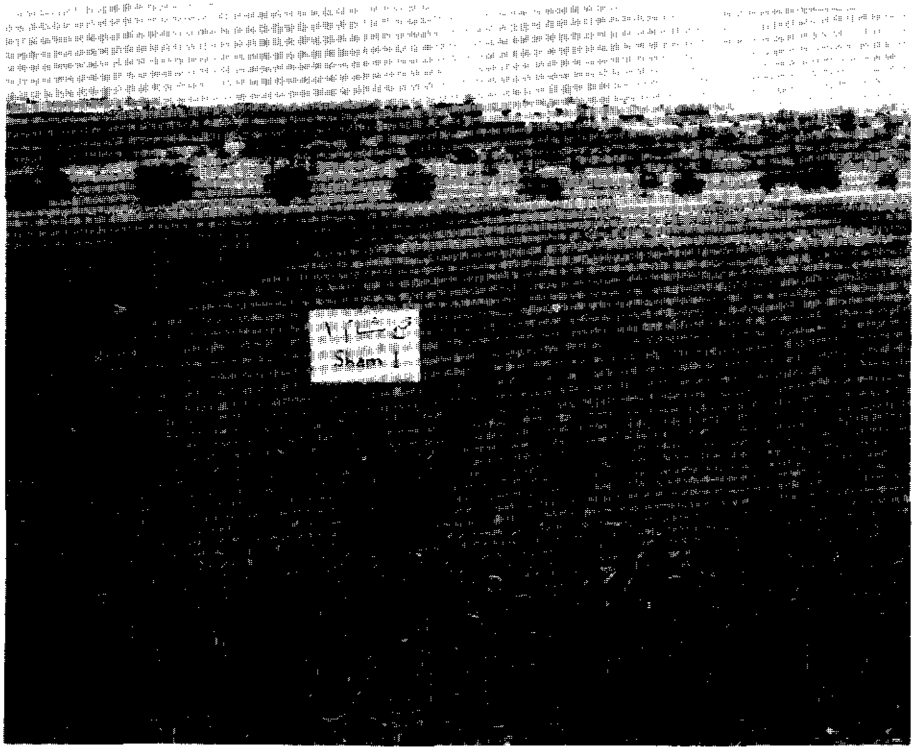
Observation nurseries. Regional durum wheat observation nurseries screen promising advanced lines at the national program testing sites. Data for 1983/84 have been reported to national programs and some highlights are reported here.

Results of DON and DON-Rf (Durum Observation Nursery - rainfed) were obtained from 35 locations and selected entries from the 1983/84 DON-Rf are shown in Table 21. Overall, grain yield was 2337-4217 kg/ha with a grand mean of 3337 kg/ha. The mean number of days to heading was 104-124 with a grand mean of 113 days although there was large variation between sites. The number of days to maturity was 146-176 with a grand mean of 154 days, also with large variation between sites.

A number of durum wheat entries are resistant to the diseases of moderate- and low-rainfall areas (Table 22). Stem rust resistance should be further improved.

In DON-Rf and DON, high grain yields were associated with earliness, more in the rainfed DON than in the DON with moderate rainfall. This highlights the importance of selecting for earliness in low-rainfall areas.

Regional yield trials The regional durum wheat yield trials are of two types; moderate rainfall (RDYT-MR) and low rainfall (RDYT-LR), each comprising the lines with best performance from regional durum observation nurseries. The RDYT-MR is for favorable environments and the RDYT-LR for the low-rainfall areas in the Mediterranean region. Yield data were received from 21 locations for RDYT-MR and 20 for RDYT-LR and a



Durum wheat variety Sham 1 being cultivated by Syrian farmers on large scale.

number of lines were selected by national programs from these trials. The average grain yield in 1983/84 was 4238-5154 kg/ha for RDYT-MR and 3477-5164 kg/ha for RDYT-LR. Omrabi and Belikh which have consistently high yields with early heading and maturity performed well at most test sites (Table 23).

Entries from RDYT with good performance in different subregions are shown in Table 24. Several lines outyielded the checks in more than one subregion, while Cr/Albe, Omrabi, Belikh, and Quadalete had high yields at several testing sites. Eider, which was the top yielder in the Middle East was released for commercial production in the Benghazi area in 1984 under the name Marjawi. These lines also performed well in Pakistan, Afghanistan, Canada, and Mexico. The highest subregional yield was in the irrigated Nile Valley and the lowest in rainfed Maghreb.

Genetic Studies

Two crosses (Gezira 17/Belikh and Cando/Stk) were studied in the F_3 and F_4 generations at Tel Hadya. Each of 67 random F_2-derived families from each cross was grown using a split-plot design with three replications. Each cross included a late- and an early-maturing parent. Heritability estimates using parent-offspring regression for heading and maturity dates were 0.43 and 0.39 for cross I and 0.67 and 0.53 for cross II, respectively. Grain yield with heritability values of 0.30 and 0.45 for crosses I and II, respectively, was affected by environmental and nonadditive variations.

In another experiment, three cultivars C_1=Har'S', C_2=Bit'S', and C_3=Win'S' and the single crosses among them (as F_2 bulks) were grown at Tel Hadya at four seeding rates

Table 21. Yield and agronomic data of the top-yielding lines, DONRF, 1983/84.

Entry no.	Name	GY	DHE	DMA	PHE	YR	ACI LR	SR	Quality ST	Prot	Vitr	TKW
32	Gs/AA//Ple/3/Cit	4257	113	150	86	4.00	1.8	27.5	4	13.3	100	36
15	Lahn 2	3938	107	147	94	7.10	10.8	24.3	5	14.0	100	36
58	S15/Cr/3/Cit/AA/Fg	3720	110	147	82	11.50	14.3	32.0	4	13.5	100	38
24	Stw 63/Gll//RD 119/3/Gta	3714	108	147	80	0.50	10.1	37.3	5	13.2	100	43
31	Gdo VZ 569/Plc/5/21...	3690	109	150	81	2.60	0.8	32.2	6	14.9	100	43
Haurani mean (Regular check)		2959	118	159	102	17.5	16.5	45.5	4	12.1	95	36
No. of locations		15	28	19	21	4	6	4	4	3	3	3

GY = Grain Yield, DHE = Days to heading, DMA = Days to maturity, PHE = Plant height, YR = Yellow rust, LR = Leaf rust, SR = Stem rust, ACI = Average coefficient infection, ST = Septoria tritici, Prot. = Protein, Vitr. = Vitreousness, TKW = Thousand-kernel weight.
DONRF = Durum Observation Nursery - Rainfed.

Table 22. Entries of durum wheat combining grain yield potential with disease resistance, DONRf, 1983/84.

Entry (DONRf)	Grain yield (kg/ha)	Average of coefficient of infection: Yellow rust	Leaf rust	Stem rust	*Septoria tritici*
Kabir	3545	1.1	0.9	33.0	4.3
D.D.15/Belikh	3122	1.1	4.2	27.0	4.2
Sajour	2953	0.1	1.4	19.8	5.5
No. of locations	15	4	6	4	4

Table 23. Performance of the highest and most consistent yielding entries, RDYT-LR.

Entry	1981/82	Rank	1982/83	Rank	1983/84	Rank
Omrabi	n.i	n.i	n.i		4772	1
Belikh	3759	2	4222	2	4692	2
Sahl (improved check)	3579	11	3791	15	4430	11
Nursery mean	3562		3852		3814	
LSD (0.05)	192		209		216	
CV (%)	17		15		15	
No. of locations	23		17		28	

n.i = not included in the trial.

Table 24. Performance in different subregions of the most promising entries, RDYT, 1983/84.

Subregion/entry	Grain yield (kg/ha)	Rank	% yield over Jori C69
Maghreb (3 sites)			
Jllo (Tcl)	4219	1	124
Cr/Albe	4191	2	123
Omrabi	4097	3	120
Quadalete	4038	4	119
Jori C69 (Long-term check)	3397	21	100
Improved check (Sham 1)	3862	5	114
Middle East (9 sites)			
Eider	6015	1	113
Gta/Tc60//Mexi	5805	3	109
Belikh	5788	4	109
Omrabi	5703	5	107
Jori C69 (Long-term check)	5303	13	100
Improved check (Sham 1)	5951	2	112
Nile Valley (3 sites)			
Belikh	6533	1	153
Cr/Albe	6259	2	146
D.Dwf S15/Belikh	6067	3	142
Ain Arous	6066	4	142
Jori C69 (Long-term check)	4275	24	100
Improved check (Sham 1)	5319	19	124
Mediterranean Europe (4 sites)			
Cr/Albe	5651	2	135
Quadalete	5278	3	127
Omrabi	5181	4	125
Eider	5020	5	121
Jori C69 (Long-term check)	4159	24	100
Improved check (Sham 1)	5691	1	137

(20,60, 100, and 140 kg/ha). Genotypic ($P<0.01$) and seeding rate ($P<0.05$) effects were significant with no interaction between them. The highest average yield (4154 kg/ha) was recorded for a seeding rate of 140 kg/ha.

The best cultivar was C1 for performance and in crosses with other cultivars, while C_3 was the lowest yielding cultivar. Yields for the F_2 populations were significantly higher than the respective midparental values, with increases of 36, 29, and 91% for C_1 x C_2, C_1 x C_3, and C_2 x C_3, respectively, which may be due to heterotic effects and/or better performance of heterogeneous plant populations. To determine whether heterogeneous plant populations have an advantage over homogeneous varieties in moisture-limited environments, 50-50 mixtures of the parents for each cross will be grown with the parents and the crosses in dry environments in 1985/86.--*M. Nachit and H. Ketata.*

Component 2: Pathology

Screening for Resistance to Common Bunt

Common Bunt Nursery I and II were used to screen for resistance to common bunt (*Tilletia foetida* and *T. caries*). Common Bunt Nursery I (CBNI-85) had 1272 lines. The inoculum was a mixture of 27 isolates from within Syria and in total, 190 lines were resistant (<5% infected heads) to the disease. Most resistant lines (62.5%) were in the Observation Nursery-High Altitude (DOH-85), and the Crossing Block-High Altitude (DCH-85) with 49.3%.

In Common Bunt Nursery II (CBNII-85), 14 lines in two replicates were screened for resistance to different common bunt isolates from the region: three from Syria (01,11, and 12 SY), two from Turkey (02 and 03 TR), and one each from Lebanon (4/58 LE), Tunisia (05 TU), and Iran (06 IR). Eight lines were resistant (<5% average infected heads) to all isolates (Table 25). In 1984, lines 1-7 were also resistant to a mixture of isolates from Syria (CBNI-84). Lines 1, 3, and 6, though susceptible to isolates 12 SY, 01 SY, and 5 TU, respectively, performed well against the remaining isolates. Senatore Cappelli, once a widely used cultivar in Syria, was the only line immune to all isolates.

Screening for Resistance to *Septoria tritici* Blotch

The material screened this season for resistance to *Septoria tritici* consisted of 1472 lines: 508 from Durum Preliminary Disease Nursery (DPD-85), 250 from Durum Key Location Disease Nursery (DKL-85), 93 from Durum Observation Nursery - Moderate Rainfall (DON-MR-85), 143 from Durum Observation Nursery-Low Rainfall (DON-LR 85), 24 from Durum Regional Yield Trial - Moderate Rainfall (DRYT-MR-85), 24 from Durum Regional Yield Trial - Low Rainfall (DRYT-LR-85), 150 from Durum Crossing Block (DCB-85), 80 from Durum Stem Rust Nursery (DSR-85), and 200 from Durum Septoria Nursery (DST-85). All lines were planted at El Ziereh/Lattakia. The inoculum used for El Ziereh was a mixture of 14 isolates from bread and durum wheat collected within Syria and mixed in the ratio 1:1. Lines from DPD, DKL, and DST were also planted at Beja (Tunisia) and Elvas (Portugal).

Of the 1472 lines screened, 122 (8.3%) were resistant to the disease. From the nurseries DPD, DKL, DON, DRYT, DCB, and DSR, 94 lines were resistant. For evaluation of the DST, data from the previous season and the different sites were also included and there were 28 resistant lines. Resistant lines from DPD, DKL, and DST will be included in the DST-86 for further testing. Three lines from the DST-85 were resistant (2.6-3.2 average infection at seven sites over the years) to the disease for the third year.

Table 25. Durum wheat lines resistant (< 5% infected heads) to isolates of common bunt (*T. foetida* and *T. caries*) from ICARDA region (CBN II-85).

	% infected head under different isolates									
Name or cross/pedigree	01 SY[1] 1:0*	11 SY[1] 1:0	12 SY[1] 1:1	02 TR[2] 1:0	03 TR[2] 1:0	4/58 LE[3] 1:0	05 TU[4] 36:1	06 IR[5] 1:0	Average infection (%)	Source CBNII-85
Cr'S'/3/21563//61-130/Lds/4/ Ente'S' ICD 78-0029-2AP-4AP-0AP	7	0	14	0	5	0	3	2	3.9	2
Gediz 75/Bit'S' CD 26820-1AP-1AP-0AP	2	5	7	3	5	0	3	2	3.4	3
Shwa/Ptl CD 20632-2AP-2AP-3AP-0AP	19	4	4	9	2	1	0	1	5.0	4
Ovi/Cp//Cando ICD 78-0001-7AP-2AP-2AP-0AP	2	1	0	0	0	0	0	4	0.9	5
W-2057	1	0	3	0	0	0	0	0	0.5	7
GdoVZ 469/Plc'S'//Jo ICD 77-0027-4AP-2SH-1AP-0AP	5	2	2	2	2	0	16	0	3.6	8
Cit'S'/GdoVZ 579 ICD 74-0105-4L-1AP-2AP-1AP 0SH-0AP	2	3	0	0	0	0	0	0	0.6	10
Senatore Cappelli	0	0	0	0	0	0	0	0	0.0	11

* T. foetida to T. caries ratio.
- Inoculum density : 0.8 x 10^5 spores/head.
- Spore germination in vitro : 39.9 - 90.2%
- Isolates: 1 from Syria, 2 from Turkey, 3 from Lebanon, 4 from Tunisia, 5 from Iran.

Multilocation Testing for Disease Resistance

The Key Location Disease Nursery (KLDN) contains lines of the Advanced Yield Trials and lines selected for resistance to one specific disease. It is sent to several 'hot-spots' in the region and elsewhere to be screened for resistance to prevailing diseases. In 1983/84, KLDN-84 was sent to 20 locations. Useful information was obtained from eight locations on yellow rust (*Puccinia striiformis*), leaf rust (*P. recondita*), stem rust (*P. graminis*), *Septoria tritici* blotch (*Mycosphaerella graminicola*), and common bunt (*Tilletia foetida* and *T. caries*).

Table 26 summarizes the disease data of the KLDN-84. The names or crosses/pedigrees of lines resistant to two diseases were given in Table 27. Two lines were resistant to both yellow rust and common bunt. Four lines were resistant to both yellow rust and septoria blotch combination, but only one line was resistant to both leaf rust and stem rust.--*O. Mamluk and J. van Leur.*

Component 3 : Agronomy

Comparison of Improved and Traditional Agronomic Practices

The difference between the average yield of experimental stations, on-farm trials, and farmers' fields is usually large. Although farmers may not achieve the average yields of the experimental stations, they should be

Table 26. Number of durum wheat lines resistant to yellow rust, leaf rust, stem rust, *Septoria tritici* blotch and common bunt in different locations (KLDN-84).

Disease	Location codes[1]	No.of resistant lines[2]
Yellow rust	SYR 01, LEB 01, KEN 01, POR 01	55
Leaf rust	SYR 51, POR 01	116
Stem rust	KEN 01	6
Septoria blotch	SYR 02, SYR 51, SYR 53, TUN 01,POR 01	11
Common bunt	SYR 01	10

1. Syria = SYR 01 and 02 screening sites Tel Hadya; SYR 51, Lattakia; SYR 53, Al Ghab. Lebanon = LEB 01, Terbol. Kenya = KEN 01, N'Jora. Portugal = POR 01, Elvas. Tunisia = TUN 01, Beja.
2. Total lines tested = 494 excluding checks.

Selection criteria: rusts < 5% severity; septoria blotch <615 on the combined 0-9 scale; common bunt < 10% infected heads.

Table 27. Durum wheat lines resistant to yellow rust and common bunt; yellow rust and *Septoria tritici* blotch; leaf rust and stem rust (KLDN-84).

Name or cross	Seed source
Yellow rust and common bunt	**KLDN-84**
Ruff'S'//Jo'S'/Cr'S'/3/Fg.3	115
GdoVZ469/Plc'S'//Jo	217
Yellow rust and *Septoria tritici* blotch	
GgoVZ385/Gs'S'/4/D.dwarfS15 //T.dic.V.Vern/ Gll'S'/3/Plc'S'	155
GgoVZ385/Gs'S'/4/D.dwarfS15//T. Gll'S'/3/Plc'S'	156
Pin'S'/Gre'S'//Cit'S'/Fg'S'	405
Pin'S'/Gre'S'//Cit'S'/Fg'S'	406
Leaf rust and stem rust	
Ovi 65/Amarelejo//Ruff'S'/Fg'S'/3/Ruso	12

aware of the agronomic practices required for newly-released varieties.

Two experiments (one each for durum wheat and barley) were conducted at Kesebeh village near Tel Hadya, average annual rainfall is 250-350 mm. The land was planted to lentil the previous year. Rainfall in 1984/85 was higher than average, around 373 mm, but the climate was unfavorable for cereal production due to poor rainfall distribution and very low winter temperatures.

Sixteen large plots (668 m^2) were used in farmers' fields and the experimental design was split-plot with four replications. Agronomic practices (improved vs farmers') were the main plots, and genotypes (improved vs traditional) were the sub-plots. Eight plots were planted by the farmer, using his own practices; ridges were opened with a duck's foot cultivator, the seed was broadcast and then covered using the cultivator. The seed rate was 190 kg/ha for wheat and 160 kg/ha for barley and nitrogen was applied at tillering. The remaining plots were sown with an experimental plot drill at 120 kg seed/ha for durum wheat or 100 kg seed/ha for barley with split nitrogen application. For durum wheat, the newly-released cultivar Sham 1 was used as the improved variety and Gezira 17 as a check. In the barley experiment Rihane'S' (a high-yielding line developed at ICARDA) and Arabi Abiad (the local variety) were used.

Table 28. Quality characteristics of some durum genotypes.

No.	Pedigree	Source	Protein (%)	Vitreous kernel count (%)	1000-kernel weight (g)	Yellow pigment content (ppm)	Sedimentation volume (ml)
Good quality lines							
1	Shwa/Ptl (1)	RDYT-MR-3	12.9	99	36.0	5.7	36
2	" (2)	" -10	12.8	99	37.6	5.2	33
3	Oronte	RDYT-LR-18	14.3	100	40.1	5.7	37
4	Erp/Mal	" -21	13.7	100	35.0	5.7	36
Poor quality lines							
5	Jordan	RDYT-LR-10	14.8	98	38.7	4.2	11
6	Bit/GgoVZ394	" -19	13.1	99	38.7	4.1	14
7	Gr/Boy	" -17	13.5	96	42.5	4.5	31

The improved practices produced significantly higher yields than the farmer practices: 12.% and 8.3% (305 and 194 kg/ha) more for Sham 1 and Gezira 17, respectively. There were no significant differences between cultivars under the two cultural treatments.

In the barley experiment, plots with improved practices significantly outyielded those with farmer practices by 12.5 and 7.2% (482 and 267 kg/ha) for Rihane'S' and Arabi Abiad, respectively. There was no significant difference between the two varieties under farmers' practices, but with improved practices, Rihane'S' had a higher yield than Arabi Abiad. This is consistent with the previous year's results using the same genotypes in a similar location but with much lower total rainfall (230 mm).--*I. Naji and J.P. Srivastava.*

Component 4: Grain Quality

Table 28 illustrates some durum genotypes with superior and indifferent quality. Genotypes 6, 7, and 8 were of inferior quality and 6 and 7 had very low SDS sedimentation values. Lines 7 and 8, when grown under low-fertility conditions, had very low vitreous kernel percentages (12 and 29%, respectively), and the SDS values dropped to 8 and 18, which are very low.

Full quality testing was done on the advanced lines subjected to Farmers Field Verification Trial (FFVT) testing. This showed the ICARDA line Korifla to be slightly superior in quality to Haurani in zone B, while Khabour was the best quality line in zone A.--*P. Williams and A. Sayegh.*

Component 5 : Entomology

Resistance to Wheat Stem Sawfly

One hundred and twenty advanced durum wheat lines were screened for resistance to wheat stem sawfly at Suran under natural infestation and 66 of these were screened at Tel Hadya under artificial infestation. There were three replications at each site. Some of these lines, from different sources were resistant to stem sawfly:

Bari - 5898	IC12775	
Preto Amareljo//Ovi/AA	DSSN-83	(21)
D56 - 89C P1324938	DSSN-83	(27)
Marroccos 46 3617 P1191621	DSSN-83	(36)

Other improved durum wheat entries were also identified with a good level of resistance to stem sawfly;

Kabir 1	RDYTLR-85	(9)
Oronte	RDYTLR-85	(18)
Cando	RDYN-85	(12)
Valricardo	IDYN-85	(14)
Gediz/Yavaros	EDYT-85	(8)

Resistance to Cereal Aphids

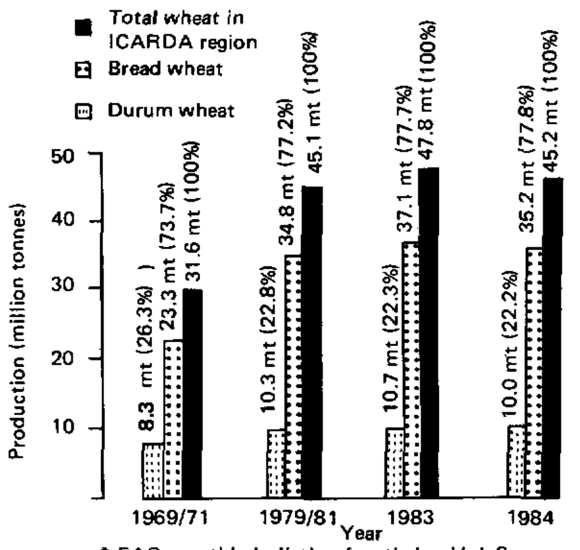
Durum wheat lines were screened at Tel Hadya for resistance to cereal aphids under natural infestation. There were three replications and aphid scoring was done when the aphid population reached peak reproduction. Of the 66 lines tested, none was resistant.

As part of the collaborative project between Egypt, Sudan, CIMMYT, and ICARDA, 150 lines of the Durum wheat Crossing Block 84/85 were screened for resistance to cereal aphids in plastic houses. There were two planting dates and three replications. Seedlings were artificially infested with two aphid species, *Rhopalosiphum maidis* and *R. padi* in the first planting and *Schizaphis graminum* and *Sitobion avenae* in the second planting. Two lines, Edmore and Mesaoria, were less susceptible to aphid infestation in the first planting and in the second planting four lines, Senator Capelli, Timpanas, Cr/Albe, and Mallard were less susceptible.--*C. Cardona and A. Rashwani.*

Project III: Bread Wheat Improvement

Bread wheat ranks first in production among food crops in the Middle East and North Africa. During 1984/85, this region produced 45.2 million tonnes of wheat (Fig. 7); approximately 35.2 million tonnes were bread wheat and the rest was durum wheat.

Over 65% of the bread wheat in the region is grown in rainfed areas with 300-650 mm annual rainfall and about 50% of the area receives less than 400 mm. In these areas, besides the erratic and unpredictable rainfall and temperature extremes, other biotic



* FAO monthly bulletin of statistics, Vol. 8, March 1985.

Fig. 7. Production (million tonnes)* of bread and durum wheat in the ICARDA region for the periods 1961-71, 1979-81, 1983, and 1984.

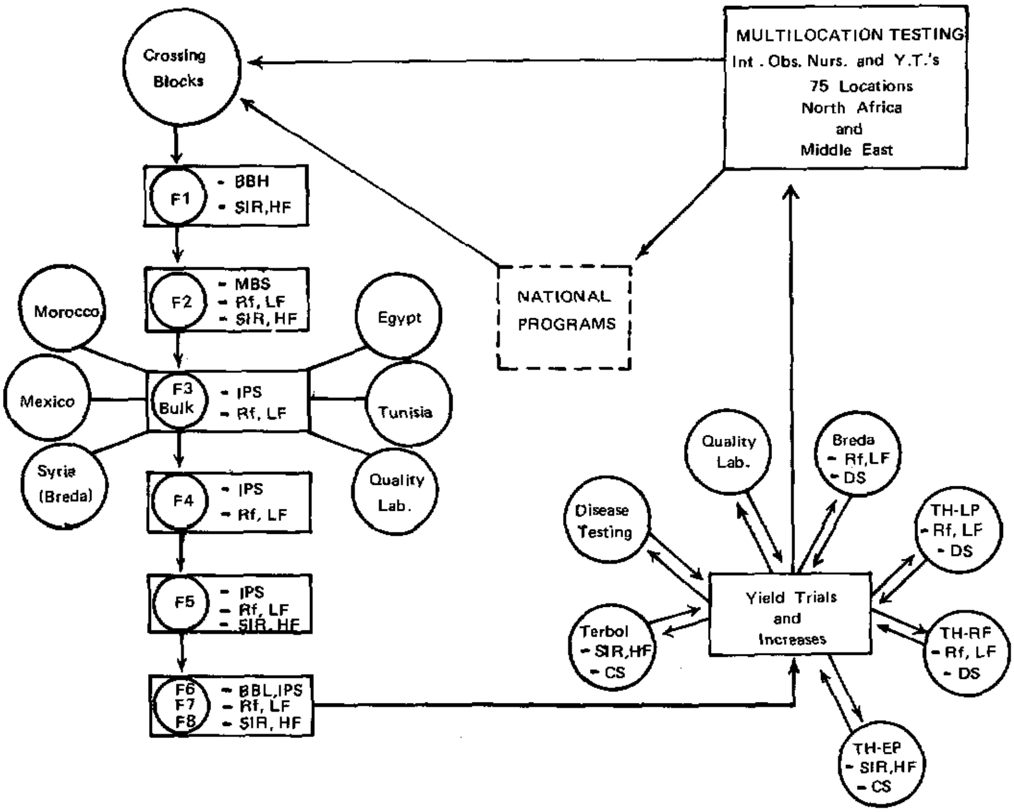
stresses such as diseases (yellow rust, septoria, bunts, etc.), and insect pests (sawfly, hessian fly, suni bug, aphids), are important factors limiting production. Current practices of land preparation, sowing, weed control, and moisture conservation also limit production.

The ICARDA/CIMMYT bread wheat improvement program aims to produce genotypes for the ICARDA region with resistance to the above stresses, and develop improved management practices in coordination with national programs.

Component 1: Breeding

Breeding Procedures

The breeding strategy of the bread wheat improvement program is shown in Fig. 8. Targeted F_1 single crosses are made every year and segregating populations from F_2 to F_8 are grown and evaluated at Tel Hadya and Breda (dry site) under both favorable and stress conditions. Favorable conditions include early planting (early October), 100 kg N/ha



BBH = Bulk Best Hybrids
SIR = Supplementary Irrigation
HF = High Fertility
MBS = Modified Bulk Selection

LF = Low Fertility
IPS = Individual Plant Selection
BBL = Bulk Best Lines
LP = Late Planting
Rf = Rainfed

EP = Early Planting
DS = Drought Stress
HS = Heat Stress
CS = Cold Stress
TH = Tel Hadya

Fig. 8. The breeding strategy of the bread wheat program.

and 60 kg P_2O_5/ha, and two irrigations, simulating 400 mm overall rainfall, for germination and disease enhancement. Stress conditions include low rainfall (200-300 mm) and low fertilizer rates (40 kg N/ha and 40 kg P_2O_5/ha).

The program emphasizes multilocation testing of early segregating material which is done with a modified bulk method of selection in the F_2 generation. Plants are individually selected in each of the most desirable F_2 crosses, then bulked within each cross. The resulting F_3 bulk families are evaluated for disease resistance and overall agronomic performance in five "hot spots" in the region. Undesirable families/plants are then discarded early in the segregating phase. Quality information on these F_3 bulk families is also used in the selection. From F_3 to F_7, individual plant selection is used and replicated yield testing of advanced lines starts with the F_6 to F_8 generations.

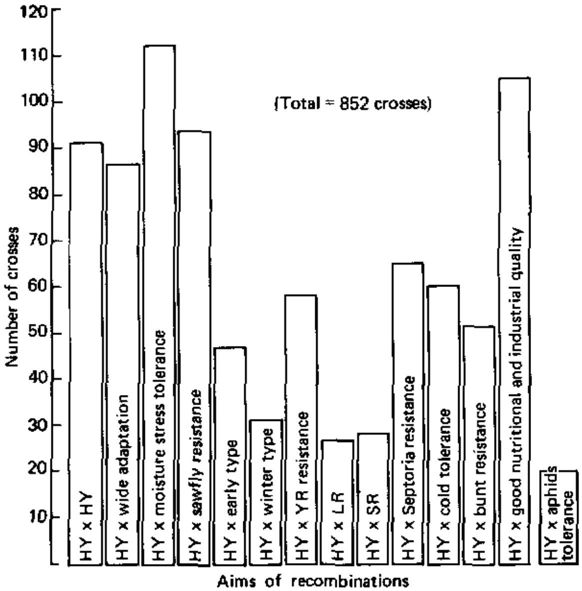
Prior to distribution to national programs, promising lines are yield tested in preliminary trials over 2 years and three sites in Syria. The most promising lines are promoted to advanced yield trials over 1 or 2 years in five environments with a long-term annual average rainfall gradient of 280-600 mm.

Information on disease resistance is collected as soon as lines are bulked for preliminary yield testing. When the lines are promoted to advanced testing, multilocation information on disease resistance is obtained from the Key Location Disease Nursery (KLDN). Promising lines are then promoted to international nurseries for multilocation testing at about 75 locations in the region.

Germplasm Development

Genetic variability is essential in the bread wheat breeding program. Since 1980, on average, 21% of incoming material has been evaluated and used by this program. Incoming materials, as collections or observation nurseries from national programs, provide additional genetic variability to meet the demands of the different environments in the ICARDA region.

During 1984/85, 884 crosses (simple and topcross) were made. Special emphasis was placed on incorporating specific traits, such as disease and insect resistance, and tolerance to stresses, such as drought and cold, into widely-adapted, high-yielding, and good quality lines and varieties (Fig. 9).



HY = High yield, YR = Yellow rust, LR = Leaf rust, SR = Stem rust

Fig. 9. Purpose and number of crosses made in the bread wheat crossing program for the 1984/85 season. (Total = 852 crosses).

Selection for yield potential and stability. Increased yield and stability are necessary for any variety to be recommended for rainfed areas. The variety must give larger yields under stress conditions and possess the genetic potential for much higher yields should environmental conditions, such as moisture and fertilizer availability, improve.

A considerable number of lines yielded higher than the checks, Mexipak 65 (local check) and Sham 2 (improved check), by at

Table 29. Number of lines that were significantly (5% level) higher yielding than the local check, Mexipak 65, and the improved check, Sham 2, in the advanced wheat yield trials*, 1984/85.

Location and condition	Average yield (kg/ha)	Rainfall of the season (mm)	No.of lines higher yielding (P<5%) than	
			Mexipak 65	Sham 2
Breda NP-RF	1200	283	11 (55)	3 (19)
Tel Hadya LP-RF	1672	300	20 (156)	9 (98)
Tel Hadya NP-RF	2578	342	21 (71)	6 (50)
Tel Hadya EP-SIR	3350	450	15 (48)	15 (51)
Terbol NP-IR	5198	600	20 (99)	21 (88)

Figures in parentheses indicate the number of lines outyielding the check from 5%-60%.
NP = normal planting; LP = late planting; EP = early planting.
RF = rainfed; SIR = supplementary irrigation; IR = irrigation.
* = 210 entries.

least 5-60 % in advanced yield trials (Table 29). With stronger selection pressures only a few lines significantly outyielded the checks. 1984/85 was extremely cold and, since both checks were cold tolerant, the identified lines should also be cold tolerant.

The performance of six lines with significantly higher yields than the checks under low- and high-input conditions at Tel Hadya is shown in Table 30. Under stress conditions, these lines yielded 17-29% more than the check, Mexipak 65, and 12-69% more than the check, Sham 2, in the favorable environment. Of these lines, two-thirds were of the spring x winter type, indicating the potential of this type of cross in the bread wheat program.

The 1983/84 crop season was extremely dry and total rainfall at Tel Hadya was 229 mm, 113 mm below the average long-term rainfall. The 1984/85 crop season was unusually cold and freezing temperatures were registered for 20-25 days at Tel Hadya. Several advanced lines were identified from material selected in these two seasons (Table 31) which were superior in yield and also had some degree of drought and cold tolerance. These lines were incorporated in the crossing block for use in the crossing program of 1985/86.

Selection for drought tolerance. Of the total area in all developing countries 37% is semiarid, so moisture is the primary constraint to wheat production. The Middle East and North Africa constitute about 59% of the semiarid environment in the Third World. Efforts continued, therefore, to develop and identify high-yielding lines for the limited rainfall areas of the ICARDA region.

From preliminary and advanced yield trials

Table 30. Bread wheat lines in the PWYT significantly (P<0.05) outyielding Mexipak 65 under rainfed conditions and Sham 2 under high input management, Tel Hadya, 1984/85.

Cross and pedigree	Rainfed Yield (kg/ha)	Rainfed LSD (5%)	Rainfed % of Mexipak 65	Irrigated Yield (kg/ha)	Irrigated LSD (5%)	Irrigated % of Sham 2
Snb'S' CM 35630-D-3M-3Y-1M-1Y-0M	4422	527	117	5177	811	127
71St 2959/Crow'S' SWM 11623-2AP-2AP-1AP-0AP	3666	401	124	4977	766	131
WW33/Vee'S' SWM-11619-12AP-7AP-1AP-0AP	3622	401	122	5022	766	132
Rd1/P101*2//Torim SWM 766319-01P-2P-2P-0P	3566	336	117	6000	936	169
WW33/Vee'S' SWM 11619-12AP-10AP-2AP-0AP	3533	401	119	4766	767	125
TR380.16/3A614//Chat'S' CM 64868-1AP-1AP-1AP-0AP	3422	395	129	4900	491	112

Table 31. Advanced bread wheat lines with superior yield (significant at P < 0.05) and drought and cold tolerance compared to the checks, Mexipak 65 and Sham 2, in the PWYT 1983/84 and AWYT 1984/85, respectively, at Tel Hadya.

Cross and pedigree	PWYT 83/84 Rainfed Yield (kg/ha)	LSD (5%)	% MXP	DTS L C	AWYT 84/85 EP-SIR Yield (kg/ha)	LSD (5%)	% Sham2	CTS L C
C182.24/C168.3/3/Cno*2/7C//Cc/Tob SWM 6828-6AP-2AP-2AP-3AP-0AP	4544	619	146	1.6/3.3	4388	653	119	1.3/2.6
Chat'S' CM 33090-T-1M-3Y-0M-124B-0K-0AP	4288	714	134	1.0/3.3	4388	407	114	1.3/2.0
Chr/4/Inia'S'/7C//Cno/Gll/3/Pci//Bb/Inia CM 46935-2AP-0AP-6AP 1AP-2AP-0AP	4200	572	141	1.0/3.3	3966	433	121	1.6/1.7
Jup'S'/4/LR64*2/Sn64//Cc/3/Ska L 764-4L-1AP-0AP-1AP-1AP-0AP	4111	619	132	2.0/3.3	4427	653	120	2.0/2.6
Rannaya/LovrinL3//Tes SWM 8211-4Y-1Y-2Y-0AP	3888	611	145	1.0/2.3	4488	573	120	1.6/2.6

MXP = Mexipak 65, DTS = drought tolerance score, CTS = cold tolerance score,
1 = Best 5 = Worst.
EP = early planting; SIR = supplementary irrigation.
L = line; C = check.

Table 32. Highest yielding lines under low-rainfall conditions (230-350 mm) for two consecutive years in the PWYT 1983/84 and AWYT 1984/85 planted at Tel Hadya.

Cross and pedigree	PWYT 1983/84 RF			AWYT 1984/85 RF		
	Yield (kg/ha)	LSD (5%)	% Check	Yield (kg/ha)	LSD (5%)	% Check
P106.19//Soty/Jt*3 L 489-2L-1AP-2AP-1AP-1AP-0AP	3366	619	109	3344*	479	141
Kal/Huac'S' CM 39604-4S-3AP-0AP-1AP-1AP-1AP-0AP	3288	587	99	3222*	461	116
Bch'S'//Y50E/Kal*3 CM 39761-5K-4AP-0AP-5AP-1AP-1AP-0AP	3966*	587	120	3161	461	114
Maya 74'S'/On//II60.147/3/Bb/G11/4/Chat CM 58924-1AP-2AP-1AP-0AP	4344*	598	141	3327*	467	122
Kvz/HD 2009 SWM 2894-1M-1Y-1M-2Y-0M-0Mm	4355*	399	149	3133*	335	124

RF = rainfed; * Significant at $P < 0.05$; Check = Mexipak 65.

planted under low-moisture conditions (230-350 mm annual rainfall) and tested over two consecutive years, several lines superior to the check, Mexipak 65, were identified (Table 32). In 1983/84, the highest yield was 4355 kg/ha, 49% greater than the check. The highest yield in 1984/85 was 3344 kg/ha, 41% higher than Mexipak 65. F_2-F_8 segregating populations were grown at Tel Hadya with limited moisture and suboptimal fertilizer. Selection criteria for these segregating generations included seedling vigor, tillering ability, and large fertile heads. Other environments, such as Breda (283 mm long-term average annual rainfall) and Tel Hadya (late planting), were also used.

Selection for grain characteristics and wide adaptation. Bread wheat is important in the diets of people in the countries of the ICARDA region. There is an estimated average consumption of 150 kg wheat/capita per year and demand is increasing. Nutritional and industrial quality receive special attention in the program. Lines with high protein content, high 1000-kernel weight and good adaptation to the region are identified through ICARDA's international nursery testing system (Table 33). All these lines were selected by 12 or more national programs in the region for further testing and may be released as commercial varieties. The program continued to evaluate early segregating material for several quality characteristics.

Performance of Bread Wheat Lines in the Region

The highest yielding lines in the Regional Wheat Yield Trial, evaluated at 38 locations in West Asia and North Africa during 1983/84, are shown in Table 34. These lines were selected by national programs based on their superiority over the national check, which is usually a recommended high-yielding variety with proven adaptation at a particular

Table 33. Bread wheat lines with high protein content, 1000-kernel weight, and good adaptation in the region in the Wheat Observation Nursery, 1983/84 (28 locations).

Cross and pedigree	Protein* (%)	1000-kernel weight (g)*	Loc.** selected
WA4767/3/391//56D.18/14.53/3/1015/6410 /4/W22/5/Ana	14.5	39.8	14
SWM 6525-1AP-0AP-1K-0AP			
Vee'S'	13.3	37.2	13
CM 33027-F-15M-500Y-0M-11B-0Y-OPTZ-0AP			
Bb/7C*2//Y50E/Kal*5	13.1	35.7	12
CM 29014-7S-2AP-1AP-2AP-0AP			
P106.19//Soty/Jt*3	14.8	40.0	12
L 489-2L-1AP-2AP-1AP-1AP-0AP			
Mexipak 65 (Regional check)	12.6	34.9	6

* Data from two locations.

** Number of locations where the entry was selected as promising, based on visual evaluation of agronomic type and disease resistance.

Table 34. Performance of the highest yielding lines in the Regional Wheat Yield Trial at 38 locations in West Asia and North Africa, 1983/84.

Cross and pedigree	Yield (kg/ha)	Rank	No. of locations: Rank > long-term check	Rank > improved check	Rank > national check
Flk'S'/Hork'S'	5266	1	25*	24*	19*
CM 39816-1S-1AP-0AP					
NWYT 11	5238	2	21	22	20
Pato(R)/Cal/3/7C//Tob/Cno/4/Yd'S'	5228	3	21	23	1
CM 30115-1L-1AP-0AP					
Bow'S'	5184	4	21	20	23
CM 33203-F-4M-4Y-1M-1Y-0M-0AP					
Waha (Durum wheat check)	5032	10	18	0	18
Mexipak 65 (Long-term check)	4987	13	0	19	16

* No. of locations at which the line was higher yielding than the checks.

location. FlK'S'/Hork'S' was the highest yielding line (average yield 5266 kg/ha) and outyielded the national check at 19 locations. This line was also among the three top yielding lines in the Regional Wheat Yield Trial of 1982/83, so it may be released as a variety by countries in the ICARDA region.--*G. Ortiz Ferrara and D. Mulitze.*

Component 2: Pathology

Screening for Resistance to Yellow Rust

In addition to the screening of the Programs' material for resistance to yellow rust (*Puccinia striiformis*) in Syria and other locations, advanced lines were screened against different isolates of the pathogen from the region and other parts of the world available at IPO, the Netherlands. Results of this screening will be published separately.

Screening for Resistance to Common Bunt

Two nurseries, Common Bunt Nursery I and II, were used to screen for resistance to common bunt (*T. foetida* and *T. caries*). In Common Bunt Nursery I (CBNI-85), there were 1234 lines and the inoculum was a mixture of 27 isolates from Syria. The total number of lines resistant to the disease (<5% infected heads) was 383.

In Common Bunt Nursery II (CBNII-85), 12 lines in two replicates were screened for resistance to different common bunt isolates from the region. Three lines were resistant to all the isolates (Table 35). Line 3 was moderately susceptible (9% infected heads) to the isolate from Lebanon, but performed well against all other isolates. These lines have been tested for 3 years and continue to be resistant to common bunt.

In developing bunt-resistant germplasm, 707 lines resistant or moderately resistant to common bunt (< 10% infected heads) in the previous season were planted at Tel Hadya in 1984/85, to be increased and evaluated for growth habit, heading time, and yellow rust resistance. The results of this evaluation are presented in the High-Elevation Cereal Project in this Report.

Table 35. Bread wheat lines resistant (< 5% infected heads) to isolates of common bunt *Tilletia foetida* and *T. caries*) from the ICARDA region (CBN II-85).

	% Infected head under different isolates (%)									
Entry	01 SY 1:0*	11 SY 1:0	12 SY 1:1	02 TR 1:0	03 TR 1:0	4/58 LE 1:0	05 TU 36:1	06 IR 1:0	Average infection (%)	Source CBNII-85
1.	2	3	1	2	0	0	4	0	1.5	17
2.	0	0	1	0	0	4	0	0	0.6	19
3.	0	2	1	2	0	9	0	0	1.8	20

* T. foetida to T. caries ratio

Inoculum density : 0.8 x 10^5 spores/seed.

Spore germination in vitro : 39.9 - 90.2%.

Isolates: 01 SY, 11 SY and 12 SY from Syria; 02 TR and 03 TR from Turkey; 4/58 LE from Lebanon; 05 TU from Tunisia; 06 IR from Iran.

Entry 1. Bb(Son64-An64*Nad/Jar'S'//LR64-TZPP*AnE3/Jar'S'

L 918-0L-4AP-0AP-1AP-0AP.

Entry 2. Sx/Cardinal; Entry 3. HD 2169.

Screening for Resistance to *Septoria tritici* Blotch

The germplasm material screened in 1984/85 for *Septoria tritici* blotch resistance consisted of 1133 lines: 150 from Wheat Crossing Block (WCB-85), 552 from Wheat Preliminary Disease Nursery (WPD-85), 232 from Wheat Key Location Disease Nursery (WKL-85), 125 from Wheat Observation Nursery (WON-85), 24 from Wheat Regional Yield Trial (WRYT-85), and 50 from Wheat Septoria Nursery (WST-85). All the materials were planted in El Ziereh/Lattakia. The inoculum was a mixture of 14 isolates from bread and durum wheat collected from Syria and mixed in the ratio 1:1. The WPD, WKL, and WST were also planted at Beja (Tunisia) and Elvas (Portugal).

Of the lines screened, 177 (15.6%) were resistant to the disease. From the nurseries WCB, WPD, WKL, WON, and WRYT, 170 lines were resistant. Seven lines from the WST were resistant this year and in previous years. Four of these seven lines had undergone a third year of screening and maintained their resistance.

All resistant lines from 1984/85 will be included in the WST-86 and tested next season.

Multilocation Testing for Disease Resistance

The Key Location Disease Nursery (KLDN) comprises lines of the Advanced Yield Trials and lines selected for resistance to a specific disease. This nursery is sent to several 'hot-spots' in the region and elsewhere to be screened for resistance to the prevailing diseases. In 1983/84, KLDN-84 was sent to 20 locations and useful information was obtained from 10 locations on: yellow rust (*Puccinia striiformis*), leaf rust (*P. recondita*), stem rust (*P. graminis*), *Septoria tritici* blotch, and common bunt (*Tilletia foetida* and *T. caries*).

The disease data of KLDN-84 is shown in Table 36. Of the 171 lines tested, 12, 45, 78, 36, and 2 were resistant to yellow rust, leaf rust, stem rust, septoria blotch, and common bunt, respectively. None of the lines were resistant to both yellow rust and common bunt. For yellow rust and septoria blotch, five lines were resistant to both.

Thirty-five lines were resistant to both leaf rust and stem rust but there was a low incidence of stem rust on bread wheat at the only site, KEN01, where information was available.--*O. Mamluk and J. van Leur.*

Table 36. Number[1] of bread wheat lines resistant[2] to yellow rust, leaf rust, stem rust, *Septoria tritici* blotch and common bunt in different locations (KLDN-84).

Disease	Location codes[3]	No.of lines
Yellow rust	SYR 01, SYR 53, LEB 01, KEN 01, POR 01, ECU 01	12
Leaf rust	SYR 51, POR 01, PAK 01	45
Stem rust	KEN 01	78
Septoria blotch	TUN 01, POR 01	36
Common bunt	SYR 01	2

1. Total lines tested = 171 excluding triticale lines and checks.
2. Selection criteria: rusts <5% severity; septoria blotch < 6/5 on the combined 0-9 scale; common bunt < 10% infected heads.
3. Syria = SYR 01, screening sites Tel Hadya; SYR 51, Lattakia; SYR 53, Al Ghab. Lebanon = LEB 01, Terbol; Kenya = KEN 01, N'Jora;
Portugal = POR 01, Elvas; Pakistan = PAK 01, Islamabad; Tunisia = TUN 01, Beja.

Component 3: Agronomy

Nitrogen Efficiency

The response of 50 bread wheat and 30 durum wheat genotypes to nitrogen was studied at Tel Hadya. Genotypes were selected from ICARDA and national program yield trials in the region. High grain-yielding ability, disease resistance, seed quality, and wide adaptability to environmental conditions were the criteria used to select the material.

Two split-plot experiments with four replications were carried out, one for durum and one for bread wheat. The cultivars were allocated to the sub-plots while the main plots were nitrogen rates. Fertilizers were drilled as urea at 0, 40, and 80 kg N/ha (main treatments) and as triple superphosphate at 60 kg P205/ha before sowing.

Fig. 10 summarizes the main results, which are compared with similar experiments performed in 1981/82 with ammonium nitrate and a different set of cultivars. The yield-uptake curve is the same for bread and durum wheat with an average slope (nitrogen utilization efficiency) of 71 kg grain (15% moisture)/kg N taken up for the first tonne of grain produced. In the literature this value is 70 kg grain (15% moisture)/kg N taken up for small grains. Presumably, the slope of the initial part of the curve is crop-specific and largely independent of environmental conditions. At higher uptakes, the curve deviates from linearity, reflecting a higher nitrogen concentration in the tissue. Finally, the curve levels off, indicating that nitrogen is no longer a constraint. The plateau level is determined by the growth factor in short supply and the yield potential of the cultivars in a particular environment.

When very large amounts of N are applied, the capacity of the crop to absorb and synthesize the element may become limiting, as could be the case for bread wheat in 1984/85, although no conclusions were made due to the large LSD and small differences in N rates.

The two sets of lines showing application-uptake relations (Fig. 10) represent 1981/82 and 1984/85. Nitrogen uptake without fertilizer (intercept) is a characteristic of the soil, governed by the quantity and quality of organic matter. It is influenced by environmental conditions, mainly soil temperature and moisture, and management practices such as crop rotation and previous fertilizer applications. In this case, the two sets of experiments were performed in the same soil. In 1981/82, a maize crop was grown during the summer prior to the winter crop to deplete the soil nitrogen, but in 1984/85, a barley-legume mixture was grown the previous season. Initial mineral soil N was 14 and 500 ppm for 1981/82 and 1984/85, respectively. The change in intercept of the application-uptake curve from 14 to 82 kg/ha between the two seasons indicated that the actual amount of nitrogen from the soil available to the crop during growth may vary widely.

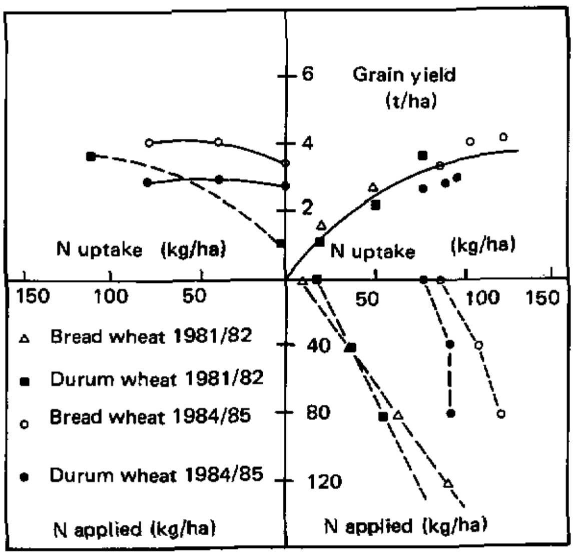


Fig. 10. Relationships between grain yield, nitrogen applied, and nitrogen uptake for both bread and durum wheat. Experiments carried out at Tel Hadya in 1981/82 and 1984/85. Curves fitted by hand.

The slope of the application-uptake curve (uptake efficiency or fertilizer recovery fraction) is partly influenced by the same factors which affect nitrogen uptake without fertilizer. Fertilizer recovery may also be influenced by the type of fertilizer used, and the timing and method of application.

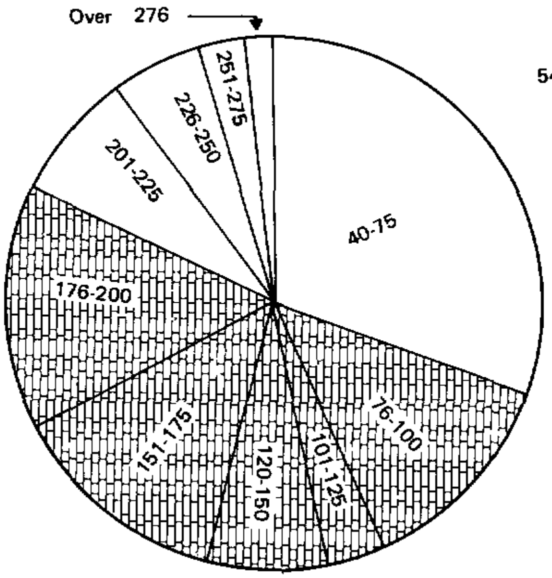
These results show that most of the variability in the application-yield relation (nitrogen response curves) for wheat (Fig. 10) was due to variations in the *application-uptake curve.*

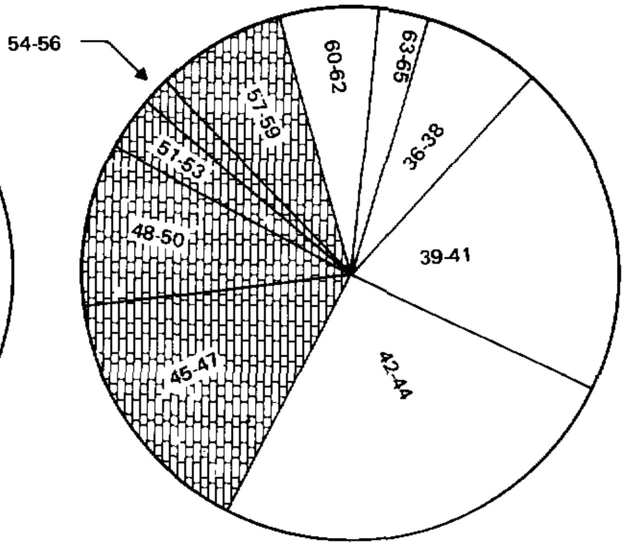
There were highly significant differences ($P < 0.01$) in grain and straw yields among cultivars, both for bread and durum wheat, but there was no genotype X N rate interaction. The harvest index and the nitrogen harvest index were not affected by N treatments. There were highly significant differences ($P < 0.01$) among N rates and cultivars in kernel weight, but the interaction was nonsignificant.

Therefore, to improve the average N uptake-yield relation, i.e., the average N utilization efficiency, it is necessary to increase the harvest index and grain yield for Mediterranean conditions and the associated constraints of this region. This would raise the plateau of the uptake-yield curve. Simulation models can be used to approximate an upper level and one can try to reach the simulated maximum by breeding for resistance to some of the environmental constraints such as drought, cold, and heat.--*E. Acevedo.*

Component 4 : Grain Quality

The overall quality of bread wheat lines planted in advanced yield trials verified the continuing trend of ICARDA's material towards medium hardness, medium protein strength, and increased kernel size. Figs 11-14 summarize the main parameters tested for early generation genotypes and give the distribution of the 1984/85 material. The shaded areas represent optima for selection of lines for flat bread and French bread (baguette) baking. These optima would be applicable to any wheat

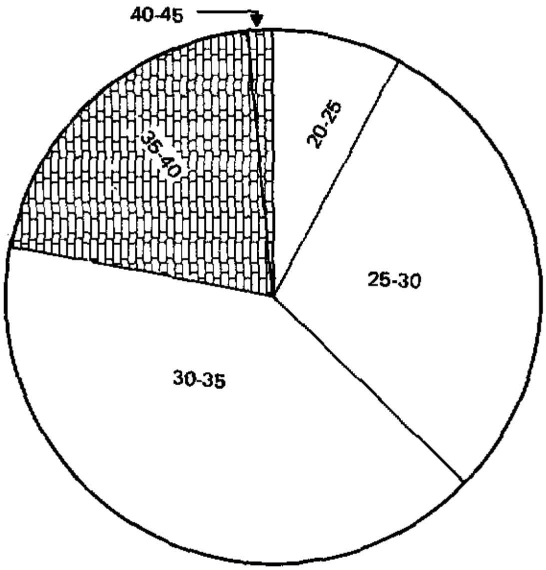


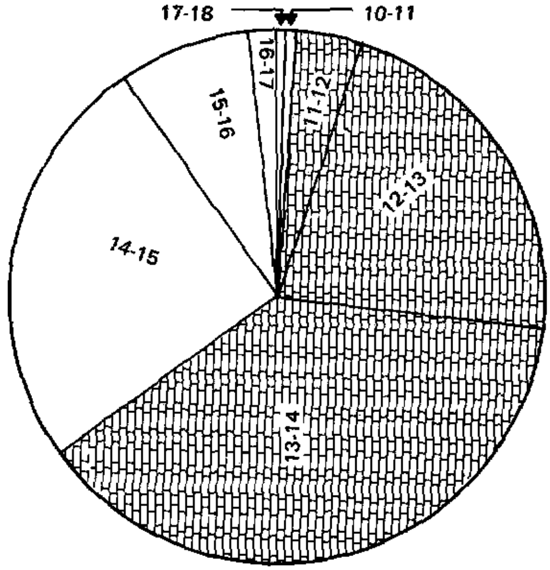


The shaded areas represent the optimal values for flat and French bread making.

Fig. 11. Wheat meal fermentation time (min) distribution for the 1985 bread wheat breeding materials.

Fig. 12. Hardness (Particle Size Index, PSI) distribution for the 1985 bread wheat breeding materials.





The shaded areas represent the optimal values for flat and French bread making.

Fig. 13. 1000-kernel weight (g) distribution for the 1985 bread wheat materials.

Fig. 14. Protein (%) distribution for the 1985 bread wheat materials.

breeding program aiming to produce wheat for baking breads of this type although due to seasonal variations in growing conditions the most promising material may not always comply with these optima.--*P. Williams and F.J. El Haramein.*

Component 5 : Entomology

Resistance to Wheat Stem Sawfly

Over 100 advanced bread wheat lines were assessed for resistance to wheat stem sawfly at Suran under natural infestation, and at Tel Hadya, under artificial infestation. Four lines were resistant and they were more resistant than the local check, Arabi Abiad.

Resistance to Cereal Aphids

The same bread wheat lines were screened at Tel Hadya for resistance to cereal aphids under natural infestation. There were three replications and the check was planted every ninth entry. The number of aphids was scored when the aphid population reached peak reproduction. All the lines were susceptible to cereal aphids, i.e., more than 500 aphids/plant.

As part of the collaborative project between Egypt, Sudan, ICARDA, and CIMMYT, 147 lines of the Bread Wheat Crossing Block 84/85 were screened for resistance to cereal aphids in plastic houses. There were two planting dates, each with three replicates. Seedlings were artificially infested with two aphid species: *Rhopalosiphum maidis* and *R. padi* for the first planting; *Schizaphis graminum* and *Sitobion avenae* for the second planting. Only one line, Mt-773 CI 19294/Fortuna, was less susceptible to cereal aphids under both plantings.--*C. Cardona and A. Rashwani.*

Project IV: Triticale Improvement

Component 1: Breeding

The breeding strategy focuses on the development of high-yielding, drought- and cold-tolerant lines with acceptable grain quality for dry areas in the region. Emphasis was placed on broadening the genetic base and improving selection procedures.

Germplasm Development and Evaluation

Genetic diversity is increased by developing secondary triticale and using high-yielding wheat varieties, developed at ICARDA, and good seed type rye lines in interspecific crosses (triticale x wheat and triticale x rye). Cold tolerant bread wheat parents were selected from the High-Elevation Cereals Project.

In 1984/85, 214 F_2 populations were sent to Quetta (Pakistan), Tabriz (Iran), Terbol (Lebanon), and Rabat (Morocco) for evaluation in different environments. These F_2's were also planted at Tel Hadya and Breda for single-head selection.

Observation nursery. Seventy high-yielding triticale lines were planted at Breda and Sarghaya for drought and cold tolerance evaluation, respectively. Those planted at Sarghaya were covered by snow in winter. In general, most of the lines were more tolerant to cold and drought than the wheat (Sham 1 and Sham 2) and barley (Rihane'S') checks. They also had early seedling vigor.

Sixty-two high-yielding lines were planted as an observation nursery at four locations outside Syria: Quetta (Pakistan), Tabriz (Iran), Rabat (Morocco), and Terbol (Lebanon). Although the results of this nursery are not available, the triticale lines looked better than the wheat and barley checks during the season.

Yield trial. The lines in the yield trials were classed into three groups; exotic elite, new genotypes developed through hybridization and selected at ICARDA, and new exotic introductions. The proportion of high-yielding lines in the ICARDA-developed germplasm was much higher than in exotic elite and new exotic introductions (Table 37). None of the lines in exotic elite and new exotic introductions significantly outyielded Doc-7 (the best triticale check), while six lines in the ICARDA-developed germplasm significantly outyielded Doc-7.

Preliminary Yield Trial. A total of 98 lines were tested in the PTYT, of which 57 were developed from ICARDA crosses. Five, four,

Table 37. Comparative performance of three groups of triticale lines under normal planting at Tel Hadya, 1984/85.

Germplasm	No. of entries: Total	No. of entries: High yielding	No. of entries: Outyielding Doc-7* sig.(P=5%)	Yield of best line as % of Doc-7
Exotic elite	61	17 (27%)	0	112
ICARDA selection	59	25 (42%)	4	113
ICARDA crosses	59	31 (53%)	2	133
New exotic introduction	14	2 (14%)	0	108

* Check, mean yield = 2529 kg/ha.

Table 38. Performance of triticale lines compared with checks in different yield trials under different environments, 1984/85.

Trials	Total no. of entries	No. of lines outyielding checks			
		Triticale (Doc-7)	Barley	Durum wheat	Bread wheat
ATYT - NP**	95	22 (2)*	0	32 (3)	43 (4)
EP	40	2	0	36 (18)	30 (15)
BR	40	11	31 (6)	24 (4)	29 (7)
PTYT	98	59 (5)	0	80 (9)	18 (4)

* Number of lines which significantly outyielded the checks ($P < 0.05$).
** NP = Tel Hadya normal planting; EP = Tel Hadya early planting; BR = Breda.

Table 39. Yield performance of the best lines in the Preliminary Triticale Yield Trials, 1984/85.

Line/cross	Yield (kg/ha)	Yield as % of checks			
		Triticale (Doc-7)	Barley	Durum wheat	Bread wheat
IRA/Bgl//Jlo (B 2659-17)	2844	114*	86	127*	126*
IRA/Bgl//Jlo (B 2659-10)	2986	134*	65	137*	104
Drira/FAS477//Drira/M2A	2975	133*	71	138*	108
Doc//IRA/Bgl	2952	117	82	127*	111
Doc/3/M2A/UP301//Bgl'S'	3591	122*	91	143*	109

* = Significantly higher yield at 5% level.

and nine lines significantly outyielded the triticale, bread, and durum wheat check, respectively (Table 38). Most of the higher yielding lines were from ICARDA crosses. The best triticale lines are compared with the wheat, barley, and triticale checks in Table 39.

Advanced Yield Trials. Of 95 lines tested under normal planting at Tel Hadya, 2, 3, and 4 significantly outyielded the triticale, durum, and bread wheat checks, respectively (Table 38). Under early planting, some lines had higher yields than the checks, although the differences were not statistically significant.

In both the advanced and preliminary yield trials at Tel Hadya, none of the triticale lines gave higher yields than the barley check. However, at Breda, triticale performed better than barley (Fig. 15). Of 40 lines, 6, 4, and 7 significantly outyielded the barley, durum, and bread wheat checks, respectively (Table 38).

The high-yielding lines for all three environments (Tel Hadya-normal planting, Tel Hadya-early planting, and Breda) are shown in Table 40. One of them, IRA/Bgl//Jlo, gave higher yields than the triticale check Doc-7 in each environment.

Table 40. Performance of some high- and stable-yielding triticale lines in three different environments: Tel Hadya normal planting (TH-NP), Tel Hadya early planting (TH-EP), and Breda.

	Yield (kg/ha)			Yield as % of Tcl check(Doc-7)		
Line/cross	**TH-NP**	**TH-EP**	**Breda**	**TH-NP**	**TH-EP**	**Breda**
Jlo 95	2633	2458	1119	106	74	121
Ram'S'-5	2633	3052	888	106	92	146
IRA/Bgl/4/IA/ Kla//Cal/3/Bgl	2658	2929	1400	101	80	146
IRA/Bgl//Jlo	2533	3430	966	103	94	101
IRA/Bgl//Jlo	2375	4077	1033	111	110	108

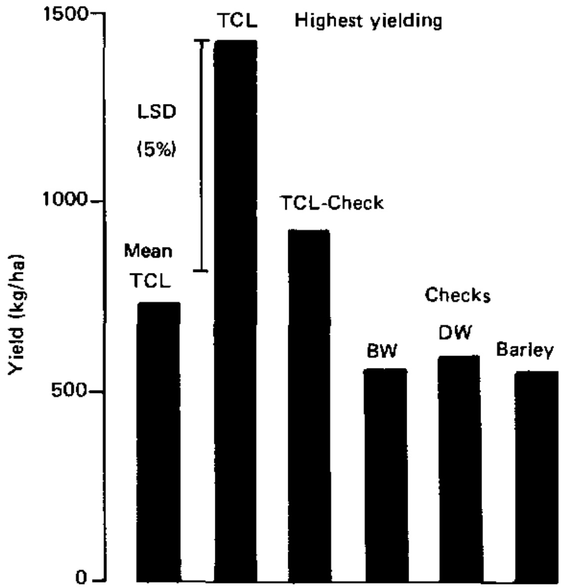


Fig. 15. Yield performance of triticale in comparison with the wheat and barley checks at Breda. (Tcl = triticale; BW = bread wheat; DW = durum wheat).

Total biological yield. In dry areas, where fodder is limited, straw is an important feed for livestock. Therefore, consideration of total biological yield is important in triticale improvement. In 1984/85, of the 40 lines tested at Breda, 2, 3, and 7 significantly outyielded the barley, durum, and bread wheat checks, respectively. A number of lines significantly outyielded the wheat and barley checks at Tel Hadya.

The total biological yield of triticale over barley was much higher in the dry environment (Breda) than in the favorable environment (Tel Hadya). As a whole, triticale lines had higher total biomass than the wheat and barley checks in all the environments and locations tested.

Performance of Triticale in the Middle East

In 1983/84, new promising triticale lines were included in the regional yield trials of wheat and barley to compare their performance with the two crops under different environments in the region. In the Regional Barley Yield Trial (RBYT), the triticale line Drira/M2A had the highest yield, producing 29% more than the improved barley check Rihane'S' (Table 41). In the Regional Rainfed Durum Wheat Yield Trial, the triticale line Doc-7 was the top yielder with a 24% higher yield than the improved durum check, Sahl. In the Regional Bread Wheat Yield Trial, one of the triticale lines tested had a higher yield than Mexipak.

Table 41. Yields of three triticale lines compared to either, the wheat or barley check in the Middle East (Syria, Labanon, Cyprus, and Jordan) in the 1983/84 regional barley, durum wheat, or bread wheat yield trials.

Line/cross		Trial (1983/84)	Average yield (kg/ha)	Rank
Drira/M2A	(Triticale)	RBYT	5160	1
Rihane	(Barley)	"	4011	12
Doc-7	(Triticale)	RDYT-Rf	6075	1
Sahl	(Durum wheat)	"	4862	19
Cin/Pi//Pato/3/Bgl	(Triticale)	RWYT	5282	5
Mexipak	(Bread wheat)	"	4471	24

Table 42. Improvement in grain characters of some new high-yielding triticale lines.

Line/cross	Yield (kg/ha)	Yield as % of check (Doc-7)	Test weight (g)	1000-kernel weight (g)
6 x 8 Tcl-D-G-176	2708	121	70	41
Doc//IRA/Bgl	2952	117	71	42
Doc//IRA/Bgl	2816	112	69	40
Doc/3/M2A/UP301/Bgl	3591	122	71	42
Doc/Bta'S'	3361	114	69	44
Doc-7 (check)	2478	100	67	37

Improvement in Grain Appearance

Grain plumpness, which is directly related to high test weight and high kernel weight, is the most sought after quality in triticale. Many of the high-yielding triticale lines have been rejected by producers and consumers due to shrivelled seed so special care has been taken in improving the grain appearance of high-yielding lines.

Test weight and kernel weight of new genotypes have been improved. The performance of some of the ICARDA-developed lines with high-yield potential and good grain characters is compared with the best triticale check (Doc-7) in Table 42. Beside higher yield they have high test weight and kernel weight. For example, one of the lines derived from the ICARDA cross "Doc/3/M2A/UP301/Bgl" had a 22% higher yield, 6% higher test weight, and 15% higher kernel weight than Doc-7.

Grain color has also been improved, through interspecific hybridization and effective selection in early segregating populations.--*M.A. Malik.*

Component 2 : Grain Quality

Early-generation triticale lines were subjected to the same tests as bread wheats except for the wheatmeal fermentation time

Table 43. Promising triticale lines with good combinations of kernel hardness, grain size, and protein content.

Pedigree	Source	PSI* (%)	TKW (g)	Protein (%)
Doc-7	ATYT 205	46.6	40.2	10.8
Doc//IRA/Bgl	PTYT 412	44.6	41.1	11.1
IA/M2A//Pi62/3/Bgl/4/Drira/FAS204	" 506	49.4	40.5	10.7
Doc/3/M2A/UP301//Bgl	" 516	47.9	41.0	10.3
Doc/3/M2A/UP301//Bgl'S'	" 517	45.7	40.5	10.5
Doc/Bta'S'	" 518	48.3	42.3	10.2
Mexipak (Bread wheat check)		39.3	27.2	12.1

* PSI = Particle size index (indication of hardness).

test, which is unreliable for triticale screening. The most promising lines, with good combinations of kernel hardness, grain size and appearance, and protein content are shown in Table 43.

Quality studies on advanced triticale material from 1983/84 revealed several lines with improved milling and baking quality. Provided triticale flours have adequate dough strength, they behave in a similar manner to bread wheat flours in two-layered flat bread baking. They are therefore suitable for commercial production for human food in areas where flat breads are a staple. This work confirmed earlier studies on the baking of single-layered *tannour-* and *saaj*-type flat breads from triticale.--*P. Williams and F.J. El Haramein.*

Component 3 : Entomology

Twenty-seven advanced triticale lines were screened for wheat stem sawfly and cereal aphid resistance in 1984/85. One of them, IRA/Bgl//Jlo, was resistant to wheat stem sawfly, but none were resistant to aphids.--*C. Cardona and A. Rashwani.*

Project V: High-Elevation Cereals Research

There are several production-limiting problems in the high altitude areas of West Asia and North Africa and cereal production per unit area is low. Research at ICARDA aims to remove or reduce these problems.

Agroclimatically, the high altitude areas can be classed into two broad categories:

1. Areas with a continental Mediterranean climate, e.g., parts of Afghanistan, Iran, Pakistan, Turkey, Iraq, Morocco, and Algeria.
2. Areas that have a tropical monsoon climate, including countries such as North Yemen, Ethiopia, and the Andean region in South America.

The agroclimatic features of some of the representative sites in the continental Mediterranean high altitude areas were examined. The long-term average temperature data indicate severe cold during winter in West Asian countries, followed by a short spring and a hot summer. Generally, temperatures start rising rapidly from April onwards and there is a moisture deficiency as the rains stop towards the end of April. In the Atlas mountains in Morocco and Algeria the climate is similar to that of the West Asian high-altitude areas, but less severe.

Crop phenology of wheat varieties from various winter wheat-growing regions was studied at Quetta. Data on the vegetative phase (sowing to heading) and the reproductive phase (heading to maturity), are shown in Fig. 16.

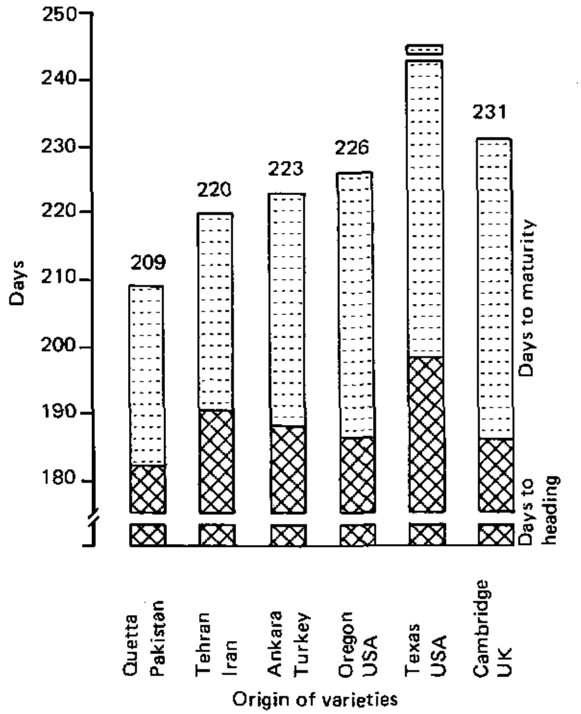


Fig. 16. Days to heading and maturity of a number of winter wheat varieties grown at Quetta, Pakistan.

There were small differences in number of days to heading but large differences in time to maturity. The varieties from Quetta, Ankara, and Iran took 27, 30, and 35 days, respectively, to mature after anthesis, whereas varieties from Oregon and Cambridge matured in 40 and 46 days, respectively. The variety Tx 1A 562-6 from Texas did not mature at all. Heading time for wheat in Quetta is around the last week of April when the rains stop, the temperature starts rising rapidly, and there are strong warm gusty winds. The wheat varieties tested respond to this changing climate by maturing faster. However, the high temperature and reduced moisture had an adverse effect on the 1000-kernel weights of the varieties from Oregon, Texas, and Cambridge (which had longer reproductive phases) compared to varieties from Quetta, Ankara, and Iran. Varieties successful in such environments should have a long vegetative phase to survive the severe winter and a short reproductive phase to avoid the high temperatures and moisture deficiency.

Component 1: Breeding

A breeding and germplasm development strategy was developed (Fig. 17) in which germplasm and parental lines are screened for various stresses, primarily at three sites: Quetta (Pakistan), Annoceur (Morocco), and Sarghaya (Syria). Supplementary information is gathered from other sites in Syria, such as

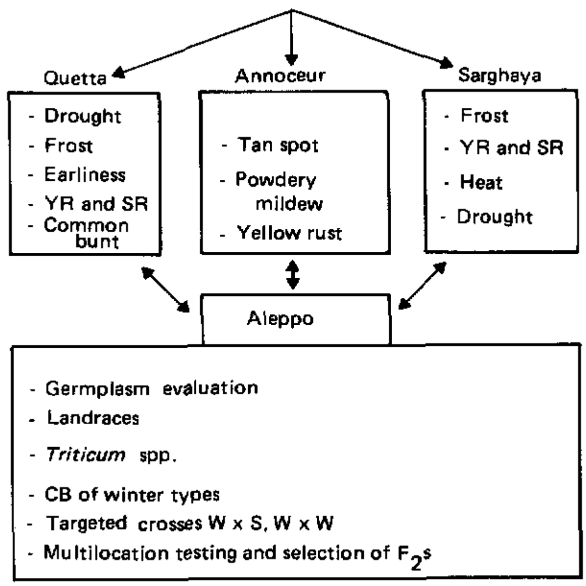


Fig. 17. Cereal breeding strategy for high-altitude areas.

Lattakia, (disease resistance), Breda (drought tolerance) and Hagla (salt tolerance).

A complete set of the material is planted every year at Tel Hadya to make targeted crosses of winter x winter or winter x spring types. Local landraces are used as one of the parents in the majority of crosses. The targeted crosses for specific adaptability are then supplied to the countries of West Asia and North Africa for testing and selection.

Evaluation of Introduced Germplasm

In the past 5 years more than 10000 germplasm entries have been evaluated for use in the crossing program. To broaden the genetic base, 1570 lines/varieties from different countries were evaluated at Sarghaya and Tel Hadya in Syria; 127 lines with good agronomic performance, earliness, frost tolerance and disease resistance were selected.

There is close contact between ICARDA and other winter wheat programs around the world. Five different types of winter wheat nurseries were evaluated at Tel Hadya. Of 664 lines/varieties screened, 109 were selected for further evaluation and utilization. Three lines of the International Winter Wheat Performance Nursery (IWWPN) were selected with large yield, early maturity, plant height, and tolerance to frost. They have been included in the observation nursery for 1985/86 to test their performance in high-altitude sites.

Germplasm Development

The crossing blocks of durum and bread wheat contained 154 and 72 entries with diverse genetic make-up, respectively. Lines from those crossing blocks and the germplasm screening plots were used to combine desirable characteristics into targeted crosses. A total of 850 and 390 crosses were made in bread and durum wheat, respectively. One hundred crosses in each of the wheat species were either top, back, or double crossed to further improve the genetic makeup of the F_1 lines from last year.

Segregating populations. The total number of segregating populations in F_2, F_3, F_4, F_5, and F_6 was 1112, 867, 1208, 1845, and 541, respectively. From these, 4192 selections were made. For selections from F_2 populations, information from other high altitude sites is used. To combine the desirable characteristics in future germplasm, 1730 F_1 crosses (bread wheat, 850; durum wheat, 390; and inter-specific, 490) were made.

The number of selected F_2 populations at various sites in the region is given in Table 44. The selection frequency for bread wheat was high, whereas the selection frequency in durum wheat was still low at the high-altitude sites.

Table 44. Number of F_2 populations selected at four different locations in ICARDA region, 1984/85.

Populations	Total entries	Location: Tel Hadya	Annoceur	Ankara	Quetta
F_2 durum wheat	150	153*	20	17	17
F_2 bread wheat	200	745**	118		98

*, ** out of 252 and 860 entries, respectively.

Table 45. No. of lines selected from the bread and durum wheat observation nurseries for high-altitude areas, 1984/85.

		Syria		Lebanon	Morocco	Turkey	Commonly selected at			
Nursery	No. of lines	Tel Hadya	Sarghaya (S)	Terbol	Annoceur (A)	Ankara (T)	SA	AT	ST	STA
BWON-HA*	150	36	27	50	22	21	3	2	7	0
DWON-HA	112	32	17	39	13	25	1	5	4	2

* Total lines at Tel Hadya were 285 from which 60 were selected.

Observation nurseries. One hundred and fifty and 112 lines of bread and durum wheat, respectively, were tested at high-altitude sites and the number of selected lines at each site is given in Table 45. The average selection frequency in bread and durum wheat at the three high-altitude sites (Annoceur, Ankara, and Sarghaya) was 16%. However, 25% of the selected lines at Sarghaya also performed well at Ankara in Turkey. Very low frequency of commonly selected lines at various sites limelights the importance and need of breeding for specific adaptability in these areas. The yields of selected lines at Tel Hadya were higher than the check varieties, Bezostaya 1 (5.3 t/ha) and Mexipak 65 (2.7 t). The results from Tehran were not available.

For five seasons germplasm has been screened at Sarghaya against cold, drought, disease, and agronomic performance. During 1984/85, 1569 entries/varieties of durum wheat, bread wheat, barley, and triticale in various nurseries were planted in early October to identify suitable parental lines for future use. Two hundred and eighty lines/varieties with good agronomic score and cold tolerance were selected.

The overall selection frequency of ICARDA-supplied winter wheat lines at Annoceur (Morocco) increased from 2% in 1981 to 25% in 1985. At Quetta (Pakistan), 27% of the material was selected in 1985 compared to 8% in 1981 and at Sarghaya the frequency went up from 10 to 30% in this period. The overall genetic base at Tel Hadya has also been considerably improved. For the high altitude bread and durum wheat observation nurseries at Ankara last year, 15% of the lines were selected against tan spot and yellow rust and for agronomic score, compared to 2% in 1980.

In 1983/84 the selection frequency of bread wheat material was higher than durum wheat at various high-altitude sites (Table 46). The poor performance of most of the durum wheats in these environments was primarily due to their low disease and cold tolerance and narrow adaptation. Large amounts of durum wheat germplasm from various countries were screened for these traits, but only a few lines could be selected. This highlights the need to broaden the genetic base for these traits in cultivated durum wheat.

Evaluation and Utilization of *Triticum dicoccoides*

The results on screening and utilization of *T. dicoccoides* are summarized in Table 47.

Most of the lines were tolerant to frost, whereas most the durum wheats were susceptible. A large number of lines/varieties of *T. aestivum* were resistant to frost/cold. *T. dicoccoides* also performed better under moisture stress (230 mm) than durum and bread wheat. Of 15 *dicoccoides* lines, four were moderately to completely resistant to stripe rust. The resistant gene(s) for stripe rust in *dicoccoides* could be valuable as they might be different from

Table 46. Number of lines selected from the winter cereal germplasm at different sites, 1983/84.

Nursery	No.of Entries	Location: Pakistan Quetta	Morocco Annoceur	Syria Sarghaya	Syria Tel Hadya
HA - DON	400	42	35	45	127
HA - BWON	150	38	13	35	85
IWBWYT*	150	31	13	30	56
IWDWYT**	178	11	6	23	99
F_2'S' HA-DW	150	41	22	29	74
F_2'S' HA-BW	150	62	51	60	81

* Initial Winter Bread Wheat Yield Trial.

** Initial Winter Durum Wheat Yield Trial.

Table 47. Evaluation of *T. diccocoides* lines collected from Syria.

ICARDA accession no.	Protein content %	Plant height (cm)	Days to heading after germination	Yellow rust	Spike length (cm)	Growth habit	Frost tolerance*	Leaf character	1000-KW (g)
SY - 20010	24.06	115	179	R	14.0	SP	1	NL	20.10
SY - 20013	20.79	120	169	50S	11.3	P	1	BL	25.20
SY - 20017	20.15	100	166	R	10.0	P	1	BL	18.75
SY - 20021	20.97	115	170	5R	12.0	P	1	NL	26.00
SY - 20085	21.52	120	171	20MR	13.6	P	1	NL	22.75
SY - 20089	22.07	100	181	R	11.0	P	1	NL	26.15
SY - 20090	24.98	105	178	20MR	11.6	P	1	NL	22.10
SY - 20096	23.80	95	171	30MS	9.3	SP	1	NL	18.20
SY - 20101	20.52	105	171	70S	12.0	SP	1	NL	20.50
SY - 20110	23.72	95	175	65S	11.3	SP	1	NL	22.95
SY - 20121	20.43	80	159	60S	8.0	SP	1	NL	16.00
SY - 20122	20.43	90	164	85S	10.0	SP	1	NL	15.10
SY - 20124	22.62	95	176	80S	9.3	SP	1	NL	16.10
SY - 20184	23.57	80	175	75S	10.3	P	2	NL	18.50
IQ - 55132	21.97	90	159	80S	7.6	SP	2	BL	10.50

* Frost tolerance : on a scale 1 (< 10% damage) to 5 (> 90% damage). Check variety Bezostaya scored 2.

P and SP : Prostrate and semi prostrate, respectively.

BL and NL : Broad leaves and narrow leaves, respectively.

those in durum and bread wheats. On average, *T. dicoccoides* had 25 tillers/plant, compared to 3.5 and 5 in durum and bread wheat, respectively. *T. dicoccoides* also had a very high protein content (20.2-25%).

A study on 75 F_1 derivatives of *T. durum* x *T. dicoccoides* indicates that the gene(s) for these characteristics can be transferred into *T. durum* (Rachis 2: 14-15, 1983). All the interspecific F_1's were cold tolerant, resistant to stripe rust, and had very good tillering (22.5 tillers/plant) and protein content (15.0-20.4%). Therefore, research on the utilization of *T. dicoccoides* to improve *T. durum* and *T. aestivum* was expanded. *T. dicoccoides* was crossed with durum and bread wheat as follows:

T. durum/T. dicoccoides//T. durum
T. durum/T. dicoccoides//T. aestivum
T. aestivum/T. dicoccoides//T. aestivum.

In 1984/85, 450 F_1 crosses and 100 backcrosses were made. The number of progenies from earlier crosses were F_2 (112), F_3 (45), F_4 (390), and F_5 (240).

Most of the F_4 progenies had desirable plant type with frost and disease tolerance and *T. dicoccoides* considerably improved the protein content of the progenies without sacrificing kernel weight of *T. durum* (Table 48).

Since *T. dicoccoides* contains desirable gene(s) for several agronomic characteristics, more dicoccoides will be screened from other sources.

Yield trials. Preliminary Yield Trials and Advanced Yield Trials of materials for high altitude environments were carried out at Tel Hadya and at the high altitude out-reach sites in the region. Each experiment contained 24 entries in a randomized complete block design with three replications.

Preliminary yield trials. Two experiments on durum wheat were carried out. The overall

Table 48. Protein percentage and 1000-kernel weight of F_4 seeds from interspecific crosses.

Parents and crosses		Protein (%)	1000-KW (g)
BD 272		15.2	38.0
BD 1658		15.6	37.5
T. dico. SY 20101		20.5	20.0
T. dico. SY 20189		22.1	26.0
BD 272/T.dico. SY 20101	= ICS 234	21.6	37.6
"	= ICS 253	18.1	37.6
"	= ICS 236	20.7	37.6
"	= ICS 237	18.3	41.4
BD 1658/T.dico. SY 20189	= ICS 243	20.3	36.3
"	= ICS 244	17.5	47.2

average yield of the 48 entries was 2778 kg/ha, compared to 2517 kg/ha for the check, Sham 1. Eleven entries, with an average yield of 3404 kg/ha, significantly outyielded the check (Fig. 18).

One hundred and twenty lines/varieties of cold tolerant bread wheat were tested with Bezostaya 1 (winter type) and Mexipak 65 (Spring type) as checks. The average yield of these lines was 3095 kg/ha, compared to 3671 kg/ha and 3209 kg/ha for Bezostaya 1 and Mexipak 65, respectively. Only three entries, with an average yield of 4248 kg/ha (Fig. 18) significantly out-yielded the best check.

The yield and other agronomic characteristics of these lines are presented in Table 49. They were selected at Quetta and Annoceur last year and at Sarghaya and Ankara on the basis of agronomic score and disease tolerance. All three lines have intermediate growth habit, are resistant to stripe rust, and contain over 12% protein.

Advanced yield trials. In durum wheat, six lines significantly outyielded the check, Sham 1. The top-yielding five lines were all resistant to yellow rust and had higher 1000-kernel weights than the check (Table 50). Only two entries, 9 and 11, had intermediate growth habit while the other three were spring type with a high level of cold tolerance. Entries 16 (61-130/414//44/3/AA'S') and 17 (CP/GVZ 156//Kohak 2916/D/Sincape 9) also outyielded the check and were resistant to frost damage. Entry 9 was selected at three high-altitude sites, Ankara, Annoceur, and Sarghaya while entry 13 performed well in Turkey.

In the bread wheat experiment, two varieties, Katya and Trakia, have significantly higher yields than the best winter wheat check (Table 51). Yield data from other outreach sites in the region are not available, but, based on yields and observations in various nurseries at various sites, variety Katya seemed to perform well in various environments.

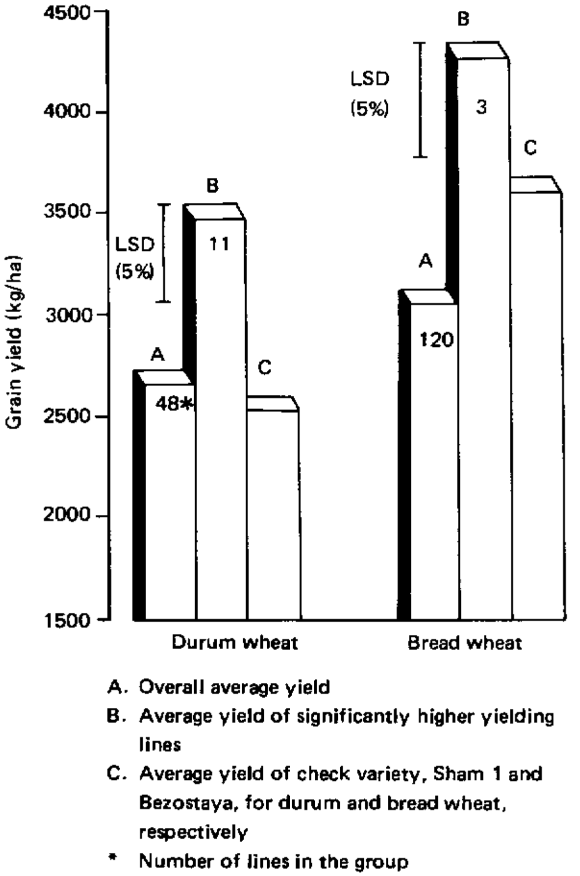


Fig. 18. Performance of new durum and bread wheat lines in the High-Altitude Preliminary Yield Trials at Tel Hadya, 1984/85.

The high-altitude areas of the region have very diverse agroclimatic conditions, so more emphasis will be given to breeding for specific adaptability. The crossing program and breeding strategy will be further diversified in close collaboration with national scientists.

More emphasis will be given to developing frost/cold tolerance and disease resistance using other *triticum* species, especially *T. dicoccoides*. The research on barley for high-altitude areas will be further expanded.--*M. Tahir.*

Table 49. Characteristics of the most promising bread wheat lines in the PWYT - HA at Tel Hadya, 1984/85.

Entry no.	Yield (kg/ha)	Days to heading	Days to maturity	Plant height (cm)	Growth habit*	Yellow rust	Protein (%)	1000-KW (g)
21	4388	146	179	90	I	R	12.1	26.8
3	4222	147	177	90	I	R	12.8	33.3
22	4133	147	176	80	I	R	13.3	28.2
12	3333	147	181	85	W	MR	14.0	39.1
24	3277	145	175	75	S	S	11.6	24.2
LSD (5%)	572							

Ent. 3 : T.aest. (Rom)//Tob'S'/8156/Tx 69 A460-1/Emu'S' ICW 81-1341-1AP-3AP-0P.
Ent. 21 : Chambord/5133//Mt/3/KKC/4/Lfn//ND/2* P101/5/Rom//CC/Inia ICW 81-1610-1AP-2AP-0AP
Ent. 22 : ICW 81-1610-1AP-3AP-0AP.
Ent. 12 : Bezostaya.
Ent. 24 is Mexipak.
*W = Winter type; S = Spring type; I = Intermediate type.

Table 50. Performance of the highest yielding lines in the Advanced Durum Wheat Yield Trial (High-altitude) at Tel Hadya, 1984/85.

Entry no.	Yield (kg/ha)	Days to mature	Days to head.	Plant height at maturity (cm)	Growth habit*	Yellow rust	1000-KW (g)	Protein (%)
10	4189	146	177	80	S**	R**	51.6	13.3
11	3566	148	181	110	I	R	52.7	12.9
13	3522	148	177	85	S	R	47.5	13.3
9	3400	152	181	70	I	R	46.1	14.0
20	3233	148	177	80	S	R	51.4	12.0
Check	2500	153	186	80	S	R	40.8	14.6
LSD (5%)	758	1.7		10.1				

No.10 - Castel Projiano/Boy'S'.
No.11 - Bit'S'/Gdo VZ 394.
No.13 - AA'S'/3*Cpe/GZ//3*Bye/TC/4/Fg'S'/GVZ 466.
No. 9 - Chap/21563//Inrat 69/3/S 15/Cr'S'/4/Int. 493.
No.20 - Mexi'S'/21563//AA'S'/3/BD 1708/BD 1543.
Check - Sham 1.
* S : Spring type, I = Intermediate type.
** R : Resistant.

Table 51. Performance of the highest yielding lines in the Advanced Winter Bread Wheat Yield Trial (High-Altitude) at Tel Hadya, 1984/85.

Variety	Yield (kg/ha)	Days to heading	Plant height (cm)	1000-KW (g)	Protein (%)	Yellow rust
Katya A-1	4778	141	90	30	12.6	R*
Trakia	4778	143	85	37	12.3	R
Bezostaya 1 (Check)	3789	145	95	39	14.0	MR
LSD (5%)	918.5	N.S.	10.7			

*R = Resistant, and MR = Moderately resistant.

Component 2 : Pathology

Three major diseases, common bunt (*Tilletia foetida* and *T. caries*), yellow rust (*Puccinia striiformis*), and tan spot (*Helminthosporium tritici-repentis*), cause economic losses to wheat crop in the high-altitude areas of West Asia and North Africa. Artificially created epiphytotics are used to screen for common bunt and yellow rust at ICARDA. For tan spot, natural infestation is required; material is therefore screened at Annoceur (Morocco), where tan spot occurs every year to varying degrees. A two-pronged approach is followed to develop new wheat germplasm for the high-altitude areas with disease resistance:

a. Introduced germplasm is screened to identify new resistance sources for use as parental stock in the development of new germplasm.
b. Advanced lines/varieties and early segregating populations are screened.

This work will be expanded in collaboration with the national programs.

Screening of Introduced Wheat Germplasm

A total of 1304 lines of wheat germplasm primarily from Turkey were supplied by Dr. R.J. Metzger, Oregon State University, for screening against common bunt during 1983. From this material, 707 lines resistant or moderately resistant to common bunt (< 10% infected heads) were selected for further screening during 1984/85. Eighteen lines did not germinate and the remaining 689 were grouped into three catagories based on growth habit i.e., winter, facultative, and spring types. There were 118, 249, and 322 lines in each category and the mean number of days to heading was 137, 131, and 127, respectively.

Ninety-three (80.8%) lines in the winter type, 110 (45.5%) in the facultative type, and 79 (27.7%) in the spring type were resistant or moderately resistant to yellow rust (0-15% severity) and common bunt (0-10% infected heads). The higher percentages of resistant and moderately resistant lines in the winter and facultative groups compared to the spring group could be due to natural selection of the winter and facultative types in the Turkish Anatolian Plateau where common bunt is the most serious disease. Alternatively the entries of these two categories might have escaped the disease due to their lateness at Tel Hadya. Therefore, all 285 lines resistant or moderately resistant to both diseases will be tested again in 1985/86 to confirm their resistance to common bunt before release to the national programs.

Screening of Advanced and Parent Lines for Common Bunt Resistance

In Common Bunt Nursery I (CBNI-85) the material included from high-altitude project was:

Durum Wheat Crossing Block - HA (DCH): 69 entries

Durum Wheat Observation Nursery - HA (DOH): 104 entries

Bread Wheat Observation Nursery - HA (WOH): 149 entries

Bread Wheat Crossing Block - HA (WCH): 149 entries

In durum wheat, DOH had the highest percentage (62.5%) of resistance lines (< 5% infested heads), followed by DCH with 49.3%. On average, 55.9% of durum wheat lines from the high-altitude project were resistant compared to 17.1% of other durum material.

The frequency (%) of resistant lines in WOH and WCH was 56.1 and 49.7, respectively, the highest among all the bread wheat material. A very high proportion of tested lines in both durum and bread wheat were completely resistant. Resistant lines (< 5% infected heads) will be re-tested for confirmation.

Table 52. Quality characteristics of advanced lines for high-elevation areas.

Pedigree	Source	PSI (%)	WMFT (min)	TKW (g)	Protein (%)
Bread wheat					
RL 6010/Inia 664	CBW110	42.8	188	36.1	13.2
CMH 78.616.6Y-2B-3Y-1B-0Y					
Lovrin 6/Samson	" 132	39.6	159	40.2	14.0
MV 22-77	" 98	38.8	159	35.7	13.1
Bez//Cno'S'/Gll	" 42	42.0	175	33.8	14.5
SWM 754493*-04 P-5H-1P-0P					
F_3 71/NKT'S'	WON 96	48.9	216	41.3	15.3
SWM 11287-4AP-2AP-1AP-0AP					
4-22/SKP 35//C 126-15/C74-6 /5/Chambord/5133//Mt/3/KA /4/Lfn//MK/2*P 101	" 70	44.1	226	35.0	16.0
ICW 81-1630-1AP-9AP-0AP					

Pedigree	Source	SDS (ml)	TKW (g)	Protein (%)
Durum wheat				
T.SP.V.NP.CV-Oued Zenati 368	CBD 5	38	41.4	15.7
T.SP.V.NP.CV. Gdo 621	" 19	35	50.9	14.3
Fg'S'/Rabi'S'	" 23	36	44.7	13.2
L.74.113-4L-1AP-1AP-1AP-0SH-0AP				
Argamas	" 77	35	41.6	14.2
CD 22356-A-9M-2Y-2M-0Y				

PSI = Particle size index (hardness), WMFT = wheat meal fermentation time (protein strength), TKW = 1000-kernel weight, SDS = Sodium dodecyl sulfate sedimentation volume (strength in durum wheats).

Table 53. Durum lines from spring x wheat crosses with high protein content and kernel weight.

Cross and pedigree	Source	SDS (ml)	TKW (g)	Protein (%)
Alforge/Sert Bagday	IC-F4.durum	40	61.6	18.2
ICD 81.1798-7AP-9AP-0AP	293			
Alf/Sert Buday	289	43	60.8	17.7
ICD 81.1798-7AP-5AP-0AP				
Alf/Sert Bugda	291	34	57.9	17.3
ICD 81.1796-7AP-7AP-0AP				
Alf/Sert Bugda	288	34	63.5	15.7
ICD 81.1798-7AP-4AP-0AP				

Screening Segregating Populations for Yellow Rust Resistance

All the segregating populations were artificially inoculated with yellow rust. Highly susceptible populations were discarded and selection was carried out only in resistant populations.--*O. Mamluk and J. van Leur.*

Component 3: Grain Quality

Over 2500 tests were performed on high-elevation breeding material. Promising genotypes from the advanced material are shown in Table 52.

The lines from durum wheat crosses of spring x winter types of local landraces have high kernel weights and protein percentages (Table 53). They were also characterized by high SDS sedimentation volume, which is associated with high protein strength.

The particle size index (PSI) method was used to identify genotypes with durum wheat-type hardness in crosses between bread and durum wheats. This selection method for F_3 and F_4 material indicated that the distribution shifted towards the bread wheat-type hardness in F_4. Durum types in this early generation material were tested for protein strength using the SDS sedimentation test. SDS volumes were 11-57 ml, with a mean of 33 ml for 217 selections. Therefore, crossing bread wheat lines with durum wheats enables the selection of genotypes which retain their durum wheat hardness and vitreousness, but have significantly improved gluten strength.--*P. Williams, F.J. El Haramein and A. Sayegh.*

Project VI : International Cooperation

The Cereal Improvement Program aims to provide national cereal scientists with the technology and information to improve cereal production in their own countries, and enhance their skills and ability to use them effectively. Active and close cooperation with national research organizations is important so ICARDA and national scientists jointly identify problems and priorities and draw up a shared agenda for research and training.

The needs of the region are great and the program's budget limited, so organizations around the world are encouraged to supplement ICARDA's activities. This global network of cereal researchers and the region's scientists and policy-makers influence the program's priorities and strategies. During 1984/85 the program strengthened cooperation with national programs and developed new links with institutions within the region as well as centers of excellence in the developed world.

Collaborative Projects with National Programs

The 1984/85 results from the collaborative projects for each of the countries in the region were individually reviewed and workplans for 1985/86 were jointly developed. Highlights of these projects are reported here.

Cyprus

The collaborative project to identify early-maturing, drought-tolerant barley and durum wheat lines continued with the Agricultural Research Institute, Nicosia, Cyprus. The material was tested at three locations in Cyprus by Cypriot scientists and the lines selected were brought back to the program. These sites are used to develop germplasm for low-rainfall and mild-winter areas.--*A. Hadjichristodoulou and C. Josephides, Agric. Res. Inst., Nicosia.*

Egypt

Aphid is becoming a major pest of small grain in Egypt, Sudan, and other countries. Yield losses due to aphids are estimated to be about 20% in Egypt, and many farmers must spray their field once at least, especially in upper and middle Egypt. The most common aphid species in Egypt are *Rhopalosiphum padi*, *Schizaphis graminum*, *R. maidis*, and *Sitobion avenae*.

A collaborative project between Egypt, ICARDA, and CIMMYT was initiated in 1984/85 to screen for aphid resistance in winter cereals. This season, 140, 150, and 166 lines of bread wheat, durum wheat, and barley from the Regional Crossing Block 84/85 were screened in glasshouses and in the field (Shandwell Station).

In bread wheat, three lines were moderately resistant to aphids in the glasshouse but not in the field. Three entries (7, 45, and 79) were less susceptible under both conditions.

In durum wheat, one variety (Creso, entry no. 25) was resistant in the field and moderately resistant in the glasshouse. Fifteen other entries were less susceptible in the glasshouse and in the field.

Eight lines of barley were moderately resistant in the glasshouse, but none were resistant in the field. Four lines (142, 141. 143, 55) were less susceptible in the field and in the glasshouse.

A number of barley lines was screened in the coastal area of Egypt where short-season, drought-tolerant barley is predominantly grown. This cooperation is being further strengthened to develop heat- and aphid-tolerant, wheat and barley lines.--*National Program scientists and ICARDA/CIMMYT scientists.*

Ethiopia

Barley is one of Ethiopia's major food crops, grown on more than one million hectares in the highlands under stress conditions. Yields are 400-2000 kg/ha. Under the agreement signed between ICARDA and Ethiopia in 1984, ICARDA assisted the Ethiopian program by providing consultancies, germplasm, literature, and training.

Iran

During 1984/85 a small project was initiated for cooperation in cereal improvement. The program exchanged germplasm, scientists, scientific information, and literature with the Iranian national program. During 1984/85 four Iranians were trained in the Cereal Program's Residential Course, five Iranian scientists received individual training, and about 30 Iranian researchers visited the program.

Jordan

The Winter Cereal Project was extended in 1984/85 and involved the Ministry of Agriculture, University of Jordan, and ICARDA, with funds from USAID administered by ICARDA. The main aim of the project is to demonstrate and encourage the use of improved cultivars and beneficial cultural practices recommended by the Cooperative Cereal Improvement Project.

In 1984/85, two types of field experiments were carried out; variety verification trials and traditional vs. improved farming practices demonstrations. They were planted in large plots in five farmers' fields, two in zone A (> 350 mm average annual rainfall), two in zone B (250-350 mm average annual rainfall), and one in zone C (< 250 mm average annual rainfall). In the variety trials, three or four durum wheat lines/varieties and two barley genotypes were tested in zones A and B. In the farming practices experiments, the effects of seed drilling, and fertilizer and herbicide application were demonstrated, using Haurani or Deir Alla 2 in zones A and B, and Deir Alla 106 in zone C.

A report on the Jordan Cooperative Improvement Project 1978/79-1982/83 is available from the program.

The program also collaborated with the University of Yarmouk, Jordan, in evaluating durum wheat landraces from Jordan. The landraces, collected from different agroclimatic zones in Jordan, were evaluated at two locations in Syria, at the University of Yarmouk, Jordan, and at the University of Saskatchewan, Canada. Researchers at the University of Saskatchewan are studying the isozyme patterns in the evaluation of stress tolerance, particularly drought tolerance.--*M. Duwayri, N. Katkhuda, A.M. Tell, and A. Jaradat (Jordan); J.P. Srivastava and M. Nachit (ICARDA); S. Jana (Univ. of Saskatchewan, Canada).*

Lebanon

The program continued to use Terbol Station extensively as a high-rainfall site for testing germplasm performance. Yield trials, observation nurseries, segregating populations, crossing blocks, and disease screening nurseries for barley, durum wheat, and bread wheat were planted. Results from the station complemented those from Tel Hadya. The program provided assistance and support to ARI, Tel Amara, in varietal improvement and seed production.

In 1985, the Terbol Research Station was also used as a summer nursery site. Results were encouraging and further improvement is envisaged.

The most promising wheat and barley lines were multiplied and provided to Lebanese scientists and to farmers in the Bekaa Valley. In spite of difficulties in Lebanon, there is close cooperation between ICARDA, the Lebanese national program, the American University of Beirut, and the University of St. Joseph, Zahle.--*N. Rubeiz and A. Aziz.*

Morocco

During 1984/85 special efforts were made to assist the Moroccan national program to improve barley and wheat research. Besides the regular international nurseries of barley, wheat, and triticale, targeted germplasm for high elevation or with resistance to septoria leaf blotch, tan spot, and Hessian fly, were provided to the Cereal Program of INRA. One in-country course and one travelling workshop were organized in Morocco, and several program staff participated with Moroccan scientists in selection and evaluation. Several scientists from the national program visited ICARDA.--*National Program scientists and ICARDA/CIMMYT scientists.*

Pakistan

Significant achievements in collaborative research between ICARDA, PARC, and the provincial agriculture departments during the past 4 years include:

a) development of a package of production practices for the high-altitude areas of Baluchistan,
b) identification of a number of disease resistant, drought and cold tolerant, and high-yielding lines/varieties of bread and durum wheat, and
c) strengthening of research capabilities by supplying essential equipment and technical support to the wheat research section at ARI-Sarvale.

The package of production practices is being demonstrated to farmers under the FAO/ICARDA/PARC project "On-farm demonstration trials in wheat." Detailed results of the project are available from the program. A FAO/ICARDA/PARC review team recommended the continuation of this work and its further expansion. FAO and PARC will contribute extra funds and ICARDA will continue to provide technical assistance.

The collaboration, which was initiated in 1980/81 has resulted in a joint collaborative project between USAID/ICARDA/PARC to strengthen the research capabilities of the Arid Zone Research Institute, Quetta, for the semiarid environments of Pakistan.--*S. Mohammed (Quetta), and M. Tahir.*

Sudan

The collaborative project between Sudan, ICARDA, and CIMMYT on screening for aphid resistance in winter cereals was initiated in 1984/85. During the season, 150, 191, and 166 lines of durum wheat, bread wheat, and barley from ICARDA, CIMMYT, Egypt, and Sudan were tested against the two prevalent aphid species, *Rhopalosiphum maidis* and *Schizaphis graminum*, at three locations, Gezira Research Station, Turabi, and Hudeiba.

The season was characterized by a short, warm winter and this, coupled with late planting, adversely affected plant development and probably also the natural buildup of aphids. The two aphid species were prevalent in the three test sites. The *R. maidis* was the first to infest plants but disappeared by mid-January, to be followed by *S. graminum*, which persisted to the first week of March when the plants got dry. Infestation was highest in the Gezira area, followed by Turabi, but it was exceptionally low in the Hudeiba area. At Gezira and Turabi, all the lines were more than 30% infested, which is the economic level for chemical spraying. Therefore, the lines were all highly susceptible to aphid attack. A number of lines were not infested at Hudeiba, but this does not indicate resistance because the aphid population was exceptionally low at that site.

In the 1984/85 season, the on-farm wheat yield trial was initiated with the participation and financial support of ICARDA and CIMMYT. There were two objectives (1) to enable breeders to test their elite materials outside the experimental stations, and (2) to demonstrate to farmers the potential of new varieties and improved cultural practices. Since this was the first year of the project, only six sites were used. There were 10 entries in the trial: the first and second entries were checks while the rest were promising lines from the two breeding programs at Wad Medani and New Halfa. One entry, Wadi El Nil, was among the top yielders at each site and had the highest mean yield across sites.

To improve wheat production ICARDA and Sudan have undertaken a new project, financed by OPEC, modeled on ICARDA's Nile Valley Project for faba beans in Egypt and Sudan. ICARDA and Sudanese scientists and extension workers have developed a recommended package of technologies to be verified and demonstrated to farmers on a large scale.--*National Program scientists and ICARDA/CIMMYT scientists.*

Syria

The cooperative cereals (wheat and barley) on-farm trials, jointly conducted by the Syrian Ministry of Agriculture and Agrarian Reform (through ARC-Douma) and ICARDA's Cereal Improvement Program were carried out according to the workplan jointly developed at the beginning of the season. These trials test a number of cereal lines proved to be promising in the research stations, in large plots in farmers' fields. The varieties tested came from the Syrian national program, ACSAD, and ICARDA. A report on the findings is available from the program.

In 1984/85, 31 wheat and barley variety verification trials were planted. Trial sites were selected to represent the major agricultural zones where cereal crops are grown. Bread and durum wheat were tested under irrigation, in zone A (> 350 mm annual rainfall) and in zone B (250-350 mm annual rainfall). Barley was tested in zones B and C (< 250 mm annual rainfall).

For durum wheat, Sebou had the highest mean yield under irrigation and in the last three seasons, it yielded 6-46 % more than the local variety, Gezira 17, under irrigation. This line may be released in Syria. In zone A, the new line, Kabir 1, was the top yielder and it will be further tested in the coming seasons. In zone B, Om Rabi, Korifla, and Haurani did well.

The bread wheat line, Flk'S'-Hork'S', had an outstanding performance for the third consecutive year. It ranked first both under irrigation and in zone A. The average yield advantage over Mexipak in the last three seasons was 20% under irrigation and 21 % in zone A. Grain quality characteristics and disease resistance were also better than Mexipak so it is recommended for release for zone A and irrigated areas in Syria.

In zone B, the barley line, Furat 1113, ranked first in grain yield, followed by the local check, Arabi Abiad. However, the difference between the two was not significant, except at one location. No lines performed better than the local check, Arabi Aswad, in zone C.

Cooperation with ARC-Douma extended to cereal pathology, and included:

(a) monitoring cereal diseases in the different agroclimatic areas of Syria,
(b) evaluating lines planted in FFVTs for their performance to diseases under national field infection and under artificially created epidemics, and
(c) screening ARC-Douma promising lines in ICARDA's regular disease sites.

The weather during the season did not favor rust or *Septoria tritici* blotch development. Common bunt, covered smut, and bacterial leaf-streak were the major diseases in zone A. Major diseases of zone B were scald and barley stripe, the latter being the major disease of zone C.

Valuable information was obtained on the performance of wheat and barley lines planted in FFVTs towards the major diseases prevailing in Syria: common bunt and septoria blotch of wheat; yellow rust, scald and powdery mildew of barley.

Advanced yield trials, segregating populations, crossing blocks, and disease nurseries of wheat and barley from ICARDA were planted at a number of research stations in Syria. Joint planning, visits, and discussions were arranged by the Ministry and ICARDA scientists and useful selections and crosses were made from these materials. Training, from short intensive courses on specific topics to informal instruction, was an important feature of the collaborative program.--*National Program (ARC) scientists, J.P. Srivastava, S. Ahmed, M. Michael, and other Cereal Improvement Program scientists.*

Tunisia

The detailed results of the Tunisian Collaborative Project are available from the program. *Highlights of the season's* activities and results are reported here. In the first year of durum wheat yield trials, three lines had good yields and resistance to septoria leaf blotch and yellow rust and they outyielded Karim by 8, 7, and 6%.

Of 423 bread wheat lines yield-tested and compared to Tanit, 128 were selected for their yield and reaction to yellow rust. The most promising were Snb'S' and Bow = 1 and they were more resistant to yellow rust and septoria. Snb'S' and Bow = 1 will be yield-tested for two more seasons and, if their outstanding performance is confirmed, they may replace Tanit.

In late February 1985, the barley lines ER/Apam, Roho, and WI 2198 were officially released for Tunisian farmers under the names Faiz, Roho, and Taj, respectively.

In the advanced yield trials, many Rihane sister lines confirmed their superior performance. Rihane'S' (Sel. 2L-1AP-3AP-0AP) was significantly superior to the improved checks at both Beja and El Kef (Table 54) and is recommended for further testing in the Field Verification and Demonstration Trials. It is a six-row type and should be acceptable to farmers.

Table 54. Grain yield (kg/ha) of the barley line Rihane'S' compared to local checks in Beja and El Kef, Tunisia, 1984/85.

	Location	
Entry	El Kef	Beja
Rihane'S' Sel. 2L-1AP-3AP-0AP	6406	4726
Roho	4917	3794
Taj	5322	3097
Faiz	5350	3188
Ceres	4417	3563
Martin	5228	3440
LSD (5%)	*428*	*315*
CV (%)	12.1	13.2

Most of the pathology nurseries were planted at Beja and Ariana, with some at El Kef. The available wheat and barley germplasm (about 7000 entries) was evaluated for disease resistance under artificial epiphytotics and natural conditions as follows:

(a) Artificial: yellow rust, septoria leaf blotch, tan spot, common bunt (for wheat), scald and net blotch (for barley).

(b) Natural: leaf rust and powdery mildew (barley). Inoculum isolation and multiplication were carried out at the genetics laboratory of the National Agronomic Institute of Tunis (INRAT).

Screening against tan spot by artificial inoculation was carried out in 1984/85. Although most bread wheat entries in the KLDN were affected by this disease at the seedling stage, some lines had acceptable resistance at the adult stage to tan spot, septoria, and yellow rust.-*A. Maamouri, M. Deghais, M.L. Faleh (INRAT); M. Harrabi and A. Daaboul (INAT); A. El Ahmed (ICARDA).*

Turkey

A collaborative project in winter cereals improvement was signed by Turkey and ICARDA in 1984. In 1984/85, materials from ICARDA, including Sham 1 and 2, the different observation nurseries, yield trials, crossing blocks, and segregating populations of bread wheat, durum wheat, and barley were planted by Turkish scientists.

In the Aegean region, the line 'Flk'S'-Hork'S' was the most promising of the bread wheat nurseries tested. For durum wheat, Korifla performed better than the local check, and will be promoted to multilocation trials in 1985/86. A number of lines was also selected from other durum wheat and barley nurseries.

The durum and bread wheat material showed good adaptation to the south-eastern region of

Turkey but the barley material was heavily damaged because the season was exceptionally cold. The bread wheat cultivar Sham 2 was very good and will be substituted for the existing commercial cultivar, Malabadi, in large-scale demonstrations in farmers' fields in 1985/86.

In the Cukurova region of southern Turkey, the durum line Om Rabia performed better than the local check at the six test sites. Korifla also performed well. For bread wheat, the line 'Flk'S'-Hork'S' was the best, outyielding the three checks. Though barley is not grown in this region, it could be incorporated into the present rotation system because of its earliness.

From the winter habit material tested in the Central Anatolian Plateau, some promising lines were promoted to the local preliminary yield trials for testing in 1985/86.

In general, Turkish scientists think that spring wheat material from ICARDA fits better in the south and southeast of Turkey, but winter habit material is required for the Aegean and Central Anatolian Plateau regions. Greater input from ICARDA was requested to improve barley production in Turkey, particularly for the stress environments in which barley is generally grown.--*National Program scientists and ICARDA/CIMMYT scientists.*

Cooperative Projects with Advanced Research Institutions

Collaboration with University of London, UK

The ODA-funded collaborative project between Birkbeck College and ICARDA aims to develop screening techniques for resistance to drought in barley and durum wheat. Physiological and biochemical responses to drought are studied, primarily in the field, and their possible use in assessing and screening for drought resistance is being evaluated. In particular, the application of a metabolic index of stress to the quantification of drought stress is being actively pursued.

In 1984/85, varieties, including two landraces, were subjected to irrigation gradients from a line-source sprinkler. Plant tissue samples were harvested at various stages of plant development. Plant metabolites were analyzed and these data were supplemented with physiological measurements of plant water status.

In sites of high nitrate availability, there were marked increases in the nitrogen content of stressed plants. There were marked alterations in amino acid levels during drought, for example glutamine, asparagine, and aminobutyric acid levels decreased while proline increased. Accompanying these changes were increased levels of glycine betaine and, in some varieties, putrescine. An integrated index of these metabolic changes correlated with the rate of water stress development. This metabolic profiling was complicated by short- and long-term fluctuations in plant water status.

With barley there were marked changes in the metabolic profiles of developing grain subjected to varying levels of moisture stress. As grain yield decreased in response to drought, grain proline content increased.--*G.R. Stewart, J. Pearson (University College London), N. Smirnoff (now University of Exeter),* and *Issam Naji, ICARDA.*

Collaboration with the University of Saskatchewan, Canada

Collaborative work continues between the program and the University of Saskatchewan on collection, evaluation, and conservation of barley and durum wheat germplasm and their wild relatives. Germplasm is being evaluated for a variety of characters at ICARDA and the University of Saskatchewan.--*S. Jana (Univ. of Saskatchewan) and J.P. Srivastava.*

Collaboration with Agriculture Canada, Swift Current, Canada

Over 4000 durum wheat lines received through ICARDA were grown at Swift Current in 1984. Observations were made on morphological characters such as growth habit, leaf size, glaucousness, height, and heading date. In addition, lines were screened for water loss under rainfed conditions. Excised leaf water retention capability was determined during the vegetative phase and water loss of the lines ranged from slower than the slowest local check (Pelissier) to faster than the fastest local check (Hercules). The 4000 durum lines were characterized and a computerized catalog prepared.

Six hundred and forty of these lines were chosen for study in replicated trials in 1985. The lines were selected on the basis of fast and slow water loss within the morphological categories of leaf rolling, glaucousness, maturity, leaf size, and general agronomic score.--*J.M. Clark, P.L. Gautum, S. Jana, T.N. McGaig*, and *T.F. Townley-Smith.*

Collaboration with University of Tuscia, Viterbo, Institute of Germplasm, and ENEA, Italy

A joint collaborative project was initiated during 1984/85 between ICARDA (Cereal Improvement Program, Genetic Resources Unit) and the Institute of Agricultural Biology, the University of Tuscia, Viterbo, the Institute of Germplasm, CNR, Bari, and ENEA, Casaccia, Rome. The major objective of the project is to evaluate diverse durum wheat germplasm material (landraces and wild progenitors) and identify desirable traits for breeding. The project will document and disseminate the information generated for use by national programs in the region and elsewhere. It will also provide training opportunities for national program staff in germplasm evaluation and utilization.--*E. Porceddu, J.P. Srivastava, and B. Somaroo.*

Collaboration with Montana State University, USA

A new collaborative project, funded by USAID "Collaborative Research and Training Program Relating to Barley Diseases and Associated Breeding Methodologies" was initiated in 1985 between Montana State University, USA, and ICARDA. The project addresses the need to study the major barley diseases in developing countries, particularly in the ICARDA region. The overriding objective is to create a model integrated approach to the incorporation of disease resistance into adapted, high-yielding barley cultivars through national, university, and international research program cooperation. Major and minor gene resistance sources will be collected and studied. The second, equally important objective is to upgrade the national research capabilities of developing countries through long- and short-term training, graduate degree (MSc) training, and seminars and workshops in pathology and associated plant breeding methodologies.--*E. Sharp, O. Mamluk, and J. van Leur.*

Collaboration with the Plant Breeding Institute, UK

The project aims to characterize barley genotypes for improved performance in dry areas, and is funded by ODA.--*R.B. Austin and E. Acevedo.*

Collaboration with Agriculture Canada, Saint-Foy, Canada

The project, funded by Agriculture Canada/IDRC, screens ICARDA's advanced wheat and barley germplasm for barley yellow dwarf virus (BYDV) resistance.--*A. Comeau, and K. Makkouk.*

Collaboration with Canadian Grain Commision, Winnipeg, Canada

The senior cereal chemist of the Canadian Grain Commission visits ICARDA for several months each year to oversee grain quality testing. Several new and very useful techniques have been developed to evaluate barley and wheat germplasm for local consumer uses. Funding is by CIDA.--*P. Williams.*

Collaboration with University of Bonn, Federal Republic of Germany

This project studies the probable causes of yield reduction when cereals are continuously grown. The incidence and significance of cereal root diseases in northern Syria and their control by crop rotation, especially through the inclusion of a legume pasture phase are being investigated. The project, funded by GTZ, is jointly conducted by the Pasture, Forage, and Livestock Program, the Farming Systems Program, and the Cereal Improvement Program of ICARDA and the University of Bonn.

Collaboration with University of Reading, UK

The photothermal responses of barley to flowering are being studied in this project which is entering its second 3-year phase. The objective is to provide precise information on the effects of temperature and daylength on barley development and growth. The study will help scientists to understand how different barley genotypes adapt to different environments. Current work is focused on the effect of daylength and temperature on the time of flowering of six diverse barley varieties and has shown that:

(a) vernalization, photoperiod, and temperature can dramatically affect time to heading; the relative effects of these factors depend on the genotype,

(b) mean diurnal temperature modulates development rather than day or night temperature, and

(c) traditional analyses are inappropriate; analysis based on rates of development towards heading is more informative. ODA-funded project. --*E.H. Roberts, R.J. Summerfield, J.P. Cooper, M.S. Mekni and S. Ceccarelli.*

Collaboration with University of Reading, UK

The aims of this project are to study the extent of varietal differences in root systems and to determine how root growth and water and nutrient utilization can be manipulated to improve crop yields. From field work in Aleppo and detailed controlled experiments in Reading, location, management, and variety affect the root growth and distribution of root systems of barley plants. 1985/86 is the last season of the first phase of this project. The work is being done jointly by the Farming Systems and Cereal Programs and is funded by ODA. - *P. Gregory, S. Brown, H. Harris, M.S. Mekni and S. Ceccarelli.*

Collaboration with Institut fur Pflanzenzuchtung, University of Munich at Freising, Federal Republic of Germany

With GTZ support, a PhD student screened barley and wheat germplasm for tolerance to salinity in the field. The work was supervised by a senior cereal scientist and laboratory work is being done in F.R. Germany. Barley landraces were also collected in Syria and Jordan.--*E. Weltzien.*

Collaboration with Institut fur Pflanzenzuchtung, Saatgut Forschung und Population-Genetik, University of Hohenheim, Federal Republic of Germany

This project, initiated in 1984, analyzed the interaction between the plant's response to daylength and its vernalization requirement. Under German crop-growing conditions, photoperiod insensitivity and a higher vernalization requirement increased the number of flowering primordia, leading to higher grain yields in durum wheat. The project also screens for cold tolerance. --*P. Ruchkenbauer*, and *M. Nachit.*

Workshops and Conferences

North Africa Travelling Cereal Workshop, Morocco, 15-22 April 1985

This workshop, organized by ICARDA, CIMMYT, and national programs in the Maghreb and the Iberian Peninsula, was hosted by INRA in Morocco, 15-22 April 1985. Participants from the two centers and from Morocco, Portugal, Spain, and Tunisia visited seven research stations in Morocco (Codea, Cidera, Merchouch, Beni Mellal, Jamat, Shaim, and Tessaout) and participated in the selection of barley and wheat under various stress conditions including drought, diseases, and insects. There were fruitful discussions during the visits. Dr. Ignacio Cubero, a member of the ICARDA's Board of Trustees from Spain, attended the workshop.

Middle East Travelling Cereal Workshop, Jordan/Syria, 9-17 May 1985

The Middle East travelling workshop was held in Jordan and Syria, 9-17 May 1985. Twenty-five scientists from 10 countries and 10 from ICARDA and CIMMYT visited research plots of wheat and barley at Maadaba, Deir Alla, Ramtha, and Marrow. Participants reviewed the breeding, agronomy, and pathology nurseries of the national program, ACSAD, ICARDA, and CIMMYT.

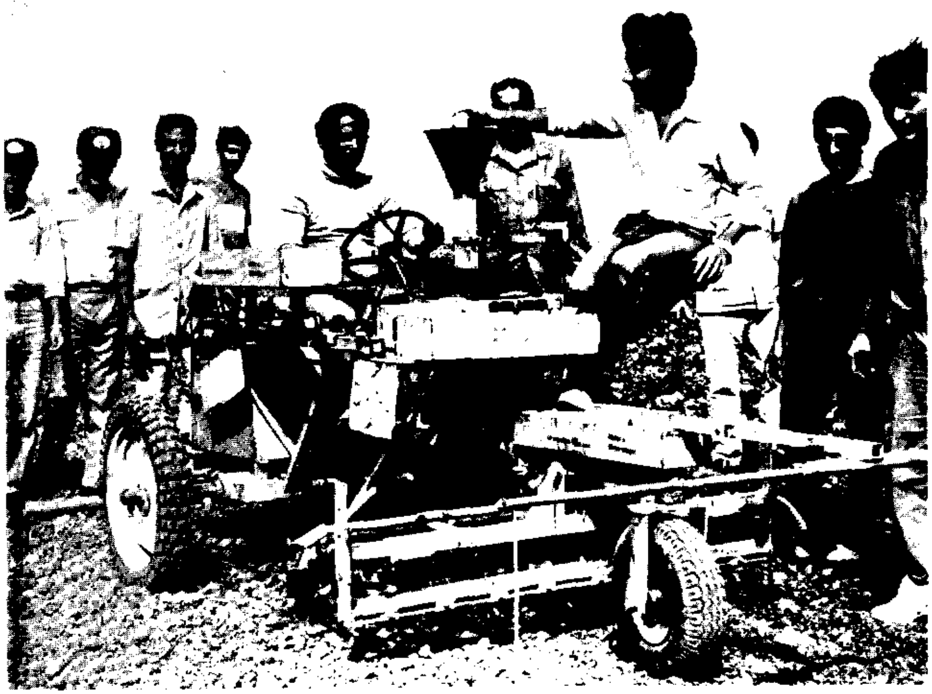
In Syria, participants visited the research stations at Izraa, Karahta, Homs, and El Ghab, and the on-farm trials at Lattamneh. On the last 2 days of the workshop the cereal research work at ICARDA was presented.

Seminars

An international seminar, "Improving Winter Cereals for Moisture Limiting Environments," was jointly organized by the Cereal Improvement Program, ICARDA, and CNR, Italy, and was held in Capri, Italy, 27-31 October, 1985. The seminar aimed to share experiences and recommend ways to integrate knowledge of plant physiology into plant breeding programs. It was concluded that as the type and intensity of physical stresses vary with environment, it is not possible to generalize in terms of desirable plant traits. The target environment must be adequately defined, the crosses must be targeted and selections must be made in the environments under consideration. The adaptive nature of some physiological traits was emphasized.

During the season program scientists presented papers at the following conferences and meetings:

1. Workshop on Rainfed Agricultural Information Network, Amman, Jordan, 17-20 March, 1985.
2. Montpellier/ICARDA Workshop, 1-4 July, 1985.
3. The International Winter Wheat Conference, Mexico, 25-31 August, 1985.
4. Seminar on "Improving Winter Cereals for Moisture Limiting Environments," ICARDA/CNR, Capri, Italy, 27-31 October, 1985.
5. Science Week, organized by the Supreme Council of Sciences, Damascus, Syrian Arab Republic, November 1985.



Trainees from national programs practicing use of plot seed drills for improving reliability and efficiency of field plot experiments as part of cereal training course.

Visitors to the Program

During the season about 165 scientists visited the program from: Australia, Canada, Chile, China, Cyprus, Ecuador, Egypt, Ethiopia, France, Germany, the Netherlands, Iran, India, Italy, Jordan, Lebanon, Libya, Mexico, Morocco, Pakistan, Spain, Sudan, Syria, Thailand, Turkey, Tunisia, UK, USA, USSR, Yemen Arab Republic, and the Peoples Democratic Republic of Yemen.

Visits to National Programs by Program Scientists

Program scientists spent time with national colleagues in their research plots and laboratories and discussed problems and research information on crop improvement and priorities. The program was requested by some national programs to review their research activities and suggest changes to accelerate cereal production.

Information Exchange

The program promotes information exchange among cereal researchers and encourages national scientists to share useful research findings in Rachis, a barley and wheat newsletter. Two issues of Rachis were published in English and Arabic in 1985. Program scientists published papers in refereed journals, and several reports and occasional publications. The program also produced a field guide to wheat and barley diseases and training manuals.--*J.P. Srivastava.*

Project VII : International Nurseries System

The prime objective of the international nurseries system is to provide improved cereal germplasm for the national plant breeding programs. A detailed description of the system is given in the booklet "An Introduction to the International Cereal Nurseries System", available from the program.

Germplasm Distribution

In 1984/85, 21 different sets of nurseries, with 2793 entries, were distributed to 94 cooperators in 45 countries. The high-altitude area (HAA) and higher rainfall area (HRA) nurseries for barley were renamed cold tolerance (CT) and moderate-rainfall area (MRA) nurseries, respectively. The Regional Durum Yield Trials and Observation Nurseries were distributed as low-rainfall area (LRA, formerly called the rainfed sets) and moderate-rainfall area (MRA) sets.

A total of 800 sets were distributed in August 1984 to Maghreb countries, the Nile Valley, West Asia, East Asia, other African countries, Europe, and North America. The remaining 3% of the nurseries were distributed to a few countries in South America and Oceania. The number of sets distributed for barley, durum, and bread wheat represented 37, 33, and 30% of the total, respectively. Approximately 70% of all nursery sets were distributed to countries within the ICARDA region.

Experimental Results of the International Nurseries:Data Analysis, Summarization, and Feedback

A Preliminary Report of the 1983/84 Regional Yield Trials and Observation Nurseries, containing the results received from cooperators until 31 October 1984, was distributed in February 1985. A Final Report, containing results from cooperators until 30 March 1985, was distributed in June 1985. For the Regional Yield Trials, the number of locations from which data were received for the RBYT, RDYT-MRA, RDYT-LRA, and RWYT were 36, 29, 28, and 39, respectively.

Some of the new features incorporated in the 1983/84 Final Report of the Regional Yield Trials were:

(a) Additional checks on the yield performance of entries. The number of times that each entry ranked in the top five, or ranked above the three checks, and the number of times that an entry significantly exceeded (LSD test, P = 0.05) the three checks were determined. Results of the 1983/84 RBYT, for example, with replicated yield data from 34 locations, indicated that entry No. 5 (Rihane'S', selection no 3) most frequently ranked greater than the improved, long-term, and national checks (23, 27, and 16 times, respectively) and in total most often significantly exceeded the checks (7,9, and 10 times, respectively).

(b) Average grain yields and relative grain yields (mean yield of an entry divided by the trial grand mean) were estimated for each entry for countries, specific groups of locations, and over all locations. Such estimates give equal weight to sites, thereby removing the effect of favorable high-input sites on simple averages and providing another measure of relative genotypic performance.

(c) Important supplementary information on the conduct and conditions of each trial, where supplied, was reported in a Cooperators' Notes section of each RYT.

(d) Test environments were compared using histograms of average grain yields for all locations for each RYT. This gave an overall classification of unfavorable to most favorable environments and the range of environments. The average range in grain yield for all RYT was 6487 kg/ha, with the greatest for the RWYT at 975-8115 kg/ha, for a range of 7.14 t/ha.

(e) A full correlation matrix was computed for each RYT of all possible pair-wise simple phenotypic correlations of average grain yield (excluding national checks and triticales). On the basis of yield alone, only a few locations correlated significantly (P = 0.01), attesting to the large genotype x location interactions for grain yield in the ICARDA region as a whole.

For the Observation Nurseries, the following new features were incorporated in the final report:

(a) Summary statistics and entry rankings for each location for grain yield, days to heading, and days to maturity, where data were reported. There was greater expression of genetic differences at some locations in days to maturity, for example, than at other locations. In the WON, for example, the location (out of 21 locations) with the smallest range in days to maturity was Tel Hadya rainfed at 7 days (164-171 days) whereas Darab (Iran) had the maximum range at 59 days (121-180 days). Summary statistics assist in site classification by crop response and provide more information to cooperators. The entry numbers in rank order for the 20 earliest or largest yielding lines, for example, gave flexibility for constructing selection criteria based on a chosen subset of locations, rather than simply the grand overall mean which can be misleading.

(b) Correlation matrices were computed for each observation nursery, excluding national checks and triticales, using all pair-wise site combinations for days to heading and days to maturity. Generally, correlations were positive and highly significant (P = 0.01), and varied from 0.27, with an accordingly low coefficient of determination, to 0.98. The only exception was DON-LRA, where there were proportionately more insignificant correlations than in the other observation nurseries and a number of significant negative correlations. Such correlation matrices, and the summary statistics, allowed ICARDA and national program scientists to compare and group environments and choose those where entries can be more reliably assessed for earliness, which is important for genotypes in rainfed areas.

(c) The best 20% of entries in each observation nursery for a specific trait were identified using the SELECT module in CERINT. The entries with largest average grain yield, least average days to heading, least average days to maturity, and least average score or coefficient of infection were identified and reported for each observation nursery. In the WON, for example, entry No. 19 (Kvz/Cgn) was among the three entries with the lowest ACI for yellow rust (0.40, from six locations) and one of two entries with the lowest ACI for leaf rust (0 from 10 locations). Entries most frequently selected by national program scientists were also identified, and often were the entries with relatively high average grain yields and good disease resistance. In each observation nursery, several entries were selected in 30-60 % of the locations for which data were received. Using the extensive data base for each observation nursery with the SELECT module, and other ancillary modules, ICARDA scientists can identify promising genotypes for promotion to the RYT for further evaluation or recycling to the crossing blocks.

Interaction and cooperation with the national programs is the fundament of the international nurseries system, and is not confined to germplasm distribution, data analysis, and feedback. Expansion of the data management and analysis component of the system could assist the national programs, where requested, in analyzing and interpreting their plant breeding or agronomy data. Collaboration in data analysis with the Office des Cereales, Tunisia, was initiated this year to extract as much information as possible from several years' results of farmers' demonstration trials and other experiments. Such developments are additional avenues of technical assistance in germplasm development for individual national programs.--*D. Mulitze and other Cereal Improvement Program scientists.*

Project VIII: Cereal Training

Residential Training Course

Fifteen research workers from 12 countries (Table 55) participated in a 3-month course (3 March - 5 June 1985). All trainees worked in cereal research in their countries as breeders, pathologists, or agronomists and their education varied from a university diploma to an M.Sc degree, although most had a B.Sc degree.

Training was carried out at ICARDA's main station at Tel Hadya, although there were occasional visits to trials at other sites in Syria, namely Breda, Bouider, and El Ghab. Classroom lectures comprised 25% of the course and practical training the remaining 75%. The lectures and related activities shared by trainees in all programs included: statistics and experimental design, genetic resources, plant protection and seed health, weed control, machinery and land preparation, library facilities and information system at ICARDA, farming system research, and country reports (prepared by the trainees).

The lectures and practicals specific to cereal trainees covered the topics: improvement of barley, bread wheat, durum wheat, and triticale; improvement of cereals for high-elevation areas; and cereal pathology, entomology, agronomy/physiology, and grain quality.

Table 55. Participants in the 1985 Cereal Residential Training Course.

Trainee's name	Country	Project
Mr. Amin Al Hakimi	Yemen: (AR)	Barley improvement(grazing)
Mr. Noureddine Ben Abdallah	Tunisia	Durum wheat improvement
Mr. Ahmed Said Ben Jewad	Yemen: (PDR)	Bread wheat improvement
Ms. Irshad Begum Bhutta	Pakistan	Cereal improvement for high elevation areas
Mr. Yasir Gasim Mohamed	Jordan	Durum wheat improvement
Mr. Goodarz Gorjian	Iran	Bread wheat improvement
Mr. Mohamed Reza Islampoor	Iran	Cereal agronomy
Mr. Abdel Majid Ismail	Syria	Cereal pathology
Ms. Fatima Jarari	Morocco	Barley improvement
Mr. Hussein Sabere Khabaz	Iran	Bread wheat improvement
Mr. Mustafa Khalil Mohamed	Sudan	Bread wheat improvement
Mr. Syrous Mahfoozi	Iran	Barley improvement
Mr. Kiflemariam Menghistu	Ethiopia	Barley improvement
Mr. Ahmed Oraby El Bawab	Egypt	Barley improvement
Mr. Nusret Zencirci	Turkey	Durum wheat improvement (genetic study)

In addition, specific field projects were assigned to each trainee (Table 55). Most projects included an evaluation of a certain type of germplasm (e.g., segregating populations, observation nurseries, or yield trials) for a given cereal species (barley, durum, or bread wheat). The evaluation was made by the trainees by observing certain plant attributes, such as frost tolerance, agronomic type, heading and maturity dates, plant height, and disease reaction. In addition, each trainee had to plan and implement a crossing program and write a project report summarizing his/her project activities.

Each trainee's performance was assessed by pre- and post-course technical evaluation, continuous observation and discussion, and three interim 1-2-page report on the on-going training activities.

In-Country Training Courses

Pakistan

The Cereal Improvement Program, in cooperation with the Computer Services, developed a training course on Analysis and Interpretation of Cereal Research Data. The course was conducted at the Training Institute, NARC, Islamabad, 5-16 May 1985.

The course aimed to improve the technical knowledge of cereal researchers for conducting sound agricultural experiments, analyzing the data, and drawing valid conclusions from the results.

Twenty-one researchers from NARC and the other research centers in the different provinces of Pakistan participated in the course. The participants were statisticians, cereal breeders, and agronomists.

Major topics included some of the most important experimental designs used in cereal research, and useful modifications of those designs for single- and multiple-factor experiments, linear correlation techniques, simple and multiple regression, sampling in agricultural experiments, multiple comparisons and trend analysis in factorial experiments, and analysis of genotype x environment interactions. Lectures were practically oriented with emphasis on procedures and interpretation and the trainees were given data analysis and interpretation assignments using the microcomputer facilities available at NARC. Field plot techniques, including experiment layout and related field experiment issues, were also discussed.

Morocco

A practical training course on cereal on-farm verification and demonstration trials was jointy organized by the Cereal Improvement Program, ICARDA, the Institut National de la Recherche Agronomique (INRA), Morocco, and FAO to train cereal researchers on testing, at the farm level, research results obtained at experimental stations and to expose young extension workers to recent research results. This should help to establish or strengthen workable linkages between research and extension and so improve the diffusion of research information to farmers.

Twenty-six trainees participated in the course held in two areas (Fes and Romani) of Morocco, 16-25 October 1985.

The course focused on the objectives, methodology, and implementation of on-farm cereal trials with particular emphasis on the proper choice of farm site, farmer, and adequate improved technology.

Trainees attended lectures and movie or slide presentations and participated in the preparation and sowing of verification and demonstration wheat and barley variety trials at two farms in each of the two areas.

The trainees expressed a desire to continue the course by applying necessary inputs on the trials and taking notes during the growing season at the four sites. This *part of the course will take place at crop* maturity when all trainees will be invited to meet, visit the sites, and discuss the outcome of the trials.

Short Courses

A 2-week course on disease methodology was jointly organized by the Cereal Improvement Program and the Food Legumes Improvement Program to train 15 Syrian researchers. The course emphasized disease etiology, symptomatology, epidemiology, field and laboratory inoculation techniques, and germplasm scoring for important cereal and food legume diseases.

Another course on experimental design and field-plot techniques was jointly organized with other ICARDA programs following a request from the Syrian National Program. Sixteen research assistants from different provinces participated in this course. Experimental designs were discussed in relation to field layout and data analysis and interpretation.

A three-week course on seed technology, sponsored by AOAD provided training for 18 trainees from nine Arab countries.

Individual Training

Three Iranian researchers participated in a 2-week training course on cereal breeding and pathology. One researcher from Morocco was trained for 3 weeks on barley breeding and participated in hybridization and selection activities at Tel Hadya. Another researcher from Syria spent 1 week studying ICARDA's cereal entomology research particularly that on wheat stem sawfly and cereal aphids. A research technician from INAT, Tunisia, was given 5 weeks of training on cereal breeding and germplasm characterization, while two researchers from Tunisia and Cyprus were trained for two weeks on grain quality in the quality laboratory at Tel Hadya.

Degree Studies

Two graduate students from Tunisia and the Federal Republic of Germany are doing research for a PhD in cereal improvement. Another student has successfully completed an MSc degree in agronomy at Aleppo University with supervision and support from the Cereal Improvement Program and two MSc degree candidates from the University of Jordan were supported by the Program. In addition, the program has supplied germplasm, literature, and information to several graduate students within the region and elsewhere.

As part of the ICARDA/Montana State University Barley Project, a provision was made for graduate training of national scientists in barley pathology.--*H. Ketata and other Cereal Improvement Program scientists.*

Publications

Journal Articles

Amara, H., Ketata, H., and Zouaghi, M. 1985. Use of barley (*Hordeum vulgare* L.) for forage and grain in Tunisia. Rachis 4(2): 28-33.

Anderson, W.K. 1985. Production of green feed and grain from grazed barley in northern Syria. Field Crops Research 10:57-75.

Anderson, W.K. 1985. Differences in response of winter cereal varieties to applied nitrogen in the field. I. Some factors affecting the variability of responses between sites and seasons. Field Crops Research 11: 353-367.

Anderson, W.K. 1985. Differences in response of winter cereal varieties to applied nitrogen in the field. II. Some factors associated with differences in response. Field Crops Research 11: 369-385.

Ceccarelli, S., and Mekni, M.S. 1985. Barley breeding for areas receiving less than 250 mm annual rainfall. Rachis 4(2):3-9.

Grando, S., Falistocco, E., and Ceccarelli, S. 1985. Use of wild relatives in barley breeding. Genetica Agraria 39:65-76.

El Faleh, M., Maamouri, A., Deghais, M., and El Ahmed, A. 1985. Three new barley cultivars for Tunisia. Rachis 4(2):50-51.

Mulitze, D. 1985. Distribution of international cereals nurseries. Rachis 4(1):43-44.

Mulitze, D. and Baker, R.J. 1985. Evaluation of biometrical methods for estimating the number of genes. 1.Effect of sample size. Theoretical and Applied Genetics 69:553-558.

Mulitze, D. and Baker, R.J. 1985. Evaluation of biometrical methods for estimating the number of genes. 2.Effect of type I and type II statistical errors. Theoretical and Applied Genetics 60:559-566.

Mulitze, D. and Baker, R.J. 1985. Genotype assay and method of moments analyses of five quantitative traits in a spring wheat cross. Crop Science 25:162-167.

Nachit, M.M., Ketata, H., Azrak, M., and Rashwani, A. 1985. Occurrence of Hessian fly (*Maytiola destructor* Say) in high elevation areas. Rachis 4(1):37.

Naji, I. 1985. Effect of growth regulator and photoperiod on spring wheat (*Triticum aestivum* L.em. Thell.). Rachis 4(1):38-39.

Rashwani, A. 1985. Days to heading and days to maturity as important factors of barley resistance to wheat stem sawfly. Rachis 4(1):35.

Rashwani, A. 1985. Reconfirmation of levels of resistance to wheat stem sawfly in some bread wheat lines. Rachis 4(1):37-38.

Srivastava, J.P. 1985. Ahgaf - A new wheat variety released in the Peoples Democratic Republic of Yemen. Rachis 4(1):35-36.

Srivastava, J.P., and Winslow, M.D. 1985. Improving wheat and barley production in moisture-limiting areas. Rachis 4(1):2-8.

Williams, P.C. 1985. Survey of wheat flours used in the Middle East. Rachis 4(1):17-20.

Williams, P.C., and Jaby El Haramein, F. 1985. Frekeh making in Syria - a small but significant local industry. Rachis 4(1):25-27.

Williams, P.C., and Jaby El Haramein, F. 1985. Influence of experimental method on wet gluten determination in wheat flour. Rachis 4(2):47-49.

Yau, S.K., and Mekni, M.S. 1985. Characterization of dual-purpose barley - An approach. Rachis 4(1):33-34.

Conference Papers

Acevedo, E. 1985. Phenological adaptation of winter cereals to Mediterranean environments. Paper presented at the seminar on Improving Winter Cereals for Moisture Limiting Environments, ICARDA/CNR, 27-31 Oct 1985, Capri, Italy.

Ceccarelli, S., Nachit, M.M., Ferrara, G.O., Mekni, M.S., Tahir, M., Van Leur J.A.G., and Srivastava, J.P. 1985. Breeding strategies for improving cereal yield and stability under drought. Paper presented at the seminar on Improving Winter Cereals for Moisture Limiting Environments, ICARDA/CNR, 27-31 Oct 1985, Capri, Italy.

Jenkins, G. and Srivastava, J.P. 1985. Information network for wheat and barley research in the Middle East and North Africa. Paper presented at the Workshop on Rainfed Agricultural Information Network, 17-20 Mar 1985, Amman, Jordan.

Ketata, H. 1985. Actual and potential yields of cereal crops under drought. Paper presented at the seminar on Improving Winter Cereals for Moisture Limiting Environments, ICARDA/CNR, 27-31 Oct 1985, Capri, Italy.

Malik, M.A., Nachit, M.M., and Massoud, K. 1985. Triticale: Its potential as a commercial crop for dry areas in Middle East. Paper presented in Science Week in the Supreme Council of Science, 2-7 Nov 1985, Damascus, Syria.

Srivastava, J.P. 1985. An overview of Program activities. Paper presented at the Montpellier/ICARDA Workshop, 1-4 July 1985, Montpellier, France.

Srivastava, J.P. 1985. Status of winter cereal improvement for low rainfall areas in West Asia and North Africa. Paper presented at the seminar on Improving Winter Cereals for Moisture Limiting Environments ICARDA/CNR, 27-31 Oct 1985, Capri, Italy.

Tahir, M. 1985. Breeding of winter cereals for high altitudes of West Asia and North Africa. Paper presented at the International Winter Wheat Conference, 25-31 Aug 1985, Mexico.

Miscellaneous

Ceccarelli, S. 1985. Status of Dual-Purpose Barley in the Region. Paper presented at the 12th Program Committee Meeting, January 1985, Tunis, Tunisia.

Cereal Improvement Program, ICARDA. 1985. Collaboration Research Program on Wheat and Barley. Results of the Cereal Field Verification Trials 1984/85, Sept 1985. ICARDA, Aleppo, Syria.

Cereal Improvement Program, ICARDA. 1985. Regional Yield Trials and Observation Nurseries, 1983/84. Final Report. ICARDA, Aleppo, Syria.

Cereal Improvement Program, ICARDA. 1985. Rachis 4(1). ICARDA, Aleppo, Syria.

Cereal Improvement Program, ICARDA. 1985. Rachis 4(2). ICARDA, Aleppo, Syria.

Duwayri, M., Tell, M., Arabiat, S., Katkhuda, N., Yagmur, A. Srivastava, J.P., Anderson, W.K., and Somel, K. 1984 A Report on the Jordan Cooperative Improvement Project 1978-79 to 1982-83.

Kamel, A.H., 1985. Field guide to the most important barley and wheat pests. Brochure (1).

Maamouri, A., Deghais, M., El Faleh, M., Ben Salem, M., Tounsi, L., and El Ahmed, A. Progress Report 1984/85.

Srivastava, J.P. 1985. Triticale Improvement Project at ICARDA. Position paper presented at the 12th Program Committee Meeting, Jan 1985, Tunis, Tunisia.

FOOD LEGUME IMPROVEMENT

ICARDA Annual Report 1985

INTERNATIONAL CENTER FOR AGRICULTURAL
RESEARCH IN THE DRY AREAS (ICARDA)
Box 5466, Aleppo, Syria

Contents

FOOD LEGUME IMPROVEMENT

The Food Legume Improvement Program (FLIP) continued its effort 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 of immense value in the farming system of the dry areas of ICARDA region and elsewhere because of their protein rich seeds for human nutrition, their nutritive by-products for animal feed, and their role in fixing atmospheric nitrogen. Research on kabuli-type chickpeas continued to be a joint activity with ICRISAT (International Crops Research Institute for the Semi-Arid Tropics), based in Hyderabad, India.

Though research on all three crops was conducted by a multidisciplinary team of scientists from FLIP and other programs, the results are presented here by the discipline. The strategy employed to develop improved genetic stocks and cultivars and production technology using the experimental sites available to FLIP and linkages with national programs has already been reported earlier (ICARDA Annual Report 1984, page 150). Research at ICARDA's principal research station at Aleppo and at subsites in Syria and Lebanon was complemented by that conducted in the Nile Valley of Egypt and Sudan and in the ICARDA/INRAT cooperative project on food legumes in Tunisia. Stronger linkages were developed with Ethiopia, Pakistan, and Turkey to achieve this complementarity.

Staff Changes

The ICRISAT chickpea breeder remained on sabbatical leave until September 1985, and the ICRISAT chickpea pathologist position remained vacant after the departure of Dr. M.V. Reddy in early 1985. A pathologist from ICRISAT headquarters, however, visited the program twice during the crop season. The legume entomologist left in November 1985 to join CIAT. There were four postdoctoral fellows in 1985 in the following areas: faba bean breeding (Nile Valley Project), agronomy/crop physiology, international testing program, and *Orobanche* control (GTZ-supported special project). The program also had two visiting research associates/fellows: one to work on an annotated bibliography on faba bean agronomy and crop physiology, and the other to work in an EEC-supported University of Wageningen/Royal Tropical Institute, Amsterdam/ICARDA joint project on *Orobanche*. Four students, registered for Ph.D. with European Universities, worked for their thesis research in the program.

Research Highlights

The 1984/85 season was characterized by an exceptionally cold winter with 38 frost days at Jindiress, 42 at Tel Hadya, 43 at Breda and 63 at Khanasser with minimum temperature dropping to well below -9°C. What made the season exceptional was the magnitude of temperature drop in February and March when the crop usually starts picking up rapid growth. This caused severe winter kill in faba beans and chickpeas and, to some extent, in lentils. However, the season provided an excellent opportunity to screen the legume germplasm and breeding material for cold tolerance. Several breeding lines and genetic stocks of kabuli chickpeas developed by the program tolerated the cold well. This is very reassuring for the winter sowing strategy developed by the program for kabuli chickpeas in the region. The rainfall during the season was more or less normal: 409 mm at Jindiress, 373 at Tel Hadya, 277 at Breda, and 199 at Khanasser.

The major achievements of the program during the 1984/85 season are summarized below.

Faba beans

(1) Selfing and purification of 5005 BPL accessions was done; 288 new ILB accessions were increased and development of BPL's from these started. Significant progress was made in the project on developing a computerized data base of the ILB accessions' passport information. Further purification of 44 chocolate spot, 25 ascochyta, and 30 rust-resistant inbred lines was done for distribution and crossing.

(2) A total of 685 germplasm accessions were distributed to 11 countries and approximately 3000 lines and populations from ICARDA's breeding program were distributed to 15 countries.

(3) For the first time 67 BPL and ILB accessions with frost resistance were identified.

(4) Thirty-eight new sources of resistance were identified for chocolate spot. Selections were made for single plants in the crosses made for ascochyta blight, chocolate spot, and durable resistance. Twenty-eight sources resistant to a wide range of isolates of *Botrytis fabae* and 67 entries resistant to a wide range of isolates of *Ascochyta fabae* were identified.

(5) From the 3000 breeding lines distributed to national programs, the following were selected: (a) North Yemen - six lines from advanced trials, (b) Sudan - 15 lines for resistance to BLRV, (c) Tunisia - more than 300 single plant selections from F_3 bulks, (d) China - 25 determinate and 53 indeterminate progenies, and (e) Egypt - several large-seeded lines.

(6) A crossing program was started for the utilization of the 'Independent Vascular Supply' trait.

(7) In the Nile Valley Project, the economic advantage of improved package of production was demonstrated in the major production areas of both Egypt and Sudan through farmer-managed, large-plot on-farm trials and pilot-production program. Highlights of research from NVP have been published separately. The Ethiopian national program joined the Nile Valley Project for the applied on-farm research on faba beans and the first set of on-farm trials was laid out in July 1985 in Shoa region.

(8) A new screening technique for resistance to *Orobanche* was developed.

Lentil

(1) Both preliminary and advanced yield trials were grown across a rainfall cline at the three sites: Breda, Tel Hadya, and Terbol. Amongst the 238 small-seeded selections the percentages of entries yielding significantly more than the local check were 52, 32, and 56 at the three locations, respectively. Amongst the 171 large-seeded entries the corresponding percentages were 19, 8, and 12.

(2) In cooperative on-farm trials in Syria, ICARDA 2 large-seeded, and 2 small-seeded

ICARDA selections were tested against local checks. The average yield advantage from the large-seeded entry 78S26002 over three seasons was 16% above the check. This selection is easy to harvest mechanically because of its reduced lodging and is now in prerelease multiplication.

(3) Variety NEL (ILL) 358, which demonstrated rust resistance and a 50% yield advantage over the local check, was released in Ethiopia to farmers in the highland areas.

(4) Four selections in Tunisia and two in Spain were identified for prerelease multiplication. ILL 4605 is being considered for release in some areas of Pakistan.

(5) Two inexpensive tractor-pulled lentil harvesters were tested at Tel Hadya. The first, with angled blades, gave a return of 96% for the straw and seed compared to hand harvest. The second, with a double-knife cutter bar, gave in a lower return because of the straw loss, but its performance was improved by harvesting nonlodging cultivars sown on unridged soil.

(6) Advancing the sowing date of lentil genotypes from late to early winter resulted in 117 and 165% increase in seed and straw yield, respectively.

Kabuli-Type Chickpea

(1) Taking full advantage of severe winter of the 1984/85 season, over 10,000 lines including germplasm accessions, breeding lines, and advanced segregating generations were screened for cold tolerance and a few tolerant lines identified. The tolerance of several lines was reconfirmed.

(2) Several large-seeded and tall types combining cold tolerance, ascochyta blight resistance, and high yield were identified.

(3) ICARDA developed/supplied chickpea lines were increasingly used by national programs. Egypt used ILC 482 for on-farm trials; Turkey identified ILC 195, 201, and 482 for on-farm evaluation; Spain registered ILC 72 and ILC 200 as 'Fardon' and 'Zegri,' respectively; Cyprus released ILC 3279; Syria identified ILC 3279 as a candidate for eventual release; Morocco conducted on-farm trials with ILC 482, 484, and 195 with the intention of their eventual release.

(4) A pot-culture technique for screening resistance to cyst nematodes has been developed and 253 chickpea lines were screened; 11 lines with good tolerance were identified.

(5) In the ICARDA/INRAT cooperative project in Tunisia, 21 lines combining ascochyta blight resistance and tolerance to wilt were identified with yield potential equivalent to the best local check. These will be yield-tested in an elite yield trial, multiplied in 1986/87, and the promising ones considered for release for winter sowing. Twenty-one lines from single-plant selections for wilt resistance in the local cultivar Amdoun will be retested and one or more will be considered for release for spring sowing in 1986/87.

(6) Agronomic studies in ICARDA/INRAT cooperative project have reconfirmed the superiority of winter sowing over spring sowing and the need for effective weed control. These results are in conformity with those obtained earlier by several other national programs.

(7) Supplemental irrigation of winter- and spring-sown chickpeas at Tel Hadya gave 73 and 142% increase, respectively, in seed yield, highlighting the importance of supplemental irrigation for this crop.

International Testing

Nearly 1200 sets of international nurseries and trials were supplied to 129 cooperators in

52 countries for the 1985/86 season. The requests received accounted for about 1500 sets. The report for the 1982/83 season was published. The report for 1983/84 was finalized.

Training

(1) Our residential training course at ICARDA had an enrollment of 18 trainees from 10 countries (Argentina, Ethiopia, Iran, Pakistan, Peoples Democratic Republic of Yemen, Sudan, Syria, Tunisia, Turkey, and Yemen Arab Republic).
(2) An in-country training course was organized for one week in Morocco, in which 30 technicians from 10 research stations of Morocco and one from Tunisia participated. A manual is being developed from the lectures and practical excercises given to the participants.
(3) The program also participated in the conduct of a national training course on cereal and food legume pathology and a seed technology training course, both held at ICARDA.
(4) Twenty individual trainees received specialized training in different areas of food legume research. Four new graduate students did their thesis research work in the program.
(5) An audio-tutorial module on the ascochyta blight of chickpea was prepared and distributed to the national program scientists.--*M.C. Saxena.*

Faba Bean Improvement

Research on faba bean improvement continued to be conducted under four projects: (1) development of improved cultivars and production practices for high rainfall/assured moisture environments; (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. Work on 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 in the International Cooperation section.

Since faba beans are predominantly grown in the high-rainfall/assured-moisture environments, a major effort was assigned to the development of genotypes and production and plant-protection techniques for such environments.

Germplasm

The ILB[1] collection stood at 3233 accessions in 1984/85. A total of 288 ILB accessions from 14 countries were multiplied in the screenhouse at Tel Hadya, Syria, for the first cycle of selfing to produce BPL[2] accessions. From these, approximately 390 new BPL accessions will be derived. Over 5005 BPLs were grown in 1985 in various stages of pure-line development. Seed was increased and purified of 634 BPL accessions (six or more selfing cycles), and 4371 BPL accessions were advanced one selfing cycle.

A total of 685 accessions from both ILB and BPL collections were distributed to 11 countries. Also, 2956 lines and populations from the breeding program were distributed to 15 countries.

Work was started to catalog ILB passport information for the IBPGR/ICARDA faba bean descriptor list.--*L.D. Robertson and M. El-Sherbeeny.*

---

1. ILB = ICARDA legume faba beans
2. BPL = Faba bean pure lines

Development of Cultivars and Genetic Stocks

Development of Trait-Specific Genetic Stocks

Development and distribution of genetic stocks with specific traits such as adaptation to a specific environment, or resistance to one or more common pathogens and pests, was given high priority in 1984/85. Work on disease resistance included screening and selection within ILB accessions for resistance to *Botrytis fabae* at the disease screening site at Lattakia. However, emphasis is shifting to using resistance sources that have already been found. As a result, most work now involves screening F_2 population and F_3 to F_6 progenies from crosses of resistance sources to different high-yielding lines with adaptation to various environments in the region.

Germplasm for disease resistance. For chocolate spot (*Botrytis fabae*) 253 ILB accessions were screened and 241 single-plant selections made at Lattakia. These will be rescreened in 1985/86 with further within-line selection to purify the resistance. Of 253 accessions tested, 38 were rated 3. All of these originated from Ecuador; the highly resistant lines to chocolate spot were BPL 1179 and BPL 710.--*S. Hanounik and L.D. Robertson.*

Disease-resistant inbred lines. In 1982/83 the lines most resistant to chocolate spot, ascochyta blight, and rust were grown in bee-proof cages, and the progenies were grown again in 1983/84 and 1984/85 in bee-proof cages for further purification. There are now 44 chocolate spot, 25 ascochyta blight, and 30 rust-resistant lines purified for three cycles by disease inoculation and single-plant selection. In 1985/86 a diallel will be produced to study *Botrytis fabae* resistance using these sources of 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, Syria, and the UK as international disease nurseries in 1984/85. Three lines (BPL 710, 1179, and 1196) were found resistant or moderately resistant to chocolate spot across all four locations (Egypt, the Netherlands, Syria, and the UK) where the international chocolate spot nursery (FBICSN 85) was grown. These lines have also shown resistance for several years at all locations tested. From the data returned for the international ascochyta blight nursery (FBIABN-85) 12 out of 23 lines were rated resistant in Canada, Syria, and the UK (BPL 74-1, 74-3, 365, 460, 465, 471-1, 471-2, 471-3, 472-2, 472-3, 818, and BPL 2485). The remaining entries were resistant at some locations and susceptible at others. Data for the international rust nursery (FBIRN-85) were returned from only Canada, Syria, and Egypt. The results indicated the presence of location-specific resistance only. However, the chocolate spot resistant entries BPL 710 and BPL 1179 showed some resistance to rust also.--*S. Hanounik, L.D. Robertson, and R.S. Malhotra.*

Recombination of disease resistance with local adaptation. Germplasm from Ethiopia, Egypt, China, and Sudan was crossed at Tel Hadya to disease-resistant, early, and determinate lines (Table 1), but many crosses were lost due to frost. In 1985/86 crosses will be made with lines from Egypt, Ethiopia, Morocco, and Tunisia to introduce *Ascochyta fabae*, *Uromyces fabae*, *Orobanche crenata*, *Botrytis fabae*, and virus resistance. Additionally, crosses will be made with determinate, IVS (independent vascular supply), and such lines as Reina Blanca and New Mammoth which have shown good adaptation in the above mentioned countries.--*L.D. Robertson and S. Hanounik.*

Table 1. Number of crosses made for various traits or reasons in the 1984/85 season and those planned for the 1985/86 season (excluding crosses for alternative plant types).

Trait/Reason	Number of crosses 1984/85	1985/86
Resistance to :		
Ascochyta fabae	50	60
Botrytis fabae	64	60
Uromyces fabae	10	20
Multiple diseases	16	20
Protein percentage		10
Earliness	20	
Yield	26	
National program requests	26	204
Total	212	374

Resistance to *Aphis fabae*. From the 1984/85 yield trials, 1027 lines were screened for resistance to *Aphis fabae* in a plastic house at Tel Hadya. Five plants per line were infested with aphids and were later scored on a 1-5 scale (1=very resistant, 5=very susceptible). Most lines (83%) were susceptible with 848 rated 4.1-5.0, 8 rated 2.1-2.5, 23 rated 2.6-3.0, and 50 rated 3.1-3.5. Lines rated 1-3.5 will be rescreened in 1985/86.--*L.D. Robertson and C. Cardona.*

Frost resistance screening. Because of the extreme frosts at Tel Hadya in 1985 the 5005 BPL and 288 ILB accessions grown in the 1984/85 season were evaluated for frost resistance using the following 1-5 rating scale: 1, no visible symptoms of damage; 2, up to 20% leaflets in most plants show yellowing or withering but no damage to the stem; 3, 20-50% leaflets show damage, and some stem damage--up to 20% plants killed above ground but later most plants recover; 4, 50-75% leaflets and stem damage and 20-50% plants killed above ground level but later some plants recover; 5, all leaflets and stem above ground level killed - most plants do not recover.

Among the germplasm lines, 132 (2.5%) were rated 1 (Table 2). Of the 132 cold-tolerant accessions, only 52 BPLs and 10 ILBs set pods and produced seeds while the rest only set pods and no or very few seeds were produced. However, during the pod-filling stage in 1985 temperature was very high, and this indicated that these 62 germplasm lines were also tolerant to high temperature during their critical reproductive stage. This will be investigated by sowing these genotypes very late in 1986, so as to expose them to high temperature during pod-setting and pod-filling stage.--*M. El-Sherbeeny and L.D. Robertson.*

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 the most common diseases and pests are needed. In the crosses made in the 1984/85 season, at least one parent was resistant to a pest (Table 1). This approach will continue with the aim of involving at least one pest-resistant parent in most crosses.

Crosses were made in the 1984/85 season at Tel Hadya for several national programs including Egypt, Ethiopia, China, and Sudan. Extreme frost led to the loss of many crosses because of kill of parents and lateness of plants after frost recovery which led to seed loss due to high temperature at the end of the season. In 1985/86, crosses will be made of Ethiopian, Egyptian, Sudanese, Chinese, Tunisian, and Moroccan parents with lines possessing various traits requested by national programs. The crosses involving parent lines from Ethiopia, Egypt, and Sudan will be made at the Lattakia coastal site to avoid frost.

Table 2. Screening of faba bean germplasm lines for cold tolerance in the screenhouse at Tel Hadya, 1984/85.

Self-generation	No. of BPL	No. of lines in different scores of cold tolerance[1]				
		1	2	3	4	5
Increase[2]	58		4	6	29	19
Purification[2]	576	2	35	76	160	303
5	376	6	6	26	120	218
4	491	2	15	22	120	332
3	161			3	24	134
2	1494	21	110	265	559	539
1	1849	80	99	326	692	652
ILB	288	21	45	76	92	54
Total	5293	132	314	800	1796	2251
% of total		2.5	5.9	15.1	33.9	42.5

1. On the basis of 1-5 visual scale where 1 = no damage; 5 = all plants killed.
2. Six or more self-generations.

Yield potential. The breeding program at ICARDA and its linkage with national programs is schematically presented in Fig. 1. This scheme makes use of an off-season nursery at Shawbak, Jordan, at the F_1 and F_4 preliminary screening nursery stage, resulting in a 2-year time saving. Also, *Brassica napus* is used for segregating populations, progeny rows, preliminary screening nurseries, and preliminary yield trials for pollination control. 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 (F_4) progeny rows grown where selections are made for preliminary screening nurseries (after off-season increase). Selections are made among F_3 progeny rows with bulking of acceptable plants within rows. Lines are then advanced through preliminary screening nurseries and preliminary, advanced, elite, and international trials using multilocation testing.

The extreme frost in 1985 at Tel Hadya resulted in a loss of many faba bean yield trials and increases. In the trials harvested the yield levels were very much reduced with the highest yield reported in a replicated trial of only 2.5 t/ha compared to 4.9 t/ha in the 1983/84 season (Table 3). Replicated yield trials of 1150 lines were conducted at Tel Hadya under irrigated and at Jindiress under rainfed conditions in 1984/85. Only 18 entries exceeded the best check at the 5% probability level. A combination of high CVs and the frost resistance of the best check was responsible for this. In the FBIYT-S and FBEYT-S, 26 entries exceeded the best small-seeded check.

At Terbol, the 1984/85 season yields were high, the best yield being 5.8 t/ha (Table 4). Out of 965 entries tested at Terbol in 1984/85, only four exceeded the best check at the 5% probability level. In the FBIYT-S and FBEYT-S, 20 lines exceeded the best small-seeded check at the 5% probability level.

A total of 3838 F_2 single-plant selections were made in the 1984/85 season which will be grown in F_3 progeny rows during the 1985/86 season. From the preliminary yield trials (large and small) 665 single-plant selections

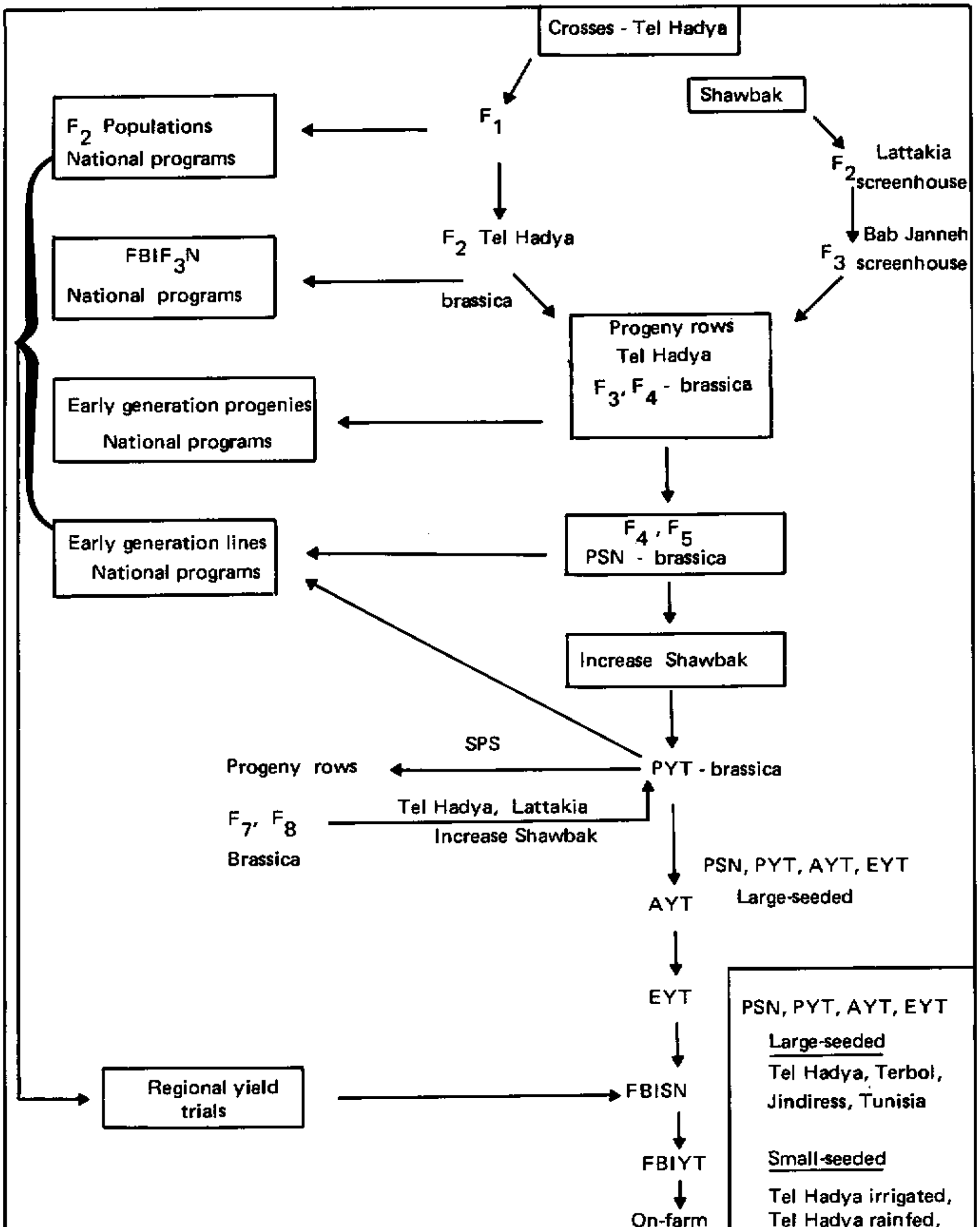


Fig. 1. Faba Bean Breeding Program at ICARDA.

were made which will be grown in progeny rows in the 1985/86 season. From the F_3 progeny rows of 1984/85, 282 large-seeded and 141 small-seeded selections were made and sent to the off-season for increase to include in the 1985/86 preliminary yield trials. Additionally, 562 large-seeded and 55 small-seeded selections were made from the F_3 progeny rows to start F_4 preliminary screening nurseries in the 1985/86 season.

Table 3. Results of Faba Bean Yield Trials grown at Tel Hadya and Jindiress, 1984/85.

Trial	No. of test entries	No. of lines exceeding best check	No. of lines significantly exceeding best check (5%)	Grain yield (kg/ha) Trial(s) mean	Best line mean	Best check mean	LSD Check vs line (5%)	CV (%)	Checks
FBIYT-L	22	0	0	1155	1352	1803	431	26	ILB 1814
FBIYT-S	22	0	0(13)[3]	1211	1769	1926(671)[4]	427	25	ILB 1812, ILB 1819
FBISN-L[1]	48	0	0	1629	2691	2782	3265	63	ILB 1814, ILB 1270
FBISN-S	60	51	13	1148	1955	491	543	43	ILB 1278, ILB 1820
FBEYT-L[2]	34	3	0	1429	2002	1917	491	21	ILB 1814
FBEYT-S	33	0	0(13)[3]	1413	2103	2510(938)[4]	650	28	ILB 1814, ILB 1816
FBAYT-L[2]	94	9	0	1093	1778	1376	428	24	ILB 1814, ILB 1817 ILB 1270
FBAYT-S	83	1	1(19)[3]	927	2078	1690(740)[4]	374	38	ILB 1812, ILB 1816
FBPYT-L	712	28	4	1142	2322	1798	345	31	ILB 1814, ILB 1817
FBPYT-S	90	2	0(20)[3]	952	1945	1659(860)[4]	313	32	ILB 1814, ILB 1816

1. Data from unreplicated screening nursery, augmented design.
2. Data from Jindiress, Syria; all other trials from Tel Hadya, Syria.
3. Number of lines significantly exceeding small-seeded check.
4. Mean of best small-seeded check.

Table 4. Results of Faba Bean Yield Trials grown at Trebol, Lebanon, 1984/85.

Trial	No. of test entries	No. of lines exceeding best check	No. of lines significantly exceeding best check (5%)	Grain yield (kg/ha) Trial(s) mean	Best line mean	Best check mean	LSD check line (5%)	CV (%)	Checks
FBIYT-L	22	8	0	5010	5440	5120	N.S.	9	ILB 1814, ILB 1817
FBIYT-S	22	0	0(1)[1]	5065	5565	5616(5009)[2]	525	7	ILB 1812, ILB 1819 ILB 1816
FBISN-L	48	9	2	3970	4731	4287	N.S.	18	ILB 1814, ILB 1820
FBISN-S	60	35	0	3880	4852	3988	937	15	ILB 1278, ILB 1820
FBEYT-L	34	3	0	4474	5326	5071	947	13	ILB 1814, ILB 1817
FBEYT-S	33	0	0(19)[1]	4734	5309	5789(4113)[2]	584	8	ILB 1814, ILB 1816
FBAYT-L	94	39	1	4679	5659	4768	820	11	ILB 1814, ILB 1817 ILB 1270
FBAYT-S	60	33	0	4103	5204	4201(3670)[2]	N.S.	23	ILB 1812, ILB 1816
FBPYT-L	636	28	1	3742	4926	4274	424	11	ILB 1814, ILB 1816

1. Number of lines significantly exceeding best small-seeded check.
2. Mean of best small-seeded check.

From 712 large-seeded and 90 small-seeded lines tested in the preliminary yield trials, 94 were selected for inclusion in the 1985/86 advanced yield trials. From 94 large-seeded and 83 small-seeded lines tested in the 1984/85 advanced yield trials, 45 each were selected for the 1985/86 elite yield trials.--*L.D. Robertson.*

Disease resistance. Most disease resistance work, as mentioned earlier, 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 50 crosses for ascochyta blight in 1984/85. Nine F_4 progenies, selected from a cross between BPL 460 and ILB 37, were screened in the 1984/85 season. Seven lines were rated 1 and the other two were rated 3. These lines will be tested in preliminary yield trials in 1985/86. F_2 populations from eight crosses for ascochyta blight resistance were screened in 1984/85 and 75 single-plant selections made for increase in the off-season and rescreening in 1985/86.

Chocolate spot: In the F_4 nursery, 45 lines selected from 14 crosses in 1984 were screened; 41 were rated 3, and the remaining 4 entries rated 5. Spreader rows were rated 9.

Seed from 27 single-plant selections and 36 uniform bulk rows was harvested and was multiplied at Bab-Janneh in the 1985 off-season for further evaluation for disease resistance, and also to provide seed for F_6 preliminary screening and yield trials. One line (S81077-1), selected from a cross between BPL 18 (chocolate spot resistant) and Reina Blanca (large seeded) was mass selected for resistance and yield and increased in the off-season for multilocation yield testing.

From 13 crosses screened for *B.fabae* resistance, 68 single-plant selections were made and seed from these was increased in the off-season for rescreening. Additionally, 64 new crosses were made for chocolate spot resistance.

Durable disease resistance: Considerable evidence is now available on the presence of a wide pathogenic variability in *B. fabae* and *A. fabae*. Combination of genes from plants with different mechanisms for resistance should result in lines with more durable resistance than those with simply one mechanism for resistance. In our program, genotypes were observed that had different mechanisms for resistance, such as hypersensitivity, tolerance, disease escape, and others. Therefore, several crosses were made in 1983 to combine genes for such mechanisms into one cultivar with durable resistance.

F_4 botrytis x botrytis: This nursery included 31 F_4 test entries selected from F_2 progenies of 17 crosses made in 1983 between several chocolate spot resistant sources. In this nursery 4 entries were rated 1, and 27 rated 3. Plants in spreader rows were rated 9. Seed from 21 single-plant selections, and also from 21 uniform bulk rows was increased at Bab-Janneh during the 1985 off-season for multilocation evaluation, purification, and preliminary screening and yield trials in 1985/1986.

F_4 ascochyta x ascochyta: This nursery consisted of 68 F_4 test entries selected from F_2 progenies of 31 crosses made in 1983 between several ascochyta blight resistant sources. In this nursery 7 entries were rated 1, and 60 rated 3. Plants in spreader rows were rated 9. Seed from 90 single-plant selections was increased at Bab-Janneh during the 1985 off-season for multilocation evaluation, and also for purification and a preliminary yield trial in 1985/86.

Multiple disease resistance: In 1984/85, 16 crosses were made combining resistance to two pathogens. These will be evaluated in 1985/86 at Lattakia.--*L.D. Robertson and S.Hanounik.*

Yield testing of disease resistant selections: From 356 progeny rows of disease-resistant selections from Lattakia, 111 selections for yield were made and increased in the off-season for preliminary yield trials in 1985/86. In 1984/85, 71 disease-resistant selections were grown in preliminary yield trials and 39 selected for advanced yield trials in 1985/86.--*L.D. Robertson and S. Hanounik.*

Adaptability of faba beans. Our earlier work has shown that faba bean lacks wide adaptability to different environments. In 1984, 25 crosses were made between five lines from ICARDA and five from north Europe (University of Hohenheim) to produce populations for simultaneous selection and reciprocal testing, followed by selection and recombination, to develop a faba bean germplasm pool with wide adaptability. In 1985, double crosses among the F_2s of the original 25 crosses were made and these will be grown in 1985/86 to produce the base population for selection.

Another approach to improve adaptability in faba bean is to send to different locations the segregating populations from crosses of local populations with lines selected for specific traits. This provides useful variability for selection for those environments. Providing populations with specific traits and adaptability to various conditions will be of increasing importance in the coming years.

Additionally, F_3 progenies and lines from preliminary and advanced yield trials have been sent to national programs for selection in different environments. Populations and lines distributed for the last 2 years of this type are listed in Table 5.

Material has been used directly and through selection within bulks and lines by breeders on site. Six lines were selected in north Yemen for further testing in replicated trials. In Sudan, 15 lines were selected for resistance to bean leaf roll virus. These lines are proposed to be crossed with Sudanese parents in 1985/86. In Tunis, more than 300 single-plant selections were made from ICARDA supplied F_3 bulks and progenies. In China, 11 determinate progenies were rated very good and 14 good. Of the F_3 progenies 9 were very good and 44 good.--*L.D.Robertson.*

Table 5. Distribution of F_2 and F_3 bulks and early-generation lines to national programs in 1984 and 1985.

Year/Country	No. of lines/ crosses	Type of material
1984		
Tunisia	47	AYT-L
Tunisia	88	PYT-L
Tunisia	600	F_3 Progenies
Tunisia	83	F_3 bulks
China	249	F_4 progenies
China	273	Determinate progenies
China	31	F_3 progenies
China	17	PYT lines
Ethiopia	198	F_2 and F_3 bulks
Egypt	885	PYT lines
Sudan	345	PYT lines
1985		
North Yemen	38	Elite tria
Ethiopia	600	F_3 progenies
Morocco	32	F_2 and F_3 bu
Tunisia	18	F_3 bulks
Tunisia	784	F_3 progenies
Tunisia	959	Screening nursery-early generation lines
Sudan	253	F_3 bulks
Egypt	4	4 mass selections
China	100	Determinate lines

Alternative Plant Type Faba Bean Genetic Stocks

Determinate faba bean genetic stocks: The determinate habit is of potential importance in faba bean production areas which are either irrigated or are highly fertile. Its use will stem from the curtailment of vegetative growth, which is currently excessive under these conditions, and a corresponding increase in harvest index.

The 'topless' (determinate) mutant from north Europe is poorly adapted to the Mediterranean environment, and efforts are being made to transfer the character into an adapted background. Crosses made with at least one determinate parent numbered 296 this season. These were increased in the off-season and F_2 populations will be screened for determinate plants in the 1985/86 season.

From F_2 populations, 1362 determinate single plants were selected and will be grown in F_3 progeny rows during 1985/86. In the 1984/85 season, 237 single plants were selected from F_3 progeny rows and they will be grown in F_4 progeny rows during 1985/86. Also, 237 F_3 progenies and PYT-determinate single plants were selected for a preliminary screening nursery.

Replicated yield trials were conducted with 348 determinate lines. Because of frost the determinate lines were much poorer than the check compared to the 1983/84 season. No lines were as high yielding as the best check (ILB 1814), but 66 were as high yielding as the second check (ILB 1816) in the preliminary yield trials. In 1985/86 the determinate trials will be planted at Lattakia (where frost is not a problem) and at Tel Hadya to ascertain the yield potential of determinate lines.--*L.D. Robertson.*

Independent vascular supply lines (IVS): These are lines in which each flower in a raceme has an independent vascular supply, the result of which is that all flowers in a raceme produce pods and flower shedding is greatly reduced. These IVS lines have been grown at ICARDA in 1984/85 for the first time and 10 crosses were made though only a few seeds of each cross were obtained because of frost susceptibility of the six lines received from the University of Durham. Crosses will again be made in 1985/86 with Mediterranean types and a replicated yield trial of IVS lines and selections from IVS F_3 and F_4 populations grown in 1984/85 will be conducted at Tel Hadya and Lattakia.--*L.D. Robertson.*

Breeding Methods

Studies on outcrossing. In large-scale breeding programs outcrossing due to insect pollinators is undesirable because this makes it difficult to maintain the genetic identity of many different lines. To prevent outcrossing, cumbersome and costly methods of isolation, such as distance, insectproof cages or individual bagging of plants with nylon nets have had to be used.

The effect on bee activity and outcrossing rates of using *Brassica* and triticale to surround faba bean increase plots is shown in Tables 6 and 7. *Brassica* and, to a lesser extent, triticale were very efficient in reducing bee activity within 6 x 12 m faba bean plots. However, this significant reduction in bee activity did not result in a corresponding reduction of interplot outcrossing rates (the reduction was only 11 to 9%). Counts of bee activity took into consideration interplot and intraplot activity. To separate these would have required watching when each bee came into and out of the 6 x 12 m the plot, an impossible task. Faba bean outcrossing is not possible without bee activity and normally a reduction or increase of bee activity will result in a decrease or increase in rates of outcrossing. Since there was not a significant reduction of interplot outcrossing with *Brassica* or triticale separation of faba bean plots, even though there was a large decrease of bee activity within the plots, it can be assumed that the effect of the attractant crop (*Brassica*) and the physical barrier (triticale) was to reduce mostly the intraplot bee activity, which should be followed by a concomittant reduction in intraplot outcrossing rates.

Table 6. Effect of isolation mechanisms on the number of honey bees and solitary bees making positive visits to faba bean flowers. Means of six scoring dates, four replications, Tel Hadya, Syria.

	No. of positive visits/3-min observation period			
	1983		1984	
Separator	**HB**[1]	**SB**[2]	**PB**	**SB**
Brassica	0.5	0.7	0.3	0.7
Triticale	7.5	2.7	1.6	1.6
Bare-ground check	21.7	8.2	1.9	2.4
SE ±	3.1	1.1	0.4	0.4
CV (%)	54.6	49.2	53.5	38.8

1. Honey bees.

2. Solitary bees, mainly Anthophora canescens.

Table 7. Interplot outcrossing using triticale, *Brassica*, and bare ground to separate faba bean plots for the years 1982, 1983, and 1984 at Tel Hadya, Syria.

	Outcrossing percentage			
Separator	**1982**	**1983**	**1984**	**Mean 1983/84**
Triticale	9.0 ± 0.60[1]	11.3 ± 1.10	6.8 ± 0.57	9.1 ± 0.64
Brassica	7.4 ± 1.05	11.1 ± 0.90	5.9 ± 0.57	9.0 ± 0.57
Bare ground	-	10.5 ± 1.10	10.3 ± 0.57	10.4 ± 0.64
CV (%)	24.3	28.5	21.2	27.0

1. SE ±.

Although *Brassica* and triticale did not differ in interplot outcrossing, *Brassica* was more efficient in reducing bee activity. This should be followed by lower intraplot outcrossing rates. Work will continue using *Brassica* and, since the widths of separation with *Brassica* did not affect bee activity, future studies will be conducted with 2 m separation between faba bean plots. This will lead to a substantial reduction in land planted to *Brassica* and make the system more efficient.

If the hypothesis that *Brassica* reduces intraplot outcrossing is correct, then it could be used for breeding programs when large numbers of plants or lines are grown closely packed and there is a need to minimize interline or interplant outcrossing. Also, this would provide a technique for selfing lines in early generations so as to fix their genetic composition. This will be investigated by growing six 1-meter rows of a white hilum check, Reina Blanca, distributed evenly within 12 x 12 m *Brassica*-surrounded

Table 8. Direct and indirect effects of yield components on yield of 15 F_2 populations grown at Tel Hadya, 1983/84.

Character	Pods/ plant	Seeds/ plant	Seeds/ pod	10-seed weight	Pod length	Seeds/ ovule	Ovules/ ovary	Correlation with yield
Pods/plant	0.0067NS	-0.0126	0.7191	-0.2348	-0.0708	-0.0017	0.0134	0.419**
Seeds/pod	-0.0017	0.0481NS	0.2155	-0.0250	0.0954	-0.0129	-0.0379	0.282**
Seeds/plant	0.0056	0.0121	0.8550**	-0.2442	-0.0270	-0.0084	-0.0063	0.586**
10-seed weight	-0.0028	-0.0022	-0.3762	0.5551**	0.1168	0.0044	-0.0008	0.294**
Pod length	-0.0022	0.0209	-0.1052	0.2937	0.2192**	-0.0003	-0.0204	0.408**
Seeds/ovule	0.0004	0.0197	0.2283	-0.0766	0.0024	-0.0315NS	0.0020	0.144**
Ovules/ovary	-0.0021	0.0423	0.1257	0.0105	0.1037	0.0015	-0.0431NS	0.239**

** $P < 0.01$.

plots containing 120 progeny rows in six ranges. A similar pattern will be grown in a separate field with no *Brassica* to serve as a check.

Studies on selection criteria. A subset of the F_2 populations from 15 crosses involving 5 for large x large-seeded parents, 5 for large x small-seeded parents, and 5 for small x small-seeded parents was grown in 1983/84 at Tel Hadya and studied for yield and yield components. Analysis was done using path coefficients to determine direct and indirect effects in 1985. Table 8 shows direct and indirect effects for yield for all 15 crosses. This shows that the trait with the largest direct effect on yield is seeds/plant followed by 10-seed weight. Even though pods/plant had a nonsignificant direct effect on yield, it had a strong correlation due to a large indirect effect through seeds/plant. Indirect selection for seed number can easily be done using pods/plant because of the high correlation between the two ($r = 0.841^{**}$). Also pod length can be used to increase yield because it has both a direct effect and an indirect effect through 10-seed weight which is not negated by a large indirect effect through seed/plant as with selection for 10-seed weight itself. The same general pattern was found regardless of seed size of the parents of the cross.--*L.D.Robertson.*

Faba Bean Diseases: Epidemiology and Integrated Control

As already indicated, chocolate spot, ascochyta blight, rust, and stem nematodes are considered to be among the most important diseases of faba beans throughout West Asia and North Africa. Use of resistant cultivars is believed to be the most practical and the least expensive means of control of these diseases. Efforts in this area have been outlined in the previous section dealing with the development of genetic stocks and cultivars. However, studies on integrated control, epidemiology, and disease development as related to certain components of host resistance, undertaken at Lattakia in the 1984/85 season, are reported below.

Integrated Control of Ascochyta Blight

The objective of this work was to develop integrated control strategies for ascochyta blight through the combination of genetic resistance and chemical treatments. Three ascochyta blight resistant (BPL 472, 460, and 74), one moderately resistant (ILB 1814), and one susceptible (ILB 1820) faba bean genotypes were evaluated for their response to four different treatments: (1) Bravo-500 (chlorothalonil 40%), a contact fungicide

Table 9. Influence of host resistance and chemical treatments on development of ascochyta blight in faba bean.

Ttreatment	Method of application	Disease reaction[1] BPL 74	BPL 472	BPL 460	ILB 1814	ILB 1820
Bravo-500 (2.5 ml/l)	Foliar	1.00a	1.00d	1.00f	1.00h	4.33k
Derosal-60 WP (0.5 g/l)	Foliar	2.33b	3.66e	3.66g	4.33i	9.00l
Derosal-60 WP (7.5 g/1kg seeds)	Seed dressing	3.66c	3.66e	4.33g	4.33i	9.00l
Untreated (water spray only)		3.00c	3.66e	3.66g	5.00j	9.00l

1. Disease reaction was recorded 4 months after planting using a 1-9 rating scale.
Numbers followed by different letters within a column are significantly different (P 0.01) according to Duncan's Multiple Range Test.

applied to the foliage once only at the rate of 2.5 ml/l of water, 1 day before artificial inoculation; (2) Derosal-60 WP (carbendazim 59%), a systemic fungicide applied to the foliage once only at 0.5 g/l of water, when first lesion was observed after artificial inoculation; (3) Derosal-60 WP, used as a seed dressing treatment at the rate of 7.5 g/kg seeds, and (4) untreated control sprayed with water only (Table 9). A split-plot design, with chemical treatments in the main plot and faba bean genotypes in the subplot, was used with three replications. All treatments were inoculated artificially with *A. fabae* 300,000 spores/ml of water 110 days after sowing.

The results of this test (Table 9) indicated that disease severity was affected by chemical treatments and the host resistance but more so by the combined effects of the two. Disease severity on the ascochyta blight susceptible genotypes ILB 1820 decreased significantly from a high level of 9 in untreated to a low level of 4.33 in Bravo-treated plots (Table 9, Fig. 2). Similar trends were observed for the remaining genotypes. One foliar application of Bravo-500 was significantly more effective than both foliar and seed dressing treatments with Derosal-60 WP. In untreated plots, the use of host resistance only decreased disease severity significantly from a high level of 9

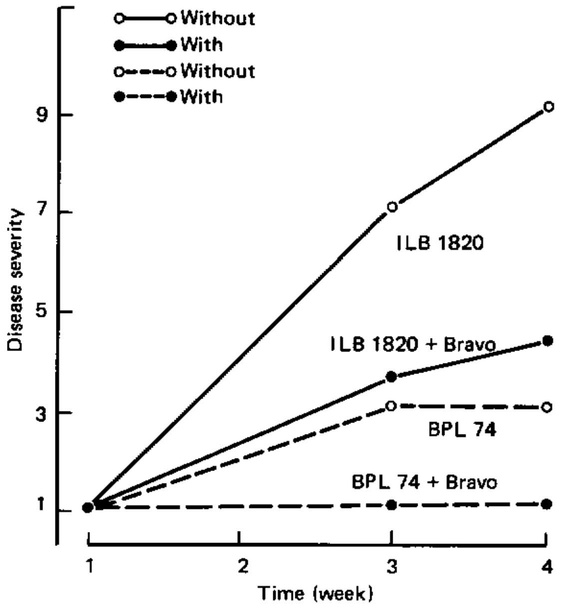


Fig. 2. Progress of ascochyta blight on the susceptible host ILB 1820 and the resistant host BPL 74 with and without chemical protection.

on the ascochyta blight susceptible genotype ILB 1820 to an intermediate level of 5 on the moderately resistant genotype ILB 1814, and finally to a low level of about 3 on the remaining resistant genotypes BPL 460, 472, and 74. Although decreases in disease severity due to chemical treatment or host resistance alone were significant, they were sharper when both application of an effective chemical and host resistance were combined.

Epidemiology

Relationship between faba bean leaf age and susceptibility to *Botrytis fabae* and *Ascochyta fabae*. Information on the relationship between the age of faba bean plants and their susceptibility to *Botrytis fabae* and *Ascochyta fabae* is limited. Results from 1983/84 indicated that at the 100% podding stage leaf tissue was more susceptible to *B. fabae* than pod tissue, but there were no significant differences in susceptibility to *A. fabae* among leaf, stem, or pod tissues. It is known that these pathogens first infect leaf tissue and then other plant organs. Therefore, additional information on the relationship between leaf age and susceptibility to *B. fabae* and *A. fabae* is needed to help understand the development of these diseases and their epidemiology, and also to improve existing screening techniques and chemical control strategies.

Healthy leaves from the 2nd, 4th, 6th, 8th, 10th, and 12th node positions of the Syrian Local Large faba bean cultivar ILB 1814 were collected from the field. These were laid flat on a moist 2-cm thick sponge, lining the bottom of a 90 x 40 x 5 cm metal pan, then inoculated separately with *B.fabae* and *A.fabae*. After 6 days from inoculation, infections by each pathogen were rated on ICARDA's 1-9 scoring scale. A split-plot design with leaf-node position in the main plot and pathogens in the subplot was used with five replications.

The results of this study indicated that disease severities were significantly lower (P = 0.05) on younger top leaves than on older bottom ones (Fig. 3). Although the level of damage by *B.fabae* was significantly (P = 0.05)

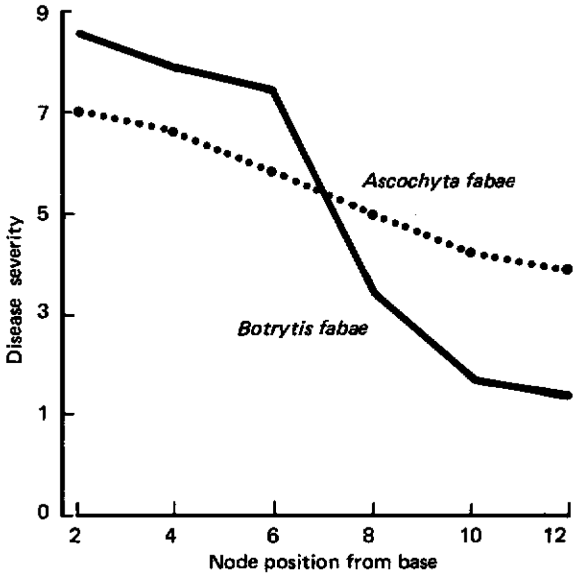


Fig. 3. The relationship between faba bean leaf age (as indicated by node position) and susceptibility to *Botrytis fabae* and *Ascochyta fabae*.

higher than that by *A.fabae* on leaves from node positions 2, 4, and 6, it was significantly (P = 0.05) lower on leaves from node positions 8, 10, and 12. Results from this study indicated that artificial inoculations, when bottom leaves have fully developed, may be more efficient for effective screening.

Chocolate spot in relation to certain components of resistance in faba bean. Several lines with resistance to chocolate spot have recently been identified at ICARDA. Although these lines prevented the buildup of high epidemic proportion at many locations, the speed of disease progress was found to vary from one line to another under the same field conditions. This indicated that differences among these lines can probably be due to differences in their efficiency to suppress or delay spore germination, penetration, incubation and latent periods, or sporulation.

Therefore, an attempt was made to determine some of these components on certain chocolate spot resistant lines to help identify lines that affect most the speed of disease progress. This will also help to develop lines with durable resistance by gene recombination.

Healthy leaves at the 8th node position were collected from the chocolate spot resistant BPL 710, 1179, and 1196 and also from the chocolate spot susceptible (Rebaya-40) faba bean lines grown in the field. These leaves were inoculated separately with two isolates of *B.fabae*, employing a modification of the detached-leaf technique. A split-plot design with five replications, with faba bean genotypes in the main plot and isolates of *B.fabae* in the subplot, was used.

Three parameters (apparent infection rate, incubation, and latent periods) were determined. The apparent infection rate (r) was determined to measure the speed of disease progress using the equation

$$r = \frac{1}{t_2 - t_1} (\log X_2 - \log X_1)$$

where: r = apparent infection rate, t = time in days, X_1 = % necrosis at t_1, X_2 = % necrosis at t_2. The incubation and the latent periods were determined by measuring the time from the arrival of spores to leaf surface until the appearance of the disease symptoms, and the formation of a new spore generation, respectively.

The results (Fig. 4) indicated that isolates B-9 and A-10 of *B.fabae* differed significantly (P = 0.05) in their apparent infection rate and incubation and latent periods across the four faba bean lines included in this test. The faba bean line BPL 710 had the longest incubation and latent periods, followed by 1179, 1196, and Rebaya-40. BPL 710 with the longest

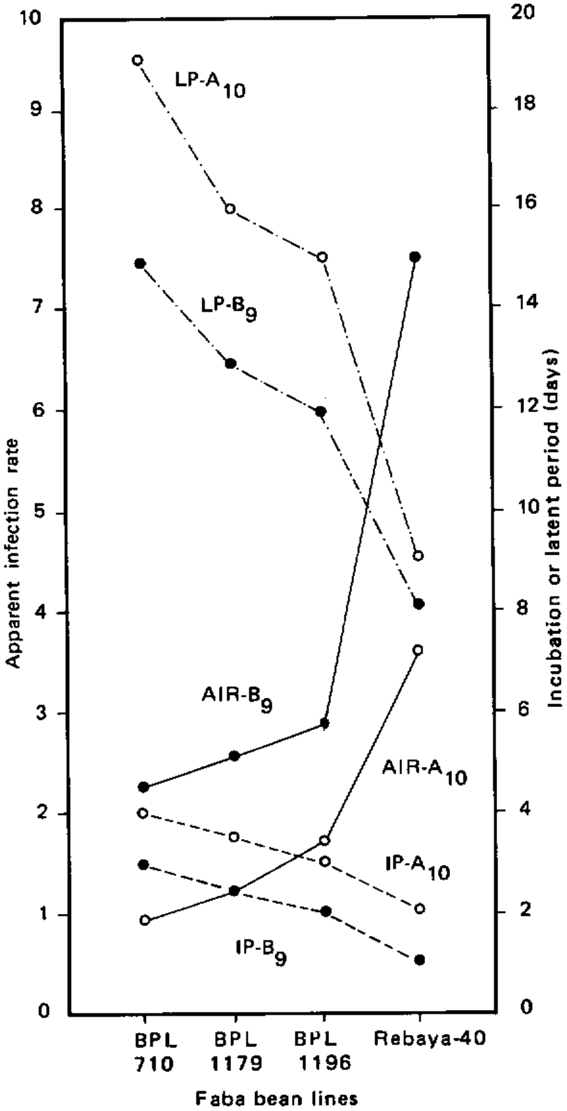


Fig. 4. The apparent infection rate (AIR) as related to the incubation (IP) and latent (LP) periods of isolates B_9 and A_{10} of *Botrytis fabae* on four faba bean lines in detached leaf test at Lattakia, 1984/85.

incubation and latent periods had the lowest apparent infection rate (slow disease progress), whereas Rebaya-40, with the shortest incubation and latent periods, had the greatest apparent infection rate (fast disease progress). These findings were

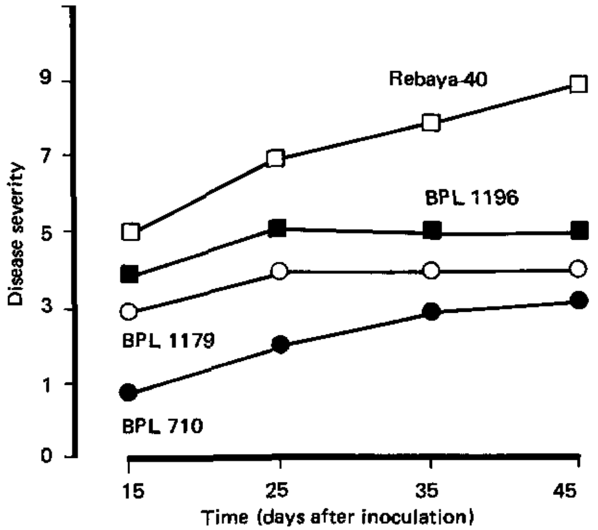


Fig. 5. Chocolate spot progress on faba bean lines BPL 710, 1179, 1196, and Rebaya-40 in the field in Lattakia, 1984/85.

supported by field observations (Fig. 5). BPL 710, 1179, and 1196 with longer latent and incubation periods, and lower apparent infection rates, allowed for slower disease progress than Rebaya-40 with shorter incubation and latent periods and a greater apparent infection rate. The study provided a quantitative model to rank chocolate spot resistant lines according to their increasing latent and incubation periods and to their decreasing apparent infection rates. It also explained why some chocolate spot resistant lines (such as BPL 710) are more efficient than others (BPL 1179 or 1196) in allowing the development of only minimum disease levels.--*Salim Hanounik.*

Faba Bean Insects and their Control

Insect Populations

In all trials as well as in farmers' fields, the black aphid, *Aphis fabae*, was the most important insect pest on faba beans. *Sitona limosus*, *Apion*, thrips, *Lixus algirus*, and *Bruchus dentipes* occurred at low population levels and did not, in general, reach economic injury levels.

Studies on natural enemies of *Sitona limosus* revealed that egg parasites were responsible for an average seasonal egg mortality of 9.3% and that predators killed only 0.4% of the eggs. As *S. limosus* females lay an average of 1800 eggs/female, these levels of natural control are not considered adequate to keep weevil populations below economic levels. Aphid predators, mainly *Coccinella* spp., were not efficient in suppressing black aphid populations.

Insect Control Recommendations

In the absence of reliable natural enemies of faba bean insect pests, rational chemical control is an appropriate alternative. Selective control of *Sitona* with a plant-neutral insecticide (heptachlore) applied at planting, and aphid control at the preflowering and pod-setting stages with a highly selective aphicide (pirimicarb), were compared in a full factorial trial with four replications (Table 10). *Sitona* damage did not have a significant effect on yields, confirming the previous seasons' findings. On the other hand, losses due to aphids ranged from 17% in plots treated twice with pirimicarb to 84% in check plots (Fig. 6). Early or preflowering aphid control was more important than the late or podsetting one, both for preventing yield losses and economic returns. Maximum net benefits were obtained with two sprays. This suggests that in outbreak years, when aphid populations are high from the preflowering to the pod-filling stage, up to two applications may be needed to achieve adequate levels of crop protection. The risk involved seems to be low because the cost of chemical treatment is small compared with the losses associated with large aphid infestations.

Table 10. Yield (kg/ha) of Syrian Local Medium faba beans as affected by selective control of *Sitona* weevils and aphids. Means of four replications, Tel Hadya, 1984/85.

Sitona[1] control	With late aphid control[2]: With early aphid control	With late aphid control[2]: Without early aphid control	Difference	Without late aphid control: With early aphid control	Without late aphid control: Without early aphid control	Difference
Yes	1465	507	958**	1036	339	697**
No	1215	395	820**	842	236	606**
Difference	250ns	112ns		194ns	103ns	

ns = nonsignificant; ** significant at 1% level; CV for yields = 30.3%

1. Mostly Sitona limosus; with heptachlor, 2.0 kg a.i./ha.

2. Mostly Aphis fabae; with pirimicarb, 0.15 kg a.i./ha.

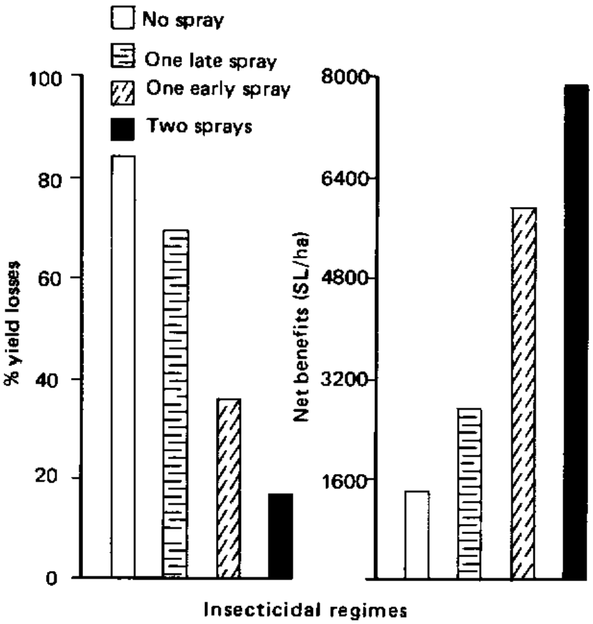


Fig. 6. Yield losses on faba beans and resulting net benefits obtained through different insecticidal regimes for the control of aphids. Means of four replications, Tel Hadya, 1984/85.

The profitability of control to prevent either aphid mechanical damage or damage due to aphid-transmitted viruses was confirmed in another trial. Simple insecticidal regimes with a broad-spectrum, longer lasting systemic insecticide (methidathion) or with pirimicarb had a highly significant effect on yield and net benefits (Table 11).

For faba bean aphid control the timing of application is critical, given the short residual effect of aphicides and the high capacity of this insect to reinfest the crop. Based on previous results, three methods to assess aphid populations or damage were compared: (i) visual infestation scores (1 = no aphids present, 5 = many indistinguishable colonies present in practically all plants), (ii) visual damage scores (1 = no damage, 4 = very severe damage), and (iii) per cent stems infested. Visual infestation scores correlated well with yield ($r = -0.84^{**}$) but were found to be more difficult to follow by untrained operators. Better correlations were found with visual damage scores and percentage stems infested (Fig. 7). Both are easy and could be utilized as tools in the decision - making process for aphid control. When tested, visual damage scores were found to be more easily understood by untrained operators.

The usefulness of visual aphid damage scores in predicting yield losses was confirmed in another trial in which combined scores at flowering and pod setting were correlated with yield losses (Fig. 8). The steep slope confirms the importance of black

Table 11. Yields and net benefits obtained in faba bean plots treated to prevent aphid and aphid-transmitted bean leaf roll virus damage. Means of four replications, Tel Hadya, 1984/85.

Treatment	Yield (kg/ha)		Net benefits (SL/ha)	
	Without virus infection	With virus infection	Without virus infection	With virus infection
One spray[1]	950	1020	6040	6495
Two sprays[2]	872	1076	5582	6908
No spray	399	19	2593	123
LSD (1%) for yields	315.8	211.6		
CV(%) for yields	21.0	21.7		

1. With methidathion, 0.5 kg a.i./ha
2. With pirimicarb, 0.15 kg a.i./ha

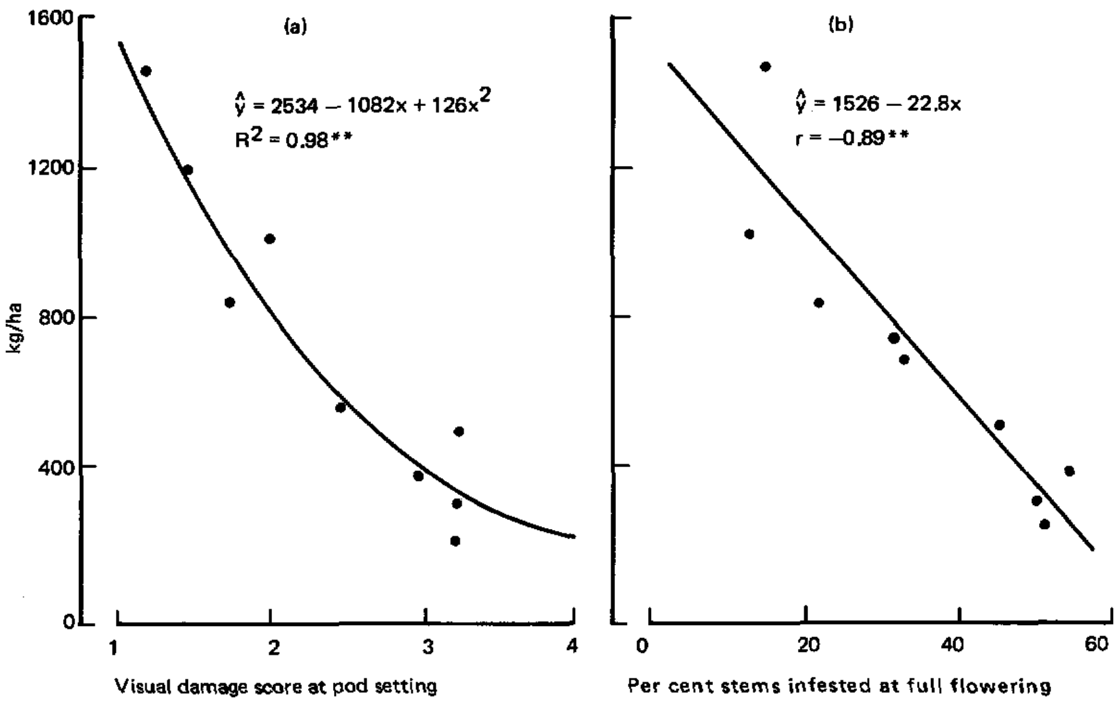


Fig. 7. The regression of yields of faba beans on (a) visual aphid damage scores at pod setting and (b) per cent of stems infested at flowering. Means of four replications, Tel Hadya, 1984/85.

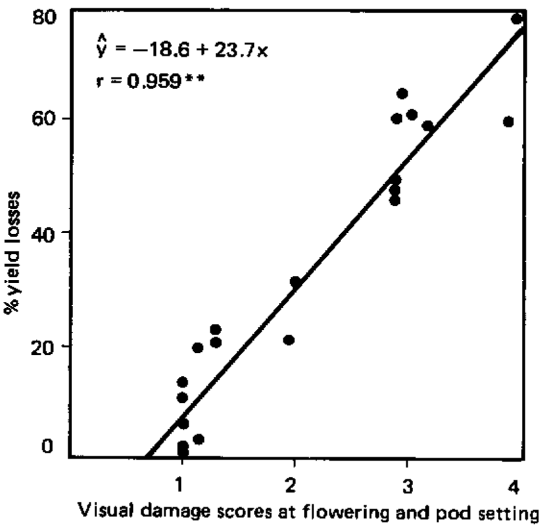


Fig. 8. The regression of percent yield losses due to faba bean aphids on aphid visual damage scores at flowering and pod setting. Means of four replications, Tel Hadya, 1984/85.

aphids as pests of faba beans; it also suggests that, when infestations are high at the preflowering stage, early applications would be justified before damage reaches grade 2 on a 1-5 score scale.

Economic Importance of the Stemborer

Previous observations had suggested that the stemborer (*Lixus algirus*), though common along the Mediterranean coast, does not seem to have an economic impact on the yield of faba beans. To test this hypothesis, faba bean plots were artificially infested with a level two times as much as the average natural populations found in Syria (1.5 females/m^2). There was a nonsignificant (13.9%) reduction in yield due to stemborer damage (Table 12). If this result is reconfirmed in 1986, work on this species could be discontinued.--*Cesar Cardona.*

Weed Control

Work was carried out on both parasitic and nonparasitic weeds. The major parasitic weed in faba beans was *Orobanche* spp. The dominant nonparasitic weed species were *Avena sterilis*, *Phalaris brachystachys*, *Sinapis arvensis*, *Geranium tuberosum*, *Galium tricorne*, *Vaccaria pyramidata*, *Carthamus syriacus*, *Cephalaria syriaca*, and *Euphorbia helioscopia*.

Control of *Orobanche* spp.

Host resistance. Field screening for *Orobanche* resistance has been carried out for several years at ICARDA but no resistant line could be found. In order to have uniform standardized conditions so that the level of *Orobanche* seed infestation for all the test lines is the same, the screening work was moved from the field to the greenhouse and laboratory. Hence

Table 12. Effect of a high level of infestation (3 females/m^2) with *Lixus algirus* on the yields of Syrian Local Medium faba beans. Means of three replications, Tel Hadya, 1984/85.

Level of infestation	Percentage stems			Yield
	Perforated	Infested	Lodged	(kg/ha)
3 females/m^2	70	27	22	710
Uninfested check	0	0	10	825
F - test			ns	ns

ns = nonsignificant.

a series of experiments has been conducted, some with the help of the Royal Tropical Institute, Amsterdam, The Netherlands, to develop techniques of laboratory screening that can give field-applicable results. A greenhouse procedure for single-plant selection of *Orobanche*-resistant faba bean from a population of Giza 402 has been developed. This will permit purification of Giza 402 for *Orobanche* resistance and the purified source can be used for future breeding program.--*J. Sauerborn and S. Kukula.*

Chemical control of *Orobanche*. A trial on chemical control using glyphosate was conducted at Lattakia. The trial site had a low *Orobanche* infestation, so the chemical control measures were not beneficial. However, the results indicate that applying glyphosate once at the beginning of flowering at 0.08 or 0.12 kg a.i./ha did not depress yield or harvest index (HI). Delaying spraying by 15 days or increasing the frequency of application to twice or thrice decreased yield and harvest index substantially, this effect increasing with increase in rate and frequency of spraying.--*S. Kukula, S. Silim, and M.C. Saxena.*

Control of Nonparasitic Weeds

As a part of the International Faba Bean Chemical Weed Control Trials, studies were conducted during the 1984/85 season at Jindiress (Syria) and Terbol (Lebanon). In Jindiress, all weed control measures significantly reduced the level of weed infestation. Hand weeding twice was as effective as continuous hand weeding. Seed yield, however, did not increase significantly in response to weed control measures, largely due to the low level of weed infestation. In addition, a slight reduction in both seed and biological yields was observed in treatments that included Igran due to the phytotoxicity of the chemical following severe frost in February and March.

In Terbol, yield loss due to weeds was significant (73%). Hand weeding twice was as effective as repeated hand weeding. Preemergence application of Igran, Igran with Kerb, Maloran, Maloran with Kerb, Tribunil with Kerb, and Bladex (0.5 kg a.i./ha) with Kerb gave very good control of weeds and resulted in yields similar to those obtained by hand weeding.

Faba Bean Production Agronomy and Physiology

Water-Use Efficiency in Genotypes Selected for Low-Rainfall Environments

In environments where rainfall is low, faba bean growth is restricted and this results in inadequate ground cover and evaporative losses of soil moisture. At a given population, one way of reducing evaporation from the bare ground and at the same time increasing the amount of intercepted radiation and thus increasing productivity and water-use efficiency is to narrow the interrow spacing. Starting in 1983/84, therefore, a trial was initiated using faba bean genotypes that had performed well under low rainfall to investigate the yield performance and water-use efficiency at two populations (22 and 44 plants/m^2) and two row spacings (22.5 and 45 cm). The trial was repeated in the 1984/85 season. Pressure chamber was used for measurement of plant water potential and soil moisture changes were monitored using the neutron-probe technique.

There were significant differences in yield among genotypes. ILB 1814 gave the highest yield, and 80S 43856. Line 80S 44367 gave the lowest yield (Table 13). Substantial yield increases were obtained by either reducing row spacing from 45 to 22.5 cm or increasing plant population from 22 to 44/m^2, and a combination of narrow row spacing and high population gave the highest yields.

Table 13. Means for seed yield (SY), total biological yield (TBY) and harvest index (HI) of different faba bean genotypes, 1984/85.

Genotype	Yield (kg/ha) SY	TBY	HI
80S 64214	1753	2948	0.60
80S 43856	2174	3573	0.61
80S 44358	1829	2923	0.63
80S 45057	1732	3011	0.58
80S 44815	1861	3224	0.58
80S 44367	1396	2270	0.61
80L 90121	1820	3154	0.57
ILB 1814	2569	4278	0.60
LSD (5%)	253	411	0.027
SE$\pm$	90	146	0.010
CV (%)	16.5	16.0	5.6

Table 14 presents seed yield, evapotranspiration, and water-use efficiency for eight genotypes studied at Tel Hadya rainfed conditions (378 mm) in 1984/85. ILB 1814 followed by line 80S 43856 were more efficient in their water use than other genotypes. In ILB 1814, both narrow row spacing and high plant population resulted in improved water-use efficiency.

The soil moisture profile extraction was not influenced much by treatments (Fig. 9). However, the general pattern shows that planting at narrow spacing (22.5 cm), regardless of the population, resulted in moisture extraction at a greater soil depth and a combination of high population and narrow row spacing resulted in a larger amount of water extracted and at a greater soil depth (Fig. 9). Similarly, leaf water potential did not show any consistent pattern from flowering to pod fill.

Table 14. Seed yield, evapotranspiration (ET) and water-use efficiency of ILB 1814 at 22 and 44 plants/m^2 and at 22.5 and 45 cm row spacings,and for seven other genotypes at 22 plants/m^2 and 45 cm spacings, Tel Hadya rainfed (378 mm), 1984/85.

Genotype	Population and row spacing combination *	Seed yield (kg/ha)	ET (mm)	Water-use efficiency (kg/ha/mm ET)
80S 64214	P_1 R_2	1043	262.2	3.98
80S 43856	P_1 R_2	1463	279.6	5.23
80S 44358	P_1 R_2	1234	262.2	4.71
80S 45057	P_1 R_2	1327	268.5	4.94
80S 44815	P_1 R_2	1241	268.6	4.62
80S 44367	P_1 R_2	836	239.4	3.49
80L 90121	P_1 R_2	1196	271.2	4.39
ILB 1814	P_1 R_1	1766	281.4	6.28
ILB 1814	P_1 R_2	2685	292.8	9.17
ILB 1814	P_2 R_1	2496	303.4	8.23
ILB 1814	P_2 R_2	3327	298.1	11.16

* R_1 and R_2 = 22.5 and 45.0 cm row spacing, respectively; P_1 and P_2 = 22 and 44 plants/m^2, respectively.

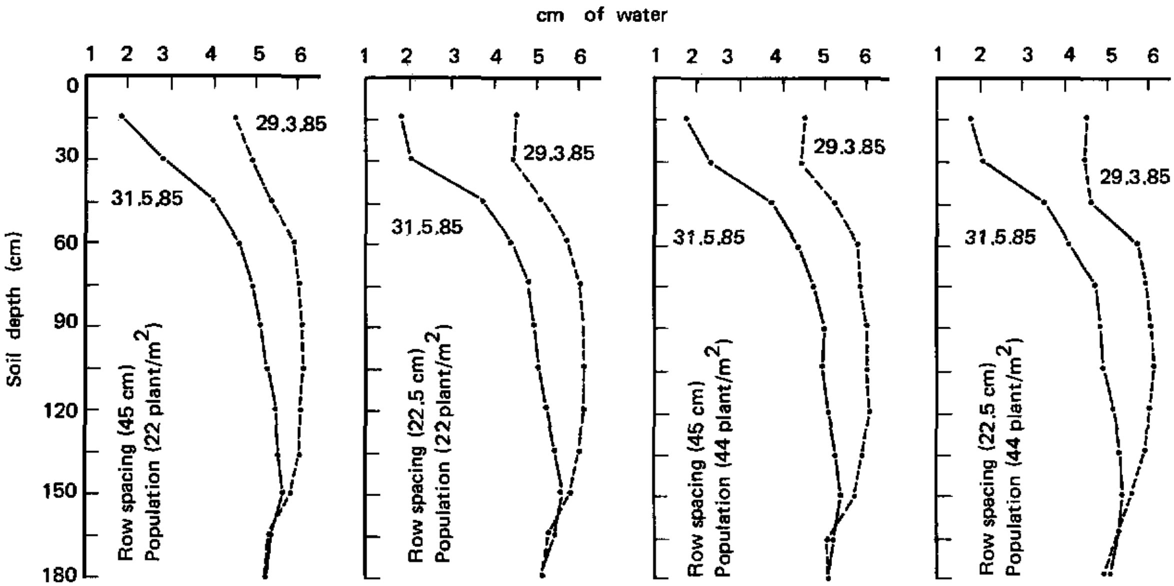


Fig. 9. Soil moisture extraction along the profile at maximum recharge and at maturity as affected by plant population/m^2 (22 = P1 and 44 = P2) and row spacing in cm (45 = R1 and 22.5 = R2) in ILB 1814, Tel Hadya, 1984/85.

It can be concluded that when moisture is *not limited early in the season (as in* 1984/85), sowing at narrow row spacing and high plant population can result in a better exploitation of soil moisture along the profile, and therefore high biological and seed yields.

Effect of Row Spacing and Plant Population

As a part of international trials, the performance of local faba bean landraces under rainfed conditions was examined at Tel Hadya and Terbol at four row spacings (30, 40, 50, and 60 cm) and three populations (30, 45, and 60 plants/m^2). At Tel Hadya, total biological yield was significantly increased both by reducing row spacing and increasing plant population. Seed yield, however, was increased only when row spacing was reduced. At Terbol, only row spacing significantly affected the crop performance. Reduction in row spacing resulted in increase in both seed and biological yields/ha.--*Said Silim and M.C. Saxena.*

Lentil Improvement

Considerable progress was made in developing improved production practices, cultivars, and genetic stocks of lentils with high and stable seed yields adapted to the three main agroecological regions of production, with improved seed quality and nitrogen-fixing ability, and with the additional specific characters for each region, namely: (i) high-altitude region (above 1000 m elevation) --cold tolerance to allow winter sowing and attributes for mechanical harvest (tall, nonlodging growth habit and pod retention and indehiscence), (ii) middle- to low-elevation region around the Mediterranean Sea--attributes for mechanical harvest, maintained straw quality and yield, tolerance to

Orobanche and *Heterodera* sp., resistance to vascular wilt, and tolerance to drought stress during the reproductive growth period, and (iii) lower latitudes region (Indian subcontinent, Ethiopia, and Sudan) --phenological adaptation to the warm, short-photoperiod environment, and resistance to rust, vascular wilt, and ascochyta blight.

Development of Lentil Cultivars and Genetic Stocks

Breeding Scheme

About 350 crosses are made annually for the aims outlined above. Last season's crosses were divided between the three major target regions: 71% for the low-elevation Mediterranean region, 28% for the southern latitudes, and 1% for the high-elevation area. The resulting crosses are then handled as three streams within the core breeding project, with the material for each target region being of a different maturity type: southern latitudes, early maturation stream; Mediterranean region, medium maturation stream; and high-elevation areas, late maturation stream.

The three streams are handled together for the first few generations. A diagrammatic representation of the scheme employed is given in Fig. 10. All crosses resulting from the crossing block at Tel Hadya are grown as F_1 generation in an off-season, summer nursery at Shawbak, Jordan, with irrigation. The F_2 generation is sown at Tel Hadya in winter and bulk harvested. Seed from these bulks is used for the international F_3 trials, early and medium maturity (LIF_3T and LIF_3T-E). A subsample is sent to the off-season nursery for generation advancement through the F_3 generation by the bulk method.

For the Mediterranean stream, the procedures for F_4 generation through single-plant selection to yield trials in F_8 were described previously (ICARDA Annual Report 1984). Beginning with 1983/84 development of the early stream material for southern latitudes has been carried out in cooperation with the Pakistan national pulse program, NARC, Islamabad. Segregating populations from early crosses at F_5 generation are sent to Islamabad for single-plant selection. In addition, selections for earliness made at Tel Hadya are sent to Islamabad in yield trials for screening for ascochyta blight resistance. In the high elevation - late maturity stream, developments have taken place in collaboration with the Turkish national pulse program, Ankara, whereby the F_5 generation of crosses made with cold-tolerant parents can be screened for winter hardiness at Haymana near Ankara at > 1000 m elevation. These two bilateral developments with national programs have enabled more selections and tests for disease resistance and adaptation to be made within the target environments.

Yield Trials

Selections from the breeding program are tested both in preliminary and advanced yield trials in three contrasting locations representing an average rainfall of 283 mm at Breda, 330 mm at Tel Hadya, and > 500 mm at Terbol (Lebanon). This year, 238 small-seeded selections (seed size < 4.5g/100 seed) and 171 large-seeded selections were tested across the three sites.

Amongst the small-seeded entries the percentage of those yielding significantly ($P=0.05$) more than the local check (ILL 4401) was 52, 32, and 56 at Tel Hadya, Breda, and Terbol, respectively (Table 15). With more than half the entries outyielding the local check by a significant margin and additional material merely ranking above the check, there are prospects for considerable yield increases in the future. Amongst the large-seeded entries, 19, 8, and 12% yielded significantly

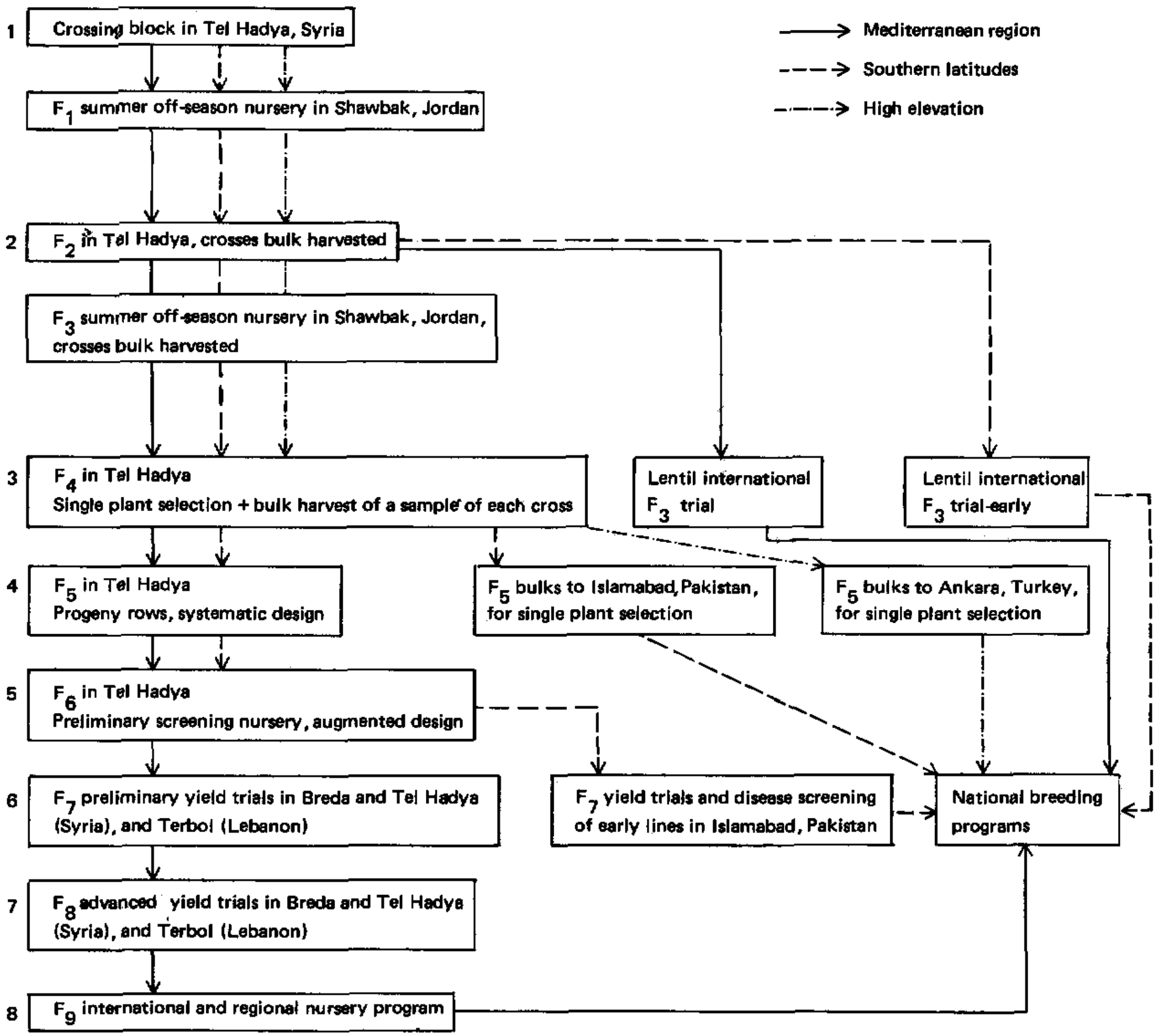


Fig. 10. Scheme of lentil breeding used at ICARDA showing streams for different target areas.

Table 15. Results of yield trials (advanced and preliminary) conducted for large (L)-(> 4.5g/100 seeds) and small (S) - seeded selections at Tel Hadya and Breda in Syria and Terbol in Lebanon in the 1984/85 season.

	Tel Hadya		Breda		Terbol	
	L	S	L	S	L	S
No. of yield trials	8	11	8	10	7	10
No. of test entries[1]	171	238	171	205	146	204
% of entries sig. exceeding check[2] ($P<0.05$)	19	52	8	32	12	56
% of entries ranking above check (excluding above)	5	10	11	13	12	5
Check mean yield	1241	976	881	603	1645	1334
S.E. check mean[3]	60.0	46.6	46.3	27.7	61.2	47.4
Location mean	1190	1050	603	522	1469	1462
CV (%)	20.1	19	24.2	22.5	13.2	13.8

1. Entries were common across locations.
2. Large-seeded check = ILL 4400 (Syrian local large); small-seeded check = ILL 4401 (Syrian local small).
3. A combined analysis of large-seeded trials and another for small-seeded trials was undertaken for each site.

($P=0.05$) more than the local check (ILL 4400) at Tel Hadya, Breda, and Terbol, respectively.

At Tel Hadya, the 1983/84 and 1984/85 seasons provided an interesting contrast. The 1983/84 season had a precipitation of 229 mm and drought stress increased from flowering through the reproductive phase. In 1984/85, the total rainfall was a well-distributed 373 mm and the crop did not suffer from drought stress; however, the major stress was one of cold with 3 weeks of subzero nights in late February/early March during mid-vegetative growth.

The response of the large-seeded and small-seeded entries in yield trials to conditions in the two seasons illustrates the contrasting adaptation of *macrosperma* and *microsperma* lentils. In the droughty season (1983/84) the overall average seed yield of all the small-seeded yield trials at Tel Hadya was 957 kg/ha, which was 23% more than the mean of the corresponding large-seeded yield trial (779 kg/ha). In the following cold season (1984/85) the reverse was found with a small-seeded yield trial mean of 1050 kg/ha and a value for the corresponding large-seeded trial of 1190 which was 13% greater. Since these means are based on at least 150 entries, statements on the adaptation of the two subspecies may be made. It is clear that in the Middle East the large-seeded *macrosperma* group is more sensitive to drought stress during the reproductive period of growth and less sensitive to cold stress during vegetative growth than the *microsperma* group.

On-Farm and Regional Trials in Syria

From the advanced yield trials material is selected for inclusion in international screening nurseries and regional yield trials. The two regional yield trials, large-seeded and small-seeded, are targeted for Jordan, Lebanon, and Syria. In the 1984/85 season, both the regional yield trials were grown at five sites as part of the cooperative program with the Ministry of Agriculture, Syria. In the small-seeded trial the location means for seed yield varied from a minimum of 691 kg/ha at Gelline in south Syria to 1117 kg/ha at Tel Hadya. The yield advantage over the local check for mean seed yield was 37% for the best entry. The corresponding yield advantage over the local check in the large-seeded regional trial was less at only 8% because of the cold susceptibility of the test entries in comparison to the check.

The regional yield trials are the source of new entries for on-farm trials. Three years of on-farm trials in Syria have now been conducted in cooperation with the Syrian government. ICARDA selections, two large-seeded and two small-seeded, were tested against two local checks at 6, 7, and 13 sites in the 1982/83, 1983/84, and 1984/85 seasons, respectively. The yield advantage of the selections over the local checks was reduced in the season 1984/85 because of the cold winter. Among the large-seeded entries the average yield advantage over the three seasons was 16% for 78S 26002 over the check, Kurdi 1. 78S 26002 also has a reduced tendency to lodge, an important attribute with respect to mechanical harvesting. This selection has now been recommended for prerelease multiplication by the Syrian Ministry of Agriculture. Amongst the small-seeded, red-cotyledon entries the overall yield advantage over the three seasons was 11% for 78S 26013 over the check, Haurani 1.

Use of ICARDA Lentils by National Programs

There was an increased use of ICARDA lentils by national programs in 1984/85. NEL (ILL) 358 was released in Ethiopia to farmers in highland areas. This cultivar has rust resistance and a 50% yield advantage over the local check. Two selections each were selected in Tunisia and Spain for prerelease multiplication; this is in addition to the prerelease multiplication of 78S 26002 in Syria (see previous section) (Table 16). ILL 4605 is at the prerelease stage in Pakistan and Morocco. For the 1985/86 season, on-farm trials of ICARDA lentils are planned in Lebanon, Jordan, Syria, Turkey, and Pakistan (Table 16).--*W. Erskine.*

Table 16. Use of ICARDA lentils by national programs (1984/85 and 1985/86).

Region	Country	No. selections
North Africa	Morocco	1* + 34
	Tunisia	2
West Asia	Jordan	2
	Lebanon	2
	Syria	1 + 2
	Turkey	4
	Yemen A.R.	2
South Asia	India	1
	Pakistan	1 + 4
Nile Valley	Ethiopia	1
	Sudan	10
Europe	Spain	2
Australasia	Australia	5
N. & S. America	Argentina	3
	Canada	1

* Underlined: Released cultivars or in pre-release multiplication. Other entries are in on-farm trials and national yield trials.

Genetic Variation in Lentil Straw Quality

Lentil straw (leaflets, branches, and pod walls) is an important livestock feed in the Middle East, entering into both national and international trade. We reported earlier (ICARDA Annual Report 1983) on significant genetic variation for lentil straw quality for such parameters as fiber content (neutral detergent), *in vitro* digestibility, and straw protein content based on a single year's data from Tel Hadya farm.

However, a combined analysis over two seasons of the lentil straw quality of 11 *macrosperma* lines has revealed a more complex picture. There were profound seasonal effects on straw quality with, for example, seasonal means for digestibility of 39 and 60 g digestible organic matter per 100 g dry matter. Superimposed on the seasonal effects was a substantial genotype x season interaction for all straw quality traits. This resulted in a negative rank correlation coefficient between the genotype means of both seasons of r = -0.25 for *in vitro* digestibility. The magnitude of the interaction was such that genotypic effects were nonsignificant when tested against the genotype x season interaction, indicating zero heritability for the straw quality traits: *in vitro* digestibility and both protein and fiber (neutral detergent) contents. The implication for breeding is that without heritable genetic variation the response to selection for straw quality traits will be low. The importance of season for straw quality suggests that the effects of environmental factors such as location, fertilizer regime, inoculation etc. on straw quality should be assessed.--*W. Erskine, S. Rihawi, and B. Capper.*

Genetic Variation in Response to Irrigation

In Egypt, before the construction of the Aswan Dam, lentils were grown on moisture left by the annual flood of the Nile. Irrigation became widely available when the high dam was constructed, but Egyptian lentils are ill-adapted to extra irrigation. Most introductions to Egypt come from rainfed areas with similar ill-adaptation. This study, conducted by a Ph.D. student with financial support from the the Nile Valley Project, was designed to estimate the genetic variation in lentils in response to irrigation in order to develop a selection methodology for irrigated conditions.

The study was conducted during the 1984/85 season with 34 diverse accessions from the lentil germplasm collection in five environments at three locations: (1) Tel Hadya, unirrigated (373 mm); Tel Hadya, one supplementary irrigation (before flowering); Tel Hadya, two supplementary irrigations (before flowering and before pod filling), (2) Breda, without irrigation (277 mm), and (3) Terbol, without irrigation (444 mm).

The overall mean for seed yield was 1840 kg/ha with a range across locations of 599 kg/ha at Breda, the dry site, to 2809 kg/ha at Tel Hadya with two supplementary irrigations. At Tel Hadya the mean yield was 2195 kg/ha without irrigation, 2324 with a single irrigation and, 2809 with two irrigations, the last representing an irrigation response of 28%. The genotype x environment interaction for seed yield was highly significant, illustrating the differential response of genotypes to irrigation. This study will be continued for a further season.--*A. Hamdi (Durham University, UK) and W. Erskine.*

Diseases of Lentils

Survey of Wilt Damage on Lentils

Previous research had indicated that wilt was the major pathogenic disorder on lentils in Syria. Therefore, a survey of farmers' lentil fields was conducted in the main growing areas of Aleppo, Idlib, and Hama Provinces (northern Syria), to quantify wilt damage and determine the causal organisms.

The survey covered 28 fields with an average estimated area of 1.4 ha. The proportion of plants with wilt symptoms across all fields was 13% with a range in incidence of 2-70% plants/field. Since wilt symptoms were observed on plants at the flowering and podding stage, there is no possibility of compensation from neighboring healthy plants. Wilted plants give no seed yield and consequently the proportion (13%) of plants affected probably approximates the yield loss due to wilt.

Isolation from the collected wilted samples showed *Fusarium* sp. from most of the fields. A pathogenicity test in pots in an illuminated incubator showed wilting symptoms. Microscopic examination of wilted shoots from this test revealed fungal hyphae in the xylem vessels, and the reisolation of the wilted shoots resulted in *Fusarium oxysporum* f.sp. *lentis* growth. We now plan to inititate screening for disease resistance to vascular wilt.--*B. Baya'a (University of Aleppo) and W. Erskine.*

Screening Lentils for Resistance to Cyst Nematode

In Syria surveys conducted in cooperation with the University of Bari have revealed cyst nematode (*Heterodera sp.*) as a major yield reducer. The host range (40 Mediterranean crops) does not extend beyond the *Leguminosae*, consequently crop rotation with cereals does not increase the frequency of the nematode. Possible additional control measures include the use of host-plant resistance. Screening for resistance to cyst nematode was undertaken on 100 germplasm accessions at Bari in Italy and on 75 elite lines at ICARDA in pot trials with infested soil (2000 eggs/pot). In Italy, although significant differences of 169-1937 cysts/5 g roots were found after 2 months, none of the germplasm accessions showed resistance. An accession of *Lens orientalis* (ILWL 7) was also found susceptible in the test. Significant differences in vegetative damage score and total root weight were found among the 75 lines screened in the plastic house at Tel Hadya with 15 seeds/pot and a high cyst rate (300-350 cysts/200 g soil). However, the cyst count/g root showed no significant differences between lines. In summary, although there may be differences in susceptibility to cyst nematode in lentils, no resistance was found after screening 175 cultivated lentil entries and one line of *Lens orientalis.*--*W. Erskine (ICARDA), and N. Greco and M. di Vito (Bari, Italy).*

Lentil Insects and Their Control

Insect Populations

As in previous seasons the pea-leaf weevil, *Sitona macularius*, was the main pest. Thrips occurred at levels comparable to those recorded previously but other insects such as *Apion*, leafhoppers, aphids, pod borer, and pea moth appeared in small numbers at six locations sampled in northern Syria.

Improved trapping of *Sitona* adults showed that initial migrations of *S. macularius* and *S. lineatus* occurred in mid-November, soon after planting lentils. A second, larger wave of immigration occurred in mid-January. Possibly as a result of very cold weather, populations crashed in February and March and as a consequence of this, moderate levels of nodule damage (x = 66%) were detected in late April, a time at which, in previous seasons, most fields sampled were showing 100% nodule damage. This is important for understanding the yield responses to *Sitona* control.

Egg mortality in *S. macularius* due to parasites and predators averaged 6.4% (range: 4.5 - 20.1%). No natural enemies of larvae, pupae or adults were recorded. These levels are inadequate for effective *Sitona* population regulation. In the absence of resistance and response to cultural practices, most emphasis is now on the study of effective, economic chemical control of *Sitona.*

Partitioning of Yield Losses among Species

Proper separation of the effect of *Sitona* and foliar insects on yields has been reported earlier (ICARDA Annual Report 1983, 1984). An attempt to further partition yield losses due to *Sitona* from those due to aphids and thrips was made in the past season. Aphid populations were of no major consequence and selective control of thrips with formothion 0.5 kg a.i./ha, significantly increased straw and seed yields by 7.6 and 9.1%, respectively. The key pest status of *Sitona* has then been reconfirmed and this line of research could now be terminated.

Effect of Sitona Larval Damage on the N-Fixation Process

The effect of increasing levels of infestation with *S. macularius* larvae on the acetylene reduction activity (ARA) of lentils was studied under greenhouse (19°C; 47% RH). Regressions of ARA on the percentage of nodules damaged indicated no significant effect up to 46 days after infestation. As nodule damage increased to about 40%, there was a rapid decline in ARA between 46 and 60 days after infestation. On a seasonal basis the results are shown in Fig. 11. These findings support previous field results on the effect of larval damage on the functionality of lentils nodules.

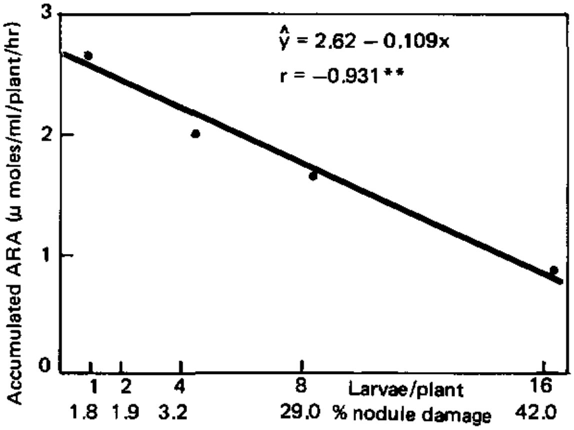


Fig. 11. The regression of acetylene reduction activity (ARA) in lentils on increasing levels of infestation with larvae of *Sitona macularius.* Means of four replications, Tel Hadya, 1984/85.

Economic Aspects of *Sitona* Control

The feasibility of chemical control of *Sitona* was studied at farmers' fields at five locations: Souran, Maara, Tel Hadya, Breda, and A'azaz. Infestation levels varied from 19.5% nodules damaged at Souran to 75.2% at Tel Hadya, average 48%. This average is lower than previous seasons' means of 65% nodule damage registered in northern Syria. With little or no interference from other insects, yield losses due to *Sitona* damage ranged from 5% in Souran to 33% in A'azaz (average 13%). There was not a significant treatment x location interaction, but both carbofuran and heptachlore significantly increased straw and seed yields (Table 17). The economic analysis of data through partial budget analysis and subsequent calculation of an economic threshold for *Sitona* (Fig. 12) indicated that chemical control with a pesticide such as carbofuran would be justified at infestation levels of 43% or higher. As indicated by many previous field trials, the economic impact of *Sitona* on yield is significant in lentils, showing 70% or more nodule damage, a situation which is common in most lentil-growing areas of Syria. Since *Sitona* control is preventive in nature there would be a need to reduce costs so as to make this practice less risky for the farmer. One way to do this is to cut dosages of the chemicals or find others less costly. Quinalphos, methiocarb, and disulfoton failed to provide adequate protection (Table 18), but a lower dosage (0.5 kg a.i./ha) of carbofuran compared favorably with the previously tested standard dosage of 1.0 kg a.i./ha. The search for cheaper chemicals for *Sitona* control and the testing of this practice under farmers' fields conditions is to be continued.

Table 17. Yield responses of Syrian Local Small lentils to *Sitona* control. Combined analysis of data obtained in five farmers' fields. Means of two replications per site, 1984/85.

	STRAW YIELD				SEED YIELD			
	All sites		Excluding 2 sites[1]		All sites		Excluding 2 sites	
Treatment	kg/ha	% increase	kg/ha	% increase	kg/ha	% increase	kg/ha	% increase
Carbofuran	2275	14.4	2719	18.4	981	15.9	1156	20.9
Heptachlore	2138	7.5	2586	12.6	950	12.2	1108	15.9
Check	1988		2296		846		956	
LSD (5%)	174.1		213.5		98.5		101.1	
CV (%)	5.6		5.5		6.7		5.4	

1. Excluding Maara and Souran which showed significantly lower levels of infestation (29 and 19% nodule damage, respectively).

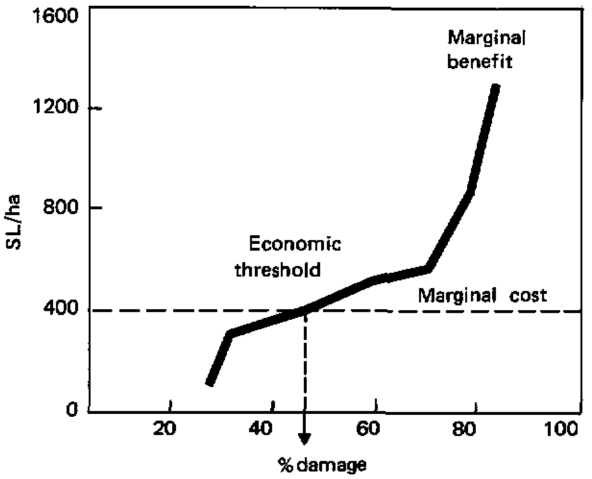


Fig. 12. Economic threshold determination for *Sitona macularius* on lentils.

Production Agronomy and Crop Physiology

Growth Habit in Lentils

In ICARDA's lentil germplasm collection there is a range of tall accessions suitable for mechanical harvest. The variation in plant architecture amongst these accessions has not been explored. Accordingly, we made a detailed, quantitative analysis of the growth habit of 25 contrasting lentil genotypes including some tall materials. The trial was conducted at Tel Hadya, and the anatomy of 10 plants taken at random from each plot was examined.

Striking differences in growth habit were evident. The mean height ranged from 26 cm (ILL 4605) to 41.5 cm (ILL 922), with the average being 33.5 cm, and the lowest pod was 18.5 cm above the ground. On average, there were 19 nodes on the main stem, hence a mean internode length of 1.8 cm. However, internode length varied according to position on the main stem and decreased greatly at the upper and lower ends of the main stem. The diameter of the base of the main stem ranged from 1.7 to 2.9 cm, with a mean of 2.2 cm.

Branching is divided into primary (arising from the main stem), secondary (arising from the primary branches), and tertiary (arising from the secondary branches) systems. There was a considerable variation in the amount of branching between genotypes. Adding up the number of primary, secondary, and tertiary branches, the total ranged from a mean of six branches on ILL 5748 to 12 on ILL 922.

Overall, the mean number of both primary (4.16) and secondary branches (4.29) greatly exceeded that of the tertiaries (0.5). Over half of all pods were found on the main stem and the two lower-most primary branches.

Table 18. The efficiency of different insecticides to control *Sitona macularius* on lentils as measured by four population parameters. Means of four replications, Tel Hadya, 1984/85.

Chemical	Dosage (kg a.i./ha)	Method of application	% control on the basis of: Adult visual damage scores	% leaflets damaged	% nodules damaged	Neonate adults/ 1500 c.c. soil
Heptachlore	2.0	drilled	35	29	94	90
	2.0	broadcast	46	46	85	84
	1.5	drilled	30	44	92	84
	1.0	drilled	19	1	92	89
Carbofuran	1.0	drilled	57	76	89	96
	1.0	broadcast	51	55	88	91
	0.5	drilled	57	60	92	85
Quinalphos	0.7	drilled	0	0	11	0
Methiocarb[1]	30g	seed tr.	46	52	48	37
	20g	seed tr.	51	59	49	56
	10g	seed tr.	57	47	32	62
Aldrin	3.7	drilled	51	45	86	78
Disulfoton	1.0	drilled	19	20	0	2
LSD (5%)			0.7	5.2	14.2	7.6
CV (%)			37.4	30.6	37.4	51.1

1. Seed treatment: grams of commercial product/kg of seed.

Growth habit is much influenced by environmental or nongenetic factors. Thus the severe frosts encountered in March 1985 tended to produce a more bushy growth habit, as a result of enhanced branching following the death of the main stem in susceptible genotypes. Within-genotype variation in growth habit was also evident.

A path analysis will be conducted to identify those anatomical traits which have a direct effect on plant height, lodging, and seed yield.--*W.J. Goodrich and W. Erskine.*

Growth and Yield in Relation to Sowing Date

In the low-elevation areas of the ICARDA region, lentils are generally sown in late winter. Earlier studies at ICARDA have shown that early planting (before Mid-December) results in better growth and yield. However, recent work (1982/83 and 1983/84) has indicated that winter sowing increases total biological yield but not seed yield. Cold damage and greater infestation by *Orobanche* were among the factors that offset the advantage of early winter sowing.

In 1984/85 season, the study was repeated using the same six genotypes (ILL 8, 9 , 16, 223, 4400, and 4401) to evaluate their performance when sown early and late in winter (14 November and 12 February, respectively). The November-sown crops took 139 to 147 days to flower and 178 days to reach physiological maturity. However, the February-sown crops took only 72 days to flower and 95 to 107 days to reach physiological maturity.

In spite of the very severe frost in February/March which severely damaged the November-sown ILL 8, 9, 16, and 223, all November-sown crops produced more dry matter than February-sown crops. At each sowing, genotypes varied in growth rate and total dry matter at maturity (Fig. 13) The varieties that grew fastest when sown in November (ILL 8, 223, and 4401) produced the most dry matter at maturity.

Early winter-sown crops produced significantly more seed yield (900-1330 kg/ha) than late winter-sown crops (330-670 kg/ha).

In early winter sowing, varieties that had the fastest rate of growth (ILL 8, 223, 4401) produced the most dry matter and seed yields. Harvest index in late winter sowing was larger ($P = 0.05$) than early winter sowing. Smaller seed yields in late winter sowing, therefore, are a result of the smaller total dry-matter production following the drought which occurred early and hastened maturity.

In the last three seasons (1982-85) advancement of winter sowing has always resulted in an increase in total dry-matter production and sometimes in seed yield. In some seasons, frost damage in the reproductive phase resulted in an increase in seed yield. Since lentil straw is used as animal feed in the ICARDA region, advancing date of planting to November should increase farmers' income.

Response to Plant Population and Row Spacing

The effect of four plant population densities (100, 200, 300, and 400 plants/m^2) and four row spacings (20, 30, 40, and 50 cm) on lentils was studied at Breda and Terbol. At both locations, the total biological yield was significantly increased with the increase in plant population. However, this effect on seed yield was significant only at Breda. Planting lentils at narrow row spacing increased both biological and seed yields at Terbol but not at Breda. Yields obtained at Terbol were almost double those obtained at Breda due to better moisture supply. At Terbol, there was a gradual improvement in partitioning of dry matter with the decrease in plant population, whereas at Breda only the lowest population (100 plants/m^2) improved it.

Lentil Fertility-cum-Inoculation Trial

Investigations on management practices which favor symbiotic association between lentil crop and rhizobium should be made so that symbiotic nitrogen fixation may be increased and crop dependence on soil nitrogen reduced. Lentil fertility-cum-inoculation trial was therefore conducted in 1984/85 at Terbol (Lebanon) and Breda (Syria) to study the response of lentils to fertilizers and inoculation with rhizobia, with or without *Sitona* weevil control.

Table 19 gives the results of yields and harvest indices at both Breda and Terbol. The findings at Breda indicated that the main limiting factor to both high seed and biological yields was the damage done to the root nodules by *Sitona* weevil. Control of *Sitona* weevil resulted in 13 and 16% increase in seed and biological yields, respectively. Inoculation with rhizobium plus control of *Sitona* did not result in additional advantage which implies that there was no advantage of introducing this new strain in Breda soil. At Terbol there was no significant response to fertilizer treatments because of high fertility of the soil. Again, as at Breda, control of *Sitona* weevil resulted in a very large increase in both seed and biological yields, largely as a result of presenting nodule damage (31% of nodules were damaged in control as compared with 11% when *Sitona* was controlled.)

Lentil Harvest Mechanization

Mechanization of lentil harvest in the Middle East is a major research goal of FLIP, because lentil areas are declining due to increased labor costs for harvest in comparison to world lentil prices. Research on lentil harvest mechanization has been intensified at ICARDA following a grant from the International Development Research Centre, Canada. The major trial conducted at Tel Hadya in the 1984/85 season gauged the minimum change from traditional agronomy needed for the successful operation of the harvesting machines. The traditional method of sowing lentils in Syria is by hand broadcasting followed by a cultivator pass to cover the seed, leaving a

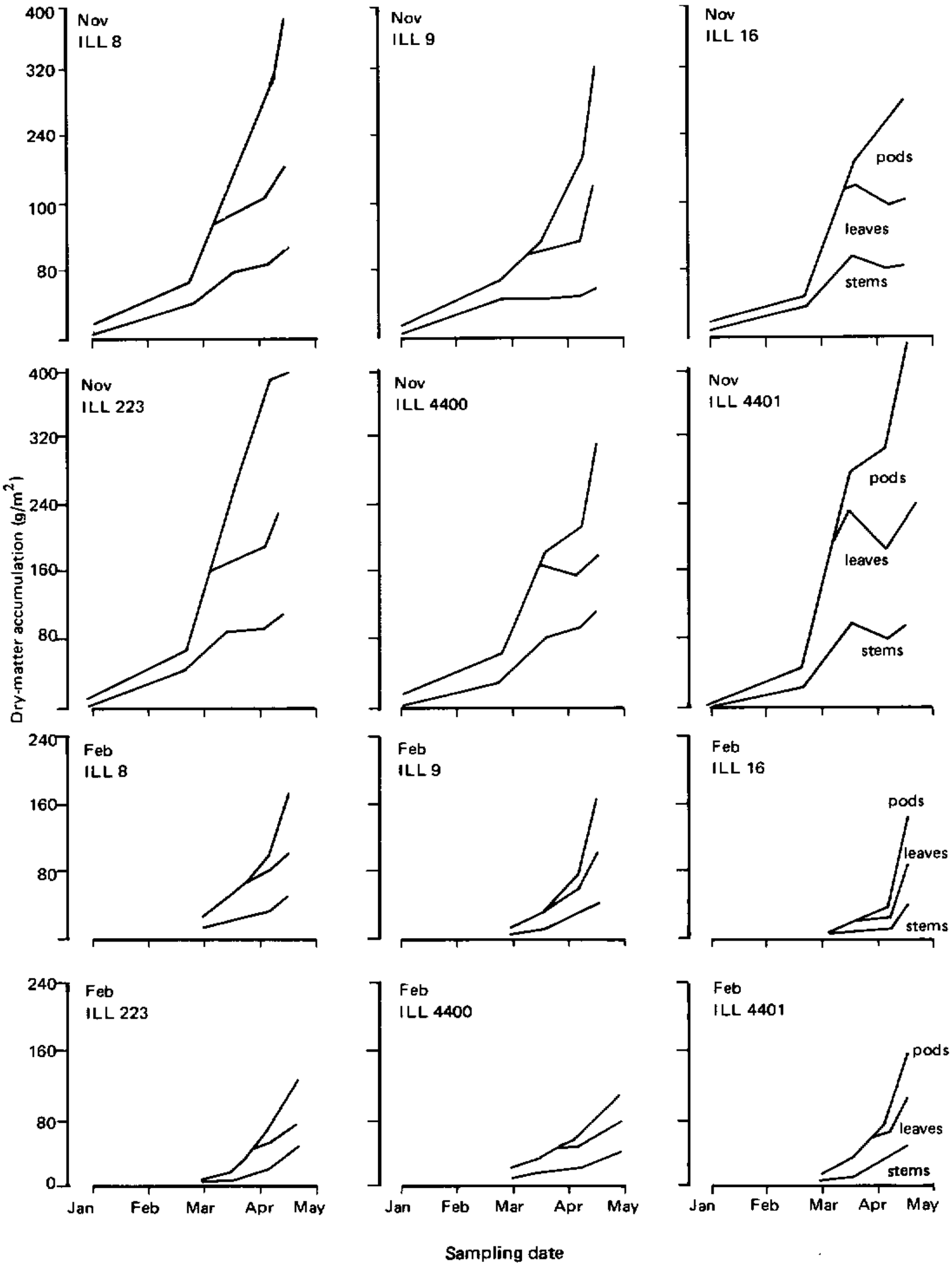


Fig. 13. The buildup and partitioning of dry matter for six lentil genotypes as affected by date of sowing.

Table 19. The effect of fertilizer cum-inoculation and carbofuran on yield and harvest index of lentils at Breda and Terbol, 1984/85.

	Breda			Terbol		
	Yield (kg/ha)		Harvest	Yield (kg/ha)		Harvest
Treatment	Seed	Biological	index	Seed	Biological	index
Control	783	1892	0.43	2120	6101	0.35
P_2O_5 @ 50 kg/ha	786	2035	0.39	2083	6153	0.34
Carbofuran @ 1.0 kg a.i./ha	885	2198	0.39	2169	6513	0.33
Inoculation with rhizobium	788	1885	0.42	2014	5986	0.34
Inoculation+Phosphate	834	2036	0.41	1951	5944	0.33
Inoculation+Carbofuran	886	2094	0.42	2102	6465	0.33
Inoculation+Carbofuran+P_2O_5	920	2278	0.41	2031	5975	0.34
100kg N/ha+P_2O_5+Carbofuran	905	2184	0.42	1889	6073	0.31
LSD (5%)	56.5	121.2	ns	ns	ns	ns
CV (%)	4.53	5.2	4.0	9.0	7.1	7.6

ridged field. This was compared with lentils sown with a locally available drill, and also to broadcasting followed by a cultivator with a heavy bar behind. The sowing treatments were thus:

(i) Broadcast by hand (300 seeds/m^2), covering with tractor-pulled cultivator; (ii) broadcast by hand (300 seeds/m^2), covering with tractor-pulled cultivator towing a heavy bar; (iii) drilled (200 seeds/m^2) by local cereal drill; and (iv) drilled (200 seeds/m^2) by local cereal drill towing a heavy bar.

Comparison of a local cultivar with an ICARDA selection was also included as one of the factors in the trial. These main plots were then split and harvested by hand, by a double-knife cutter bar, and by angled blades passing just under the soil surface.

Differences between harvest methods and the interactions between harvest and sowing methods were highly significant for both seed and straw yields (Table 20). With the hand harvest, the use of a heavy bar behind the cultivator covering seed increased lentil seed yield over the traditional cultivator alone. The double-knife cutter bar required land flattened by either a bar or a seed drill to optimize straw yields. The angled blades worked best on the traditional broadcast seed bed.

The selection 78S 26002 yielded 1161 kg/ha seed, which was 21% more than the local cultivar. Since 78S 26002 lodged less than the local, its advantage over the local was greatest with a cutter-bar harvest.

Next year it is proposed to test the best harvesting systems in on-farm trials agronomically and economically.--*W. Erskine, J. Diekmann, P. Jegatheeswaran, and Said Silim.*

Effect of height of cut on the yield and straw quality: As part of a major effort to mechanize harvesting at ICARDA, a trial was conducted using a self-propelled cutter bar at Tel Hadya during the 1984/85 season to investigate the effect of height of cut

Table 20. Lentil seed and straw yields (kg/ha) from different sowing and harvesting methods.

Method	Hand harvest		Cutter bar		Angled blades	
	Seed	Straw	Seed	Straw	Seed	Straw
Broadcast	1152	2896	951	1094	732	3531
Broadcast + bar	1479	2976	1075	1617	829	3262
Drilled	1618	3294	1071	1600	616	2142
Drilled + bar	1479	2929	1092	1780	633	2348
Mean	1432	3024	1047	1523	703	2820

LSD (5%) Harvest method: Seed = 91 kg/ha; Straw = 399 kg/ha.

LSD (5%) Harvest x sowing methods: Seed = 183 kg/ha, Straw = 799 kg/ha.

(ground level, 5 cm and 10 cm above ground) as compared to hand pulling on loss in seed and straw yields and quality of three lentil genotypes with different plant stature: ILL 8 (erect and nonlodging), ILL 4400 (local line with lodging), ILL 554 (erect and late maturing). Because of lack of significant interaction between height of cut and genotype, only the main effects are presented.

The effect of height of cut on seed and straw yields, percentage straw digestibility, and protein content are shown in Table 21. Compared with hand pulling, cutting at the ground level and 5 cm and 10 cm above ground resulted in seed yield losses of 9.0, 15.6, and 16.7%, respectively. Percentage losses in straw yields were 7.3, 31.5, and 38.6. By contrast, significant increases in percent digestibility and protein content of straw were obtained at all three cut heights as compared with hand pulling. Digestibility of straw cut at the ground level was similar to that of straw cut at 5 cm above ground, but significantly lower than that cut at 10 cm above ground. Percentage protein content increased progressively with increase in the height of cut.

Seed and straw yields, percentage digestibility, and protein content of the three genotypes are given in Table 21. Percent losses due to cut in straw yield were 30.2, 24.2, and 22.4, respectively, for ILL 4400, ILL 8, and ILL 554 and the respective seed yield losses were 15.6, 5.3, and 20.3%.

This study shows that the mechanical harvesting of lentil by cutter bar results in straw and seed yield losses, the former due to roots being left in the soil and the latter due to pod drop. Harvest was carried out at full maturity in this study, and it is possible that seed yield losses can be reduced by harvesting at physiological maturity. ILL 4400, which is a local cultivar, had the highest losses in both seed and straw yields and losses in ILL 8, an improved line, were low.--*Said Silim, Willie Erskine, and M.C. Saxena.*

Weed Control

Weeds are a major constraint to increased production in lentils, particularly in early-sown crop. Hence studies were carried out to evaluate the common herbicides for broadspectrum weed control. The dominant weed species were the same as those indicated in the relevant section on faba beans.

International Weed Control Trial. As part of the International Chemical Weed Control Trial, studies were conducted in 1984/85 at Breda and Terbol to quantify yield losses due to weeds and identify promising herbicides for weed control.

Table 21. Main effects of height of cut and genotypes on straw and seed yields, percentage straw digestibility and protein content of lentils, Tel Hadya, 1984/85.

Harvesting	Yield (kg/ha)		Percentage for straw	
	Seed	Straw	Digestibility	Protein
Hand pulling (control)	879	1729	48.0	5.2
Cut at ground level	800	1603	52.0	5.5
Cut 5 cm above ground	756	1184	51.9	5.8
Cut 10 cm above ground	741	1042	53.4	6.2
LSD (5%)	92.0	186.6	1.91	0.5
CV (%)	12.5	14.5	15.4	8.7
Genotype				
ILL 4400	938	1678	51.4	6.1
ILL 8	929	1322	50.4	5.2
ILL 554	515	1168	51.9	5.8
LSD 5%	56.4	102	ns	0.62
CV (%)	9.7	10.1	16.9	12.7

At Breda weed infestation was light. Weeds reduced yield by 8% and chemical weed control and hand weeding gave similar results. At Terbol, weeds reduced yield by 69%. Hand weeding twice was as effective as repeated hand weeding and was superior to chemical weed control. Preemergence application of Bladex (1.0 kg a.i./ha), Maloran (1.5 kg a.i./ha) + Kerb (0.5 kg a.i./ha), Tribunil (2.0 kg a.i./ha) + Kerb (0.5 kg a.i./ha), and Gesagard (1.5 kg a.i./ha) + Kerb (0.5 kg a.i./ha) gave very good control of weeds and increased yield by 121, 145, 157, and 177%, respectively, over the weedy check.

Evaluation of New Herbicides for Pre- and Postemergence Applications. The experiment was conducted at Tel Hadya during the 1984/85 growing season to identify and evaluate the best herbicides for broadspectrum weed control in lentil. Some of the herbicides have already been tested in field experiments, and others are newly developed and being tested for the first season in ICARDA region. The trial was an RCB design with four replications.

The level of weed infestation was rather low with the following dominant species: *Avena sterilis*, *Phalaris brachystachys*, *Sinapis arvensis*, *Geranium tuberosum*, *Galium tricorne*, *Vaccaria pyramidata*, *Carthamus syriacus*, *Cephalaria syriaca*, and *Euphorbia helioscopia*.

Among all herbicide treatments, the best was cyanazine (Bladex) applied preemergence at the rate 0.5 kg a.i./ha, with no significant differences in grain yield between this and hand weeded (weed free) treatment (Table 22). This confirms previous observations on the excellent performance of this product. All newly tested products (treatments 7 to 14) provided poor weed control or had a phytotoxic effect on the crop, causing a significant grain yield reduction.

Table 22. Effect of chemical weed control on lentil crop phytotoxicity, total dry weight (TDW) of weeds, and grain yield, Tel Hadya, 1984/85.

Treatment	Rate (kg a.i./ha)	Timing*	Phytotoxicity**	TDW (kg/ha)	Grain yield (kg/ha)
Weedy check				1221.5	961
Weed free				108.6	1220
Cyanazine	0.5	Pre	1.25	639.6	1129
Cyanazine +	0.5	Pre	3.75	498.2	960
Pronamide	0.5	Pre			
Dinoseb-acetate	1.0	Post	3.25	606.0	928
Dinoseb-acetate +	1.0	Post	2.25	351.6	963
Fluazifop-butyl	0.5				
Napropamide	1.0	PPI	8.00	1061.3	81
Napropamide	2.0	Pre	8.00	381.8	50
Carbotamide	1.0	Pre	1.75	1036.1	778
Phenoterb	3.5	Pre	1.00	1079.5	878
Codal	2.0	Pre	4.00	927.2	728
Fomesafen	0.25	Post	5.75	372.1	688
Fomesafen +	0.25	Post	6.00	212.9	691
Fluazifop-butyl	0.5	Post			
Fomesafen +	0.25	Post	6.00	299.3	626
Sethoxydim	0.5	Post			
CV (%)				51.5	16
LSD (5%)				463.8	180

* Pre = Preemergence application; Post = Postemergence application; PPI = Preplanting incorporation.

** 1 = no phytotoxicity symptoms and 9 = total crop injury.

Resistance to *Orobanche* spp. Lentils are seriously damaged by *Orobanche crenata* especially in Syria and Morocco. No satisfactory control method exists. Development of resistant varieties is the best method of control. Field screening of lentils for *Orobanche* resistance has been undertaken for several years at ICARDA. Some lines were found to have lower infestation than the local check (ILL 4400) but no line could be identified as resistant. Over 400 genotypes were tested in four replications in 1984/85 at Tel Hadya in soil infested with *O. crenata.* As a result of frost, 265 lines were severely damaged, and only 135 lines could be evaluated for resistance. Of these, seven lines (ILL 262, 326, 560, 672, 748, 814, and 912) were found less susceptible than the local check (ILL 4400).--*S. Kukula and W. Erskine.*

In order to have standardized conditions for all the lines tested, to get comparable results over the years, to screen during the whole year, and to have the results as quickly as possible, it is proposed to move the screening work from field to laboratory. To allow the rapid screening of lentil genotypes for *Orobanche* spp. resistance, a laboratory test was developed. Pregerminated lentils are planted in petridishes (1 plant/petridish), filled with a mixture of soil and sand (3:1 weight proportion) which is infected with preconditioned *Orobanche* seed. To precondition the *Orobanche* seeds the filled petridishes are stored for 10 days at 20°C. After planting the lentils the petridishes are stored in an incubator at 25/20°C (day/night) and 12 hours light. Following this procedure, the resistance can be evaluated within 20-25 days.--*S. Kukula and J. Sauerborn.*

Kabuli Chickpea Improvement

The kabuli chickpea improvement is a joint activity with ICRISAT. Kabuli chickpeas are widely grown as a spring-sown crop on conserved moisture in West Asia, North Africa, and southern Europe, and as a winter-sown crop in the Indian subcontinent, Nile Valley, and Mexico and other Latin American countries. The objective of the kabuli chickpea improvement research is to develop production technology and genotypes suitable for different agroecological conditions to increase the productivity of kabuli chickpeas.

Three sites, namely, Tel Hadya (low elevation, 325 mm annual rainfall), Jindiress (low elevation, 450 mm annual rainfall), and Terbol (medium elevation, 550 mm annual rainfall) have been used for testing genotypes for yield potential and adaptation before they are furnished to national programs.

Germplasm

During 1984/85, 400 new accessions were added mainly from Pakistan, Turkey, and the USSR; the total now stands at 5990 accessions. Publication and distribution of a Kabuli Chickpea Germplasm Catalog resulted in an increased demand for germplasm accessions. A total of 6265 germplasm lines were furnished to eight countries (Table 23).

Table 23. Distribution of chickpea germplasm lines to national programs, 1984/85.

Country	No. of accessions
The Netherlands	5
India	57
Tunisia	2000
Turkey	2000
UK	11
USA	2000
USSR	139
West Germany	53
Total	6265

Cold Tolerance

The winter of the 1984/85 season in Syria was a severely cold one. Temperature fell below freezing point on 41 nights: -9.8°C being the lowest. The temperature was below 0°C on most nights between 20 February and 15 March, when the crop had grown substantially. Though this adversely affected the crop, it provided an excellent opportunity to screen chickpeas for cold tolerance. Germplasm accessions, breeding lines, and advanced segregating generations were screened for cold tolerance. None of the lines was found unaffected, but 207 accessions (1.67% material) were killed. Fortunately, 85 lines were found to be tolerant, 782 moderately tolerant, and 207 were killed.

Screening for cold tolerance is done by advancing the sowing date to October. Cold was so drastic during 1984/85 that most of the genotypes sown in October were killed. However, two lines (ILC 3426 and ILC 3470) had a rating of 7, and later they recovered fully. These lines could be used as donor parents for cold tolerance.

Advanced breeding lines (10185 progenies) were also screened for cold tolerance and 7218 progenies or 70.87% material was rejected

Table 24. Reaction of chickpea advanced segregating generations to cold (low temperature) at Tel Hadya, 1984/85.

	Scale									
Generation	1	2	3	4	5	6	7	8	9	Total
F_4	0	0	73	635	771	974	2452	4133	138	9176
F_5	0	0	2	92	137	155	277	209	0	994
F_6	0	0	3	23	45	48	97	78	1	295
F_7	0	0	3	15	24	52	89	82	1	266
Total	0	0	81	765	979	1236	2948	4582	140	10731
% of total	0.00	0.00	0.75	7.13	9.12	11.52	27.47	42.70	1.30	

Scale: 1 = free; 9 = killed.

(Table 24). Many lines rated 3 or 4 and were very productive and uniform. Promising lines from these were bulked.--*K.B. Singh and R.S. Malhotra.*

Ascochyta Blight Resistance

The 1984/85 season proved unfavorable for ascochyta blight development and spread. The spores of the pathogen present in the debris were killed due to low temperature between 20 February and 15 March. Thereafter, the temperature abruptly rose and the weather became dry, not permitting the disease to develop. Even repeated spore suspension sprays followed by sprinkler irrigation failed to produce the disease. It appears that if temperature is high and weather dry, spore suspension sprays and sprinkler irrigations will not help in creating an epiphytotic of ascochyta blight.--*K.B. Singh and R.S. Malhotra.*

Improved Kabuli Chickpea Cultivars and Genetic Stocks

Crossing

Using one ascochyta blight resistant parent, 413 crosses were made, which included the crosses requested by Egypt, Jordan, Lebanon, and Tunisia. In keeping with the demand by national programs for large-seeded and early-maturing germplasm, 55% of the crosses combined these traits with high yield and ascochyta blight resistance.

Segregating Populations

The F_1 generation was raised as usual in the off-season nursery under continuous light at Sarghaya. This procedure helped in transferring the desired genes from the late-maturing lines, which otherwise do not mature during summer. The F_2 populations were grown at Tel Hadya in the ascochyta blight disease nursery.

A total of 14,225 F_3 to F_7 progenies were grown during 1984/85. Of these 5111 F_3 were grown in the off-season where the material was screened for less-photoperiod sensitivity. The remaining progenies were grown in the main season at Tel Hadya and the susceptible material was eliminated; 179 lines were bulked for off-season screening for less photoperiod sensitivity in 1985. The lines selected from this screening will be tested for yield and adaptation in the 1985/86 season.

Table 25. Mean yield performance of newly developed lines during the 1984/85 winter season.

Location	Trials conducted	Entries tested	Entries exceeding check[1]	Entries significantly exceeding check[1]	Yield range for best entries (kg/ha)	Range for CV (%)	Range for LSD at 5%
Tel Hadya (Syria)	15	255	208	123	633-2525	15.1-51.7	138-970
Jindiress (Syria)	11	193	100	27	1475-2292	16.5-34.1	320-710
Terbol (Lebanon)	13	229	152	12	1875-2597	11.0-22.7	441-757

1. ILC 482.

Yield Trials for Winter Sowing

Seed yields of 255, 193, and 229 newly bulked lines were investigated at Tel Hadya, Jindiress, and Terbol, respectively. As many as 123 entries at Tel Hadya, 27 at Jindiress, and 12 at Terbol exceeded the check by a significant margin (Table 25). A few lines outyielded the check at all locations, thus revealing their wide adaptation. While most lines had a variable response to seasons and locations, a few had a stable performance. Performance in terms of ranks of a few lines is given in Table 26.

The lines significantly outyielding the check also had better tolerance to ascochyta blight and cold.

Yield Trials for Spring Sowing

A total of 237, 193, and 229 newly bulked lines were evaluated for yield at Tel Hadya, Jindiress, and Terbol, respectively. Although many genotypes exceeded the check, only one line each at Tel Hadya and Terbol superseded the check by a significant margin. Analysis of results from the past several years indicated that most of the newly developed lines are later in maturity than the check. Crop growth period in spring sowing being short, it favors early-maturing lines.

Table 26. Performance (in terms of yield rank) of some chickpea lines at Tel Hadya, Jindiress, and Terbol as also across all these locations in the 1984/85 season.

Entry	Tel Hadya		Jindiress		Terbol		Overall	
	W	S	W	S	W	S	W	S
FLIP 83-13C	2	1	1	15	3	5	1	3
FLIP 83-98C	5	11	2	8	6	2	2	1
FLIP 83-88C	3	7	5	9	3	4	3	4
FLIP 84-70C	3	11	1	4	2	7	1	6
FLIP 84-104C	7	2	4	1	5	1	5	1
FLIP 84-116C	2	3	1	5	8	8	1	3

W=Winter; S=Spring

Large-Seeded Chickpeas

In view of the great demand by the national programs for ascochyta blight resistant large-seeded chickpeas, the development of such types has been given special emphasis . During 1984/85, 1234 F_3 to F_5 progenies were grown, 2099 plants selected, and 26 promising progenies bulked. Many of the newly bulked lines have seed size exceeding 50 g/100 seeds.

Eighteen newly bulked large-seeded lines were evaluated for yield; performance of the six best yielding lines is shown in Table 27. One of the major reasons for the higher yield of test entries over check was their better cold tolerance. After one more year of evaluation, these entries will be provided to cooperators for winter sowing.

Table 27. Performance of six best yielding large-seeded chickpea entries in the winter-sown preliminary yield trial at Tel Hadya, 1984/85.

Entry	Days to flowering (No.)	Plant height (cm)	Cold tolerance (1-9 scale)	100-seed weight (g)	Yield (kg/ha)
FLIP 84-19C	133	38	5.0	46	1958
FLIP 84-18C	132	40	3.0	44	1792
FLIP 84-17C	138	34	5.5	45	1650
FLIP 84-1 C	144	31	7.0	43	1375
FLIP 84-12C	140	30	7.0	41	1225
FLIP 84-2 C	142	33	7.0	40	1033
ILC 482 (check)	136	19	8.0	26	333
SE ±					180.71
CV (%)					31.01

Scale: 1 = tolerant; 9 = killed.

Tall Chickpeas

In the Mediterranean region farmers prefer tall chickpeas for machine harvest. Tall chickpeas available in our germplasm have three major defects: (1) poor seed type (intermediate- type, classified as pea shaped), (2) poor yield, and (3) late maturity. We have developed high-yielding lines with true kabuli-type seed (Table 28), but these lines are not early maturing and this is where future emphasis will be laid. The plant height is also less than generally attained by the tall types, mainly due to severe cold.

Thirty-four tall chickpea progenies have been bulked, some of which have seed size exceeding 40 g/100 seeds. A few of them are as early as ILC 482.--*K.B. Singh and R.S. Malhotra.*

Desi Chickpeas

A small proportion of our resources has been devoted towards development of ascochyta blight resistant desi types, especially suited for Pakistan and northwest India. The crosses were made at the ICRISAT Center and F_2 seed supplied to ICARDA. During 1984/85, more than 50 promising F_5 progenies were bulked and grown in the off-season nursery in 1985. If they prove less-photoperiod sensitive, their seed will be furnished to breeders in Pakistan and at ICRISAT for evaluation of their yield and adaptation.--*K.B. Singh, R.S. Malhotra, and ICRISAT scientists.*

On-Farm Trial

The on-farm trials, which started in Syria during 1979/80, have been extended to other countries. During 1984/85, we furnished seed for on-farm trials to Syria (ILC 3279, FLIP 82-236C), Morocco (ILC 195, ILC 482, ILC 484), Turkey (ILC 482, ILC 3279), and Egypt (ILC 482, ILC 484, ILC 195).

Syria. The on-farm trials were jointly conducted by the Ministry of Agriculture and Agrarian Reform, Syria and ICARDA at 11 locations during 1984/85. Winter-sown ILC 482, ILC 3279, and FLIP 82-326C chickpea lines were compared with spring-sown Syrian Local landrace. ILC 3279 tolerated cold very well

Table 28. Performance of six tall chickpea lines in the preliminary yield trial at Tel Hadya, 1984/85.

Entry	Days to flowering	Plant height (cm)	Cold tolerance (1-9 scale)	100-seed weight (g)	Seed type	Yield (kg/ha)
FLIP 84-20C	136	37	5.5	32	K	1825
FLIP 84-43C	138	32	3.0	30	K	1625
FLIP 84-46C	137	43	4.5	34	K	1467
FLIP 84-22	140	40	6.0	34	K	1275
FLIP 82-42	142	39	6.0	32	K	1050
FLIP 82-33	139	47	5.5	37	K	975
ILC 3279 (check)	141	42	6.0	29	I	1258
SE ±						
CV (%)						

Scale: 1 = tolerant; 9 = killed.
K = kabuli; I = intermediate.

and produced higher yield than both FLIP 82-236 C and ILC 482 (check). ILC 3279 has been tested in on-farm trials for 4 years at 69 locations and produced 1296 kg/ha yield. It exceeded Syrian Local sown in spring by almost 100%. ILC 3279 has better resistance to ascochyta blight and cold than ILC 482 and being taller is better suited to machine harvest. Because of these special attributes, the Syrian Ministry of Agriculture has identified this cultivar for release.

Morocco. Three cultivars, ILC 195, ILC 482, and ILC 484 were evaluated during winter in the on-farm trials in Morocco. Due to their superior performance, the Moroccan Government has decided to issue the seed to the farmers.

Turkey. In the Mediterranean region of Turkey, introduction of winter sowing has been investigated. As a result there is a possibility of release of ILC 195 and ILC 3279 *for winter sowing in Izmir*. On-farm evaluation of ILC 482 for early-spring sowing was done in the Diyarbaker region during 1984/85. The crop of ILC 482 showed better yield than local and the farmers have asked for larger quantities of seed of this variety. The Turkish program may release ILC 482 for spring sowing in this region if it maintains its superiority in 1986.

Egypt. Three cultivars, ILC 195, 482, and 484 were tried in new areas in northern Egypt with a possibility of introducing chickpea with limited sprinkler irrigation. The results were promising and the trials will continue in the following year.--*K. B. Singh, and R. S. Malhotra and scientists from national programs.*

Chickpea Diseases and their Control

The 1984/85 season was the most unfavorable for the development and spread of ascochyta blight. Consequently, germplasm and breeding lines could not be properly screened. Work on nematodes continued in cooperation with the Instituto di Nematologia Agraria, C.N.R., Bari, Italy. Results of laboratory and greenhouse experiments are reported.

Spore Concentration of *Ascochyta rabiei* and Disease Development

The effect of spore concentration (from 50,000/ml to 7,500,000/ml) of race 3 was studied on the disease development in 10 genotypes of chickpea (Table 29). In general, higher spore concentrations increased the disease severity, but the threshold level differed among the genotypes. For example, ICC 3996 could resist the pathogen load until 5 million/ml concentration, but at 7.5 million/ml it showed susceptible reaction. However, ILC 182 and ILC 482 had nearly consistent resistant and tolerant reactions, respectively. Some genotypes, such as ILC 215 and ILC 1929, had susceptible reactions both at low and high spore concentrations. There is an indication of 'slow blighting', at least in one genotype (ICC 3996), and it will be interesting to pursue this study.

Effect of Relative Humidity on Severity of Ascochyta Blight

The effect of 100% relative humidity for variable period of time on ascochyta blight development was studied in 10 chickpea genotypes differing in their reaction to race 3. Longer periods of 100% relative humidity increased the disease severity. The threshold period differed in different genotypes. For example, ILC 182 showed consistently resistant reaction from 0 hr to 30 days, ILC 3279 maintained resistant reaction for one day and thereafter had tolerant reaction, and ICC 4935 had a variable reaction. It can be concluded that if the weather conditions remain favorable for a protracted period, even the resistant lines under normal situation may suffer heavy loss in yield due to this disease.

Table 29. Effect of spore concentration (1000/ml) on reaction of chickpea genotypes to race 3 of *Ascochyta rabiei* at Tel Hadya (greenhouse), 1984/85.

	Blight severity[1] at different spore concentrations						
Genotype	50	100	500	1000	5000	7500	Mean
ILC 182	2.0	3.7	4.3	4.7	3.3	4.3	3.7
ILC 187	3.3	4.3	4.0	4.3	5.7	6.0	4.6
ILC 200	2.7	4.3	5.7	5.7	5.3	5.7	4.9
ILC 215	7.3	6.0	8.0	8.0	8.7	8.7	7.8
ILC 482	5.0	5.0	6.0	6.0	5.7	6.7	5.7
ILC 1929	8.7	8.7	9.0	7.3	9.0	9.0	8.6
ILC 3279	3.0	3.0	5.7	5.7	5.3	6.3	4.8
ILC 3346	5.7	4.7	6.0	6.0	6.0	6.3	5.8
ICC 3996	2.0	2.0	3.0	3.3	3.0	6.7	3.3
ICC 4935	4.0	3.0	5.0	6.0	5.7	6.7	5.1
Mean	4.4	4.5	5.7	5.7	5.8	6.6	5.5

CV (%) Spore concentration	12.48
CV (%) Genotypes	13.71
LSD (5%) Spore concentration at same level of genotype	1.21

1. Rating scale: 1 = free, 9 = killed.

Disease Severity and Sporulation of Six Races of *Ascochyta rabiei*

Only a weak relationship between disease severity and sporulation was observed. For example, ILC 72 had one million spores/g of tissue with race 1 and 5, but disease rating, respectively, was 3.5 and 6.0 on a 1-9 scale. On the other hand, both sporulation and disease severity were high for genotype ILC 1929 with the races 1 and 5. Sporulation rates were different for different races. It was low for races 3, 4, 5, and 6 and high for race 1 and 2. Race 1 seemed to be the most mild one. The most aggressive one was race 5 against which none of the tested genotypes were resistant. Two genotypes (ILC 72 and ILC 3279) were resistant against all the races, except race 5 which is not common in Syria.

Cross Protection Between Two Races of *Ascochyta rabiei*

Cross protection between the most common race (race 3) and an aggressive race (race 6) in Syria was studied. The hypothesis was that the two races may provide protection against each other and the severity may be reduced in genotypes. In general, the results did not support the hypothesis. However, in 40% genotypes, when inoculated with both race 3 and race 6, the reaction equalled the mean reaction of the two races inoculated independently. This year's finding was contrary to last year's. Therefore, this aspect will be studied further. --*R.S. Malhotra, K.B. Singh, M.V. Reddy, and M.P. Haware.*

Studies on Nematodes

Survey. A survey of nematodes was again conducted in 1984/85. Soil and plant samples were collected, mostly from northern Syria and some from southern and central parts of Syria. Infestation with cyst nematode (*Heterodera* sp.) was very widespread and reached destructive levels in some fields. While root-knot (*Meloidogyne artiellia*) and root-lesion (*Pratylenchus thornei*) nematodes seem to be sporadic on winter-sown chickpeas, cyst nematode is more common on the spring-sown chickpeas and is also widely prevalent in the farmers' fields, especially along the Idleb-Saraqeb road.

Host range of root-knot nematode (*Meloidogyne artiellia*). The root-knot nematode, *Meloidogyne artiellia*, has been reported to cause yield losses of chickpea in Spain, Italy, and Syria. Chemical control of the nematode is not feasible because of the high cost of treatment, but crop rotation could provide a satisfactory solution. Unfortunately, information on the host range of the nematode is scanty. Therefore, a greenhouse investigation was undertaken at Bari (Italy) to assess the host status of 53 economically important plant species. Plants were grown in clay pots containing 750 cm^3 of soil. When the plants had germinated, each pot was inoculated with 20,000 eggs and juveniles of the nematode. Forty-five days later the plants were lifted and the nematodes in 5 g of roots extracted and counted. Numbers of *M. artiellia* collected from the roots showed that all tested members of *Cruciferae*, *Leguminosae*, and *Graminaceae* were good hosts. Most of the members of *Solanaceae*, *Umbelliferae*, *Chenopodiaceae*, *Cucurbitaceae*, and *Malvaceae* were, instead , poor or non-host. Also, species of *Compositae*, *Liliaceae*, *Linaceae*, and *Rosaceae* were non-host. Among the *Leguminosae* and *Graminaceae*, cowpea, lupin, and corn were non-host, and bean, lentil, soybean, sanfoin, and oat were poor hosts of the nematode and could be included with profit in a rotation program to limit yield losses by *M. artiellia*. Many of these crops, such as lentil, oat, sunflower, sugarbeet, cotton, and flax, are grown on large areas in many Mediterranean countries.

Host range of the chickpea cyst nematode (*Heterodera* sp.). In Syria chickpea has been reported to be seriously damaged by *Heterodera* sp., whose host range was not known. Research on the host range of *Heterodera* sp. at Bari (Italy) and ICARDA (Syria) was conducted on the same 50 plant species tested for their host status toward *M. artiellia.* Experimental conditions were the same as for *M. artiellia,* but the pots were inoculated with 15,000 eggs of the nematode/pot before sowing or transplanting, and the nematode extracted from the root 2 months later. The host range of the nematode was found confined to members of the *Leguminosae* family and only a few females were collected from roots of carnation, reported to be a good host of some populations of *H. trifolii,* occurring in Mediterranean countries. All *Trifolium* sp. tested were found to be non-hosts, but the nematode was collected in large numbers from roots of chickpea, lentil, and pea. Cowpea and grasspea were also good hosts. Faba bean, *Medicago* spp. lupin, and vetch were poor hosts. No nematode reproduction was observed on *Rumex crispus*, the type host of *H. rosii.* Because of the rather narrow host range of the chickpea cyst nematode, crop rotation with non-leguminous crops should help avoid yield loss due to this nematode.

In Syria, species common to the Mediterranean region were tested against cyst nematode to understand its host range. This study was done in artificially infested soil (75 cysts/200g soil) in the greenhouse. The crops tested comprised food and forage legumes, cereals and others grown in winter, spring, and summer: chickpea, faba bean, lentil, peas, vetch, medic, *Lathyrus,* durum wheat, bread wheat, triticale, potato, beet-root, lettuce, turnip, cabbage, cauliflower, radish, carrot, parsley, spinach, coriander, *Phaseolus, Vigna,* soybean, lupins, maize, sorghum, sunflower, cotton, linseed, tomato, chillies, watermelon, muskmelon, pumpkin, gourds, cucumber, onion, garlic and okra. Peas, chickpeas, Medics, *Lathyrus,* and lentils were found good hosts and barley, faba bean and sunflower as poor or non-hosts.

Screening of chickpea lines for resistance to *M. artiellia.* Three hundred forty-one lines of *Cicer arietinum,* three samples each of the wild species *C. judaicum* and *C. pinnatifidum,* and one sample each of *C. reticulatum, C. cuneatum,* and *C. bijugum* were evaluated in pot culture, for their resistance to *M. artiellia* at Bari. Even though some differences were observed on the reproduction of *M. artiellia* on lines of *C. arietinum,* none was resistant to the nematode. All wild species of *Cicer* were highly susceptible to the root-knot nematode.

Greenhouse screening at ICARDA in 1983/84 of 290 ascochyta blight resistant, newly-developed kabuli lines revealed that 27 were resistant. These lines were included in an advanced screening trial in 1984/85 and four of them (FLIP 82-215, FLIP 82-144, FLIP 83-11, and FLIP 83-85) were found to show resistance to cyst nematode. At the same time, 183 of our newly developed lines (FLIP 84) were screened by using an augmented design and adding three checks to each block: ILC 482 (susceptible), ILC 1929 (susceptible), and ILC 3279 (tolerant). Out of these lines, 26 were resistant, with low number of cysts/g roots. These 26 lines plus four lines from the previous screening were screened in an advanced trial, and were identified as resistant or tolerant to cyst nematode.

In addition, 70 lines from our 1984/85 crossing program were screened in an augmented design and seven were tolerant to cyst nematode. These lines will be retested in 1985/86. In another screening of nine wild species lines only one was tolerant: NEWC 7 (*Cicer bijugum*).--*M.V. Reddy, R.S. Malhotra, and K.B. Singh; and N. Greco and M. di Vitto, Bari, Italy.*

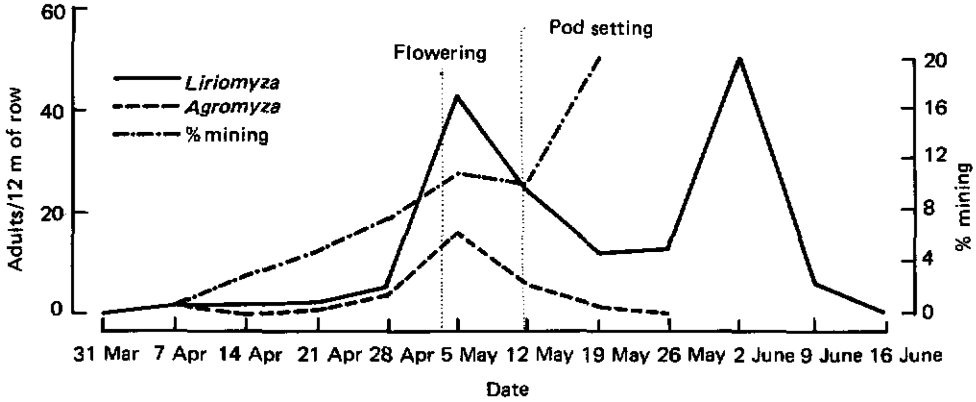


Fig. 14. Seasonal fluctuation in adult chickpea leafminer populations and percentage leaflets mined, Tel Hadya, 1984/85.

Chickpea Insects and their Control

Insect populations

In general, leafminer and pod borer populations were lower in the 1984/85 season, possibly because of very low temperatures in winter. Frost damage caused the loss of all winter trials, and lower leafminer populations did not permit the detection of significant effects in four spring trials aimed at establishing critical periods and populations for leafminer control.

Studies on seasonal population dynamics of leafminers were continued. The Commonwealth Institute of Entomology has confirmed that the second species of leafminer reared from chickpea crops in Turkey, Syria, and Jordan is *Agromyza* sp.nr. *lathyri* Hendel. This species is of much lesser importance than the well known chickpea leafminer, *Liriomyza cicerina* (Rondani). In what has been a consistent pattern for the past three seasons, both leafminers come out of diapause in early April. While *Agromyza* goes through one generation, *Liriomyza* is capable of producing two generations per season, the second one being larger than the first (Fig. 14). Mining of leaves starts 1 week after the initial adult feeding and oviposition, increases to 20-25% in mid-flowering and then increases sharply towards 40-50% after pod setting. These studies are important as previous work has shown that damage due to the first generation is more important than due to the second generation when the plant is more capable of compensating for damage.

Studies on Resistance to Leafminer

Screening for resistancae to leafminer continued. A total of 1001 cultivars were rated for resistance: 859 breeding lines, 111 lines in the rescreening nurseries, and 31 lines in the Chickpea International Leafminer Nursery. Of these, 70 lines will be rescreened in 1985/86 season and 5 will go into yield assessment to measure tolerance to the insect.

In an attempt to find a discriminant function for leafminer resistance, 101 varieties with varying degrees of resistance to leafminer and diverse morphological and physiological characteristics were planted in replicated nurseries and rated several times for leafminer damage. No significant correlations between visual damage scores and the following characters were found: duration of flowering, days to maturity, canopy width, seed yield, and protein contents. A

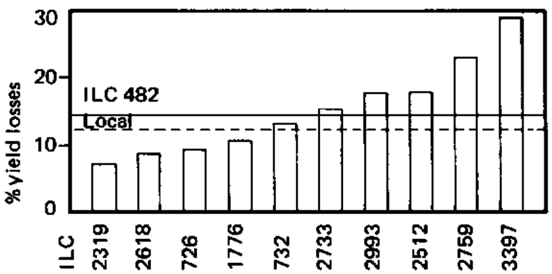


Fig. 15. Percentage yield losses due to leafminer in 12 chickpea genotypes selected for varying degrees of resistance to the insect. Means of three seasons (1983-1985), four replications per season.

significant correlation with height does not seem to be supported by previous field experience. The correlations which were more meaningful and tended to corroborate field observations are those with days to 50% flowering and 100-seed weight. The evidence tends to indicate that late, small-seeded cultivars are resistant whereas most early, large-seeded ones are susceptible or very susceptible. A detailed analysis of the 90 cultivars selected for resistance during the past three seasons tends to confirm these findings. However, a few of the cultivars rated 5 (tolerant) are large-seeded and not so late and could be utilized as sources to incorporate leafminer resistance.

An important approach to select for resistance to leafminer has been the testing for yield losses both in the presence and absence of the insect and the determination of corresponding yield losses in resistant and susceptible genotypes. Fig. 15 summarizes the information on mean yield losses due to leafminer in three consecutive seasons. Losses have ranged from 7% in ILC 2319 to 28.5% in ILC 3397, a very susceptible check. Cultivars ILC 2319, 2618, 726, and 1776 have consistently performed better than ILC 482 and the local which have been utilized as standard checks, and can be recommended as sources for the breeding program.

The studies on mechanisms of resistance to leafminer were continued. New, significant

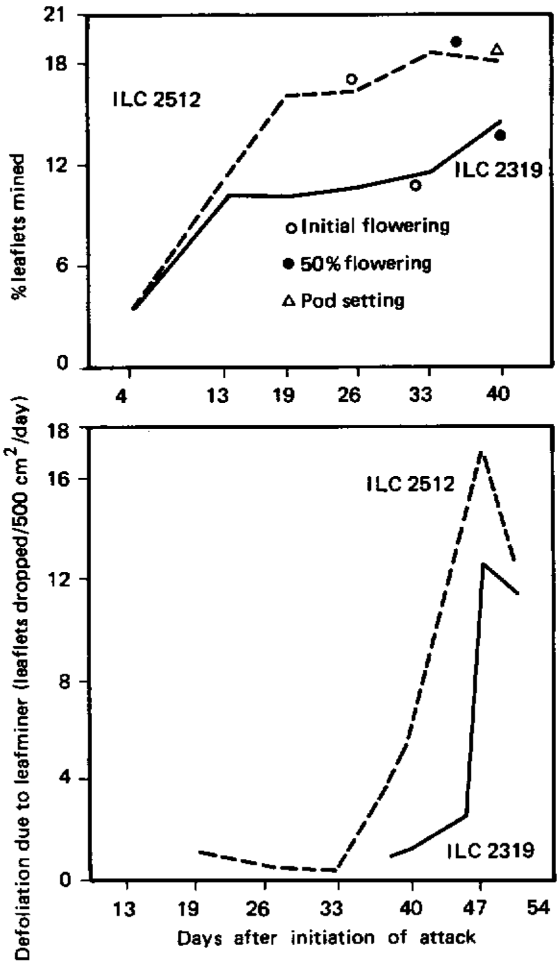


Fig. 16. Comparative seasonal levels of damage due to leafminer in a resistant (ILC 2319) and a susceptible (ILC 2512) chickpea genotype. Means of four replications, Tel Hadya, 1984/85.

evidence of differential levels of damage in terms of mining and defoliation was obtained. The resistant variety ILC 2319 had consistently less damage and defoliation than the susceptible variety ILC 2512 (Fig. 16). There are preliminary indications that non-preference for oviposition may be involved but more precise tests under controlled conditions are needed to reconfirm this. In terms of tolerance, expressed as percentage yield loss due to the insect, the resistant

ILC 2319 significantly outyielded the susceptible check ILC 2512 in the absence of insecticidal protection. ILC 2319 had lower yield increases when protected, showing less insecticide-dependence than the susceptible check, this being in the final analysis the ultimate goal of developing resistance to insects.--*C. Cardona, R.S. Malhotra, and K.B. Singh.*

Chickpea Microbiology

Acetylene Reduction Activity of Chickpea Cultivars in Relation to Inoculation

The 1984/85 was the second and final year of monitoring the acetylene reduction activity (ARA) in six promising lines of chickpea: ILC 482, 484, 202, 3279, 72, and 95. The lines were planted with, and without, inoculation with chickpea-specific *Rhizobium.* The field chosen for the 1984/85 trials had inoculated chickpeas in 1984/85. By reusing the field some indication of the establishment of the *Rhizobium cicer* population could be ascertained and the value of inoculation in the presence of the naturalized flora established.

Fig. 17 shows the effect of inoculation on ARA. Coating of the seed at the time of planting with a chickpea-compatible *Rhizobium* significantly increased its ARA. A comparison of Figs. 17 and 18 indicates that although inoculation increased ARA in all cultivars, there was a difference between cultivars in their ARA potential with ILC 72 showing the greatest potential. The effect of inoculation on ARA with time is shown in Fig. 19.

With the exception of ILC 482, inoculation did not significantly increase grain yields when the two treatments were compared (Fig. 20). The lack of significance in five out of six lines may be due to high coefficient of variability because of *Heliothis* damage. Averaged over all the genotypes, inoculation significantly increased seed yield over uninoculated check.--*J. Stephens.*

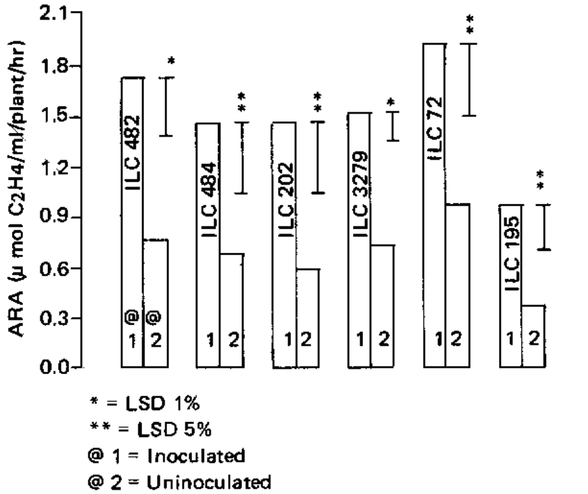


Fig. 17. A comparison of seasonal mean acetylene reduction values for six chickpea lines with and without inoculation.

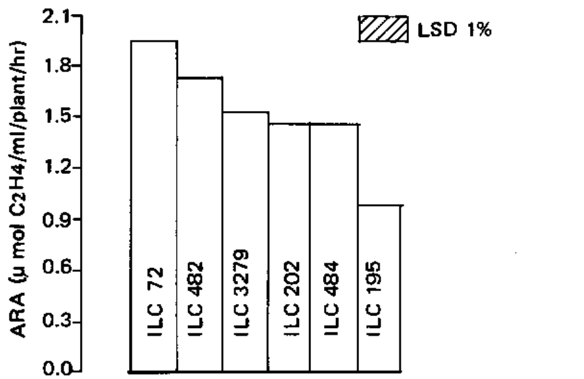


Fig. 18. A comparison of seasonal mean acetylene reduction values for six chickpea lines treated with inoculation only.

Studies on VA Mycorrhiza

Research on mycorrhiza was started in the 1984/85 season with a view to further investigate legume crop nutrition under mineral and water stress conditions. Several pot experiments were carried out in greenhouse at Tel Hadya to investigate mycorrhizal effects on chickpea growth under different conditions.

Elimination of mycorrhiza by soil sterilization prior to sowing resulted in

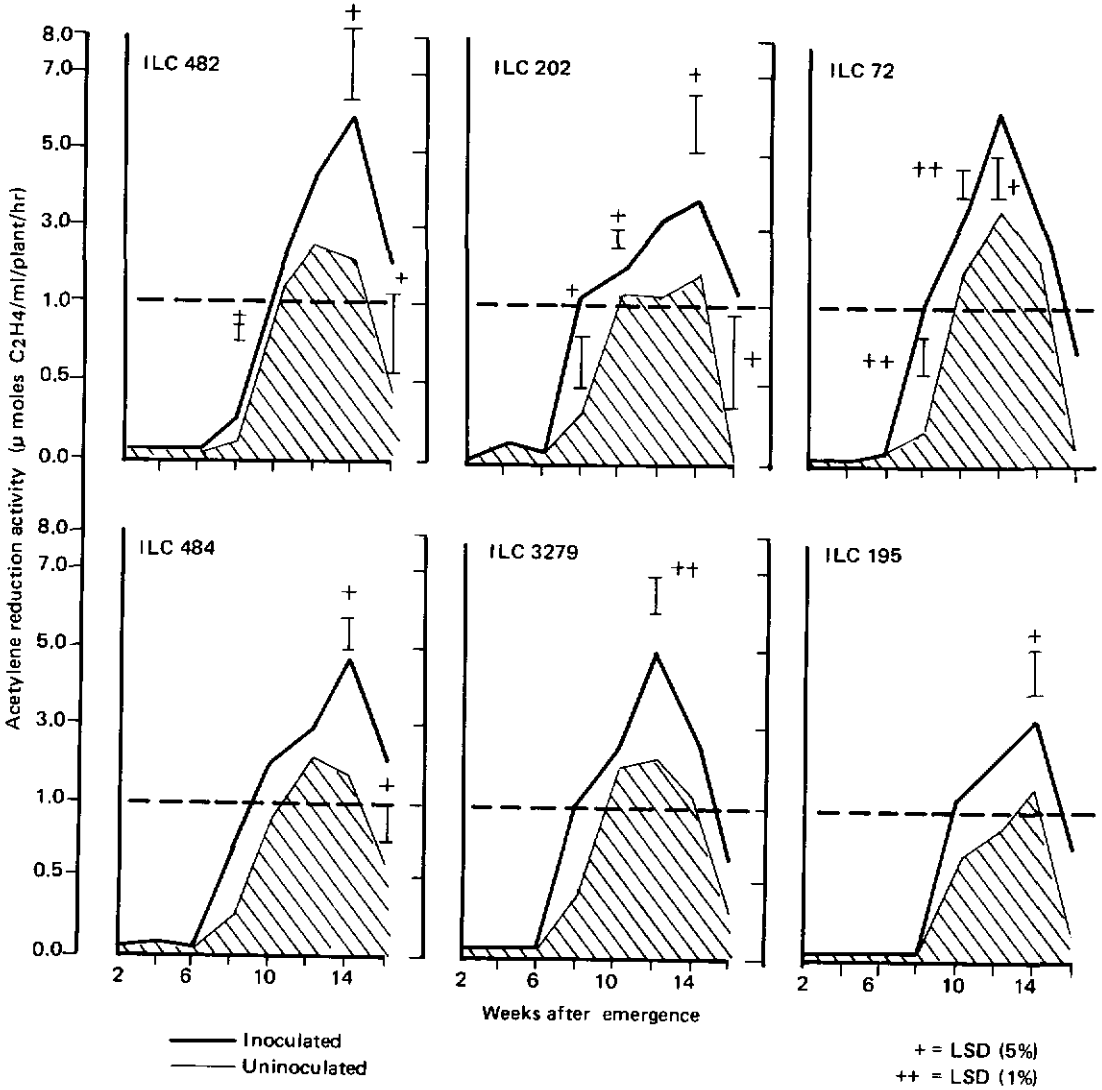


Fig. 19. A comparison of inoculated and uninoculated treatments for acetylene reduction with time for six chickpea cultivars.

drastic plant growth reductions. These effects were overcome by inoculation with indigenous mycorrhiza strains. In all experiments mycorrhiza influence on plant growth interacted strongly with phosphorus application. The promotion of growth due to mycorrhiza was most conspicious when medium levels of phosphorus were given, and was much reduced with very low or very high phosphorus levels. Additionally, if a range of different phosphorus levels was used, mycorrhizal plants showed a lower threshold of response than control plants. In the field, root samples were taken to observe the effects of different rates of triple-superphosphate on mycorrhiza infection and root growth.--*E. Weber and E. George (University of Hohenheim, West-Germany) and M.C. Saxena.*

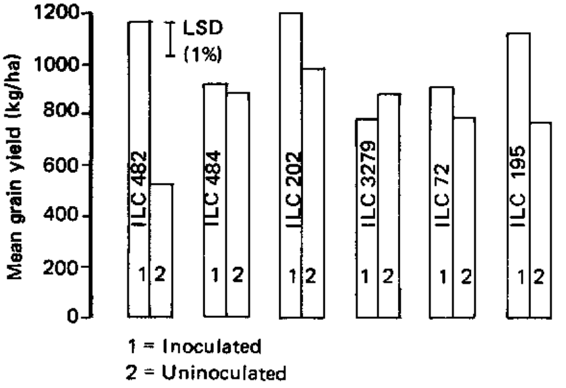


Fig. 20. A comparison of mean grain yield between inoculated and uninoculated treatments. Inoculated seed was coated with an effective strain of *Rhizobium cicer.*

Chickpea Production Agronomy and Crop Physiology

Response of Some Promising Lines to Date of Sowing

In West Asia and the Mediterranean region chickpeas are normally sown in spring, largely due to their susceptibility to ascochyta blight and frost. The reproductive stage of the spring-sown crop coincides with periods of water deficits and high temperatures, hence low seed yield is obtained. Following the introduction of ascochyta-resistant lines, it is now possible to sow in winter. The potential advantage of winter sowing is completion of flowering and pod development before soil moisture becomes limiting and temepratures rise high. A study was therefore initiated in 1984/85 to investigate the effect of a range of winter and spring dates of sowing (3 December 1984, 6 January, 5 February, 4 March, and 18 March 1985) on growth, development, and yield of three chickpea varieties: ILC 3279 (standard check), FLIP 82-39, and FLIP 82-236 (new promising lines).

Seed yield ranged between 500 and 1200 kg/ha (Fig. 21). ILC 3279 gave high seed

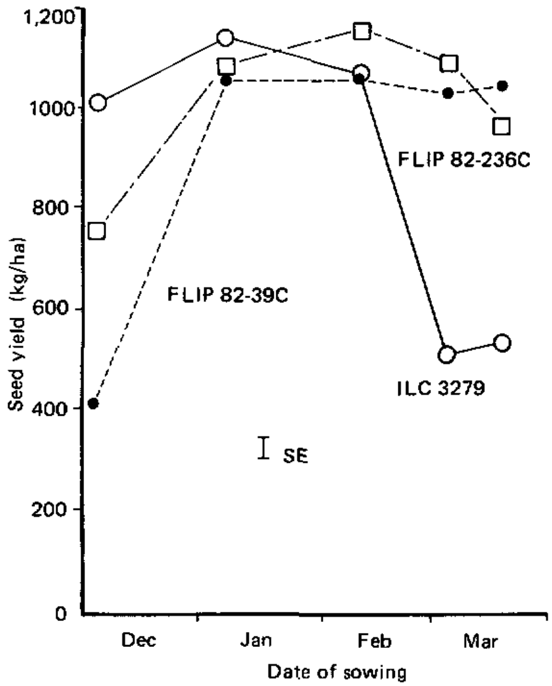


Fig. 21. Effect of sowing date on yield of three chickpea genotypes.

yield when sown in winter and delaying sowing to March resulted in reduction in yield. Sowing the new lines (FLIP 82-236 and FLIP 82-39) in early December resulted in significant reduction in seed yield mainly as a result of low plant population due to high winter kill. However, unlike ILC 3279, when sowing was delayed until March, there was no significant reduction in seed yield, indicating the suitability of these new lines for mid-winter and early spring sowings. All three lines produced high seed yield when sown in early January.

The main factors that appeared to have determined crop yield were the amount of dry matter accumulated and the way it was partitioned. For example, when FLIP 82-236 and FLIP 82-39 were sown in December, total biological yield obtained was low and seed yield was also low. The importance of dry-matter partitioning on seed yield was shown by ILC 3279 sown in March which, in

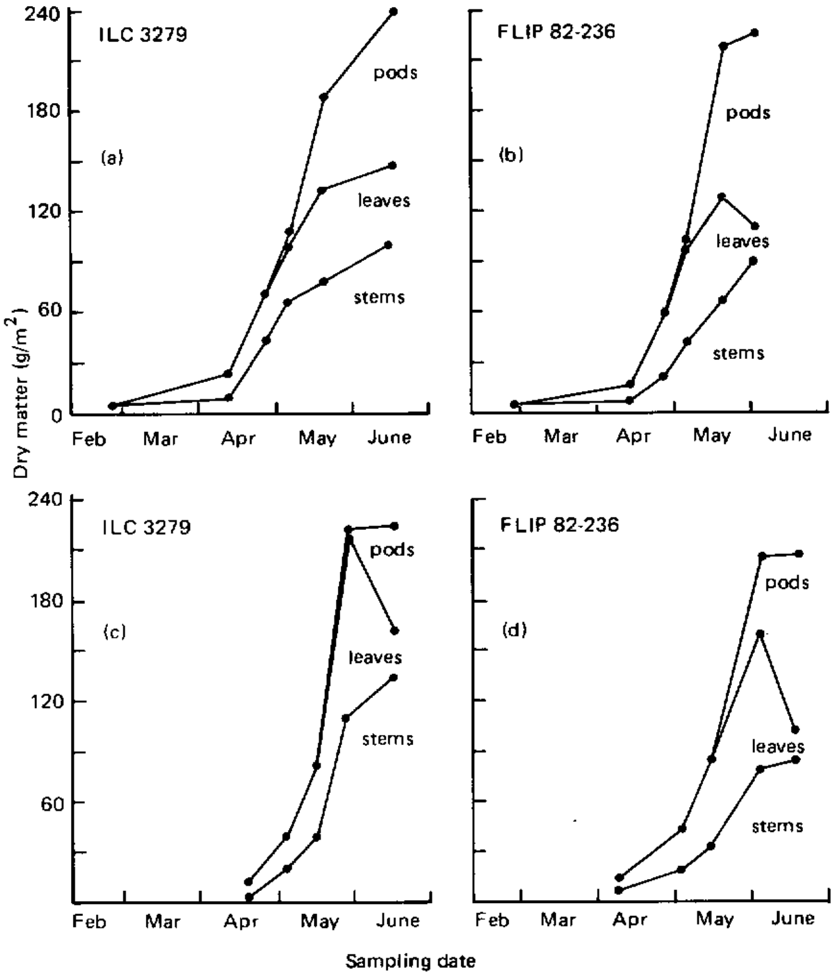


Fig. 22. Effect of sowing date (a & b = 6.1.1985, c & d = 4.3.1985) on dry-matter accumulation and partitioning in ILC 3279 and FLIP 82-236.

spite of attaining high total biological yield, gave low seed yield due to poor partitioning of assimilates to seeds (Fig. 22).

In conclusion, the results of the study indicate that ILC 3279 which is a late-maturing line should not be planted after January because of its poor dry-matter partitioning to seeds, and FLIP 82-236 and FLIP 82-39 perform well as mid- to late-winter crops, and sowing in early winter makes the crops prone to frost damage.

Response to Supplemental Irrigation

Little is known about the effect of supplemental irrigation on the winter- and spring-sown chickpeas in the Mediterranean conditions. Therefore, a trial was initiated in 1984/85 to investigate the role of supplemental irrigation (one each at flowering and pod set) on ILC 3279 sown in winter (28 November 1984) and spring (28 February 1985).

Irrigation extended the reproductive period of both winter- and spring-sown crops.

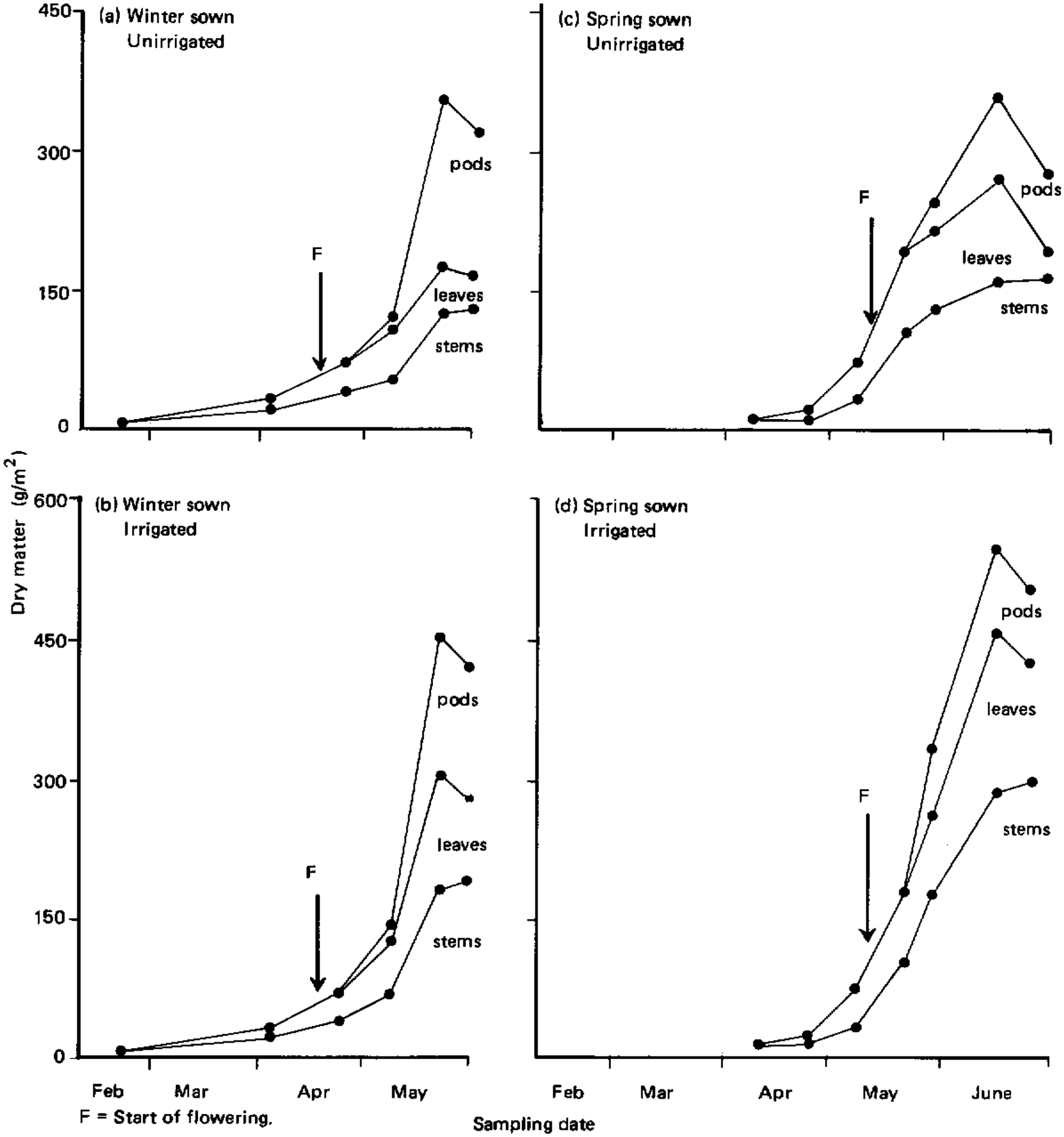


Fig. 23. Effect of date of sowing and supplemental irrigation on dry-matter production and partitioning.

The duration from flowering to maturity for winter-sown unirrigated and irrigated and spring-sown unirrigated and irrigated was 41, 52, 33, and 44 days, respectively. Total dry matter per unit area (Fig. 23) and photosynthetic area index (Fig. 24) were both increased by irrigation.

The effects of date of sowing and supplemental irrigation on yields and some of the components are given in Table 30.

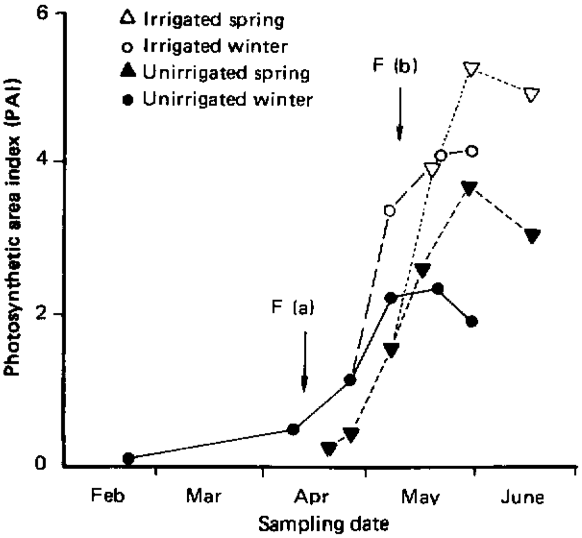


Fig. 24. Effect of time of sowing and irrigation on photosynthetic area index (PAI).

Advancing date of sowing into winter and irrigating the crop increased seed yield by 65% and 95%, respectively. At each date of sowing, 73% and 142% seed yield increases were obtained in winter and spring sowings, respectively, following supplemental irrigation. The increase in seed yield was mainly through increase in total biological yield (r = 0.91) and improved partitioning (increase in harvest index) of dry matter (r = 0.71) to seeds. Winter-sown and irrigated crops attained high biological yield and partitioned a larger proportion of assimilates to seeds, hence high seed yields (Table 30). The poor partitioning of dry matter to the seeds in spring sowing was perhaps due to the reproductive stage coinciding with the onset of high temperatures which favored vegetative growth and encouraged flower abortion.

In conclusion, the study indicated the usefulness of irrigation in both winter- and spring-sown chickpea line, ILC 3279. Even higher seed yields can be obtained in spring sowing through irrigation, if the improvement in partitioning of the total dry matter to seeds could be achieved.--*S. Silim and M.C. Saxena.*

Weed Control

The International Weed Control Trial in 1984/85 was conducted at Jindiress (Syria) and Terbol (Lebanon). Seed yield reduction due to weeds was 89% and 74% at Jindiress and Terbol, respectively (Table 31). Hand weeding twice as compared with repeated hand weeding resulted in a 19% yield increase at Jindiress but at Terbol it reduced yield by 22%. At Terbol, terbutryne (Igran) at 3.0 kg a.i./ha; terbutryne at 3.0 kg with pronamide (Kerb) at 0.5 kg a.i./ha and chlorbromuron (Maloran) at

Table 30. Effect of sowing date and supplemental irrigation on yield, harvest index, and 1000-seed weight of ILC 3279, Tel Hadya 1984/85.

Irrigation	Seed yield (kg/ha)		Biological yield (kg/ha)		Harvest index		1000-seed wt (g)	
	Winter	Spring	Winter	Spring	Winter	Spring	Winter	Spring
No irrigation	1153	557	2543	1866	0.46	0.30	289	309
Irrigation	1997	1349	4299	3521	0.47	0.39	293	268
Mean	1575	953		3421	0.46	0.34	291	289
	LSD	CV%	LSD	CV%	LSD	CV%	LSD	CV%
Sowing date	86.3	8.2	244.9	9.6	0.043	12.6	NS	10.6
Irrigation	151.8	15.8	338.8	14.6	0.044	14.3	NS	12.5
Interaction	NS		NS		NS		NS	

Table 31. Effect of different weed control treatments on yield and harvest index of chickpea, Jindiress and Terbol, 1984/85.

	Jindiress			Terbol		
Treatment	Seed yield (kg/ha)	Biological yield (kg/ha)	Harvest index	Seed yield (kg/ha)	Biological yield (kg/ha)	Harvest index
Weedy check	142	260	0.37	550	2008	0.26
Repeated hand weeding	861	1669	0.52	2124	3857	0.55
Hand weeding twice	1021	1953	0.53	1664	3096	0.54
Maloran @ 1.5 kg a.i./ha	75	150	0.46	505	2411	0.21
Tribunil @ 3.0 kg a.i./ha	142	297	0.47	752	2244	0.33
Igran @ 3.0 kg a.i./ha	307	602	0.51	1672	3871	0.40
Bladex @ 0.5 kg a.i./ha	361	745	0.48	439	2210	0.20
Cyanazine @ 1.0 kg a.i./ha	340	680	0.49	719	2154	0.32
Maloran @ 1.5 + Kerb @ 0.5 kg a.i./ha	293	604	0.48	1617	3130	0.52
Tribunil 3.0 + Kerb @ 0.5 kg a.i./ha	302	615	0.49	1418	2856	0.49
Igran @ 3.0 + Kerb @ 0.5 kg a.i./ha	299	596	0.49	1666	3829	0.45
Bladex @ 0.5 + Kerb @ 0.5 kg a.i./ha	456	912	0.50	1060	2421	0.44
LSD (5%)	147	280	0.05	653	1095	0.13
CV (%)	26.9	25.7	6.6	38.4	26.8	3.7

2.5 kg with Kerb at 0.5 kg a.i./ha were as effective in controlling weeds as hand weeding twice. At Jindiress, all hand weeding treatments were superior to chemical weed control. The reduction in yield at Jindiress with herbicides was due to phytotoxicity of herbicides following crop exposure to severe frost. The most phytotoxic herbicides were Maloran and Tribunil.

The 1984/85 season results indicate that some herbicides were as effective as hand weeding. However, in areas prone to frost, there is need to screen for phytotoxicity.--*M.C. Saxena and S. Kukula.*

Food Legume Seed and Straw Quality

General

Over 14000 tests were performed in the Food Legume Quality Laboratory during 1984/85 (Table 32). An earlier observation that overnight soaking significantly reduced the cooking time of food legumes was verified by further testing. Cooking time for chickpea, faba bean, and lentil was reduced by 62, 72, and 69%, respectively, by overnight soaking. A further reduction was obtained if sodium bicarbonate was used.

Chickpea

Useful information concerning early-generation evaluation was provided to breeders. Work on determination of protein, cooking time, and 100-seed weight of the International Nursery of Kabuli Germplasm was completed. Earlier observations on the correlation between seed size and cooking time were confirmed; the correlation was 0.87 for 3003 entries. Work was completed on a study of the effect of site and planting time on protein content, seed size, and yield for 207 genotypes, at two locations, Terbol and Tel Hadya. Winter planting increased yield by 78% at Tel Hadya and 44% at Terbol. Winter

Table 32. Tests carried out in Food Legume Quality Laboratory, 1984/85.

Test	Chickpea	Faba Bean	Lentil	Agronomy
Seed protein (NIR)	7089	1304	576	475
100-seed weight	240	1304	576	212
Cooking time	240	80	576	148
Seed size			576	
Straw digestibility			192	
NDF (Fibre) straw			192	
Moisture			308	
Total nitrogen (NIR) straw	36		228	
Total	7605	2768	3224	835

planting reduced protein content by 1% at Tel Hadya and 0.7% at Terbol but increased seed size by 4% and 5%, respectively. Though there was no significant difference in protein content between the two locations, both the 100-seed weight and yields were significantly higher at Terbol.

Faba Bean

Over 1400 lines were tested for breeders. Protein content was found to be a highly heritable parameter in a study of 21 selections of widely different protein content, over five locations and two seasons. Several genotypes retained high protein consistently, which enables the high protein characteristic to be transferred fairly simply to any genotype. These data are summarized in Table 33.

Lentil

Data on early-generation lines were provided to breeders. Studies on lentil decortication continued, and ICARDA received the Tangential

Table 33. Stability of faba bean protein (total nitrogen X 6.25, dry basis).

Acc. No. BPL	Tel Hadya 1981/82	Tel Hadya 1983/84	Terbol 1983/84	Terbol 1984/85	Lattakia 1984/85	Overall	CV (%)
303	34.2	29.8	31.3	29.9	30.0	31.3	5.7
400	32.5	35.2	33.7	30.7	32.3	32.6	5.0
585	33.5	30.3	30.7	30.3	29.3	30.3	5.1
361	22.5	26.2	26.7	23.1	23.4	24.1	5.9
369	21.4	25.7	24.1	21.3	23.7	23.3	8.4
759	23.6	26.0	25.4	24.1	20.9	24.8	7.5

The heritability for low and high protein lines was 87.6% for two locations over two seasons.

Abrasive Dehulling Device (TADD) machine, for the small-scale decortication of lentils (10 g sample size). The TADD was developed at the Plant Biotechnology Institute, Saskatoon, Canada, and was donated to ICARDA via a grant from the International Development Research Centre (IDRC), Ottawa, Canada. Decortication studies during 1984/85 focused on development of procedures whereby comparable results could be obtained for decortication, using the TADD, the ICARDA laboratory decorticator, and the F.H. Schule laboratory decorticator.

Quality assessment of the nutritive value of straw of advanced lines of lentils grown in on-farm trials was commenced. This consisted of determination of pepsin/cellulose digestibility (PCD), neutral detergent fibre (NDF), which is an indication of voluntary intake, and crude protein (CP = total nitrogen x 6.25, dry basis). The results are summarized in Table 34.

The trials were grown at eight locations in the lentil-growing region of Syria. A strong location effect was apparent, but interactions between genotype and location were not statistically significant. The influence of growing location is summarized in Table 35.--*P.C. Williams, K.B. Singh, L.D. Robertson, and W. Erskine.*

Table 34. Quality parameters of straws of advanced lentil genotypes.

Genotype	PCD	NDF	CP
ILL 8	48.6	58.5	7.1
ILL 9	48.4	59.3	6.8
ILL 2126	46.0	63.8	7.6
ILL 16	48.9	61.5	6.4
ILL 223	47.2	64.0	6.3
ILL 2130	51.0	58.6	7.4
LSD (P=0.05)	2.4	3.4	0.6

Table 35. Influence of location on lentil straw quality.

Location	PCD	NDF	CP
Tel Hadya	45.6	61.8	5.8
Heimo	48.0	58.6	7.5
K.Naseb	50.1	57.7	6.0
Izra'a	49.8	64.2	9.0
Afess	53.0	58.1	5.7
M.Mesrin	48.2	63.4	6.2
Gelline	49.2	56.3	8.9
Squelbeya	42.7	67.5	6.5
LSD (P=0.05)	2.7	3.9	0.6

PCD = Pepsin/cellulose digestibility (%)
NDF = Neutral detergent fiber (%)
CP = Crude protein content (%)

Variation in Straw Quality in Lentil, Faba Bean, and Chickpea

The nutritive values of lentil, chickpea, and faba bean straw grown at Tel Hadya are summarised in Table 36. The overall mean for the digestibility of lentil straw was 49.5 g digestible organic matter per 100 g dry matter, but this resulted from the seasonal means of 60.0 and 39.0 g/100g. The corresponding mean digestibility value for chickpea straw, also grown at Tel Hadya during 1983, was 41.5 g/100 g; whereas for faba beans it was 44.6 g/100 g. The crude protein value for lentil straw was higher than that of chickpea and faba beans; but the neutral detergent fiber means showed chickpea as having the lowest value.

The influence of year or time of planting is very much greater than the effects of genotype (Table 37). With lentils there were substantial genotype x year interactions. Genotypic effects were nonsignificant when tested against the genotype x year interaction for digestibility, crude protein content and neutral detergent fiber level (Table 37). With chickpeas the effects of planting time

Table 36. Nutritive values of lentil, chickpea, and faba bean (mean and standard error).

	Lentil		Chickpea 1983		Faba Bean
	1982	1983	Winter	Spring	1983
Digestibility[1]	60.0(1.98)	39.0(2.06)	40.4(0.51)	42.5(0.35)	44.6(0.64)
Crude protein (%)	6.7(0.51)	6.4(0.65)	3.8(0.08)	4.7(0.15)	5.0(0.13)
Neutral detergent fiber (%)	60.0(1.61)	64.0(3.13)	60.9(0.55)	57.2(0.25)	65.7(0.80)
Ash (%)	9.1(0.65)	6.5(0.45)	10.6(0.24)	10.8(0.19)	8.3(0.22)

1. Digestible organic matter (g/100 g dry matter).

Table 37. Significance of genotypes differences compared with year or time of sowing.

	Genotype	Year of Sowing
Lentils		
Digestibility[1]	NS	XXX
Crude protein (%)	NS	NS
Neutral detergent fiber (%)	NS	XXX
Ash (%)	NS	XXX
		Time of Sowing
Chickpea		
Digestibility[1]	NS	XX
Crude protein (%)	NS	XXX
Neutral detergent fiber (%)	NS	XXX
Ash (%)	NS	XXX

1. Digestible organic matter (g/100 g dry matter).
NS ; $p > 0.05$
XX ; $p < 0.01$
XXX; $p < 0.001$

were significant when considered against genotype x season interactions for digestibility, crude protein content, and neutral detergent fiber level but genotype effects were nonsignificant. These results suggest that in contrast with cereals the prospects for selection for straw quality using laboratory evaluation are poor. It may be noted that only limited number of genotypes have been evaluated and more differences might become apparent when material from germplasm collection is evaluated.

It is difficult to generalize the influence of plant characteristics on straw value because of exceptions. However both days to flowering and days to maturity appear to be associated with reduced neutral detergent fiber content. Thus, in general, voluntary feed consumption should be higher in late flowering or maturing genotypes or when these are delayed by climatic conditions. Similarly, with the exception of winter-sown chickpeas, digestibility is reduced in taller plants and neutral detergent fiber value is increased, but many of the correlation coefficients are nonsignificant. The most encouraging aspect is that, with the exception of faba beans, digestibility is associated with higher seed yields. Thus there is no evidence that selection for seed yield or adoption of agronomic practices to increase yield would, in general, adversely affect straw quality in food legumes.

In spite of the limited number of genotypes evaluated, the extent of genotypic variation in straw quality in food legumes is large enough to provoke interest. However, in contrast to cereals it seems it will be more difficult to predict this. It is likely that climatic variations, which may produce differences in degree of secondary thickening, will tend to mask genotypic variation. Variations in agronomy which lead to the plant experiencing different climatic conditions, e.g. winter/spring-sown chickpeas may produce variations in the degree of lignification, associated low molecular weight lignin precursors (ferulic, diferulic and coumaric acids), and tannins which are all known to influence straw value for ruminants. An investigation of these parameters may provide explanations for the observed variation. It would also be important to use animals to conduct voluntary intake and digestibility studies of food legume straws since these may reveal differences, particularly in voluntary intake, which cannot be accurately assessed in the laboratory.--*Willie Erskine, Brian Capper, L.D. Robertson, K.B. Singh, and M.C. Saxena.*

Collaborative Projects

International Testing Program

The international nurseries play a significant role in dissemination improved germplasm to cooperators in different countries. We continued coordinating the international testing program between ICARDA and the legume scientists in national programs. The main thrust continued to be on the identification of superior genotypes with wide adaptation, resistance to diseases and insect pests, and acceptable seed quality, and finding an optimum package of practices for food legumes in varying environments.

The 1984/85 season being exceptionally cool, a large number of lines in seed increase plots were severely affected especially faba beans. This resulted in a relatively limited number of available sets of faba bean nurseries/trials to cooperators. For 1985/86 season, we supplied 1182 sets of 39 different types of nurseries and trials to 129 cooperators in 52 countries (79% of the total demand). The increasing demand for nurseries every year reveals the increasing awareness and interest of food legume scientists in the national programs in ICARDA materials.

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 1985/86.

ICARDA/IFAD Nile Valley Project

In 1985, this special project reached the last year of its second 3-year phase. The objectives of this project have already been described in our previous annual reports as also in a special publication, 'The Nile Valley Project - A Model of Cooperation between International and National Programs in Research and Extension', issued by ICARDA. A comprehensive 6-year report of the project is under preparation. The major highlights of research during the 1984/85 season in the project are described here.

On-Farm Trials in Egypt

On-farm research was carried out in three governorates with farmers' participation using large plots of 0.4 ha each to reduce farmers' bias and to have better estimates of the package impact on yield and economic return. Some of these plots also served as demonstration plots for neighboring farmers and extension agents under IFAD Agricultural Development Project in Minia. Twenty-two trials in Minia, 17 in Kafr El-Sheikh, and 6 in Fayoum governorates were conducted to study

The NVP has demonstrated economic yield advantages at the farm level with imroved irrigation management.

the important factors at test and farmers' levels (Table 38).

In the Samallot district of Minia, the test package including plant population, fertilizers, and weed control gave consistent yield increases with an average of 960 kg/ha (30.1%) seed and 760 kg/ha (13.8%) straw over farmers' practices at 4 of 5 sites. The same test package increased yield by 350 kg/ha (10.5%) at five sites in Abo-Korkas. The overall performance for this package in the Minia governorate is shown in Table 39. When irrigation was included as a test variable the yield advantage of the whole test package was relatively lower at 380 kg/ha (11.0%).

In the Kafr El-Sheikh district, the whole test package (plant population, fertilizer, weed control, and disease control) increased

Table 38. Factors studied in on-farm trials in Egypt.

	Test factors				
Governorate	**Plant[1] population**	**Fertilizers[2]**	**Weed[3] control**	**Irrigation[4]**	**Disease[5] control**
Minia	+	+	+	+ (12 sites)	
Kafr El-Sheikh	+	+	+		+
Fayoum	+	+	+		

1. 33 plants/m^2; 2. 35.7 kg N + 71.4 kg P_2O_5/ha ; 3. Igran 3.57 kg product/ha;
4. Two irrigations before canal closure in January at 25-30 days intervals + three irrigations after canal opening.
5. Spray with Diathane M45 + Triton B 1956.

Table 39. Average seed and straw yields, gross benefit, variable costs, and net benefit as affected by the test and farmers' levels of plant population, fertilizers, and weed control in Minia Governorate, Egypt, 1984/85.

	Seed yield (kg/ha)		Straw yield (kg/ha)		Gross benefit	Variable costs	Net benefit	
	Yield	SD	Yield	SD	(EP/ha)	(EP/ha)	EP/ha	SD
Test package	3870	490	6190	620	1100.5	314.4	786.1	120.9
Farmers' practice	3330	440	5590	620	952.8	230.0	722.8	125.3
Test increase	540	380	600	650	147.7	48.4	63.6	
% Test increase	16.0		11.0		16.0	36.0	9.0	

SD = Standard deviation.
EP = Egyptian Pound.

Table 40. Average seed and staw yields, gross benefit, variable costs, and net benefit as affected by the test and farmers' levels of the whole package, in Kafr El-Sheikh Governorate, Egypt, 1984/85.

	Seed yield (kg/ha)		Straw yield (kg/ha)		Gross benefit	Variable costs	Net benefit	
	Yield	SD	Yield	SD	(EP/ha)	(EP/ha)	EP/ha	SD
Test package	4230	580	4170	590	1275.2	467.8	807.4	162.4
Farmers' practice	3500	600	4170	580	1072.6	330.8	741.8	170.3
Test increase	730	420	0	500	202.6	137.0	65.6	
% Test increase	20.0		0.0		19.0	41.0	9.0	

yield at 8 of 12 sites by an average of 940 kg/ha (26.3%) over farmers' practices. In Motobus, seed yield response to the test package was consistent at all sites and ranged from 450 kg/ha (15.3%) to 1210 kg/ha (53.3%) with an average of 810 kg/ha (29.4%). As an average of all sites in the Kafr El-Sheikh governorate, the whole test package increased yield by about 20% (730 kg/ha) over farmers' practices (Table 40).

In Fayoum and Etsa districts, the farmer-managed trials at 5 of 6 sites gave higher yields with test levels of plant population, fertilizer, and weed control. The grain yield increase ranged from 10% (380 kg/ha) to 24% (970 kg/ha) with an average of about 14% (680 kg/ha). Straw yield increased from 14 to 31% with an average of 22% (1520 kg/ha) over farmers' practices at three sites. As an average of all sites in Fayoum governorate, the test package increased seed yield by 450 kg/ha (12%) and straw by 640 kg/ha (13%) over farmers' practices (Table 41).

Three farmer-managed trials and three researcher-managed trials on *Orobanche* spp. control were conducted in Minia in infested fields to test different treatment combinations involving the use of Giza 402 (tolerant) and Giza 2 (susceptible) cultivars with a test package of high plant population, fertilizer application, *Rhizobium* inoculation,

Table 41. Average seed and straw yields, gross benefit, variable costs, and net benefit as affected by the test and farmers' levels of the reduced package[1] in Fayoum Governorate, Egypt, 1984/85.

	Seed yield (kg/ha)		Straw yield (kg/ha)		Gross benefit	Variable costs	Net benefit	
	Yield	SD	Yield	SD	(EP/ha)	(EP/ha)	EP/ha	SD
Test package	4180	1020	5640	1870	1166.9	247.9	919.0	271.2
Farmers' practice	3730	720	5000	1470	1040.5	222.9	817.6	202.6
Test increase	450	360	640	810	126.4	25.0	101.3	
% Test increase	12.0		13.0		12.0	11.0	12.0	

and use of glyphosate compared with farmers' practices. The improved test package increased grain yield, as an average of all sites, by 1530 kg/ha (53.4%) and straw by 2560 kg/ha (62.4%) over farmers' practices. Use of glyphosate with Giza 402 at the high test level increased yield by 990 kg/ha (29.1%) over no spray. Giza 402 at the test level of management but without glyphosate increased yield by 540 kg/ha (19.0%) over the farmers' package.

Economic analysis of the farmer-managed on-farm trials in the three governorates revealed a high net return from the test package. The partial budget showed that the test package gave additional net benefits of Egyptian Pound 63, 66, and 101/ha in Minia, Kafr El-Sheikh, and Fayoum, respectively.

On-Farm Trials in Sudan

In 1984/85, farmer-managed trials were conducted for the third season in Aliab and Selaim, and for the first season in Shendi, in the Northern Province of Sudan, to compare an improved package of management with farmers' practices. The test package consisted of early planting, frequent irrigation, and pest control. Hand weeding was added to the package in Selaim basin. The trial was conducted at nine, eight, and seven sites, of 0.5 ha each in Aliab, Shendi, and Selaim, respectively. In each case, a neighboring farm was considered for comparison of the test package with that of farmers' practices. The yields were lower in 1984/85 than in 1983/84 because of higher temperatures.

The test package resulted in significant yield increases at all test sites in Aliab and Shendi but not in Selaim. The average yield increase over farmers' practice was 1010, 1140, 110 kg/ha in Aliab, Shendi, and Selaim, respectively. Averaged across locations, the test package increased net benefits by Sudanese Pound 1534 in Aliab, 1807 in Shendi, and 116 in Selaim (Table 42).

Pilot Production/Demonstration Program in Zeidab and Aliab Schemes in Sudan

In 1984/85, a pilot production/demonstration program was run for the second season in Zeidab (22 plots) and for the first season in Aliab (15 plots) to evaluate a recommended package of early planting, more frequent irrigation, and pest control on large plots managed entirely by farmers. The total area of these plots was 62.85 and 57.1 ha, with 43 and 46 participating farmers, in Zeidab and Aliab, respectively.

In Zeidab scheme, the grain yield of the pilot production plots was considerably higher than that of the neighboring farms (general practices) at 20 out of 22 locations. As an

Table 42. Average seed yield,gross benefit, variable costs, and net benefits as affected by test and levels of the recommended package at Aliab, Shendi, and Selaim, in Northern Province, Sudan, 1984/85.

	Aliab		Shendi		Selaim	
Test package:						
Average yield (kg/ha)	1640	(260)[a]	2700	(760)	2160	(540)
Gross benefit (SP/ha)	2624	(414)	4595	(1287)	411	(1036)
Variable costs (SP/ha)	224	(7)	393	(14)	736	(138)
Net benefit (SP/ha)	2400	(418)	4302	(1283)	3380	(1110)
Farmers' practices:						
Average yield (kg/ha)	630	(207)	1560	(340)	2050	(730)
Gross benefit (SP/ha)	1005	(332)	2649	(582)	3914	(1385)
Variable costs (SP/ha)	139		153		650	(107)
Net benefit (SP/ha)	866	(332)	2496	(566)	3264	(1388)
Difference in net benefits (SP/ha)	1534	(557)	1807	(791)	116	(1446)

a. Values in parentheses are standard deviations.

SP = Sudanese Pound.

average of all sites, there was a 100% (280 kg/ha) increase in seed yield in this scheme. In the Aliab scheme the pilot production plots recorded yield increases ranging from 4% to 129% over farmers' practices with a mean increase of 59% (460 kg/ha). The yield levels were low because of exceptionally high temperature at critical stages of reproductive growth. Partial budget analysis showed that the net return from the pilot production/demonstration plots was Sudanese Pound 339 and 661 per hectare more than that from neighboring farms with marginal rates of return of 390% and 974% in Zeidab and Aliab schemes, respectively (Table 43).

Collaborative Research with the Syrian National Program

The collaborative applied research with the Syrian National Program (ARC-Douma) in the improvement of faba beans, kabuli chickpea, and lentils continued during 1984/85. The work included yield trials, disease and pest screening nurseries, disease control, and agronomy and on-farm trials. The details of the on-farm trials on kabuli chickpeas and lentils have already been discussed in the relevant sections of this report.

Faba Bean

Regional yield trials on irrigated faba bean were conducted at Hama, Deir Ezzor, Al Ghab, and Raqqa. The yield exceeded 6000 kg/ha at Deir Ezzor and this was obtained with H15. Elegant 5MCI, which has earlier shown a wide adaptability in the international yield trials, yielded 5500 kg/ha. Averaged over all the test locations, line H15 yielded highest consistently over 1982/83, 1983/84, and 1984/85; Cyprus Imp. was second; and these two genotypes outyielded the rest by a significant margin. Also a rainfed regional yield trial

Table 43. Average yield and partial budgets of the pilot production/demonstration plots in Zeidab and Aliab, Sudan, 1985.

		Zeidab (22 plots)	Aliab (15 plots)
Pilot production plots (package farmers)			
Average yield	(kg/ha)	550	1230
Gross benefit	(SP/ha)	851	1975
Variable costs	(SP/ha)	191	190
Net benefit	(SP/ha)	660	1785
Neighboring farms (Non-package farmers)			
Average yield	(kg/ha)	280	780
Gross benefit	(SP/ha)	425	1242
Variable costs	(SP/ha)	104	118
Net benefit	(SP/ha)	321	1124
Difference in yield	(kg/ha)	280	460
Difference in net benefit	(SP/ha)	339	661

was conducted at Izra'a, Gelline, and Tel Hadya and as an average of all the test locations, Cyprus Imp. gave highest yield and Syrian Local Large (ILB 1814) stood second, over the two seasons, 1983/84 and 1984/85. The yields of rainfed trials were 1/3 those of the irrigated trials. It is, therefore, proposed to start an on-farm trial of faba beans using H15, H4, Cyprus Imp., ILB 1814, and local check landrace genotypes during the 1985/86 season.

Lentil

Regional yield trials were conducted using large- and small-seeded lentil genotypes jointly entered by ICARDA and ARC Douma. They were conducted at Gelline, Izra'a, Heimo, Breda, and Tel Hadya. In the large-seeded group the highest mean yield of 1100 kg/ha was obtained with FLIP 84-75 L followed by FLIP 84-26L, Kurdi 1, and FLIP 84-153L. In the small-seeded group, again a FLIP entry (FLIP 84-5L) yielded highest followed by FLIP selections 81S15 (ILL 5883) and 76TA 66015 (ILL 5564). These genotypes will be further evaluated for consistency of their performance. Meanwhile, from the on-farm trials conducted over the last 3 years, genotype 78S 26002 (ILL 8) came out to be the highest yielding large-seeded type, giving a yield advantage of 16% over the local check (Kurdi 1). Hence it has been identified for eventual release to the Syrian farmers and a village project to produce its seeds on a 0.5 ha area in two villages will be jointly executed by ARC and ICARDA during the 1985/86 season. This genotype tends to lodge less than the local one and is, therefore, better suited for mechanical harvesting.

Kabuli Chickpea

Unlike faba beans and lentils, only international yield trials and disease and pest screening nurseries were conducted in the cooperative work on kabuli chickpeas. The CIYT-W-MR-85 was conducted at nine locations but data were available from six locations: Izra'a, Hama, Gelline, Jableh, Tel Hadya, and Jindiress. FLIP 82-150C gave highest mean yield followed by FLIP 82-232C and FLIP 82-115C. These genotypes will be further evaluated in the 1985/86 season. In the CIYT-Sp-85 trial none of the test entries yielded higher than the local check (ILC 1929) at all the test locations-Izra'a, Gelline, Kamishly, El-Ghab, Tel Hadya, and Jindiress. The yields of spring-sown trials were less than 50% of those obtained from winter-sown trials. In the CIYT-L-85 trial, which was conducted at Hama, Heimo, Izraa, Gelline, Al-Ghab, Tel Hadya, and Jindiress, again the local check (ILC 1929) gave the highest yield, closely followed by ILC 451 and ILC 263. There is a need to evaluate newer large-seeded lines that have now become available from the hybridization program at ICARDA. The CIABN-85 was conducted, with 40 test entries, at Jableh, Tel Hadya, Lattakia, and Gelline. Since the disease did not develop at Gelline, the data for the remaining three locations are given in Table 44. It is clear that most of the test entries showed a high level of tolerance to ascochyta blight.

Table 44. Mean ascochyta blight rating[1] for 40 test entries and one local check (ILC 1929) included in CIABN-85 conducted at Jableh, Tel Hadya, and Lattakia, 1984/85.

Number of test entries	Rating class for mean ascochyta blight disease score
24	2.0 to 3.0
16	3.1 to 4.2
Local check	6.6

1. On 1-9 scale, where 1 = free and 9 = dead.

Results of studies on the effect of date of sowing (winter vs. spring), row spacing (30, 40, and 50 cm), and population (30, 45, and 60 plants/m^2), with landraces of chickpeas at Gelline and Homs showed a significant increase in yield with advancing the sowing from spring to winter and by raising the population level at both the locations. Row spacing effect was significant at the rainfed site in Gelline where wider row spacing was superior to the narrower one, whereas at Homs, where the crop was grown with irrigation, there was no difference due to the row spacing variable.

ICARDA Tunisia Cooperative Project

In this cooperative project between ICARDA and the Institut National de la Recherche Agronomique de Tunisie (INRAT), ICARDA and Tunisian food legume scientists work together to identify superior genotypes and production techniques for all three food legumes with backup from staff at the headquarters in Aleppo. This season the breeding 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 progenies and bulks in observation nurseries, and screening genetic material in a range of disease nurseries. The agronomy program evaluated crop responses to sowing dates and differing levels of plant population, phosphate and nitrogen application, and the effectiveness of a range of herbicides in controlling weed infestation throughout the growing season.

Faba Bean Breeding

Both large- and small- seeded faba beans are cultivated in Tunisia and the program's objective is the improvement of both these types through the selection of high- yielding lines and identification of sources of resistance to the prevalent diseases and pests. In 1984/85, the aggressive stage of chocolate spot (*Botrytis fabae*) occurred in trials at the Sejnane location and a light infection of the non-aggressive leaf spotting stage was observed at other locations. A high level of infestation of *Orobanche* spp. again occurred at the Beja location, resulting in high coefficients of variation for seed yield in many trials, and a relatively early attack of rust (*Uromyces fabae*) was observed at the Tunis and Sejnane locations.

Progress in achieving seed yield improvements over the local cultivars has so far been limited, and ideally any improvements should be stabilized by being combined with resistance/tolerance to the major diseases. With the irregularity of natural disease development, increased attention was given to disease screening methods for developing epiphytotic conditions through artificial inoculation. In 1984/85 the chocolate spot and ascochyta blight nurseries were artificially inoculated, although only in the latter was a good level of infection obtained. Next season it is expected that inoculation of both nurseries will be undertaken in a plastic tunnel with irrigation facilities to ensure adequate humidity levels necessary for good disease development. It is also planned to develop an *Orobanche*-sick plot at Beja for effective screening.

The local check in all trials was a large- or small-seeded local cultivar, and although only used as a single entry in the international yield trials, was repeated at least three times in the advanced and preliminary yield trials.

Sixty-one large-seeded advanced breeding lines were yield tested at two or more locations in three trials: an international yield trial from ICARDA (IYT-L) with 23 lines, and an advanced (AYT-L) and preliminary (PYT-L) yield trial each with 19 lines. In all trials a number of lines yielded more than the local check at one or more locations but only nine lines in the IYT-L at one location did so significantly.

In the small-seeded breeding program, 76 advanced breeding lines were yield tested at two or more locations in four trials: an international yield trial from ICARDA (IYT-S) with 23 lines, two advanced yield trials (AYT-S-1 and AYT-S-2) with 19 and 13 lines, respectively, and a preliminary yield trial (PYT-S) with 21 lines. In all trials a number of lines outyielded the check at more than one location but none did so significantly.

During this and the previous two seasons, five large-seeded and three small-seeded lines were retained in trials at more than one location, as overall they outyielded the local check. Table 45 gives such yield data, expressed as a percentage of the local check. For most lines there was a marked within and between season variation at a particular location for the percentage increase or decrease, although in certain instances this reflects high coefficients of variation. In spite of this, ILB 1217 (Reina Blanca) was the most stable line, outyielding the check on 5 out of 6 occasions, followed by ILB 10 (78S 49907), ILB 398 (76TA 56 264), and X77sd 11 (80S 45676), all of which outyielded the check on four occasions. However, only one increase for these lines was significant.

Because of the limited progress achieved so far. more emphasis is being put on selection within a testing of early generation material from ICARDA's base program, and collection of and selection within Tunisian local landraces. This season, 329 single plant selections were made in 1299 early generation bulks and progenies from ICARDA, and 101 single plant selections in 14 local landraces. These selections will be advanced next season under insect-proof conditions to examine variation for agronomically useful characters. A further range of early generation bulks and progenies from ICARDA base program and a considerable number of pure

Table 45. Seed yield expressed as percentage of the local check cultivar of five large- and three small-seeded lines at two locations over three seasons.

Location	Season	Large-seeded lines				
		ILB 10 (78S 49907)	ILB 398 (76TA 56264)	ILB 1266 (Aquadulce)	ILB 1217 (Reina Blanca)	ILB 1269 (New Mammoth)
Beja	82/83	110	138	120	152[a]	124
	83/84	133	146	201	150	162
	84/85	126	92	113	123	100
Kef	82/83	93	101	82	135	94
	83/84	107	131	96	102	95
	84/85	78	81	80	86	68
	Mean	108	115	115	125	107

Location	Season	Small-seeded lines		
		X77 Sd 11 (80S 456 76)	ILB 269 (74TA 367)	ILB 269 (78S 48821)
Beja	82/83	144	ND[b]	156
	83/84	110	124	91
	84/85	66	89	86
Kef	82/83	117	118	129
	83/84	100	99	92
	84/85	95	108	178
	Mean	105	108	122

a. Value significantly ($P < 0.05$) greater than the local check cultivar.

b. ND: no data available.

line accessions from ICARDA's germplasm collection will be evaluated under local environmental conditions.

Chickpea Breeding Program

Sowing date trials conducted by INRAT and the Office des Cereales (Cereals Office) again confirmed the yield advantage of winter over spring sowing and this practice will be extensively tested and demonstrated in farmers' fields next season. This season, the winter-sown trials gave excellent seed yields, with a few winter-sown lines exceeding 4000 kg/ha. At present, however, the chickpea crop is largely spring-sown and the program is breeding for both winter- and spring-sown crops. Ascochyta blight-resistant genotypes are a pre-requisite for winter sowing, although the spring-sown crop can also be severely affected by the disease. Accordingly, all the genetic material from ICARDA has resistance to blight. This season a natural infection of blight occurred at a number of experiment stations but it was not observed in farmers' fields.

During the previous two seasons, wilt was observed at experiment stations and in farmers' fields, but this season, the incidence was generally lower except in the wilt-sick plot at Beja. However, from observations and surveys in previous seasons, this disease is considered to be potentially as big a constraint to production as ascochyta blight. Last seasons's report indicated that a *Fusarium* sp. and a *Verticillium* sp. had been isolated from wilt-infected plants, and the species have now been identified at Montana State University, USA, as *F. oxysporum* and *V. albo-atrum*.

In the winter program, 203 advanced breeding lines, 46 F_3 populations, and 12 F_4 populations were assessed for seed yield at two or more locations in 10 trials; two international yield trials (IYT 1 and 2) from ICARDA each with 23 lines; two advanced yield trials (AYT 1 and 2) with 32 and 12 lines, respectively: three preliminary yield trials (PYT 1, 2, and 3) with 45, 30, and 38 lines, respectively; an international F_3 and F_4 yield trial (F_3/F_4 IYT) from ICARDA each with 23 populations; and an advanced F_4 yield trial (AYT F_4) with 12 populations. In the above trials, the PYT-3 was two sets of the ICARDA international screening nursery grown as a replicated trial. Unfortunately, an irregular virus infection at Beja and a soil problem at Sejnane resulted in many missing plots in some trials and statistical analysis has still to be done. In all the international trials, only one entry of the local check cultivar was included and this was not protected against ascochyta blight. In all other trials there were usually at least two protected and two unprotected entries of the local check, and in the results the seed yield of the test entries is compared against the former.

A number of lines in the international trials yielded more than the local check at one or more locations but none did so significantly. None of the F_3 or F_4 populations significantly outyielded the check but single plant selections from the best populations will be advanced for disease screening.

Although no ascochyta-resistant lines significantly and consistently outyielded the local check cultivar, yield data (Table 46) for the five resistant lines FLIP 81-56W, 81-41W, 81-57W, ILC 484, and 3279 over 3 years, show that these lines have a seed yield equivalent to the check. They also have a major advantage over the check in that a farmer could safely use them, without fear of yield loss from blight, and benefit from the higher yields from early or winter planting. However, wilt is a problem in both winter and spring planting and with 2 years' screening of ascochyta-resistant material in the wilt-sick plot at Beja a few lines have been identified that have some wilt tolerance. Data on four ascochyta-resistant lines with the best combination of seed yield and wilt tolerance over 2 years are given in Table 47. One or

Table 46. Seed yield, expressed as percentage of local check, of five ascochyta-resistant lines tested over three seasons at Beja and Kef.

	1982/83		1983/84		1984/85		
Line	Beja	Kef	Beja	Kef	Beja	Kef	Mean
FLIP 81-56W	61	112	129	159	63	124	108
41W	85	67	132	131	107	108	105
57W	94	65	108	122	101	116	101
ILC 484	94	112	90	85	107	162	108
3279	79	69	101	128	104	109	98

Table 47. Seed yield, as percentage of the local check, and wilt ratings (WR) of four ascochyta-resistant lines at Beja and Kef in 1983/84 and 1984/85.

	1983/84			1984/85			Mean	
Line	Seed yield Beja	Seed yield Kef	WR[1] Beja	Seed yield Beja	Seed yield Kef	WR Beja	Seed Yield	WR
FLIP 81-67	144[2]	93	ND[3]	99	162	4.5	125	4.5
82-79 C	54[2]	82	6.0	107	116	5.0	90	5.5
81079	136	177	5.0	97	125	5.0	109	5.0
ILC 195	105	93	6.0	97	112	4.0	102	5.0

1. WR: Wilt rating in wilt-sick plot at Beja where, 1 = no symptoms and 9 = complete kill.
2. High coefficient of variation in the trial in which the line was tested.
3. ND: no data.

more of these lines may be considered for pre-release multiplication next season. The major problem with these lines is that their seed size is considerably smaller than that of the local (check) cultivar.

In the spring program, 81 advanced breeding lines were yield tested at two locations in four trials: one international yield trial (IYT 1, the ICARDA large-seeded trial) with 23 lines, and three advanced yield trials (AYT 1,2, and 3) with 12, 12, and 34 lines, respectively. In the IYT 1, 17 lines significantly exceeded the local check cultivar at Kef. Only in the AYT 1 and 3 did a number of lines yield more than the check at the two locations but only one line in the AYT 1 at the Beja location did so significantly.

However, in the AYT 2 and 3, 20 lines were tested that stemmed from single plant selections made in the local cultivar 'Amdoun' for resistance to wilt. All these lines had a high level of resistance in the wilt-sick plot (WSP) at Beja during this and previous seasons, and in the last two seasons have significantly outyielded the local check when grown in replicated trials in the WSP. The 20

Table 48. Wilt rating (WR), seed yield (kg/ha), and seed weight of six chickpea lines selected from local cultivar Amdoun at Beja and Kef over three seasons.

Line	1982/83				1983/84			1984/85		
	WR[1] Beja	Seed yield[2] Beja	Seed yield[2] Kef	100 seed weight (g)	WR Beja	Seed yield Beja	Seed yield Kef	WR Beja	Seed yield Beja	Seed yield Kef
PL-Se-Be- 81 - 6	1.0	1193[3]	1370	ND[4]	1.5	1391	1281	1.0	1775	690
11	1.0	1243	1413	ND	1.5	1635	1713	1.5	1775	706
Local check (Amdoun)	8.0	49	1500							
SE ±		91.5	167.0							
CV%		22.9	21.6							
PL-Se-Be- 81 - 48	1.0	1680	970	54.4	1.8	1737	1725	1.0	2000	784
87	1.0	1360	1200	51.0	1.5	1875	1819	1.0	1975	781
103	1.0	1490	950	52.1	1.0	1793	1600	1.0	1450	865
120	1.5	1420	1580	53.8	1.8	1653	1363	1.0	1700	681
Local check (Amdoun)	8.5	49	1015	43.8	6.0	460	1413	2.5	2062	657
SE ±	0.40	123.9	230.7			155.1	161.8		100.1	75.0
CV %	24.9	14.4	30.2			22.6	20.5		10.8	21.5

1. WR: Wilt rating in wilt-sick plot at Beja where 1 = no symptoms and 9 = complete kill.
2. Seed yield in wilt-infested land at Beja in 1982/83 and 1983/84, otherwise in wilt-free land.
3. Values underlined were significantly ($P < 0.05$) better than the check.
4. ND: no data.

lines were grown in wilt-free land this season at Beja and Kef and in the previous two seasons also in wilt-free land at Kef. In all cases seed yields did not differ significantly from that of the local check cultivar Amdoun. Data on six lines tested over 3 years in both wilt - infected and wilt-free land are given in Table 48. Since wilt is a major constraint to production, and as these lines are resistant and possess seed yield and seed quality characters (particularly large seed size) similar to the local cultivar, one or more of them will be put into pre-release multiplication as a potential new cultivar for spring sowing.

To develop lines with dual resistance to wilt and ascochyta blight, all the ascochyta-resistant lines in the IYTs from ICARDA and in the national AYTs and PYTs are routinely screened in the WSP. In 1983/84, such screening in the IYTs showed that 14 had reasonable to good wilt resistance (a rating of 5 or less on a 1-9 scale where, 1 = no symptoms and 9 = complete kill). Further screening of these lines this season, however, showed that some lines were more susceptible than previously recorded, emphasizing the care needed in identifying wilt resistance. Of the 216 ascochyta- resistant lines received from ICARDA this season, 26 were rated 5 or less for wilt.

Lines for spring planting without ascochyta resistance, such as those in the large-seeded international yield trial (IYT1), are also screened in the WSP. This season, 10 lines in the IYT1 had wilt ratings of five or less. In addition to field screening, seedlings of all the lines are screened in test tube culture for resistance to isolates of *F. oxysporum* and *V. albo-atrum* from the WSP. So far, there is a good correlation between wilt ratings in the laboratory and in the field for those lines showing wilt symptoms early in the season. Hopefully, further refining of the technique in the laboratory will permit initial screening (and discarding of material) prior to field screening.

Other work on dual resistance this season involved the screening of F_4 and F_5 progenies, derived from ICARDA population trials, in the WSP in combination with artificial inoculation with a local strain of ascochyta blight. Thirty-six F_4 and 30 F_5 single plants from 22 and 9 crosses, respectively, were selected for a good level of resistance to both diseases. In addition, the cross ILC 237 x ILC 191, which was an entry in the 1982/83 F_3 population trial, has been given special attention as ILC 237 has a high level of wilt resistance and ILC 191 is blight-resistant. In 1983/84, F_4 single plant progenies were screened in the WSP and the wilt-resistant plants bulked, and this season the resulting 133 F_5 progenies were screened against wilt and ascochyta blight. Eighty-seven F_5 single plants were selected for a good level of resistance to both diseases and will be further evaluated next season.

Crosses have been made by the base program at ICARDA Aleppo, between ascochyta-resistant lines with highest yields in Tunisia and wilt-resistant Amdoun selections, to combine dual resistance with large seed size in a locally. well-adapted background. From these crosses, 23 F_1 and 22 F_2 populations were grown this season in wilt-free land at Kef. The F_2 populations were harvested as single plants and about 4000 F_3 progenies will be simultaneously screened next season for wilt and ascochyta resistance. The F_1 populations will be advanced in wilt-free land at Kef next season.

Lentil Breeding Program

Last year's report indicated that further evaluation of the seed yield of local cultivars was required, as a local cultivar from Beja, which was used as check in the first 2 years of the program, was lower yielding than three other local cultivars. Accordingly, the highest yielding of these last three cultivars, one from Oueslatia, has since been used as a check in yield trials, and this season, although only put as a single entry in the international trials, was repeated at least four times in the advanced and preliminary trials. However, there was no significant difference between the seed yields of 14 local cultivars tested this season, and until further data are obtained, the Oueslatia cultivar will continue to be used as the check in all trials.

During the 1984/85 season, 179 advanced breeding lines and 48 F_3 and 30 F_4 populations were tested at two or more locations in nine replicated yield trials: one large-seeded and one small-seeded international yield trial from ICARDA (IYT-L and IYT-S) each with 23 entries; two advanced yield trials (AYT-1 and -2) each with 30 entries; two preliminary yield trials (PYT-1 and -2) with 43 and 30 entries, respectively; two international F_3 population yield trials (IF_3 T-1 and -2) each with 24 entries and an advanced F_4 population trial (AYT F_4) with 30 entries.

Although a number of lines and populations yielded more than the local check cultivar at one or more locations in all trials, significant increases over the check were only evident at one location for one line in the IYT-S, six lines in the PYT-2, and seven F_4 populations in the AYT F_4. Unfortunately, none of these lines had good mechanical harvest characteristics in that none were particularly erect and all tended to lodge.

Data were reported last year on four lines which. over 3 years of testing, produced a minimum mean increase in yield of 45% over the local check cultivar. These data and those of this season on the four lines are given in Table 49. This season, the lines were generally lower yielding than the local check cultivar, but over four seasons these lines gave a mean increase over the check of 21%. These lines will be retested next season and one or more will be considered for pre-release multiplication, especially ILL 4400 which gave a mean increase of 34% over the check.

Table 49. Seed yield (kg/ha) of four lentil lines over four seasons at Beja, Kef, and Jendouba.

Line[1]	1981/82		1982/83		1983/84		1984/85				
	Beja	Kef	Beja	Kef	Beja	Kef	Beja	Kef	Jendouba	Mean	% check
ILL 28	1685[2]		1583	1363	1558	1275	1887	1375	1700	1553	122
262	1683		1562	1304	1692	1050	1862	1025	1050	1404	110
Tunisian local check	665		754	1113	1108	1383	(1918)	(1750)	(1533)	1278	100
SE ±	219.3		65.5	138.1	140.7	152.9					
ILL 4354	1634	1716	1904	1253	1358	792	1462	1175	1475	1419	118
4400	1774	1334	1796	1350	2000	1167	2300	1225	1500	1605	134
Tunisian local check	1059	626	1225	633	1592	475	1918	1750	1533	1201	100
SE ±	227.1	139.5	141.5	74.3	232.8	138.1	422.6	327.0	234.5		

1. ILL 28 and 262 not tested at Kef in 1981/82 and all lines only tested in the same trial in 1984/85.
2. Values underlined significantly ($P < 0.05$) outyielded the local check.

Agronomic Studies

Agronomic experiments were conducted at Beja and Kef research stations to determine optimum production practices for the three legumes. The factors tested were date of planting, plant population, fertilizer application, and weed control. In all studies the best adapted local cultivars were used and the crop was protected from pests and diseases.

The date of planting, plant population, and fertilizer application trials were very similar to those conducted in the past two seasons, and the results obtained this season were very similar to those reported in Tunisia-ICARDA annual reports. Only a brief summary will be given here. For all three legumes, seed yield was significantly reduced by delaying planting from early November to late January, and generally showed a linear increase by raising the plant population from 5 to 12 plants/m^2 for faba bean (large seeded), 12 to 31 for chickpeas, and 41 to 115 for lentils. Results indicated that further increasing the plant population of lentils might produce an additional yield increase, and this will be examined next season. There was no such indication for faba beans or chickpeas. No crop showed a significant seed yield response to nitrogen and phosphate application, and no difference was observed between applying phosphate as di-ammonium phosphate or as triple superphosphate.

Previous results showed that the seed yield of the three legumes can be severely reduced by weed infestation. This season the International Weed Control Trial was conducted for these crops at Beja and Kef. In all trials there was a significant difference between treatments. The average reduction across locations and crops due to weed infestation was 81%, and was larger at Kef. In faba beans, the high level of *Orobanche* infection at Beja was a confounding factor. Hand weeding at two 45-day intervals after emergence gave reasonable weed control, except for lentils at Kef. Excluding the Kef result hand weeding gave an average yield reduction of only 19% in comparison to 'weed free' treatment. No herbicide or combination of herbicides could be considered effective in controlling the weed population. The best was Igran + Kerb on faba beans at Beja, showing a 29% yield reduction. This combination was also the best with a 43% reduction across the two locations. For chickpeas no treatment was as effective, with Igran + Kerb and Igran alone the best and showing similar large yield reductions across locations of 65% and 67%, respectively. The results were similar for lentils, with the best treatments being Bladex and Tribunil + Kerb showing reductions of 65% and 67%, respectively, across locations.

Training

Group Training

Food Legume Residential Course

The Food Legume Improvement Program conducted a residential course at Tel Hadya research station, 3 Mar-5 June 1985. The course was attended by 18 trainees from 10 countries (Argentina, Ethiopia, Iran, Pakistan, Peoples Democratic Republic of Yemen, Sudan, Syria, Tunisia, Turkey, and Yemen Arab Republic.

The course covered practical techniques for the improvement of faba bean, lentils, and kabuli chickpeas and included field and laboratory activities. The syllabus focused on breeding, agronomy, field experimentation, diseases, insects, microbiology, and general aspects such as farming systems. The main emphasis was a multidisciplinary approach to improving food legumes while still maintaining individual attention to cater to the needs of national programs. To achieve the latter, each individual trainee was assigned a small experiment, supervised by a senior scientist. The trainees conducted their experiments, analyzed results, and wrote reports.

Classroom lectures were given by the food legume scientists as background information to the field activities. Training reference materials, which included publications and visual aids, were provided during the course.

In-Country Course on Food Legume Improvement in Morocco

The Moroccan Food Legume National Program of INRA and the Food Legume Improvement Program of ICARDA jointly conducted the Food Legume Improvement Training Course, 11-16 Feb 1985 at Rabat, Morocco. Thirty technicians from 10 research stations in Morocco and Tunisia participated in the course.

Instruction was given by seven Moroccan and two ICARDA scientists. Lectures covered all aspects of food legume improvement (breeding, agronomy, pathology, entomology, weed control, and field experimentation). About 30% of the time was covered by practicals, such as handling of breeding experiments, crossing techniques, visits to research stations, and analysis of experimental data.

In this course, training manuals and ICARDA general publications were distributed in addition to the lecture handouts. Visual aids including the audio-tutorial module Screening Chickpeas for Resistance to Ascochyta Blight were used extensively by the scientists. Lecture notes will be edited and published as proceedings in the near future.

National Course on Cereal and Food Legume Pathology in Syria

The Syrian National Program (ARC) and the Food Legumes and Cereals Improvement Programs of ICARDA conducted a course on the pathology of cereals (wheat, barley) and food legumes (lentils, chickpeas, and faba beans), 21 Apr-2 May 1985, at ICARDA's stations, Tel Hadya and Lattakia. The course was attended by 15 trainees from the various Syrian research stations.

The course covered the biology of pathogens, epidemiology of diseases, and control measures for diseases. Techniques to create epiphytotics and score damage in the field and greenhouse were given high priority.

Seed Technology Training Course

The Arab Organization for Agricultural Development (AOAD) and ICARDA conducted the Seed Technology Course, 9-26 September 1985 at Tel Hadya research station. The course was attended by 19 participants from nine countries (Syria, Saudi Arabia, Yemen Arab Republic, Peoples Democratic Republic of Yemen, Jordan, Algeria, Iraq, Morocco, and Sudan).

Table 50. Participants in individual training with the Food Legume Improvement Program, ICARDA, 1985.

Training category	Subject	Duration	Country	No.
Senior research fellow	Agronomy/physiology	7 months	India	1
Training research associate	Agronomy/data collection	1 month	Sudan	3
	Field experimentation and data collection	2 months	Tunisia	1
	Lentil breeding	2 months	Pakistan	1
		2 weeks	Morocco	1
		1 year	UK	1
	Pathology (faba beans and chickpeas)	6 months	Morocco	1
		3 weeks	Tunisia	1
		3 months	Ethiopia	1
	Data collection X crossing techniques	1 month	Sudan	1
	Field X laboratory research equipment X crossing techniques	3 months	Ethiopia	1
	Microbiology lab. techniques	1 month	Sudan	1
	Entomology	1 month	Syria	1
	Faba bean breeding for *Orobanche* resistance	4 months	Netherlands	1
Higher Degree				
Research scholar(M.Sc.)	Agronomy	4 months	Germany	1
	Pathology	4 months	Afghanistan	1
Research fellow (Ph.D.)	Agronomy/physiology	3 years	Syria	1
	Breeding	3 years	Egypt	1
Total				20

The course covered general aspects of seed technology and included variety testing, seed health, processing, storage, certification, and marketing. Practical skills in these areas of seed technology were also covered for ICARDA mandated crops. In addition, topics on breeding and production of food legumes (lentils, faba beans, and kabuli chickpeas) were covered.

Individual Training

The Food Legume Improvement Program increased the opportunities for individual training. Eighteen trainees were hosted by the program during 1985 which represents a 50% increase over 1984. The topics offered are shown in Table 50.

In this category, the trainees had different academic backgrounds and work experience. Many conducted experimental research jointly with ICARDA scientists. Each topic was addressed in a modullar fashion to include field and laboratory practicals as well as visual aids.

Training Reference Material

The program made its first slide-tape audio-tutorial module entitled Screening Chickpeas for Resistance to Ascochyta Blight. This module has so far been used in the 1985 residential course, in-country courses in Morocco and Pakistan, and a specialized pathology course at Tel Hadya Research Station. The feed-back from trainees and the demand from national programs indicated that the objective of producing this reference material was met. New reference material in press includes Food Legumes Crop Physiology and Proceedings of a Training Course on Ascochyta Blight Resistance in Chickpeas.

Publications

Journal Articles

Erskine, W. 1985. Selection for pod retention and pod indehiscence in lentils. Euphytica 34: 105-112.

Erskine, W., Williams, P.C. and Nakkoul, H. 1985. Genetic and environmental variation in the seed size, protein, yield and cooking quality of lentils. Field Crops Research. (In press.)

Reddy, M.V. and Kabbabeh, S. 1985. Pathogen variability in *Ascochyta rabiei* in Syria and Lebanon. Phytopathologia Mediterranea (In press.)

Silim, S.N., Hebblethwaite, P.D. and Heath, M.C. 1985. Comparison of autumn and spring sowing date on growth and yield of combining peas. Journal of Agricultural Science (Cambridge) 10: 35-46.

Simons, M.D., Robertson, L.D. and Frey, K.J. 1985. Association of host cytoplasm with reaction to *Puccinia coronata* in progeny of crosses between wild and cultivated oats. Plant Disease 69: 969-971.

Summerfield, R.J., Roberts, E.H., Erskine, W. and Ellis, R.H. 1985. Effects of temperature and photoperiod on flowering in lentils (*Lens culinaris* Medic.) Annals of Botany. (In press.)

Conference Papers

Hanounik, S.B., and Maliha, N.F. 1985. Horizontal and vertical resistance in *Vicia faba* to chocolate spot caused by *Botrytis fabae*. Proceedings of the 25th Science Week, University of Damascus, 2-7 Nov 1985. 16 pp.

Hussein, M.M. and Sherbeeny, M.H. 1985. Faba bean improvement in the ICARDA/IFAD Nile Valley Project. Paper presented at the Arab Conference for Agricultural Research on Basic Foods, 31 March-4 April 1985, ICARDA, Aleppo, Syria.

Ibrahim, M.E.H. 1985. ICARDA's role in manpower development. Paper presented at the Arab Conference for Agricultural Research on Basic Foods, 31 March-4 April 1985, ICARDA, Aleppo, Syria.

Saxena, M.C. 1985. Food legume research networks for West Asia and North Africa region. Paper presented at the Rainfed Agriculture Information Networks Workshop, 17-20 March 1985, Amman, Jordan.

Saxena, M.C., Stephens, J.H. and Cardona, C. 1985. Some studies on biological nitrogen fixation by food legumes in dry areas of northern Syria. Paper presented at the 25th Science Week, 2-7 November 1985, Damascus, Syria.

Singh, K.B. 1985. Past improvement and future prospects of genetic improvement of chickpea. Paper presented at the Fifth Congress of SABRAO (The Society for the Advancement of Breeding Researches in Asia and Oceania), 25-29 Nov 1985, Bangkok, Thailand.

Singh, K.B. 1985. Chickpea genetic resources and their exploitation in the Mediterranean region. Paper presented at the Relancio della coltura del cece (*Cicer arietinum* L.) in Italia problematiche e prospettire, 5 November 1985, Sala delle Minose, Centro Recerche Energia Casaccia, via Anguillarese, 301, Rome, Italy.

Singh, K.B. and Malhotra, R.S. 1985. Inheritance of protein content and other agronomic characters in chickpea. Paper presented at the Sixth Meeting of the EUCARPIA Section - Oil and Protein Crops, June 10-13 1985, Junta De Andalucia, Cordoba, Spain.

Miscellaneous

Augustin, B. 1985. Biologie, Verbreitung, und Bekaempfung des Stengelaelchens, *Ditylenchus dipsaci* (Kuehn), Filipjev an *Vicia faba* L. in Syrien und anderen Laendern des Nahen Ostens und Vorderafrikas. Inaugural-Dissertation zur Erlangung des Grades eines Doktor der Landwirtschaftlichen Fakultaet der Rheinischen Friedrich-Wilhelms. Universitaet zu Bonn, West Germany. 160 pp.

Bernier, C.C., Hanounik, S.B., Hussein, M.M. and Mohamed, H.A. 1984. Field Manual of Common Faba Bean Diseases in the Nile Valley. Information Bulletin No. 3. ICARDA, Aleppo, Syria. 40 pp.

Bhardwaj, B.D., Ibrahim, A.A., Nassib, A., Hussein, M. and Salih, F. 1985. The ICARDA/IFAD Nile Valley Project on Faba Beans. Pages 325-338 *in* Proceedings of the International Workshop on Faba Beans, Kabuli Chickpeas, and Lentils in the 1980's. (Saxena, M.C. and Varma, S. eds), ICARDA, 16-20 May 1983, Aleppo, Syria. Martinus Nijhoff, The Hague, The Netherlands.

Bond, D.A., Lawes, D.A., Hawtin, G.C., Saxena, M.C. and Stephens, J.H. 1985. Faba bean (*Vicia faba* L.) Pages 199-265 *in* Grain Legume Crops (Summerfield, R.J. and Roberts, E., eds). Collins Professional and Technical Books, UK.

Cardona, C. 1985. Insect pests of faba beans, lentils and chickpeas in North Africa and West Asia: A review of their economic importance. Pages 159-168 *in* Proceedings of the International Workshop on Faba Beans. Kabuli Chickpeas, and Lentils in the 1980's. (Saxena, M.C. and Varma, S. eds). ICARDA, 16-20 May 1983, Aleppo, Syria. Martinus Nijhoff, The Hague, The Netherlands.

Cardona, C., Fam, E.Z., Bishara, S.I. and Bushara, A.G. 1984. Field Guide to Major Insect Pests of Faba Bean in the Nile Valley. Information Bulletin No. 2. ICARDA, Aleppo, Syria. 60 pp.

Eagleton, G.E., Khan, T.N. and Erskine, W. 1985. Winged bean (*Phosphocarpus tetragonolobus* (L.) D.C.). Pages 624-657 *in* Grain Legume Crops (Summerfield, R.J.

and Roberts, E., eds). Collins Professional and Technical Books, UK.

Erskine, W. 1985. Lentil Genetic Resources. Pages 29-34 *in* Proceedings of the International Workshop on Faba Beans, Kabuli Chickpeas, and Lentils in the 1980's. (Saxena, M.C. and Varma, S. eds). ICARDA, 16-20 May 1983, Aleppo, Syria. Martinus Nijhoff, The Hague, The Netherlands.

Erskine, W. 1985. Perspectives in lentil breeding. Pages 91-100 *in* Proceedings of the International Workshop on Faba Beans, Kabuli Chickpeas, and Lentils in the 1980's. (Saxena, M.C. and Varma, S. eds). ICARDA, 16-20 May 1983, Aleppo, Syria. Martinus Nijhoff, The Hague, The Netherlands.

Gridley, H. 1985. North African Regional Food Legume Improvement Program. Pages 339-350 *in* Proceedings of the International Workshop on Faba Beans, Kabuli Chickpeas, and Lentils in the 1980's. (Saxena, M.C. and Varma, S. eds). ICARDA, 16-20 May 1983, Aleppo, Syria. Martinus Nijhoff, The Hague, The Netherlands.

Haddad, Ali. 1985. Variabilite de l'*Ascochyta rabiei* (Pass) Lab. en Tunisie et Heredite de la Resistance a la Maladie de Pois-chiche. Memoire de Fin d'Etudes du 3eme Cycle de l'INAT. 108 pp.

Hanounik, S. and Maliha, N.F. 1985. Screening for resistance to, and chemical control of major diseases in faba beans. Pages 107-118 *in* Proceedings of the International Workshop on Faba Beans, Kabuli Chickpeas, and Lentils in the 1980's. (Saxena, M.C. and Varma, S. eds). ICARDA, 16-20 May 1983, Aleppo, Syria. Martinus Nijhoff, The Hague, The Netherlands.

IBPGR and ICARDA. 1985. Faba Bean Descriptors. IBPGR Secretariat, Rome, Italy. 19 pp.

IBPGR and ICARDA. 1985. Lentil Descriptors. IBPGR Secretariat, Rome, Italy. 15 pp.

IBPGR, ICARDA and ICRISAT. 1985. Chickpea Descriptors. IBPGR Secretariat, Rome, Italy. 15 pp.

Ibrahim, H. 1985. Training and communication needs for food legume programs. Pages 315-324 *in* Proceedings of the International Workshop on Faba beans, Kabuli Chickpeas, and Lentils in the 1980's. (Saxena, M.C. and Varma, S. eds). ICARDA, 16-20 May 1983, Aleppo, Syria. Martinus Nijhoff. The Hague, The Netherlands.

ICARDA. 1985. Harvest of Research. Farmers and Scientists Finding Ways to Grow More Faba Beans in Egypt and Sudan. Highlights of the IFAD/ICARDA Nile Valley Project 1979-1985. ICARDA, Aleppo, Syria. 48 pp.

Keatinge, J.D.H., Saxena, M.C., Cooper, P.J.M. and Stephens, J. 1985. Biological nitrogen fixation by food legumes in dry areas - The scope for increase by improved management. Pages 219-228 *in* Proceedings of the International Workshop on Faba Beans, Kabuli Chickpeas, and Lentils in the 1980's. (Saxena, M.C. and Varma, S. eds). ICARDA, 16-20 May 1983, Aleppo, Syria. Martinus Nijhoff, The Hague, The Netherlands.

Malhotra, R.S., Robertson, L.D., Singh, K.B., Erskine, W., and Saxena, M.C. 1985. Cooperative International Testing Program on Faba Beans, Kabuli Chickpeas and Lentils. Pages 227-314 *in* Proceedings of the International Workshop on Faba Beans, Kabuli Chickpeas, and Lentils in the 1980s. (Saxena, M.C. and Varma, S.,eds). ICARDA, 16-20 May 1983, Aleppo, Syria. Martinus Nijhoff, The Hague, The Netherlands

Malhotra, R.S. and Singh, K.B. 1985. Kabuli chickpea germplasm at ICARDA. Pages 23-28 *in* Proceedings of the International Workshop on Faba Beans, Kabuli Chickpeas, and Lentils in the 1980s. (Saxena, M.C. and Varma, S. eds). ICARDA, 16-20 May 1983, Aleppo, Syria. Martinus Nijhoff, The Hague, The Netherlands.

Murinda, M. V. and Saxena, M. C. 1985. Agronomy of faba beans, lentils and chickpeas. Pages 229-244 *in* Proceedings of the International Workshop on Faba Beans, Kabuli Chickpeas, and Lentils in the 1980's. (Saxena, M.C. and Varma, S. eds). ICARDA, 16-20 May 1983, Aleppo, Syria. Martinus Nijhoff, The Hague, The Netherlands.

Reddy, M.V. and Singh, K.B. 1985. Exploitation of host-resistance in the management of ascochyta blight and other diseases of chickpeas. Pages 139-152 *in* Proceedings of the International Workshop on Faba Beans. Kabuli Chickpeas. and Lentils in the 1980's. (Saxena, M.C. and Varma, S., eds). ICARDA, 16-20 May 1983, Aleppo, Syria, Martinus Nijhoff, The Hague, The Netherlands.

Robertson, L.D. 1984. A note on the I.L.B. source of *Botrytis fabae* resistance. *In* Systems for Cytogenetic Analysis in *Vicia faba* L., (Chapman, G.P. and Tarawali, S.A. eds). Martinus Nijhoff, The Hague, The Netherlands. 79pp.

Robertson, L.D. 1985. Faba bean germplasm collection, maintenance, evaluation, and use. Pages 15-21 *in* Proceedings of the International Workshop on Faba Beans, Kabuli Chickpeas, and Lentils in the 1980s, (Saxena, M.C. and Varma,S. eds). ICARDA, 16-20 May 1983, Aleppo, Syria. Martinus Nijhoff, The Hague, The Netherlands.

Robertson, L.D. 1985. Genetic improvement of faba beans for increased yield and yield stability. Pages 35-53 *in* Proceedings of the International Workshop on Faba Beans, Kabuli Chickpeas, and Lentils in the 1980s, (Saxena, M.C. and Varma, S. eds). ICARDA, 16-20 May 1983, Aleppo, Syria. Martinus Nijhoff, The Hague, The Netherlands.

Robertson, L.D., Nakkoul, H. and Williams, P.C. 1985. A note on the possibility of selection for higher protein content in faba bean (*Vicia faba* L.). FABIS 11: 11-12.

Sauerborn, J. 1985. Untersuchungen zur Segetalflora in Taro (*Colocasia esculenta* L. Schott) und zur Keimungsbiologie ausgewaehlter Unkrautarten auf West-Samoa. Dissertation ander Universitaet Hohenheim, West Germany, 85 pp.

Saxena, M.C. 1985. Food Legume Improvement Program at ICARDA - an overview. Pages 1-14 *in* Proceedings of the International Workshop on Faba Beans, Kabuli Chickpeas, and Lentils in the 1980's (Saxena, M.C. and Varma, S., eds). ICARDA, 16-20 May 1983, Aleppo, Syria. Martinus Nijhoff. The Hague, The Netherlands.

Saxena, M.C. and Varma, S. (eds). 1985. Faba Beans, Kabuli Chickpeas, and Lentils in the 1980's. Proceedings of the International Workshop, ICARDA, 16-20 May 1983. Aleppo. Syria. 395 pp. Martinus Nijhoff. The Hague. The Netherlands.

Saxena, M.C. and Wassimi, N. 1984. Photoperiodic response of some diverse genotypes of lentil (*Lens culinaris* Med.) LENS 11(2): 25-29.

Singh, K.B., Reddy, M.V. and Malhotra, R.S. 1985. Breeding kabuli chickpeas for high yield, stability and adaptation. Pages 71-90 *in* Proceedings of the International Workshop on Faba Beans, Kabuli Chickpeas, and Lentils in the 1980's. (Saxena. M.C. and Varma, S. eds). ICARDA, 16-20 May 1983, Aleppo, Syria. Martinus Nijhoff, The Hague, The Netherlands.

Turk, M. and Agha, M. 1985. Bean production in Syria. Pages 109-111 *in* Potential for Field Beans (*Phaseolus vulgaris* L.) in West Asia and North Africa. Proceedings of a Regional Workshop in Aleppo, Syria. 21-23 May 1983. CIAT, Cali,Colombia.

Williams, P.C. and Nakkoul, H. 1985. Some new concepts of food legume quality evaluation at ICARDA. Pages 245-256 *in* Proceedings of the International Workshop on Faba Beans, Kabuli Chickpeas and

Lentils in the 1980's. (Saxena, M.C. and Varma, S. eds). ICARDA, 16-20 May 1983, Aleppo, Syria. Martinus Nijhoff, The Hague, The Netherlands.

Zahid, M.A., Saxena, M.C. and Murinda, M.V. 1984. Effect of fertilizer and *Rhizobium* application on nodulation and seed yield of ILC 482. International Chickpea Newsletter Dec 1984: 39-41.

PASTURE, FORAGE, AND LIVESTOCK

ICARDA Annual Report 1985

INTERNATIONAL CENTER FOR AGRICULTURAL
RESEARCH IN THE DRY AREAS (ICARDA)
Box 5466, Aleppo, Syria

Contents

PASTURE, FORAGE, AND LIVESTOCK

The objective of the Pasture, Forage, and Livestock Program (PFLP) is to improve the livestock production and the stability of rainfed farming systems in West Asia and North Africa. In attempting to do this we have identified two major agroecosystems: the cereal zone where the basic product is wheat or barley, and marginal land within and adjacent to the cereal zone. The Program's work is divided into four projects: (1) annual pastures to replace fallow, (2) forage breeding and agronomy, (3) marginal-land improvement, and (4) livestock management and nutrition.

The first two projects are designed for the first agroecosystem, specifically to replace fallow in cereal/fallow rotations with either annually resown forages or self-regenerating pastures. In the case of forages, the objectives are to breed adapted cultivars of vetch (*Vicia* spp.) forage pea (*Pisum sativum*), and chickling (*Lathyrus* spp.). With annual pastures, the objectives are to introduce self-regenerating populations of annual legumes and to devise management systems suitable for local economic and social conditions.

The objective of the marginal-land project is to increase the stability and productivity of non-arable land within and adjacent to the cereal zone. The specific aim is to define the resource base: nature and fertility status of soils, kind of plants found, soil productivity, and management practices. From these studies new proposals are being formulated to develop this greatly undervalued resource. The first of the proposals in 1984/85 was the use of superphosphate on marginal land. A large experiment involving two stocking rates of sheep and three rates of superphosphate application was initiated.

Livestock management and nutrition is the Program's integrating project in which scientists test various production systems from the point of view of sheep, the Program's 'commodity'. There is emphasis on 'on-farm' experimentation. Extensive work on nutrition was conducted, particularly, on the quality of barley and wheat straw.

Throughout the Report we have used the common names of plants, while the scientific name is given when the species is first discussed. However, for easy reference some of the more important species in the Program's work are listed here:

Vetch - various species of *Vicia*, including common vetch (*V. sativa*), narbon vetch (*V. narbonensis*), bitter vetch (*V. ervilia*), and woollypod vetch (*V. villosa* subsp. *dasycarpa*).

Chickling - *Lathyrus sativus*

Forage pea - *Pisum sativum*

Medics - various species of *Medicago*: of these only barrel medic (*M. truncatula*), snail medic (*M. scutellata*), strand medic (*M. littoralis*) and gama medic (*M. rugosa*) have widely accepted common names. *M. polymorpha*, although often called bur medic, is referred to by its scientific name.

Clovers - various species of *Trifolium*, including subterranean clover (*T. subterraneum*) and rose clover (*T. hirtum*).

Some of commonly-used terms used in this Report are also defined below:

accession - an ecotype as collected in its native habitat and used in a breeding project.

selection - resulting from selection within an accession. In its numbering system ICARDA allocates both an accession number and, where applicable, a selection number.

variety - a taxonomic unit beneath species.

cultivar - a genotype or ecotype which is used in agriculture, including locally evolved 'landraces'.

strain - a general term to cover accession, selection, variety and cultivar. It is also used to describe a culture of *Rhizobium* of different origin to other cultures.

forage - monocultures of certain legumes, namely: vetch, forage pea, and chickling or mixtures of these species with cereals. In general, forages are crops sown and harvested in the same year and used for hay, straw, or grazing.

self-regenerating pasture - pastures which re-seed and establish from dormant seeds after the cereal phase of a pasture/cereal rotation.

ley farming - in Mediterranean regions, the farming system in which self-regenerating pastures are grown in rotation with cereals.

marginal land - land receiving more than 200 mm annual rainfall and which is too dry, too steep, or in which the soil is too shallow for cultivation.

steppe - nonirrigated land (in Syria) which receives less than 200 mm annual rainfall.

Research Highlights

(1) Based on 6 years' data ('Unit Farm' project), a linear program was used to analyze the profitability of different management levels and contrasting 3-course rotations, one of which included vetch and the other lentils. Including vetch and improved management practices in the rotation increased sheep numbers by up to 100% and farm profitability by up to 75%.

(2) Barley yields after forage depended on the amount of cereal included in the forage mixture. Even small amounts of cereal reduced subsequent grain yield regardless of the species of forage legume.

(3) Palatability of forage pea was less than that of common vetch or chickling at all growth stages, and less than barley at all except the straw stage. Sheep lost weight when pure forage pea was fed either fresh or as hay or as straw.

(4) Resistance to root-knot nematode (*Meloidogyne artiella*) was discovered in several strains of common vetch. This nematode causes serious losses in herbage and seed yields, of many food and forage legumes of potential importance in the region.

(5) Strains of common vetch with non-shattering seed pods were hybridized with several well adapted strains: 524 successful crosses were made.

(6) Woollypod vetch was well adapted to Tel Hadya environment. It produced large quantities of herbage and seed, tolerated frost, and was resistant to broomrape (*Orobanche* sp.) and root-knot nematode.

(7) The native medics (including *M. rigidula, M. rotata,* and *M. noeana*) were more frost-tolerant than any of the Australian medic cultivars. Moreover, strains originating from cold environments were more likely to be frost-tolerant. Tolerance of susceptible strains depended on plant density and seemed to be related to leaf-area ratio.

(8) An ecogeographic survey of native legumes in western Syria revealed the habitats of 21 medic species. *M. polymorpha, M. orbicularis, M. minima,* and *M. rigidula* were the most common but in certain specific environments there were high populations of *M. rotata, M. blancheana,* and *M. turbinata.*

(9) Certain strains of self-regenerating *M. rigidula* produced large quantities of herbage and seed following wheat. In an experiment with 25 native medics the average quantity of seed after 3 years of pasture/cereal rotation was more than 700 kg/ha.

(10) Sheep grazing medic pasture in summer increased weight when the amount of seed available exceeded 10 kg/ha. At a stocking rate of 5.3 sheep/ha, seed available remained above this figure until mid-September. Each sheep consumed about 450 g medic seed/day.

(11) When inoculated with an exotic strain of *Rhizobium,* medic nodulation was improved by the additional use of a protective seed coating.

(12) A large experiment was established in which the reponse in productivity of sheep grazing marginal land top-dressed with superphosphate will be measured. In the first year, both herbage and seed yield were increased (especially with native legumes), indicating that the use of superphosphate on marginal land can increase farm profitability.

(13) Studies on voluntary intake of barley straw confirmed that proportion of leaf is the most important factor determining straw quality. Proportion of leaf is dependent on maturity time and plant height, both of which are genetically controlled. Factors influencing straw quality in barley also appear to influence straw quality in wheat.

(14) Weight of Awassi ewes at mating had a marked effect on reproductive function between body weights of 38 and 50 kg.

(15) On-farm work continued using forage and pasture legumes and preliminary results indicate that both systems can increase farm profitability.

The Program wishes to acknowledge the collaboration of the Italian Government and the University of Perugia in the marginal-land project; the Tropical Development and Research Institute of the Overseas Development Administration, UK, in the straw project; the Japanese International Cooperation Agency in the animal health work; and the Syrian Agricultural Research Center and Steppe Directorate in all our work.--*P.S. Cocks.*

Annual Pastures to Replace Fallow

The idea of using annual pasture legumes to replace fallows in cereal/fallow rotations originated in southern Australia, where pastures provide nutritious grazing throughout the year, replenish soil fertility, and provide a disease-controlling break between cereal crops. In the 30 years since it was introduced, the ley farming system, has increased livestock numbers by up to four times and doubled cereal yields.

The main advantage of annual pastures over forages is that with the appropriate species, they do not need re-sowing after the initial year of establishment. This is particularly true for certain pasture legumes, mainly *Trifolium subterraneum* (subterranean clover) and several *Medicago* (medic) species, which can regenerate in the pasture phase of the rotation from seed set in the previous pasture phase, 2 years earlier. This saves the expense of re-sowing since the natural re-seeding rates are much higher than farmers can afford to use, and provides a rapid and early pasture establishment and a much longer grazing period. Ideally, livestock are introduced to the pasture in early winter. Since annual legumes are prostrate in winter, and many weed species are erect, winter grazing is a good method of weed control. The sheep continue to graze in spring, when the main problem is ensuring good flowering and seed set; in summer, when sheep eat the nutritious seed pods, the problem is ensuring that an adequate seed population remains for pasture regeneration in later years. In summer and autumn the farmer also uses cereal stubbles for grazing.

In the second year the farmer waits until the autumn rains and then, after weed germination, prepares his seed bed and sows the crop. Most of the legume seed produced in the previous year remains dormant due to seedcoat impermeability, sometimes referred to as hardseededness. It is important that tillage depth is such that seeds are placed at a depth (no more than 10 cm) from which they can emerge in the third year.

Success of the system depends on several factors. First, the greatest feed shortage is usually in autumn and winter, when low temperatures and low light intensity inhibit plant growth. Indeed many people believe that one of the most important differences between West Asia and southern Australia is that winter temperatures are about 5°C less in the former. Therefore rapid pasture growth in winter and resistance to frost are important attributes. Second, the survival of pastures depends on their ability to produce enough material to provide summer grazing and enough seed for a dense germination in the autumn, 2 years later. Third, the seeds must resist germination in the crop year and germinate promptly in the third, or pasture year. Finally, the pasture must fulfill its role as a nitrogen source and, in association with *Rhizobium*, fix sufficient atmospheric nitrogen for its own and the cereal's requirements.

We reported in the 1984 Annual Report that the native medics, *M. rigidula*, *M. rotata*, *M. noeana*, and *M. polymorpha* show great promise for use in the ley farming system. They all produced more herbage than Australian cultivars of *M. truncatula*, *M. littoralis*, *M. rugosa*, and *M. scutellata*. Our research is now directed towards fitting these species into workable farming systems, in particular the adaptation of native medics to crop rotations, their response to grazing animals, the impact of low temperatures on production, and plant/*Rhizobium* interactions.

All these problems were studied in 1985. In this Report we highlight (i) the effect of frost, both on the ecology of its impact and sources of resistance; (ii) the studies on flower and seed production in the presence and absence of grazing animals, and (iii) the ability of promising medics to survive in a cereal/pasture rotation. We also conducted further studies on *Rhizobium*, especially on new methods of inoculation, and have started to find out more about its ecology. Finally, we report on our first attempt to introduce ley farming at the village level and present data which will help to evaluate the future expansion of ley farming.

Severe frosts occurred in late winter so the effect of frost was measured in several experiments which were also continued for their original objectives. To avoid repetition in describing procedures, the experiments are numbered 1 - 6: where the same number is referred to in different sections, different results from the same experiment are being described.

The Impact of Severe Frost on Native and Introduced Annual Medics

Although introduced cultivars of *M. truncatula*, *M. scutellata*, and *M. littoralis* have grown well in parts of North Africa, they have often failed in the highlands and in West Asia. In his review of pasture and forage legumes, Kernick (1978) records that in northern Iraq, frosts lasting 1 week or longer killed *M. truncatula* seedlings, and he quotes similar results in Syria, Jordan, Iran, and Yemen. This is perhaps not surprising in view of the mainly littoral distribution of these species: the native habitats of both are in areas of mild winters near the sea. Use of productive native medics is one method by which cultivars resistant to frost may be identified.

An opportunity to study frost resistance occurred in December 1984 and late February 1985 when the minimum air temperature at Tel Hadya was 0°C or less for 46 days (Fig. 1). Many experiments were affected, including those where several introduced and native medics were being compared (Experiment 1), where a large collection of Syrian medics was being evaluated (Experiment 2), and three medic species were growing at several plant densities (Experiment 3).

Experiment 1

The effect of stocking rate on flower and seed production was compared for seven medic strains. There were three stocking rates, controlled by plot size: 2.25, 1.125, and 0.75 ha. Each 'main' plot was replicated twice

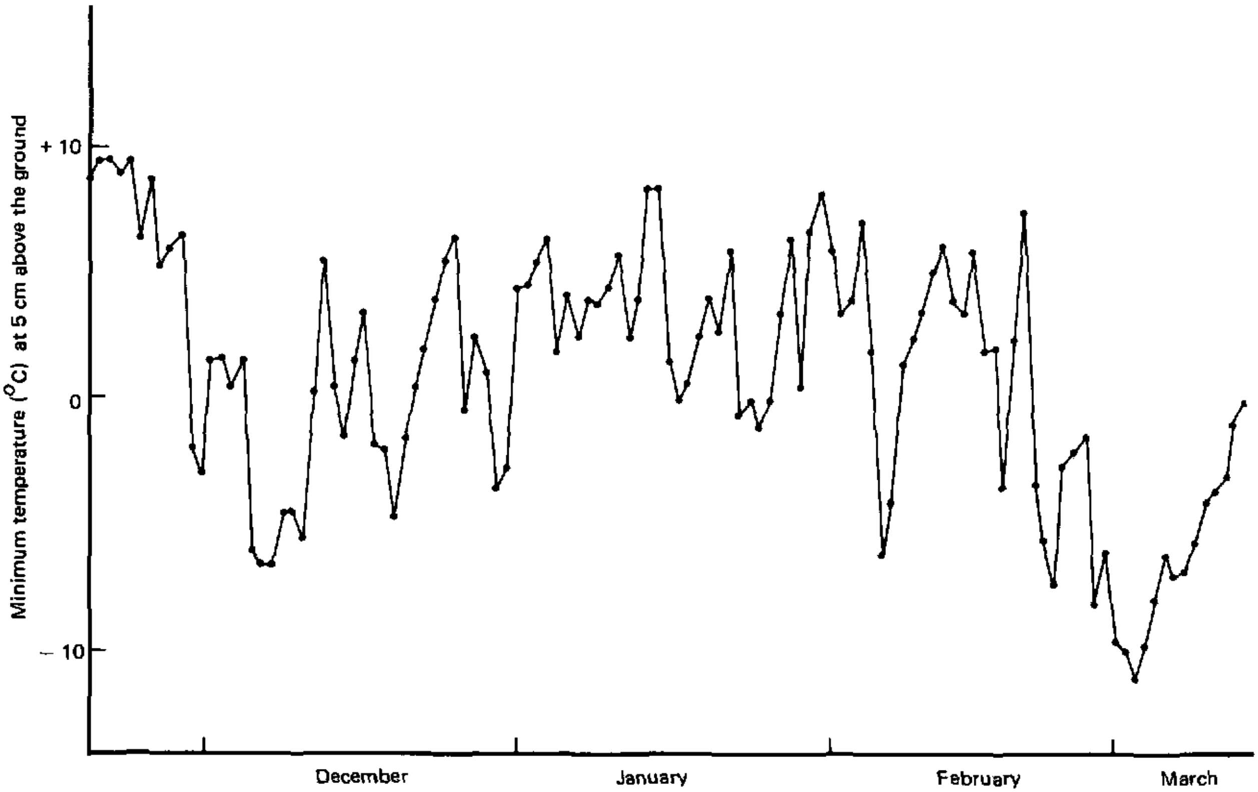


Fig. 1. Minimum daily temperatures 5 cm above ground at Tel Hadya (winter 1984/85). There were 46 frosts.

Table 1. Establishment and survival after severe frost of seedlings of seven accessions (five species) of medic, including four Australian cultivars.

Species and genotype	No. of seedlings/m^2	Survival (%)
M. scutellata cv Robinson	232	5e*
M. truncatula cv Cyprus	536	7de
cv Jemalong	432	14cd
M. polymorpha cv Circle Valley	856	21c
M. rotata sel. 2123	1144	90b
M. rigidula sel. 716	816	95ab
sel. 1919	864	98a

* Survival percentages with the same superscript not significantly different ($P < 0.05$): analysis of variance of data after angular transformation.

and, within each replicate, two replicates of each strain were sown as subplots. The subplots were sown on 3 December at a seed rate of 100 kg/ha.

On 7 February frost occurred and, before any plants died, a count of the established seedlings was made to quantify the damage. On 12 March, after severe frosts in the preceeding 3 weeks, the seedlings were recounted in the same quadrats (three, 12.5 x 50 cm) in each subplot and the percentage survival of each strain was calculated (Table 1).

The medics fall into two distinct groups: a low-surviving group comprising the Australian cultivars and a high-surviving group comprising the native accessions. Within the Australian group, survival of cultivars Jemalong and Circle Valley was superior to that of Robinson and Cyprus, and within the native group, *M. rigidula* appeared to survive a little better than *M. rotata*, although the difference was barely significant. The loss of plants in the native group was hardly enough to effect productivity, while 3 of the 4 Australian cultivars were so badly damaged that they were excluded from the experiment.--*P.S. Cocks*.

Experiment 2

Annual legumes were collected from 95 sites throughout northwestern Syria, including the coastal plain, the mountains, and the cereal belt to the east of the mountains. The exact position of each site was recorded and an area of approximately 0.5 ha was chosen for sampling. Within the area, one or two strip quadrats about 40 m long were chosen for detailed study, the size and direction of the strips depending on site heterogeneity in terms of topography and species richness. At least 25 pods of each species were sampled.

A much smaller area was sampled more intensively to measure population size and obtain detailed information on physical and chemical characteristics of the soil. A homogenous area of about 25 m^2 was chosen, typical of the site as a whole, and all legume seeds in five quadrats (1 m x 0.25 m) were collected. At the center of each quadrat the soil was sampled to a depth of 10 cm. The seed was sorted into species, threshed, and weighed to determine total yield.

Seeds from both the larger and smaller area were germinated in 'Jiffy' pots in a greenhouse and, after hardening outside for 2 weeks, were transplanted into the field in rows of up to 15 plants each.

All frosts shown in Fig. 1 seemed to affect the plants, some ecotypes more severely than others. The late frosts were especially severe and the opportunity was taken to record survival. Fig. 2 relates mean survival of all species occurring at a site to the mean number of days on which the temperature fell below 5°C at that site. Frost resistance was an excellent character to demonstrate the benefit of choosing adapted species from native populations. There was a strong relationship ($100\ r^2 = 50$, $P < 0.001$) between frost resistance and number of days below 5°C, a relationship even more impressive than the statistics suggest since temperatures were read from isotherms in published maps and no account was taken of microclimate.

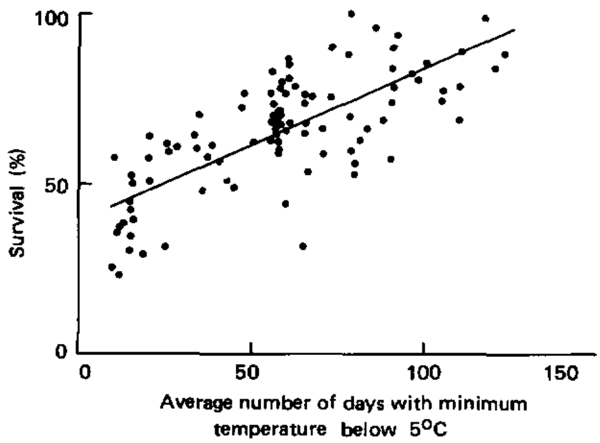


Fig. 2. The relationship between frost survival at Tel Hadya and the average number of days below 5°C at 95 sites in western Syria from which annual legumes were collected. Each point represents the mean for all accessions collected at a site.

Some species showed ecotypic differentiation for frost resistance; ecotypes from cold environments were more resistant to frost than those from milder areas. Statistical parameters for seven of the medics are shown in Table 2. Neither *M. rigidula* nor *M. minima* showed variation in frost resistance and ecotypes from almost all sites were resistant. On the other hand, some ecotypes of *M. scutellata* exhibited strong resistance and the relationship with the environment was also strong. In *M. turbinata*, *M. orbicularis*, and *M. polymorpha*, although resistance was strong in some ecotypes, it was only weakly related to the incidence of cold in their native habitats. Other results from this survey are discussed later.--*T. Ehrman (Genetic Resources Unit) and P.S. Cocks.*

Table 2. Statistical parameters for the relationship between genotype survival and minimum temperature of the site at which genotypes were collected: n, number of genotypes collected; b, slope of the regression line for relationship; and $100\ r^2$, percentage of variation accounted for.

Species	n	b	$100\ r^2$
M. rigidula	50	NS	0
M. polymorpha	102	0.523***	13.2
M. turbinata	23	0.607*	20.1
M. orbicularis	43	0.240*	11.6
M. minima	43	NS	1.2
M. scutellata	11	1.000**	56.4

NS, not significant; * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

Experiment 3

Three medic species (*M. rigidula* sel. 1919, *M. rotata* sel. 2123, and an Australian cultivar of *M. polymorpha* - cv. Circle Valley) were sown at 11 seed rates (1-500 kg/ha) on 31 October 1985. The treatments were combined factorially using two replicates. Plot size was 15 m x 2 m, weeds were chemically controlled, and the whole area received a basal dressing of 15 kg phosphorus/ha.

From 18 December herbage yield was measured, initially at about 3-week intervals, and after 29 January at 2-week intervals. The final harvest was on 20 April. For the first six harvests samples were cut to ground level in 1 m x 0.5 m quadrats and for the final three harvests quadrats were 1 m x 1 m. Plant numbers were estimated at each harvest by weighing 50 plants and leaf-area index calculated from the area in a subsample.

On 20 April, herbage yield varied markedly between species and seed rates (Fig. 3). Yield of *M. rigidula* was highest, that of *M. polymorpha* was lowest, but in both species yield fell substantially. The decline in the yield of *M. rotata* was small at high seed rates which is normal for this kind of relationship. The yield of *M. rigidula* exceeded 9 t/ha at a sowing rate of 60 kg/ha, a very high yield indeed.

The time course in leaf-area index (LAI, leaf area per unit ground area) of two of the seed rates (60 and 500 kg/ha) reflected the differential leaf loss of the three species following severe frosts at the end of winter (Fig. 4). All species suffered some leaf loss at the high rate, although that of *M. polymorpha* was greatest with the LAI falling from 3.2 to 0.25 between 27 February and 13 March. Frosts on 3 and 4 February also affected the LAI of *M. polymorpha* and possibly *M. rigidula*, but the first frosts (in December) apparently had no effect on any species. The late winter frosts also reduced the LAI of *M. polymorpha* at the low rate, but at that rate did not affect the other two

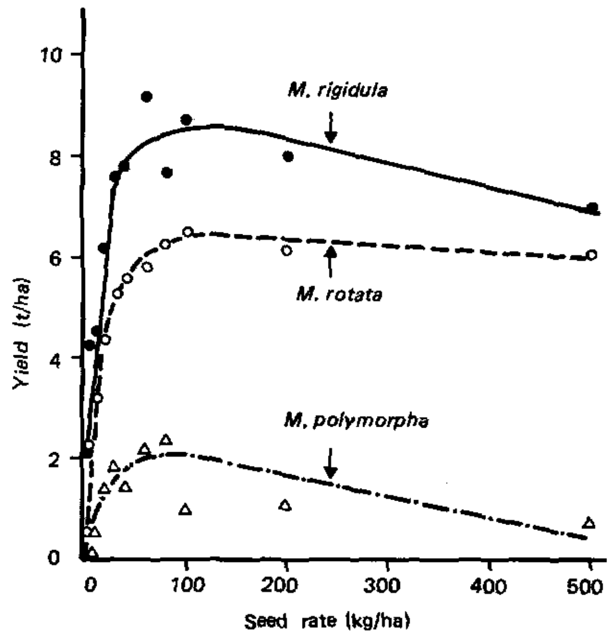


Fig. 3. Herbage yield of three medics (*M. rigidula, M. rotata,* and *M. polymorpha*) sown at 11 seed rates.

species. Indeed, *M. polymorpha* was affected by the frost at all 11 seed rates whereas the other species were affected only at the 500 kg/ha rate.

The interaction between species and seed rate is partly explained by the ratio of leaf area to leaf weight (leaf-area ratio): low ratios indicate relatively thick leaves, and high ratios indicate thin leaves (subject to minor variations in leaf structure and moisture content). Frost damage, indicated in Fig. 5 by the percentage change in leaf-area between 27 February and 13 March, is related to leaf-area ratio, the latter accounting for 55% of variation in change of LAI. At a leaf area ratio of 275 cm^2/g there was no change in LAI between the two dates, and presumably the level at which no frost damage occurred was a little below this figure. The relationship probably differs between species since *M. polymorpha* suffered damage at all leaf-area ratios, but this species had a higher ratio

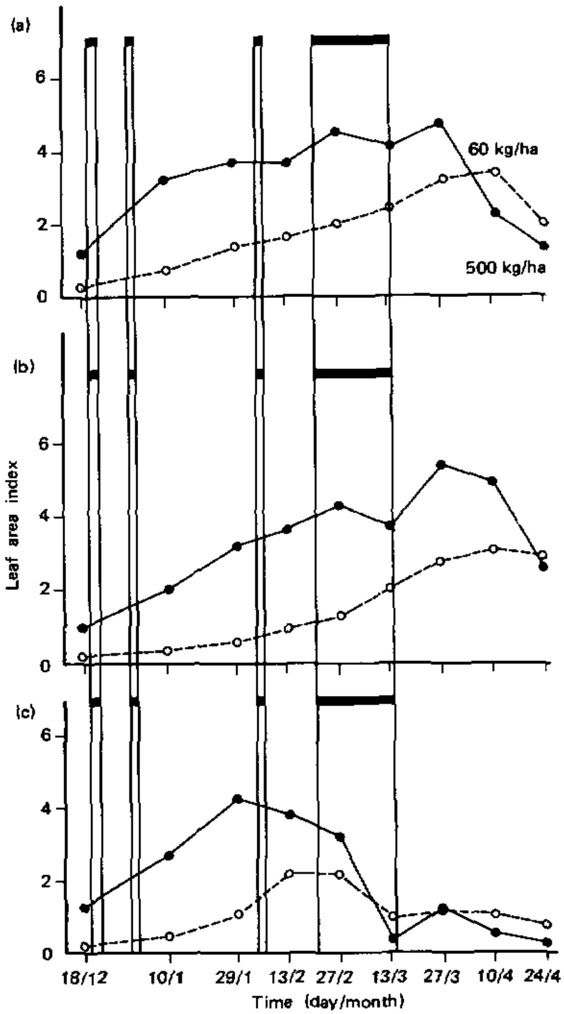


Fig. 4. Time course of leaf area index (LAI) of (a) *M. rigidula* (b) *M. rotata*, and (c) *M. polymorpha*, sown at two rates (60 and 500 kg/ha). The bars and parallel lines indicate the periods of severe frost.

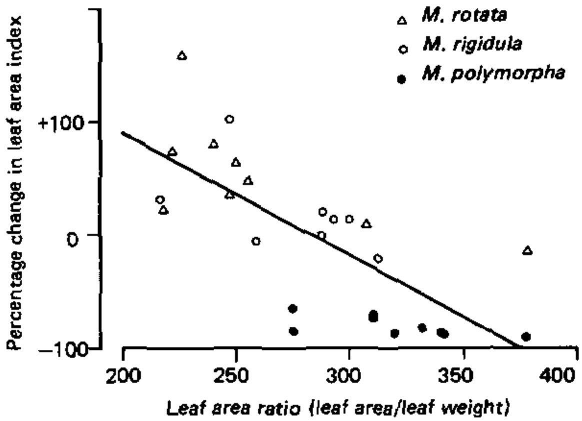


Fig. 5. Relationship between percentage change in leaf area index (27 Feb - 13 Mar) and leaf area ratio (cm^2/g) after frosts in late February and early March. Data are the mean for 11 seed rates.

than either *M. rigidula* or *M. rotata* in all treatments. Low leaf-area ratio (i.e. thick leaves) is clearly an important attribute in a plant's ability to resist frost, but it does not explain all the variation in frost damage.

The time course for leaf-area ratio in each species is shown in Fig. 6. The leaf-area ratio of all species was lowest early in the season, increased until the end of January, decreased during February, increased for a short period in the spring and declined again in late spring. If leaf-area ratio is important, then all three species were likely to be most susceptible to frost in January. *M. polymorpha* was clearly the most vulnerable species at all times except late spring when frosts are unlikely. The data suggest that if frosts of equal severity to those experienced in late February had occurred in January then damage would have been even more severe. It also explains why the frost which occurred in December (Fig. 1) had so little effect: at this stage of the growing season leaf-area ratio was at its lowest.

Fig. 7 shows the relationship between leaf-area index and leaf-area ratio: in all cases leaf-area index increases with leaf-area ratio, the slope and origin of the lines for *M. rotata* and *M. rigidula* being identical, while the origin of *M. polymorpha* is higher.

In earlier results (Table 1) we referred to the differential survival of individual seedlings among native and introduced medics. It is also of great interest to analyze the impact of plant density on seedling survival,

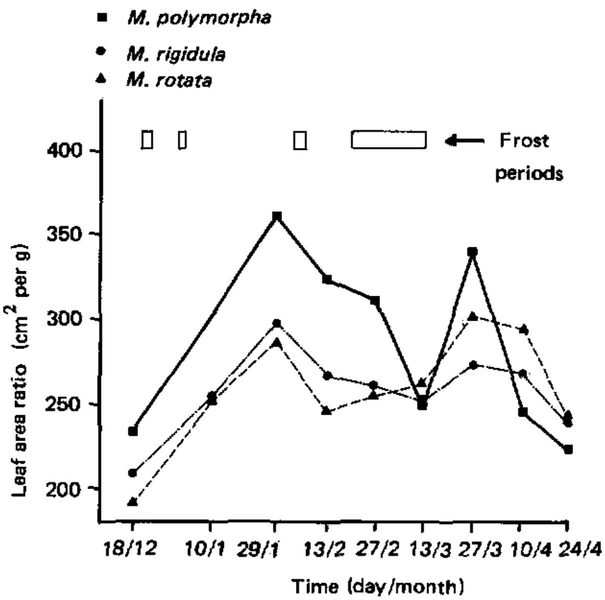


Fig. 6. Time course of leaf area ratio (cm^2/g) of *M. polymorpha, M. rigidula,* and *M. rotata.* Frost periods are indicated by the bars at the top of the figure. Data for each harvest are the means for 11 seed rates.

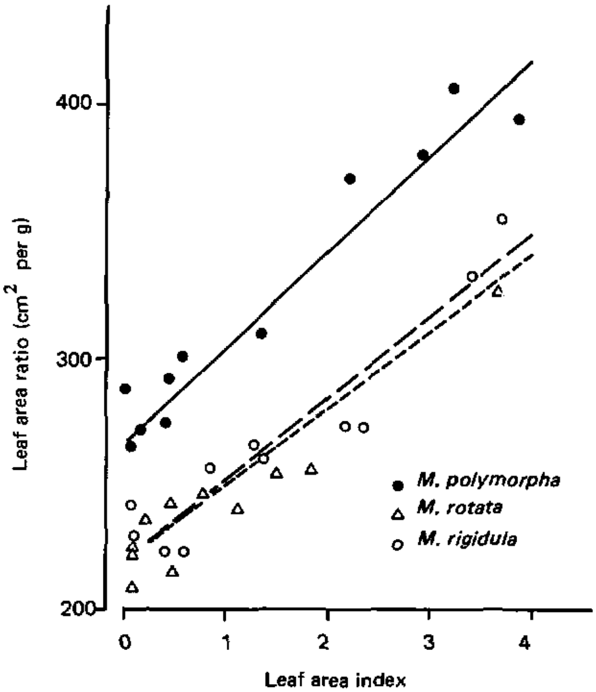


Fig. 7. Relationship between leaf area ratio (cm^2/g) and leaf area index of *M. polymorpha, M. rotata,* and *M. rigidula.* The lines are fitted regressions all of which were significant at $P < 0.001$. Data are for 11 seed rates, each point being for herbage harvested on 13 February.

but, since self-thinning occurs at high density, it is not always easy to separate the impact of frost from other factors causing plant death. One method is to use the 3/2 thinning law which states that once self-thinning begins the graph of the relationship between mean plant weight ($\log_{10}$) and the number of plants ($\log_{10}$) has a slope of 3/2. The law applies to all plant communities, including grasses, herbs, and trees (White and Harper 1970) and is therefore an excellent description of self-thinning in dense plant communities. In our experiment, any deviation from the law is likely to be due to the effect of frost.

The law as applied to *M. rigidula* and *M. polymorpha* is shown in Fig. 8. The line on the right of each graph has a slope of 3/2 and, for *M. rigidula,* it is clear that the change in plant numbers is in accordance with the law but for *M. polymorpha* plant loss in all densities was greater than predicted. Any changes in plant numbers in *M. polymorpha* are therefore likely to be due to frost. There was no plant death due to frost in either *M. rigidula* or *M. rotata* (not shown).

There was a highly significant relationship between plant death and density in *M. polymorpha* (Fig. 9), which accounts for 83% of variation in plant death (the two lowest densities have been excluded from this relationship because random errors in plant counts in the 0.5 m^2 quadrats are such that the calculation of percentage death is unreliable). The percentage of plants killed when density was 500 - 800 plants/m^2 agrees closely with the percentage of plants killed in Experiment 1 (Table 1) where the same cultivar of *M. polymorpha* was used.

The results of this study can be summarized as follows:

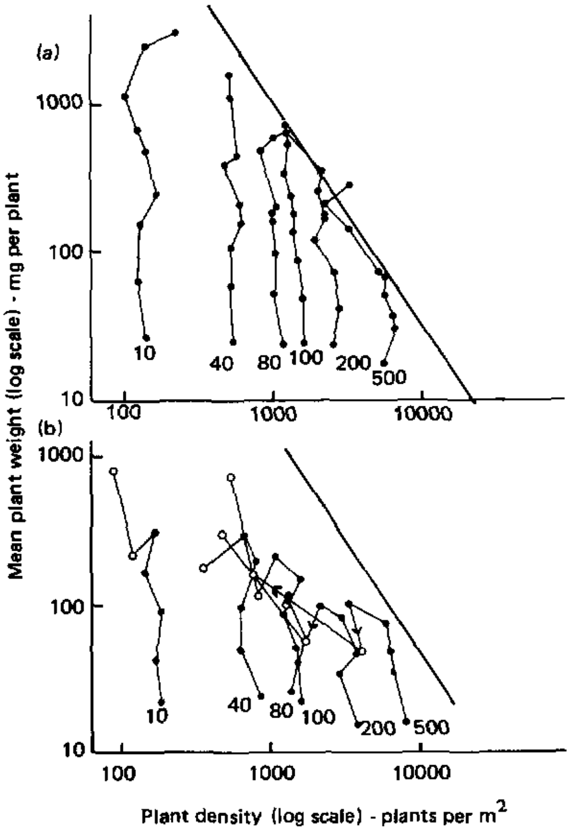


Fig. 8. Relationship between actual plant density of (a) *M. rigidula* and (b) *M. polymorpha* and mean weight per plant at nine harvests (18 Dec - 24 Apr). There are six sowing densities (from left to right 10, 40, 80, 100, 200, and 500 kg/ha) and the points joined by continuous lines represent changes of actual density and plant weight with time during the course of the experiment. The straight line at the right has a slope of 3/2. The open circles in (b) represent harvests after the severe frosts in early March.

- native medics are more resistant to frost than the Australian cultivars,
- the advanced selections of *M. rigidula* and *M. rotata* are very resistant to frost,
- frost resistance in native populations of annual legumes is related to frost frequency in their native habitats,
- herbage and seed yield of susceptible species is greatly reduced by frost,

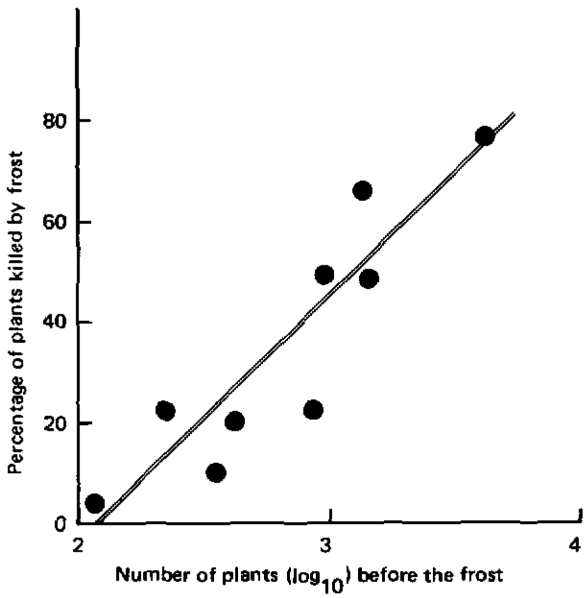


Fig. 9. Relationship between percentage of *M. polymorpha* plants killed by frosts and actual plant density before the frosts. The points represent 9 of the 11 seed rates studied.

- frost resistance is affected by plant density, and much of the variation in frost resistance with different densities and species is associated with variation in leaf-area ratio,
- annual legumes were most susceptible to frost in January, and
- if plant death occurs, the percentage of plants dying is closely related to density.--*P.S. Cocks*.

Adaptation of Native Medics to Pasture/ Cereal Rotations (Experiment 4)

Prior to 1984 the evaluation of *M. rigidula* was largely confined to small plots, sown and harvested in the same year. This species has shown great promise so far, but it must be examined under on-farm conditions in Syria where we expect it to be used in rotation with cereals and be grazed by sheep. Therefore, the next step towards commercial evaluation is to test regeneration in the third year of a pasture/cereal rotation. This was done in 1984/85 when the natural regeneration and herbage yield were measured for 25 promising medics whose initial establishment 2 years ago was followed by wheat last year.

The treatments comprised 23 entries of *M. rigidula* and one each of *M. rotata* and *M. noeana.* The entries were selected after 2 years' measurement of herbage and seed yield from 343 accessions of 14 species in nursery rows, and 124 selections of 9 species in small plots, in 1980/81 and 1981/82, respectively. The selections of *M. rigidula* originated from Turkey (13 selections), Syria (5), Algeria (2), Libya, Jordan, and Lebanon; *M. noeana* came from Siirt and *M. rotata* from Kazanli in Turkey (Table 3).

A randomized block design was chosen with *six replicates and plot size was 4.8 x 5 m.* Three replicates were used to measure herbage yields in 1982/83, while the remainder were for seed yields. The experiment was sown on 27 November 1982, at 15 kg/ha. Herbage was harvested to ground level when plants reached 50% flowering, which varied among selections between 30 March and 19 April. Seed was harvested in July 1983, when pods were fully mature. Both herbage and seed yields were measured in 1 x 4 m quadrats: subsamples of herbage were dried at 85°C for 24 hours and weighed, while mature pods were threshed and the seeds cleaned and weighed.

In the replicates used for seed harvest the unharvested pods were spread evenly over each plot. Following cultivation to a depth of 10cm, *wheat (cv Senator Cappelli) was* sown on 15 December 1983 over the whole experimental area at 100 kg/ha and fertilized with 18 kg phosphorus/ha as in the previous year. In February each plot was split: half was sprayed with Brominil Plus at 1 l/ha to control broad-leaved weeds and half was unsprayed. Each half was harvested separately and its yield recorded.

In autumn 1984 the medics were allowed to regenerate naturally. In December the number of regenerating seedlings was counted in 0.5 m^2 quadrats placed randomly in each plot. Herbage yield was measured in 1985 on 1 January, 7 February, 12 March, and 14 April by cutting the crop to ground level in 0.5m^2 quadrats. Subplots (sprayed and unsprayed) were sampled separately. Herbage was weighed after drying at 85°C for 24 hours.

The amount of residual seed (from previous years) was measured on 19 April. Some seed was buried during the cultivation and sowing of wheat in the previous year while some remained on the surface. Surface seed was harvested by removing herbage in 0.5 m^2 quadrats and carefully collecting all pods, while buried seed was harvested by removing five cores of 336 cm^2 total surface area to a depth of 10 cm. The cores were collected in quadrats from which the surface pods had previously been removed. Both above - and below - ground samples were sieved to remove soil, washed in water, and dried. The pods were threshed and cleaned by hand. Viability of both fractions was determined by placing four replicates of 100 scarified seeds of each selection on moist filter paper and germination was assessed 7 days later.

Yield of new seed in 1985 was determined by measuring the total amount of seed on the surface on 16 June, and subtracting the amount present on 19 April. Buried seed was left undisturbed. *Quadrats of 0.5 m^2 were* harvested, threshed, and cleaned as before. Since there was no response of herbage yield to spraying, final seed yield was measured *only on unsprayed half-plots.*

Total rainfall was 322mm, 228mm, and 369mm in the 1982/83, 1983/84, and 1984/85 seasons respectively. Rainfall was evenly distributed in 1982/83, in 1983/84 it was exceptionally dry from January onwards, and the wet winter of 1984/85 was followed by a dry spring. There were 52, 25, and 41 days of frost in the three seasons, respectively.

Table 3. Origin of the 25 *Medicago* selections used in Experiment 4, their first year seed yield (kg/ha), weight of germinating seed in the third year (kg/ha), time to 50% flowering (days), residual seed in the third year (kg/ha), and yield of new seed in the third year (kg/ha).

Selection number[1]	Origin	Flowering time	First year seed	Germinating seed	Residual seed	New seed
716	Jisr Al Shagour, Syria	127	779	45	590	346
1304	Mardin, Turkey	141	547	41	301	102
1531	Bergana, Turkey	141	613	64	350	333
1569	Siirt, Turkey	140	672	60	342	355
1850	Vadda, Libya	131	698	56	513	279
1851	Setif, Algeria	143	475	71	267	83
1852	Saida, Algeria	131	641	38	501	219
1856	Turkey[2]	130	603	25	938	285
1861	Urfa, Turkey	132	648	58	422	133
1865	Hankendi, Turkey	143	603	167	308	112
1868	Elazig, Turkey	142	665	126	484	208
1878	Diar Baker, Turkey	140	473	38	346	99
1881	Jerash, Jordan	123	770	48	765	274
1891	Urfa, Turkey	140	559	32	531	213
1893	Diar Baker, Turkey	140	463	53	635	124
1894	Mardin, Turkey	134	574	61	253	234
1900	Kahranan Marash, Turkey	132	738	106	231	217
1902	Elazig, Turkey	142	721	133	351	243
1913	Aleppo, Syria	133	717	80	404	147
1915	Rago, Syria	133	571	63	427	284
1917	Rago, Syria	131	731	50	449	355
1919	Terbol, Lebanon	126	792	83	570	225
1938	Siirt, Turkey	146	681	68	191	132
1943	Kazanli, Turkey	143	489	57	218	28
1963	Safita, Syria	137	536	53	482	172
Mean		136	630	67	435	208
SE (±)			16.7	8.0	154.9	98.6

1. All selections except 1938 and 1943 are M. rigidula: sel. 1938 is M. noeana and sel. 1943 is M. rotata.

2. Exact origin of this selection is not known.

Production and Survival of Seed

Seed yields of *M. rigidula* in 1982/83 were 463 kg/ha (sel. 1893) - 792 kg/ha (sel. 1919) with a mean of 634 kg/ha. The single selections of *M. rotata* and *M. noeana* produced 489 and 681 kg/ha, respectively (Table 3). In terms of seed number, *M. rigidula* varied from 9900/m^2 to 23100/m^2 (mean 15600/m^2) while there were 21300 seeds/m^2 of *M. noeana* and 6000 seeds/m^2 of *M. rotata*. Although seed yield and number were correlated ($P < 0.001$), the number accounted for only 55% of variation in yield, indicating considerable variation in seed size among the selections.

Of the 634 kg seed/ha of seed produced by *M. rigidula* in 1982/83, 458 kg/ha or 72% of the original population was present in April 1985 (Table 3). Seed present in any one year which was produced in previous growing seasons is termed residual seed. The seed population at any one time is the total quantity present above and below ground, irrespective of when it was produced. If the amount harvested in 1982/83 (4 m^2 or 17% of the plot area) is taken into account, 87% of the original population was still present. Most had been buried by the previous year's cultivation: only 9% of seed remained on the surface. There was double this amount of both *M. rotata* and *M. noeana* but since these figures are from single genotypes only, the difference is within the range of experimental error. Quantities of residual seed of selections 1856 and 1893 are apparently anomalous since both represent considerably more than the original population. Twenty-seven percent (32% taking into account the 1982/83 harvest) of *M. noeana*, 45% of *M. rotata*, and 38 - 187% of *M. rigidula* seed 'survived'.

Table 3 also shows the weight of germinating seed, calculated from number of plants present in December 1984, and weight of individual seeds. About 25 - 167 kg/ha of *M. rigidula* germinated in 1984/85, compared with the 15 kg/ha sown in 1982/83. If the mean weight of germinating seed is added to the mean weight of residual seed, a total of 525 kg/ha of *M. rigidula* seed, or 99% of the original population survived through the wheat crop of 1983/84. Survival of other species was markedly less, 44% for *M. noeana* and 65% for *M. rotata*. These results are summarized in Fig. 10.

The residual seed remained viable, with no significant differences in viability: germination was more than 99%, regardless of selection, species, and whether or not the seeds had been buried.

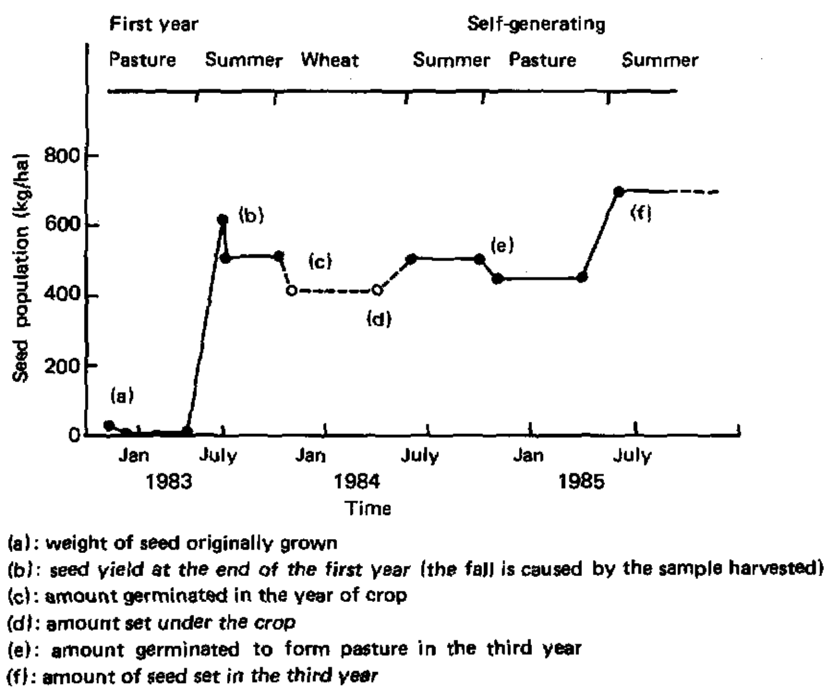


Fig. 10. Changes in seed population over 3 years in a medic/cereal rotation where *M. rigidula* was the most important medic. The dashed lines and open circles in the second year are estimates based on the level of seed dormancy at point (c).

Herbage Production

First year (1982/83) herbage dry-matter yield of *M. rigidula* varied from 1.27 t/ha (sel. 1856) to 4.06 t/ha (sel. 1868) with a mean of 2.65 ± 0.39 t/ha. Yield of *M. noeana* was 3.63 t/ha, ranking third of the 25 selections, and that of *M. rotata* was 1.81 t/ha, ranked 21st.

Herbage yields in the regenerating year were considerably higher than those of the first year: the mean yield of all selections was 4.37 ± 0.254 t/ha on 14 April, and the highest was 6.14 t/ha (*M. rigidula* sel. 1963). Early winter yields (1 January) reached 1.92 t/ha (*M. rigidula* sel. 1865) although the mean was only 0.84 ± 0.352 t/ha. By 7 February, selection 1963 had produced 2.97 ± 0.659 t/ha, and its growth rate was 33 kg/ha/day. Indeed between 1 January and 7 February the average growth rate of all selections was 29 kg/ha/day. *In February and early March,* growth virtually stopped and some selections suffered severe frost damage although, with one exception (*M. rotata*), plants were not killed. Mean growth rate before the final harvest was 69 kg/ha/day, selection 1963 reaching 101 kg/ha/day.

The interrelationships between herbage yield of regenerating pasture (1984/85) and seed size, percentage impermeable seeds, first year (1982/83) herbage and seed yields, days to flowering, and number of regenerating seedlings are shown in Table 4. The number of regenerating seedlings accounted for 92% of variation in early winter yield but its importance declined such that, while on 7 February it still accounted for nearly 80% of yield variation, by 14 April it accounted for only 20%. None of the independent variables in Table 4 accounted for more than 24% of variation in final yield.

The relationship between plant number/m^2 (plant density) and herbage yield is shown in Fig. 11. On 1 January the relationship was linear (Fig. 11a) but by 7 February *significant curvilinearity was apparent* (Fig. 11b). This remained true on 7 March (Fig. 11c), but the relationship reverted to linearity on 14 April (not shown) though only weakly ($P < 0.05$).

Table 4. Correlation matrix of the 10 variables recorded in Experiment 4.

	(1)	(2)	(3)	(4)	(5)	(6)
Seed size (mg)						
Impermeable seeds (%)	0.30					
Plant number 1984/5 (per m^2)	-0.47*	0.13				
Herbage yield 1982/3 (t/ha)	-0.56**	-0.02	0.70***			
Seed yield 1982/3 (kg/ha)	0.15	0.10	0.19	-0.07		
Days to flowering	-0.43*	0.13	0.39*	0.51**	-0.59**	
Herbage yield, 1 Jan 1985 (kg/ha)	-0.43*	0.08	0.96***	0.68***	0.28	0.38
Herbage yield, 7 Feb 1985 (kg/ha)	-0.47*	-0.02	0.89***	0.72***	0.25	0.44*
Herbage yield, 7 May 1985 (kg/ha)	-0.57**	-0.27	0.72***	0.69***	0.09	0.44*
Herbage yield, 14 April 1985 (kg/ha)	-0.49*	-0.27	0.45*	0.45*	0.07	0.24

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

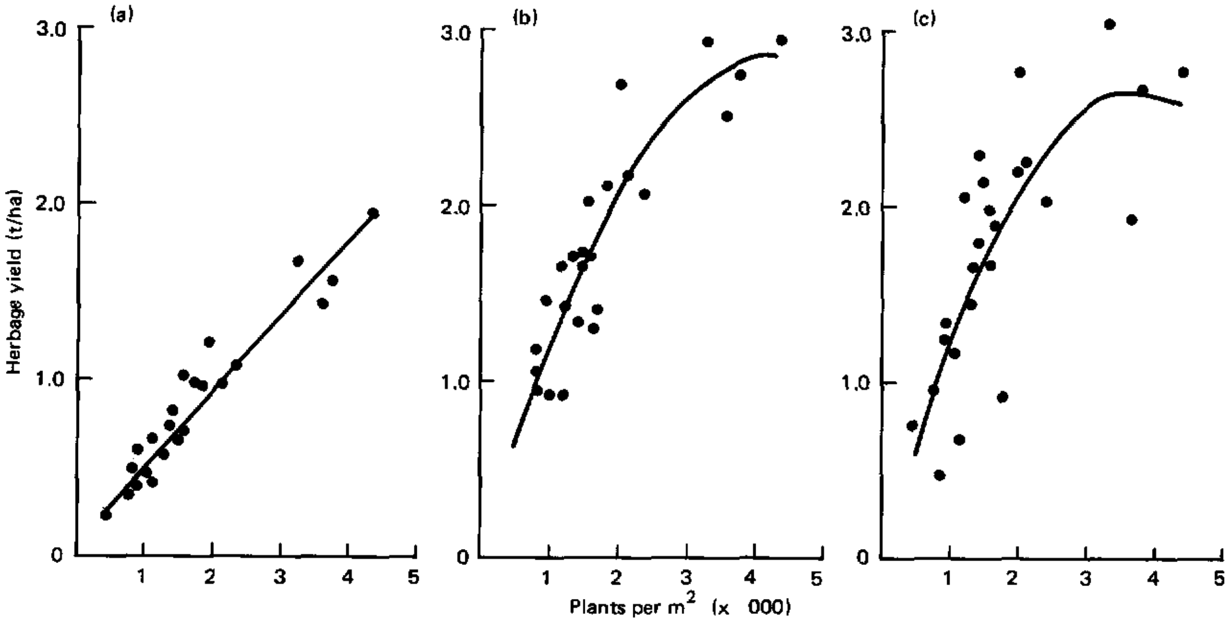


Fig. 11. Relationship between herbage yield of regenerating pastures and plant density in (a) early winter (1 January), (b) mid-winter (7 February), and (c) early spring (7 March). Points represent 23 selections of *M. rigidula*, one of *M. rotata*, and one of *M. noeana*.

The percentage of impermeable seed and first-year seed yield were not related to any other variable. The other variables - seed size, first year herbage yield, regenerating plant number, days to flowering, and herbage yields of regenerating pasture - were significantly interrelated (Table 4).

Wheat Yields

The average wheat yield (416 kg/ha) reflected the poor season of 1983/84. There were no significant effects of the previously grown medic selection on yield, but spraying the plots with Brominil Plus increased grain yield from 383 kg/ha to 449 kg/ha (SE $\pm$ 20.1, P $<$0.01).

Conclusions

The data clearly show that *M. rigidula* can regenerate naturally and form productive pastures in rotation with wheat. This experiment, and the selection work which preceded it, have resolved one of the important problems preventing the introduction of ley farming: the need to identify a suitable annual legume adapted both to the soils and climate of north Syria and to the ley farming system.

As a result of this work several selections of *M. rigidula* are being included in grazing experiments and on-farm trials. On the basis of number of regenerating seedlings, selections 1965, 1902, 1868, and 1900 will advance in this way, while selections 716 and 1919 are being further tested because of their high seed yields. Seed multiplication of these selections has commenced.

Of course many other questions remain, including 'what is the response of *M. rigidula* to grazing ?' Management systems must be developed which maximize livestock production while maintaining an adequate seed population.

Table 5. Herbage yield (kg/ha) of annual medics grown in arable and non-arable soil at Tel Hadya, 1984/85.

	Cultivation site	
Host species/variety	**Arable**	**non-arable**
Medicago noeana	3,914	2,340
M. rigidula var *cinarescens*	3,128	2,847
M. radiata	1,646	2,041
M. rigidula var *agrestis*	1,820	2,021
M. constricta	1,608	962
M. minima	889	819
M. rigidula var *submitis*	541	286
M. orbicularis	361	290
M. sativa	297	133
M. rotata		216
LSD (0.05)	684	573
CV (%)	24.0	27.4

Social and economic problems should be carefully defined before ley farming can be successfully introduced. These problems are discussed in the following sections.--*Ali Abd El Moneim and P.S. Cocks.*

Natural Nodulation in Annual Pastures

Very little is known about the indigenous populations of *Rhizobium* which inhabit West Asian soils and which nodulate and fix nitrogen with agronomically important pasture legumes, including the medics. The two main objectives of this research are to investigate the nodulation response of several medic and clover species produced by the naturally occurring populations of soil *Rhizobium*, and to acquire information about its population size and symbiotic characteristics to determine inoculation strategies.

Uninoculated seed of 17 annual medics and 13 annual clovers was sown in 4 m^2 plots in non-arable land: the medics were also sown in arable land. The seed was not inoculated because natural populations of *Rhizobium* were being investigated. Each group of legumes was sown in a completely randomized block design and replicated three times. The plots were fertilized at sowing with 18 kg P/ha as triple superphosphate.

M. noeana, M. rigidula (var *cinarescens* and *agrestis*), and *M. radiata* produced functional (nitrogen-fixing) nodules. However, *M. minima, M. rigidula* var *submitis, M. orbicularis*, and *M. sativa* had ineffective nodulation, while *M. constricta* was effectively nodulated in arable land but ineffectively nodulated in non-arable land. Plots were harvested when plants reached the flowering stage, and nodulation characteristics were recorded in the early stages of growth before the frost. Herbage yields were greater in the plants that showed effective nodulation (Table 5).

Eight medics were severely affected by frost in February and March, including *M. rotata* (Table 5), *M. blancheana, M. aculeata, M. intertexta, M. turbinata, M. truncatula*, and two varieties of *M. polymorpha* (var

Table 6. Response of *Medicago rigidula* to inoculation and the use of inoculant adhesives.

Treatment	Herbage DM yield[1] (kg/ha)	Increase due to inoculation (%)	Symbiotic effectiveness (%)[2]
Adhesive materials			
Gum cellulose	4,830	41.2	81.0
Sucrose	4,174	32.0	70.0
Molasses	4,031	29.6	67.6
Gum arabic	3,824	25.8	64.1
Water	3,815	25.6	64.0
Corn oil	3,557	20.2	59.6
Uninoculated controls			
Phosphorus (18 kg/ha)	2,838		47.6
P + Nitrogen (27.7 kg/ha)	5,963		100.0
LSD (0.05)	1,062		
CV (%)	21.7		

1. Sowing date: 27 November 1984.
2. (DM yield of inoculated treatment ÷ DM yield of P + nitrogen control) x 100.

polymorpha and *vulgaris*). Of the clovers, *Trifolium alexandrinum*, *T. cherleri*, *T. purpureum*, *T. hirtum*, and *T. lappaceum* were effectively nodulated and their herbage production was 700 - 2000 kg/ha. Seedlings of *T. campestre*, *T. tomentosum*, *T. subterraneum*, *T. scutatum*, *T. scabrum*, *T. argutum*, *T. resupinatum*, and *T. spumosum* showed ineffective nodulation.

These preliminary observations indicate that further investigations are needed on the response of pasture legumes to indigenous *Rhizobium* to monitor their effectiveness and establish whether there is a need for inoculation. - *L.A. Materon.*

Inoculation Techniques for Small-Seeded Legumes

For inoculation to be successful, the *Rhizobium* strain must be able to remain and survive on the seed surface long enough to colonize the developing root system, the primary target being the radicle. The materials used to ensure inoculant adherence to the seed increase the chances of *Rhizobium* survival and also give some protection against the adverse environmental factors lethal to the bacteria. Covering inoculated seed with a coating, in addition to the adhesive, gives extra protection.

Preliminary investigations have been made to determine the effect of various adhesives and coating materials on the effectiveness of inoculation of pasture legumes. Seed of *Medicago rigidula* selection 716 was inoculated with peat-based inoculants of *Rhizobium meliloti* strains WSM244 and CC169, which were attached to the seed by several adhesives (Table 6).

No differences in herbage yield were detected for the different bacterial strains. However, herbage production of plots established using seed, treated with organic gums, sucrose, and local beet molasses,

Table 7. Yield response of *Medicago rigidula* to inoculation and seed coating.

Treatment	Herbage DM yield[1] (kg/ha)	Increase due to coating (%)	Symbiotic effectiveness (%)
Coating materials			
Sodium molybdate	3,278	16.9	81.7
Milk powder	3,175	13.3	79.2
Calcium carbonate	3,119	11.3	77.8
Charcoal	3,055	9.0	76.2
Uncoated	2,803		69.9
Uninoculated controls			
Phosphorus (18 kg/ha)	2,543		63.4
P + Nitrogen (27.7 kg/ha)	4,010		100.0
LSD (0.05)	1,149		
CV (%)	25.0		

1. Sowing date: 12 December 1984.

increased approximately 1.5 fold compared to the uninoculated control (Table 6).

In another experiment to measure the effect of coating, a slurry was made of a peat-based inoculant and a molasses solution (the adhesive) and used to inoculate seed of *M. rigidula* sel. 716, followed by the coating treatments listed in Table 7. The lower yields obtained with this experiment are attributed to late planting. However, the results indicate a positive yield response due to coating the inoculated seed (Table 7). A broader investigation of seed inoculation techniques, using several other species of annual medics, will be conducted in 1985/86.--*L.A. Materon.*

Medics on Farmers' Fields - Adaptation of Ley Farming to Northern Syria

Throughout the pasture section of this report certain assumptions are made about the *management of self-regenerating pastures*. Pastures are expected to be grown in a two-course rotation with cereals grazed by sheep, the system of grazing being set stocking (the most appropriate system), and cultivation to establish the cereal phase being no deeper than 10 cm.

ICARDA believes that great progress will be made if a West Asian or North African version of ley farming evolves. The change will depend on many factors, particularly on the efforts of farmers. There will inevitably be problems, if only because the assumptions are based on farming practice in southern Australia where a great many socioeconomic factors differ from West Asia and North Africa. However, we believe that ICARDA's role is to introduce concepts to farmers and, by working closely with them, to help solve problems associated with the implementation of the concepts. An approach such as this is especially important in introducing ley farming because it differs in many ways from current livestock practice. Accordingly, a three-way collaborative project involving ICARDA, Syrian Ministry officials, and local farmers has been established and is described below.

On 25 March 1984, program staff visited Tah, a village a few km east of Ma'aret on the main Aleppo-Hama road. Tah, typical of many villages producing livestock, has an average of about 350 mm annual rainfall. One of the farmers has land which, until 1982, was used in the traditional way but had spontaneously become dominated by medics. At the time of the visit the pasture was extremely productive and demonstrated the great value of medics in the region. As a result, local Ministry officials and farmers were invited to a field day at the farms. This attracted a great deal of interest and it was decided to use the farm as a focal point for developing the medic system. We hoped that by using the awareness and enthusiasm of farmers at Tah, and the experience and local knowledge of Ministry of Agriculture officials, we could establish working models of the ley farming system. Subsequently we measured herbage and seed yield of the pasture and found that it produced 4.5 t/ha of herbage and 500 kg/ha (ungrazed) or 150 kg/ha (grazed) of seed. The pasture species were *M. polymorpha*, *M. minima*, *Onobrychis crista galli*, wild vetches, and several annual grasses.

In 1984/85 we conducted a survey of farmers to establish a socioeconomic basis for the project, and sowed 1 ha of medic pastures (*M. rigidula*, *M. polymorpha*, and *M. truncatula*) on each of six fields. Local machinery was used, and subsequent grazing was carefully monitored. The productivity of sheep on the original farm was measured and careful assessment made of herbage and seed production. Several small experiments were established to test which of the various medic species was best adapted, measure their response to superphosphate, and determine the need for *Rhizobium* inoculation.

Results of the Survey

Forty-eight farmers, including the six at Tah, were interviewed on various aspects of their farming systems. Information was gathered on the way in which livestock are fed, prices of the various livestock foodstuffs, the kind of rotations used, and the profitability of the various crops and rotations. Much of this information awaits analysis but some preliminary results are presented here.

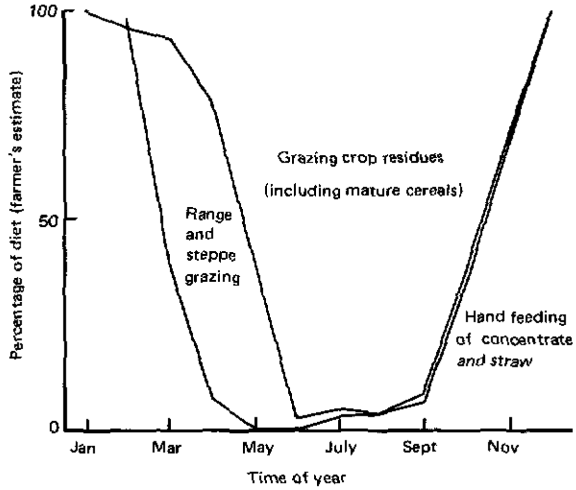


Fig. 12. Sources of feed for sheep on a seasonal basis: in winter, sheep are hand fed using concentrates and straw, in spring they are grazed on the steppe and on marginal land, while in summer they graze crop residues, cereal stubbles, and mature cereals. The percentages are based on farmers' estimates in a survey at Tah, south of Aleppo.

When asked how they fed their livestock, farmers estimated the proportion of the animals' diet which comes from 13 'hand-fed' and 10 'grazing' sources. Examples of the former (in order of farm usage) are barley grain, lentil straw, barley straw, wheat bran, cottonseed cake, and cottonseed hulls, and of the latter are grazing of cereal stubble, marginal land, mature cereal crops, cotton residues, and steppe. Results are given in Fig. 12 for the various sources of feed divided into three categories: hand feeding of concentrates and straw, range and steppe grazing, and grazing of mature crops and crop residues. The distribution of the three categories is plotted on a monthly basis in the figure. From October to March sheep rely heavily, and, in December and January exclusively, on hand-fed concentrates and straw. This pattern continues until grazing on marginal land and in the steppe becomes available in spring. Various sources of grazing (chiefly cereal stubbles) are used through the summer. The cycle is completed by grazing of cotton and sugar beet residues in late summer and autumn.

The survey also produced valuable information on crop rotations. The survey area was divided into three zones: a zone wetter than Tah, (up to 400 mm), an intermediate rainfall zone which includes Tah, and a drier zone (down to 250 mm). In the wetter zone the predominant rotations were wheat/chickpeas, wheat or barley/fallow, and wheat/forage legume. In the Tah zone 3-course rotations were common; about half were wheat/lentil/summer crop and the other half barley/lentil/summer crop. Rotations involving fallow were rare. In contrast, nearly all of the rotations in the drier zone were wheat or barley in rotation with fallow. If medics are to be used in the Tah region, farmers may change from a 3-course rotation to a 2-course rotation and adopt pastures at the expense of lentils and summer crops (sesame or watermelons).

The farmers' costs and returns (averaged over all zones) are shown in Table 8. Cereals are far more profitable than other crops in the area. Harvesting costs are a strong disincentive to growing lentils, and if pastures are to be introduced, the best point in the rotation may be the beginning of the lentil year. The data in Table 8 indicate the levels of profitability which must be achieved if pastures are to be introduced.

Productivity of Pastures

A very early indication of gross returns from pastures was obtained from the original medic field where the milk yield of grazing ewes was monitored during the 5 months of lactation. Records of milk weight were made at approximately 2-week intervals from 10 of the 100 ewes grazing the 4 ha of medic, and another 10 ewes fed at the discretion of the farmer. Over the whole period, ewes grazing medic only (without supplements) produced almost 1 kg milk/ewe more than those in the control flock, although the latter were fed concentrates and shepherded to other pastures (Fig. 13). The medic carried 20 ewes/ha for the 5-month period and resulted in 1470 kg milk/ha. If the milk was sold for 3 Syrian pounds/kg (a conservative estimate) the gross return from medic would be 4400 Syrian pounds,

Table 8. Costs, returns, and profits of crops grown in the Tah region, 1985 (Syrian pounds/ha).

	Cost*			
	Establishment	Harvest	Return	Profit
Wheat	654	267	2791	1870
Barley	801	388	3037	1848
Lentil	542	1154	2200	504
Sesame	400	209	1323	714
Watermelon	527	368	1869	974

* Includes mid-season costs (sprays etc.).

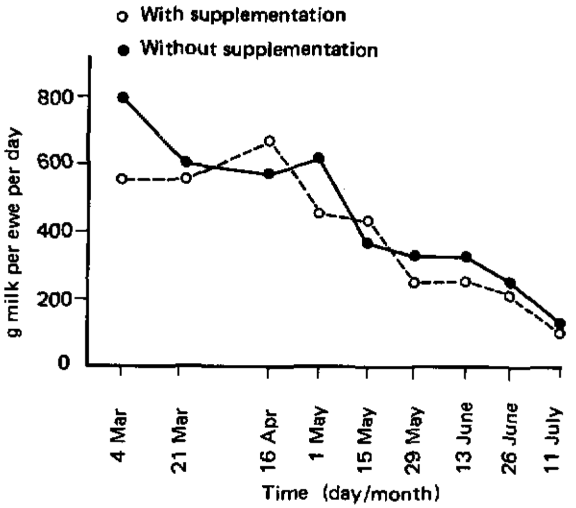


Fig. 13. Milk production from farmers' ewes grazing medic pasture without supplementation, or marginal land with supplementation at Tah, south of Aleppo.

more than 40% higher than that from wheat or barley. Although this figure takes no account of the relative skills of the one medic farmer compared with average farmers and does not include an estimate of costs, it suggests that a cereal/pasture rotation would be economically attractive to farmers in the Tah area. Further economic analysis of medic pastures is planned for 1985/86.

Herbage production from the indigenous medic at Tah was similar to that at Tel Hadya. By 11 January, 1.3 t/ha of herbage was available and this increased to 6 - 8 t/ha (depending on which part of the field was sampled) by 2 May. The annual stocking rate was 8.3 ewes/ha/year, which agrees closely with recent estimates in New Zealand of the appropriate stocking rate for pastures giving a similar herbage yield.

The newly-sown pastures were less productive than the indigenous pasture (Table 9). However, seed yields (75-400 kg/ha) after grazing are of the same order for the two pastures, indicating that future herbage yields are likely to be comparable. Indeed it is normal for medic pastures to be less productive in the first year than in later years.

Table 9. Herbage DM and seed yield (kg/ha), and number of grazing days for six medic fields sown on farms in the Tah district.

Field	Herbage yield: Winter 1984/85	Herbage yield: Spring[1] 1985	Seed yield: Before[2] grazing	Seed yield: After[3] grazing	Grazing days/ha
1	2.2[a]	4.4	457	167	450
2		3.8	410	279	100
3		1.7	133	76	150
4		2.8	423		120
5		1.7	170		0[c]
6	1.6[b]	3.4	368		900

1. All spring yields measured 3 May: Values for fields 1 and 6 relate to regrowth after winter grazing.
2. Measured 29 May before summer grazing.
3. Measured 1 August in fields 1 to 3 only.
a. Measured 11 April 1985 not measured in winter.
b. Measured 20 March.
c. No grazing in field 5.

Table 10. Effect of frost on nine *Medicago* selections at Tah and on seed yield (kg/ha).

	Frost effect (percentage plants killed)	Seed yield
M. rigidula sel. 716	3	510
M. rotata sel. 1943	3	467
M. blancheana sel. 2099	1	429
M. truncatula cv Cyprus	49	306
M. aculeata sel. 2008	4	301
M. truncatula cv Jemalong	37	259
M. scutellata cv Robinson	45	245
M. polymorpha cv Circle Valley	37	183
M. littoralis cv Harbinger	70	67
LSD (0.05)	13	151

At Tah there was no response to phosphorus either in indigenous or in new pastures, nor was there a response to inoculation. Of the medic accessions, *M. rigidula* sel. 716, *M. rotata* sel. 1943, and *M. blancheana* sel. 2099 produced most seed and these accessions, with *M. aculeata* sel. 2008 were most frost-resistant (Table 10). In general the results support our findings at Tel Hadya.--*H. Sawmy, P.S. Cocks, T.L. Nordblom (Farming Systems Program); Y. Swedan, D. Dadesh (Syrian Ministry of Agriculture and Agrarian Reform).*

Forage Breeding and Agronomy

Forage crops are one of the alternatives being studied to replace fallow in cereal/fallow rotations. They are defined as leguminous species sown and harvested in a single year as hay or straw and which can also be grazed. They are not managed for self-seeding and are not expected to regenerate spontaneously, as would be the case for annual pastures. Forages are not used extensively: in Syria about 8% of zone 1 and about 5% of zone 2 is used for forage crops. Forage crops may be sown in mixture with a cereal and harvested as above.

In spite of a huge diversity of legumes in the Mediterranean region, few have been used specifically as forage crops. Kernick (1978) notes that three species of *Lathyrus* and nine species of *Vicia* (vetch) are potentially important, but of these probably only nine have been tested and even fewer used. In Syria only chickling (*Lathyrus sativus*), where rainfall is < 300 mm; bitter vetch (*Vicia ervilia*), where rainfall is > 400 mm; and common vetch (*V. sativa*), where rainfall is 300 - 500 mm, are actually grown. There are only very small areas of chickling. Several other species have been tried, most notably forage pea (*Pisum sativum*), and possibly *Scorpiurus muricatus*, some annual clovers (*Trifolium* spp.), and snail medic (*Medicago scutellata*).

Three forage taxa are being evaluated by ICARDA: vetches, forage pea, and chickling, in order of resource allocation. Only in vetch has more than one species been studied. As well as common vetch, there has been exploratory work on narbon vetch (*V. narbonensis*), woollypod vetch (*V. villosa* subsp. *dasycarpa*), and bitter vetch (*V. ervilia*). Recent work questions the role of forage pea, so more emphasis is being placed on vetch and chickling.

Until recently, the Program conducted research both on breeding and agronomy of forage crops. In 1984/85 emphasis shifted to breeding, while most of the agronomic work will continue in the Farming Systems Program. The breeding work aims to select widely adapted cultivars to ensure their success in contrasting environments for resistance to several foliar (bacterial blight, and downy and powdery mildew) and root diseases (root knot and cyst nematode) in common vetch and forage pea, and select for non-shattering seed pods in common vetch. Selection of improved narbon vetch, woollypod vetch, and chickling expanded in 1984/85 and will be expanded further in 1985/86.

Selection for Wide Adaptation

Selection for wide adaptation involves preliminary screening and seed multiplication in nursery rows, evaluation in microplots and in advanced yield trials at Tel Hadya (in advanced yield trials the number of entries is reduced and plot size increased), and multilocation (regional) testing at five sites in Syria and Lebanon. Disease screening is done at all stages and the palatability of the most promising accessions is evaluated. The latter step is discussed in the Livestock Management and Nutrition section of this Report.

In 1984/85 only forage peas were screened in nursery rows. Strains of common vetch and forage pea were included in microplots, and *these species, plus narbon vetch and woollypod* vetch, were included in advanced yield trials and multilocation testing.

Preliminary Screening in Nursery Rows

Forage pea accessions of different origins were screened in nursery rows in a cubic lattice design with three replicates. In this preliminary screening, 121 accessions were visually scored on a 1-5 scale for establishment, seedling vigor, frost-tolerance, winter and spring growth, leafiness, growth habit, plant vigor, time to flowering and maturity, and disease susceptibility.

For 42 days during February and March 1985, temperatures were below zero which gave a good opportunity for screening for frost-tolerance. Frost drastically affected the growth of most peas: five strains were tolerant, others were damaged by frost to various extents (Fig. 14).

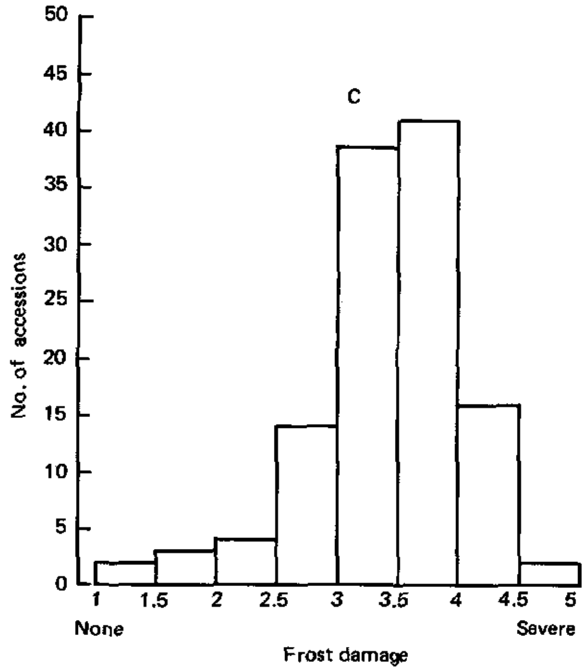


Fig. 14. Variability in frost damage of 121 forage pea accessions grown in nursery rows at Tel Hadya, 1984/85. Frost damage is based on a visual score, recorded on a 1-5 scale where 1 = no damage and 5 = all plants killed. C indicates the score achieved by the local strain.

There was a wide range of variability (Fig. 15), using the mean score for all characters (the 'selection coefficient'), which has been fully documented for reference and future exploitation. Twenty-three strains were identified as promising and 10 were superior to the local control, which itself was one of the best with a coefficient of 3.5.

Evaluation in Microplots

The study of variation in agronomic characters helps the breeder establish a suitable program to develop improved cultivars. Selection for desirable traits such as high herbage production and seed yield, and early flowering, begins in microplots in a year after nursery row evaluation. This leads on to more critical evaluation in advanced yield trials at Tel Hadya before multilocation testing of selected cultivars.

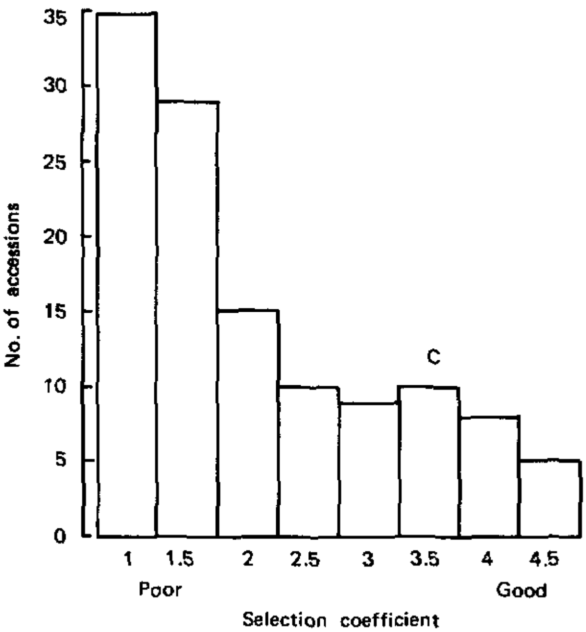


Fig. 15. Variability in selection coefficient (1 = very poor; 5 = very good) of 121 forage pea accessions grown in nursery observation rows at Tel Hadya in 1984/85. C indicates the score achieved by the local strain.

Vetches and peas were planted in 3.5 m^2 microplots in a triple lattice design. A seed rate of 80 kg/ha and fertilizer application of 16 kg P/ha was used for both crops. The whole trial was duplicated: one was harvested at the 100% flowering stage for the determination of herbage yield and the other allowed to mature to measure seed yield.

Forty-nine selections of common vetch were tested in microplots for two seasons, 1983/84 and 1984/85. There were large differences in herbage production, seed yield, and days to 100% flowering between strains and between years. Fifteen strains, which combined both high herbage and seed yield with frost-tolerance and early flowering, were identified for advanced yield trials.

An analysis of variance for the 2 years combined revealed highly significant interactions between strains and years. This indicates that the rank-order of selections is not the same for yield in each of the 2 years. The selections which will advance are therefore those which are highly productive despite environmental fluctuations from year to year (Table 11).

Results for average yield in the 2 years showed that sel. 2097 had the lowest dry-matter yield of 2292 kg/ha (not in Table 1), while sel. 2023 had the highest, at 4194 kg/ha. The yield of the local strain (accession 2541) was lower than, but not significantly different from, 13 selections due to greater susceptibility to frost. Seed yield ranged from 303 kg/ha (sel. 2011, not in Table 1) to 2638 kg/ha (acc. 2541), with the control yielding significantly more seed ($P<0.05$) than all other selected strains, except sel. 2073.

There were differences in growth between the 2 years. Mean seed yields were 1584 and 1072 kg/ha in 1983/84 and 1984/85, respectively, while herbage yield was 4682 and 1849 kg/ha in the two seasons. The highest yields were thus obtained in 1983/84 in spite of drought, whereas yields were relatively poor in 1984/85, which had a high rainfall (372 mm). The rainfall distribution during the growing season, irrespective of the total, probably caused these differences although frost may also have had an effect in 1984/85.

Thirty-six pea selections were also evaluated in microplots. There were significant differences in herbage and seed yields, days to 100% flowering, and frost damage. Herbage yield varied from 41 kg/ha (sel. 702) to 1118 kg/ha (sel. 640), with the control (acc. 205) yielding 524 kg/ha, which was exceeded significantly by six selections. Seed yield ranged from 76 kg/ha (sel. 572) to 909 kg/ha (sel. 692). The control yield was 382 kg/ha, which was exceeded by 14 selections, three being significant. None of the selections tested was completely frost-tolerant: five were moderately tolerant, while the others were severely damaged by frost.

Table 11. Mean herbage and seed yields, number of days to 100% flowering and frost damage for selected strains of common vetch (*Vicia sativa* L.) grown in 1983/84 and 1984/85.

Selection No.	Dry-matter yield (kg/ha)	Seed yield (kg/ha)	Days to flowering	Frost* damage
2027	4153	1272	131	1.35
2020	4152	1491	132	1.04
2021	4057	1401	132	0.99
2032	3959	1631	125	2.41
2025	3618	1636	133	0.97
2024	3274	1468	131	1.35
2023	4194	1192	130	1.42
2003	3468	1983	126	2.10
2068	3818	2066	131	1.25
Acc.No. 1				
2541	3221	2638	123	2.30
2040	3040	2151	125	1.61
1429	3427	2000	123	2.93
Acc.No. 1				
713	3466	2067	122	2.07
2100	3798	1360	130	2.34
2073	3522	2353	123	2.27
Mean	3266	1328	131	2.99
LSD (0.05)	1143	374	1.09	0.70

* On a visual scale where 1 = no damage; 5 = all plants killed by frost.

1. Strain which was promising and sufficiently uniform to be tested as a complete accession, hence no selection number.

Seed and dry-matter yields were closely related ($r=0.90$, $P<0.01$). This was due to their association with frost-tolerance, as indicated by significant negative correlations between DM yield and frost damage ($r = -0.679$, $P<0.01$), and seed yield and frost damage ($r = -0.699$, $P<0.01$).

The results show that forage peas generally produce less DM and seed than vetches (489 vs 3265 kg/ha and 325 vs 1328 kg/ha, respectively). The superior yield of vetch was similar in 1982/83 and 1983/84, but in 1984/85 the difference was more marked due to frost.

Advanced Yield Trials

Two experiments were carried out to evaluate promising lines of forage vetch and pea. In the first, 23 lines of common vetch, one of woollypod vetch, and one of narbon vetch were included. Thirty-six forage pea lines were included in the second experiment. Both legumes were sown and managed as microplots but with a larger plot size (28 m^2).

Herbage yield of vetch varied from 838 kg/ha (sel. 2063) to 3130 kg/ha, (narbon vetch acc. 67). The yield of the local common vetch was exceeded by woollypod vetch (NS) and narbon vetch ($P<0.05$) but not by other selections of common vetch.

Seed yields ranged from 257 kg/ha (sel. 874) to 1435 kg/ha, (sel. 2003). The local control (acc. 2541) and narbon vetch produced high seed yields of 1415 and 1372 kg/ha, respectively. Days to 100% flowering were 122 (narbon vetch) - 145 (sel. 972). The high herbage and seed yields of narbon vetch were attributed to early flowering and frost-tolerance. The effect of frost on common vetch was less than on forage pea. In vetch, five selections were severely affected, 13 were moderately frost-tolerant, while the remaining 7, including woollypod vetch and the local common vetch, were tolerant.

Dry-matter and seed yields were closely related ($r=0.64$, $P<0.01$). The major factors affecting herbage production and seed yield were frost damage and number of days to 100% flowering as shown by significant correlations between frost damage and DM and seed yields ($r=-0.62$, $P<0.01$ and $r=0.43$, $P<0.05$, respectively). There was also a significant correlation between number of days to 100% flowering and DM and seed yields ($r=-0.51$, $P<0.05$ and $r=-0.75$, $P<0.01$, respectively). The influence of frost damage on herbage yield is illustrated in Fig. 16.

The results for forage peas in the advanced yield trials were similar to those in the microplot trials. Herbage yields varied from 18 kg/ha (sel. 550) to 1269 kg/ha (sel. 536), while seed yields varied from 15 kg/ha (sel. 550) to 487 kg/ha (sel. 541). Three selections produced a significantly ($P<0.05$) higher seed yield than the control. Only two strains, selections 541 and 324, had reasonable frost-tolerance while the remaining selections were severely damaged.

Dry-matter and seed yields were closely related ($r=0.85$, $P<0.01$) and both characters were correlated with frost damage ($r=-0.658$, $P<0.01$ and $r=-0.674$, $P<0.01$, respectively). The influence of frost on herbage yield is illustrated in Fig. 17. The number of days to flowering was not associated with DM and seed

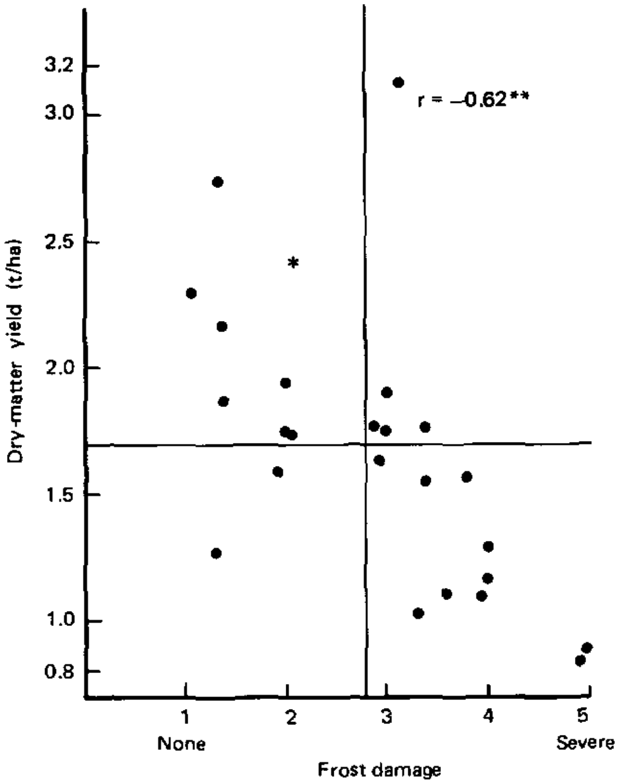


Fig. 16. Relationship between herbage DM yield and frost damage for 25 strains of vetch at Tel Hadya in 1984/85. (*Frost damage assessments are given in Fig. 14.*)

yields ($r=-0.244$, N.S., and -0.248 N.S., respectively), in contrast to the results for vetch.

Multilocation Testing

Twenty-five promising strains each of vetch and forage pea were tested at four representative sites in Syria (Tel Hadya, Kamishly, Homs, Izra'a) and one in Lebanon (Terbol) to obtain information on the response of strains to different environmental conditions. Details of the sites are given in Table 12.

At each site, both peas and vetches were planted in 28 m^2 plots and managed as for

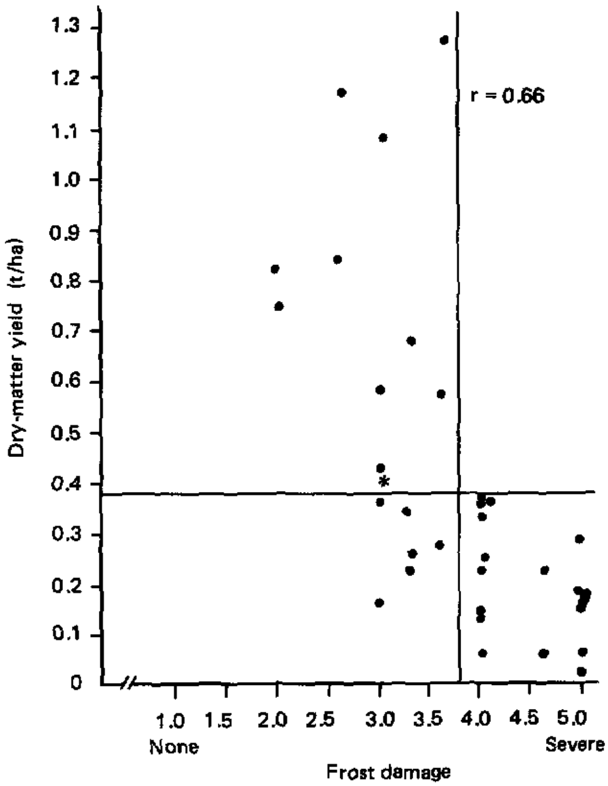


Fig. 17. Relationship between herbage DM yield and frost damage for 36 strains of forage pea at Tel Hadya, 1984/85. (Other details as for Fig. 16.)

microplot evaluation. In vetch, the mean herbage yield was 2792 kg/ha, varying between sites from 885 kg/ha in Kamishly to 4490 kg/ha in Terbol. The mean seed yield was 965 kg/ha, varying from 555 kg/ha in Kamishly to 1560 kg/ha in Homs (Table 13). The results emphasize the very large effect of environmental variation on yield.

The mean DM and seed yields of individual selections over sites varied widely. Narbon vetch (acc. 67) gave the highest yields while common vetch (acc. 2541) had relatively high herbage and seed yields at all sites indicating wide adaptability. Other strains showing wide adaptability were woollypod vetch (acc. 683) and common vetch accessions 715 and 2019.

The mean herbage yield of forage pea for the five sites was 1691 kg/ha and site means varied from 190 kg/ha at Kamishly to 3443 kg/ha at Izraa (Table 14). Mean seed yield was 990 kg/ha and varied from 88 kg/ha at Kamishly to 2536 kg/ha at Homs. These results demonstrate the large effect of environmental differences among sites, which was also observed with vetch.

Herbage and seed yields in 1984/85 were generally less than those of 1983/84 (3081 vs

Table 12. Location and meteorological data for five sites in Syria and Lebanon where multilocation testing of vetches and forage peas took place in 1984/85.

Location	Latitude	Longitude	Altitude (m)	Air temperature °C (Oct - May) Mean Max.	Mean Min.	Rainfall (mm)
Syria						
Tel Hadya	35° 55'N	36° 55'E	362	24.3	10.4	372.6
Kamishly	37° 03'N	41° 13'E	467	28.0	9.6	363.7
Homs	34° 45'N	36° 43'N	487	27.0	8.0	392.0
Izra'a	32° 51'N	36° 15'N	575	28.2	5.9	221.9
Lebanon						
Terbol	33° 50'N	36° 00'E	950	20.4	2.9	516.4

Table 13. Mean herbage and seed yield (kg/ha) of vetch at five sites in Syria and Lebanon in 1984/85.

	Syria				Lebanon	
	Tel Hadya	Kamishly	Izra'a	Homs	Terbol	Mean
Herbage yield	1610	885	2600	3877	4490	2792
Seed yield	693	555	1022	1560	995	965

Table 14. Mean herbage and seed yield (kg/ha) of forage at five sites in Syria and Lebanon in 1984/85.

	Syria				Lebanon	
	Tel Hadya	Kamishly	Izra'a	Homs	Terbol	Mean
Herbage yield	559	190	3443	3154	1113	1691
Seed yield	183	88	1341	2536	803	990

1691 kg/ha and 1557 vs 990 kg/ha, respectively). Conventional analyses of variance for each site showed that strains differed significantly in both attributes.

Unreliability of herbage and seed yields has always been a problem in forage pea. Information on genotype x environment interaction is therefore important and has been obtained from an analysis of variance of the combined data (25 strains, 5 sites, and 2 years), involving an examination of the relative magnitudes of different sources of variation. The methods of Finlay and Wilkinson (1963) and Eberhart and Russel (1966) were used, in which the environmental mean yield (average of all strains grown in a particular site in a particular year) is subtracted from the mean of all strains in all environments to produce an environmental index for that site. The regression coefficient (b) of individual yields on site mean yields, mean square deviation from regression (S^2d), deviation about the regression line ($\pm$Sb), and the coefficient of determination (r^2) were computed. The statistic (b) is a measure of the average increase in yield of a strain per unit of increase in the environmental index, whereas the deviation from the regression line ($\pm$Sb) is a measure of stability.

Stable strains are characterized by regression coefficients near 1.0, low deviations about the regression lines, and high coefficients of determination (r^2). The last figure is considered the best index for measuring the validity of the linear regression, because it ranges from zero to unity, regardless of the scale of measurement of individual strains. The closer it is to 1.0, the better the fit to a straight line. A high mean yield (average performance) is also a desirable attribute.

Ten strains had above-average herbage yields and of these, selections 493, 323, and 335, had regression coefficients near 1.0 and high r^2 values. They were the most stable, high-yielding strains, having wide adaptability. Selections 323 and 335 were superior in herbage and seed yields for all parameters ($\bar{x}$, b, S_b, and r^2) (Table 15).

Estimates of S_b showed that there were

Table 15. Mean dry-matter and seed yields ($\bar{x}$, kg/ha) and estimates of stability parameters b, Sb, and r^2 for 10 strains of forage pea.

	Dry-matter yield				Seed yield			
Strain (selection no.)	$\bar{x}$	b	±Sb	r^2	$\bar{x}$	b	±Sb	r^2
454	2461	1.02	0.15	0.85	837	0.40	0.108	0.61
325	2589	1.30	0.18	0.87	1537	1.17	0.07	0.96
323	2593	1.09	0.09	0.93	1308	0.94	0.100	0.91
335	2625	1.10	0.11	0.92	1476	1.18	0.103	0.94
321	2683	1.20	0.15	0.89	1052	0.83	0.07	0.94
175	2822	1.19	0.14	0.90	1176	0.65	0.110	0.79
205[a]	2906	1.31	0.15	0.90	1679	1.15	0.106	0.93
92	3570	1.20	0.19	0.82	643	0.34	0.060	0.80
61	3667	1.26	0.25	0.85	674	0.30	0.067	0.70
493	3679	0.90	0.12	0.91	817	0.41	0.103	0.66
LSD (0.05)	1104				402			

a. Local strain.

distinct differences between strains in their deviations from the regressions. Strains such as sels. 61, 240, 100, 289, 166, 496, and 466 with high S_b values are unstable. The control (acc. 2541) had low S_b with high r^2 values and can thus be considered stable for both DM and seed yield, although DM yield was not as high as in sel. 493.

Estimates of the pertinent variance components (Miller *et al.* 1959) are presented in Table 16. The relative magnitudes of these indicate the relative importance of the corresponding source of variation. The strains x sites term was large and highly significant, whereas the strains x years term was small and nonsignificant. The presence of a strains x sites interaction indicates that certain strains tended to rank differently in herbage yield at different sites while the small strains x years interaction indicates that year had little effect. The occurrence of a strains x sites x years interaction indicates that the strains showed differential responses when grown in different environments. There were similar results for seed yield but here the strains x years interaction was significant.

The 25 strains studied, which were a highly selected group that had survived previous testing at Tel Hadya, represented the most promising material resulting from our breeding program. Such strains might be expected to have wide adaptation, but this was not so, possibly because they originated from selections from accessions collected in the ICARDA region.--*Ali Abd El Moneim.*

Disease Screening

Foliar Diseases

Twenty-five promising vetch and pea strains were screened in the field using artificial infections of ascochyta blight and downy mildew (*Peronospora viciae*) for vetch and ascochyta blight, powdery mildew (*Erysiphe pisi*) and other pathogens (*Ascochyta pisi*,

Table 16. Variance components (mean squares) from a combined analysis of 50 strains of forage pea grown at 5 sites for 2 years.

Variance source	Dry-matter yield	Seed yield
Strains	238,501NS	98,888NS
Strains x years	20,610NS	47,102**
Strains x sites	277,978**	152,154**
Strains x sites x years	184,458**	92,524**

** $P < 0.01$; NS, not significant.

Mycosphaerella pinodes, Phoma medicaginis var *pinodella, Pseudomonas pisi*) for peas.

Common vetch (sel. 2019), narbon vetch (acc. 67) and woollypod vetch (acc. 683) were resistant to ascochyta blight, while 17 common vetches were moderately resistant and 5 were susceptible. Downy or powdery mildew symptoms did not appear as conditions were unfavourable.

Two forage pea strains (sels 493 and 335) were resistant to both ascochyta blight and bacterial blight, seven were resistant and nine were moderately resistant to ascochyta blight, and eight were susceptible. Six pea lines were susceptible to ascochyta blight but resistant to bacterial blight, one was moderately resistant, and eight were susceptible.

Observations made on other microplots (not artificially inoculated) showed that none of the 36 pea strains had symptoms of ascochyta or bacterial blight. Similarly in vetches, there were no symptoms of ascochyta blight or downy mildew on the 49 lines tested. This year was probably not typical, as there was a low chance of natural infection.

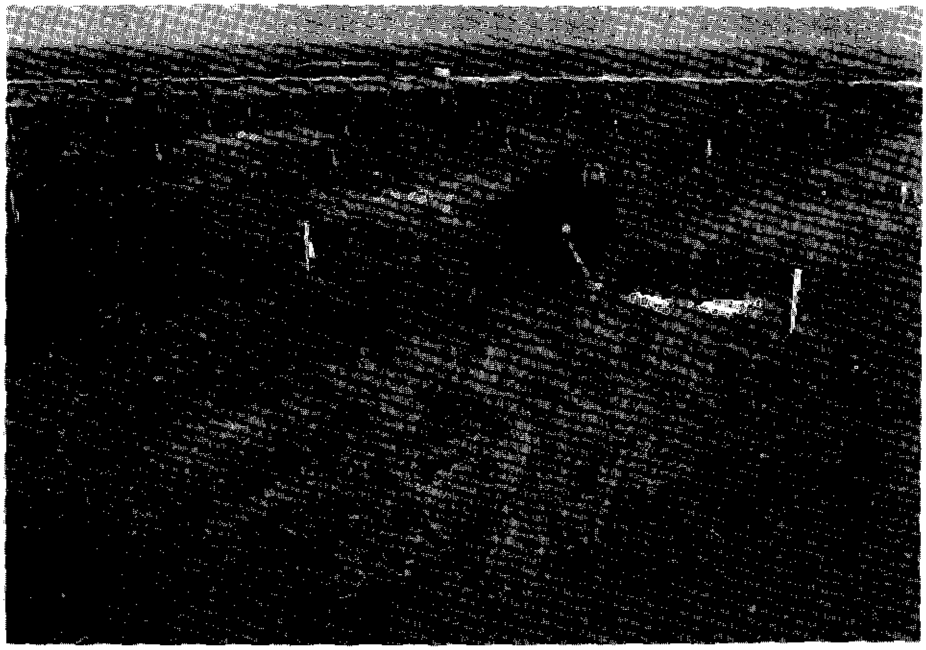
Nematode Resistance

Nematodes can cause serious infections in the roots of many legumes. In the case of forage legumes, vetches are attacked by root knot nematode (*Meloidogyne artiella*) and forage peas by cyst nematode (*Heterodera rossi*). Since both nematodes can attack cereals, a legume/cereal rotation is a poor form of cultural control, and may even result in a build-up of the diseases. Not only forage but also food legumes are attacked by the nematodes which can cause serious losses of herbage and seed yields. The above-ground symptoms are similar to nitrogen deficiency (or poor nodulation) in winter, and drought in spring.

The high incidence of root-knot and cyst nematodes during the last 3 years led to the initiation of a program of screening for resistance. One hundred strains of forage pea and 81 of vetch (including common vetch and woollypod vetch) were examined for cyst and root knot nematodes in 1984/85 in a heavily infested field at Tel Hadya. The strains included all those which had previously been evaluated in other microplot, advanced yield, and mulilocation trials.

Nematode populations were monitored by taking soil samples before planting and during crop growth. For each sample, ten 1 kg lots of soil were collected at random, thoroughly mixed, and 1 kg sub-samples removed for testing. One such sample was taken for each of the four replicates within the experiment.

Observations were made after germination and continued throughout the growing season. Random samples of plants were taken to isolate the nematodes and determine the degree of root



Disease screening in forage legumes.

infestation. Root symptoms were diagnosed as root knots or root galls, excessive root branching, and injured root tips. The reaction of each strain against nematode invasion was estimated using a 1 - 5 scale, where 1 is very resistant (VR): nematodes were not found or there were very few on the roots, and 5 is very susceptible (VS): nematodes are found on the majority of the plants, causing serious damage.

Mean numbers of cysts per 200 g soil and of root knot nematodes per 500 g soil are presented in Table 17. The soil was heavily infested by both nematodes and was thus ideal for the screening experiments.

The preliminary observations confirmed that vetches are severely attacked by root knot nematodes and peas are severely attacked by cyst nematodes. Only six strains of common vetch were attacked by both cyst and root knot nematodes.

Three vetches (common vetch sels 2095, 1432, and woollypod vetch acc. 683) were highly resistant (score 1) to root knot nematode (Fig. 18), 27 were moderately resistant, and the remaining 51 were moderately susceptible or susceptible (scales 3 and 4). Those having scores of 1 and 2 have been selected for further screening. Resistance to root knot nematode increases the value of woollypod vetch, which was also resistant to attack by *Orobanche* sp. The local common vetch was moderately susceptible to root knot nematode.

In forage pea, the mean number of cysts per gram of roots was 471, varying from 9 (sel. 61) to 3021 (sel. 571). In field screening, no strains were highly resistant to cyst nematode, but some were scored resistant (sel. 61) or moderately resistant, (Fig. 19). In these initial tests, resistance was characterized by a small number of plants having roots with a few galls, the rest having none. These strains have been retained and will be tested under artificial infestation in a greenhouse.--*Ali Abd El Moneim.*

Table 17. Number of cyst and root-knot nematodes present in soil samples of five sampling occasions.

Sampling date	Cyst nematode[1]	Root-knot nematode[2]
30.11.1984	29	495
3. 3.1985	33	231
4. 4.1985	34	783
6. 5.1985	35	1275
14. 6.1985	33	

1. 200g soil; 2. 500g soil.

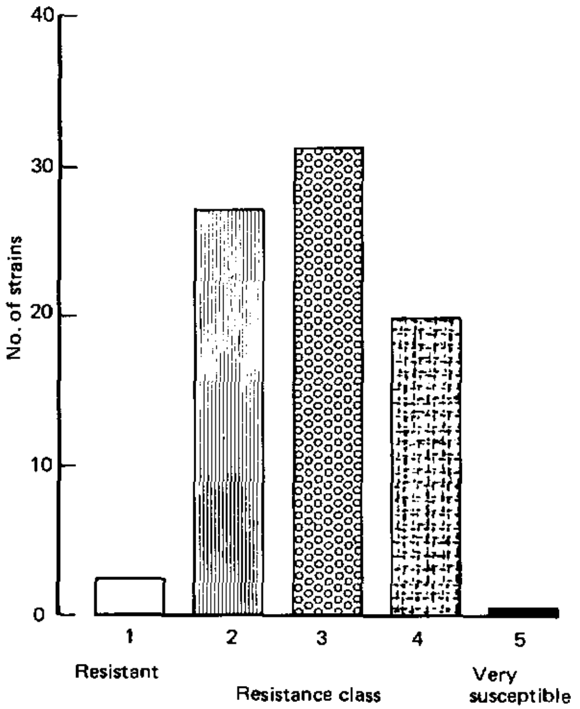


Fig. 18. Variability in resistance to root-knot nematode among 81 strains of vetch, based on the following scores: 1 = resistant: no galls or very light galling; 2 = moderately resistant: light galling; 3 = moderately susceptible: moderate galling; 4 = susceptible: heavy galling; 5 = very susceptible: very heavy galling.

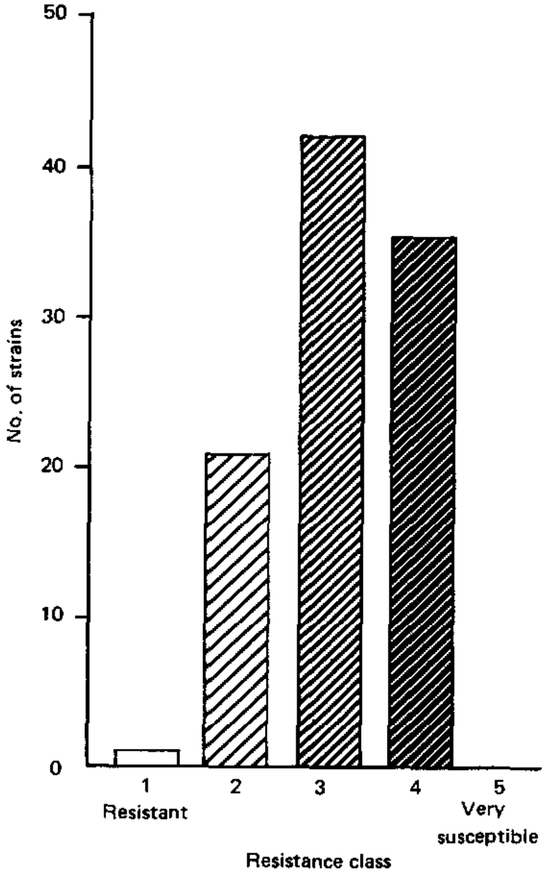


Fig. 19. Variability in resistance to cyst nematode among 100 strains of forage pea. (Details as for Fig. 18.)

Breeding Non-Shattering Common Vetches

One of the problems in using common vetch is that the pods shatter and seeds fall. This makes harvesting time critical and inevitably results in lower seed yields and higher prices. Since the high price of seed is one of the constraints to the use of common vetch, varieties able to retain their seeds would be of great value. Moreover, the feed value of standing vetch crops which are used for grazing in summer would be greatly improved as seed loss results in a serious loss of nutrients, especially protein.

In 1983/84, certain strains of common vetch with non-shattering pods were identified. A breeding program was initiated in 1984/85 to combine the non-shattering character with other desirable traits, such as high herbage and seed yields, early flowering and maturity, and disease resistance.

A number of crosses were made using parents sels. 1361, 1416, and 2014, all of which are characterized by non-shattering pods, late flowering, and low herbage and seed yields, and sel. 716 and the local common vetch (acc. 2541), both characterized by a high proportion of pod-shattering, early flowering, and high herbage and seed yields. All crosses were made in the greenhouse. The combinations and number of pods set are shown in Table 18.

Table 18. Number of pods set in *Vicia sativa* crosses in a greenhouse (1984/85).

Strains crossed	Number of pods set
716 x 1416	110
2541 x 1416	118
716 x 1361	69
2541 x 1361	121
2541 x 2014	55
716 x 2014	51

The F1's will be sown in the field along with their parents, to produce F2 populations. These will be studied for the type of gene action controlling the non-shattering character, and selection of non-shattering strains with good agronomic features will begin.--*Ali Abd El Moneim.*

Rotation Experiments

Wheat Grain Yield After Pastures and Forages

An adequate feed supply is essential for the rapidly increasing livestock population of West Asia and North Africa. This could be achieved through intensive forage and pasture production on available arable land, but several problems must be resolved. Some problems are technical (varieties, seed supply, management etc.) while others are educational, since many farmers in the region have not grown pasture or forage crops before. One important concern for farmers would be the effect of these pasture and forage crops on the grain yield of cereal grown in the following year. Therefore, an experiment was established in 1983/84 to study the long-term effect (4-5 years) of pasture and forage crops on wheat yield. The experiment is located in four wheat-growing areas of Syria: Kamishly (north east Syria), Tel Hadya and Hama (central Syria), and Izraa in the south. There are four treatments (wheat, medic, forage mixture, and fallow), each of which is rotated on the same piece of land with wheat. There is a two-phase start to each treatment, both crops for each rotation being present in each year.

The cultivars are: Mexipak for wheat, *M. rigidula* sel. 1295 for medic, sel. 2541 for vetch, and Badia for barley. The last two are used in equal proportions as a forage mixture. The rotations are wheat/fallow, wheat/forage mixture, wheat/medic, and wheat/wheat. The experimental plot size is 8 x 21 m and treatments are laid out in a randomized

Table 19. (a) Wheat grain yield (t/ha) in relation to the preceding crop or fallow and (b) the dry-matter yield (t/ha) of pasture and forage crops at four locations in 1984/85.

(a)	Rotation				
Location	**W/Fallow**	**W/Mixture**	**W/Medic**	**W/W**	**LSD (0.05)**
Izra'a	1.3	1.0	0.9	0.4	0.6
Hama	4.0	3.0	3.1	2.5	1.2
Tel Hadya	1.4	2.2	2.5	1.3	1.1
Kamishly	2.5	2.3	2.4	2.3	NS
Average	2.3	2.1	2.2	1.6	

(b) Location	Medic	Forage mixture
Izra'a		4.2
Hama	2.0	5.2
Tel Hadya	2.5	4.6
Kamishly	2.6	4.6
Average	2.4	4.7

W = wheat; NS = not significant.

complete block design with three replicates. At the beginning of each season, soil samples (depth 0 - 20 cm) representing the various treatments are being collected to monitor changes in soil nitrogen.

Grain yields in the 1984/85 season are given in Table 19a. At all locations, wheat yield was lowest after wheat compared with other treatments except in Kamishly, where there were no significant differences. The result at Kamishly may be attributed to very poor crop growth at this location in 1983/84 due to frost followed by drought. At both Izraa and Hama, the highest grain yield was recorded after fallow although the difference was not significant when compared with the yield after either medic or forage mixture. At Tel Hadya, the highest grain yields were after the medic and forage treatments; the yield after medic was highest but not significantly higher than after forage.

Forage yields were 2-2.6 t/ha for medic and 4.2-5.2 t/ha for the forage mixture (Table 19b). For forage mixtures, these values are comparable with yields from the same locations recorded in previous studies, but medic yields were lower than expected, especially at Tel Hadya.

Average grain yields for the four locations (Table 19a) were approximately the same after the fallow, medic, and mixture treatments. This suggests that the above forage production levels can be obtained on arable land, in replacement of fallow, without any deleterious effect on subsequent grain yield. However, a final conclusion should not be made until several more years of data are available.

Impact of Seed Ratio in Forage Mixtures on Grain Yield in the Following Year

The advantages of legume-cereal forage mixtures over their monocultures were reported in the 1983 and 1984 Annual Reports. It was concluded then that vetch-cereal or pea-cereal mixtures gave the best yields and qualities. Moreover, vetches and peas grow taller when present in mixtures with barley, triticale, or oats and thus are easier to harvest. However, since forage mixtures are to be produced in a rotation with grain crops, it is also essential to consider their impact on grain yield.

In previous studies the effect of the legume-cereal proportion on forage productivity was evaluated. In the present experiment the effect of different seed ratios on grain yield in the following cereal year is examined. The experiment also assesses the need for nitrogen fertilizer in the grain crop following these mixtures.

In the 1983/84 season, six forage mixtures were established, consisting of vetch or pea, each grown with three cereals (barley, triticale, or oats). Each mixture was sown at three seed rates (120, 160, and 200 kg/ha) with five legume-cereal seed ratios (0:100, 33:66, 50:50, 66:33, and 100:0). Seed rates were laid out as main plots (52.5 m^2) and the seed ratios as subplots (10.5 m^2), the treatments being replicated three times. The plots were harvested for hay in April 1984.

Barley was grown for grain in 1984/85 on the plots previously used for forage mixtures. The plots were cultivated in November to a depth of 10 cm and sown to barley on 4 December 1984, using cultivar Badia at a rate of 100 kg/ha and fertilized with 40 kg P_2O_5/ha. Nitrogen fertilizer rates of 0, 20, and 40 kg N/ha were applied as main plot treatments in place of the seed rate treatments of the original experiment, since the latter gave no significant differences in forage yield. Nitrogen was broadcast; one half at sowing, the other half 2 months later. Barley was harvested on 9 June 1985.

The effect of seed ratio and nitrogen rate on grain yield is shown in Table 20. There were only small differences among cereal species in their effect on subsequent grain yield, so their results are combined. Barley yield increased with increased nitrogen rate at all seed ratios of both vetch-cereal and pea-cereal. Both 20 and 40 kg N/ha gave significantly higher ($P<0.05$) average yields than the control, but there were no significant differences between N rates. Grain yield was highest after the pure legumes (100:0), lowest after pure cereal (0:100), and increased with increasing proportion of legume in the previous year. There were no significant differences between grain yields after pure vetch and the 66:33 vetch-cereal mixture or between yield after pure pea and the 50:50 pea-cereal mixture.

The highest grain yield was recorded after pure legumes or mixtures containing a high legume proportion. While the effect of nitrogen input by the legumes cannot be overlooked, similar findings by Rovira (1980) in Australia on wheat yield after medic and peas and by Cocks (personal communication) on wheat after medic were attributed to the control of cereal root disease by the legumes.--*A.E. Osman.*

Marginal Land Improvement

The importance of marginal land is extensively discussed in the 1984 Annual Report. Such land in Syria is characterized by low productivity, and animals using it are heavily supplemented from various sources. Improving the productivity of such land should reduce the need for supplementation and increase its carrying capacity. In western Syria, marginal land constitutes about 30% of the total and up to 60% of the land of some villages, so its improvement is important for the village economy as well as for the country as a whole. However, improvement of marginal land is

Table 20. Yield of barley grain (kg/ha) as affected by nitrogen rate and the seed ratio (%) of the preceding vetch-cereal or pea-cereal forage crop.

Nitrogen rate (kg/ha)	Seed ratio 0:100	33:66	50:50	66:33	0:100	Mean
			Vetch-cereal			
0	1581	1920	2098	2069	2195	1972
20	2488	2584	2521	2538	2979	2622
40	2726	3021	2947	3496	3398	3117
Mean	2265	2508	2522	2701	2857	
			Pea-cereal			
0	1658	1849	1966	2074	2511	2011
20	2469	2750	2995	2488	2849	2710
40	2941	2876	3354	2983	3285	3087
Mean	2356	2491	2771	2515	2881	

	Vetch-cereal	Pea-cereal
LSD (P = 0.05) for nitrogen rates	620	422
LSD (P = 0.05) for seed ratio	287	338
LSD (P = 0.05) for seed ratio within nitrogen rates	NS	NS

difficult because it is not arable, is often steep, usually stony, and the soils are often shallow. It is intensively grazed and in many cases there is severe soil erosion. Nevertheless, we believe three possibilities exist for improving marginal land productivity. The first, and possibly the only method applicable to marginal land with low rainfall (<300 mm), is to change grazing management so that grazing pressure is eased during the critical period of seed set. The second method is to change botanical composition by sowing improved pasture species. The third possibility is to apply suitable fertilizer(s). Both the second and third approaches require favorable climatic conditions and proper grazing management.

Effect of Fertilizer Application on Marginal Land

In this study fertilizer application is being tested at Tel Hadya in a long-term experiment to study three aspects of marginal land development:

- the effect of phosphorus application on the botanical composition of grazed pastures with particular reference to its effect on legume content,
- the economic results of phosphorus application in terms of animal productivity, and
- the effect of stocking rate and its interaction with phosphorus application on

Investigation of productivity of marginal land pastures.

the stability of the marginal land ecosystem.

The experiment consists of three rates of superphosphate (0, 25, and 60 kg P_2O_5/ha equivalent to 0, 10, and 24 kg P/ha) and two stocking rates: low (1.2 ha/sheep) and high (0.6 ha/sheep). The treatments are arranged in a randomized complete block design with three replicates and a total area of approximately 83 ha. This season the animals were excluded from the experiment while plot fencing was being completed, so the research was restricted to the effect of superphosphate application on the natural vegetation.

Triple superphosphate was broadcast by hand in early November 1984 following soil sampling at 0 - 10 cm depth for phosphorus analysis. Herbage was sampled on six occasions, at monthly intervals from December to May. At each sampling date, 10 samples were collected from each plot along a transect between two opposite corners. Each sample consisted of four cylindrical units (10.5 cm diameter) taken to a depth of 10 cm, removing the plants together with a large portion of their root systems. These were separated in the laboratory into legumes, grasses, and other species, and the number of plants of each was recorded. The roots were separated and discarded and the shoot portion of each category was dried (70°C) and weighed. Samples were stored for chemical analysis.

Seed yield was measured in June. Twenty and 40 quadrat samples (50 x 50 cm) were taken from the high and low stocking rate plots, respectively, taking all vegetation and the top 1 cm of soil. Seeds were separated from the soil and vegetation of each sample, bulked, counted, and weighed.

Analytical results indicate that the soil is low in phosphorus (Fig. 20): over 87% of the samples analyzed had values less than 10 ppm. The effect of fertilizer application on dry-matter yields of legumes, grasses, and weeds is shown in Figs 21, 22, and 23,

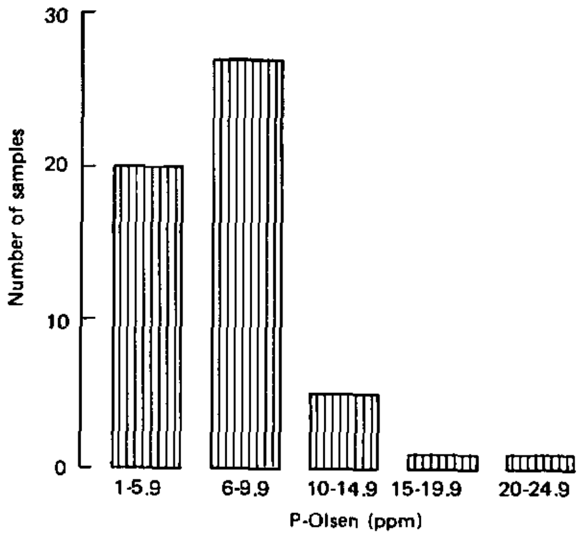


Fig. 20. Distribution of phosphorus levels (ppm) in 54 soil samples from marginal land prior to the application of superphosphate fertilizer.

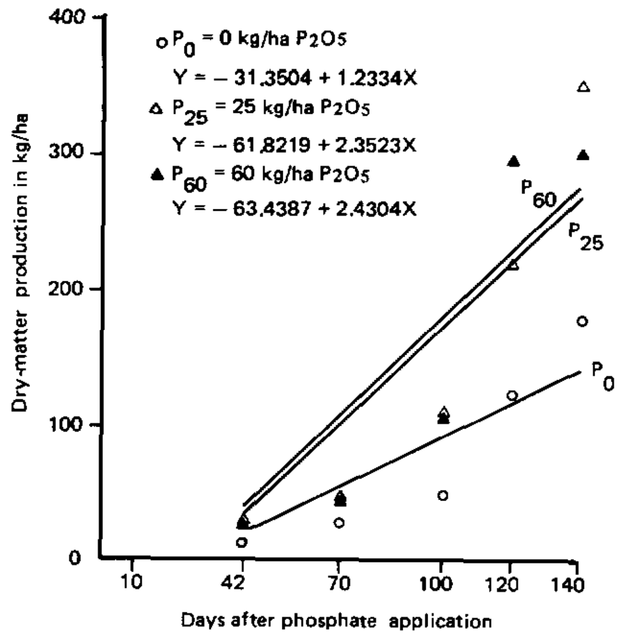


Fig. 21. Dry-matter production of legumes as influenced by phosphate fertilizer in the 1984/85 season.

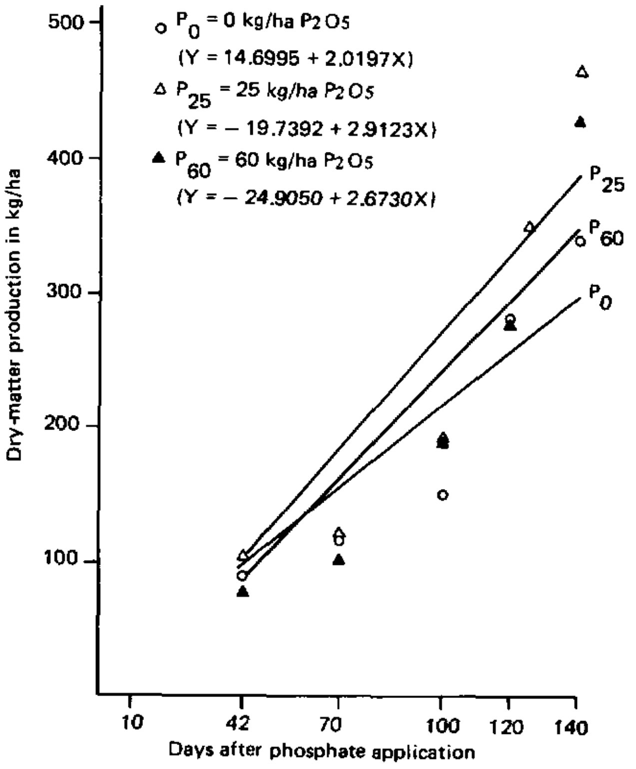


Fig. 22. Dry-matter production of grasses as influenced by phosphate fertilizer in the 1984/85 season.

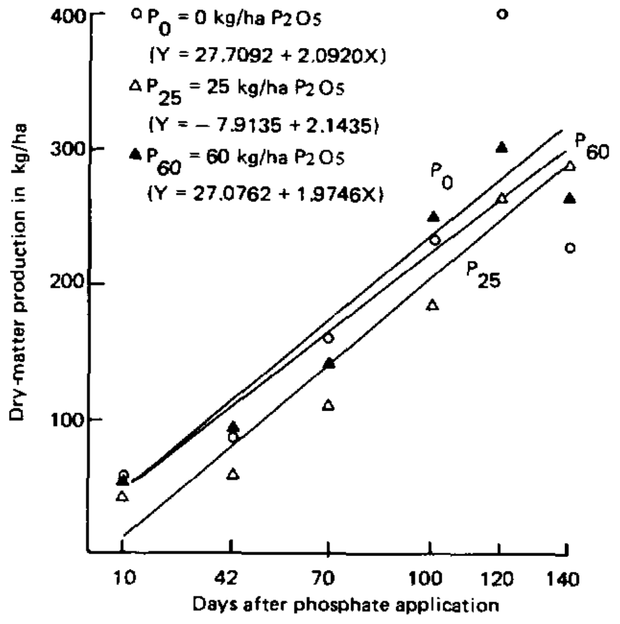


Fig. 23. Dry-matter production of weeds as influenced by phosphate fertilizer in the 1984/85 season.

respectively. While phosphorus application appeared to result in a total yield increase for all components of the pasture, the most significant individual increase was recorded in the legume component. The slopes of the regression lines for the 25 and 60 kg/ha rates were significantly greater than that of the control (Fig. 21).

A significant improvement in total herbage yield (legume + grass) was recorded at the March sampling as a result of fertilizer (100 days after P application) and this continued through the rest of the growing season (Fig. 24). A survey carried out in April 1985 indicated that over 40 legume species were present in the plots (Table 21), the most dominant being *T. campestre*, *T. tomentosum*, and *T. stellatum*.

The most important effect of fertilizer, however, is probably the one shown in Table 22, where legume seed yield on marginal land was increased by 27 and 61% over the control as the result of applying 25 and 60 kg P_2O_5/ha, respectively. This is expected to reflect favourably on legume growth, forage quality, and more importantly, on the sheep-carrying capacity of the pasture in the coming season.--*A.E. Osman and L. Russi.*

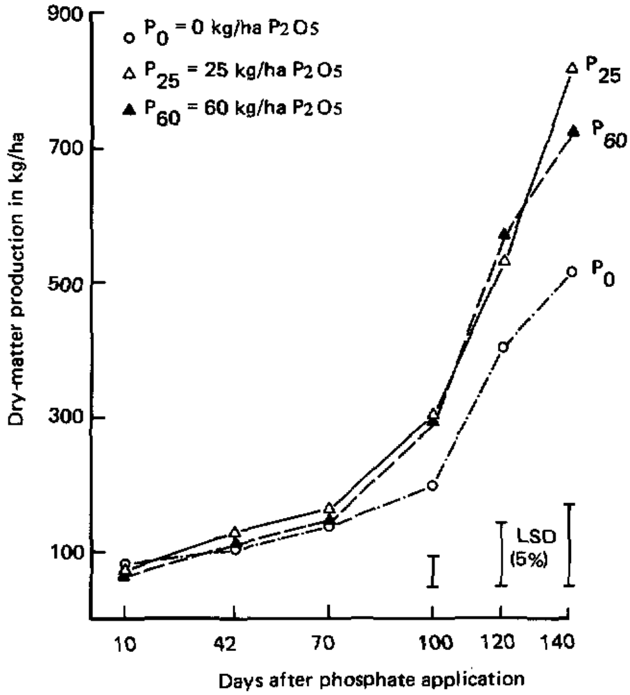


Fig. 24. Total dry-matter production of legume and grass species during 1984/85 under different phosphate fertilizer levels.

Ecology and Productivity of Marginal Land Near Terbol, Lebanon

In Lebanon, only 23% of the total area is considered cultivatable, while marginal lands constitute over 50% of the whole area of the country. The latter is classified into four main categories - the hills and foot hills of the temperate zone, the temperate mountain ranges facing the Mediterranean Sea, the slopes of the Beka'a Valley, and the northern Beka'a Valley - all of which are used primarily for sheep and goat grazing.

This report deals with the slopes of the Beka'a Valley, where the land is generally steep with hills rising above 500 m. The soil is shallow and covered with rocks which, in some areas, occupy over 50% of the land surface. In early winter, spring and early summer, the area is used for intensive sheep and goat grazing. In late summer, animals from nearby villages pass over the land on the way to the Beka'a Valley to feed on crop residues. The land is controlled by individual villages or groups, but grazing is not controlled, so accessible areas are overgrazed. A survey conducted in the spring of 1985 revealed that goat grass (*Aegilops triuncialis*) and bulbous barley (*Hordeum bulbosum*) are the dominant species. Presence of the former is often considered to be an indication of overgrazing under Mediterranean conditions. Although several legume species are present (*Trifolium stellatum*, *T. pilulare*, *T. tomentosum*, *T. subterraneum*, *Medicago rigidula*, *M. orbicularis*, and *Hymenocarpus circinnatus*), their contribution

Table 21. Legume species present in a survey of marginal land at Tel Hadya during April 1985.

Astragalus hamosus	*Trifolium stellatum*
A. triradiatus	*T. argutum*
A. suberosus	*T. pauciflorum*
A. asterias	*T. cherleri*
Coronilla scorpioides	*T. tomentosum*
Coronilla sp.	*T. scabrum*
Hippocrepis unisiliquosa	*T. spumosum*
Hymenocarpus circinnatus	*T. campestre*
Lathyrus aphaca	*T. haussknechtii*
L. inconspicuus	*T. pilulare*
L. annuus	*T. angustifolium*
L. cicera	*Trigonella foenum-graecum*
Medicago rigidula	*T. stellata*
M. coronata	*T. astroites*
M. rotata	*T. mesopotamica*
M. orbicularis	*T. monspeliaca*
M. minima	*T. monantha*
Onobrychis crista-galli	*T. filipes*
O. kotschyana	*Vicia sativa*
Ononis sp.	*V. peregrina*
Pisum sativum	*V. villosa*
Scorpiurus muricatus	

Table 22. Effect of superphosphate fertilizer rate on seed yield* (kg/ha) and seed number* for legume species on marginal land in 1985.

Fertilizer rate (kg/ha)	Seed yield	Seed number/m^2
0	28.6	2072
25	36.6	3114
60	46.1	3995
LSD (0.05)	11.7	825

* *Each value is an average for 180 quadrat samples.*

to the overall productivity of the pasture is low.

The aim of work carried out in 1984/85 was to collect data on the biological and environmental resource base of the grazing land of these mountain slopes and to relate soil fertility, plant genetic resources, and plant numbers to the primary productivity and level of available herbage. Primary productivity was measured along five transects: two on north-facing slopes of two separate hills, one on a south-facing slope, one on a west-facing slope and the last in the valley between two hills. Each transect was about 200 m long. Plant population, available herbage, and total primary productivity were measured at 50 sites together with soil depth and soil chemical composition. Available herbage was measured at monthly intervals while total herbage was measured once at the end of the season after being protected in metal cages, 50 of which were placed along the transects in November 1984. Vegetation was sampled using the cylindrical units described for the marginal land work at Tel Hadya. Sampling was done at monthly intervals for 6 months (Nov - Apr). Two hundred samples were taken at each sampling date and an additional 200 samples were taken in April from inside the cages (4 samples each) to estimate total productivity. Measurements on all samples were as described for the work at Tel Hadya. Soil samples (0 - 10 cm depth) were collected in November from each site on the transect for chemical and physical analyses.

Seed yield was measured in early May on open pasture and inside the cages using 0.5 m x 0.25 m quadrats. The straw and the top 2 cm of soil were collected, and seeds were separated into species, counted, and weighed.

Although a full analysis of data is not yet complete, the results show that pasture productivity was low in winter (Nov - Jan) varying from 250 to 600 kg/ha and consisted mainly of grasses (Fig. 25), which contributed 65, 74, and 98% to the available herbage in November, December, and January, respectively. From the beginning of spring, legumes become a more important component of the pasture reaching 37% of the total in April. At this stage other broad-leaved plants were contributing 18% to total herbage.

Plant numbers varied through the season reaching a peak of more than 9000/m^2 in December and falling to a little more than 1000/m^2 in April (Fig. 25). Although these numbers seem high they compare with up to

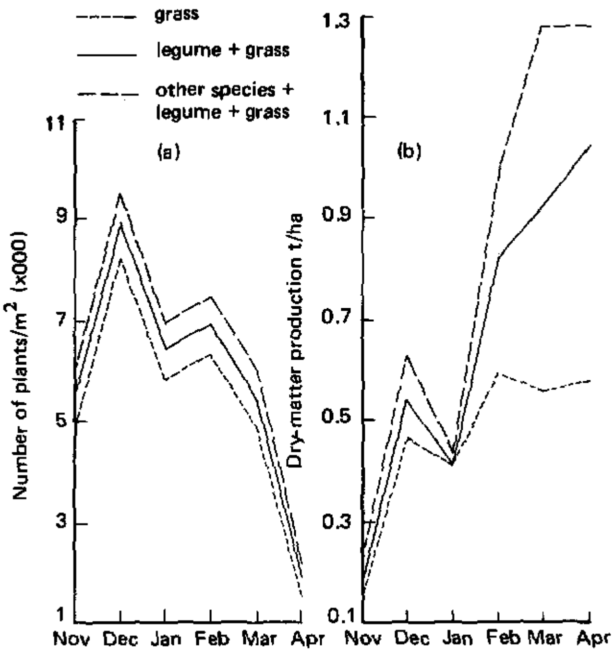


Fig. 25. Number of plants per m^2 (a) and dry-matter production in kg/ha (b) of grass, legume + grass, other species + legume + grass recorded at monthly intervals (Nov - Apr) on marginal land at Terbol, Lebanon, in the 1984/85 season under grazing conditions.

200,000/m^2 on similar land in California (Biswell and Graham 1956). Moreover, the number of legumes (500/m^2) is very low compared with that necessary for maximum production at Tel Hadya.

The yield of pasture in protected plots was 1.8 t/ha in April. In view of the high rainfall (516 mm in 1984/85) and high soil phosphorus (35 ppm) this yield seems low. Reasons for this are being sought in current studies and possibilities include inadequate legume populations and low overall plant numbers.

Several legume species were recognized at the site, the most dominant being clovers (Table 23) suggesting that sowing improved pastures with annual clovers may be the best way of increasing the productivity of this high-rainfall marginal land. Commercial cultivars are available (especially of

Table 23. Seed yield (kg/ha) and seed number (seed/m^2) for legume species in protected plots and on open range at Terbol in 1985.

Species	Protected		Open range	
	Yield	Number	Yield	Number
Hippocrepis unsiliquosa	0.2	4	0.1	2
Hymenocarpus circinnatus	0.1	2	0.5	9
Medicago rigidula	2.0	33	0.6	14
M. orbicularis				2
Trifolium stellatum	16.9	664	10.5	468
T. pilulare	5.5	210	4.3	175
T. tomentosum	1.0	104	0.1	23
T. campestre				6
T. subterraneum	0.1	3	1.0	29
T. scabrum	0.6	66	0.9	105
Trigonella sp.	0.9	110	0.8	106
Total	27.3	1196	18.8	939

subterranean clover) and are commonly used for improving the productivity of Mediterranean pastures with neutral to slightly alkaline soils (soil pH of this site is 7.1-7.9) in other parts of the world. It may not even be necessary to sow clovers since the total seed yield of legumes was 19 kg/ha in the open range and 27 kg/ha within the cages, suggesting that protection, even for only 1 year, will increase seed yield by 40% or more. It is clear that there are many options for improving this land.--*A.E. Osman.*

Livestock Management and Nutrition

Livestock research is mainly concerned with the way in which forage crops, pastures, marginal land, and cereal by-products are used for meat and milk production. We work on sheep since they are the most important domestic animals in the ICARDA region. Included in our research is an animal health component - the study of internal parasites - but like the rest of our work, it reflects problems concerned with the feeding of sheep.

The Program's livestock work includes extensive on-farm research. Particularly important is the forage utilization research being carried out at Breda in collaboration with the Farming Systems Program. Although reported by that Program, PFLP is heavily involved in the project and provides a significant proportion of the manpower and resources. Collaboration with other ICARDA Programs is of great importance, and this project in particular is a good example of inter-Program cooperation.

In 1985, several long-standing projects were concluded and the opportunity is taken here to present the final year's results. Such projects include the effect of body condition on ewe fertility, cottonseed cake supplementation of ewes grazing stubbles, and seasonal patterns of parasite burdens in sheep. Also included is the Unit Farm project, completed this year, and which has been replaced by a new experiment to study sheep productivity in wheat/medic systems. A summary of the Unit Farm data and some preliminary analyses using linear programming are presented. The three experimental flocks, subjected to contrasting levels of nutrition, will continue to be used for one more feeding trial before the complete data for 6 years are analyzed.

The work on straw continued. Studies in 1985 concentrated on: confirmation of *in vivo* differences in the quality of barley straw using a wider range of cultivars; effect of different supplements on the nutritive value of barley straw from contrasting cultivars; investigations on plant morphology in traditional barley cultivars (landraces) grown at Breda; and preliminary observations on variation in wheat straw morphology.

Unit Farms: a Basis for Profitability Analysis

The Unit Farm project at Tel Hadya was completed after six cropping cycles. This project aimed to compare the biological productivity and profitability of combinations of cropped land, marginal land, and sheep. The main elements of the project were: two 3-year rotations on deep soil; two 2-year rotations on shallow soil; three experimental flocks; and three adjacent areas of unimproved marginal land.

A traditional 3-year rotation - wheat/lentils/summer crop (watermelon), typical of the Tel Hadya area - was compared with one in which a forage crop replaced lentils and 'improved' management practices were adopted (Table 24). A traditional 2-year rotation - barley/fallow - also typical of the poorer cultivated land around Tel Hadya was compared with a barley/forage legume rotation, again using improved management practices which included reduced tillage, higher fertilizer levels, better cultivars, and machine-planting.

The experimental flocks of genetically similar sheep were subjected to a low (L), medium (M), or high (H) level of nutrition during pregnancy and lactation. In summer, all flocks grazed cereal stubbles or marginal land and the H flock received some supplementary feed. The M flock was attached to the land cropped using traditional practices and the H flock to the land cropped using improved management practices. The L flock was supported only by marginal land. The L, M, and H flocks contained 30, 30, and 35 ewes and 10, 10, and 12 female yearlings, respectively, and one ram except during the

Table 24. Rotations, area of cropped and marginal land, and stocking rate of two Unit Farms having traditional or improved managements.

	Unit Farm	
	Traditional	**Improved**
Rotation[1]:		
- shallow soil	B/F	B/V
- deep soil	W/L/S	W/H/S
Cropped land area (ha):		
- shallow soil	4.0	3.0
- deep soil	10.3	7.8
Marginal land area (ha)		
Stocking rate (sheep/ha):	9.9	9.9
- cropped land	2.87	4.44
- marginal land	4.14	4.85

1. B= barley, F= fallow, V= vetch, W= wheat, L= lentils, S= summer crop (watermelon), H= vetch-wheat hay.

Table 25. Crop yields at two levels of management (quadrat data from 1980 to 1985).

Crop yields (kg/ha)	Management level		
	Traditional	Improved	SED
Wheat grain	1877	2328[a] 2034[b]	178.8
Barley grain	1600	2639	225.7
Water melon	3945	4162	672.9
Wheat straw	3690	3772[a] 4567[b]	547.4
Barley straw	2524	3507	1519.1
Lentil grain	1072		
Lentil straw	2376		
Vetch/wheat hay		2814	
Vetch pasture		2292	

a. Durum wheat; b. Bread wheat.

mating season when a second ram was added. These differences in flock size resulted in a higher stocking rate on the Unit Farm managed according to improved practices (Table 24).

The differences in productivity between the traditional rotations and those using a forage crop and improved management were considerable. Although wheat yields in the 3-year rotation were increased by only 10 - 20% (Table 25), barley yields with the 2-year rotation were increased by 39%. The fact that the improvement in wheat yield was lower than that of barley, even though they were grown on deep and shallow soils respectively, suggests that the management practices applied to the wheat may not have been ideal. This is confirmed by the low hay yields which were a little higher than those of lentil straw. Straw yields reflected grain yields although improved wheat varieties tended to produce 22 - 25% more straw than Hourani, the local variety. The yield of water melon was similar in the two rotations and lentil yields were typical of the area.

In addition to considerable biological data, the project provided information for a linear program which will be valuable for comparing the whole-farm profitability of several systems and in the development of better marginal land use. A model was developed which divides the year into four discreet periods according to the reproductive calender of the local Awassi sheep as follows: June to September - mating; October to December - pregnancy; January and February - early lactation; and March to May - late lactation. For any combination of cropped and marginal land, the model determines maximum profit and optimum combinations of crop sales, feed purchases, grazing management, and ewe numbers. A summary of some initial results is presented here, while a complete analysis for 6 years, taking seasonal variations into account, will be reported next year.

Initial runs were made for the following conditions: no sales of straw, hay, or stubble were permitted; sales or feeding of wheat and lentil grain were optional; each ewe had an annual replacement value of 100 Syrian pounds; and capital for the purchase of ewes was unlimited. Upper limits on dry-matter intake, and lower limits on metabolizable energy and crude protein were specified for each flock and each period. The 18 solutions shown in Table 26 compare the two 3-year rotations either alone, or with 10 ha of unimproved or 10 ha of improved marginal land. These combinations were tested using the L, M, and H

Table 26. Optimal ewe numbers and maximum profits from two crop rotations, various combinations of cropped and marginal land and three levels of flock nutrition.

Cropped/marginal land (ha)	10/0			10/10			10/10[a]		
Level of flock nutrition	Low	Medium	High	Low	Medium	High	Low	Medium	High
Traditional rotation (wheat-lentil-melon)									
No. of ewes	19.9	19.1	10.9	36.0	27.4	23.5	52.9	52.6	40.6
Max. profit (000'SL)	9.8	9.6	9.2	12.4	12.8	12.4	13.3	14.4	14.3
Improved rotation (wheat-vetch-melon)									
No. of ewes	40.8	38.2	25.6	54.4	51.9	34.4	70.4	65.4	43.6
Max. profit (000'SL)	15.3	16.2	16.1	16.9	18.3	18.2	17.9	19.6	19.6

a. With 25 kg P_2O_5/ha applied to marginal land.

flocks separately. Results from the two-course rotations are not reported here.

The addition of unimproved marginal land to a farm using the traditional rotation almost doubles the number of ewes required for maximum profit, yet profits increase by only 25%. Improving the marginal land by applying 25 kg P_2O_5/ha increases optimum flock size by a further 47 - 92% and profits by a smaller but significant amount. The addition of marginal land to vetch rotations increases ewe numbers by 72% and profits by 21%. A major difference between the two rotations was the projected doubling of flock size caused by replacing lentils with vetch if no marginal land were available. Where marginal land was improved, the projected increase in optimal flock size was only 33% compared with the unimproved land, and profits improved by a similar amount. Shifts from grazing vetch to harvesting it as hay accompanied the change from the low to the high nutritional regime.

Changing from the low to high level of nutrition reduces flock size for every combination of cropped and marginal land, but profits increased in most cases by switching from low to medium levels of nutrition. Profits at high nutritional levels never exceeded those at medium nutritional levels because the extra feed requirement of the better-fed flock was greater than the relatively small improvements in meat and milk production.

This analysis of the Unit Farm results by linear programming shows how introducing a forage crop into a rotation should result in a substantial increase in profit. The results help to define the best crop/livestock combination which depends on the availability of cropped and marginal land. More detailed analyses using the same method will help to define the sheep performance necessary to make improved feeding regimes profitable. The method will also assist scientists to choose combinations of rotations, crops, and marginal land which maximize profits to farmers using stable farming systems.--*E.F. Thomson, T.L. Nordblom (Farming Systems Program) and F. Bahhady.*

Ewe Body Condition and Fertility

The number of lambs born each year influences the profitability of sheep production and is profoundly affected by body condition, itself a function of the nutritional regime. Poor

Table 27. Effect of level of nutrition on ewe liveweight, frequency of oestrus and conception rate.

	Level of nutrition			SED	Probability level
	Low (L)	Medium (M)	High (H)		
Number of ewes	30	30	35		
Pre-mating phase (56 days):					
- Daily liveweight gain (g)	37	22	46	19.5	0.495
- Frequency of oestrus[1]:					
- zero	53	31	9	10.4	0.016
- one	30	40	38	7.7	0.438
- two	15	26	41	7.9	0.047
- three	2	3	13	7.8	0.421
Mating phase (68 days):					
- Liveweight at mating (kg)	41	43	50	1.7	0.004
- Conception rate[1]:					
- first mating	56	70	69	14.3	0.538
- second mating	18	23	20	13.4	0.733
- subsequent matings	26	7	11	12.8	0.213

1. Percentage of ewes in category.

body condition occurs during summer when stubbles of low nutritive value are the only available feed resource. Defining the relationship between body condition and fertility is therefore an important goal, since surveys show that lambing rate is below the genetic potential of the local Awassi breed in up to 90% of flocks. A 3-year study was conducted in which liveweight was used as an indicator of body condition since a technique suitable for direct measurement of the latter has not been developed for this fat-tailed breed.

The three experimental flocks subjected to *high* (H), *medium* (M), or *low* (L) levels of nutrition, were used in the study. The average liveweight of the flocks was 50, 43, and 41 kg during mating in August and September each year. Vasectomised rams accompanied the ewes from early May until late July so that the effect of liveweight on the number of oestruses could be assessed without conception taking place. Thereafter, intact rams accompanied the ewes until late October. The ram: ewe ratio was 1:15 and all rams carried a marker crayon to indicate that mating had occurred. The L flock grazed sparse native pasture (marginal land), while the M and H flocks also had access to cereal stubbles. In addition to grazing, the H flock received small amounts of supplementary feed.

Although the H flock was significantly heavier than the M and L flocks at mating, the differences in daily liveweight gains of the flocks were not significant during the 56 day premating phase (Table 27). The frequency of oestrus increased with level of nutrition from the L to the H flock; the highest values for anoestrus occurred in the L flock and the highest values for single or multiple oestruses occurred in the H flock.

There was a tendency for more M and H ewes to conceive at the first and second matings compared with the L ewes (Table 27). As a result, 26% of L ewes were mated three or more times compared with 7 and 11% in the M and H ewes, respectively. The frequency of conception during the first and second 17 days increased with ewe liveweight.

The relationship between lambing rate and ewe liveweight at mating is given in Fig. 26. A curvilinear relationship is expected for the breed since, below 35 kg, ewes become anoestrus and above 50 kg lambing rate reaches a maximum. However, a linear regression gave the best fit for the present results as liveweights were 38 - 50 kg.

This study confirmed that ewe liveweight at mating has a marked effect on reproductive function and fertility. The reproductive season of well nourished ewes starts earlier, oestruses are less frequent, and conception rates are higher, compared with ewes in poor condition. Contrary to modern management thinking, traditional systems which allow the continuous presence of rams and an associated long lambing season, ensure satisfactory lambing rates and a supply of milk products to the family or for sale over at least 6 months of the year. These aspects must be considered when designing management strategies which allow the maximum fertility of the breed to be reached.--*E.F. Thomson and F. Bahhady.*

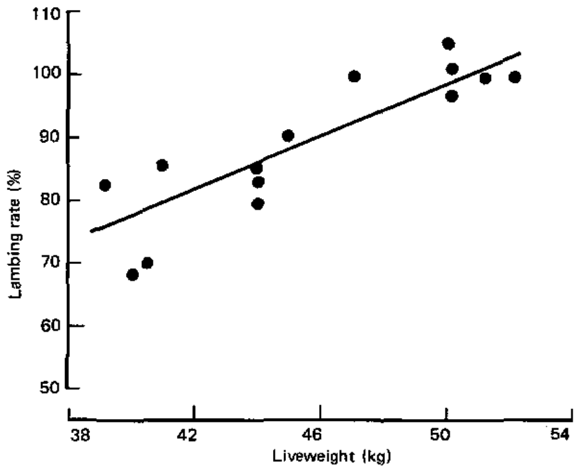


Fig. 26. Influence of ewe liveweight at mating on lambing rate: the fitted regression was significant at $P < 0.001$ (r^2 = 0.75).

Helminth Burdens of Sheep

The severity of helminth infections in sheep and the egg-laying pattern of parasites must be measured before deciding on appropriate control measures. This was the major goal of a recently completed 18-month survey using sheep selected from the L, M, and H flocks. The nutritional regimes imposed on the sheep made it possible to assess their tolerance to a parasite burden. The sheep had not previously been treated with anthelminthics.

Six ewes, six female yearlings (1 year old at the beginning of the survey), and six male lambs were selected at random from each of the three experimental flocks. This resulted in animals with different body conditions when monitoring of faecal egg and larval burdens began in February 1984. Monitoring of the lambs started 1 month after birth.

Eggs of easily identifiable nematodes (*Nematodirus* sp. and *Marshallagia* sp.) and cestodes (*Moniezia* sp.) were extracted from faecal samples by flotation in saturated salt solution and counted using McMaster slides. Lungworms, of various genera were counted as first-stage larvae after extraction from faeces. Results for *Nematodirus* and *Marshallagia* are expressed as number of eggs/g faeces; for *Moniezia* as present or absent; and for lungworms on a numerical scale from 0 to 3, where a value of 0.5 or less indicates a low level of infection and above 1.5 a severe infection.

The seasonal changes in sheep liveweight, air temperature, relative humidity, and the level of infection with four of the above parasites are shown in Figs 27 and 28, in chronological order to illustrate the transition from lambs to adult ewes. The data for yearlings and adults were obtained concurrently with those for lambs. Patterns of nematode eggs and larvae in faeces are related to climatic characteristics and to host immunity. During the hot, dry summer when host immunity following spring infection is high, faecal egg counts are low since the parasites enter the arrested or hypobiotic phase. In the autumn, as immunity levels and temperatures fall and humidity rises, the parasites become active and faecal burdens increase, reaching a peak in spring. This peak is accentuated by the post-parturient rise in parasite activity associated with lambing in winter.

Differences in infection depending on sheep age, level of nutrition, and nematode species were apparent during the season. Mean peak levels of infection from three observations in spring each separated by a month, were used to compare these factors. A high number of lungworm larvae indicated a severe level of infection in all groups of well nourished adult sheep, but only in the lambs of the poorly nourished flocks (Table 28). In the flock subjected to a medium level of nutrition, lungworm infections were high in yearling and adult ewes but low in lambs.

All egg counts were well below the threshold for a severe infection in both *Marshallagia* (2000 eggs/g) and *Nematodirus* (600 eggs/g). Lambs in the well nourished flocks tended to show higher infection levels than in the L and M flocks, but this did not occur with yearlings and adults. *Moniezia* levels, which are not shown, were low and little affected by sheep age or level of nutrition.

These results must be interpreted with care since faecal counts can be a poor indicator of a parasite burden. There are also large differences in the pathogenicity of different helminth species, which must be taken into account. Lungworms are probably the only parasites likely to cause a loss of productivity in Awassi sheep at Tel Hadya. There is evidence that burdens in well nourished sheep may be higher than in poorly nourished sheep which may indicate the ability of the former to tolerate a higher parasite burden without an effect on productivity. The continued reinfection of replacements and adults following the well known development of

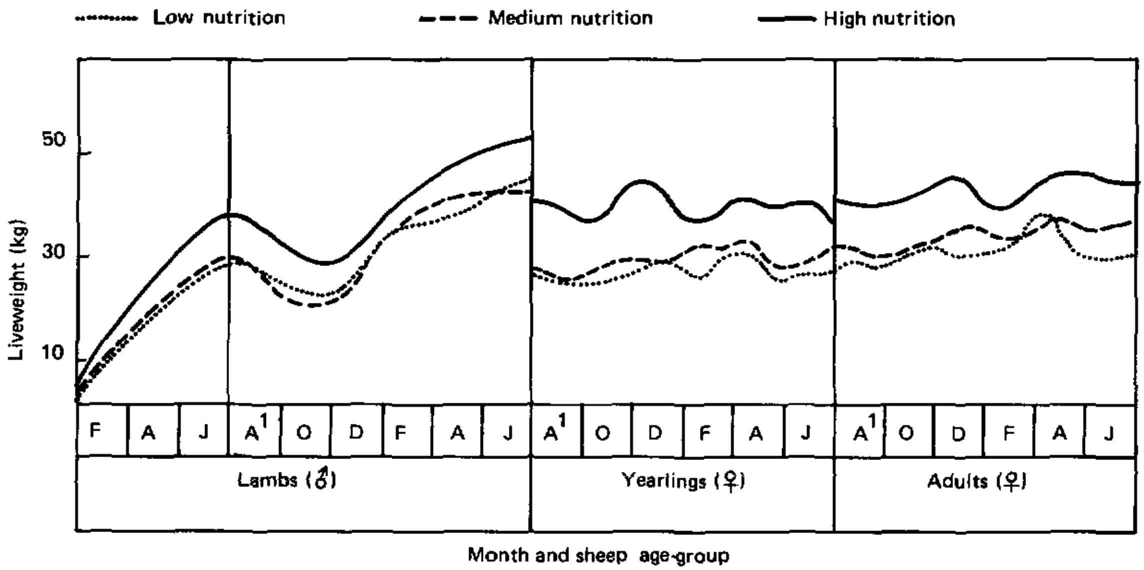


Fig. 27. Seasonal liveweight changes of male lambs, female yearlings, and adult ewes subjected to three nutritional regimes. Bimonthly means are given.

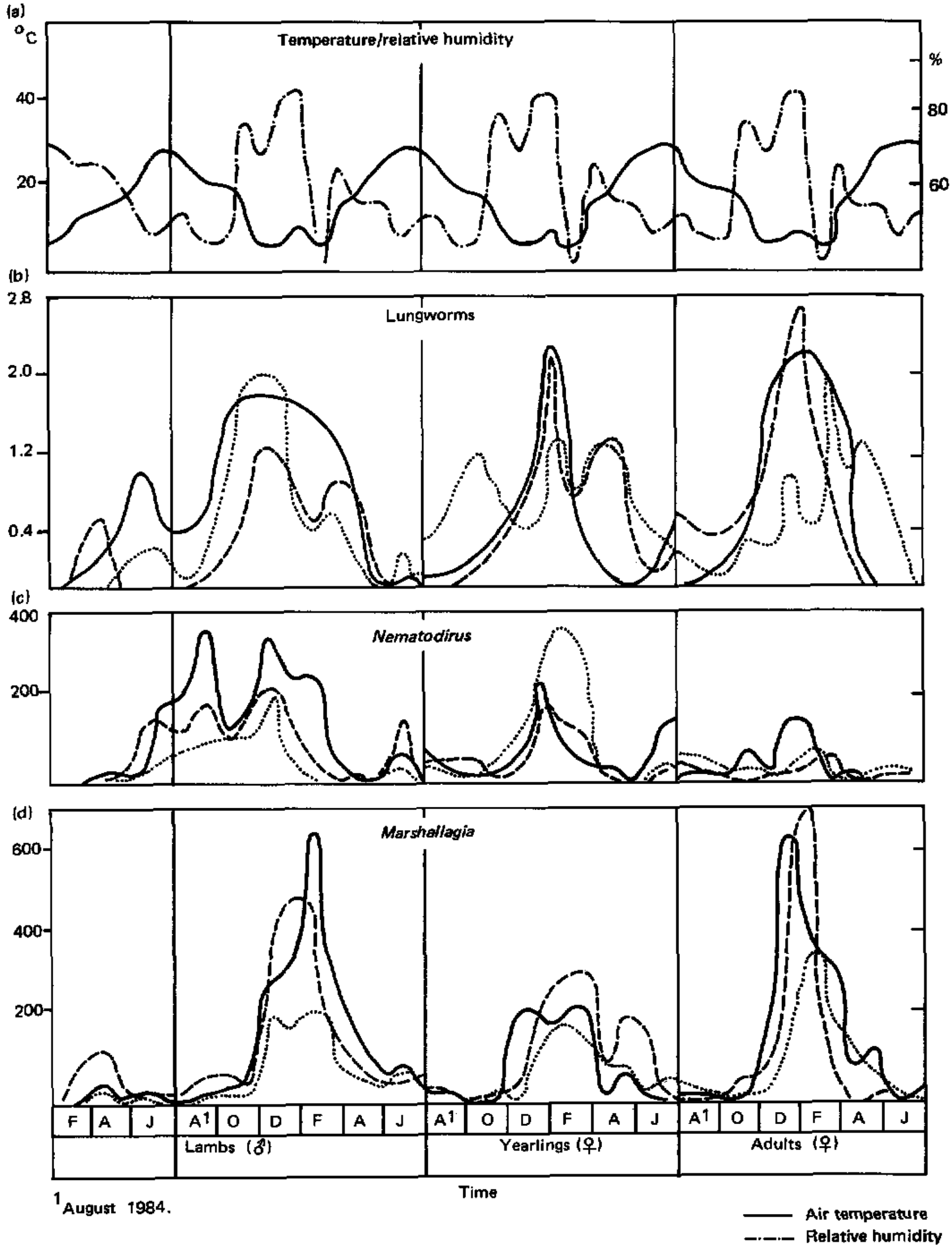


Fig. 28. Seasonal changes in (a) air temperature (°C) and relative humidity (%), and faecal burden of (b) lungworms (infection score), (c) *Nematodirus* (eggs per g faeces), and (d) *Marshallagia* (eggs per g faeces) of lambs, yearlings, and ewes subjected to a low, medium, and high level of nutrition. Bimonthly means are given.

Table 28. Peak faecal, larval, and egg burdens for four nematode genera in sheep flocks subjected to three levels of nutrition.

Nematodes	Age category	Level of nutrition: Low (L)	Medium (M)	High (H)	SED	Probability level
Lungworms[1]	Adults (♀)	0.7	2.2	1.9	0.55	<0.001
	Yearlings (♀)	1.2	1.9	1.8	0.72	0.163
	Lambs (♂)	1.7	1.0	1.6	0.45	0.018
Marshallagia (EPG)[2]	Adults	157	343	164	137.1	0.037
	Yearlings	158	179	145	123.6	0.890
	Lambs	186	428	425	99.9	<0.001
Nematodirus (EPG)[2]	Adults	35	25	97	58.7	0.080
	Yearlings	162	63	76	96.8	0.169
	Lambs	122	178	261	79.5	0.015

1. Severity of infection: 0-0.5 = mild; 0.5-1.5 moderate; 1.5-3.0=severe.
2. Eggs per gram faeces.

host immunity suggests that immunity is of short duration, a result contrary to reports in the literature.

Future research will attempt to define the threshold at which lungworms affect productivity. Studies on *Marshallagia* and *Nematodirus* will cease since the recorded levels of infection are unlikely to reduce productivity.

Generous assistance from the Japanese International Cooperation Agency made this research possible.--*G. Orita and E.F. Thomson.*

Ewe and Lamb Feeding

Barley grain and straw account for over half of the energy supplied by liberal amounts of feed given to sheep flocks in winter. Barley grain is also an important component of the concentrate feeds offered to lambs in commercial fattening operations at several locations in Syria. Such feeds represent a large proportion of the direct costs of a sheep breeding or fattening operation and any way of increasing efficiency of feed use will markedly benefit profitability. Indeed, farmers are feeding such large amounts of supplements in winter that it appears unnecessary for flocks to be taken to grazing. This is particularly true where marginal grazing is poor. Feed saved during winter and used in summer might have a positive effect on flock fertility. It might also be better to give some of the excess directly to lambs.

These questions were studied in a series of experiments. One experiment compared the performance of ewes and lambs receiving supplements in a grazing and a confined system. Two others studied supplementation of suckling lambs (creep feeding) and the growth performance of intensively fed lambs. Finally, the effect of a protein supplement on the liveweight changes of ewes grazing cereal stubbles was investigated.

Supplementary Feeding of Grazing and Confined Ewes

The three experimental flocks were offered low (L), medium (M), and high (H) levels of supplementary feed during lactation, estimated to cover 100, 115, and 130% of the metabolizable energy (ME) needs, respectively. Each flock was split to give confining versus grazing treatments. The former were penned while the latter spent about 6 hours on poor marginal land each day and were penned for the rest of the time.

The intakes of dry matter (DM), ME, and crude protein differed significantly between flocks but not between management systems (Table 29). However, differences in ME intake between flocks were smaller when expressed on the basis of metabolic body weight ($kg^{0.75}$). Differences in liveweights and liveweight changes of ewes were small. However, penned ewes tended to lose more liveweight than when grazing, and losses were higher in the L than in the H flock.

Penning during pregnancy led to significantly heavier lambs at birth. However, at weaning, lambs in the grazing flocks were slightly heavier because they had a higher growth rate.

Grazing ewes removed 200 - 300 kg DM/ha from the native pasture which offered 400 - 700 kg DM/ha at the start of winter. The

Table 29. Daily intakes by ewes of dry matter, metabolizable energy and crude protein, and liveweights and liveweight changes of ewes and lambs until 56 days after lambing.

Level of nutrition:	**Low**		**Medium**		**High**		
Management system:	**Grazed**	**Penned**	**Grazed**	**Penned**	**Grazed**	**Penned**	**S[1]**
Ewes							
Number of ewes	6	4	8	9	20	7	
Daily intakes:							
- dry matter (g)	928	952	1249	1230	1601	1753	150.5
- metabolizable energy (MJ)	10.8	11.1	13.8	13.6	17.1	19.2	1.68
- met. energy (kJ/MBW[2])	755	784	833	857	970	973	75.8
- crude protein (g)	120	123	141	139	180	198	17.3
Liveweights (kg):							
- start lactation	38.2	40.2	46.2	45.5	50.7	57.9	4.41
- after 56 days	34.2	33.3	41.9	40.1	47.1	53.5	4.06
- daily gain (g)	-73	123	-76	-96	-64	-80	52.6
Lambs							
Number of lambs	6	4	8	9	20	7	
Liveweights (kg):							
- birth weight	4.1	4.5	4.8	4.6	4.8	5.5	0.51
- after 56 days	14.8	13.1	17.7	16.4	16.6	16.2	1.89
- daily gain	190	151	230	207	211	186	30.7

1. $\sqrt{\text{residual mean square}}$.

2. Metabolic body weight.

Table 30. Growth rates of male Awassi lambs during suckling at two levels of ewe nutrition, and a subsequent fattening phase, and feed conversion ratio during fattening.

	Level of nutrition during suckling		
	Medium (M) (n=8)	High (H) (n=8)	SED
Suckling phase (70 days):			
- daily gain (g)	223	230	17.9
Fattening phase (77 days)			
- age at start (days)	68	70	1.07
- start liveweight (kg)	19.7	21.1	1.16
- end liveweight (kg)	39.2	44.0	2.81
- daily gain (g)	254	297	27.9
- feed intake (g):			
- concentrate[1]	1011	1211	
- vetch hay	100	100	
- feed conversion ratio[2]	4.0	4.2	

1. 830 kg whole barley grain, 150 kg soya-bean meal, 20 kg vitamin-mineral mix.
2. kg feed/kg liveweight gain.

herbage grazed was barely sufficient to give a slight liveweight increase. However, when herbage on offer falls below 300 kg DM/ha it may become advantageous to confine flocks. Such levels of herbage were recorded for Bueda marginal land in the winter of 1983/84.--*E.F. Thomson and F. Bahhady.*

Lamb Fattening

The intensive fattening of lambs has several important advantages. It allows the considerable growth potential of the Awassi breed to be exploited; it could allow native pasture on marginal land to regenerate by reducing grazing pressure in spring; and more of the ewe's milk is available for sale or home use.

To study growth during intensive fattening, eight male lambs from the medium (M) and well (H) nourished flocks of the ewe feeding trial were weaned at about 10 weeks and offered a concentrate diet for 77 days. Management during suckling had little effect on growth rate up to weaning (Table 30), but the small initial difference which developed between the liveweights of the two groups increased to 4.8 kg by the end of the fattening phase. The higher daily gain of the H lambs was associated with a higher concentrate intake but feed conversion ratios were unchanged.

This study confirms that male Awassi lambs are efficient feed converters up to 40 kg liveweight. However, earlier weaning may improve efficiency still further and release more milk for sale or home use. Feed conversion ratios of lambs in local feed lots could be halved through improved management and nutrition; this is equivalent to doubling the meat production from a unit of barley grain.--*E.F. Thomson and F. Bahhady.*

Creep Feeding of Lambs

Previous experiments at Tel Hadya showed that Awassi ewes produce sufficient milk to enable their lambs to reach a liveweight of 10 kg in 21 days. Thereafter, lamb growth may be limited unless additional feed is offered. Creep feeding is one way of helping lambs to reach their growth potential so a small study of this system was conducted.

Two groups of lactating Awassi ewes were selected from a flock not used in the Unit Farm project. One group received 100% ('Medium') and the other 130% ('High') of their metabolizable energy (ME) requirements from concentrates. After 21 days' suckling, half the lambs in each flock were progressively given access to concentrates where they were not in competition with their mothers (creep feeding). The remaining lambs served as controls. The experiment continued until the lambs were 70 days old.

During the first 21 days, ME intake of the Medium and High groups were similar (Table 31), and growth rates of lambs were also similar. Thereafter, lambs receiving creep feed gained 60 - 80% more weight daily than the controls. Cold weather during the second

Table 31. Ewe liveweight changes and metabolizable energy intake, and growth responses of lambs to creep feed.

	Level of supplementary feed				
	Medium		High		
	Control	Creep	Control	Creep	S[1]
Number of ewes	8	8	10	9	
Ewe performance					
Phase 1 (21 days):					
- Initial liveweight (kg)	43.6	43.8	43.6	42.4	2.63
- Daily gain (g)	-179	-167	-85	-143	105.1
- Met. energy intake (MJ)	13.5	12.3	14.6	12.6	2.28
Phase 2 (49 days):					
- Initial liveweight (kg)	39.9	40.3	41.8	39.4	2.78
- daily gain (g)	-59	-23	9	-2	47.5
- Met. energy intake (MJ)	13.1	12.8	16.8	13.9	1.22
Lamb performance					
Phase 1 (21 days):					
- birth liveweight (kg)	4.7	4.3	4.5	4.2	0.48
- daily gain (g)	225	260	216	253	53.4
Phase 2 (49 days):					
- initial liveweight (kg)	10.2	9.0	9.8	8.7	1.37
- daily gain (g)	103	187	114	183	48.7
- creep feed intake:					
- dry matter (g)		158		146	14.0
- Met. energy (MJ)		2.0		1.8	0.18

1. $\sqrt{\text{residual mean square}}$.

phase may have reduced lamb performance to atypical levels. However, this experiment strongly suggests that lambs benefit from creep feeding, and further studies are needed.--*E.F. Thomson and M. Rafiq (Arid Zones Research Institute, Quetta, Pakistan).*

Stubble Grazing and Protein Supplementation

Sheep flocks in north Africa and west Asia are heavily dependent on cereal stubbles during summer. Numerous studies show that feeding a small amount of protein promotes the intake of low quality straw, but the liveweight changes of sheep grazing stubbles of different cereal varieties, with or without protein supplementation, has not been measured.

The three experimental flocks, (L, M, and H) were used in this study which started in June 1985. The experiment had a preliminary period of 35 days when the L flock grazed wheat stubbles from several varieties and the M and H flocks grazed barley stubble (cv Arabi Abiad). During the main period of 63 days, all flocks grazed wheat stubbles. For the preliminary period, ewes within flocks were divided into a control group and a group receiving 100 g cotton seed cake daily per animal. During the main period, the control and supplemented groups of the L and M flocks grazed either mixed wheat stubbles or Hourani wheat stubble, respectively. The H flock was further subdivided to graze stubbles of the new wheat cultivars, Sham 1 and Sham 2. At the start of the trial, attempts to balance straw availabilities across treatments were only partly successfull and comparisons between varieties are confounded by straw availability.

The differences in liveweights within flocks at the start of the experiment were due to differences during the preliminary period (Table 32). Except in the L flock, straw intakes per kg metabolic body weight ($W^{0.75}$) were similar for all the controls. In the supplemented treatments they were similar.

Supplementation with protein increased liveweight gains in all treatments (Fig. 29), although the effect was significant only in the L and M flocks. If, as a result of supplementation, lambing rate increases by 2% (2 lambs/100 ewes) for every kg of extra liveweight, and the stubble is grazed in this

Table 32. Daily intakes of straw, grain and cottonseed cake and liveweight changes of Awassi sheep, with or without cottonseed cake supplementation, grazing stubbles of three wheat varieties for 63 days.

Liveweight (variety)	Low (Hourani)		Medium (Hourani)		High (Sham 1)		High (Sham 2)		
± cottonseed cake	-CSC	+CSC	-CSC	+CSC	-CSC	+CSC	-CSC	+CSC	S[1]
Number of sheep	22	22	27	27	12	12	12	12	
Area of stubbles (ha)	2.02	2.02	1.73	1.73	0.66	0.66	0.66	0.66	
Stocking rate (m^2/day)	14.6	14.6	10.1	10.1	8.8	8.8	8.8	8.8	
Daily intakes per head:									
- available straw (g)	1029	1162	1554	1668	1210	121	1577	1577	
- residual straw (g)	439	400	738	840	354	42	598	715	
- straw intake (g)	590	762	816	827	856	78	979	862	
- grain (g)	67	61	14	10	14	1	12	12	
- cottonseed cake (g)	0	100	0	100	0	10	0	100	
Straw intake (g/$W^{0.75}$)	38	46	52	48	47	21	53	44	
Liveweights:									
- end (kg)	37.9	43.4	39.4	46.0	48.0	52.8	49.6	54.1	4.00
- start (kg)	39.1	42.1	39.4	42.6	48.3	52.4	48.7	52.5	4.32
- daily liveweight gain	-18.1	19.3	0.8	53.2	-5.3	6.0	14.1	25.8	29.39

1. $\sqrt{\text{residual mean square}}$.

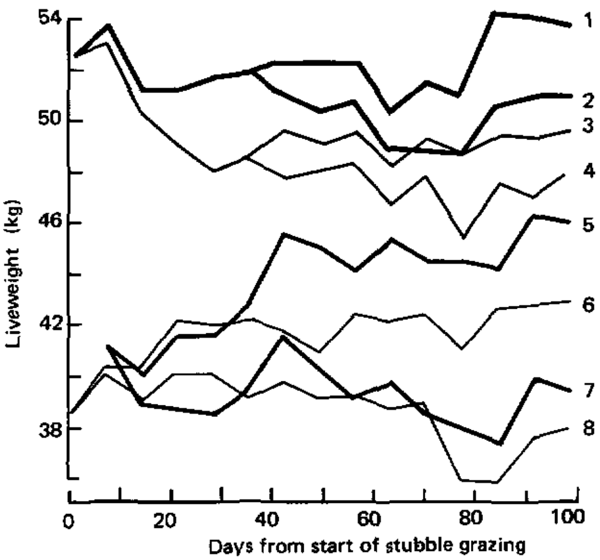


Fig. 29. Liveweight of sheep grazing cereal stubbles with and without supplementation with cottonseed cake.

1. Flock H grazing Sham 2 wheat with supplement
2. Flock H grazing Sham 1 wheat with supplement
3. Flock H grazing Sham 2 wheat only
4. Flock H grazing Sham 1 wheat only
5. Flock M grazing Hourani wheat with supplement
6. Flock M grazing Hourani wheat only
7. Flock L grazing various varieties with supplement
8. Flock L grazing various varieties only.

way for 126 days, the protein supplementation should improve lambing by a total of up to 14%, depending on cereal variety and straw availability. This increase would markedly increase flock profitability.

We know that sheep lose weight if stocked at a high rate on cereal stubble. This loss can be arrested by adding a small quantity of protein supplement, such as cottonseed cake, which is readily available in Syria. However, the local variety, Hourani, and the improved varieties, Sham 1 and Sham 2, appeared to give different animal responses under protein supplementation. Further studies are necessary to determine whether there are interactions between protein supplementation, cereal variety, and stubble availability. --*E.F. Thomson and F. Bahhady.*

Nutritive Value of Straw

Extensive research in 1984 showed that factors such as nitrogen fertilization, time of sowing, seed rate, and grazing at the tillering stage did not influence the nutritive value of barley straw. However, preliminary feeding trials indicated that there were substantial differences in straw quality between barley cultivars. These differences were associated with variations in the proportions of leaf blade, leaf sheath, and stem in the straw. Taller cultivars or those which matured early had less leaf and more stem than shorter, late maturing ones. Environment was also important because, in dry Syrian conditions, barley plants were shorter and contained more leaf than those grown in a *temperate* environment. Variation also occurred in the chemical composition and *in vitro* digestibility of the leaf blade and stem. Stems of taller cultivars were more *lignified and less digestible.*

Nutritive Value of Forage

ICARDA places considerable effort in the breeding and agronomy of common vetch (*Vicia sativa*), forage pea (*Pisum sativum*), and, to a lesser extent, chickling (*Lathyrus sativus*). However, the nutritive value of these species for ruminants has not been sufficiently studied, particularly in the case of forage pea which seems to be the least palatable. A study was therefore conducted in which fresh herbage, hay, and straw of common vetch, chickling, forage pea, and barley were fed *ad libitum* to Awassi sheep to measure intake and digestibility. Also measured were the harvesting losses during hay-making and the yields of energy and protein harvested at the hay, compared with the mature stage. Barley

Table 33. Hay yields and harvesting losses of barley vetch, pea and lathyrus (kg DM per ha, 100% flowering-early pod stage).

	Barley	Vetch	Pea	Lathyrus
Potential yield[1]	4432	4977	6181	3583
Harvested yield[1]	4432	4009	2876	3133
Apparent loss %	0	19	53	13

1. See text for explanation.

was added as a treatment because of its importance as a feedstuff in the region.

The four species were sown in two replicates. Material at the mid-flowering stage was cut every second day and fed fresh. Hay was made by machine, and the mature crop (straw) was hand-pulled and then threshed to remove the grain. All materials were chopped before feeding to Awassi wethers. Fresh herbage of each forage was offered to only three sheep, while hay and straw were offered to four sheep. The voluntary feed intake and digestibility of the materials were measured in 28-day digestibility trials.

There was a high harvesting loss from the forage legumes, similar to those reported in previous studies and mainly representing leaf loss (Table 33). This loss was virtually nil in barley. The particularly high loss from pea is difficult to explain and may have been due to difficulties in mowing the crop, which had lodged. Grazing of the aftermath by sheep reduced these losses to between 10 and 20%.

Results of intake, digestibility, and sheep performance are given in Table 34. Whereas the effect of increasing plant maturity was normal in barley, common vetch, and chickling, there was a remarkably low intake of fresh herbage and hay of forage pea. The lower digestibility of the acid detergent fibre (ADF) in forage pea is insufficient to explain the lower intake. Indeed, at the hay stage, digestibilities of forage pea, vetch, and barley ADF were similar but forage pea intake was only 32 and 38% of vetch and barley intake, respectively. By the mature stage, forage pea intake was above that of barley but still about half that of vetch and chickling.

These results show that barley, common vetch, and chickling fed as fresh herbage or as hay can provide sheep with two to three times their metabolizable energy (ME) requirement for maintenance. The liveweight gains are a clear reflection of these high intakes which would sustain an Awassi ewe at the peak of lactation. However, the ME intakes of sheep offered fresh pea and pea hay were below their maintenance requirement as can be seen from the liveweight losses in Table 34.

Intakes of vetch and chickling straw were still adequate for maintenance even though sheep offered vetch lost weight. This can be attributed to a rumen fill effect when passing from a high to a low level of intake. This source of error applies to all treatments but is most obvious when intakes change substantially between one feed and another.

The trial confirms the very low palatability of forage pea observed in several earlier studies. No satisfactory explanation for this can be found in the literature since the nutritive value of pea as a forage crop has not been determined. It is not clear whether all pea cultivars are unpalatable, but there are indications of differences. The low palatability and the high cold, insect, and disease susceptibility of forage pea offset the high yield and nitrogen fixing potential of the species. The trial has highlighted the

Table 34. *Ad-libitum* intake and liveweight changes of Awassi sheep offered fresh herbage, hay, or straw of barley, vetch, pea, and chickling.

	Fresh herbage					Hay					Straw				
	Barley	Vetch	Pea	Chickling	Sd[1]	Barley	Vetch	Pea	Chickling	Sd[1]	Barley	Vetch	Pea	Chickling	Sd[1]
Daily intakes (g):															
- dry matter	1954	2411	506	2080	329.2	2005	2422	765	2094	264.0	813	1786	842	1608	187.8
- met. energy (MJ)	19.3	25.6	4.7	22.2	3.58	18.0	22.3	7.1	19.8	2.44	4.7	13.0	6.0	11.3	1.53
Intakes ($g/W^{0.75}$):															
- dry matter	96	115	28	100	15.0	97	112	42	98	11.0	39	79	50	72	6.9
- met. energy (KJ)	944	1221	258	1072	164.5	887	1034	391	923	101.6	227	574	360	507	57.7
Digestibility (%):															
- dry matter	68.7	76.8	63.6	76.1	2.94	59.7	64.1	62.7	63.9	0.91	39.8	50.5	48.8	47.4	1.81
- organic matter	72.1	79.1	65.8	77.6	2.82	64.8	69.0	67.2	68.3	0.79	44.8	53.4	51.6	51.5	1.77
- AD fiber[2]	58.9	64.0	41.7	61.2	5.04	46.9	45.0	44.7	38.0	1.32	37.4	46.1	46.5	38.9	1.75
Liveweight changes	309	395	-210	383	112.9	321	259	-71	205	65.9	-259	-27	89	13	55.7

1. Standard error of difference.
2. Acid detergent fiber.

need to assess nutritional characteristics of major forage and pasture plants early in the evaluation process.--*E.F. Thomson.*

Proportion of Leaf and Straw Quality

Barley. The Cereal Crops Improvement Program is giving increasing attention to the selection of barley cultivars suitable for areas receiving less than 300 mm annual rainfall. As part of this research, PFLP is involved in sampling mature barley plants at Breda to investigate the influence of plant height and time to maturity on proportions of leaf blade and stem. Leaf proportion (blade + sheath) was very strongly influenced by stem length (Fig. 30), varying between 0.7 and 0.8 when stem length was 15 - 20 cm compared with 0.5 - 0.6 when stem length was 40 - 50 cm. Proportion of leaf blade was less than 0.3 in taller plants but was 0.5 - 0.6 in shorter plants (Fig. 30). Interestingly, the regression coefficient for changes in leaf blade proportion with stem length was higher (-0.01 versus -0.004) for material grown at Breda in 1985 compared with material grown at Tel Hadya in 1984. These results suggest that plant morphology is important in determining the nutritive value of different barley straws.

Similar results were obtained on straw from the traditional cultivars (landraces), Arabi Abiad (white) and Arabi Aswad (black), as can be seen from a comparison of Figs 30 and 31. Although Arabi Abiad was slightly shorter than Arabi Aswad (Table 35) they were otherwise very similar.

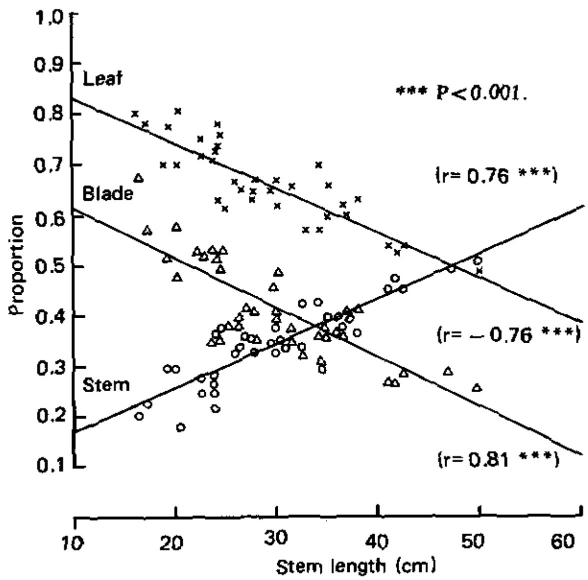


Fig. 30. Proportion of leaf (blade + sheath), leaf blade only, and stem in barley straw of F3 segregating populations at Breda, plotted against stem length.

Wheat. Previously unreported information from durum and bread wheat trials harvested in 1983 show that there is wide variation in straw quality (Table 36): straw from durum wheat may be superior to that of bread wheat. This question was studied by examining the proportion of leaf blade, leaf sheath, and stem in samples from three wheat trials conducted in 1984/85 (Table 37). Despite

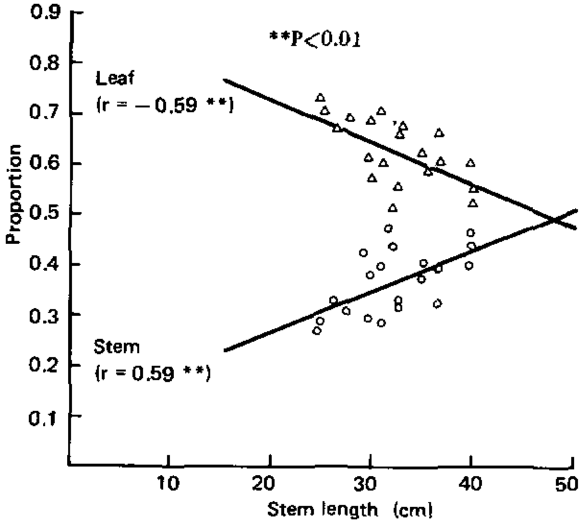


Fig. 31. Proportion of leaf and stem in barley straw of landraces at Breda, plotted against stem length.

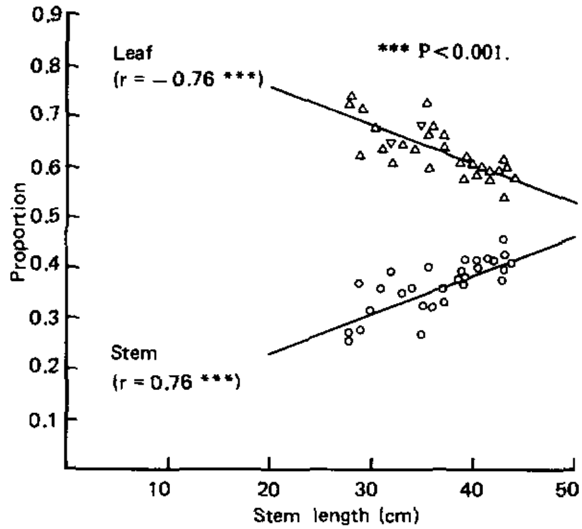


Fig. 32. Proportion of leaf and stem in the straw of 28 wheat cultivars grown at Tel Hadya, plotted against stem length.

being taller, durum wheat had similar leaf proportions compared with the bread wheats.

As has been consistently found in barley, the proportion of leaf in wheat is significantly influenced by stem length (Table 38 and Fig. 32). But, although stem diameter may influence leaf proportion, it is less important than length. An increase in the number of days to heading caused an increase in leaf proportion similar to that in barley. It appears that many of the principles of ICARDA's research with barley straw are also applicable to wheat straw.--*B.S. Capper (TDRI); S. Ceccarelli, M. Nachit, and G.O. Ferrara (Cereal Crops Improvement Program).*

Table 35. Comparison of morphology of barley varieties Arabi Abiad and Arabi Aswad at Breda.

	Arabi Abiad	Arabi Aswad
Stem length (cm)	31.7	32.9
Days to maturity	173.2	172.9
Proportion		
Total leaf	0.64	0.62
Leaf blade	0.41	0.37
Leaf sheath	0.23	0.25
Stem	0.36	0.38

Table 36. Variation in the nutritive value of wheat straw.

	Durum wheat			Bread wheat		
	Mean	SEM	Range	Mean	SEM	Range
Crude protein	2.7	0.06	2.4-3.2	2.2	0.17	1.9-2.7
D value[1]	36.1	0.29	34.4-37.6	30.9	0.51	27.1-35.5
Neutral detergent fiber (%)	78.0	0.31	75.1-80.6	78.6	1.17	76.5-80.1
Ash (%)	9.8	0.85	8.4-11.6	9.5	0.69	8.3-10.8

1. Digestible organic matter (g/100 g dry matter).

Table 37. Stem morphology and the proportion of leaf blade and sheath in wheat straw.

	Durum wheat[1]			Durum wheat[2]			Bread wheat[3]		
	Mean	SEM	Range	Mean	SEM	Range	Mean	SEM	Range
Stem length (cm)	52.0	1.27	41.2-63.2	52.2	1.12	38.8-61.4	36.8	0.94	28.0-44.1
Stem diameter (mm)	2.9	0.07	2.3-3.7	3.0	0.07	2.5-4.0	2.6	0.06	2.5-3.9
Proportion									
Total leaf	0.62	0.01	0.01-0.70	0.60	0.01	0.51-0.70	0.63	0.01	0.54-0.74
Leaf blade	0.43	0.01	0.27-0.52	0.40	0.01	0.30-0.54	0.37	0.01	0.30-0.49
Leaf sheath	0.19	0.005	0.15-0.26	0.20	0.01	0.15-0.30	0.26	0.003	0.22-0.29
Stem	0.38	0.01	0.30-0.50	0.40	0.01	0.32-0.49	0.37	0.01	0.26-0.46

Note: Materials produced by Cereal Crops Improvement Program, reference (1) Regional trial; (2) Rainfed trial; (3) CIMMYT.

Table 38. Correlation coefficients between genotype characteristics and leaf blade, leaf sheath, and stem proportions in elite bread wheat lines.

	Stem length (cm)	Stem diameter (cm)	Days to heading
Total leaf	-0.76***	-0.25	0.20
Leaf blade	-0.78***	-0.30	0.22
Leaf sheath	0.19	0.19	-0.08
Stem	0.76***	0.25	-0.20

*** P<0.001

Voluntary Intake and Digestibility of Barley Straw

Straw was obtained from seven barley cultivars which had been mechanically harvested at Tel Hadya at a cutting height of 15-20 cm. Arabi Abiad straw, harvested in a similar way, was purchased from a nearby farm. The straws were chopped to a length of 2.5 cm and each was fed for 28 days to four Awassi wethers housed in digestibility crates. Straw was offered at 20% above appetite levels without supplementation.

Voluntary feed intake (VFI) of straw varied significantly between barley cultivars so that considerable differences in daily ME supply were apparent (Table 39): intake of ME from Arabi Abiad straw was highest but C63 followed closely. Overall liveweight changes were not significantly different but animals on Arabi Abiad and C63 straw maintained liveweight without supplementation.

Correlation coefficients between the feeding values of straws and cultivar characteristics showed that intakes were higher in later-maturing cultivars (Table 40). A quadratic function described more precisely the relationship between the VFI of organic matter and days to maturity (Fig. 33). Improvement in intake was partly a result of a higher proportion of leaf since leaf material breaks down more rapidly in the rumen enabling the sheep to eat more. *In vitro* digestibility measured with cellulase indicated that leaf material from late maturing cultivars was more digestible.-*B.S. Capper (TDRI) and E.F. Thomson.*

Table 39. Feeding value of unsupplemented straw from eight cultivars of barley.

	Arar	ER/ Apam	Rihane 'S'	Arabi[1] Abiad	Beecher	Badia	C63	Antares	Sig.	SEM
Genotype characteristics										
Stem length (cm)	48.0	39.2	49.3		69.6	69.0	61.2	43.4		
Days to maturity	142	143	144		146	147	151	156		
Leaf proportion	0.62	0.63	0.65		0.53	0.54	0.69	0.64		
Digestibility										
Dry matter	44.5	42.9	45.3	46.5	42.6	40.4	43.0	40.6	*	0.47
Organic matter	47.7	45.8	47.7	49.8	45.2	43.0	45.7	43.5	ns	0.51
Intake ($g/W^{0.75}/day$)										
Dry matter	34.8	39.0	40.3	51.1	38.9	43.8	50.9	45.2	**	0.93
Organic matter	31.0	34.9	36.6	47.5	35.6	39.2	45.9	40.8	**	0.82
Digestible organic matter	14.7	15.9	17.4	23.7	16.1	17.0	21.0	17.8	*	0.50
Metabolizable energy (MJ/day)										
Supply	5.1	5.6	6.0	8.7	5.7	5.9	7.7	6.6	*	0.42
Maintenance requirement	7.5	7.6	7.4	7.9	7.7	7.6	7.9	8.0	ns	1.16
Liveweight change (g/day)	-142.9	-133.9	-107.2	+17.9	-107.1	-80.4	-8.9	-80.4	ns	16.3

1. Purchased, combine-harvested material.
ns, not significant; $*P<0.05$, $**P<0.01$.

Table 40. Correlation coefficients (r) between feeding value of barley straws and cultivar characteristics.

	Grain yield (kg/ha)	Straw yield (kg/ha)	Days to maturity	Stem length (cm)	Leaf proportion
Digestibility (%)					
Dry matter	-0.48	-0.64	-0.65	-0.28	0.40
Organic matter	-0.50	-0.68	-0.65	-0.35	0.42
Intake ($g/W^{0.75}/day$)					
Dry matter	-0.08	0.82*	0.77*	0.27	0.4
Organic matter	-0.11	0.82*	0.78*	0.27	0.3
Digestible organic matter	-0.27	0.71	0.65	0.23	0.5

$*P < 0.05$.

Effect of Barley Grain and Cottonseed Cake on Barley Straw Voluntary Intake and Digestion

Straw from four barley cultivars was offered to four Awassi wethers alone or supplemented with either barley grain, to supply energy, or cottonseed cake, to supply protein. Feeding periods lasted 28 days and supplements were fed each morning followed by straw offered at 20% above appetite. The digestibility of the two supplements was measured in separate trials and the straw digestibility calculated by difference.

Barley grain supplementation reduced the

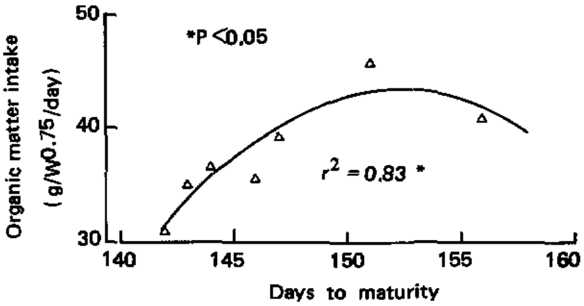


Fig. 33. Relationship between voluntary intake of barley straw, organic matter (OM), and number of days from sowing to maturity.

digestibility of Beecher, Badia, and C 63 straws but not ER/Apam (Table 41). There were substantially improved intakes of C63 and ER/Apam, which had leaf proportions of 0.63 and 0.69, respectively. Intakes of Beecher slightly increased and Badia slightly decreased, these cultivars having leaf proportions of 0.53 and 0.54, respectively. In contrast, cottonseed cake improved digestibility of 3 out of 4 straws. Intake was improved markedly for ER/Apam, Badia, and C63 straws but was less marked for Beecher.

The effects of supplementation on liveweight and the differences between varieties were significant. These results confirm that later maturing cultivars generally have better quality straw. However, supplementation with cottonseed cake improved the feeding value of straw from the early maturing cultivars ER/Apam. This, together with the results of supplementing straw from Badia, demonstrates the existence of cultivar x supplement interactions. Generally it appears better to supplement straws with cottonseed cake than with barley grain.--*B.S. Capper (TDRI) and E.F. Thomson.*

Future Straw Research

There is a global concern among livestock scientists that the breeding of cereals for increased yield and lodging-resistance may adversely affect the nutritive value of straw. It is considered that shorter, thicker, and stiffer stems would give straw of less value. However, research at ICARDA has shown that breeding for shorter material may actually improve straw value; stem diameter is not important and consumption of early-maturing cultivars appears to be lower. This can be partly explained by lower proportions of leaf blade and by structural or chemical factors which may influence rumen degradation. For example, variation in levels of certain phenolic compounds of low molecular weight, such as p-coumaric and ferulic acids, have been implicated in affecting straw digestion by rumen micro-organisms. The extent to which these substances vary in straws from different cultivars will be investigated.--*B.S. Capper (TDRI).*

Training

Training is considered an essential part of the Program's activities. It is a way by which our results can be put into practice and disseminated to other countries. The Program aims to improve technical skills for research in the subjects of pastures, forages, and livestock.

The following training was offered in 1984/85.

1. A residential course of 3 months duration (March-June).

2. Individual training for Junior Scientists.

Residential Course

The residential course took place at Tel Hadya where eight trainees from seven countries (Egypt, Ethiopia, Somalia, Syria, North Yemen, Pakistan, and China) participated. The syllabus focused on field and laboratory techniques for annual forage production and

Table 41. Influence of barley grain (BG) and cottonseed cake (CSC) supplementation on the feeding value of straw from contrasting barley cultivars.

	ER/Apam			Beecher			Badia			C63			Significane		
Type of supplement	**Nil**	**BG**	**CSC**	**Nil**	**BG**	**CSC**	**Nil**	**BG**	**CSC**	**Nil**	**BG**	**CSC**	***Cultivars***	***Supplementation***	***SEM***
Amount of supplement (g dry matter/day)		165.6	123.9		171.6	132.8		163.9	130.3		176.2	132.6			
Straw digestibility (%)															
Dry matter	42.9	42.9	46.2	42.6	40.8	42.9	40.4	35.3	43.7	43.0	40.6	42.6	**	***	0.39
Organic matter	45.8	45.7	49.1	45.2	43.6	45.9	43.0	37.7	46.8	45.7	43.5	45.1	**	***	0.41
Straw intake ($g/W^{0.75}/day$)[1]															
Dry matter	39.0	46.6	62.1	38.9	40.9	47.6	43.8	45.4	61.0	50.9	57.5	61.9	**	***	0.99
Organic matter	34.9	41.7	55.6	35.6	37.4	43.5	39.2	40.6	54.5	45.9	51.8	55.7	**	***	0.89
Digestible organic matter	15.9	18.9	27.3	16.1	16.3	20.0	17.0	15.7	25.5	21.0	22.5	25.1	**	***	0.48
Estimated metabolizable energy supply (MJ/day)															
Straw	5.6	6.9	9.8	5.7	5.9	7.2	5.9	5.5	9.4	7.7	8.4	9.5	**	***	0.22
Supplement		2.3	1.3		2.4	1.4		2.3	1.4		2.5	1.4			
Total	5.6	9.2	11.1	5.7	8.3	8.6	5.9	7.8	10.8	7.7	10.9	10.9			
Estimated ME requirement for maintenance (MJ/day)	7.6	7.7	7.7	7.7	7.7	8.0	7.6	7.4	8.0	7.9	8.1	8.2	ns	ns	0.15
Liveweight change (g/day)	-133.9	+17.9	+196.4	-107.1	+17.9	+98.2	-80.4	+80.4	+169.7	-8.9	+133.9	+232.2	*	***	12.0

1. Metabolic body weight where W = liveweight in kg.

ns, not significant, * $P<0.05$, ** $P<0.01$, *** $P<0.001$.

breeding, annual pastures, marginal land improvement, germplasm evaluation and utilization, microbiology, and livestock husbandry. Seventy-five percent of the time was devoted to practical work and 25% to lectures.

Each participant was assigned a small experiment and supervised by a senior scientist, taking into account the previous experience and background of the trainee and his country's needs. This gave the trainee experience in planning, conducting, analysing, and reporting experimental work. Details are given in Table 42.

Individual Training

Seven junior scientists were trained individually, the duration of their training varying from 2 weeks to 9 months. They worked closely with senior scientists on subjects relevant to research in their national programs.

Two research assistants from the Syrian Agricultural Research Centre (ARC) were trained in the screening of annual forage legumes for disease resistance. One from the Steppe and Range Directorate received 1 month's training on survey techniques for the natural vegetation of marginal land.

Another scientist from the Steppe and Range Directorate and one from the Pakistan Agricultural Research Council were trained for 9 months (November 1984-July 1985). Their training focused on experimental sheep flocks, livestock on-farm trials, keeping records and their analysis, and reporting feeding experiments.

Table 42. Experiments assigned to 1985 residential course participants.

Name of trainee	Country	Title of experiment	Supervisor
Adel Ismaeil El Daly	Egypt	Determination of residual seeds of certain annual *Medicago* spp. in medic-cereal rotation	Dr P.S. Cocks
Tedese Tsadik	Ethiopia	Isolation of rhizobia and plant inoculation	Dr Luis Materon
Mohamed Muffareh	N. Yemen	Response of marginal land to superphosphate application	Dr A. Osman
Khadija Mahdi	Somalia	Effect of seed size and seed rate on agronomic characters of forage vetch	Dr Ali Abd El Moneim
Basam Mawlawi	Syria	Selection criteria for forage vetch	Dr Ali Abd El Moneim
Ihtisham Ali Sayed	Pakistan	Effect of seed size and seed rate on herbage and seed yield of forage pea	Dr Ali Abd El Moneim
Ghen Guxiand	China	Forage pea germplasm evaluation	Dr Ali Abd El Moneim
Zhou Lixia	China	Evaluation of annual forages for frost-tolerance	Dr Ali Abd El Moneim

One young scientist from Tanzania was trained on marginal land evaluation and improvement for a period of 7 months (January-July 1985). His training focused on the effect of superphosphate on pasture productivity, with special emphasis on indigenous legumes.

From Nepal, a trainee received instruction on annual forage production (February - April 1985). His training focused on agronomic characteristics of forage legumes and the determination of yield and its components.

Former trainees were included in the mailing list for relevant publications and were provided with seeds for use in their own countries. Results are fed back to ICARDA. The Program's Training Scientist and senior scientists try to visit the former trainees in their home countries when on official business. In these ways trainees maintain contact with the Program, and the success of their training can be evaluated.--*Ali Abd El Moneim.*

References

Baslow, N.D. 1985. New Zealand Journal of Experimental Agriculture 13: 5-12.

Biswell, H.H., and Graham, C.A. 1956. Plant counts and seed production on California annual-type range. Journal of Range Management 9: 116-118.

Eberhart, S.A., and Russel, W.A. 1966. Stability parameters for comparing varieties. Crop Science 6: 36-40.

Finlay, K.W., and Wilkinson, G.N. 1963. The analysis of adaptation in a plant-breeding programme. *Australian Journal* of Agricultural Research 14: 742-754.

Kernick, M.D. 1978. Ecological management of arid and semid-arid rangeland in Africa and the Near and Middle East. Vol. IV, FAO, Rome, Italy.

Miller, P.A. Williams, J.C., and Robinson, H.F. 1959. Variety x environment interactions in cotton variety tests and their implications on testing methods. Agronomy Journal 51: 132-134.

Rovira, A.D. 1980. Soil-borne diseases of field crops and pastures associated with dryland farming. Pages 546-580 *in* Proceedings of International Congress on Dryland Farming, Adelaide, South Australia. South Department of Agriculture, Adelaide, Australia.

White, J., and Harper, J.L. 1970. Journal of Ecology 58: 467.

Publications

Journal Articles

Abd El Moneim, M.A., and Cocks, P.S. 1986. Adaptation of *Medicago rigidula* to a cereal-pasture rotation in north west Syria. Journal of Agricultural Science, Cambridge. (In press.)

Capper, B.S., Mekni, M., Rihawi, S., Thomson, E.F. and Jenkins, G. 1985. Observations on barley straw quality. Animal Production 40(3), 569 (Abstract).

Capper, B.S., Thomson, E.F., Rihawi, S., Termanini, A. and MaCrae, R. 1985. The feeding value of straw from different genotypes of barley when fed to Awassi wethers. Animal Production 42:337-342.

Smith, A., and Allcock, P.J. 1985. The influence of species diversity on sward yield and quality. *Journal of Applied* Ecology 22: 185-198.

Smith, A., and Allcock, P.J. 1985. Influence of age and year of growth on the botanical composition and productivity of swards. Journal of Agricultural Science, Cambridge, 105: 299-325.

Conference/Workshop Papers

Bahhady, A.F. 1984. Methods of sheep breeding and their development possibilities in Syria. *In* Proceedings of the FAO Expert Consultation on Small Ruminant Research and Development in the Near East. 23-27 October 1985, Tunis, Tunisia.

Bahhady, A.F. 1985. The potential for increasing small ruminant production in the Near East. *In* Proceedings of the FAO Expert Consultation on Increasing Small Ruminant Production. 8-12 July 1985, Sofia, Bulgaria.

Capper, B.S., Rihawi, S., Mekni, M.S. and Thomson, E.F. 1985. Factors affecting the nutritive value of barley straw for Awassi sheep. Pages 842-844 *in* proceedings of the 3rd Animal Science Congress, Asia-Australasian Association of Animal Production Societies, Seoul, Korea.

Capper, B.S., Rihawi, S., Termanini, A., Maskall, C.S., Jenkins, G., Mekni, M.S. and Thomson, E.F. 1985. Grazing, environmental and genotypic influences on barley determining feeding value of straw for Awassi sheep. *In* Proceedings of the First International Conference on Animal Production in Arid Zones. (Awa, O., ed.). ACSAD, Damascus, Syria. (In press.)

Cocks, P.S. 1985. Integration of cereal/livestock production in the farming systems of north Syria. Workshop on Potentials of Forage Legumes in Farming Systems of sub-Saharan Africa, Addis Ababa (also published as PFLP Internal Document No. 1).

Cocks, P.S. 1985. The role of annual medics in Syrian farming systems. *In* proceedings of Science Week, Damascus (also published as PFLP Internal Document No. 2).

Cocks, P.S. 1985. Selection of improved pasture and forage species at ICARDA. *In* proceedings of Expert Consultation on Rangeland Rehabilitation and Development in the Near East, FAO (also published as PFLP Internal Document No. 4).

Osman, A.E. 1985. Forage production: a step towards better management of arid and semi-arid rangelands in countries of north Africa and west Asia. *in* proceedings of the First International Conference on Range Management in the Arabian Gulf, Kuwait (also published as PFLP Internal Document No. 6).

Osman, A.E. and Nersoyan, N. 1985. Annual legumes for integrating rainfed crop and livestock production. *In* proceedings of the International Grassland Congress Kyoto, Japan. (In press.)

Thomson, E.F. 1985. Impact of management and health factors on sheep production in semi-arid zones. Pages 410-411 *In* proceedings of 36th Annual Meeting of the European Association for Animal Production, Thessaloniki, Greece. Conference Summaries.

Thomson, E.F., Jaubert, R. and Oglah, M. 1985. On-farm comparisons of milk yield of Awassi ewes grazing introduced forages and communal village lands in the barley zone of NW Syria. *In* proceedings of the First International Conference on Animal Production in Arid Zones. (Awa, O., ed.). ACSAD, Damascus, Syria. In Press (also published as PFLP Internal Document No. 3).

Tully, D., Thomson, E.F., Jaubert, R., and Nordblom, T.L. 1985. On-farm trials in north western Syria: testing the feasibility of annual forage legumes as grazing and as conserved feed. Pages 209-236 in proceedings of the IDRC/ ICARDA Workshop on Livestock On-Farm Trials. (Nordblom, T. L., Ahmed, A.K. and Potts, G.R., eds). International Development Research Center, Ottawa, Canada.

GENETIC RESOURCES

ICARDA Annual Report 1985

INTERNATIONAL CENTER FOR AGRICULTURAL
RESEARCH IN THE DRY AREAS (ICARDA)
Box 5466, Aleppo, Syria

Contents

GENETIC RESOURCES

The Genetic Resources Unit (GRU) was established to safeguard and make available for crop improvement purposes, the genetic variability of those crop species which are of interest to the Center.

To achieve its objectives, the GRU is actively pursuing a vigorous program of exploration, collection, conservation, characterization, evaluation, documentation, and distribution of the germplasm of these crops. The GRU also conducts short training courses on all aspects of germplasm activities and deploys a portion of its resources to germplasm research.

A seed health laboratory forms part of the Unit, to protect against the accidental spread of seed-borne diseases and pests as a result of the movement of germplasm or breeders' materials. More recently, a virology section was established (February 1985) in the GRU to (a) study the incidence of virus diseases, (b) develop methods of control (or prevention) based on ecological and epidemiological studies, (c) develop methods of screening, and (d) establish methods for seed testing for virus infections.

In 1984/85, germplasm rejuvenation, evaluation, documentation, and conservation were again accorded high priority in the program as specified in the 5-year work plan developed in 1983/84. Significant progress was also made in enlarging the germplasm stocks by collecting geographically and genotypically representative germplasm of ICARDA's mandate crops. Genetic resources research and training activities, although very important, were restricted because of the limited resources available for germplasm work.

As a result of germplasm collecting expeditions conducted in Egypt, Jordan, Pakistan, Turkey and Syria, a total of 1593 new entries were added to the genebank. Staff in the GRU multiplied and evaluated 6158 accessions of barley and 562 entries of medics. Also, a total of 5510 accessions of durum wheat entries was evaluated by the Cereal Improvement Program. The documentation of genetic resources information maintained its momentum. Additional passport descriptors were assigned to as many as 16306 germplasm entries and all the evaluation data generated for 6158 accessions of barley, 4000 of durum wheat, 3341 of chickpeas, 482 of lentils, and 562 of medics have been added to the genetic resources data base.

Genetic resources-related research continued in 1984/85 to provide the information needed to establish effective guidelines for collecting strategies and for rationalizing the germplasm collections. Experiments were conducted using polyacrylamide gel electrophoresis to determine the potential of this technique to differentiate between accessions within the lentil collection and within the faba bean collection and to identify marker genes which might be associated with resistance to ascochyta blight in chickpeas. Provisional results from these investigations are encouraging and further work will be carried out using electrophoresis and protein banding.

A detailed evaluation was conducted on 22 durum wheat landraces and varieties from Greece and it suggests that a determined effort should be made to acquire and utilize similar germplasm material from that country.

The combined efforts of GRU and PFLP, together with support from IBPGR in the form of a research fellowship, were employed in a project to investigate the natural distribution and ecology of forage legumes native to Syria. The project is now nearing completion. About 3000 accessions of forage legumes were collected from the most important areas in Syria where legumes grow. A technique known as modal block classification was used to group collection sites according to climate and soil. The distribution pattern of annual *Medicago* species (medics) and their ecological interrelationships were studied to define ecological groups. Similar analyses are in progress for *Trifolium* and other genera.

Training of regional scientists and technicians in genetic resources work was limited by the lack of staff and resources. Individual short-term training was given to three participants, one each from Egypt, Tunisia, and Ethiopia.

New Germplasm in 1984/1985

Most of the germplasm collection at ICARDA has come from other centers and institutes and by direct exchange with scientists. These provide the basic material for the ICARDA crop improvement programs to develop cultivars and breeding lines. Additional variability is required if the crop improvement programs are to continue to make an impact. Based on available passport information, the specified requirements of plant breeders at ICARDA, and taking into account genetic erosion, priorities for germplasm collection were established in a 5-year work program for the GRU in 1983. Special importance was given to the collection of germplasm in North Africa and the Near East countries to fill both genetic and geographic gaps in the collections. In 1984/85, staff members of the GRU cooperated with national organizations and other scientists and conducted collecting missions in Pakistan, Turkey, Jordan, Egypt, and Syria.

Food legume germplasm from Pakistan is poorly represented in ICARDA's collection. The rate of genetic erosion is considered severe in most parts of the country because of the high frequency of ascochyta blight epidemics and the spread of introduced cultivars. The main aim of a joint mission with the Plant Genetic Resources Laboratory of the Pakistan Agricultural Council was to obtain samples of kabuli chickpea which represent the range of genetic variation in the local populations. During this expedition in April 1985, over 4000 kilometers were travelled. As many as 120 sites were sampled in Sind and Punjab provinces which were not covered by earlier missions. A total of 356 samples were collected, consisting of chickpea (259), lentil (57), *Lathyrus* (14), *Vigna* (6), and some cereals (20). Most of the chickpea samples were kabuli type.

Food legume germplasm was collected in a joint mission organized by the Aegean Regional Agricultural Research Institute (ARARI), Izmir, and the USDA Plant Germplasm Introduction Center, Pullman. Turkey represents a unique source of food legume germplasm because the southeastern part of the country is considered to be the center of origin of chickpea and lentil. Many of the wild species closely related to cultivated lentil and chickpea also occur in certain parts of the country. The main aims of the expedition were (1) to obtain additional sources of ascochyta blight resistance and cold tolerance in chickpea and lentil, and (2) to collect their wild relatives in southeast Turkey and the Central Anatolian Plateau. A staff member of GRU participated in the expedition, and collected 232 germplasm samples from 112 sites located mainly in the Central Anatolian Plateau. The materials collected include chickpea (109), lentil (48), cultivated *Vicia* and *Lathyrus* (28), and different wild legumes (47). Seven samples of *Lens orientalis* and *L.nigricans* were found but no wild *Cicer* species were discovered.

Jordan is an important source of wheat and barley germplasm. Wild relatives of wheat, especially *Triticum dicoccoides*, which are found in Jordan and southern Syria are considered to be an important source of drought tolerance. In May 1985, a short mission was conducted in Jordan in collaboration with a scientist from Yarmouk University, Jordan, and another scientist from the University of Saskatchewan, Canada, to explore and collect cereal germplasm in the northwestern part of the country. A total of 54 samples were obtained from local populations of barley and wheat and their wild relatives.

During the initial stage of a joint project between the PFLP, and the Desert Institute of Cairo, scientists from the GRU, PFLP, and the Desert Institute collected forage germplasm in Egypt. Forage legume germplasm from Egypt, (except *Trifolium alexandrinum* and *Pisum* species) are of considerable importance because of their poor representation in existing collections at ICARDA and elsewhere. During 2 weeks in May, over 50 sites were surveyed to explore and collect annual legumes growing on marginal lands. A total of 140 samples were collected from 30 sites in the northeast coastal area (Sinai, annual rainfall 100-150mm, sandy soils), the Jebel Maghara (Sinai, hilly area, stony "hammada" soils, and very low rainfall), and in the northwestern coastal belt between Alexandria and Marsa Matruh (annual rainfall 60-150mm, very saline soils). These samples include *Astragalus* spp. (24), *Coronilla* sp. (5), *Hippocrepis* spp. (14), *Hymenocarpus* sp. (2), *Lens culinaris* (2), *Lotus* spp. (17), *Medicago* spp. (32), *Melilotus* sp. (1), *Onobrychis* sp. (1), *Scorpiurus* sp. (6), *Trifolium* spp. (17), *Trigonella* spp. (12), and *Vicia* spp. (2).

In the north, northeastern, and southern parts of Syria, the GRU and PFLP jointly collected a total of 865 samples of different legume species. This material forms part of the germplasm collected during an ecogeographic survey of annual forage and pasture legumes in Syria. The most important genera collected were *Trifolium*, *Medicago*, *Onobrychis*, *Trigonella*, *Astragalus*, *Hypocrepis*, *Hymenocarpus*, *Scorpiurus*, *Coronilla*, and *Vicia*.

A substantial portion of the new germplasm materials was collected from very dry habitats, some with varying levels of soil salinity. Some of the food legume germplasm obtained from Turkey were sampled from high-altitude areas. Ascochyta blight infection was only mild or sometimes completely absent in some of the chickpea fields sampled in Turkey. Altogether, the germplasm obtained during these missions represents valuable genetic resource materials for the improvement of ICARDA's mandate crops. All the material will be multiplied during the 1985/86 season to obtain sufficient seeds for detailed evaluation and conservation.

In addition to field expeditions, passport information on existing collections at other institutes, were requested and obtained by the GRU. This resulted in a number of accessions being added to the Center's collection through exchange from other genebanks and scientific institutions. Altogether, 4488 new samples from 15 countries were added to the ICARDA germplasm collection (Table 1).

Germplasm Evaluation

The characterization and evaluation of germplasm are important for its effective utilization by plant breeders and other scientists. In 1984/85, the appraisal of germplasm accessions was carried out as in the previous year to obtain morphological and agronomic data on individual accessions.

The GRU continued to evaluate and document the barley germplasm collection. An additional 6158 accessions were evaluated for 25 quantitative and qualitative traits recommended in the IBPGR descriptor list (AGPG.IBPGR/82/49). The total number of barley accessions evaluated and documented to date has increased to 14215.

Complete evaluation and passport information has been documented for the first 8000 accessions. The evaluation data were, statistically analyzed and the first volume of

Table 1. Country of origin and number of new germplasm accessions.

	Cereals			Food legumes			Forages		
Country	**Barley**	**Durum wheat**	**Bread wheat**	**Lentil**	**Chickpea**	**Faba bean**	**Medics**	***Trifolium* spp.**	**Other species**
Argentina.				3					
Australia							111	58	12
Bangladesh				1					
Cyprus									31
Ethiopia				79			43		
France					5				
Greece		32							
Italy		2568							
Jordan	29	5	4	9	1				
Morocco									1
Pakistan	12			57	189				
Romania				1		10			
Soviet Union				22	38				
Syria				93	191		150	67	73
Turkey	9	5	404	50	110	13			2
Total	50	2610	408	315	534	23	304	125	119

a barley germplasm catalog has been prepared for publication.

The evaluation data were summarized in the catalog for two- and six-row barleys, for different growth classes and for different years. Histograms showing the range and frequency distribution of different characters, were prepared to illustrate the genetic diversity available. The evaluation data were analyzed, by country of origin, and the means for each character, with appropriate measures of variance (Table 2), were printed in the catalog. Table 2 shows the geographic distribution of the genetic variation for seven traits. This information helps to identify the most probable sources of some desirable traits. For example, Colombia, Pakistan, and South Africa are potentially good sources of barley germplasm that is early flowering and early maturing; germplasm with high protein content could be obtained from Ethiopia and Japan.

A correlation matrix (Table 3), also included in the catalog, shows the relationships between selected characters. Plant height is strongly correlated with days to maturity and lodging. Days to heading is associated with days to maturity, growth habit, and with growth class. On the other hand, no correlation is observed for some economically important characters. No relationship appears to exist between protein content and kernel size or between spikelet groups per spike and spike density. The correlation matrix table can assist the breeder to select germplasm with specific

Table 2. Means and standard deviations according to country of origin for seven traits in 8000 barley accessions.

Origin	Spikelet groups/spike		Days to heading		Protein percentage		Days to maturity		Plant height		Lysine/ protein		1000 Seed weight	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Afghanistan	23	0.75	132.29	0.89	12.48	0.20	161.37	0.93	44.71	0.71	3.92	0.08	33.08	0.80
Austria	26	1.08	134.29	1.00	13.81	0.37	166.04	1.78	58.57	2.86	3.71	0.05	36.31	1.09
Bulgaria	21	0.47	154.65	1.38	12.07	0.16	194.19	0.43	96.15	1.19	3.71	0.03	32.67	0.74
Canada	23	0.35	134.52	1.00	11.41	0.11	187.46	0.75	87.11	1.32	3.70	0.02	34.45	0.42
Switzerland	28	0.18	134.41	0.30	14.45	0.08	163.38	0.23	52.98	0.28	3.71	0.01	35.98	0.23
China	25	1.09	130.95	2.53	12.56	0.27	173.05	3.94	81.32	4.42	3.84	0.06	32.97	1.59
Colombia	19	0.13	124.53	0.21	12.01	0.07	155.72	0.15	51.24	0.33	4.01	0.01	34.49	0.13
Ethiopia	21	0.09	127.40	0.13	14.31	0.03	160.30	0.18	54.51	0.26	3.68	0.00	41.05	0.11
Germany	25	0.17	136.33	0.27	11.87	0.05	188.03	0.23	92.63	0.51	3.88	0.01	38.38	0.24
Japan	24	0.57	128.50	1.13	14.45	0.16	161.21	0.96	39.40	1.77	3.49	0.02	31.68	1.07
Morocco	18	0.25	132.18	0.80	11.83	0.15	162.24	0.72	52.13	1.07	4.01	0.03	41.20	0.55
Pakistan	22	0.36	122.84	0.68	11.98	0.12	152.01	0.39	55.77	0.98	3.86	0.03	25.88	0.54
Soviet Union	25	0.27	144.36	0.59	11.96	0.08	183.56	0.85	81.97	1.44	3.74	0.01	38.49	0.40
Tunisia	19	0.43	128.52	0.34	10.71	0.09	185.84	0.30	75.10	1.16	3.60	0.02	37.30	0.49
Turkey	24	0.15	139.22	0.32	11.73	0.04	183.02	0.43	77.64	0.71	3.88	0.01	40.12	0.21
United States	24	0.13	140.23	0.29	12.42	0.05	189.70	0.16	92.55	0.52	3.69	0.01	34.64	0.29
Yugoslavia	22	0.33	143.02	0.57	12.36	0.11	178.33	0.73	71.39	1.27	3.83	0.02	35.57	0.42
South Africa	23	0.29	124.99	0.36	12.54	0.10	156.18	0.24	51.39	0.45	3.87	0.02	42.60	0.33
Overall	23	4.93	133.12	9.79	12.99	1.89	171.27	15.6	67.17	22.1	3.77	0.26	37.97	6.81
F. Value	146.14		307.67		266.47		1142.6		627.38		104.31		36.987	

Table 3. Correlation matrix between some characters of 8000 barley germplasms.

	GCL	RNO	RHL	SDE	DHE	DMA	PLH	SGS	KWT	PRO	LYS/ PRO	LOD
GHA	-0.56	-0.22	-0.08	0.20	0.53	0.30	0.19	0.08	-0.13	-0.17	0.08	-0.01
GCL		0.24	0.08	-0.16	-0.66	-0.50	-0.35	-0.02	0.21	0.21	-0.06	-0.06
RNO			0.11	-0.48	-0.14	-0.20	-0.17	0.41	0.42	0.37	-0.28	-0.07
RHL				0.05	-0.09	0.01	0.01	0.21	-0.03	-0.07	-0.04	0.10
SDE					0.21	0.24	0.15	-0.01	-0.16	-0.22	0.13	0.07
DHE						0.66	0.42	0.51	-0.12	-0.13	-0.01	0.08
DMA							0.83	0.25	-0.03	-0.35	-0.04	0.52
PLH								0.28	0.04	-0.37	-0.01	0.53
SGS									0.09	0.04	-0.19	0.11
KWT										0.14	-0.12	0.05
PRO											-0.70	-0.34
LYS/PRO												0.11

GHA	Growth habit	PLH	Plant height (cm)
GCL	Growth class	SGS	Spikelet groups/spike
RNO	Row number	KWT	1000 kernel weight (g)
RHL	Rachilla hair length	PRO	Protein (%)
SDE	Spike density	LYS/PRO	Lysine/protein ratio
DHE	Days to heading	LOD	Resistance to lodging
DMA	Days to maturity		

combinations of traits required for a barley breeding program.

In 1984/85, durum wheat germplasm was evaluated by the Cereal Improvement Program. A total of 2941 accessions were evaluated for 18 characters. A further 2569 durum wheat accessions from the Germplasm Institute at Bari, Italy, were evaluated for 25 characters with the support of the Italian Government.

In addition to the 627 annual medics accessions of 7 species (*M. aculeata, M. blancheana, M. noena, M. radiata, M. rotata,* *M.scutellata*, and *M.turbinata*) which were evaluated in the 1983/84 season, 562 *Medicago rigidula* accessions of 4 varieties were screened for 17 characters last year. The characters evaluated in the field included number of days to flower, 50% flowering, growth habit, length of five randomly chosen branches, number of secondary branches per plant, number of tertiary branches per plant, number of pods per inflorescence, and reaction to frost. The exceptionally cold winter allowed the evaluation of the accessions for frost resistance. Data were obtained in the laboratory on secondary branching, tertiary branching, length of the longest branch, internode length, number of nodes to the first flower, petiole length, leaf area, 100-pod weight, number of seeds/100 pods, seed weight/100 pods, and 1000-seed weight.

The data obtained in the 2 years have been statistically analyzed. A wide range of variation was observed within and between the seven species of medics for the traits studied (Table 4). Selection for pasture plants based on the genetic diversity inherent in these species, would favor *M.noeana*. The mean values of the vegetative traits are as high as, or higher than, the values obtained for the other species. *M.radiata*, on the other hand, does not stand out as a highly desirable species. *M.aculeata*, *M.blancheana*, *M.rotata*, *M.scutellata*, and *M. turbinata* are better seed producers and have better pod and seed characteristics than *M.noeana* and *M.radiata*. *M. scutellata* is the only tetraploid species and this is reflected in the large leaf area and increased seed size noted in this species. These data could complement additional information on regrowth characteristics, ability to withstand grazing, regeneration characteristics, and stress resistance to enable the pasture specialist to identify and select desirable germplasm material.

Also, the analyses of the evaluation data generated in 1984/85 indicated that there are differences in some of the quantitative traits studied in the four botanical varieties of *M.rigidula*. A comparison of the minimum, maximum, and mean values obtained for the descriptors suggests that accessions of *M.rigidula* var *agrestis* have a broad range of variability (Table 5).

Germplasm Documentation

For accessions in any collection to be useful to breeders, as much information as possible must be made available concerning the samples and their genetic characteristics. The documentation of both passport and evaluation information using a computerized data base system, enables the breeder to fully exploit the genetic diversity inherent in a germplasm collection. Such a data base system can also assist in the identification of duplicate entries and geographic gaps in collections.

In 1984/85, passport information for 12138 barley, 2075 food legume, and 446 forage accessions was added to the data bank. Collection information for 1647 recently collected germplasm samples was also recorded on magnetic tapes (Table 6).

Effort has also been made to collect and record reliable information on the characteristics of germplasm accessions of ICARDA's genetic resources collections. In 1984/85, evaluation data on 6158 barley accessions (24 descriptors), 4000 durum wheat accessions (22), 3341 chickpea entries (4), 482 lentil entries (12), and 562 annual *Medicago* (medics) entries (17 descriptors) were documented and added to the genetic resources data base (Table 7).

The passport information and evaluation data already recorded for 6158 barley accessions will be analyzed statistically to produce a second volume of a barley germplasm catalog. Also, the data obtained from the evaluation studies on 627 accessions of medics in 1983/84, and 562 accessions of *Medicago rigidula* in 1984/85 have been processed and analyzed for a medics germplasm catalog (Tables 4 and 5). These catalogs will be

Table 4. Minimum, maximum, mean, and standard deviation for 15 characters in seven species of medics, 1983/1984.

	M. aculeata				*M. blancheana*			
Characters	**Min.**	**Max.**	**Mean**	**SD**	**Min.**	**Max.**	**Mean**	**SD**
Days to flower (50%)	97.0	137.0	111.2	7.849	98.0	130.0	120.0	5.851
No of branches/plant	3.2	8.6	5.4	1.228	1.2	8.6	5.1	1.411
Length of random branches (cm)	7.0	52.1	19.1	7.573	17.0	58.1	36.3	9.187
Length of longest branch (cm)	9.4	53.5	24.3	7.963	20.1	63.4	41.5	8.800
Internode length (cm)	1.6	6.0	3.4	0.885	1.9	5.8	4.3	0.774
No of nodes to 1st flower	1.6	12.0	5.1	1.369	5.0	11.6	8.0	1.359
No of pods/inflorescence	1.0	2.6	1.2	0.241	1.0	2.6	1.6	0.362
Petiole length (cm)	0.4	2.9	1.3	0.382	0.4	1.4	1.0	0.250
Leaf area (cm^2)	8.6	44.3	22.4	6.990	13.3	38.3	23.4	6.318
Vigor	1.0	4.0	2.7	0.593	1.0	4.0	3.0	0.599
100-pod weight (g)	*5.6*	*34.7*	*20.1*	*5.168*	5.7	*20.1*	15.0	2.846
Seed weight/100 pods (g)	1.8	11.4	5.1	1.240	1.3	6.3	4.4	0.840
Seed no/100 pods	435.0	842.0	612.4	60.256	358.0	798.0	670.0	75.792
Seed weight (g)	2.0	209.0	81.3	38.086	0.7	212.0	101.6	54.666
1000-seed weight (g)	2.9	12.8	8.7	1.708	4.0	8.8	6.6	1.033

	M. noeana				*M. radiata*			
Characters	**Min.**	**Max.**	**Mean**	**SD**	**Min.**	**Max.**	**Mean**	**SD**
Days to flower (50%)	114.0	131.0	124.4	3.907	102.0	139.0	122.0	8.616
No of branches/plant	4.2	9.4	6.2	1.221	2.2	9.2	5.1	1.385
Length of random branches (cm)	10.8	55.7	40.4	9.145	8.4	35.7	21.0	6.577
Length of longest branch (cm)	13.8	58.5	42.1	8.580	12.4	37.6	22.4	6.368
Internode length (cm)	2.4	8.7	5.6	1.027	1.0	4.6	2.7	0.791
No of nodes to 1st flower	3.8	8.6	6.4	1.162	2.8	7.8	5.6	0.903
No of pods/inflorescence	1.2	4.4	2.4	0.705	1.0	3.6	1.8	0.562
Petiole length (cm)	0.6	1.9	1.3	0.265	0.4	1.5	0.9	0.259
Leaf area (cm^2)	11.8	30.4	21.9	4.182	6.1	18.6	12.0	2.614
Vigor	1.0	4.0	3.3	0.624	1.0	3.0	2.2	0.591
100-pod weight (g)	2.6	5.5	4.0	0.663	1.0	5.9	2.9	1.029
Seed weight/100 pods (g)	0.8	1.7	1.2	0.226	0.3	3.2	1.4	0.607
Seed no/100 pods	309.0	524.0	401.2	47.953	249.0	602.0	412.9	76.978
Seed weight (g)	24.0	169.0	75.5	32.921	3.0	144.0	63.3	41.090
1000-seed weight (g)	2.6	4.2	3.2	0.359	1.4	6.1	3.3	0.995

Table 4. (*Cont'd*).

Characters	*M. rotata* Min.	Max.	Mean	SD	*M. scutellata* Min.	Max.	Mean	SD	*M. turbinata* Min.	Max.	Mean	SD
Days to flower (50%)	102.0	132.0	114.1	6.948	104.0	131.0	116.8	7.730	98.0	139.0	117.2	8.723
No of branches/plant	3.4	8.0	5.3	0.941	2.4	9.2	3.9	1.340	2.8	7.6	4.7	1.023
Length of random branches (cm)	13.0	52.9	26.5	8.641	11.1	49.5	24.7	11.388	6.3	60.4	29.0	13.624
Length of longest branch (cm)	18.0	59.2	32.4	7.814	14.3	55.4	27.6	9.923	11.0	53.8	30.7	9.759
Internode length (cm)	1.5	5.9	3.7	0.888	1.9	5.2	3.4	0.812	2.1	8.6	4.9	1.529
No of nodes to 1st flower	5.0	9.2	7.0	1.081	3.2	7.2	5.1	1.165	2.8	8.0	5.3	1.228
No of pods/inflorescence	1.4	5.0	2.7	0.875	1.0	2.0	1.4	0.255	1.0	4.0	2.2	0.696
Petiole length (cm)	0.3	2.1	1.1	0.379	0.9	2.7	1.9	0.402	0.3	2.8	1.5	0.600
Leaf area (cm^2)	11.2	42.1	20.8	5.960	13.4	45.4	28.7	6.514	9.5	38.8	23.1	6.114
Vigor	2.0	4.0	3.1	0.569	1.0	4.0	2.4	0.638	1.0	4.0	2.6	0.852
100-pod weight (g)	4.0	17.8	8.8	3.470	10.1	29.0	18.6	3.973	3.8	13.8	8.2	2.292
Seed weight/100 pods (g)	1.5	7.1	3.4	1.257	3.0	9.3	5.6	1.418	1.2	3.8	2.0	0.468
Seed no/100 pods	351.0	891.0	552.6	120.406	341.0	542.0	425.9	48.023	346.0	725.0	484.5	84.570
Seed weight (g)	20.0	262.0	118.6	58.491	0.9	71.0	26.6	16.290	3.0	107.0	49.4	30.342
1000-seed weight (g)	3.9	8.9	6.2	1.257	6.9	20.1	12.9	2.452	2.2	10.0	4.6	1.302

Table 5. Minimum, maximum, mean, and standard deviation for 12 characters in four subspecies of *M. rigidula*, 1984/85.

Characters	*M. rigidula* var. *agrestis* Min.	Max.	Mean	SD	*M. rigidula* var. *cinerascens* Min.	Max.	Mean	SD	*M. rigidula* var. *rigidula* Min.	Max.	Mean	SD	*M. rigidula* var. *submitis* Min.	Max.	Mean	SD
Days to flower (50%)	121.0	143.0	128.4	5.397	121.0	155.0	30.8	7.761	122.0	149.0	129.1	6.775	122.0	150.0	128.8	5.463
No of branches/plant	2.0	7.8	4.6	1.398	2.6	7.2	4.8	1.080	3.0	6.4	4.5	0.935	2.8	6.8	4.5	1.017
Length of random branches (cm)	8.0	48.9	21.8	8.049	8.2	40.1	20.1	7.672	10.7	27.6	19.1	5.372	10.9	47.5	26.2	8.331
Length of longest branch (cm)	10.2	57.8	30.0	9.828	10.9	48.0	28.5	9.924	17.0	54.3	29.7	9.719	14.2	63.3	35.9	10.443
Internode length (cm)	1.4	5.9	3.3	0.954	1.6	5.5	3.1	1.021	2.0	5.9	3.1	0.884	1.6	5.7	3.9	1.030
No of nodes to 1st flower	1.9	7.6	4.4	1.181	2.2	7.8	4.4	1.500	2.2	8.0	4.6	1.499	1.8	7.0	4.4	1.256
No of pods/inflorescence	1.0	2.6	1.3	0.341	1.0	2.6	1.3	0.411	1.0	2.2	1.2	0.283	1.0	2.4	1.3	0.299
Petiole length (cm)	0.3	1.2	0.7	0.171	0.3	1.0	0.6	0.159	0.3	1.0	0.6	0.154	0.3	0.9	0.6	0.142
Leaf area (cm^2)	3.9	13.2	8.2	1.903	4.9	12.6	8.4	1.790	5.4	11.4	8.3	1.623	4.5	16.9	8.9	2.293
100-pod weight (g)	5.7	28.7	14.1	3.996	4.9	22.4	12.1	3.866	8.4	18.2	12.8	2.981	5.7	29.1	12.7	4.791
Seed no/100 pods	483.0	081.0	825.6	113.776	438.0	998.0	93.3 1	42.477	514.0	1019.0	796.7	145.333	538.0	992.0	692.4	106.356
Seed weight/100 pods (g)	1.9	9.2	4.8	1.284	1.7	8.1	4.0	1.244	2.6	5.8	4.3	1.034	2.1	9.6	4.3	1.432

Table 6. Documentation status of the germplasm passport and collection data at ICARDA.

Crop	ICARDA's holding: Number of accessions	ICARDA's holding: Descriptors to be documented	Documented in 1985: Number of accessions	Documented in 1985: Descriptors/crop	Documented to date: Number of accessions	Documented to date: Descriptors/crop
Barley	15195	15	12138	9	12138	15
Durum wheat	19438	15			10207	3
Bread wheat	2125	15			637	10
Chickpea	5920	15	370	15	5726	15
Lentil	6181	15	105	15	5525	15
Faba bean	3316	15	1600	15	1600	15
					1549	9
Medics	3536	15	304	15	3536	15
Pisum spp.	3230	15	10	7	3230	7
Vicia spp.	2869	15	132	5	2869	5
Collection data	6647	25	1647	25	6647	15/25

Table 7. Documentation status of the germplasm evaluation information at ICARDA.

Crop	ICARDA's holding: Number of accessions	ICARDA's holding: Descriptors to be documented	Documented in 1985: Number of accessions	Documented in 1985: Descriptors/crop	Documented to date: Number of accessions	Documented to date: Descriptors/crop
Barley	15195	24	6158	24	14158	24
Durum wheat	19438	22			5000	9
			4000	22	4000	22
Chickpea(W)[1]	5920	29	7		3344	29
Chickpea(S)[2]		18	3341	4	3341	18
Lentil	6181	26			4550	26
			482	12	482	12
Medics	3536	19			627	19
			562	17	562	17

1. Spring planted.
2. Winter planted.

published in 1986 after all passport information has been completely updated.

Joint efforts have also been made with the Food Legume Improvement Program, to complete and update the available passport information on faba bean ILB accessions. In 1985, passport information for 1600 accessions was completed and corrected, and additional information will be requested from donor institutions where necessary. This work will be continued in 1986 on the second part of the collection to produce a catalog of faba bean ILB passport information. The cataloged information will make it easier to use the faba bean germplasm collection efficiently. The catalog will be used to provide information to other institutes holding faba bean germplasm collections.

A computerized seed stock control system has been developed and information on the precise location of accessions in cold storage has been entered into the system. Further information on the seed stocks preserved will be continuously added, and the system will be used to record seed movement and retrieve information on existing seed stocks.

Rejuvenation, Conservation, and Distribution of Germplasm

An inventory conducted in the previous year revealed that seeds of a very large number of accessions were in short supply to meet storage requirement. High priority was therefore given to multiplication and rejuvenation of germplasm accessions, to obtain sufficient quantities of high-quality seeds for conservation in medium-term storage conditions (4 $\pm$ 2°C and 15% relative humidity). Considerable effort has been made to rejuvenate the available germplasm and provide new seed stocks for conservation under controlled conditions. Seed samples of 6524 barley accessions were processed for cold storage in 1985. A total of 12524 barley accessions are now conserved; this represents more than 82% of the entire barley germplasm collection. The remaining part of the barley collection will be rejuvenated in the 1985/86 season. About 2700 durum wheat samples also meet storage requirements and will be processed for medium-term storage of 1985. From the food legume collections, 5310 chickpea and 2080 lentil accessions were planted for multiplication. Due to the small amounts of seeds obtained as a result of frost damage during the exceptionally cold winter in 1985, some of the accessions must undergo another cycle of multiplication in the 1986 season. The seed yields of 280 lentil and 2868 chickpea accessions were sufficiently high to be processed for inclusion with the germplasm material already preserved (Table 8).

The considerable number of accessions, which must be rejuvenated prior to storage, is decreasing but there still remains an enormous backlog of accessions (about 60% of the total germplasm collection) to be multiplied before proper storage. About 5000 accessions from the durum wheat collection, all the available *Vicia* and *Lathyrus* germplasm (3313 accessions), and the remaining part of the lentil and chickpea collections (4400 entries) will be multiplied in the 1985/1986 season to obtain adequate quantities of seed for conservation and distribution.

Genetic materials are being transferred to the cold store for temporary storage to prevent further deterioration of germplasm samples which are designated for rejuvenation in later years. Part of the faba bean collection and germplasm of some wild species and forages have already been placed in controlled environment storage.

The GRU plays an important role in the distribution of ICARDA's germplasm. The Seed Health Laboratory assists in the rapid and safe movement of seed samples by establishing appropriate quarantine safeguards and monitoring the health of the germplasm samples received and dispatched. In 1984/85, 15026 samples of 20 crops were distributed upon request to 24 countries (Table 9) from the genetic resources collections.

Table 8. Present status of collections.

Crop	Total number of accessions	Number of accessions in medium-term storage	Number of accessions to be multiplied	Number of accessions in long-term storage
Cereals				
Barley	15195	12524	2671	
Durum wheat	19438	2700	16738	5475
Bread wheat	2125		2125	
Food legumes				
Lentil	6181	3846	2335	4958
Chickpea	5920	2882	3044	
Faba bean	3316	900	3316	
Wild *Lens spp.*	111	111	111	
Wild *Cicer* spp.	24	24	24	
Forages				
Annual medics	3536		2347	
Pisum spp.	3230		2980	3221
Vicia spp.	2869		2390	
Trifolium spp.	933		933	
Trigonella spp.	144		144	
Astragalus spp.	310		310	
Onobrychis spp.	746		746	
Alfalfa	858		858	
Lathyrus spp.	533		489	
Triticale (forage)	1565		565	
Barley (forage)	1719		529	
Avena spp.	531	531	87	531
Grasses	622		622	
Total	69912	23518	43364	14185

Genetic Resources-Related Research

The main objective of the genetic resources research carried out independently in the GRU or in collaboration with scientists in the crop improvement programs, is to promote the utilization of germplasm for crop improvement. Evaluation studies of germplasm of landraces, old varieties, and wild relatives of ICARDA's crops, investigations utilizing techniques for measuring genetic diversity and identifying redundant duplicate accessions in the collections, and studies aimed at defining and delimiting geographical areas and ecological environment where genetic diversity exists, are some of the projects providing information that could be used to enhance the utilization

Table 9. Number of germplasm samples distributed to different countries in 1984/85.*

	Cereals			Food Legumes			Forages		
Country	**Barley**	**Durum wheat**	**Bread wheat**	**Chickpea**	**Lentil**	**Faba bean**	**Medics**	***Vicia* spp.**	**Other spp.**
Algeria									5
Australia							148	64	18
Bangladesh					700				
China						329			
Cyprus						38		5	8
Egypt	1000	3000	852					1	3
Ethiopia					144	69			8
Iran							4		
Italy				8	100		108		11
Japan				107					1
Liberia						10			
Netherlands	3								
Pakistan					500	40		26	10
Poland							3		
Saudi Arabia								1	
Somalia								9	
Sudan					500			4	
Sultanate of Oman								2	12
Syria	184	42		818	13		3		
Tanzania							2	2	4
Tunisia				2000		2	3		
Turkey				2000					
United Kingdom					100	2			
United States				2000					
Total	1187	3042	852	6933	2057	490	271	114	80

* Figures do not include breeding materials sent for international nurseries.

of genetic resources.

During 1984/85, research was conducted (a) to further investigate the potential of electrophoretic techniques to differentiate between accessions and study the genetic variability in the germplasm collection, (b) to determine the variation between durum wheat landraces, and (c) to study the natural distribution and ecology of native forage and pasture legumes in Syria.

Electrophoresis Studies

In 1983/84, preliminary research was carried out in the GRU to determine the suitability of isozyme electrophoresis for identifying duplicates in the germplasm collection and differentiating between morphologically similar species and subspecies.

Isoenzyme electrophoresis can be used to detect a large number of genetic markers. Esterase isozyme electrophoresis is one of the most commonly used systems; these isozymes are relatively easy to detect in different plant species, and they nearly always show variation. In 1985, esterase electrophoresis was carried out to a) investigate the isozyme pattern in seven species of annual medics and one putative hybrid and to chemically differentiate between species and subspecies, b) identify duplicate accessions of lentils, c) study the isozyme pattern of accessions of chickpeas which show different reaction to ascochyta blight, and d) differentiate between genotypes of faba bean with different geographical origin.

Electrophoresis was performed through 7% polyacrylamide gels which were then assayed for non-specific esterase using ∝-naphthyl acetate substrate and Fast Blue R.R. salt as stain. The position of each band was determined following the procedures described in ICARDA Annual Report (1984) and by utilizing a densitometer.

Genetic diversity of the accessions was estimated by the Shandon-Weaver diversity index (H') which was calculated using the following formula:

$$H': = -\sum_{i=\bullet}^{n} pi \ \log \ pi - (n-1)$$

where (n) is the number of genotypes and (pi) is the proportion of the total number of entries having ith genotype (individual band).

Accessions were grouped by cluster analysis on the basis of average frequencies of individual bands, using the BMDP statistical software. Amalgamation distances were interpreted as relative genetic distances among accessions and accession groups.

Isozymes Variation Between Annual Medics (*Medicago* spp.)

A total of 74 accessions of annual medics from seven species (*M.rigidula*, *M.aculeata*, *M.blancheana*, *M.rotata*, *M.turbinata*, *M.littoralis*, and *M. trancatula*) each with two subspecies were chosen, together with one putative hybrid (*M.truncatula* x *M.littoralis*), to study their esterase isozyme pattern. The plants were grown in the field and at the 4-6 leaf stage the topmost leaves were harvested and assayed for non-specific esterases.

A total of 25 bands were detected with different frequencies in the 74 accessions studied. The observed banding patterns showed a high degree of polymorphism between species, although some of the bands were monomorphic (present or absent in all the accessions studied) within each species.

The band at Rf 0.04 is monomorphic in all accessions of *M.rotata* and *M.blancheana*, but it was also present with different frequencies in the other species. The band at Rf 0.10 is also monomorphic and therefore appeared in all accessions of *M.blancheana*, *M.littoralis*, *M.turbinata*, and in the hybrid *M.truncatula* x *M.littoralis*. The bands at Rf 0.21, 0.35, and 0.38 were present in all the accessions of the hybrid *M.truncatula* x *M.littoralis*, *M.littoralis*, and *M.turbinata*, but they were not always observed in the accessions in the other species. The band at position 0.17 was absent in all the accessions of *M.littoralis* but present with different frequencies in the other species. Notably, a band at Rf 0.02 was present in all the accessions. Some other bands with Rf values 0.44, 0.46, 0.48, 0.50, and 0.52 which were consistently absent in certain species, differentiated these species from others in which they were present.

The banding patterns shown in Fig. 1 can be used to group the germplasm accessions by

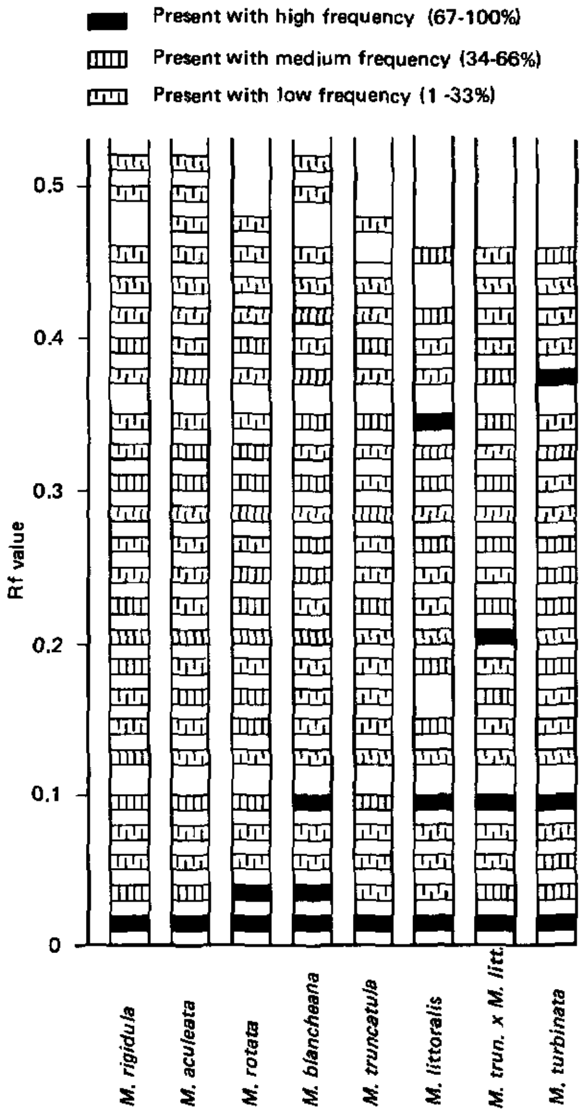


Fig. 1. Banding pattern of esterase isozymes in different *Medicago* species.

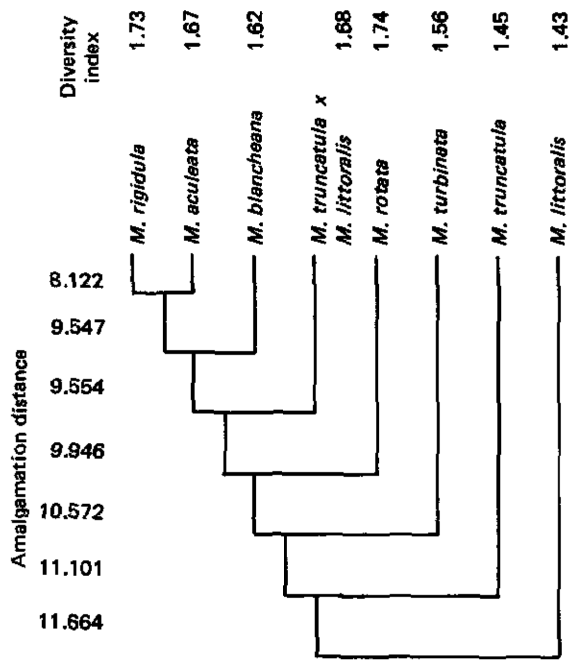


Fig. 2. Diversity indices and amalgamation distances among seven *Medicago* species and one putative hybrid.

species. Clustering the banding pattern observed in the species studied reveals existing relationships in esterase isozymes. *M. rigidula* appears to be very close to *M. aculeata* in this respect, but widely separated from *M. littoralis* (Fig. 2).

The results of this study would suggest that considerable genetic variation exists in the medics germplasm collection. The range of variability is indicated by the diversity indices (H') as shown in Fig. 2. The banding pattern observed can be used to characterize germplasm accessions and thus provide supplementary data in addition to that obtained from characterization and evaluation studies on morphological and agronomic traits.

Discrimination Between Faba Bean Lines of Different Geographic Origin

Previous study on electrophoresis of esterase isozymes in faba bean proved valuable in measuring the actual outcrossing percentage among lines using different isolation techniques. The same study showed that there is a considerable amount of variation in different germplasm accessions and that isozymes can be used to characterize some of these differences.

The aim of this study on selected lines was to investigate whether isozyme patterns reflect the geographic origin of the accessions. Thirteen lines were selected from six countries (Ethiopia, Iraq, Jordan, Lebanon, Syria, and Turkey) and grown in the experimental field at Tel Hadya. The topmost expanded leaf was collected from plants at the 4-6 leaf stage, and electrophoresis was performed through 7% polyacrylamide gels which were then assayed for non-specific esterases.

A total of 39 esterase bands were observed with different frequencies in the material studied. Within-line variation was detected in all accessions. Amalgamation distances calculated for lines from the same country showed that the Lebanese accessions were the closest to the Jordanian materials and that the Iraqi and Turkish accessions were similar. Accessions from these four countries formed a separate group, while the Ethiopian materials appeared to be most distinct; the Syrian faba bean lines occupied an intermediate position (Fig. 3).

The results show that isozyme electrophoresis can be successfully used to test the genetic homogeneity of faba bean lines and the isozyme frequencies can be related to the origin of the germplasm samples.

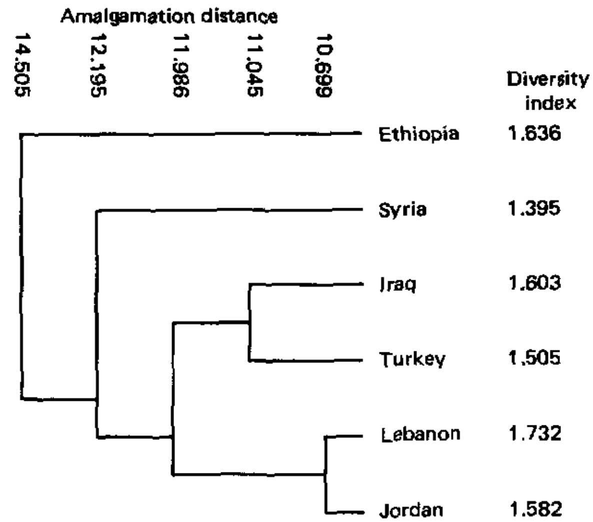


Fig. 3. Diversity indices and amalgamation distances among faba bean lines from different origin.

Table 10. Chickpea lines with different reaction to ascochyta blight.

Tolerant lines	Resistant lines	Susceptible lines
ILC 482	ILC 187	ILC 83
ILC 484	ILC 2506	ILC 132
FLIP-81-41	ILC 3279	ILC 464
FLIP-81-59	ILC 3856	ILC 613
FLIP-81-64	FLIP-81-293	ILC 629

Esterase Isozymes Variation in Chickpea (*Cicer arietinum* L.)

The variation in esterase isozyme banding from 15 lines of chickpea with different reaction to ascochyta blight (Table 10) was investigated to determine whether specific banding patterns would characterize each of these groups.

Seed samples were crushed thoroughly with 2ml of an extractant containing 20% (w/v) sucrose solution with 1% bromophenol blue (BPB) as a marker dye. Electrophoresis was performed through polyacrylamide gels which were then assayed for esterases.

A total of 41 different bands were detected in the chickpea accessions, and cluster analysis showed no grouping consistent with reaction to ascochyta blight (Fig. 4). These preliminary results suggest that there is no relationship between the overall esterase isozyme pattern and reaction to ascochyta blight in the accessions studied. The results also indicate that at least two independent sources of resistance genes can be suspected, as two of the resistant lines showed isozyme patterns which were completely different from the other resistant materials. This could also be explained by the independent segregation of genes governing

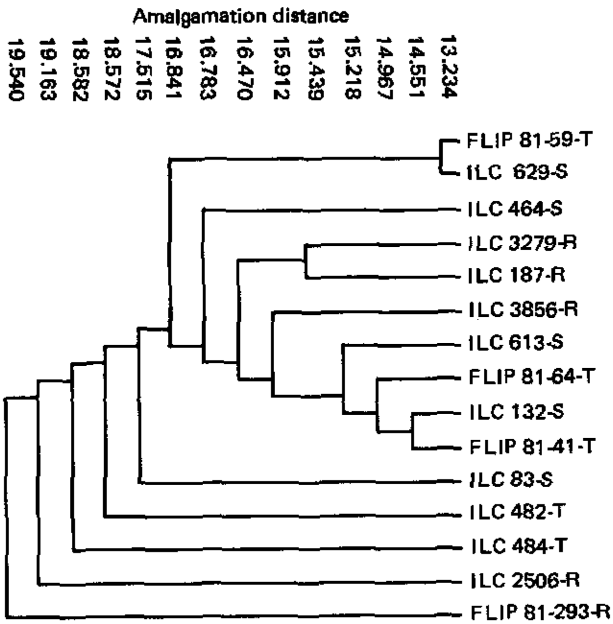


Fig. 4. Amalgamation distances among 15 chickpea lines with different reaction to ascochyta blight.

esterase isozymes and resistance. Certain bands were either completely absent or present at very low frequencies in susceptible lines, but they were observed at much higher frequencies in resistant and tolerant material. A more detailed study could reveal specific relationships between certain bands and resistance to ascochyta blight.

An extension of this study to other enzyme systems which are more directly involved in host-pathogen interactions (e.g. peroxidase, polyphenoloxidase) will probably provide more relevant information about the isozyme patterns relating to the reaction of chickpea accessions to ascochyta blight.

Comparative Study of Some Suspected Duplicates from the Lentil Germplasm Collection

Most germplasm collections have a certain number of redundant duplicates. Computerized passport information can be used to identify suspected duplicates only if complete information is available. But information is rarely complete, especially for accessions which have a history of movements through different collections. Rationalizing collections by eliminating genetically identical duplicates would save time, money, labor, and storage space. It is not easy to prove the identity of suspected duplicates, which have undergone selection and genetic drift since collection. Clear-cut and reliable procedures for dealing with genetic materials which are phenotypically similar but genetically different, are still being considered.

In 1985, a small pilot research project was initiated to study the genetic similarities and differences among suspected duplicates in the lentil germplasm collection. Sixteen accessions of five varieties were selected on the basis of introduction number and other available passport information.

The seed characteristics of the 16 accessions and the evaluation information on 10 of the accessions obtained from the ICARDA's Lentil Germplasm Catalog were compared to detect differences among accessions. All the suspected duplicates of each variety are similar in testa color, pattern of testa, seed protein percentage, and days to flowering, while most of them differ in harvest index, frequency of cotyledon color types, number of seeds/pod, and 100-seed weight. Larger differences were recorded in biological and seed yield, but these differences seem to be insufficient to discriminate between accessions of the same variety.

Twelve single seed samples from each accession were subjected to electrophoresis to characterize and compare their esterase banding patterns. A total of 25 bans were detected; the number of bands in the different accessions varied between 18 and 25. Certain slow-moving bands were absent in some of the Hungarian accessions; in the Czechoslovakian and Algerian materials the two fastest-moving bands (bands with the highest Rf values) were not observed.

Accessions and varieties were clustered on the basis of the frequencies of individual bands. Based on this character, the two Czechoslovakian varieties group together. The Hungarian variety shows some similarities to the local population from Cyprus, but the variety which originated in North Africa (Algeria) differs considerably from any of the other varieties studied. Duplicates of the Algerian and Cypriot varieties are much more homogenous in esterase banding pattern than the two Czechoslovakian and the Hungarian entries; this is indicated by their diversity indices (Fig. 5).

The analysis of band frequencies in *individual* accessions revealed considerable differences among duplicates of the same varieties; this suggests that changes in the original genetic composition of the material have taken place. These accessions therefore could be used in a more detailed study to characterize the morphological, phenological, and biochemical differences among duplicates to develop appropriate methods to eliminate duplicates in the lentil germplasm collection (Fig. 6).

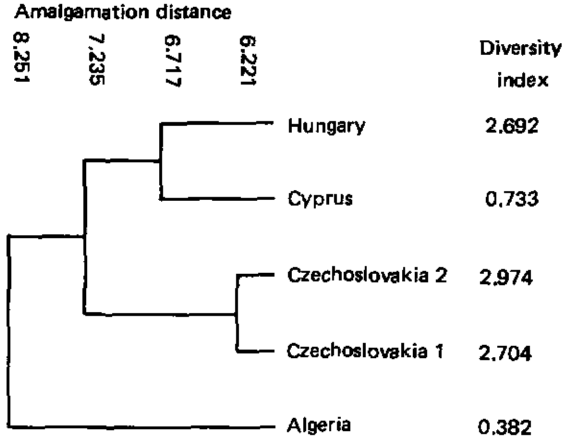


Fig. 5. Amalgamation distances among lentil varieties from different countries and diversity indices (H), according to esterase banding patterns.

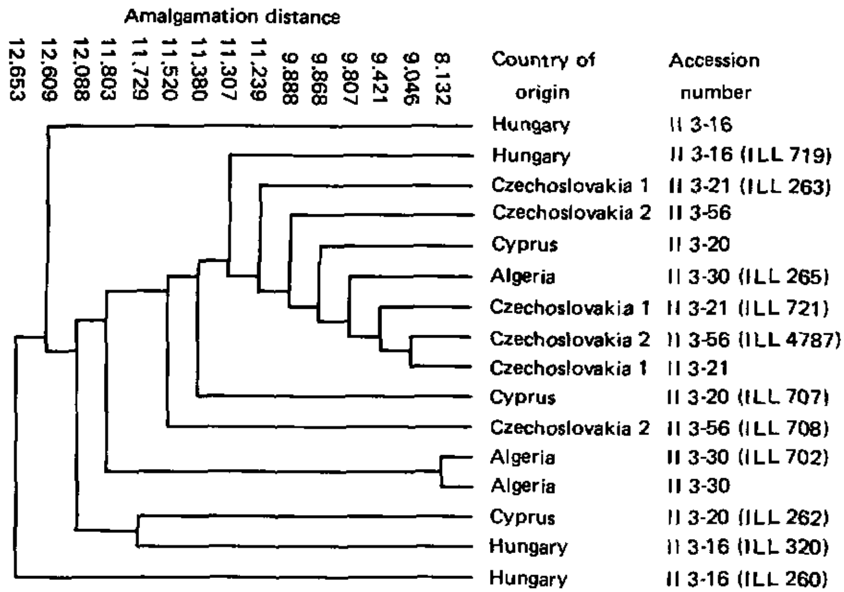


Fig.6. Amalgamation distances among 16 duplicates of 5 lentil varieties according to the observed frequencies of esterse bands.

Evaluation of Durum Wheat Landraces

Informal collaborative work was established between Professor P.Limberg (University of Berlin, W.Germany) and Mr. N.Kyzeridis (Cereal Institute, Saloniki, Greece) to conduct a detailed evaluation of durum wheat landraces from Greece at two locations (Serres and Saloniki) in Greece, and at Tel Hadya.

Twenty landraces and three varieties from Greece (Table 11), were planted together with Sham-1 and Hourani as local checks in a simple lattice design (5 x 5) experiment at Tel Hadya. The entries were planted in plots of 6 rows (4.5m long and 25cm apart) at a seeding rate of 228 kg/ha. Detailed observations and data were recorded for germination density, growth habit, tillering capacity, number of days to heading, number of days to grain filling, spike and leaf color, plant height, vigor, number of spikes/m , grain and total biological yield, and 1000-kernel weight. The harvest index was calculated. For each entry, the mean values of the harvest index and of eight other quantitative traits are given in Table 11. The average grain yield (kg/ha) and total biological yield (kg/ha) are shown in Fig. 7. Analyses of data showed that 14 entries produced grain yields greater than the overall average (1369 kg/ha) for all the landraces and varieties. The wide range of grain yield from 1875 kg/ha to 780 kg/ha reflects the different performance of the durum wheat entries at Tel Hadya. Two landraces (Myrina and Moundros) and one variety (Santa) outyielded Hourani, one of the Syrian local checks. However, the grain yield for each of these three entries was not significantly different from that of Hourani. Nine landraces, in addition to the two varieties Santa and Hourani, produced grain yields greater than that of Sham 1. The relatively poor performance of Sham 1 was probably due to the unusually low temperature experienced at Tel Hadya during the establishment and early growth phase of the plants. Sham 1 is not as cold-tolerant (frost-resistant) as Hourani, which in this respect, would compare favorably with some of the high-yielding landraces.

There is no simple and direct relationship between grain and straw yields (Fig. 7). Some entries with relatively high straw yield were dispersed among entries with low grain yields (e.g. Mavragani Arkadias and Asprostaro Chanion) and among entries with higher grain yields (e.g. v.s. Sapho and Mavratheri Chiow).

Generally the taller entries, produced spikes later, had longer grain filling time, and their overall grain yields were lower. These entries, with a greater number of days to heading, also produced grains with lower 1000-kernel weight.

The results obtained in this trial undrline the importance of evaluating and exploiting landraces and older varieties in a durum wheat program designed to improve yield and yield stability.

Ecogeographic Survey of Natural Populations of Annual Legumes in Syria

This is a collaborative project between the Genetic Resources Unit and the Pasture, Forage and Livestock Program.

The project, partly financed by IBPGR in the form of an internship based in the GRU, uses an ecogeographic approach to the collection of pasture and forage legume germplasm, with a view to determining environmental constraints which limit the distribution of annual legume species, and relating genetic characteristics of these species to their natural habitats. The resulting information may be used to predict the suitability of a given species or ecotype for a given environment within the region. During the 2-year project, annual legume germplasm (totalling over 3000 accessions) was collected from all the major environments in Syria in which annual legumes are known to occur. For each of the sites (over 250) from

Variety	Number of spikes/m²	Biological yield (kg/ha)	Grain yield (kg/ha)	Harvest index	1000-kernel weight (g)	Number of days to heading	Number of days to filling	Number of tillers/m²	Plant height (cm)
Sham - 1**	265.50	3650.00	1483.10	40.00	31.69	74.50	102.50	347.00	55.75
Mavragani Argolidos	282.50	2962.50	909.80	30.50	25.68	79.25	102.50	415.25	53.00
Local zakanthio	263.75	3225.00	780.00	24.00	29.88	85.50	112.00	430.00	83.00
Asprostaro chanion	326.25	4300.00	1221.30	27.50	29.88	77.15	110.00	422.25	76.00
Atsiki - 4	212.75	2962.50	1204.30	40.00	34.43	74.50	105.00	308.00	56.00
Myrina	281.50	4225.00	1875.30	44.50	36.73	75.75	106.50	413.25	66.75
Mavragani Arkadias	288.75	4575.00	863.50	18.25	29.05	83.50	114.50	467.00	79.50
Kontopouli-3	269.75	3975.00	1639.30	40.50	37.73	76.00	106.50	379.00	66.25
Durum sapfo**	230.00	4400.00	1464.70	33.50	33.00	77.00	104.50	346.00	54.25
Chania	175.50	3300.00	1157.50	35.25	40.05	80.00	108.25	284.75	77.25
Moundros - 3	266.25	3850.00	1495.20	38.00	39.35	76.25	106.25	364.25	64.25
Local Iraklion	229.00	3950.00	1501.80	37.75	38.23	76.25	106.50	346.00	65.50
Atsiki - 3	268.75	3800.00	1599.30	41.75	38.75	75.75	106.50	359.00	63.00
Kaminia	256.00	3850.00	1517.80	38.75	38.58	76.50	108.75	337.00	64.25
Mavratheri chiow	232.50	4800.00	1618.50	33.25	40.25	78.25	113.50	364.75	84.50
Santa**	285.50	4575.00	1827.50	38.75	38.03	79.25	110.00	447.50	58.75
Romanou	282.25	4212.50	1473.50	34.25	34.68	76.25	106.75	419.00	74.25
Atsiki - 5	210.75	2950.00	1115.00	37.00	37.85	76.25	106.00	300.75	65.50
Aestivum vergina**	351.50	3400.00	1200.00	35.25	26.93	79.50	106.50	490.50	61.25
Moundros	305.75	4050.00	1755.50	42.75	37.55	76.00	106.75	413.25	65.50
Deves	218.50	3575.00	1272.50	34.75	36.80	77.50	108.00	319.00	80.00
Asprospiti	304.25	3475.00	837.00	24.25	31.05	83.00	113.50	509.25	87.50
Limnos	209.25	3450.00	1166.00	33.00	36.98	80.50	110.00	309.75	79.25
Atsiki - 1	249.50	3925.00	1560.30	39.50	37.83	73.75	107.75	348.25	67.50
Hourani**	309.50	4175.00	1706.60	39.75	37.00	79.25	108.00	410.25	71.25
*LSD	86.71	718.20	460.03	6.38	2.72	1.86	2.67	108.10	8.10
Overall mean	263.02	3824.50	1369.80	35.31	35.12	77.91	107.88	382.04	68.80
SD	62.57	848.80	331.90	4.60	1.97	1.34	1.93	77.99	5.85

Table 11. Mean values of 9 traits for 20 landraces and 5 durum wheat varieties grown at ICARDA Aleppo, 1984/1985.

* Probability level 0.05

** Varieties

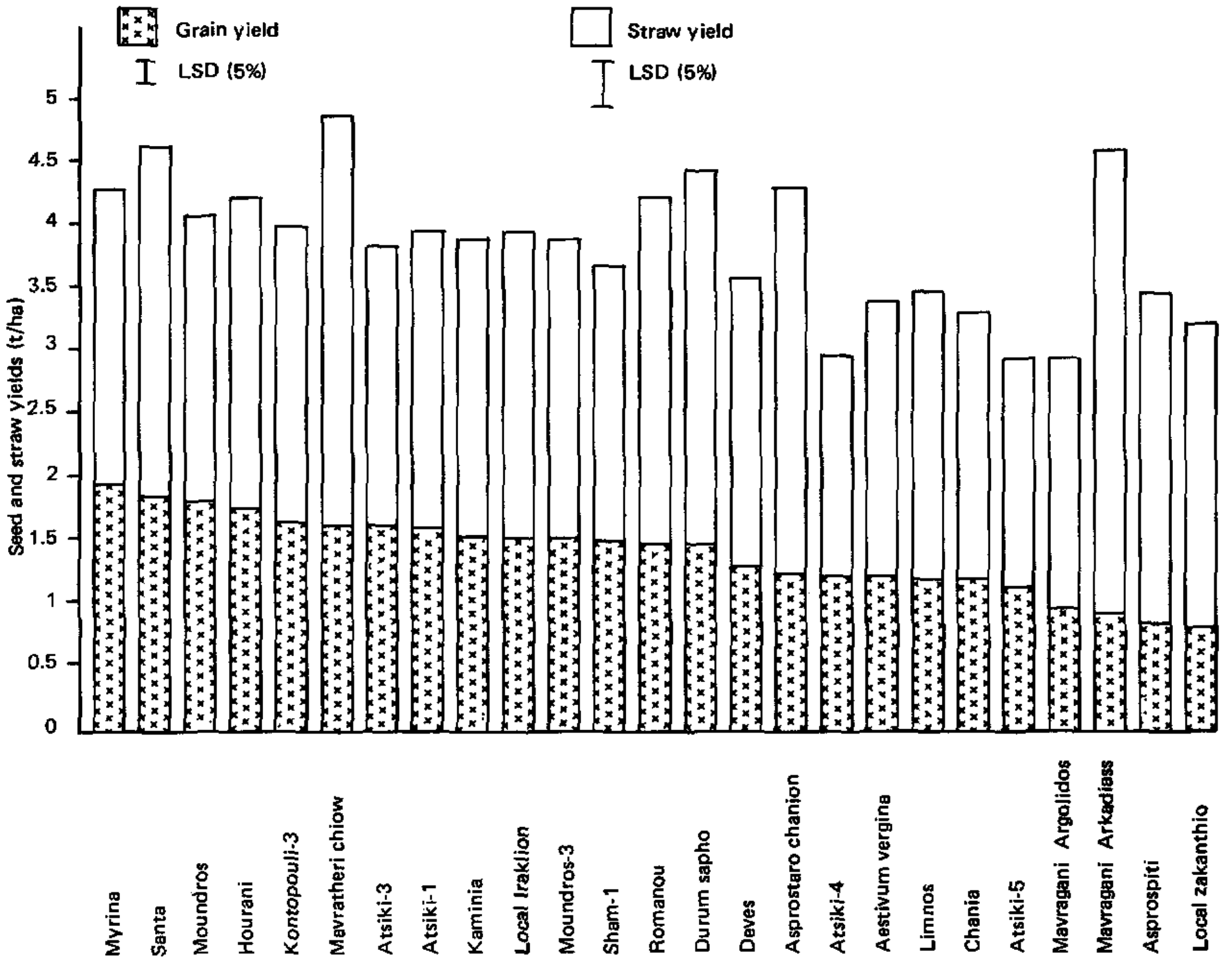


Fig. 7. Grain yield and total biological yield of twenty landraces and five durum wheat varieties.

which collections were made, detailed information on climate, soil type, and seed population numbers has been collated, in addition to other relevant passport information.

Some of the results of this survey are outlined in the Pasture, Forage, and Livestock Program report for this year. These results concern the relationships of individual medic species to soil and climatic parameters of those sites from which collections were made in the summer of 1984 in western Syria. Soil and climatic groups have been separately classified by a non-exclusive clustering technique known as modal block analysis, and medic species were sorted according to their soil/climate preferences by the same technique. Germplasm from these collections was grown at Tel Hadya in 1984/85 and scored for 14 characters including frost resistance, days to anthesis, reproductive traits, and hardseededness. Work is now underway to determine the relationships of these characters to place of origin of the germplasm.

During the summer, a legume herbarium was also set up for reference and identification purposes. This will be housed in the GRU.

In May of 1985, scientists from the GRU and PFLP again collaborated in an annual legume collecting trip in coastal areas of northern Egypt. They were accompanied by scientists from the Desert Institute of Cairo. A similar approach to that followed in Syria was adopted with soil samples being collected at each site. The trip represented the first stage of a joint project between the PFLP and Desert Institute which is concerned in pasture improvement in Egypt.

Seed Health Laboratory

In 1985, the Seed Health Laboratory (SHL) continued to monitor the seed exchange activities. These included laboratory seed health testing of collected and newly arrived seeds as well as seed consignment which were dispatched from the Center. Fields in the "isolation area" where incoming material was planted were inspected regularly during the vegetative growth of the crops. Also, fields with seed increases for the international nurseries and for germplasm multiplication were monitored for the presence of potentially dangerous pests and pathogens which are seed-transmitted.

A total of 643 shipments which include seed consignments for the International Nurseries, were dispatched during the period 1 Oct 1984 to 30 Sept 1985 to cooperators in 74 different countries. All of the shipments were inspected visually in the laboratory for contamination by soil, weed seeds, and any other undesirable materials. Steps were taken to ensure that the chemical treatments were applied. Generally, cereals are treated with thiram and carboxin, and legumes with a benomyl and tridemorph + maneb mixture, or thiabendazole. Insects are controlled by fumigation or by protective treatments with pirimiphos-methyl.

In addition to visual inspection, randomly selected samples of seeds designated for dispatch were examined for quarantine organisms using several specific seed health testing methods (Table 12). In general, the "Freezing Blotter Test" proved to be a reliable and more sensitive method for detecting *Fusarium* and *Helminthosporium* species. Chickpea dextrose agar gave the best results for *Ascochyta rabiei*; for the other *Ascochyta* species, the respective host medium was used, that is, lentil dextrose agar or faba bean dextrose agar.

Usually, all the incoming seeds are channelled firstly to the Seed Health Laboratory, where they are registered and visually inspected. If insect infestation is observed, samples are immediately disinfected either by fumigation or cold treatment. In 1984/85, 25% of the consignments had insect infestations and required treatment. Depending on the country of origin and the

Table 12. Seed health tests conducted on seed samples dispatched from ICARDA.

Crop	Centrifuge wash	Ditylenchus	Agar media	Freezing blotter	Blotter
Durum wheat	146		133		
Bread wheat	65		53		
Barley			45	45	
Lentil			151	151	151
Faba bean		31	150		
Chickpea			110	110	110
Vetch		24			

Table 13. Seed health testing of the germplasm collection.

Crop	Total number of accessions	Number of accessions: Pathogen free	Number of accessions: Infected	Pathogen identified
Barley	255	165	86	*Fusarium* spp.*
			9	*Helminthosporium* spp.
Chickpea	311	284	27	*Fusarium* spp.**
			1	*Ascochyta rabiei*
Lentil	40	38	2	*Ascochyta* sp.
Pea	42	0	42	*Pseudomonas pisi*

* mostly F.moniliforme and F.equiseti.

** mostly F.oxysporum.

quantity of the seed, specific tests were also conducted. Fungicide treatment of seeds prior to planting is a standard and routine procedure carried out at the SHL, provided the seeds have not been treated by the consigner. A total of 67% of the incoming seeds was treated in 1984/85 at ICARDA. As a rule, the first cycle of multiplication of all seeds is done in the "isolation area" at Tel Hadya where 27 hectares are reserved specifically for materials coming to the Center.

Screening of the germplasm collection for seed-borne pathogens continued and samples of untreated seeds were tested. The results in Table 13 indicate that it is necessary to apply appropriate measures for the control of pathogens. Since the chemical control of seeds could adversely affect seed viability, it is recommended that seed treatment of germplasm be done before dispatch or prior to planting. Chemical treatment of seeds earmarked for long-term storage in the genebank should be avoided.

Virology

The virology activity at GRU was initiated in February 1985 as a special project supported by the Dutch Government. Temporary Laboratory facilities were established during the first 3 months and a glasshouse was constructed and ready for use at the end of November 1985.

Virus research at ICARDA is conducted with close cooperation with the Institute of Plant Protection (IPO) at Wageningen, The Netherlands, the Lebanese National Council for Scientific Research, and the Faculty of Agricultural and Food Sciences, American University of Beirut. Tests which cannot be carried out at the ICARDA laboratory, are done in Wageningen and at the University of Beirut.

A preliminary survey was carried out to identify viruses infecting cereals and food legumes in Syria, Lebanon, Tunisia, and Morocco. Samples were collected during the spring growing season of 1985 and laboratory tests were conducted at Tel Hadya and also at Wageningen and Beirut. The results are summarized below.

Viruses of Food Legumes

The survey on viruses of faba bean, lentils, and chickpeas in the Middle East and North Africa indicated that in Syria, bean yellow mosaic virus (BYMV), pea seed-borne mosaic virus (PSbMV), broad bean stain virus (BBSV), and broad bean mottle virus (BBMV) infect faba beans either singly or in mixed infections. As many as three viruses were present in a single plant. BYMV, PSbMV, BBSV, and BBMV were found in 45.0, 23.0, 21.3, and 4.1%, respectively, of the samples tested. On lentils, only BBSV was detected. In Lebanon, BBSV, BYMV, and PSbMV infected faba beans, but only BBSV was found in lentils. In Tunisia, BBMV and BBSV were identified on faba bean and PSbMV on lentils. The above results were based mainly on serological tests (ELISA) and electron microscopy studies. Field observations suggest that bean leaf roll virus (BLRV) was the most common on faba bean in all four countries. A low incidence of chickpea stunt, a disorder believed to be caused by BLRV, was also observed in the four countries surveyed. It should be noted that all viruses identified, with the exception of BLRV, are seed-borne (Tables 14 and 15). Screening for BYMV and BLRV resistance in faba bean will be initiated in the 1985/86 season. Tests will include around 600 faba bean lines.

Table 14. Viruses identified in lentil samples collected from Syria, Lebanon, Tunisia, and Morocco during the spring growing season of 1985.

Country	Number of samples tested	Number of samples identified with			
		PSbMV	BBSV	BBMV	BYMV
Syria	7	0	5	0	0
Lebanon	9	0	5	0	0
Tunis	1	1	0	0	0
Morocco	6	5	0	0	0

PSbMV = pea seed-borne mosaic virus; BBSV = borad bean stain virus;
BBMV = broad bean mottle virus; BYMV = bean yellow mosaic virus.

Table 15. Viruses identified in faba bean samples collected from Syria, Lebanon, Tunisia, and Morocco during the spring growing season of 1985.

Country	Number of samples tested	Number of field samples which contained									
		BBMV	BBSV	BYMV	PSbMV	BBMV + PSbMV	BYMV + PSbMV	BBSV + PSbMV	BYMV + BBSV	BYMV + PSbMV + BBSV	PSbMV + BBMV + BBSV
Syria	145	1	12	41	6	2	10	5	9	7	3
Lebanon	44	0	6	5	1	0	0	0	0	0	0
Tunisia	17	9	4	0	0	0	0	0	0	0	0
Morocco	7	1	0	1	0	0	0	0	0	0	0

BBMV = broad bean mottle virus; BBSV = broad bean stain virus; BYMV = bean yellow mosaic virus; PSbMV = pea seed-borne mosaic virus.

Viruses of Cereals

Cereal samples collected from Syria, Lebanon, Morocco, Tunisia, and Sudan were assayed for the PAV strain of barley yellow dwarf virus (BYDV). The results are summarized in Table 16. Although the number of samples tested was small, it was evident that BYDV is a potential problem for cereals in the region. BYDV was detected in 10, 14.3, 52.6, and 57.1% of the

Table 16. Detection of the PAV type of barley yellow dwarf virus (BYDV) by ELISA in cereal samples from plants showing BYDV-like symptoms collected from five countries during the spring of 1985.

Country	Site	Crop	Number of samples tested	Number of samples infected with BYDV	% of BYDV infected plants/country
Syria	Tel Hadya	Barley	18	0	
	Uraymeh	Barley	3	0	
	Mjarjah	Barley	3	0	
	Tel Hadya	Wheat	22	4	
	Raqqa	Cereals[a]	2	1	
	Uraymeh	Corn	2	0	
Syria					10.0
Lebanon	Terbol	Cereals	18	3	
	AREC	Cereals	5	0	
Lebanon					14.3
Morocco	Merchouch	Cereals	8	4	
	Sidra	Cereals	8	5	
	Kodya	Cereals	2	0	
	Kodya	Wheat	1	1	
Morocco					52.6
Tunisia	Tunis	Cereals	6	1	
	Benzart Road	Cereals	1	0	
	INRAT(Tunis)	Cereals	1	0	
	Ain Ghlal	Barley	2	2	
	Ain Ghlal	Oat	3	3	
	INRAT (Tunis)	Oat	1	1	
	INRAT (Tunis)	Triticale	1	1	
	INAT (Tunis)	Wheat	1	1	
	INRAT (Tunis)	Wheat	5	3	
Tunisia					57.1
Sudan	Turabi	Barley	1	0	
	W.Medani	Barley	3	0	
Sudan					0.0

a. Cereals could be either wheat or barley. Collected samples were not identified.

samples tested from Syria, Lebanon, Morocco, and Tunisia, respectively. Based on these results, screening for BYDV resistance will be initiated in the growing season of 1985/86. Screening will include about 1800 entries of barley, durum wheat, and bread wheat, and BYDV will be introduced through artificial inoculation by aphids.

Training

The GRU's role in providing training to scientists and technicians in the region is overshadowed by the attention given to other program elements such as germplasm evaluation, documentation, and conservation which are now accorded relatively high priority.

Also, personnel and financial constraints do not permit the Genetic Resources Program to undertake independent training activities. However, the GRU is committed to participate in the residential training courses undertaken by the Crop Improvement Programs and to provide short duration (2-4 weeks) individual training in specific areas related to genetic resources work and seed health laboratory techniques.

In 1985, a scientist from Egypt was trained on different aspects of germplasm work. His training focused on field evaluation techniques, documentation procedures, and gene bank management operations. This was very important in developing links with the Genetic Resources Program now being initiated in Egypt. A technician from Tunisia also spent 2 weeks with the GRU staff to study field evaluation of cereal crops.

The Seed Health Laboratory hosted a senior technician from the Plant Genetic Resources Center of Ethiopia. During a period of 12 weeks, training was provided in field inspection techniques, laboratory methodologies for incubating and identifying various plant pathogens, and in seed treatment procedures. The GRU also provided laboratory facilities and participated in a 3-week seed production training course which was attended by 19 participants from nine countries in the ICARDA mandate region.

COMPUTER SERVICES

ICARDA Annual Report 1985

INTERNATIONAL CENTER FOR AGRICULTURAL
RESEARCH IN THE DRY AREAS (ICARDA)
Box 5466, Aleppo, Syria

Contents

COMPUTER SERVICES

Computer Services is organized 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.

Statistics and Experiment Aids

CRISP (Crop Research Integrated Statistical Package) was used as the principal statistical tool for breeding and agronomy at ICARDA. SPSS-X is used for the analysis of data related to social sciences. BMDP, Biometrical Computer Programs, a new addition to our existing library of statistical packages, is currently used for multivariate analyses, whereas BGPP and MINOS-5 are used for varied optimization problems. Training and user support in the selection of the appropriate statistical design, the analysis of data and the interpretation of the results is the second major activity in this area.

Software Production

New analysis and utility routines were added to CRISP to address specific requirements. Version 2.1 CRISP now differs from version 2.0 CRISP in its efficiency of use of the computing resources and the inclusion of the following analyses and utilities:

1. MISDAT, the missing data estimation module, computes and stores the estimated values for all the missing data in a CRISP data file. Currently it supports all the experimental designs that are used in breeding and agronomy trials. In addition to this module, there is a need of ignoring the missing data from all computation in the analysis routines. Many analysis routines are modified to address this need.

2. The adjusted or unadjusted treatment means computed from the analysis of variance routines may be saved in a CRISP data file. This file then may be used for further variety selection or for any analysis based on these treatment means.

3. The analysis of variance routines have been modified so that a range of variables from a data file may be analyzed consecutively.

4. Many statistical parameters that were missing in the earlier version are now available in the current version. For example, a summary table of mean, variance, range, etc. for the row frequencies in a cross tabulation has been added to the module CRSTAB. Another example is the addition of skewness and kurtosis in frequency distribution module DISTRB.

5. A statistical log of CRISP usage, either by responsibility centres or by analysis options has been implemented. The log file maintains a record containing the user name, the user group number (Program Identification), the CRISP option used, the date and time of usage, the elapsed

CPU time, the elapsed log-in time. A monthly usage report of CRISP is produced.

6. Termination of a program by pressing CTRL-C or CTRL-Y may result in damage to the input and/or the output files. An orderly exit feature was added to all prompts in all options. When the terminator @X is entered, a number of option-specific housekeeping tasks are performed on the data files. Control is transferred to the main driver only upon the conclusion of these tasks.

7. Results of the analysis may either be viewed on the screen, or printed on a spooled printer, or stored. If a copy of the analysis result is stored, the standard Editor or Word Processor may be used to tailor its format.

8. A routine, COLCRT, for printing column charts on a graphics terminal or on a laser printer was added. Two separate options for absolute column chart and subdivided column charts are available. The absolute column chart may be used to produce the graphs for depicting the means, for example, each mean may be represented by a column. Means related to different characters may be represented by columns of different user-selected patterns.

   To plot the varietal means over locations, the years or the different characteristics studied, the subdivided column chart may be used. In this case, one column shall represent one variety, but the column is again subdivided over each location, year, etc. Each subdivision of the column is printed with different shades.

9. A routine, TSQUAR, was added to perform the test of hypothesis related to the population mean vector of any multidimensional random variables. The testing is done through the Hotelling T^2 statistics that is a multivariate analog of the univariate t statistics. Three available options are:

   i. Testing a multidimensional mean vector equal to a specified multidimensional vector.

   ii. Testing the equality between two multidimensional mean vectors.

   iii. Testing the equality of two multidimensional mean vectors when the assumption on the equality of the covariances of the two populations cannot be made.

   A list of CRISP analysis and utility commands and their brief description is given in Table 1.

Table 1. Computerized planning of experiments.

FIELD/INIT	Initialize a randomization file.
/DESIGN	Perform randomization for experimental designs.
/PRINT	Print the randomization table.
/LABEL	Create a print file of seed packet labels.
/BOOK1	Generate fieldbook type I.
/BOOK2	Generate fieldbook type II.
/EDIT_DESCR	Edit the descriptive information in a randomization file.
/EDIT_RAND	Edit the randomization table stored in a randomization file.
/DATA_ENTRY	Initialize a data file from a randomization file.

ELEMENTARY STATISTICS

ELEM/SUMMARY	Data summarization with elementary statistics and histograms.
/CORREL	Simple correlation analysis.
/PAR_CORREL	Partial correlation analysis.
/CROSS_TABLE	Two- or three- way cross tabulation.
/MISDAT	Estimate and replace the missing values in a data file.
/T-TEST	Testing of hypothesis regarding means and correlations.
/DSQUAR	Mahalanobis D square analysis.

ANALYSIS OF VARIANCE

ANOVA/ONEWAY	Analysis for a oneway classification.
/CONTRAST	Compute sum of squares for orthogonal contrasts.
/AUGMENT	Analysis for an augmented RBD design.
/CRANDOM	Analysis for a completely random design.
/RBD	Analysis for an RBD design. Summary report of a set of variables is included.
/RCB	Analysis for an RCB design.
/RCB_CHECK	Randomized complete block design. Percentage over checks is included.
/RBD_MOP	Analysis for an RBD design with multiple observation per experimental unit.
/RCB_2TF	Analysis for an RCB with two treatment factors in a factorial combination design.
/RCB_3TF	Analysis for an RCB with three treatment factors in a factorial combination design.
/LATIN_SQUAR	Analysis for a Latin square design.
/SPLIT_PLOT	Analysis for a split-plot design with main plots in an RCB design.
/SPLIT_SPLIT	Analysis for a split-split plot design.
/SPLIT_2MF	Analysis for a split-plot design with two main treatment factors.
/SPLIT_2SF	Analysis for a split-plot design with two subtreatment factors.
/BALANCE_LAT	Analysis for a balanced lattice design.
/SIMPLE_LAT	Analysis for a simple lattice design.
/TRIPLE_LAT	Analysis for a triple lattice design.
/QUAD_LAT	Analysis for a quadruple lattice design.
/BALSQR_LAT	Analysis for a balanced lattice square design.
/2^N_FACTOR	Analysis for a factorial 2^n design.
/FACTORIAL	Generalized analysis of variance for factorial experiment of up to six factors.
/DIALEL_TWO	Dialel analysis for fixed model method 2.
/DIALEL_FOUR	Dialel analysis for fixed model method 4.
/TOPCROSS	Line x tester analysis.

ANALYSIS OF COVARIANCE

COVAR/CRAND	Covariance analysis for a completely random design.
/RBD	Covariance analysis for an RBD design.
/RCB	Covariance analysis for an RCB design.
/LATIN_SQUAR	Covariance analysis for a latin square design.
/SPLIT_PLOT	Covariance analysis for a split-plot design.

REGRESSION ANALYSIS

/MULTIPLE	Multiple linear regression analysis.
/POLYNOMIAL	Polynomial regression analysis.
/STEPWISE	Forwards stepwise linear regression.
/STABILITY	Stability analysis of varieties across environments.

FILE MANAGEMENT AND UTILITIES

FMU/CREATE	Creates a new data file .
/FAST_CREATE	Creates a data file with minimum descriptive information.
/EDIT	Data File Editor sub System.

FILE EDITING SUB-COMMANDS IN EDIT

/ADD_FACTOR	- Adds more factors to the data file.
/ADD_IDEN	- Adds more identifiers to the data file.
/ADD_LEVEL	- Adds more levels to any factor/identifier.
/ADD_ROWS	- Adds rows of data to a data file.
/ADD_VARIABLE	- Adds more variables to a data file.
/CREATE	- Creates a new data file. Same as SETUP.
/CHANGE	- Changes the file name in the computer memory.
/COPY_FILE	- Makes an additional copy of a data file.
/COPY_VAR	- Copies variables from one data file into another.
/DELETE_FACTOR	- Deletes factors from a data file.
/DELETE_IDEN	- Deletes identifiers from a data file.
/DELETE_LEVEL	- Deletes levels of Factors/Identifiers from a data file.
/DELETE_ROWS	- Deletes rows of data from a data file.
/DELETE_VAR	- Deletes variables from a data file.
/CHANGE_DATA	- Edits data values in a file.
/CHANGE_FACTOR	- Edits factor subscripts for rows in a data file.
/DESCR	- Edits descriptive information in a data file.
/CHANGE_IDEN	- Edits identifier subscripts for rows in a data file.
/EXIT	- Exits from UPDATE and returns to CRISP.
/FACTOR_COMBINE	- Forms a new factor from a set of factors.
/FACTOR_TO_VAR	- Creates a set of variables from a factor.
/IDEN_COMBINE	- Forms a new identifier from a set of identifiers.
/INSERT_ROWS	- Inserts rows of data in a file.
/IDEN_TO_VAR	- Creates a set of variables from an identifier.

/PRINT	- Prints the contents of a data file.
/REPLACE_ROWS	- Replaces rows of data in a file.
/UPGRADE_FILE	- Increases the size of a data file to accommodate more variables.
VERIFY_DATA	Data validation against a range of data values.
AVERAGE_FACTOR	Creates a file with averages over a selected set of factors.
DIVIDE_FACTOR	Subdivides a variable over the levels of a factor and stores these variables in a data file.
REORDER_FACTOR	Reorders the factors in a file and creates an output data file in standard order.
REORDER_IDEN	Reorders the identifiers in a data file and creates an output data file in standard order.
MERGE	Merges two data files into one data file. A subset of a data file may be copied to an output data file.
MULTIPLE_MERGE	Merges a set of similar data files.
SUBDIVIDE_FACTOR	Subdivides the variables over the level combinations *of the factors in a data file.m, regression curve and the* residuals from a regression model.
GRAPH_PLOTTING	Plots graphs of scatter diagram, regression curve and the residuals from a regression model.
RANKING	Creates an output data file of variables stored in ascending or descending order of a variable. The data rows corresponding to a selected level combination of factors or identifiers may be ranked.
DATA_SAMPLE	Extracts a random or user specified sample of rows of data from a data file.
SELECT	Subset data file based on logical combination of *conditions imposed on the data.*
TRANSFORM	Creates new variables by transformations of the existing variables.
WRITE_TEXT	Creates a text file from a data file.
CONVERT_ICADET	Converts data from an ICADET file to a CRISP file structure.

VMS and RSX Operating System Utilities

COPY	Creates a copy of a data file. Copies a text file from one peripheral device to another.
DELETE	Deletes data files from hard disc.
RENAME	Renames a data file.
PURGE	Purges the directory from other versions of data files from the hard disc.
DIRECT	Displays a directory of the data files.
SHOW	Displays the system characteristics eg. terminal status, default devices, etc.
WIDTH	Changes the width of the terminal.
PRINT	Prints all the listing files produced during the session.

CRISP Verification

A CRISP verification run was performed by an invited biometrician. The results confirmed the maintenance of the standards of accuracy and efficiency of resource utilization.

Micro-CRISP

CRISP version 2.1 has been tested and implemented on PDP/11-Micro under RSTS/E operating system version 7.0 and 8.0.

Training

Forty percent of the total resources of this activity area was related to training. Courses in statistical analysis were provided to 42 trainees during 1985. The list of trainees includes a wide cross-section of the scientific and technical staff of ICARDA and others from the national programs.

Computer Services participated jointly with the Cereals Improvement Program, ICARDA and National Agriculture Research Council (NARC), Pakistan, in a training course on "Analysis and Interpretation of Cereal Data" at NARC. Twenty-one participants took part. The course covered sampling techniques, analysis of variance and covariance, and regression analysis.

A short course on "Principles of Experimental Design" was organized for 24 participants and conducted by an invited biometrician.

A revised edition of CRISP Reference Manual was published. The CRISP User Guide has been completed and the manuscript circulated, selectively, for critical review.

GENERAL SYSTEM DEVELOPMENT

Most of the resources in this activity area were devoted to training, enhancements and additions of existing features of ICADET, ICARDA's data management system.

ICADET is now adopted by several international agricultural organizations as a comprehensive database management system for data manipulation, storage, retrieval and reporting.

Seven courses were held to train 38 users from different programs. User support covers both assistance in database administration and scheme definition. ICADET is, today, the main tool for data entry, storage, retrieval, analysis and reporting applications in research and administration.

More commands were added to ICADET and its dependent packages such as CERINT, METEOR and CHABIB. The available commands in ICADET are:

ADD:
Adds rows to the dataset.

ADD_COLUMN:
Merges specified attributes from a dataset with specified attributes from a different dataset, or creates new attributes in a dataset.

CLOSE:
Deactivates a specific dataset.

COMMANDS:
Displays the available commands.

COMPRESS:
Removes inactive (deleted) rows from the dataset.

CONVERT:
Creates an ICADET dataset from data stored in a free format text file.

COPY:
Copies specified attributes from a dataset to a new dataset.

CREATE:
Initializes the dataset structure.

CRISP:
Converts an ICADET dataset to a CRISP file structure.

DELETE:
Deletes an ICADET dataset.

DIRECTORY:
Lists all ICADET header and detail files.

DISPLAY:
Displays a dataset.

DUPLICATE:
Creates a new ICADET dataset from an existing dataset.

GET:
Searches for a value in a specific attribute.

MODIFY_HEADER:
Edits the header of a dataset.

EDIT: Edits data in the dataset.

EXAMINE:
Displays a range of selected attributes in a dataset.

FREE_FORM:
Prints a text file with selected attributes from an ICADET dataset.

FREQUENCY:
Calculates the frequency distribution in a given attribute.

HELP:
Displays help information.

LOGOUT:
Permits a rapid exit from ICADET and logout from the system.

OPEN:
Activates a specific dataset.

PRINT:
Prints data in a dataset on a file, ready for sending to a printer.

PRINT_LABEL:
Prints different sizes of labels using data in a given dataset.

PRINT_COLUMN:
Prints data in the dataset tabulated by rows.

PURGE:
Purges the directory from older versions of datasets.

RANK:
Creates a ranking attribute for a given attribute in the dataset.

RENAME:
Renames an ICADET dataset.

SELECT:
Selects rows with a value or a range of values in a specific column.

SET_TERM:
Changes the terminal device characteristics.

SHOW:
Enables the display of system characteristics.

SHOW_DATASET:
Displays the name and the title of the active dataset.

SHOW_HEADER:
Displays or prints the scheme and dictionary of a dataset.

SIZE:
Displays the size of a dataset in blocks of 512 bytes.

SORT:
Sorts the dataset according to any given field.

SORTX:
Same as SORT, operates in batch mode.

SPOOL:
Prints all listing files produced during the session.

SPSS:
Converts an ICADET dataset to ASCII format.

TRANSFORM:
Transforms an expression given by the user to a value and stores it in a new attribute.

TYPE:
Displays an ASCII file line by line.

WRITE:
Activates the system command EDIT/EDT.

WRITE TAPE:
Stores an ICADET dataset on a tape in ASCII format.

The release of ICADET Version 2.0 added new facilities to the base structure, the most important of which enhances the common data dictionary and implements links and pointers between 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. The selection facility in ICADET is enhanced with options to enable a more efficient intersection of two datasets. A number of datasets may now be active simultaneously, which enables cross-selection.

Batch processing is now fully implemented. This was called for by the increase of the size of the datasets processed daily by ICADET, and the need to process more than one job at the same time by one user in a synchronized or independent fashion.

The analytical and data transformations part of ICADET has been enriched with new, routines to meet the increasing users' demands. Two major commands were affected by the new additions:

TRANSFORM

Will transform data in a dataset according to standard algebraic equations, and store the result in a new attribute or in a given attribute in a specified row.

An equation can take one of the following formats:

NEWCOL=C2/2+500
C2(I)=C3(I)+5-C1(I):I=n(s)m
C2(3)=C3(5)+5-C1(2)
R1(I)=R2(I)+R3(I):I=n(s)m
R1(3)=R2(2)+R3(4)

Where, Cn(I) refers to the I-th row of the nth attribute; Rn(I) refers to the I-th attribute of the nth row.

The transformation will be applied on the range of rows defined by I=n(s)m, where:

n = start row number
m = end row number
s = row number increment

TRANSFORM permits the use of all the algebraic, trigonometric, hyperbolic, transcendental, and user-defined functions.

The following are subcommands available within the TRANSFORM command:

EXCLUDE:
Will allow the exclusion of specific values in specific attributes from computations.

INCLUDE:
Will allow the user to include values which were excluded by a previously issued EXCLUDE command.

INITIALIZE:
Will initialize the setting to include all the values in all the attributes. It will cancel all the exclusion effect.

ADD:
Will add more values to be excluded in addition to those already excluded.

SHOW:
Will display the excluded values and columns.

WRITE:
Will allow the user to store the transformations on a file.

EXECUTE:
Will execute a set of TRANSFORM commands written on a standard ASCII file created by the user. Typically, the file is created using EDIT, the standard editor, or generated by the command WRITE.

ANALYZE

Will perform analysis of meteorological data. The following commands were implemented:

USE:
Will define the variable or variables, subject of the analysis. It accepts a variable name or a variable index. For example,

USE 1,2
USE RAIN,TEMP

ADD:
Will add one or more variables to the list of variables to be analyzed. For example,

ADD 3,7
ADD HUMID,EVAPOR

DELETE:
Will delete variables from the set of variables to be analyzed. For example,

DELETE 3
DELETE HUMID

SET:
Will set the dates between which the data are to be analyzed. It will also set, if necessary, the default variables.

SET START DATE 11-Jan-1985
SET END DATE 25-Mar-1985

INITIALIZE:
Will initialize the DATES or the VARIABLES used in the analysis.

SHOW:
Will display the list of variables or dates set by the user.

CALCULATE:
Will set the frequency of totals to appear in the report. The frequency may be set to WEEKLY, MONTHLY, YEARLY, or for the entire rows of the dataset.

The accumulation of the rainfall can also be obtained for the set dates such as:

CALCULATE MONTHLY ACCUMULATION
CALCULATE YEARLY ACCUMULATION

OPEN:
Will open an output file and will save on it the result of the calculations. Ordinarily the results are displayed on the terminal device.

DISPLAY:
Will display the contents of an output file opened with the command OPEN.

CLOSE:
Will close the file used to save the result

of an analysis and opened by the command OPEN.

PRINT:
Will print the contents of the file used to save the result of the analysis on a specific printer.

CHANGE:
Will close an active dataset and open another, whose name is specified as a parameter to the command.

LIST
Will display the attributes of the active dataset.

REPORT GENERATOR

The free format print command is a flexible tool for report generation and fieldbook production. It permits the use of various types of printers, and the graphic facilities to design the output reports.

Fieldbooks are designed by the user using the report generator. Data may be read from an input dataset. The fieldbook structure may be saved for further use.

Input may be a file created by using the standard editor or the word processor, in which the user designed the layout of the file, or setup interactively with concurrent display of the layout of the report or fieldbook using the following commands:

FORMAT

Will define the line, the bar and the break characters, the break position, the line's width, the line's length or set the graphic mode. For example,

```
WIDTH=70/LENGTH=45/BAR_CHARACTER=
    |/END
```

TITLES

Will handle all the title lines and define their location, length, and contents. It also defines a page number or a date position on the output report. For example,

```
DRAW BAR/START CHARACTER=3/LINE=4
WRITE/STRING=The first column/START=
    10/LINE=1
```

DATA

This command handles all information coming from the data file, such as the file name to be used or the columns to be selected and their location on the output report. Columns may be split on several lines if necessary. A favored split character is set by the user. Will also set the line number for start of the data and determine the number of rows per page. For example,

```
USE/FILE=FILNAM
SET LINE=3
COLUMN/COLUMN=2/SPL=16/FAV=*/LINE
    =4/STA=24/NUM=3
COL/COL=4/STA=50
```

VIEW

Will display a previous form created by the user and saved on a file.

WRITE

Will save the user defined FORMAT, TITLE, DATA sections on a special file. The file may be recalled and used or modified at any time by the user.

SHOW

Will display the set FORMAT defaults sets and the datasets defined by the user.

USE

Will permit the selection and use of a specified format file in the preparation or printing of a report or a fieldbook.

DELETE

Will permit the deletion of a specified format file.

INITIALIZE

Will initialize the parameters in the sections: DATA, TITLES and FORMAT.

EDIT

Will permit editing the form such as moving a token to a different position, deleting a line or a token or modifying them at any time. Will also display them in a numeric format to assist in locating their position.

PRINT

Will print the report or fieldbook after checking that all the non-default output parameters are specified. A range of rows can be printed as well as the entire ICADET dataset. For example,

```
PRINT/OUTPUT=FILNAM.LIS/USING=
    FILNAM.FRM/START=3/END=20
```

HELP

Will display help information at all levels of report definition.

EXIT

Will exit from the program.

QUIT

Will exit from the program after deleting all definitions, modifications and editing which took place during the session.

Many of ICARDA's publications are organized, produced and printed using ICADET. These include an Annotated Bibliography of Chickpea Genetics and Breeding, the Current Awareness, a Bibliography on Durum Wheat, a Directory on Food Legumes and a Barley Germplasm Catalog

The recent introduction of laser printing equipment with various fonts and typefaces, improved the quality of the output.

ICADET and CERINT user manuals were published in June 1985.

ADMINISTRATIVE APPLICATIONS

The integrated Management Accounting and Information System (MAS) implemented on the VAX-11/750 VMS V4.2 operating system, was installed at the Tel Hadya computer centre. The current version of MAS supports:

General Ledger Sub-system;
Payroll Sub-system;
Medical Sub-system;
Budget Development and Control Sub-system;
Manpower Deployment Sub-system;
Memorandum Accounts Sub-system;
Stock Control and Order Entry Sub-system;

Medical Sub-system

This Sub-system processes the medical insurance claims of each employee in ICARDA, monitors the status of medical bills and verifies them against the medical insurance plan for hospital, surgical and medical expenses incurred by the employee and dependents according to ICARDA's Personnel Policy.

The link with the general ledger is through the automatic issue of standard ledger voucher which is posted manually or automatically. Upon posting a memorandum entry is made in the personal account of the employee and a credit notice is issued.

Stock Control Sub-System

The stock control sub-system was completed and tested against the manual system through parallel running for 2 months. It was released for use by the Purchasing and Supplies Department in July 1985.

The component of this sub-system permits the creation and maintenance of stock item files, the display of stock item file using different keys for selection, including the re-order level.

A stock taking component enables periodic, random or selective stock taking, automatic reconciliation and variance reporting.

Stores requests are handled interactively, with facilities for receiving, issuing and returns.

Payroll Sub-System

a. Bonus and Extra Days

Modification to the payroll to automate the processes of the year-end bonus and extra-days worked. The program automatically generates vouchers for posting to the relevant accounts of the project and responsibility center in the General Ledger. Entries are made in the memorandum payroll account of the employee, and a credit notice is issued.

b. Adjustment

An adjustment component was added to the Payroll Sub-system to permit pay adjustment reflecting changes in pay status which took place before or after the payslip-production stage.

COMMUNICATIONS AND DOCUMENTATION

Communications

As in previous years, communications activities focused on editing and publishing, and promoting relations with the media. With the training of some staff members from the photography laboratory, print shop, and art unit at specialized centers, we were able to provide improved services to ICARDA staff in the preparation of graphic designs, posters, and slides, as well as composing and printing.

An important achievement in editing and publishing was that a large-capacity offset printing machine was put into operation in 1985. This enabled us to print the English and Arabic versions of our 1984 Report in-house for the first time, in addition to several other publications including scientific newsletters. We produced 77 publications in 1985; 11 were in Arabic. Increased emphasis was placed on Arabic publications to reach a wider readership in the ICARDA region.

Greater efforts were made to use the facilities available in Syria to produce 4-color publications. In the past, ICARDA's 4-color publications had been sent outside Syria for printing, which was both time-consuming and expensive, but in 1985 all seven 4-color publications (including the English and Arabic versions of the 1984 Research Highlights) were printed in our host country.

With the cooperation of the research programs, the rhythm of publication of ICARDA's scientific newsletters was maintained: on faba beans (FABIS), on lentils (LENS), and on cereals (RACHIS).

ICARDA participated in six regional and international book fairs. New contacts were established with publishers and distributors and the mailing lists were improved. All mailing lists were fully computerized in 1985 to improve the efficiency of our distribution.

Significant progress was made in promoting relations with the media. Several journalists from within and outside the ICARDA region visited the Center. At least 28 stories about ICARDA were published in newspapers and magazines in 1985, 10 were in Arabic. Some important events were also covered by the radio and television, both in Syria and other countries.

As in 1984, the department faced shortages of staff, space, and equipment. Efforts are under way to relieve these constraints.

Documentation

There was a considerable improvement in the library resources and services. Compared with the average rate of 250 books and monographs in previous years, 450 titles were acquired in 1985, and the acquisition of periodicals increased from 200 to 250. Back issues of some important periodicals were added to the library holdings.

The periodicals Acquisitions List (monthly) was continued, and a new service, the ICARDA Library Bulletin (quarterly), was introduced for the benefit of ICARDA scientists.

Documentation work, however, moved at a slow pace due to the shortage of manpower. Participation in AGRIS continued, and two comprehensive bibliographies, one on durum wheat and the other on faba beans, were compiled and will be published in 1986.

VISITORS' SERVICES

The number of visitors to ICARDA has significantly increased during the past 5 years, reflecting the growing interest in the Center both at national and international level (Fig. 1).

Compared with 1200 visitors in 1984, Visitors' Services received 1686 visitors in 1985, an increase of over 35%. Of these, 57% were from Syria and 43% from 55 countries all over the world.

During the year, 17 program events were held in ICARDA. ICARDA was honored with visits by the Minister of Agriculture, Syria; the Governor of Aleppo Province; the Head of Al Baath Party in Aleppo; the Ambassadors of UK, Australia, Saudi Arabia, Mauritania, Pakistan, and Tunisia; Mrs Janet Wardlow (Chairman); and Mr Ivan Head (President) of IDRC of Canada.

ICARDA's "Guest of the Year" was Dr Robert D. Havener of Winrock International, Arkansas, USA, and formerly Director General of CIMMYT.

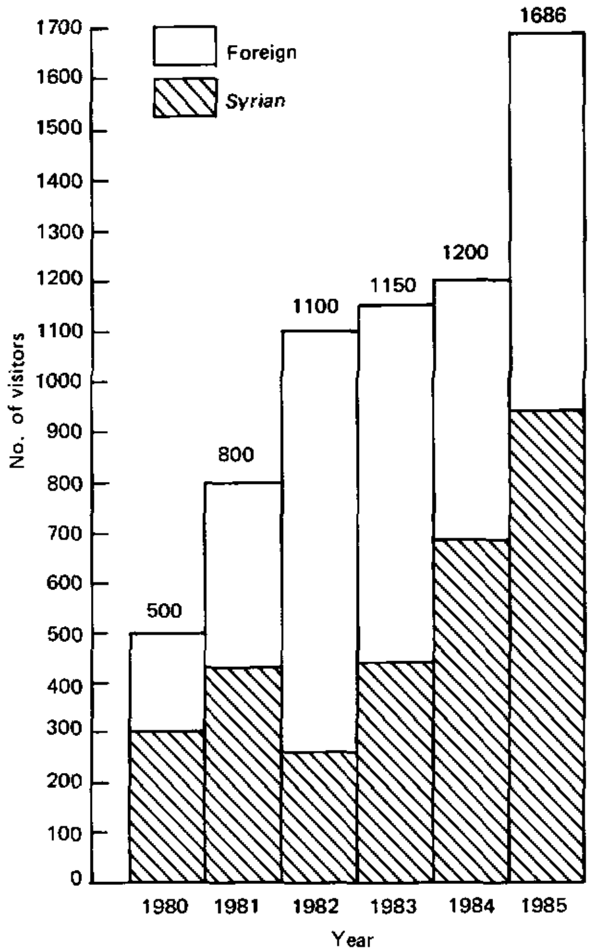


Fig. 1. ICARDA visitors during 1980-85.

Collaborative Projects With Advanced Institutions, 1985.

Subject	Cooperating Institution(s)	Funding Organization(s)
1. Nitrogen fixation studies using ^{15}N	International Atomic Energy Agency, Austria	IAEA/ICARDA
2. Screening advanced ICARDA wheat and barley germplasm for BYDV	Agriculture Canada Laval University, Canada	IDRC
3. Cereal, food legume, and forage quality evaluation	Canadian Grain Commission, Canada	ICARDA
4. Faba Bean Pathology	University of Manitoba, Canada	IDRC
5. Haploid culture of lentils	University of Manitoba, Canada	IDRC
6. Pollination studies (faba beans)	University of Manitoba, Canada	IDRC
7. Rhizobium culture production and inoculation methodologies	University of Manitoba, Canada	IDRC
8. Collection and evaluation of barley, durum wheat and their wild relatives	University of Saskatchewan, Canada	CIDA and NSERC
9. Lentil News Service (LENS)	University of Saskatchewan, Canada	IDRC
10. Chickpea breeding and pathology	ICRISAT, India	ICRISAT/ICARDA
11. Evaluating and cataloging of barley germplasm	IBPGR, Italy	IBPGR and ICARDA
12. Studies on nematodes affecting food and forage legumes in the Mediterranean region	Institute of Nematology, Bari, Italy	CNR
13. Durum germplasm evaluation	Institute of Germplasm, Bari, University of Viterbo, Italy	CNR
14. Regional study on adaptation of faba bean	University of Napoli, Italy	EEC
15. Development of marginal lands	University of Perugia, Italy	CNR
16. Screening for cold tolerance in lentils	University of Perugia, Italy	CNR
17. Yield decline in continuous cereal systems	University of Bonn, Germany (BRD)	GTZ
18. Mechanism of resistance to ascochyta blight in chickpeas	University of Bonn, University of Muenster, Germany (BRD)	Deutsche Forschungsges
19. Weed control and water-use efficiency in peas	Institute of Tropical Agriculture University of Giessen, Germany (BRD)	BMZ
20. Performance and interaction of wheat and rye genomes in triticale	Institut fuer Pflanzenbau und Pflanzenzuchtung, Goettingen University, Germany (BRD)	GTZ

Subject	Cooperating Institution(s)	Funding Organization(s)
21. Economic feasibility and impacts of increased integration of small ruminants in northern Syria	Institute of Agricultural Economics and Social Sciences, University of Hohenheim, Germany (BRD)	
22. Wide adaptability in faba beans	Institute of Plant Breeding, University of Hohenheim, Germany (BRD)	Sohn Stiftung
23. Yield physiology of durum	Institut fuer Pflanzenzuchtung, Saatgut-Forschung und Populations - Genetik Universitat Hohenheim, Stuttgart, Germany (BRD)	Eislen Stiftung
24. Phosphate fertilization and iron use in food legumes	Institute of Plant Nutrition, University of Hohenheim, Germany (BRD)	BMZ/GTZ
25. Control of *Orobanche* spp. in food legumes	Institute of Plant Production in the Tropics, University of Hohenheim, Germany (BRD)	GTZ Eislen Stiftung
26. Improvement of nutrient uptake efficiency in chickpea	University of Hohenheim, Germany (BRD)	Eislen Stiftung
27. Influence of VA-mycorrhiza on chickpea growth under semi-arid conditions	University of Hohenheim, Germany (BRD)	Eislen Stiftung
28. Salt tolerance in wheat and barley	Institut fuer Pflanzenzuchtung, University of Munich, Freising, Germany (BRD)	GTZ
29. Wheat and barley breeding	CIMMYT, Mexico	CIMMYT/ICARDA
30. Research on plant virus diseases	Institute of Plant Protection (IPO), Wageningen, The Netherlands	DGIS
31. Screening food legumes for resistance to *Orobanche* spp.	University of Wageningen and Royal Tropical Institute, Amsterdan, The Netherlands	EEC
32. Studies on the resistance of faba beans to *Botrytis fabae*	Plant Breeding Institute, Cambridge, UK	PBI
33. Nutritive value of hays and straws	Tropical Development and Research Institute, UK	ODA
34. Evaluation of independent vascular supply in *Vicia faba*	University of Durham, UK	EEC

Subject	Cooperating Institution(s)	Funding Organization(s)
35. Development of a metabolic index of stress in barley and durum wheat	University of London Birkbeck College, UK	ODA
36. Xylem combined nitrogen status in vetch and lentils under differing regimes	University of London Birkbeck College, UK	No funding involved
37. Inter-specific crossing in *Vicia*	University of Reading, UK	ODA
38. Photothermal relations in barley, faba beans, and lentils	University of Reading, UK	ODA
39. Physiologic variation in *Ascochyta rabiei*	University of Reading, UK	ODA
40. Resistance to bruchids in faba beans	University of Reading, UK	Ford Foundation
41. Root studies on barley and chickpea	University of Reading, UK	ODA
42. Studies on out-crossing in lentils	University of Swansea, UK	University of Swansea
43. Nitrogen fertilizer efficiency using ^{15}N	International Fertilizer Development Center, USA	IFDC/UNDP
44. Development of large-seeded, tall chickpeas resistant to *Fusarium* spp. and viruses	University of California, Davis, USA	USAID
45. Rangeland Development (Baluchistan)	Colorado State University, USA	USAID
46. Barley: Crop simulation model	Michigan State University/ IFDC, USA	USAID
47. Barley diseases	Montana State University, USA	USAID

Senior Staff

(as of 31 December 1985)

Director General's Office

Dr Mohamed A. Nour, Director General

Dr Peter Goldsworthy, Deputy Director General (Research)

Dr Jan Koopman, Deputy Director General (International Cooperation)

Dr A. van Gastel, Seed Production Specialist

Dr Samir El Sebae Ahmed, National Research Coordinator

Government Liaison & Public Relations

Dr Adnan Shuman, Assistant Director General (Government Liaison)

Damascus Office

Mr Abdul Karim El-Ali, Administrative Officer

Beirut Office

Ms Afaf Rashed, Executive Secretary/Office Manager

Mr Anwar Agha, Senior Accountant

Cairo Office

Dr Bhup Bhardwaj, Director of Administration & Operations, ICARDA/IFAD Nile Valley Project

Tunis Office

Dr Ahmed Kamel, ICARDA Representative/Cereal Pathologist

Finance

Mr Edward Sayegh, Financial Controller & Treasurer

Mr Pradeep Mehra, Finance Officer

Mr Suresh Sitaraman, Finance Officer

Ms Rima Musalli, Budget Officer

Mr Salah Deif, Accountant, Nile Valley Project

Mr Suleiman Is-hak, Senior Accountant

Mr Fadel Kandis, Pre-Audit & Control

Mr Mohamed Samman, Senior Accountant

Mr Mohamed Barmada, Administrative Officer/USAID-Azri Project

Computer Services

Mr Khaled El-Bizri, Director

Mr Bijan Chakraborty, Senior Programmer

Mr Bashir Bshara, Senior Programmer

Mr Bizhan Kamrava, Analyst/Programmer*

Mr Michael Sarkissian, Maintenance Engineer

Personnel

Ms Leila Rashed, Personnel Officer

Farming Systems

Dr Peter Cooper, Program Leader/Soils Physicist

Dr Abdullah Matar, Soils Chemist

Dr Kutlu Somel, Agricultural Economist

Dr Thomas Nordblom, Agricultural Economist

Dr Seweryn Kukula, Weed Scientist*

Dr Joseph Stephens, Microbiologist*

Dr Hazel Harris, Soil Water Conservation Scientist

Dr Eugene Perrier, Water Management Agronomist

Dr Bakheit Saied, Senior Training Scientist

Dr Thomas Stilwell, Agronomist (Tunisia)

Dr Dennis Tully, Anthropologist

Dr Ronald Jaubert, Post Doc. Fellow-Agricultural Economist*

Dr Wolfgang Goebel, Post Doc. Fellow-Agroclimatologist

Dr Awad el Karim Ahmad, Post Doc. Fellow-Agricultural Economist*

Mr Abdul Sattar A. Moneim, Associate Expert*

Mr Ahmad Mousa el Ali, Weed Control

Mr Abdul Bari Salkini, Agricultural Economist

Mr Ahmad Mazid, Agricultural Economist

Mr Mahmoud Oglah, Research Associate

Mr Sobhi Dozom, Research Associate
Mr Yousef Sabet, Associate Expert*

Cereal Crops Improvemet

Dr Jitendra P. Srivastava, Program Leader
Dr Edmundo Acevedo, Physiologist/Agronomist
Dr Salvatore Ceccarelli, Barley Breeder
Dr Mohamed S. Mekni, Barley Breeder
Dr Omar Mamlouk, Plant Pathologist
Dr Guillermo O. Ferrara, Bread Wheat Breeder (CIMMYT/ICARDA)
Dr Miloudi Nachit, Plant Breeder (CIMMYT/ICARDA)
Dr Mohamed Tahir, Plant Breeder
Dr Ahmed el Ahmed, Plant Breeder/Pathologist (Tunisia)
Dr Hugo Vivar, Barley Breeder (Mexico)
Dr Habib Ketata, Senior Training Scientist
Dr Dieter Mulitze, International Nurseries Scientist
Dr Sui K. Yau, Post Doc. Fellow-Barley Breeder
Mr Joop van Leur, Associate Expert-Plant Pathology (The Netherlands Government)
Mr Mumtaz Malik, Research Associate
Mr Issam Naji, Research Associate
Mr Paolo Annicchiarico, Research Associate
Mr Luciano Pecetti, Research Associate

Food Legume Crops Improvement

Dr Mohan C. Saxena, Program Leader/Agronomist-Physiologist
Dr Cesar Cardona, Senior Entomologist*
Dr William Erskine, Plant Breeder
Dr Howard Gridley, Plant Breeder (Tunisia)*
Dr Salim Hanonik, Plant Pathologist
Dr Mohamed Habib Ibrahim, Senior Training Scientist
Dr M.V. Reddy, Chickpea Pathologist (ICRISAT)*
Dr K.B. Singh, Plant Breeder (ICRISAT)
Dr Larry D. Robertson, Faba Bean Breeder
Dr R.S. Malhotra, Post Doc. Fellow-International Trials Scientist
Dr Said Nahdi Silim, Post Doc. Fellow-Agronomy/Physiology
Dr Mbagus Murinda, Post Doc. Fellow-Agronomy*
Dr Mohamed el-Sherbeeny, Post Doc. Fellow-Faba Bean Breeding (NVP)
Dr Joachim Sauerborn, Post Doc. Fellow-Orobanche (GTZ)
Mr Eckhard George, Associate Expert
Mr Ahmad Hamdi Ismail, Research Associate

Pasture, Forage, and Livestock Improvement

Dr Philip S. Cocks, Program Leader/Pasture Ecologist
Dr Alan Smith, Grazing Management Specialist
Dr Ahmed el Tayeb Osman, Agronomist
Dr Euan Thomson, Livestock Scientist
Dr Luis Materon, Microbiologist
Dr Ali Abdul Moneim Ali, Senior Training Scientist
Mr Faik Bahhady, Assistant Livestock Scientist
Mr Nerses Nersoyan, Research Associate
Mr Safouh Rihawi, Research Associate
Mr Hanna Sawmy Edo, Research Associate
Mrs Monika Zaklouta, Research Associate
Mr Munir Turk, Research Associate
Mr Luigi Russi, Research Associate**
Mr Marco Picirilli, Research Associate (University of Perugia)**
Ms Silvia Lorenzetti, Research Associate**

Genetic Resources Unit

Dr Bhal Somaroo, Program Leader
Dr Khaled Makkouk, Plant Virologist
Dr Laszlo Holly, Genetic Resources Scientist
Dr Marlene Diekmann, Plant Protection Officer (DAAD, W. Germany)
Dr Yawooz Adham, Documentation Specialist
Mr Bilal Humeid, Research Associate
Mr Thomas Ehrman, Research Associate (IBPGR)

Communications & Documentation

Mr Larry Chambers, Head*
Dr Surendra Varma, Senior Science Editor
Ms Lynn Simarski, Science Writer

Training

Dr Lawrence R. Przekop, Head
Mr Mohamed Radwan Tchalabi, Assistant Training Officer

Visitors' Services
Mr Mohamed A. Hamouieh, Administrative Officer

Travel Services
Mr Bassam Hinnawi, Travel & Visa Officer

Farm Operations
Dr Juergen Diekmann, Farm Manager (Tel Hadya)
Dr P. Jegatheeswaran, Agricultural Machinery Engineer
Mr Marwan Mallah, Administrative Officer
Mr Ahmed Sheikhbandar, Assistant Farm Manager
Mr Munir Sughayyar, Engineer, Farm Operations (Terbol)

Physical Plant
Mr Peter Eichhorn, Vehicle Workshop Supervisor
Mr Haitham Midani, Officer, General Services
Mr Ohannes Kalou, Building & Maintenance Engineer
Mr Farouk Jabri, Officer-Food & General Services

Station Development
Mr Brian Tierney, Construction Manager
Mr Khaldoun Wafaii, Civil Engineer
Mr Isaac Homsy, Civil Engineer

Purchasing & Supplies
Mr Ramaswamy Seshadri, Manager
Ms Dalal Haffar, Purchasing Officer

International School of Aleppo
Mr Denis Sanderson, Principal/Teacher
Mrs Elizabeth Fisher, Teacher*
Ms Christine Steer, Teacher

Pakistan
Dr John D. Keatinge, Team Leader/Crop Physiologist
Dr Richard Aro, Range Management/Livestock Specialist
Dr David J. Rees, Agronomist

Consultants
Mr Tarif Kayali (Syria), Legal Advisor
Dr Hisham Talas (Syria), Medical Consultant
Dr Edward Hanna (Lebanon), Legal Advisor
Mrs Gem Somaroo (Canada), Nursing
Dr Philip Williams (Canada), Analytical Services
Mr Subrata Dutta (India), Resident Consultant-Library
Dr Giro Orita (Japan) Veterinary Specialist
Dr Roger Peterson (USA), Senior Biometrician
Prof. W.B. Ward (USA), Science Writer/Editor

---

* Left ICARDA during 1985.

** Sponsored by the Italian Government.

Published by the International Center for
Agricultural Research in the Dry Areas (ICARDA)
P.O. Box 5466, Aleppo, Syria

Printed at ICARDA, Aleppo

AR-8/4000/1986