FOOD LEGUME CROPS IMPROVEMENT

Program Report 1984/85

International Center for Agricultural Research in the Dry Areas

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Draft Annual Report 1984/85

CONTENTS

INTRODUCTION

The major objective of the Food Legume Improvement Program continued to be to increase the productivity and yield stability of faba beans (Vicia faba), lentils (Lens culinaris) and Kabuli-type chickpeas (Cicer arietinum). Because of the importance of their protein rich seeds in human nutrition, their nutritive by-products for animal feed and their role in fixing atmospheric nitrogen, these food legumes are of immense value in the farming system of the dry areas of ICARDA region and other areas of their adaptation.

The productivity of the food legumes is constrained and unstable because of inherently low yield potention of the currently cultivated land races and their susceptibility to biotic and abiotic stresses. Traditional agronomic practices including costly and laborious hand harvest are additional factors reducing the production of these crops. The research in the Program during the 1984/85 season aimed to overcome these bottlenecks. Efforts were made to link our activities more closely with those of the national programs within and outside the ICARDA region so that benefits could reach the farmers as early as possible. The 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, which has worldwide responsibility for research in the improvement of chickpea crop. ICRISAT has provided a principal chickpea breeder and a principal chickpea pathologist to work with ICARDA legume scientists in the improvement of Kabuli-type chickpeas.

The research in the Program was continued to be conducted around a set of projects for each of the crops through a multidisciplinary team of scientists from within and outside the Food Legume Improvement Program. However, for the convenience of the readers, our results are presented in this report, more or less, on disciplinary basis. The strategy used to develop improved genetic stocks and cultivars and production technology using the experimental sites available to the Program and linkages with the national programs has already been reported earlier (ICARDA Annual Report 1984, page 150). Research work 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 senior staff consisted of the faba bean breeder, the faba bean pathologist, the lentil breeder, the legume entomologist, the senior training officer, the legume breeder in Tunisia and the agronomist/program leader. The ICRISAT chickpea breeder remained on sabbatical leave till end of September 1985 and the position of ICRISAT chickpea pathologist remained vacant throughout following the departure of Dr. M.V. Reddy in early 1985. The legume entomologist left the program in November 1985 to join CIAT. The senior staff was supported by four post-doctoral fellows: one in faba bean breeding through the Nile Valley Project, one in agronomy/crop physiology, one in the international testing program, and one in the Orobanche control through the GTZ supported special project. ICRISAT deputed a pathologist for a period of 4 weeks, twice in the season, to provide an input in the Kabuli-chickpea improvement work. The program also had two visiting research associates/fellows: one to work on 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. degree in European Universities, also worked for their thesis research in the Program, in the ongoing projects.

Research Highlights

The 1984/85 season was characterized by an exceptionally cold winter with 38 frost days at Jinderis, 42 at Tel Hadya, 43 at Breda and 63 at Khanasser with minimum temperature dropping to well below -9^{o}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. As a result, several experiments in the first two crops were completely damaged and much of the breeding material was damaged to different degrees. However, the season provided an excellent opportunity of screening the legume germplasm and breeding material for cold tolerance and it was heartening to find that several breeding lines and genetic stocks of kabuli chickpeas developed in the Program tolerated the cold rather well. This is very reassuring for the winter sowing strategy that the Program has developed for kabuli chickpeas in the region. From the point of view of rainfall, the season was more or less normal with a total seasonal precipitation of 409 mm at Jinderis, 373 at Tel Hadya, 277 at Breda and 199 at Khanasser.

The major achievements of the program during the 1984/85 season are summarised below:

1. **Faba beans:**

1.1. Selfing and purification of 5005 BPL accessions was done and also 288 new ILB accessions were increased and development of BPL's from these started. The project on developing a computerised data base of the ILB accessions' passport information made significant progress. Further purification of 44 chocolate spot, 25 ascochyta and 30 rust resistant inbred lines was done for distribution and crossing.

1.2. 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.

1.3. For the first time 67 BPL and ILB accessions were identified having frost resistance.

1.4. 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 were identified as being resistant to a very wide range of isolates of Botrytis fabae and 67 entries having resistance to wide range of isolates of Ascochyta fabae.

1.5. From the 3000 breeding lines distributed to the 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
e. Egypt - several large seeded lines

1.6. Work started in the utilization of the 'Independent Vascular Supply' trait through a crossing program.

1.7. 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. A 'Highlight of the NVP' has been prepared. 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 were laid out in July 1985 in Shoa region.

1.8. A new screening technique for resistance to Orobanche was developed.

2. **Lentils:**

2.1. 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, respectively.

2.2. In on-farm trials in Syria, ICARDA selections (2 large seeded, and 2 small seeded) were tested against local checks in cooperation with the government. Among the large-seeded entries the average yield advantage of 78S26002 over three seasons was 16% above the check. This selection, which is easy to harvest mechanically because of its reduced lodging, is now in pre-release multiplication.

2.3. Variety NEL (ILL) 358 was released in Ethiopia to farmers in the highland areas. The cultivar has rust resistance and a 50% yield advantage over the local check.

2.4. Four selections in Tunisia and two in Spain were identified for pre-release multiplication. ILL 4605 is being considered for release in part of Pakistan.

2.5. Two inexpensive mechanical harvest systems were tested on lentils at Tel Hadya Farm. The first, tractor-puller angled blades, gave a return of 96% for the straw and seed compared to hand harvest. The second system, double-knife cutter bar, resulted in a lower return because of the straw loss, but its performance was improved by harvesting non-lodging cultivars sown on un-ridged soil.

2.6. Agronomic studies on new lentil genotypes showed that advancing the sowing date from late to early winter resulted in 117% and 165% increase in seed and straw yield, respectively.

3. **Kabuli-type Chickpeas**:

3.1. 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.

3.2. Several large seeded and tall types combining cold tolerance, ascochyta blight resistance and high yield have been identified.

3.3. The season saw increasing use of ICARDA developed/supplied chickpea lines by the national programs. Egypt used ILC 482 for on-farm trials; Turkey has 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. Many national programs have selected chickpea lines developed by ICARDA for evaluation in the multilocation trials because they combine large seed, cold tolerance and ascochyta blight resistance in addition to high yield.

3.4. A pot-culture technique for screening resistance to cyst nematodes has been developed and using this technique 253 chickpea lines were screened and 11 lines with good tolerance were identified.

3.5. 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 one or more could be considered as new cultivar for release for winter sowing. Similarly 21 lines stemming from single plant selections for wilt resistance in the local cultivar Amdoun will be retested and one or more considered for release for spring sowing in 1986/87.

3.6. Agronomic studies in ICARDA/INRAT cooperative projects 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 from several other national programs where this comparison has been made.

3.7. Supplemental irrigation of winter and spring sown chickpeas at Tel Hadya gave 73 and 142% increase in seed yield, respectively, highlighting the importance of supplemental irrigation for this crop.

4. **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 amounted to about 1500 sets. The report for 1982/83 season was printed and distributed. The report of 1983/84 was finalised.

5. **Training:**

5.1. 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).

5.2. 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.

5.3. The program also participated in the conduct of a national training course on cereals and food legume pathology and a seed technology training course, both held at ICARDA.

5.4. Twenty individual trainees received specialised training in different areas of food legume research. Four new graduate students did their thesis research work in the program.

5.5. An audio-tutorial module on the ascochyta blight of chickpea was prepared and distributed to the national program scientists.

1. FABA BEAN IMPROVEMENT

Research on faba bean improvement continued to be conducted under the following four projects: 1. Development of improved cultivars and production practices for high rainfall/assured moisture 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. In addition, work on the germplasm resource aspects was also 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 later section on International Cooperation.

Since faba beans are predominantly grown in the high rainfall/assured moisture environments, major effort on the improvement work was assigned to the development of genotypes and production and plant-protection techniques of faba bean for such an environment.

1.1. Germplasm

The ILB[1/] collection stands at 3233 accessions. A total of 288 ILB accessions from Colombia, China, Sudan, Portugal, Greece, Indonisia, U.K., Peru, Syria, Germany, Ethiopia, Egypt, Ecuador, and Canada were multiplied in the screenhouse at Tel Hadya, Syria, for the first cycle of selfing to produce BPL[2/] accessions. Approximately 390 new BPL accessions will be derived from these ILB accessions. Nearly 5005 BPLs were grown in 1985 in various stages of pure-line development (Table 1.1). Seed was increased and purified of 634 BPL

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1. ILB = ICARDA Legume Faba Beans
2. BPL = Faba Bean Pure Lines

Table 1.1. Faba Bean Germplasm lines grown in 1984/85 and planned for 1985/86.

Stage of development	Number of lines 1984/85	1985/86
Pure line (BPL)		
Increase	58	1500
Purification	576	-
Cycle 5	376	350
Cycle 4	491	400
Cycle 3	161	651
Cycle 2	1494	1639
Cycle 1	1849	390
Autofertility (evaluation)	-	1500 (1/2 row)
New Accessions (ILB)	288	150
Total	5293	5830

accessions (6 or more selfing cycles), and 4371 BPL accessions were advanced one selfing cycle.

A total of 685 germplasm accessions from both the ILB and BPL collections were distributed to Tunisia, Morocco, Egypt, Sudan, Yemen Arab Republic, Turkey, Canada, Italy, West Germany, The Netherlands, and U.K. Also, 2956 lines and populations from the breeding program were distributed to 15 countries including Ethiopia, Egypt, Sudan, Morocco, Tunisia, Turkey, U.A.E., Yemen Arab Republic, Liberia, Greece, Italy, Spain, France, and the U.K.

The ILB collection at ICARDA was divided into two parts, each of approximately 1600 accessions. Passport information for accession Nos. 1 to 1600 has been computerized and checked for format. Form letters asking information on donated accessions with computer lists of donations and available descriptors will be sent to each donor for update and correction if possible, and also for checking on accessions of unknown origin. The same will be started with the second half of the ILB collection soon. This work was started to Catalogue passport information for the ILB collection for descriptors in the IBPGR/ICARDA faba bean descriptor list to make easier and more efficient use of the faba bean germplasm collection and for exchange of information with other institutes. The expected date for completion of this work is the end of 1986. L.D. Robertson and M. El-Sherbeeny.

1.2. Development of Cultivars and Genetic Stocks:

1.2.1. Development of Trait Specific Genetic Stocks:

The demand for genetic stocks with specific traits such as adaptation to a specific environment, resistance to one or more common pathogens and pests, etc. has continued to grow in the past years. Hence development and distribution of genetic stocks was given high priority during the 1984/85 season. Work for developing disease resistance included screening and selection within ILB accessions for resistance to Botrytis fabae at the disease screening site in Lattakia. However, more emphasis has started to be given in using resistance sources already found which resulted in most work being done on screening F2 populations and F3 to F6 progenies from crosses of resistance sources to different high yielding lines with adaptation to various countries in the region.

1.2.1.1. 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 and all of these originated from Ecuador, the source for the highly resistant lines to chocolate spot i.e. BPL 1179 and BPL 710. Screening of BPL accessions will continue in the 1985/86 season with 100 accessions tested for rust (Uromyces fabae) resistance. S. Hanounik and L.D. Robertson.

1.2.1.2. Disease Resistant Inbred Lines:

In 1982/83 the best chocolate spot, ascochyta blight and rust resistant sources were grown in bee-proof cages and progenies developed. These lines were grown in 1983/84 and 1984/85 for further purification for disease resistance under bee-proof cages. 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 (Tables 1.2, 1.3 and 1.4). This process will be repeated in 1985/86. This is providing sources of disease resistance for the crossing program and 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.

1.2.1.3. International Disease Screening Nurseries:

Seeds from resistant sources to chocolate spot, ascochyta blight and rust identified from screening our germplasm collection were distributed to Canada, Egypt, 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, Netherlands, Syria, and the UK) where the international chocolate spot nursery (FBICSN 85) was sent. These lines have also shown resistance for several previous 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

Table 1.2. Disease reaction on chocolate spot resistant inbred lines, at Lattakia, Syria in 1985.

Sel. 81-Lat.	BPL	Disease rating 1/	Sel. 81-Lat.	BPL	Disease rating 1/
24638-1	110	3	24948-1B	1179	3
24640-1	112	3	24948-6	1179	3
24640-2A	112	3	24950-2	1196	5
24640-2B	112	3	24950-3	1196	5
24640-2C	112	3	24957	1278	3
24694-1A	261	3	24996	1538	3
24694-1B	261	3	25001	1544	5
24694-1C	261	3	25003	1546	5
24694-2A	261	3	25004	1547	5
24694-2B	261	3	25005-2	1548	3
24694-3	261	3	25011	1556	5
24698-1	266	3	25075	1689	3
24698-2	266	3	25087	1749	5
24698-3	266	3	25090	1752	3
24701-1	274	3	25099	1763	3
24701-2	274	3	25100	1764	3
24799	461	3	25111	1802	3
24833	658	3	25114-1	1821	3
24857-1	710	3	25114-2A	1821	3
24857-2	710	3	25117	1832	3
24857-2	1056	3	25117-1	1832	3
24902	1058	3	Check	Rebaya-40	9
24948-1A	1179	3			

1/ Disease readings were made on ICARDA's 1-9 rating scale.

Table 1.3. Disease reaction on Ascochyta blight-resistant inbred lines, at Lattakia, Syria in 1985.

Sel. 80-Lat.	BPL	Disease rating[1)]
70015-1	74	3
70015-2	74	1
70015-3	74	3
70015-4	74	3
14200-1	230	3
14336	365	3
14399	436	3
14422-1	460	3
14427	465	1
14434-1	471	3
14434-2A	471	3
14434-2B	471	3
14434-3	471	3
14435-1	472	3
14435-2	472	3
14435-3	472	3
14435-4	472	3
14986-1	266	3
14998-2	646	3
14998-3	646	3
15025	ILB 752	3
15035-1	818	3
15035-2	818	3
A_2	F_6x75TA46	1
Sel. 82 10026	2485	3
Check	(Giza-4)	9

1/ Disease readings were made on ICARDA's 1-9 rating scale.

Table 1.4. Disease reaction on rust resistant inbred lines, at Lattakia, Syria in 1985.

Sel. 83-Lat.	BPL	Disease[1/]	Sel. 83-Lat.	BPL	Disease[1/]
30008	7	3	30320-1	484	3
30010	8	3	30320-2	484	3
30094	150	3	30328	490	3
30164-1	260	3	30374	522	3
30164-2	260	3	30378-1	524	3
30168-1	263	3	30378-2	524	3
30168-2	263	3	30384-1	530	3
30192	309	3	30384-2	530	3
30244	406	3	30386	533	3
30258	417	3	30388-1	536	3
30268-1	427	3	30388-2	536	3
30268-2	427	3	30394	539	3
30268-3	427	3	Sel.80-15563-1A	-	3
30273	ILB 1814	3	Sel.80-15563-1B	-	3
30310	476	3	Local check		3
30318	481	3			

1/ Disease readings were made on ICARDA's 1-9 rating scale.

at others. Data were returned from only Canada, Syria and Egypt for the international rust nursery (FBIRN-85). The results indicated the presence of location specific resistance only. However, the chocolate spot resistant entries BPL 710, BPL 1179 seemed to carry genes for rust resistance as well. S. Hanounik, L.D. Robertson, and R.S. Malhotra.

1.2.1.4. Recombination of Disease Resistance with Local Adaptation:

At Tel Hadya, local germplasm from Ethiopia, Egypt, China and Sudan was used for crossing to disease resistant lines, early, and determinate lines (Table 1.5), although many crosses were lost due to frost susceptibility of introduced parents. Some crosses between Sudanese parents were made in the off-season in Jordan. In 1985/86, crosses will be made with Egyptian, Ethiopian, Moroccan, and Tunisian lines to introduce Ascochyta fabae, Uromyces fabae, Orobanche crenata, Botrytis fabae, and virus resistance. Additionally, crosses will be made with determinate lines, IVS (independent vascular supply) lines, and such lines as Reina Blanca and New Mammoth which have shown good adaptation in the above countries. F_2 bulks from these and other crosses will be grown in the 1985/86 season and F_3 bulks will go into 1987 international F_3 trials. Also F_3 progeny rows will be grown and lines fed into preliminary trials. This is in addition to selection of disease resistant F_2 plants at Lattakia for development of disease resistant lines for yield testing. L.D. Robertson and S. Hanounik.

Table 1.5. 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
Ascochyta fabae resistance	50	60
Botrytis fabae resistance	64	60
Uromyces fabae resistance	10	20
Multiple disease resistance	16	20
Protein percentage	-	10
Earliness	20	-
Yield	26	-
National programs	26	204
Total	212	374

1.2.1.5. Resistance to *Aphis fabae*:

Resistance to *Aphis fabae* in faba bean breeding lines was screened using 1027 lines from the yield trials of the 1984/85 season in a plastic house at Tel Hadya, Syria. Five plants per line were infested with aphids and were later scored on a scale of 1 to 5 with 1=very resistanct, and 5=very susceptible. Most lines (83%) were susceptible with 848 rated 4.1 to 5.0 and eight were rated 2.1 - 2.5, 23 rated 2.6 - 3.0 and 50 rated 3.1 to 3.5 (Figure 1.1). All lines (81) rated 1 - 3.5 will be rescreened in 1985/86. L.D. Robertson and C. Cardona

1.2.1.6. Frost Resistance Screening

Because of the extreme frost experienced at Tel Hadya, Syria in 1985, the 5005 BPL accessions and 288 ILB accessions grown in the 1984/85 season were evaluated for frost resistance on the following 1-5 rating scale:

1. No visible symptoms of damage.
2. Upto 20% leaflets in most plants show yellowing or withering but no damage to the stem.
3. 20 to 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.

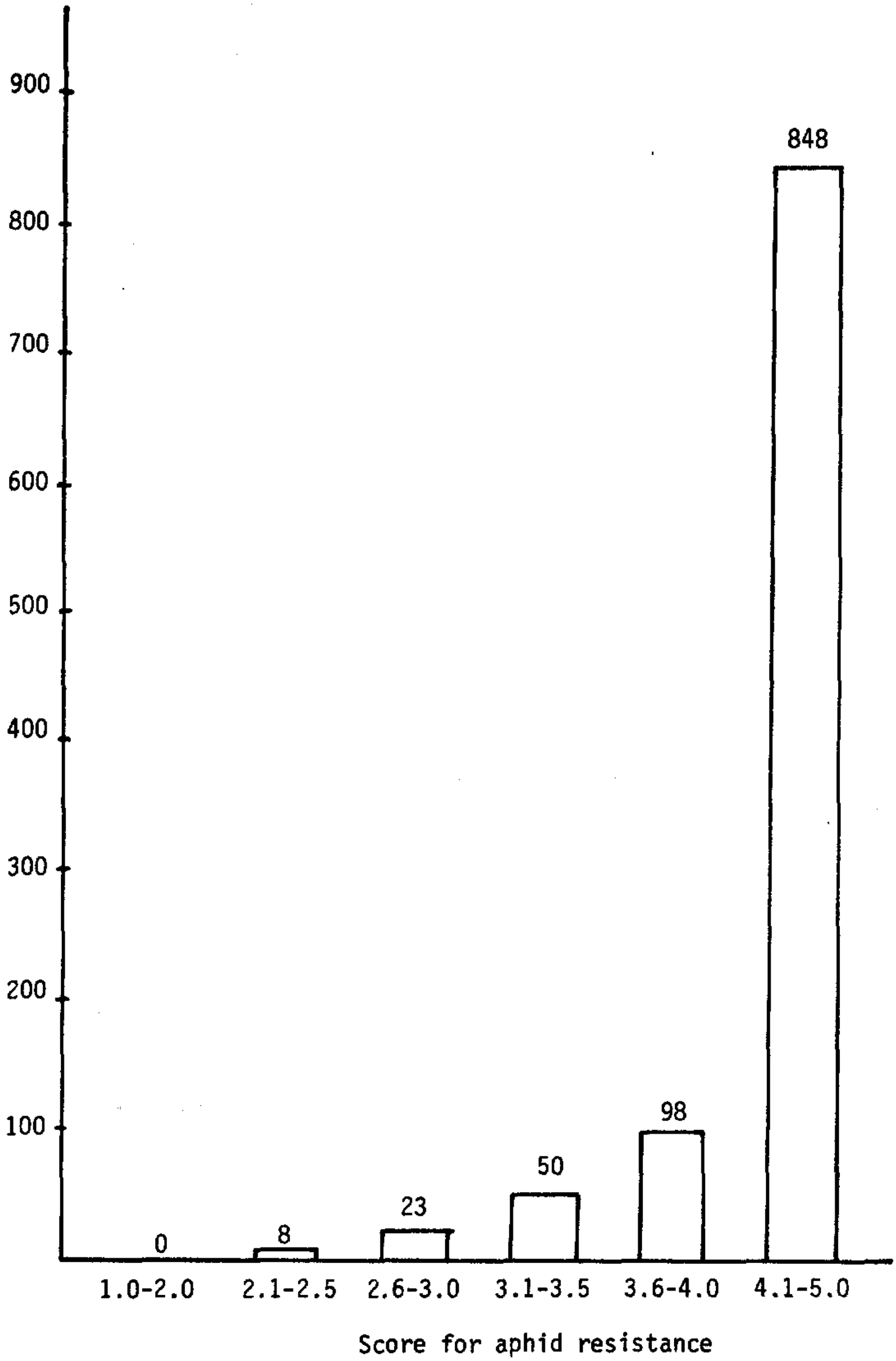


Figure 1.1. Distribution of aphid resistance in 1027 lines where 1.0-2.0 is very resistant, 2.1-2.5 resistant, 2.6-3.0 moderately resistant, 3.1-3.5 intermediate resistant, 3.6-4.0 susceptible and 4.1-5.0 is very susceptible.

Among the germplasm lines, 132 (2.5%) remained free "rated 1" (Table 1.6). Out of the 132 cold tolerant accessions, only 52 BPLs (Table 1.7) and 10 ILBs (Table 1.8) 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 may indicate that these 62 germplasm lines are also tolerant to high temperature during this critical reproductive stage. This will be investigated by planting 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.

1.2.2. Development of Improved Cultivars and Genetic Stocks for Assured Moisture Environments:

Faba beans in most of the ICARDA region are grown under high rainfall/supplementary irrigation. In order to obtain high and stable yields genotypes with high yield potential and resistance to *Ascochyta fabae*, *Botrytis fabae*, *Uromyces fabae*, *Orobanche crenata* and *Ditylenchus dipsaci* are needed. Emphasis was, therefore, placed in developing such genotypes. Sources of resistance for these parasites identified from germplasm evaluation, have been used in the crossing program in increasing frequency. For the 1984/85 season of the crosses involved at least one parent resistant to a pest (Table 1.5). This trend will continue with the aim of involving at least one pest resistant parent in most crosses.

Crosses were undertaken in the 1984/85 season at Tel Hadya, Syria for several national programs including Egypt, Ethiopia, China, and Sudan. Extreme frost led to loss of many crosses because of kill

Table 1.6. 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/ 6 or more self generations.

Table 1.7. Faba bean pure lines (BPL) tolerant to frost, identified in the screen house at ICARDA Tel Hadya, Syria 1984/85.

BPL	ILB	Origin	Self Generation
3950	2508	Spain	1
3954	2510	Spain	1
3955	2510	Spain	1
3961	2511	Spain	1
3963	2512	Spain	1
3964	2512	Spain	1
3968	2513	Spain	1
3969	2513	Spain	1
4021	2533	Spain	1
4068	2548	Spain	1
4178	2594	Morocco	1
4225	2612	Morocco	1
4279	2633	U.S.A.	1
4345	2717	Canada	1
4367	2764	Syria	1
4387	2773	Syria	1
4446	3070	Ecuador	1
4528	3100	Ecuador	1
4531	3100	Ecuador	1
4569	2825	Canada	1
4477	2844	Columbia	1
4581	2847	Columbia	1
4582	2847	Columbia	1
4584	2848	Columbia	1
4589	2849	Columbia	1
4591	2850	Columbia	1
4592	2851	Columbia	1
4594	2851	Columbia	1
4598	2852	Columbia	1
4599	2852	Columbia	1
4600	2852	Columbia	1
4628	3009	China	1
4630	3010	China	1
4632	3010	China	1
4634	3011	China	1
2901	1900	Columbia	2
3902	2777	China	2
3919	2777	China	2
3936	2779	China	2
3938	2779	China	2
3942	2779	China	2
3437	2404	Spain	2
3872	2413	Spain	2
3873	2413	Spain	2
3876	2413	Spain	2
3877	2413	Spain	2
3878	2413	Spain	2
3881	2415	Spain	2
3888	2417	Spain	2
3891	2417	Spain	2
1423	1120	Turkey	4

Table 1.8. Faba bean new accessions (ILB) tolerant to frost identified in the screen house at ICARDA, Tel Hadya, Syria 1984/85.

ILB No.	Origin	ILB No.	Origin
3128	China	3143	China
3129	China	3144	China
3130	China	3148	China
3132	China	3187	China
3135	China	3188	China

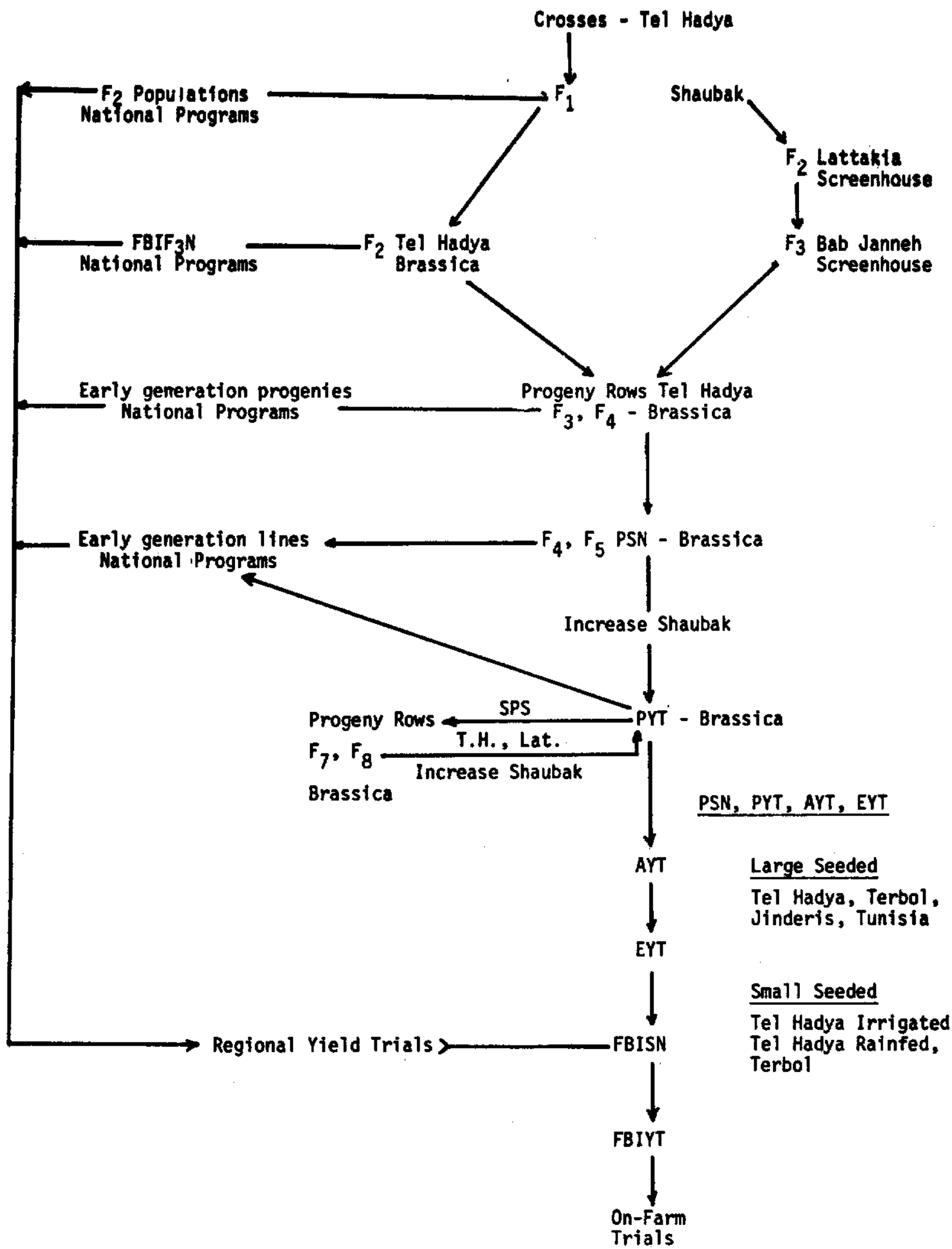
of parents and lateness of plants after frost recovery which led to many seed lost to high temperature at the end of the season. Some crosses among Sudanese parents were made in the off-season at Shaubak, Jordan. For 1985/86 crosses will be made with Ethiopian, Egyptian, Sudanese, Chinese, Tunisian and Moroccan parents with lines with various traits requested by national programs. The crosses involving Ethiopian, Egyptian and Sudanese parents will be made at the Lattakia coastal site to avoid problems of frost.

1.2.2.1. Yield Potential:

The breeding program at ICARDA for faba beans and its linkage with the national programs is schematically presented in Figure 1.2. This scheme makes use of an off-season nursery at Shaubak, Jordan at the F_1 and F_4 - preliminary screening nursery stage resulting in a two 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 Lattaquieh 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.

Brassica napus is used for pollination control for growing F_2 populations, F_3 progeny rows, preliminary screening nurseries and preliminary yield trials. This reduces the inter-mixing of genotypes

Figure 1.2. Faba Bean Breeding Program at ICARDA.



caused by bee pollination, which allows for more multi-location testing of genotypes earlier in the selection scheme because trial seed can be used for seed multiplication purposes.

During 1985 extreme frost was recorded at Tel Hadya, ICARDA which resulted in 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 1.9). Replicated yield trials of 1150 lines were conducted at Tel Hadya under irrigated conditions and at Jinderis under rainfed conditions during the 1984/85 season. Only 18 entries exceeded the best check at the 5% probability level. A combination of high C.V.'s 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 in the 1984/85 season yields were high with the best yield reported of 5.8 t/ha (Table 1.10). Entries tested at Terbol in 1984/85 numbered 965, of these 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 lend.

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 were made which will be grown in progeny rows during 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

Table 1.9. Results of Faba Bean Yield Trials grown at Tel Hadya and Jinderis, Syria during the 1984/85 season.

Trial	No. test entries	No. of lines exceeding best check	No. of lines significantly greater than best check (5%)	Grain Yield (kg/ha) Trial(s) Mean	Best Line Mean	Best Check Mean	L.S.D. Check vs. Line (5%)	C.V. (%)	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 Jinderis, 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 1.10. Results of Faba Bean Yield Trials grown at Trebol, Lebanon during the 1984/85 season.

Trial	No. test entries	No. of lines exceeding best check	No. of lines significantly greater than best check (5%)	Grain Yield (kg/ha) Trial(s) Mean	Best Line Mean	Best Check Mean	L.S.D. Check Line (5%)	C.V. (%)	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.

were made from the F_3 progeny rows to start F_4 preliminary screening nurseries in the 1985/86 season.

Ninety-four lines from both the large and small seeded preliminary yield trials were selected from 712 and 90 lines, respectively, for inclusion in the 1985/86 advanced yield trials. From 94 large seeded and 83 small seeded lines tested in 1984/85 advanced yield trials 45 each were selected for elite yield trials in 1985/86. *L.D. Robertson.*

1.2.2.2. Disease Resistance:

The major disease resistance work, as mentioned earlier, was carried out at Lattaquieh. At this location environmental conditions are conducive for 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 and these will be screened in 1985/86 at Lattakia. Nine F_4 progenies, all selected from one cross made 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 are to be tested in preliminary yield trials in 1985/86. F_2 populations from eight crosses for ascochyta bight resistance were screened in 1984/85 with 75 single plant selections made for increase in the off-season and rescreening in 1985/86.

Chocolate spot: Adopting a two-cycle screening technique considerable progress was made in identifying promising sources of resistance to Botrytis fabae. In the F_4 nursery 45 lines selected from 14 crosses in 1984 were screened. Of the 45 test entries included in this nursery, 41 were rated 3, with the remaining 4 entries rated 5. Spreader rows were rated 9.

Seeds from 27 single plant selections and 36 uniform bulk rows were harvested. These seeds were planted at Bab-Janneh in the 1985 off-season to obtain enough seeds for further evaluation for disease resistance, and also to provide seeds for an 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.

Thirteen crosses were screened for B.fabae resistance with 68 single plant selections made for resistance and increased in the off-season for rescreening for disease resistance. Additionally 64 new crosses were made for chocolate spot resistance.

Durable Disease Resistance: Considerable evidence is available today on the presence of great pathogenic variability in B. fabae and A. fabae. Therefore, the program continued to focus on the development of durable sources for resistance to these major pathogens. Combination of genes from plants with different mechanisms for resistance should result in lines having more durable resistance than those having 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 and to combine genes for such mechanisms into one cultivar with durable resistance.

F_4 Botrytis x Botrytis: This nursery included 31 test entries selected from F_2 progenies of 17 crosses made in 1983 between several chocolate spot-resistant sources. F_4 plants were grown in rows 2 m long and 50 cm apart. In this nursery 4 entries were rated 1, and 27 rated 3. Plants in spreader rows were rated 9. Seeds from 21 single plant selections, and also from 21 uniform bulk rows were planted at Bab-Janneh during the 1985 off-season to provide enough seeds for multilocatoin evaluation, purification, and preliminary screening and yield trials in 1985/1986.

F_4 Ascochyta x Ascochyta: This nursery consisted of 68 test entries selected from F_2 progenies of 31 crosses made in 1983 between several Ascochyta blight - resistant sources. F_4 plants were grown in rows 2 m long and 50 cm apart. In this nursery 7 entries were rated 1, and 60 rated 3. Plants in spreader rows were rated 9.

Seeds from 90 single plant selections were planted at Bab-Janneh during the 1985 off-season to produce enough seeds 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 sown for resistance 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 were selected for advanced yield trials in 1985/86. L.D. Robertson and S. Hanounik.

1.2.2.3. Adaptability of Faba Beans:

Previous reports have referred to the lack of wide adaptability found for faba beans over many environments. In 1984 a series of 25 crosses were made between five lines at ICARDA and five lines from N.Europe (Univ. of Hohenheim) to produce populations for simultaneous selection and reciprocal testing followed by selection and recombination to produce a faba bean germplasm pool with wide adaptability. In 1985 double crosses among the F_2's of the original 25 crosses were made and they will be grown in 1985/86 to produce the base population for selection.

Another approach to the problem of adaptability is to send segregating populations from crosses of local populations with lines selected for specific traits to provide useful variability for selection at different locations. Crosses made in 1985 and those planned for 1986 for national programs are listed in Table 1.5. Providing of populations with specific traits and adaptability to various conditions will be of increasing importance in coming years. Specific traits requested include rust, ascochyta blight, chocolate spot, stem nematode, virus, and orobanche resistance. Also, crosses to determinate and IVS types and also large seeded types such as 'Reina Blanca' and 'New Mammouth' with wider adaptability have been requested.

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 two years of this type are listed in Table 1.11.

Material has been used directly and through selection within bulks and lines by breeders on site. Six lines were selected in N.Yemen for further testing in replicated trials. In Sudan 15 lines were selected for resistance to bean leaf roll virus and a request has been made for crossing of these with Sudanese parents. These crosses will be made in 1985/86. In Tunis more than 300 single plant selections were made from ICARDA supplied F_3 bulks and F_3 progenies. In China 11 determinate progenies were rated "very good" and 14 rated "good". Of the F_3 progenies 9 were rated "very good" and 44 were rated "good". L.D.Robertson.

1.2.2.4. 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' mutant from N. 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

Table 1.11. 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
1984	Tunisia	88	PYT-L
1984	Tunisia	600	F_3 Progenies
1984	Tunisia	83	F_3 Bulks
1984	China	249	F_4 Progenies
1984	China	273	Determinate Progenies
1984	China	31	F_3 Progenies
1984	China	17	PYT lines
1984	Ethiopia	198	F_2 and F_3 Bulks
1984	Egypt	885	PYT lines
1984	Sudan	345	PYT lines
1985	N.Yemen	38	Elite trial lines
1985	Ethiopia	600	F_3 Progenies
1985	Morocco	32	F_2 and F_3 Bulks
1985	Tunisia	18	F_3 Bulks
1985	Tunisia	784	F_3 Progenies
1985	Tunisia	959	Screening Nursery-early generation lines
1985	Sudan	253	F_3 Bulks
1985	Egypt	4	4 mass selections
1985	China	100	Determinate lines

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 plant selections were selected for a preliminary screening nursery.

Replicated yield trials were conducted with 348 determinate lines and results are summarized in Table 1.12. Because of frost the determinate lines did much poorer in comparison to the check than in the 1983/84 season. This is because the determinate lines were more susceptible than the best check which has been developed at Tel Hadya over many years of selection with exposure to frost. No lines were as high yielding as the best check (ILB 1814) but sixty-six were as high yielding as the second check (ILB 1816) in the preliminary yield trials. The advanced determinate yield trial was planted at two dates to investigate the hypothesis that earlier planting was advantageous with determinate types but extreme frost with the susceptibility of the determinate lines resulted in no advantage to earlier planting and the first date of planting tried was completely killed (including the indeterminate check). In 1985/86 the determinate trials will be planted at Lattakia on the coast where frost is not a problem as well as at Tel Hadya to get a clearer picture of the determinate line's yield potential. L.D.Robertson.

Independent vascular supply lines (IVS): These are lines where 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

Table 1.12. Results of Faba Bean Determinate Yield Trials grown at Tel Hadya, Syria during the 1984/85 season.

Trial	No. of test entries	Grain Yield (kg/ha) Trial(s) Mean	Grain Yield (kg/ha) Best Line Mean	Grain Yield (kg/ha) Best Check Mean	L.S.D. Check cv. Line (5%)	C.V. (%)	Checks
FBAYT-Det(1st date)	15	747	1484	2311	334	26.9	ILB 1814
FBAYT-Det(2nd date)	15	829	1416	2252	373	27.0	ILB 1814
FBPYT-Det	321	1012	1259	1619	304	56.0	ILB 1814,ILB 1816

Table 1.13. Results of Rainfed Faba Bean Trials grown at Tel Hadya, Syria during the 1985/86 season.

Trial	No. test entries	No. of lines exceeding best check	No. of lines significantly greater than best check (5%)	Grain Yield (kg/ha) Trial(s) Mean	Grain Yield (kg/ha) Best Line Mean	Grain Yield (kg/ha) Best Check Mean	L.S.D. Check Line (5%)	C.V. (%)	Checks
FBAYT-R	32	0	0(8)[1]	1061	1520	1586(922)[2]	331	19	ILB 1814, ILB 1816
FBPYT-S	45	0	0(7)[1]	950	1595	1659(860)[2]	313	32	ILB 1814, ILB 1816

1/ No. of lines significantly exceeding best small seeded check.

is greatly reduced. These IVS lines have been grown at ICARDA in 1984/85 for the first time and ten 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.

1.2.3. Cultivars for Low-rainfall Environments:

Efforts have been made to develop high and stable yielding faba bean cultivars and agronomy capable of producing an economic dry seed yield in low rainfall (300-400 mm) environments so that farmers there may get another crop option and may diversify their cropping. Usually, two sets of all trials are planted, one rainfed and one with supplemental irrigation. This year, because all the irrigated trials were lost to frost, the rainfed trials were irrigated to provide results expected under irrigation. This led to only the FBAYT-R and FBPYT-S being grown under rainfed conditions in 1984/85 (Table 1.13). No entries significantly exceeded the best check (ILB 1814) but 15 exceeded the other, small seeded check (ILB 1816). This is mainly due to frost resistance of ILB 1814. Work on rainfed testing of faba beans will be curtailed in 1985/86 with work limited to irrigated conditions. L.D.Robertson.

1.2.4. Breeding Methods:

1.2.4.1. Studies on Outcrossing:

In large-scale breeding programs out-crossing due to insect pollinators is undesirable because this makes it difficult to maintain the genetic identify of many different lines. To prevent out-crossing 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 1.14 and 1.15 and which summarize three years of testing. Brassica and to a lesser extent triticale, were very efficient in reducing bee activity observed within 6 x 12 m faba bean plots. However, this significant reduction in bee activity did not result in a corresponding reduction of inter-plot outcrossing rates with only a non significant change from 11 to 9% found. Counts of bee activity took into consideration inter-plot and intra-plot activity. To separate these, would have required watching each bee to see when it came into and out of the 6 x 12 m faba bean plot, an impossible task. Faba bean outcrossing is not possible without bee activity and normally a reduction or increase of bee activity will decrease or increase the rates of outcrossing. Since there was not a significant reduction of inter-plot outcrossing with Brassica or triticale separation of faba bean plots, even though there was a large decrease of bee activity within faba bean plots, it can be assumed that the effect of the attractant crop (Brassica) and the physical barrier (triticale) was to reduce mostly faba bean intra-plot bee activity, which should be

Table 1.14. 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).

Separator	No. of positive visists/3-min observations period			
	1983		1984	
	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 $\pm$	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 1.15. Inter-plot outcrossing using triticale, *Brassica* and bare ground to separate faba bean plots for the years 1982, 1983, and 1984 at Tel Hadya, Syria.

Separator	Outcrossing percentage			
	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 ±

followed by a concomittant reduction in intra-plot outcrossing rates.

Although Brassica and triticale did not differ in inter-plot outcrossing, Brassica was more efficient in reducing bee activity. This should be followed by lower intra-plot 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 intra-plot 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 inter-line or inter-plant 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 one-meter rows of a white hilum check, Reina Blanca, distributed evenly within 12 x 12 m Brassica surrounded 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.

1.2.4.2. 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 at Tel Hadya and studied for yield and yield components in 1983/84. Analysis was done using path coefficients to determine direct and indirect effects in 1985.

Table 1.16 shows direct and indirect effects for yield for all 15 crosses. This shows 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 seeds/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.

Table 1.16. Direct and indirect effects of yield components on yield of 15 F_2 populations grown at Tel Hadya, Syria in 1983/84.

Character	Pods/	Seeds/ Plant	Seeds/ Pod	10 Seed Plant	Pod Weight	Seeds/ Length	Ovules/ Ovule	Correlation Ovary with Yield
Pods/Plant	.0067N.S.	-.0126	.7191	-.2348	-.0708	-.0017	.0134	0.419**
Seeds/Pod	-.0017	.0481N.S.	.2155	-.0250	.0954	-.0129	-.0379	0.282**
Seeds/Plant	.0056	.0121	.8550**	-.2442	-.0270	-.0084	-.0063	0.586**
10 Seed Weight	-.0028	-.0022	-.3762	.5551**	.1168	.0044	-.0008	0.294**
Pod Length	-.0022	.0209	-.1052	.2937	.2192**	-.0003	-.0204	0.408**
Seeds/Ovule	.0004	.0197	.2283	-.0766	.0024	-.0315N.S.	.0020	0.144**
Ovules/Ovary	-.0021	.0423	.1257	.0105	.1037	.0015	-.0431N.S.	0.239**

1.3. Faba Bean Diseases:Epidemiology and Integrated Control:

As already indicated earlier chocolate spot, ascochyta blight, rust, and stem nematodes are considered to be among the most important disease problems in faba beans throughout West Asia and North Africa. The 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 concerning integrated control, epidemiology, and disease development as related to certain components of host resistance, undertaken at Lattakia sub-site in the 1984/85 season, are reported below.

1.3.1. 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 chemical treatments as follows: 1) BRAVO-500 (chlorothalonil 40%), a contact fungicide, applied to the foliage once only, at the rate of 2.5 ml/l of water, one day before artificial inoculation, 2) DEROSAL-60 WP (carbendazim 59%), a systemic fungicide, applied to the foliage once only (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 1.17.1). A split plot design with chemical treatments in the main plot, and faba bean

Table 1.17.1. Influence of host resistance and chemical treatments on development of Ascochyta blight in faba bean.

Fungicide and rate	Method of application	Disease Reaction 1/				
		BPL 74	BPL 472	BPL 460	ILB 1814	ILB 1820 2/
Bravo-500 (2.5 ml/L)	Foliar	1.00a	1.00d	1.00f	1.00h	4.33k
Derosal-60WP (0.5 g/L)	Foliar	2.33b	3.66e	3.66g	4.33i	9.001
Derosal-60WP (7.5 g/1 kg seeds)	Seed dressing	3.66c	3.66e	4.33g	4.33i	9.001
Untreated (Water spray only)	-	3.00c	3.66e	3.66g	5.00j	9.001

1/ Disease reaction was recorded four months after planting using 1-9 rating scale.
2/ Numbers followed by different letters within a column are significantly (P = 0.01) different according to Duncan's Multiple Range Test.

genotypes in the sub-plot, was used with three replications. All treatments were inoculated artificially with A. fabae 110 days after sowing employing 300,000 spores/ml of water.

The results of this test (Table 1.17.1) 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 1.17.1,Fig.1.3). Similar trends were observed on the remaining genotypes. One foliar application of BRAVO-500, was significantly more effective than both foliar and seed dressing treatments withDEROSAL-60 WP. In untreated plots, the use of host resistance only, decreased disease severity significantly, from a high level of 9 on the Ascochyta blight-susceptible genotype ILB 1820, to an intermediate level of 5 on the moderate 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 treatments or host resistance alone were significant, such decreases were sharper when both application of an effective chemical and host resistance were combined in one treatment.

1.3.2. Epidemiology:

1.3.2.1. Relationships between Faba Bean Leaf Age and Susceptibility to Botrytis fabae and Ascochyta fabae:

Information on the relationships between the age of faba bean plants and their susceptibility to these two pathogens is limited.

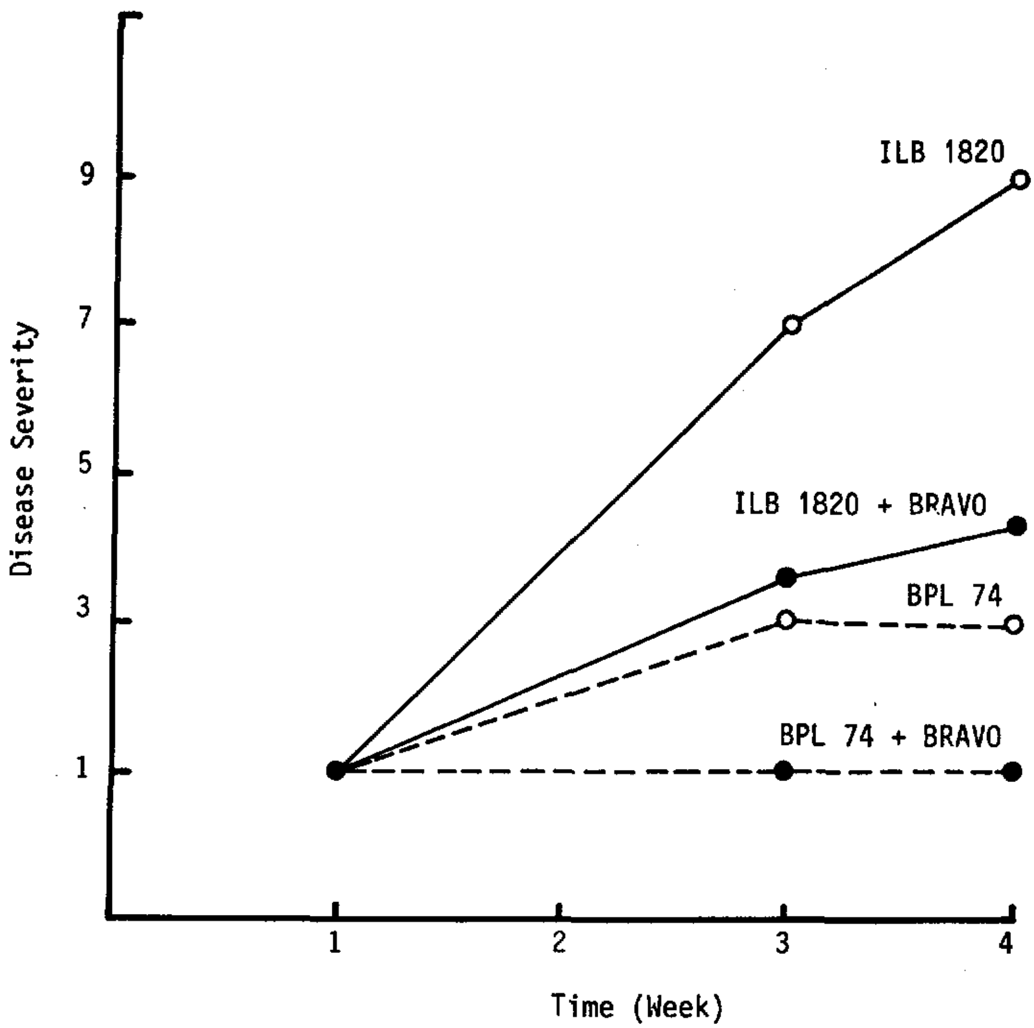


Figure 1.3. Progress of ascochyta blight on the susceptible host ILB 1820, without (o——o) and with (•——•) chemical protection, and the resistant host BPL 74 without (o---o) and with (•---•) chemical protection.

Results from last year 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 pathogen first infect leaf tissue and then other plant organs. Therefore, additional information is needed on the relationships between leaf age and susceptibility to B. fabae and A. fabae, to help understand the development of these diseases, 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 layed flat on a moist, 2 cm thick sponge, linning the bottom of 90x40x5 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 sub-plot was used with 5 replications.

The results of this study indicated that disease severities caused by B.fabae and A.fabae, were significantly lower (P = 0.05) on younger top leaves than on older bottom leaves (Fig. 1.4). Although the level of leaf damage by B.fabae was significantly (P = 0.05) greater 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, done when bottom leaves have fully developed, may become more efficient for effective screening.

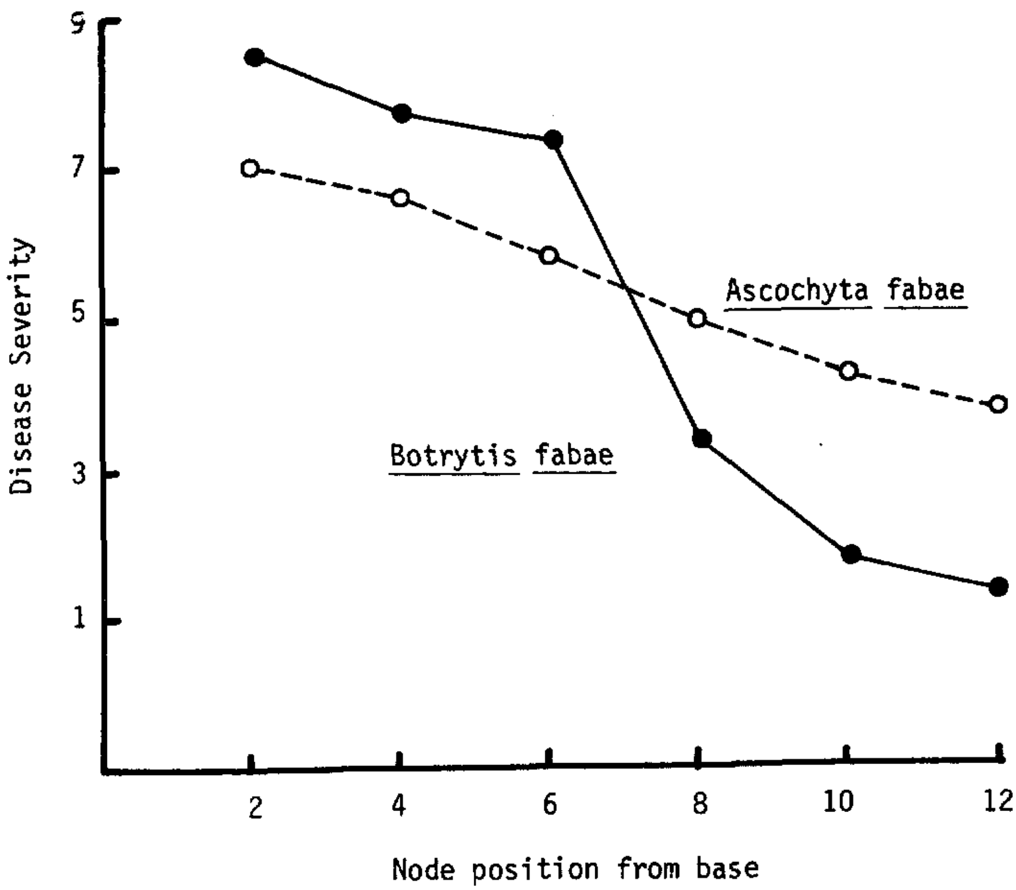


Figure 1.4. Relationships between faba bean leaf age and susceptibility to *Botrytis fabae* and *Ascochyta fabae*.

1.3.2.2. Chocolate Spot Progress as Related 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 build up 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 quantify some of these components on certain chocolate spot-resistant lines, so that it would be possible to identify lines that affect most the speed of disease progress. This will help also 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 2 isolates of *B.fabae*, employing a modification of the detached leaf technique. A split plot design with faba bean genotypes in the main plot and isolates of *B.fabae* in the sub-plot was used, with 5 replications.

Three parameters, the apparent infection rate, the incubation and the 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 of this study (Table 1.17.2 & Fig. 1.5) indicated that isolates B-9 and A-10 of B.fabae differed significantly (P = 0.05) in their apparent infection rate, 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. The faba bean line BPL 710 with the longest 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). This means that if spores of isolate B-9 of B.fabae, land on leaves of these lines at the same time, BPL 710, 1179, and 1196 would delay the appearance of diseaes symptoms by 2, 1.5, and 1 day, respectively compared ot Rebaya-40. It also indicates that BPL 710, 1179, and 1196 would delay the formation of a new spore generation by 7, 5, and 4 days, respectively compared to Rebaya-40. These findings were supported by field observations (Fig. 1.6). BPL 710, 1179, and 1196 with longer latent and incubation periods, and with lower apparent infection rates, allowed for slower disease progress, compared to 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 also according to their decreasing apparent infection rates. It also explained as to 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.

Table 1.17.2. Apparent infection rate, incubation and latent periods in the *Botrytis fabae* - *Vicia fabae* interaction in detached leaf tests at Lattakia, 1984/85.

Lines 1/	Host status 2/	Apparent infection rate3/		Incubation period3/		Latent period3/	
		B-9	A-10	B-9	A-10	B-9	A-10
BPL 710	Resistant	2.250a	0.949c	3.0a	4.0d	15.0a	19.0d
BPL 1179	"	2.550a	1.200c	2.5a	3.5d	13.0a	16.0e
BPL 1196	"	2.850a	1.699c	2.0b	3.0e	12.0b	15.0f
Rebaya-40	Susceptible	7.500b	3.600d	1.0c	2.0f	8.0c	9.0g

1/ Numbers in a column followed by different letters are significantly (P = 0.05) different according to Duncan's multiple range test.

2/ Resistance denotes a rating of 1, 3, or 5, and susceptibility a rating of 7 or 9 on 1-9 scale for the detached leaf test.

3/ See text for method of calculating apparent infection rate, incubation period and latent period.

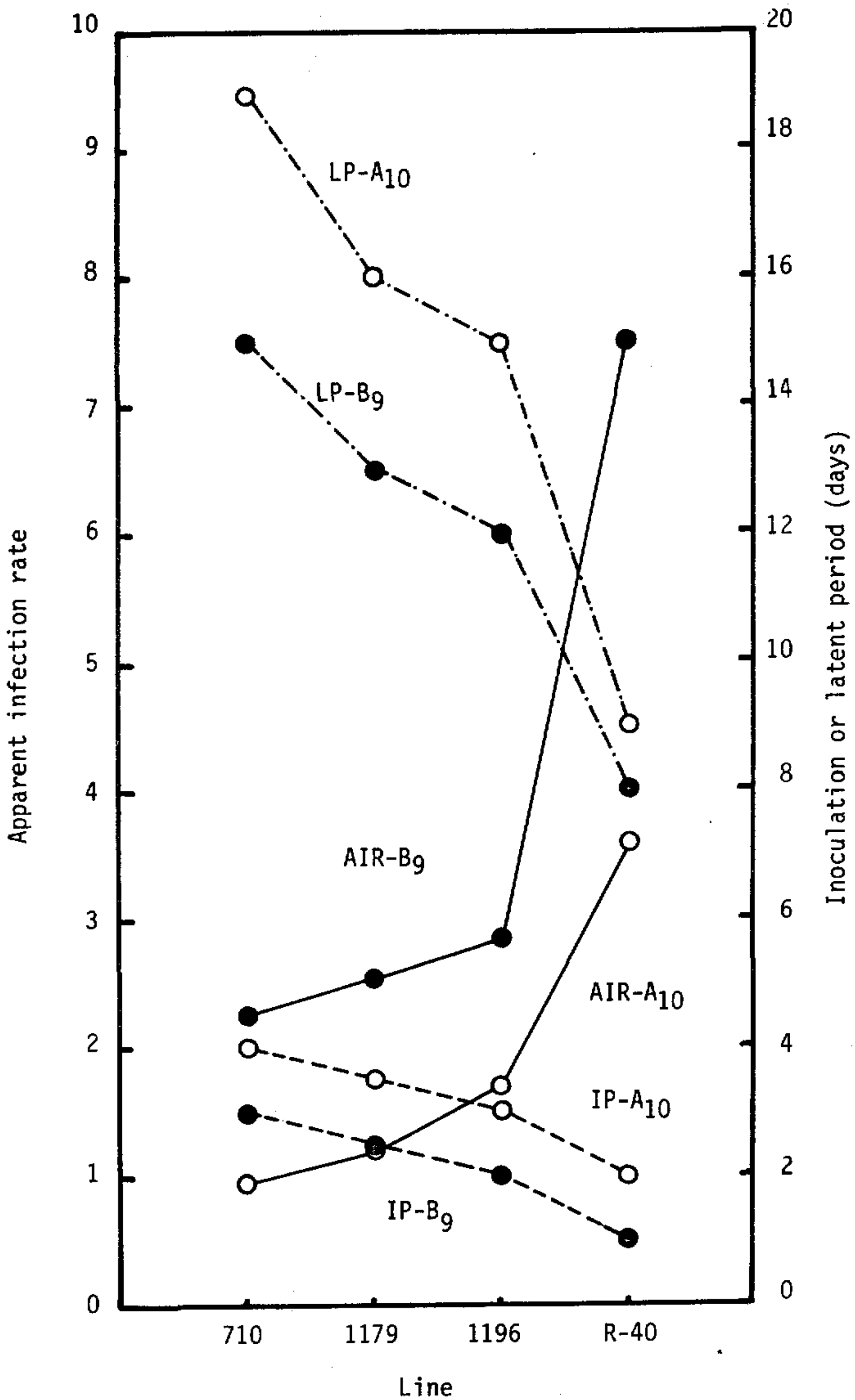


Figure 1.5. The apparent infection rate (AIR) as related to the incubation (IP) and latent (LP) period of isolates B_9 (•) and A_{10} (o) of Botrytis fabae on 4 faba bean lines in detached leaf test at Lattakia, 1984/85.

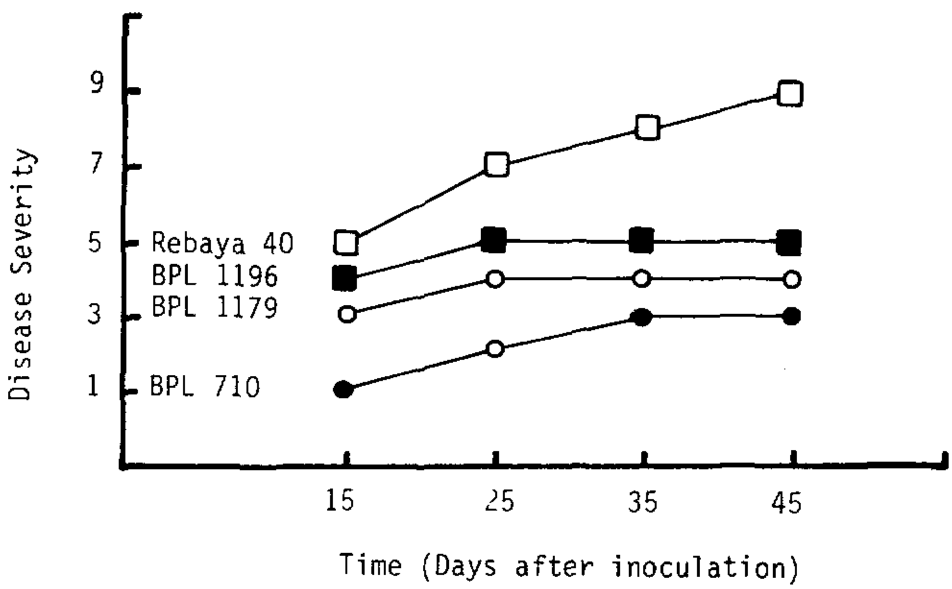


Figure 1.6. Chocolate spot progress on the faba bean lines BPL 710, 1179, 1196 and Rebaya-40 in the field in Lattakia, 1984/85.

1.4. Faba Bean Insects and their Control

1.4.1. Insect populations

In all trials, as well as in farmers' fields, the black aphid, Aphis fabae, was the most important insect pest recorded on faba beans. Sitona limosus, Apion, thrips, Lixus algirus, and Bruchus dentipes occurred at low populations 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 to be high enough to keep weevil populations below economic levels. Aphid predators, mainly Coccinella spp., were not found to be efficient in supressing black aphid populations.

1.4.2. Insect Control Recommendations

In the absence of reliable natural enemies, rational chemical control is an appropriate alternative and several trials were conducted to evaluate different possibilities. 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. Results are summarized in Table 1.18. Sitona damage did not have a significant effect on yields, a result that confirms previous seasons' findings. On the other hand, aphids did have a highly significant impact on yields. Losses due to aphids ranged from 17% in plots treated twice with pirimicarb, to 84% in check plots (Figure 1.7). Early or pre-flowering aphid control was more important than late or pod-setting aphid control, both in terms of

Table 1.18. Yield in 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 apid control[2/]		Difference	Without late aphid control		Difference
	With early aphid control	Without early aphid control		With early aphid control	Without early aphid control	
Yes	1465	507	958**	1036	339	697**
No	1215	395	820**	842	236	606**
Difference	250NS	112NS		194NS	103NS	

NS = non significant; ** 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.

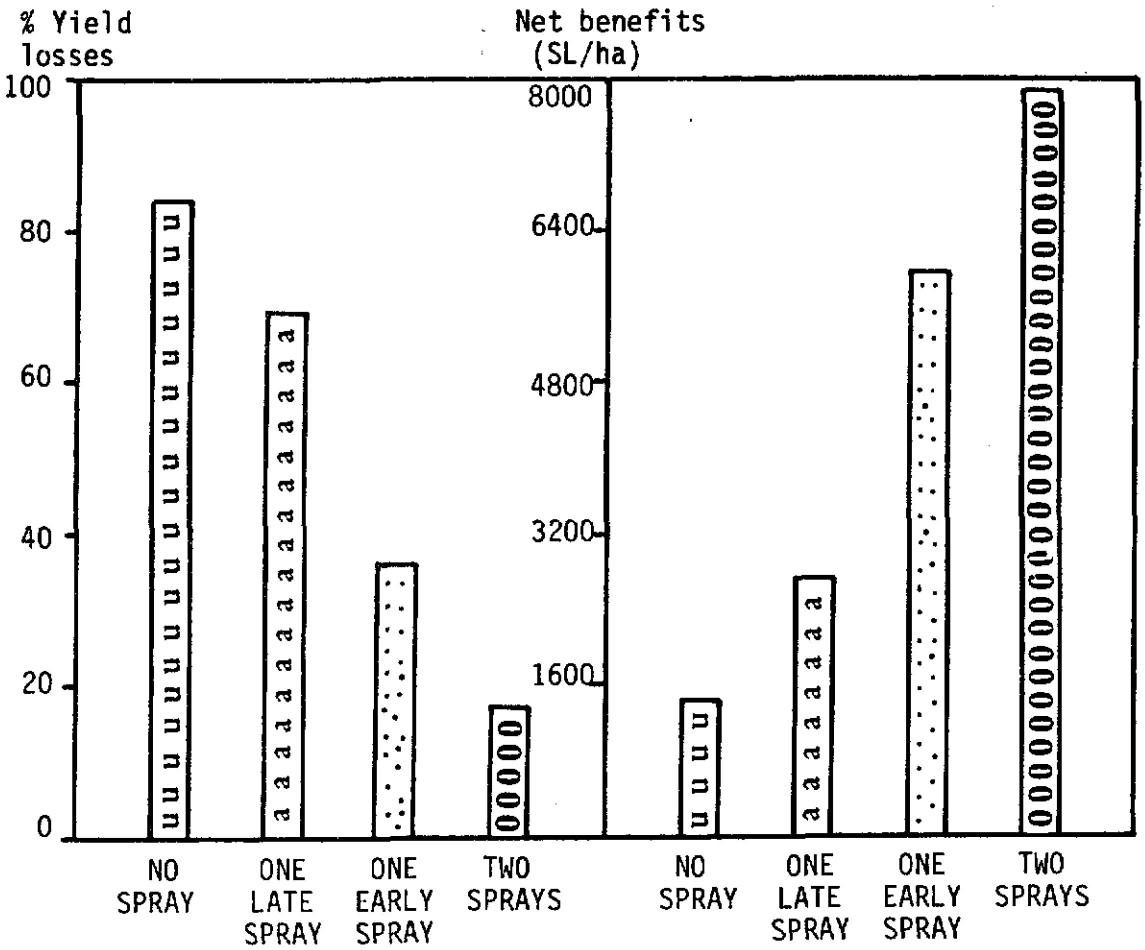


Fig. 1.7. Yield losses on faba beans and resulting net benefits obtained through different insecticidal regimes for the control of aphids. Means of four replications. Tel Hadya, 1984/85.

preventing yield losses and in terms of economic returns. Maximum net benefits were obtained with two sprays. This suggests that in outbreak years, when aphid populations are high from the pre-flowering to the pod-filling stages of the crop, 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.

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 yields and net benefits (Table 1.19).

The timing of applications for faba bean aphid control 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: visual infestation scores (1 = no aphids present; 5 = many undistinguishable colonies present in practically all of the plants), visual damage scores (1 = no damage; 4 = very severe damage), and percent 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 (Figure 1.8). 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 playing the role of farmers.

Table 1.19. 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 (S.L./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

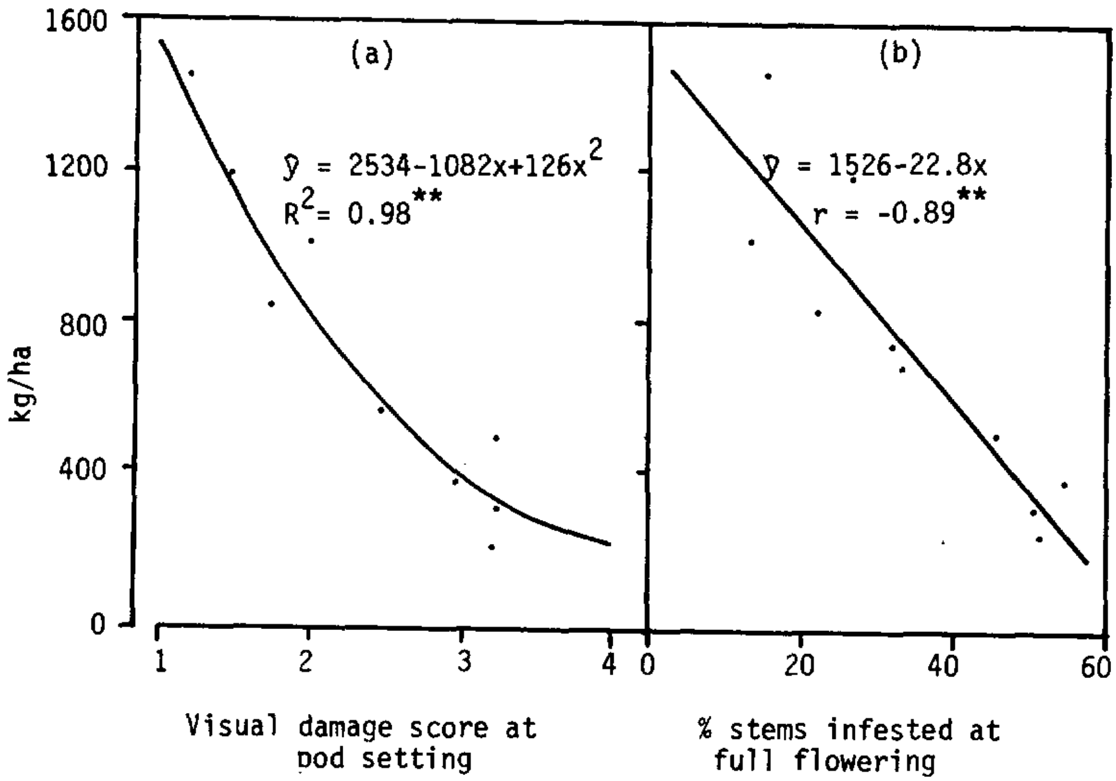


Fig. 1.8. The regression of yields of faba beans on (a) visual aphid damage scores at pod setting and on (b) the % of stems infested at flowering. Means of four replications, Tel Hadya 1984/85.

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 (Figure 1.9). The steep slope confirms the importance of black 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 in a 1-5 score scale.

1.4.3. Host Plant Resistance to Aphids

A mass rearing technique for Aphis fabae was developed under green house conditions (average 19^{o}C; 47% R.H.). When the colony was purified, a mass screening technique based on individual infestation of plants with five females/plant was developed and 1027 breeding lines were tested for resistance. On the basis of a 1-5 visual damage score (1 = no damage; 5 = death of the plant), 81 lines were selected (Table 1.20). These will be rescreened in replicated tests which will take into account not only damage scores but also populations counts.

1.4.4. 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 of infestation two times higher than the average natural populations found in Syria (1.5 females/m^2). There was a 13.9%, non significant reduction in yield due to stemborer damage (Table 1.21). If this result is reconfirmed in 1986, work on this species could be stopped. Cesar Cardona.

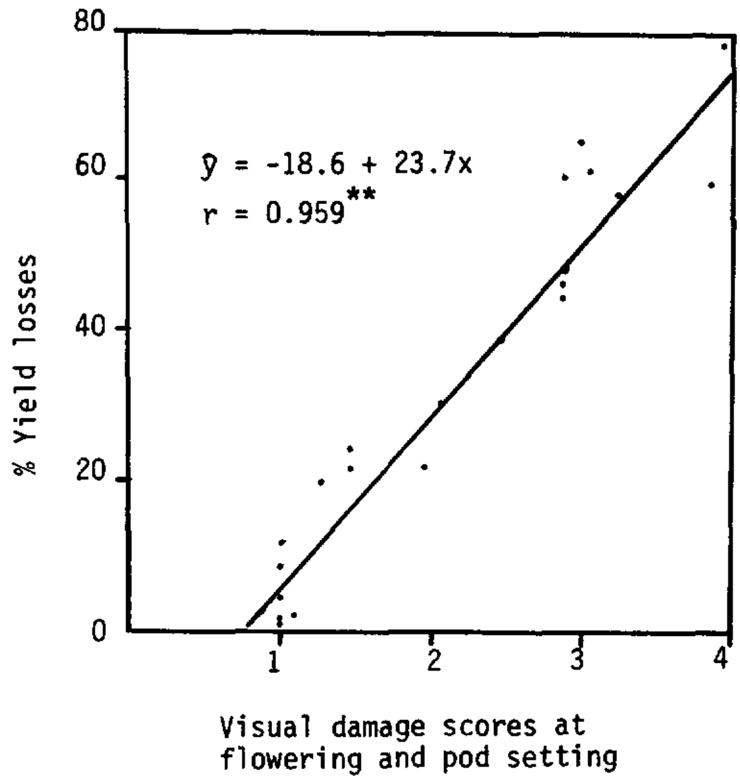


Fig. 1.9. The regression of % yield losses due to faba bean aphids on aphid visual damage scores at flowering and pod setting. Means of four replications, Tel Hadya, 1984/85.

Table 1.20. Frequency distribution of faba bean breeding materials tested for their resistance to *Aphis fabae*. Tel Hadya, 1984/85.

Visual damage score1/	No. of materials	%
1.0 - 2.0	0	0
2.1 - 2.5	8	0.8
2.6 - 3.0	23	2.2
3.1 - 3.5	50	4.9
3.6 - 4.0	98	9.5
4.1 - 5.0	848	82.6

1/ 1 - 5 rating (1 = no damage; 5 = death of the plant).

Table 1.21. Effect of a high level of infestaion (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 (kg/ha)
	Perforateol	Infested	Lodged	
3 females/m^2	70	27	22	710
Uninfested check	0	0	10	825
F - Test	-	-	N.S.	N.S.

N.S. = Non significant

1.5. Weed Control

Work was carried out on both parasitic and non-parasitic weeds. The major parasitic weed for faba beans is *Orobanche* spp. The dominant non-parasitic weed species were *Avena sterilis*, *Phalaris brachystachys*, *Sinapis arvensis*, *Geranium tuberosum*, *Galium tricorne*, *Vaccaria pyramidata*, *Carthamus syriacus*, *Cephalaria syriaca* and *Euphorbia helioscopia*.

1.5.1. Control of *Orobanche* spp.

1.5.1.1. Host Resistance:

Field screening for *Orobanche* resistance was done for several years at ICARDA but no line could be found to be resistant. In order to be able to have uniform standardised conditions and the level of *Orobanche* seeds infestation for all the test lines as also to be able to do screening round the year, the screening work is now being moved from field to the green-house and laboratory. Hence a series of experiments have been conducted, some with the help of the Royal Tropical Institute, Amsterdam, Holland, to develop techniques of laboratory screening that may give field applicable results. A green house procedure for single plant selection of *Orobanche* resistant faba bean plants out of the 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.

1.5.1.2. Chemical Control of *Orobanche*:

A trial on chemical control using glyphosate was conducted at Lattakia. The trial site had low *Orobanche* infestation and chemical control measures were therefore not beneficial (Table 1.22). 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 and harvest index (HI). Delaying spraying by 15 days or increasing the frequency of application to twice or thrice on the other hand decreased yield and harvest index substantially, this effect increasing with increase in rate and frequency of spraying (Table 1.22). S. Kukula, S. Silim, and M.C. Saxena.

1.5.2. Control of Non-parasitic Weeds

As a part of the International Faba Bean Chemical Weed Control Trials, studies were conducted during 1984/85 season at Jinderis (Syria) and Terbol (Lebanon). In Jinderis, all weed control measures reduced significantly the level of weed infestation (Table 1.23). Hand weeding twice was as effective as continuous hand weeding. Among the herbicides, Tribunil (3.0 kg a.i./ha), Bladex (1.0 kg a.i./ha), Maloran with Kerb (1.5 and 0.5 kg a.i./ha respectively) and Tribunil with Kerb (3.0 and 0.5 kg a.i./ha respectively) were the most effective in controlling weeds (Table 1.23). Seed yield, however, did not very 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 were observed in treatments that included Igran due to the phytotoxicity of the chemical following severe frost in February and March (Table 1.23).

In Terbol, yield loss due to weeds was significant and 73%. Hand weeding twice was as effective as repeated hand weeding (Table 1.23). Pre-emergence application of Igran, Igran with Kerb, Maloran,

Table 1.22. The effect of glyphosate (Lancer) on yield and harvest index (HI) of faba beans and the number and weight of _Orobanche_ spikes/m^2.

Treatments	Faba bean			Orobanche/m^2	
	Yield (kg/ha)		Harvest Index		
	Seed	Total Biological		No.	Weight (g)
Control	2982	7315	0.41	1.9	7.92
Glyphosate @ 0.08 kg a.i./ha; once at BF *	3045	6803	0.45	3.5	6.59
Glyphosate @ 0.08 kg a.i./ha; twice at BF and 15 DABF *	2892	7068	0.40	1.9	7.29
Glyphosate @ 0.08 kg a.i./ha; thrice at BF and 15 and 30 DABF	1574	6543	0.26	1.5	1.93
Glyphosate @ 0.08 kg a.i./ha; once at 15 DABF	2156	6537	0.33	1.9	1.96
Glyphosate @ 0.08 kg a.i./ha; twice at 15 and 30 DABF	1645	6617	0.25	0	0
Glyphosate @ 0.08 kg/ha; thrice at 15, 30 and 45 DABF	1835	6506	0.29	0.8	2.80
Glyphosate @ 0.12 kg a.i./ha; once at BF	2977	7136	0.42	0	0
Glyphosate @ 0.12 kg a.i./ha; twice at BF and 15 DABF	2168	6852	0.31	2.1	3.46
Glyphosate @ 0.12 kg a.i./ha; thrice at BF, and 15 and 30 DABF	1386	6222	0.22	0.4	0.64
S.E.	250	350	0.024	0.60	1.75
L.S.D. 5%	726	1017	0.069	1.75	5.07
C.V.%	22.1	10.4	14.4	85.0	97.2

* BF = Beginning of flowering; DABF = Days after beginning of flower.

Table 1.23. The effect of weed control treatments on yield, weed dry weight and frost damage of faba beans. Terbol and Jinderis, 1984/85 season.

Treatment	Terbol Yield (kg/ha)		Jinderis Yield (kg/ha)			
	Seed	Biological	Seed	Biological	Weeds	Frost Damage Score*
Weedy check	929	8425	1520	3021	611	3.0
Repeated hand weeding	3456	11900	1846	3542	41	3.0
Weeding twice	3518	11929	1557	2903	71	3.0
Maloran,1.5 kg a.i./ha	1455	8993	1596	2986	198	3.3
Tribunil,3.0 kg a.i./ha	1907	10011	1585	3087	69	3.5
Igran,2.0 kg a.i./ha	3429	12111	1372	2479	209	7.8
Bladex,0.5 kg a.i./ha	2265	10277	1705	3247	179	3.3
Bladex,1.0 kg a.i./ha	2414	10520	1599	3129	69	3.3
Maloran,+Kerb 0.5 kg a.i./ha	3369	11961	1585	2997	53	3.3
Tribunil,+Kerb 0.5 kg a.i./ha	3247	12207	1557	2861	77	3.0
Igran,+Kerb,0.5 kg a.i./ha	3424	12723	1497	2694	129	7.3
Bladex,+Kerb each 0.5kg a.i./ha	3357	12849	1587	3000	176	3.0
L.S.D. 5%	689	1441	NS	NS	111	0.53
C.V.%	17.5	9.0	14.4	14.7	48.9	9.4

* Frost damage score 1-9; where 1 = no damage, 9 = complete frost kill.

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 (Table 1.23).

1.6. Faba Bean Production Agronomy and Physiology

1.6.1. 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 cutting down moisture evaporation from the bare ground and at the same time increase the amount of intercepted radiation and thus increase productivity and water use efficiency is to narrow the inter-row spacing. Starting in 1983/84, therefore, a trial was initiated using faba bean genotypes that had done 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 neutron probe.

There were significant differences in yield among genotypes. ILB 1814 gave the highest yield, followed by line 80S 43856. Line 80S 44367 gave the lowest yield (Table 1.24). 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 1.24. Means for Seed Yield (SY), Total Biological Yield (TBY) in kg/ha and Harvest Index (HI) of different faba bean genotypes.

Genotype	Yield in 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
L.S.D. (5%)	253	411	0.027
S.E.	90	146	0.010
C.V. (%)	16.5	16.0	5.6

(Table 1.25). Regression analysis showed that seed yield/unit area was strongly correlated to total biological yield (regression accounted for 96.3% of the total variance) and the later was in turn influenced by the number of plants/m^2. Frost that occurred between February and March affected adversely all genotypes except ILB 1814 and line 80S 43856, hence differences in plant population and yield.

Table 1.26 gives seed yield, evapotranspiration and water use efficiency. 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 higher plant population resulted in improved water use efficiency.

The soil moisture profile extraction was not influenced by treatments mainly due to the very severe frost which affected the experiment adversely (Figure 1.10). However, the general pattern shows that planting at narrow spacing (22.5 cm) regardless of the population resulted in moisture extraction at greater soil depth and a combination of sowing at high population and narrow row spacing resulted in larger amount of water extracted and at a greater soil depth (Figure 1.10). Similarly leaf winter potential did not show any consistent pattern from flowering to pod fill.

It can be concluded that when moisture is not limiting early in the season (as in 1984/85 season), sowing at narrow row spacing and high plant population results in better exploitation of soil moisture along the profile, resulting in high biological and seed yields.

Table 1.25. The effect of row spacing and plant population on seed yield, total biological yield in kg/ha and harvest index of faba beans.

Row spacing (cm)	Yield in kg/ha						Harvest Index		
	Seed			Total Biological					
	Population/m^2			Population/m^2			Population/m^2		
	22	44	Mean	22	44	Mean	22	44	Mean
45.0	1263	1726	1495	2082	2975	2529	0.61	0.58	0.59
22.5	1865	2712	2289	3022	4610	3816	0.62	0.59	0.60
Mean	1564	2219		2552	3793		0.61	0.58	
	LSD	SE	CV(%)	LSD	SE	CV(%)	LSD	SE	CV(%)
Row spacing (R)	127	45.1		206	73.2		NS		
Population (P)	127	45.1		206	73.2		0.013	0.005	
R x P	179	63.8	16.5	291	103.6	16.0	NS	14.0	

Table 1.26. 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 spacing and for seven other genotypes at 22 plants/m^2 and 45 cm spacing. Tel Hadya under rainfed conditions (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_2	1766	281.4	6.28
ILB 1814	P_1 R_1	2685	292.8	9.17
ILB 1814	P_2 R_2	2496	303.4	8.23
ILB 1814	P_2 R_1	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.

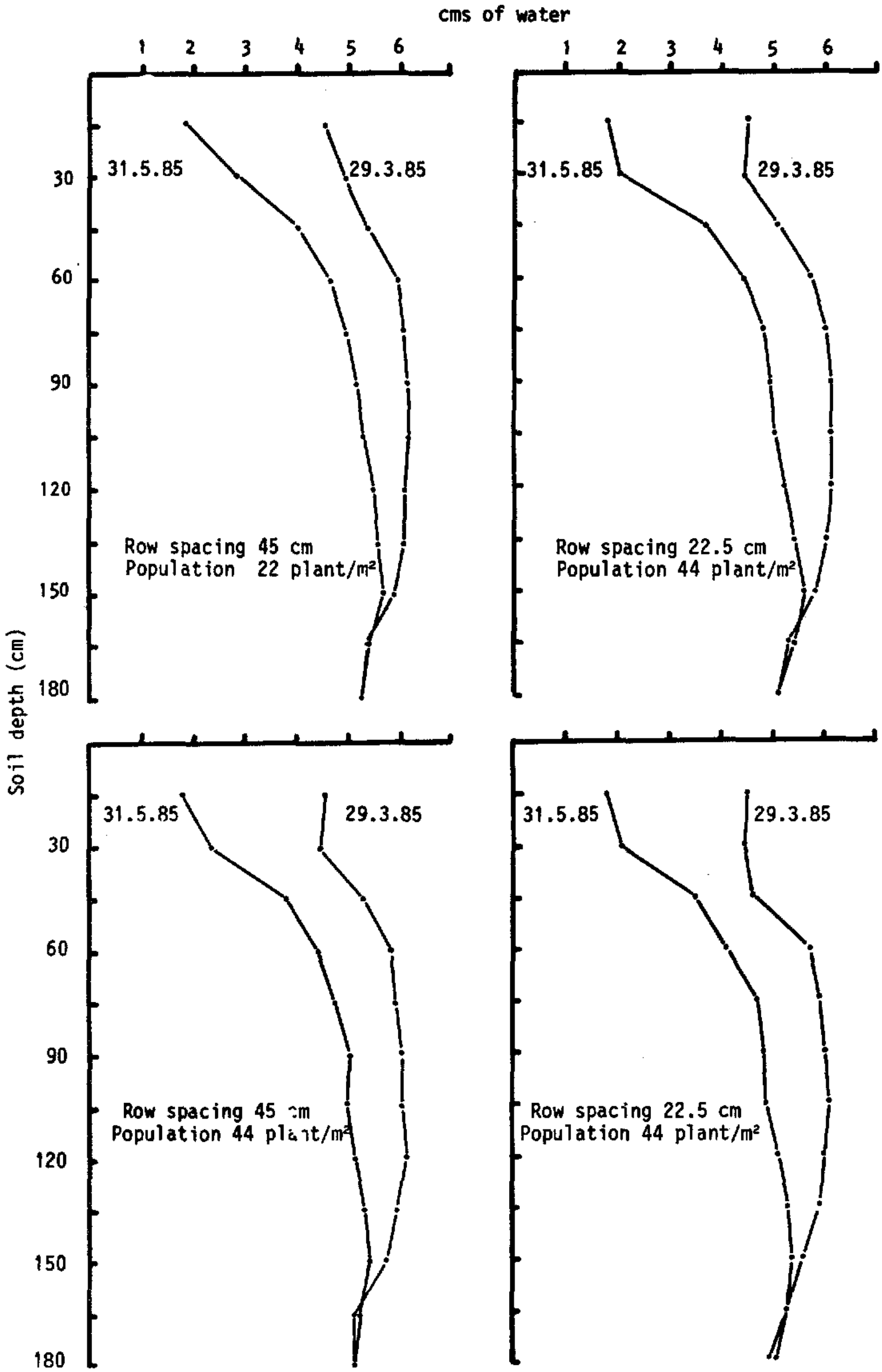


Figure 1.10 Soil *moisture* extraction along the profile at maximum rechange and at maturity as affected by plant population/m² (22 = p_1 and 44 = P_2) and row spacing in cm (45 = R_1 and 22.5 = R_2) in ILB 1814, Tel Hadya, 1984/85.

1.6.2. Effect of Row Spacing and Plant Population

As part of international trials, the performance of local faba bean land races 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). The results are given in Tables 1.27 and 1.28. In Tel Hadya, total biological yield was significantly increased both by reducing row spacing or increasing plant population. Seed yield, however, was increased only when row spacing was decreased. The lack of response in seed yield to different plant populations was mainly due to the high degree of plasticity shown by the crop (Table 1.28). For example, at low plant population, the number of seeds produced/plant was high and increase in population resulted in significant reduction in number, however, on unit area basis the number did not vary significantly. In Terbol, only row spacing affected significantly the crop performance. Successive decrease in row spacing resulted in successive increase in both seed and biological yields/ha. Said Silim and M.C. Saxena.

Table 1.27. The effect of row spacing on yield and harvest index of faba beans, Tel Hadya and Terbol 1984/85.

Row spacing (cm)	Tel Hadya Yield kg/ha Seed	Tel Hadya Yield kg/ha Biological	Tel Hadya Harvest index	Terbol Yield kg/ha Seed	Terbol Yield kg/ha Biological	Terbol Harvest index
30	2422	4752	0.51	4160	15503	0.27
40	2296	4644	0.41	3590	12858	0.28
50	2285	4547	0.52	3634	11690	0.31
60	2028	4172	0.42	3381	10189	0.33
L.S.D.	146.5	146.0	NS	397.9	1062.0	0.032
C.V.%	7.0	3.5	23.5	13.9	9.2	11.5

Table 1.28. The effect of plant population on yield and yield components of faba beans. Tel Hadya 1984/85 season.

Plant Population/m^2	Yield kg/ha Seed	Yield kg/ha Total Biological	Harvest index	Components of Yield: Seeds /plant	Seeds /m^2	Seeds Wt.(g) of 100	Pods /plant	Pods /m^2
30	2207	4111	0.54	5.7	170	125	3.2	94
45	2298	4636	0.49	4.5	193	129	2.7	116
60	2268	4839	0.47	3.6	190	124	2.2	112
L.S.D.	NS	223.7	0.017	0.80	NS	NS	0.44	16.9
C.V.	8.2	7.1	4.7	23.5	24.6	15.1	22.3	21.6

2. LENTIL IMPROVEMENT

The general objectives of the lentil improvement program continued to be to develop improved production practices and cultivars and genetic stocks with high and stable seed yields adapted to the three main agro-ecological regions of lentil production with maintained, or wherever possible improved, seed quality and nitrogen-fixing ability, and with the additional specific characters for each region namely: 1. High altitude region (above 1000 m elevation) - cold tolerance to allow a winter sowing and attributes for a mechanical harvest (tall, non-lodging growth habit and pod retention and indehiscence). 2. Middle to low elevation region around the Mediterranean Sea - attributes for a 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 period of growth. 3. Region of lower latitudes (Indian-sub continent and Ethiopia, Sudan) - phenological adaptation to the warm, short-photoperiod environment and resistance to rust, vascular wilt and Ascochyta blight.

2.1. Development of Lentil Cultivars and Genetic Stocks

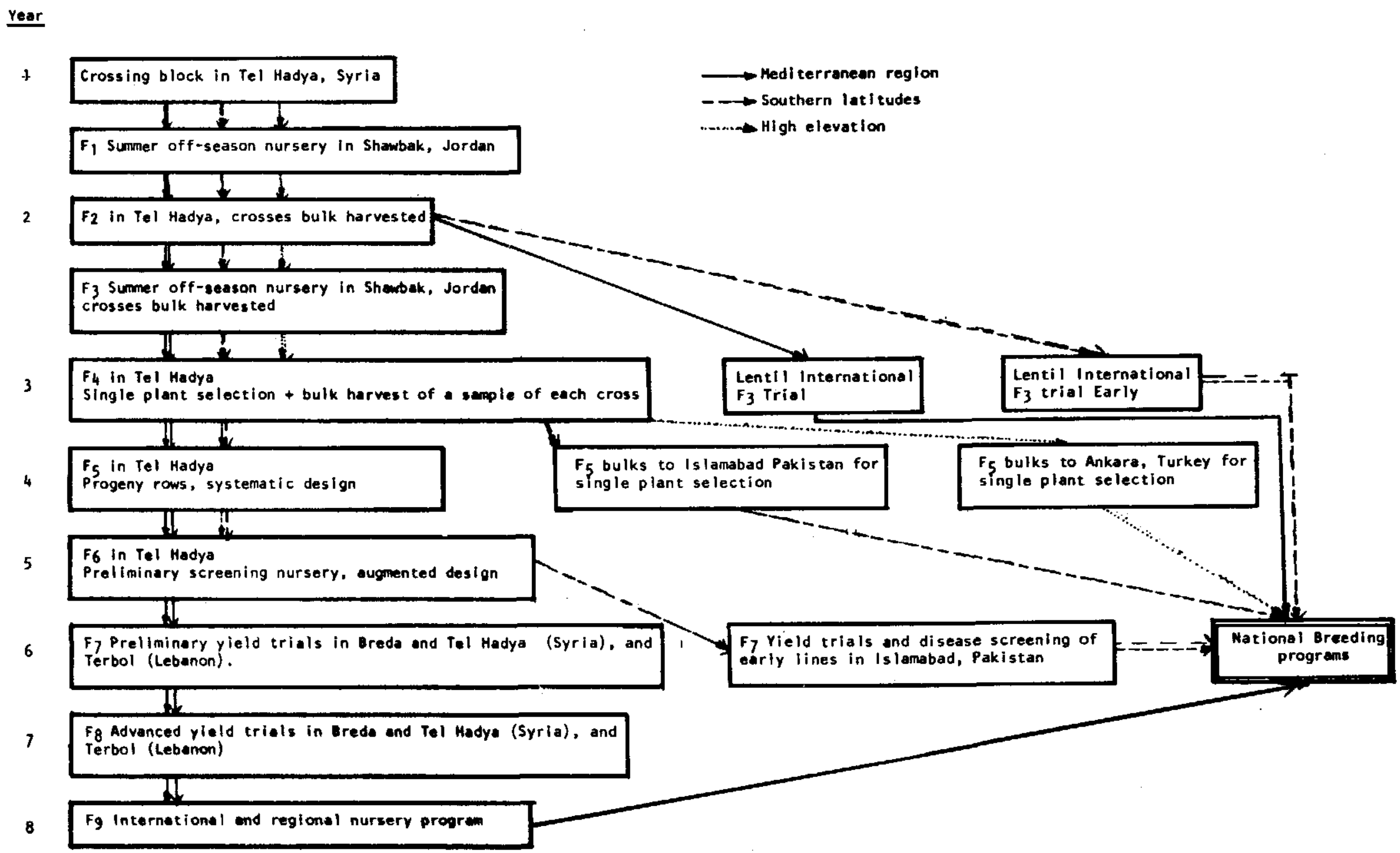
2.1.1. Breeding Scheme

In the lentil breeding program we make about 350 crosses annually for the aims outlined above. Last season the crosses were divided between the three major target regions with 71% crosses for the low elevation Mediterranean region, with 28% crosses for the southern latitudes, and with 1% crosses 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: viz. 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 Figure 2.1. All the crosses resulting from the crossing block at Tel Hadya are grown as F_1 generation in an off-season, summer nursery at Shawbak, Jordan under irrigation. The F_2 generation is sown at Tel Hadya in the winter season and bulk harvested. Seed from these bulks is used for the international F_3 trials, early and medium maturity, (LIF$_3$T and LIF$_3$T-E). A sub-sample 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 (Annual Report, 1984). In the past year developments have been made in the early stream for southern latitudes with the cooperation of the Pakistan national pulse program, NARC, Islamabad. Segregating populations from early crosses at F_5 generation are sent to Islamabad for single plant selection by the national program. In addition, selections for earliness made at Tel Hadya are sent to Islamabad in yield trials and for screening for Ascochyta blight resistance. In the high elevation - late maturity stream similar 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 assist the breeding effort so that more selections and tests for disease resistance and adaptation are made within the target environments.

Figure 2.1. Scheme of lentil breeding used at ICARDA showing streams for different target areas.



2.1.2. Yield Trials

Selections from the breeding program are tested in both preliminary and advanced yield trials in three contrasting locations representing a range in average rainfall of 283 mm at Breda, through 330 mm at Tel Hadya to > 500 mm at Terbol in Lebanon. This year 238 small-seeded selections (seed size < 4.5g/100 seed) and 171 large-seeded selections were tested across the three sites as seed permitted.

Amongst the small-seeded entries the percentages of entries yielding significantly (P=0.05) more than the local check (ILL 4401) were 52, 32 and 56 in Tel Hadya, Breda and Terbol respectively (Table 2.1). 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 the percentages of entries yielding significantly (P = 0.05) above the local check (ILL 4400) were lower at 19, 8 and 12 in Tel Hadya, Breda and Terbol respectively.

At Tel Hadya the two seasons 1983/84 and 1984/85 provided an interesting contrast. The earlier season had a precipitation of 229 mm and drought stress was increasing from flowering through the reproductive phase. In the next season (1984/85) the rainfall total was a well-distributed 373 mm and the crop did not suffer from drought stress; however the major stress was one of cold with three weeks of sub-zero nights in late February-early March during mid-vegetative growth.

Table 2.1. 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	19.9	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.

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 mean (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 trials of 1190 which was 13% greater. Since these yield trial means are based on at least 150 entries, statements on the adaptation of the two sub-species may be made. In the Middle East it is clear that 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.

2.1.3. 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 as part of the cooperative program with the Ministry of Agriculture, Syria both the regional yield trials were grown at five sites. 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%

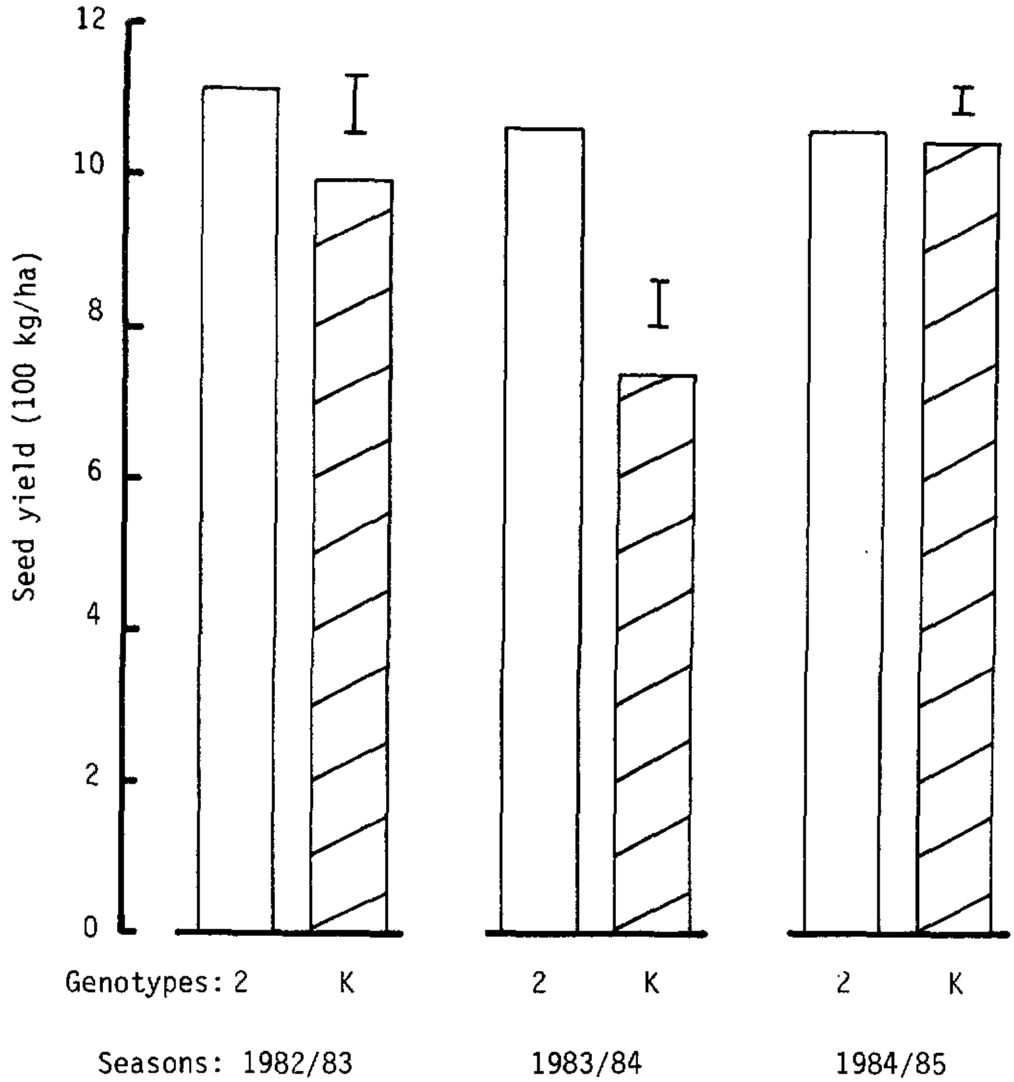
because of the cold susceptibility of the test entries in comparison to the check.

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 seasons 1982/83, 1983/84 and 1984/85 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 (Figure 2.2). 78S 26002 also has a reduced tendency to lodge, an important attribute with respect to mechanical harvesting. This selection has now been recommended for pre-release 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 Hurani 1.

2.1.4. Use of ICARDA lentils by national programs

There was an increased use of ICARDA lentils by national programs during the past year. NEL (ILL) 358 was released in Ethiopia to farmers in the Highland areas. This cultivar has rust resistance and a 50% yield advantage over the local check. Two selections in each of Tunis and Spain were selected for pre-release multiplication; this is in addition to the pre-release multiplication of 78S 26002 in Syria (see previous section) (Table 2.2). ILL 4605 is at the pre-release stage in Pakistan and Morocco. During the 1985/86 season on-farm

Figure 2.2. Seed yield (kg/ha) of an ICARDA selection 78S26002(2) and the local check Kurdi 1 (K) in three seasons on-farm trials in Syria with the standard error (I).



trials of ICARDA lentils are planned in Lebanon, Jordan, Syria, Turkey and Pakistan (Table 2.2). W. Erskine.

2.1.5. Genetic Variations 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 (Annual Report 1983) on significant genetic variation for lentil straw quality for such parameters as fibre 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 eleven diverse *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 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 non-significant when tested against the genotype season interaction, indicating zero heritability for the straw quality traits: *in vitro* digestibility, and both protein and fibre (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 on straw quality suggests that the effects of environmental factors like location, fertilizer

Table 2.2. 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.

regime, inoculation etc. on straw quality should be assessed. W.Erskine, S.Rihawi, and B.Capper

2.1.6. 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 the extra irrigation. Most possible introductions to Egypt come from rainfed areas with similar ill-adaptation. This study, a Ph.D. student project funded by the Nile Valley Project, estimated the genetic variation in response to irrigation in order to develop a selection methodology for irrigated conditions.

The study was conducted with 34 diverse accessions from the lentil germplasm collection in five environments in three locations namely 1) Tel Hadya unirrigated (373 mm, 1984/85 season) 2) Tel Hadya with one supplementary irrigation before flowering 3) Tel Hadya with two supplementary irrigations (before flowering and before pod filling.) 4) Breda, without irrigation (277 mm, 1984/85 season), and 5) Terbol without irrigation (444 mm 1984/85).

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 at Tel Hadya with two supplementary irrigations. At Tel Hadya the mean yield was 2195 kg/ha without irrigation, 2324 kg/ha with a single irrigation and, 2809 kg/ha with two irrigations, the latter representing an irrigation response of 28%. The genotype 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, U.K.) and W.Erskine

2.2. Diseases of Lentils

2.2.1. Survey of wilt damage on lentils

A survey of farmers' lentil fields was conducted in northern Syria in the main growing areas of Aleppo, Idlib and Hama Provinces for wilt damage. Previous work had indicated that wilt was the major pathogenic disorder on lentils in Syria. We aimed to quantify this damage and determine the causal organisms.

The survey covered 28 fields with an average estimated area of 1.4 ha. The percentage of plants with wilt symptoms across all fields was 13% with a range in incidence from 2-70% wilted plants/field. Since wilt symptoms were observed on plants at the flowering and podding stage, there is no possibility of compensation from neighbouring healthy plants. Wilted plants give no seed yield and consequently the incidence (13%) of plants affected probably approximates the yield loss from 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 re-isolation of the wilted shoots resulted in Fusarium oxysporum f.sp. lentis growth. We now plan to inititiate screening for disease resistance to vascular wilt. B.Baya'a (University of Aleppo) and W.Erskine

2.2.2. 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, established on studies with 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. In the plastic house at Tel Hadya with 15 seeds/pot and a high cyst rate (300-350 cysts/200g soil), there were significant differences between the 75 lines screened in vegetative damage score and total root weight. But 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, and N. Greco and M. di Vito (Bari, Italy).

2.3. Lentils Insect and Their Control

2.3.1. 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 smallnumbers 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 the planting of lentil crops. A second, larger wave of inmigration 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 ($\bar{x}$ = 66%) were detected in late April, a time at which, in previous seasons, most fields sampled were showing 100% nodule damage. This is important in the understanding of yield responses to *Sitona* control.

Work aimed at the construction of a life table for *S. macularius* revealed that egg mortality 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 of the research on *Sitona* has been placed upon the study of effective, economic chemical control.

2.3.2. Partitioning of yield losses among species

Proper separation of the effect of Sitona and foliar insects on yields has been reported before (see ICARDA'S 1983,1984 ANNUAL REPORTS). 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 (Table 2.3). The key pest status of Sitona has then been reconfirmed and this line of research could now be terminated.

2.3.3. 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 plants was studied in the greenhouse. ($19^{o}C$; 47% R.H.). Regressions of ARA on the percentage of nodules damaged indicated no significant effect up to 46 days after infestation (Table 2.4). 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 Figure 2.3. These findings support previous field results on the effect of larval damage on the functionality of lentils nodules.

2.3.4. Economic aspects of Sitona control

The feasibility of chemical control of Sitona was studied under farmers fields conditions at five locations: Souran, Maara, Tel Hadya, Breda, and Aazaz. Infestation levels varied from 19.5% nodules damaged

Table 2.3. The effect of selective *Sitona* and thrips control on the yields of Syrian Medium lentils. Means of four replications. Tel Hadya, 1984/85.

Control of	Straw yield		Seed yield	
	kg/ha	% Increase	kg/ha	% Increase
Sitona and thrips	4144	9.3	1683	12.1
Sitona	4079	7.6	1637	9.1
Thrips	3807	0.4	1528	1.8
None	3792	-	1501	-
LSD 5%	174.6		108.1	
CV	3.6		5.5	

Table 2.4. Statistics for regressions of acetylene reduction activity in lentils on the percentage of nodules damaged by increasing numbers of *Sitona macularius* larvae. Means of four replications.

Days after Infestation	Intercept	Slope	r	Significance[1/] of r
0 - 39	0.19	0.0005	0.079	n.s.
39 - 46	0.46	-0.004	-0.300	n.s.
46 - 53	0.94	-0.014	-0.740	**
53 - 60	0.73	-0.016	-0.850	**
Seasonal	2.62	-0.109	-0.931	**

1/ n = 20 in all cases; n.s. = non significant; ** = significant at 1% level

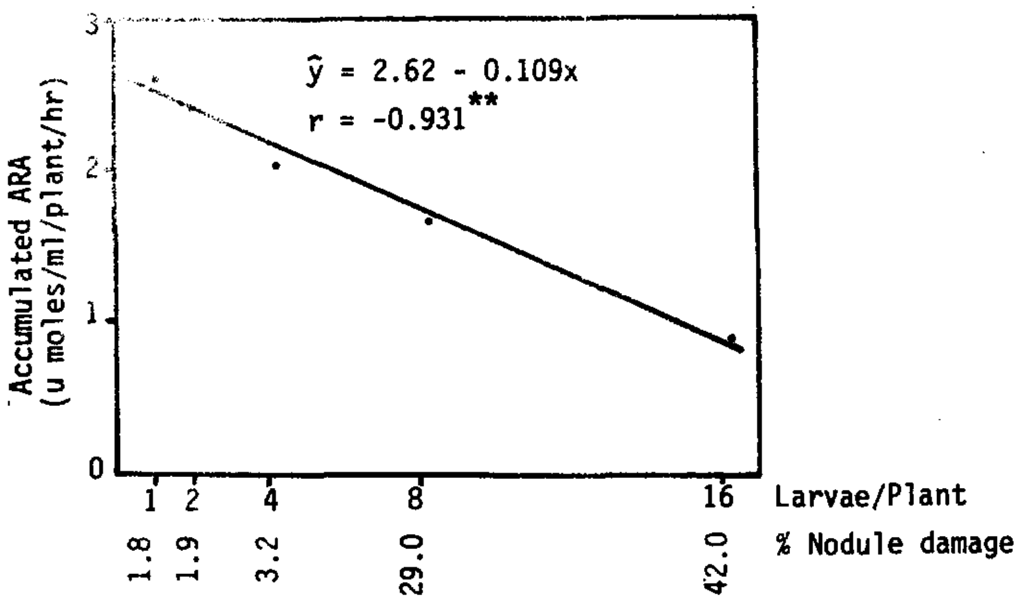


Fig.2.3. The regression of acetylene reduction activity (ARA) in lentils on increasing levels of infestation with larvae of *Sitona macularius*. Means of four replications. Tel Hadya, 1984/85.

in Souran to 75.2% in Tel Hadya, average 48%. This average is lower than previous seasons means of 65% nodule damage previously registered in northern Syria. With little or no interference from other insects, yield losses due to Sitona damage ranged from 5.0% in Souran to 33% in Azaaz, average 13%. There was not a significant treatment x location interaction, both carbofuran and heptachlore significantly increasing straw and seed yields (Table 2.5). The economic analysis of data through partial budget analysis and subsequent calculation of an economic treshold for Sitona (Figure 2.4) indicated that chemical control with a pesticide such as carbofuran would be justified at levels of infestation of 43% or higher. As indicated by many previous field trials, the economic impact of Sitona on yield is significant in lentils crops showing 70% or more nodule damage, a situation which is common in most lentils growing areas of Syria. Since Sitona control is preventive in nature there would be the 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 2.6) but a smaller dosage (0.5 kg A.I./ha) of carbofuran compared favourably in terms of control 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 2.5. Yield responses of Syrian Local Small lentils to *Sitona* control. Combined analysis of data obtained in five farmers' fields. Means of two reps. per site, 1984/85.

Treatment	STRAW YIELD				SEED YIELD			
	All Sites		Excluding 2 sites1/		All Sites		Excluding 2 sites	
	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).

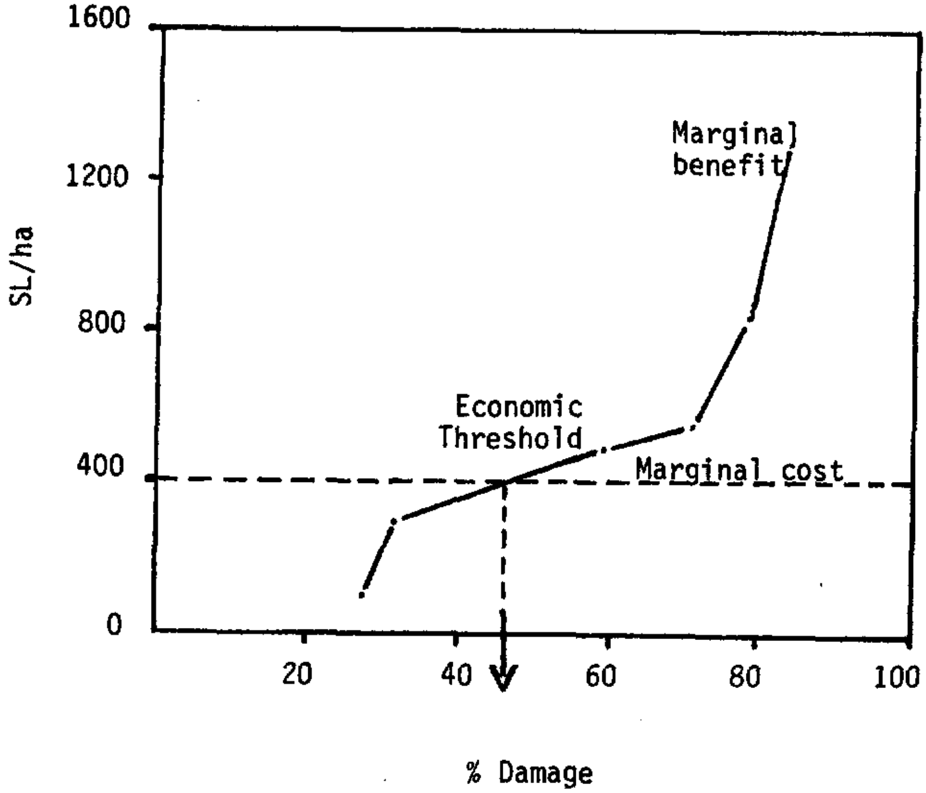


Fig. 2.4. Economic determination for *Sitona macularius* on lentils.

Table 2.6. 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 %			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.

2.4. Production Agronomy and Crop Physiology

2.4.1. Growth habit in lentils

Within the ICARDA 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, Syria and The anatomy of ten plants taken at random from each plot was measured.

Striking differences in growth habit were evident, as can be seen in Photo 2.1. There was an overall range in mean height from 26 cm (ILL 4605) to 41.5 cm (ILL 922), with the average plant being 33.5 cm high with its lowest pod 18.5 cm above the ground. There was an average of 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 considerable variation between genotypes in the amount of branching. Adding up the number of primary, secondary and tertiary branches the total ranged from a mean of 6 branches on ILL 5748 to 12 branches on ILL 922.

Overall, the mean number of both primary branches (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 two lower-most primary branches.

Growth habit is much influenced by environmental or non-genetic 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 with important, direct effects upon plant height, lodging and seed yield. The data will also be summarized in the form of plant diagrams. W.J.Goodrich and W.Erskine.

2.4.2. 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 although winter sowing increases total biological yield if does not increase seed yield. Cold damage and greater infestation of Orobanche were among the factors that off-set 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). November sown crops took between 139 to 147 days to flower and 178 days to reach physiological maturity. However, crops sown early in February took only 72 days to flower and 95 to 107 days to reach physiological maturity.

Inspite of the very severe frost which occurred between February and March and which severely damaged November sown ILL 8, 9, 16 and 223, all November sown crops produced more dry matter, than February sown crops (Table 2.7). At each sowing, genotypes varied in growth rate and the total dry matter at maturity (Figure 2.5 and Table 2.7). The varieties that grow fastest when sown in November (ILL 8, 223, and 4401) produced the most dry matter at maturity.

Seed yield varied between 900 and 1330 kg/ha in early winter sowing and 330 and 670 kg/ha in later winter sowing. Early winter sown crops produced significantly more seed yield than late winter sown crops. In early winter sowing, varieties that had the fastest rate of growth (ILL 8, 223, 4401) produced the most dry matter and the highest seed yields (Table 2.7). Harvest index in later 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 occured early and hastened maturity.

In the last three seasons (1982-85) advancement of sowing from late to early winter has always resulted in an increase in total dry matter production and sometime in an increase in seed yield. In some seasons frost damage in the reproductive phase presented any increase in seed yield. Since in the ICARDA region lentil straw is used as animal feed, advancing date of planting, therefore, to November would increase farmer's income.

Table 2.7. The effect of sowing date on total biological yield (TYB), and seed yield (SY) in kg/ha and harvest index (HI) of different genotypes of lentis, Tel Hadya 1984/85.

Genotypes	Date of Sowing					
	November 14			December 12		
ILL	SY	TYB	H_1	SY	TYB	H_1
8	1160	3904	0.30	661	1685	0.40
9	1110	3192	0.35	573	1631	0.35
16	965	2798	0.34	554	1475	0.37
223	1334	3954	0.34	463	1258	0.37
4400	902	3134	0.29	338	1079	0.32
4401	1325	4527	0.29	540	1560	0.35
Mean	1133	3585	0.32	521	1448	0.36

	SY		TYB		HI	
	CV(%)	LSD	CV(%)	LSD	CV(%)	LSD
Dates (D)	33.4	80	23.5	544	11.0	0.03
Genotypes (G)	18.4	76	14.4	371	8.6	0.03
D X G		316		524		0.04

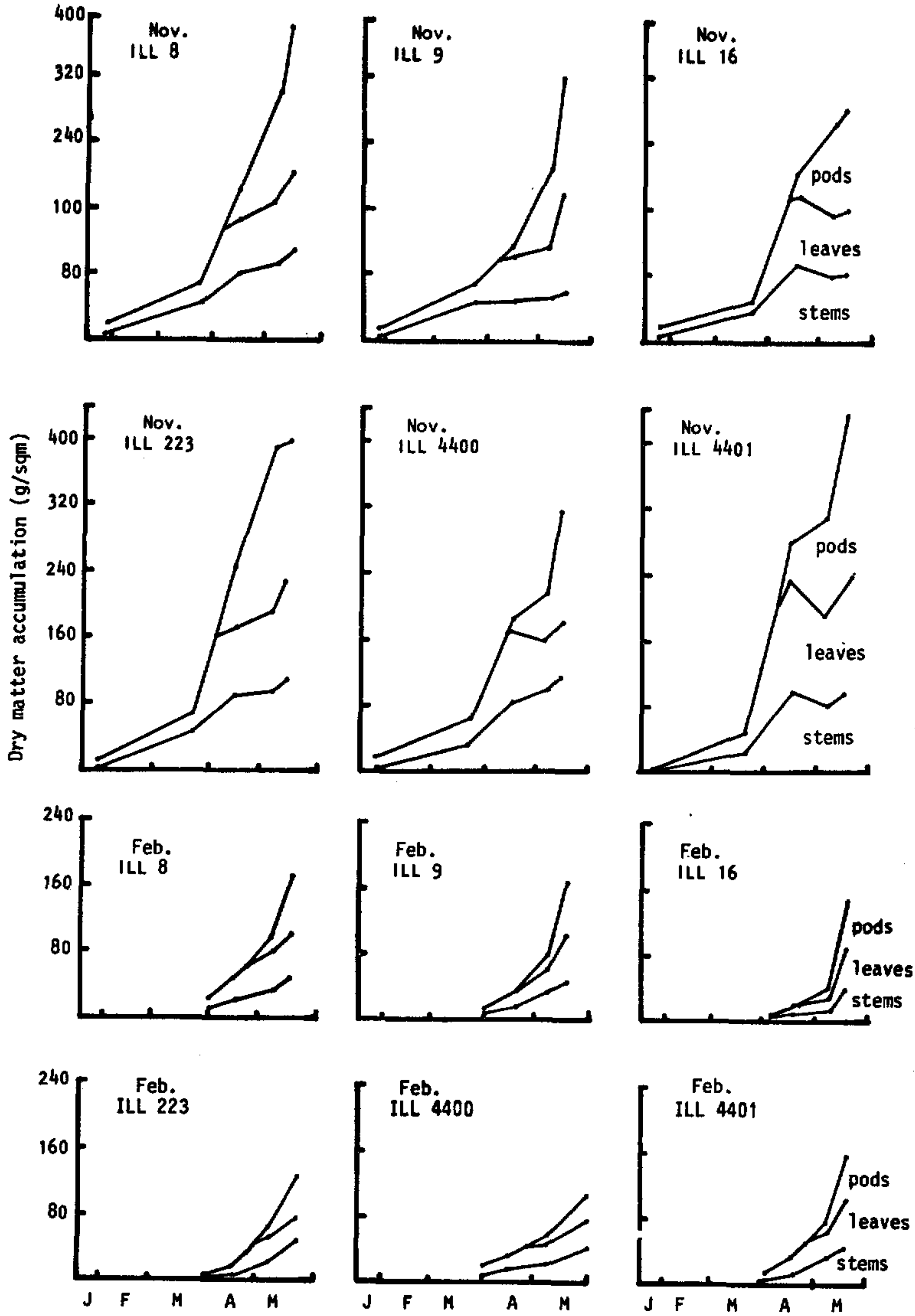


Figure 2.5.The build up and partitioning of dry matter of six lentil genotypes as affected by date of sowing.

2.4.3. Response to Plant Population and Row Spacing

The effect of plant population (100, 200, 300 and 400 plants/m2) and four row spacings (20, 30, 40 and 50 cm) on lentils was studied at Breda and Terbol. At both locations, there was a significant increase in total biological yield with increase in plant population (Tables 2.8 and 2.9). However this effect on seed yield was significant only in Breda (Table 2.8). Planting lentils at narrow row spacing increased both biological and seed yields in Terbol but had no effect in Breda. Yields obtained in Terbol were almost double those obtained at Breda due to better moisture supply. In Terbol, there was a gradual improvement in partitioning of dry matter with decrease in plant population whereas in Breda only the lowest population (100 plants/m2) improved it.

2.4.4. Lentil Fertility-Cum-Inoculation Trial

Management practices which favour symbiotic association between lentil crop and Rhizobium need investigation so that symbiotic nitrogen fixation may be increased and the crop dependence on the soil nitrogen is 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 Rhizobium culture, with or without control of Sitona weevil.

Table 2.10 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 to the root nodules by Sitona weevil. Controlling Sitona weevil resulted in 13 and 16% increase in seed and biological yields

Table 2.8. The effect of varying plant population on yield and harvest index of lentils, Breda 1984/85.

Population/m^2	Yield kg/ha		Harvest Index
	Seed	Biological	
100	483	1130	0.43
200	596	1460	0.41
300	667	1654	0.40
400	757	1972	0.41
LSD	65.0	143.1	0.023
CV %	14.5	13.1	7.7

Table 2.9. The effect of row spacing and plant population on yield and harvest index of lentils. Terbol 1984/85.

Row spacing (cm)	Seed Yield kg/ha					Total biological yield					Harvest Index				
	20	30	40	50	Mean	20	30	40	50	Mean	20	30	40	50	Mean
Population m^2															
100	978	1053	981	831	961	2764	2657	2564	2418	2600	0.35	0.40	0.38	0.34	0.37
200	1085	1041	942	904	993	2921	2939	2741	2723	2831	0.37	0.36	0.34	0.33	0.35
300	1179	969	908	873	982	3437	2850	2819	2758	2966	0.34	0.34	0.32	0.32	0.33
400	1055	906	920	856	934	3264	3063	2986	2849	3040	0.32	0.30	0.31	0.30	0.31
Mean	1074	992	938	866		3096	2887	2777	2687		0.35	0.35	0.34	0.32	

	Seed Yield LSD 5%	Seed Yield CV%	Total biological yield LSD 5%	Total biological yield CV%	Harvest Index LSD 5%	Harvest Index CV%
Row spacing (R)	51.7	6.7	165	7.2	NS	9.6
Population (P)	NS	8.7	127	6.2	0.01	7.9
R X P	NS		NS		NS	

respectively. Inoculation with rhizobium plus controlling Sitona did not result in additional advantage which implies that in Breda soil, there was no advantage of introducing this new strain. In Terbol there was no significant response to fertilizer treatments because of high fertility of the soil. Again like in Breda, controlling Sitona weevil resulted in 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.)

2.4.5. Lentil Harvest Mechanization

The mechanization of lentil harvest in the Middle East is a major research goal of the food legume improvement program, because lentil areas are declining due to increased labour costs for harvest in comparison to world lentil prices. Research on lentil harvest mechanization has 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 iin Syria is by hand broadcasting followed by a cultivator pass to cover the seed leaving a ridged field. This was compared to 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:

1. Broadcast by hand (300 seeds/m2), covering with tractor-pulled cultivator.
2. Broadcast by hand (300 seeds/m2), covering with tractor-pulled cultivator towing a heavy bar.
3. Drilled (200 seeds/m2) by local cereal drill.
4. Drilled (200 seeds/m2) by local cereal drill towing a heavy bar.

Table 2.10. The effect of fertiliter and inoculation and carbofuran on yield and harvest index of lentils at Breda and Terbol, 1984/85 season.

Treatment	Breda			Terbol		
	Yield kg/ha		Harvest	Yield kg/ha		Harvest
	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 @ 1.0kg 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

The comparison of 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 2.7). With a hand harvest, the use of a heavy bar behind the cultivator covering seed increased lentil seed yields 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.

Table 2.11. Lentil seed and straw yields (kg/ha) from different sowing and harvesting methods.

	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

L.S.D. (5%) Harvest method: Seed 91 kg/ha; Straw 399 kg/ha.
L.S.D. (5%) Harvest x sowing methods: Seed 183 kg/ha, Straw 799 kg/ha.

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 self propelled cutter bar at Tel Hadya during 1984/85 season to investigate the effect of height of cut (ground level, 5cm and 10cm above ground) as compared to hand pulling on loss in seed and straw yields and quality of three lentil genotypes of different plant stature; ILL 8 (erect and non lodging), ILL 4400 (local line, lodging), ILL 554 (erect and late maturing). Because of lack of significant interaction between height of cut and genotypes, only the main effects are presented.

The effect of height of cut on seed and straw yields, percentage digestibility and protein content are shown in Table 2.12. Compared with hand pulling, cutting at the ground level, 5 cm and 10 cm above ground resulted in seed yield losses of 9.0, 15.6 and 16.7% respectively. Percentage loss in straw yields were 7.3, 31.5 and 38.6. In contrast, significant increases in per cent digestibility and protein content of straw were obtained when the crop was cut as compared with hand pulling. Digestibility of straw cut at the ground level and 5 cm above ground were similar, 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 2.12. Seed yields of ILL 8 and ILL 4400 were similar and significantly higher than ILL 554. Straw yields of ILL 4400 was high, ILL 8 medium and ILL 554 low. Per cent digestibility of straw did not vary among the genotypes, but variation in protein content was significant. Per cent 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%.

Table 2.12. The main effects of height of cut and genotypes on straw and seed yields, percentage straw digestibility and protein content.

Harvesting	Yield (kg/ha)		Percent 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
Genotypes				
ILL4400	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

This study has shown that the mechanical harvesting of lentil by cutter bar results in straw and seed yield loss, 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. It is possible that seed yield loss can be reduced by harvesting at physiological maturity. ILL 4400, which is a local cultivar, had the highest loss in both seed and straw yields and losses in ILL 8, an improved line, were low. Said Silim, Willie Erskine, and M.C. Saxena.

2.4.6. Weed Control

Weeds are a major constraint to increased production in lentil, particularly in early sown crop. Hence studies were carried out to evaluate the common herbicides for broadspectrum weed control. The dominant weed species were same as indicated in the relevant section on faba beans.

2.4.6.1. International Weed Control Trial:

As part of the International Chemical Weed Control trial, studies were conducted in 1984/85 season at Breda and Terbol to quantify yield losses due to weeds and identify promising herbicides for weed control.

In Breda weed infestation was light. Weeds reduced yield by to weeds was about 8% and non-significant and chemical weed control and hand weeding gave similar results (Table 2.13). In Terbol, Weeds reduced yield by 69%. Hand weeding twice was as effective as repeated hand weeding and was superior to chemical weed control.

Table 2.13. The effect of weed control treatments on yields and harvest index of lentils, Breda and Terbol 1984/85.

Treatments	Breda Yield kg/ha Yield	Breda Yield kg/ha Biological	Breda Harvest Index	Terbol Yield kg/ha Yield	Terbol Yield kg/ha Biological	Terbol Harvest Index
Control	729	1933	0.38	502	2940	0.16
Repeated Hand Weeding	791	1956	0.41	1641	5415	0.30
Hand Weeding 2x	790	1988	0.40	1681	5145	0.33
Maloran, 1.5 kg a.i./ha	745	1782	0.42	585	3278	0.17
Gesagard, 1.5 kg a.i./ha	699	1734	0.40	986	4276	0.23
Tribunil, 2.5 kg a.i./ha	681	1658	0.43	442	2685	0.16
Bladex, 0.5 kg a.i./ha	800	2030	0.40	849	3875	0.21
Bladex, 1.0 kg a.i./ha	787	1979	0.40	1109	4899	0.22
Maloran 1.5kg+Kerb 0.5kg a.i./ha	769	1852	0.42	1228	4823	0.25
Gesagard 1.5kg+Kerb 0.5kg a.i./ha	730	1755	0.42	1288	5121	0.25
Tribunil 2.0kg+Kerb 0.5kg a.i./ha	754	1787	0.42	1393	5335	0.26
Bladex 0.5kg+Kerb 0.5kg a.i./ha	748	1875	0.40	879	3970	0.22
LSD 5%	NS	225	0.023	417	1222	0.05
CV%	9.1	8.4	3.9	27.7	19.7	16.1

Pre-emergence 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.

2.4.6.2. Evaluation of new herbicides for pre- and post-emergence applications.

The experiment was conducted at Tel Hadya during the 1984/85 growing season. The aim of the trial was to identify and evaluate the best herbicides for broadspectrum weed control in lentil. Some of the herbicides have already been tested in field experiments, some of them are newly developed and being tested for the first season at ICARDA region. The trial was in RCB design with four replications.

The population of weeds was small 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 pre-emergence at the rate of 0.5 kg a.i./ha, and there was no significant differences in grain yield between this and hand weeded (weed free) treatment (Table 2.14). This confirms the previous years observations about excellent performance of this product. All newly tested products (from treatments 7 to 14) provided poor weed control or had a phytotoxic effect on crop, causing a significant grain yield reduction.

Table 2.14. Effect of chemical weed control on lentil crop phytotoxicity, total dry weight of weeds (TDW) kg/ha and grain yield kg/ha, (Tel Hadya, 1984/85).

Treatment	Rate (kg a.i./ha)	Timing*	Phyto-toxicity**	TDW	Grain yield
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			
C.V.				51.5	16
L.S.D. 5%				463.8	180

* Pre. = Pre-emergence application; Post = Post-emergence application; PPI = Pre-planting incorporation.

** 1-no phytotoxicity symptoms, and 9-total crop injury.

2.4.6.3. Resistance to Orobanche spp.

Lentils are seriously damaged by *Orobanche crenata* especially in Syria and Morocco. No satisfactory control method exists. A resistant variety offers the best method of control. For several years field screening for *Orobanche* resistance on lentils has been undertaken at ICARDA. Some lines were found to have lower infestation than the local check (ILL 4400) but no line could be identified as resistant. 400 genotypes were tested in 4 replications during the growing season 1984/85 at Tel Hadya in infested soil with *O. crenata*. As a result of frost, 265 lines were severely damaged; and only 135 lines could be evaluated for resistance. Of these 7 lines were found less susceptible than the local check (ILL 4400). These lines are ILL 262, 326, 560, 672, 748, 814, and 912. 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 pre-conditioned *Orobanche* seed. To pre-condition the *Orobanche* seeds the filled petridishes are stored for 10 days at $20^{o}C$. After planting the lentils the petridishes are stored in an incubator at $25/20^{o}C$ (day/night) and 12 hours light. Following this procedure, the resistance can be evaluated within 20-25 days. S. Kukula and J. Sauerborn.

3. KABULI CHICKPEA IMPROVEMENT:

This program is jointly carried out by ICRISAT and ICARDA. Kabuli chickpeas are widely grown as spring sown crop on conserved moisture in the West Asia and North Africa Region (WANAR) as well as in Southern Europe. In Indian sub-continent, Nile Valley, and Mexico and other Latin American countries the crop is winter sown. Advancing the sowing date from spring to winter in WANAR with ascochyta blight resistant cultivars results in substantial increase in seed yield. The objective of the kabuli chickpea improvement program is to develop production technology and suitable genotypes for different agro-ecological conditions to increase the productivity of kabuli chickpeas wherever they are important.

In the past seven years, the main objective of breeding was to generate germplasm and genetic stock that were resistant to ascochyta blight. Such germplasm is expected to adapt well for both winter and spring sowing in the Mediterranean region and parts of the Indian subcontinent. To meet this objective over 14,000 germplasm accessions were screened and sources of resistance to ascochyta blight identified. Utilizing these sources, over 2800 crosses were made. With the facility of generation advancement in the off-season, a large number of ascochyta blight resistant/tolerant genetic stocks, such as small, medium and large seeded type, conventional bushy type and tall type, desi and kabuli type, have been developed. The 1984/85 season with its extended frosty period provided an opportunity to eliminate lines susceptible to cold.

Three sites; namely Tel Hadya (low elevation, 325 mm annual rainfall), Jinderis (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 the national programs. This procedure has proved useful in selection of right kind of material for them.

During 1984/85, two genotypes, namely ILC 72 and ILC 200, have been released in Spain under the names "Fardan" and "Zegri", respectively. We have information that three more cultivars selected from the International Nursery have been registered in Spain. The Moroccan program has issued seed of ILC 195, ILC 482, and ILC 484 to the farmers for winter sowing. Hence the strategy adopted in the past has been fruitful and will continue in the future. However, we propose to lay more emphasis for the development of early maturing lines (for the Indian subcontinent) and extra-large seeded type for parts of south Europe and the Americas. M.C. Saxena and K.B. Singh.

3.1. Germplasm

During 1984/85, 400 new accessions were added mainly from Pakistan, Turkey, and the USSR. With this addition the total holding of kabuli chickpea germplasm increased to 5990. Publication and distribution of the Kabuli Chickpea Germplasm Catalogue resulted in a large demand of germplasm accessions. A total of 6265 germplasm lines were furnished to eight countries (Table 3.1). Another significant development of the year was the transfer of germplasm collection to newly created Genetic Resources Unit.

Starting 1985, we have begun evaluation of germplasm lines for specific characters for which facilities do not exist with us. Towards this goal, we have furnished 2000 germplasm lines each to the University of California, Davis, USA, the Turkish national program, Ankara, and the Tunisian national program, Tunis respectively for evaluation against viruses, cold, and wilt. Depending upon its success, this kind of activity will expand in future.

Table 3.1. Distribution of chickpea germplasm lines to the 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

3.1.1. Cold Tolerance

The 1984/85 winter was perhaps the coldest ever recorded in Syria. Temperature fell below freezing point on 41 nights; -9.8oC being the lowest. Most nights the temperature was below 0oC between 20 Feb and 15 Mar, when the crop had grown substantially. This adversely affected the crop, killing many lines and severly affecting others. It, however, provided an excellent opportunity to screen chickpeas for tolerance. Taking full advantage of this opportunity, the germplasm accessions, breeding lines and advanced segregating generations were screened for cold tolerance (Table 3.2). None of the lines was found unaffected, but 207 accessions or 1.67% material was killed. Fortunately, 85 lines were found to be tolerant and 782 lines moderately tolerant. Majority of the lines (45.30%) were susceptible and produced practically nothing.

One interesting phenomenon similar to that seen in winter-hardy wheat was observed. In many lines, above ground portions were killed, but soon after warm temperatures returned plants recovered fully. Many of them produced satisfactory yield.

Cold tolerance screening is done by advancing the sowing date to October. This year's cold was so much harmful that most of the genotypes, sown during this period, 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 a donor parent for genes to cold tolerance.

Advanced breeding lines numbering 10185 progenies were screened for cold tolerance and 7218 progenies or 70.87% material was rejected

Table 3.2. Reaction of chickpea germplasm accessions and breeding lines to cold (low temperature) at Tel Hadya, 1984/85.

Material	Scale									Total
	1	2	3	4	5	6	7	8	9	
Germplasm acc.	0	0	2	8	42	73	157	816	66	1164
Breeding line	0	0	2	9	56	70	136	209	1	483
Advanced seg generations 1/	0	0	81	765	979	1236	2948	4582	140	10731
Total	0	0	85	782	1077	1379	3241	5607	207	12,378
% of Total	0.00	0.00	0.69	6.32	8.70	11.14	26.18	45.30	1.67	

1/ Advanced segregating generations include F_4 to F_7.
Scale: 1 = Free; 9 = Killed.

(Table 3.3). There were many lines which were rated 3 or 4 and were very productive and uniform. Promising lines from these were bulked. K.B. Singh and R.S. Malhotra.

3.1.2. Ascochyta Blight Resistance

The 1984/85 season was most unfavorable for the ascochyta blight disease development and spread. The spores of the pathogen present in the debris were killed due to low temperature between 20 Feb and 15 Mar. Thereafter, temperature abruptly rose high and weather became dry not to permit the disease to develop. Even repeated spore suspension sprays followed by sprinkler irrigation failed to achieve the goal. On the other hand, excessive irrigation caused water logged-condition, killing a large proportion of the breeding material planted on 7 ha for this screening work. It may be concluded from these observations that if temperature is high and weather dry, spore suspension sprays and sprinkler irrigations will not help in creating ascochyta blight disease in epiphytotic form. K.B. Singh and R.S. Malhotra.

3.1.3. Orobanche sp. Resistance

Screening of germplasm accessions and breeding lines could not be accomplished at Tel Hadya for two reasons. First, large number of genotypes were either killed or severely affected by cold. Second, Orobanche shoots did not develop at all. Whether non-development of shoots was due to low temperature or some other reasons was not known. At a coastal site, Jable, in northern Syria, most of the ascochyta

Table 3.3. Reaction of chickpea advanced segregating generations to cold (low temperature) at Tel Hadya, 1984/85.

Generation	Scale									Total
	1	2	3	4	5	6	7	8	9	
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.

blight resistant lines in CIABN were free from Orobanche while the ascochyta blight susceptible checks developed heavy Orobanche infestation. K.B. Singh, R.S. Malhotra, and S. Kukula.

3.2. Improved Kabuli Chickpea Cultivars and Genetic Stocks:

3.2.1. Crossing

A total of 413 crosses were made. Included in the crossing program were crosses for the four national programs, namely: Egypt, Jordan, Lebanon, and Tunisia. In keeping with the demand by the national programs for generation of the large seeded and early maturing germplasm, 55% of the crosses combined these traits with high yield and ascochyta blight. Like in past, one parent had resistance to ascochyta blight. We are now mostly utilizing those lines as sources of resistance that have been generated through hybridization at the center because, beside having resistance to ascochyta blight, they are better in seed size and seed type, cold tolerance and seed yield.

3.2.2. Segregating Populations

The F_1 generation was raised as usual in the off-season nursery under continuous light at Sarghaya. This procedure has helped us in transferring 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, but due to excessive irrigation we lost two-thirds populations completely and part of the remainder was bulk harvested (Table 3.4).

Table 3.4. Breeding material grown, single plants selected, and promising progenies bulked in chickpea, 1984/85.

Generation	Material grown	Plants selected	Progeny bulked
F_1	337	-	-
F_2 Population	262	87 bulk harvest	
General breeding program			
F_3 Progeny	5111	5129	
F_4 Progeny	7119	3124	88[1]
F_5-F_7 Progeny (W)	1032	438	45
F_5-F_7 Progeny (S)	963	387	80
Large Seeded Type			
F_3-F_5 Progeny	1234	2099	26
Desi Type			
F_3-F_5 Progeny	1390	2088	72

W = Winter; S = Spring
1. Includes 34 tall type.

A total of 14,225 F_3 to F_7 progenies were grown during 1984/85. Of these 5111 F_3 progenies 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. The 1984/85 season had unprecedented cold and naturally susceptible material was eliminated. Whatever material survived the cold and excessive watering was subjected to careful selection. The plants selected or progenies bulked should have high level of tolerance to cold, an important pre-requisite for winter sowing. Interestingly many lines not only survived low temperatures and water logging conditions, but were also productive and uniform. Hence, 179 lines were bulked. These lines will be screened for less-photoperiod sensitivity during 1985 off-season and the ones selected will be tested for yield and adaptation in the following season.

3.2.3. Yield Trials for Winter Sowing

The seed yield of 255, 193, and 229 newly bulked lines were respectively investigated at Tel Hadya, Jinderis and Terbol. As many as 123 entries at Tel Hadya, 27 at Jinderis and 12 at Terbol exceeded the check by significant margin (Table 3.5). A few of the lines were better than the check at all locations, thus revealing their wide adaptation. While majority of the lines had 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 3.6.

The lines that showed significantly higher yield than check also had better tolerance to ascochyta blight and cold. Such lines are expected to prove useful to cooperators in the national programs for winter sowing.

Table 3.5. Mean yield performance of newly developed lines during 1984/85 winter season.

Location	Trials conducted	Entries tested	Entries exceeding check1/	Entries significantly exceeding check1/	Yield range for best entries (kg/ha)	Range for c.v. (%)	Range for L.S.D.at 5%
Tel Hadya (Syria)	15	255	208	123	633-2525	15.1-51.7	138-970
Jinderis (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.

Table 3.6. Performance (in terms of yield rank) of some lines of chickpeas at Tel Hadya, Jinderis and Terbol as also across all these locations in the 1984/85 season.

Entry	Tel Hadya		Jinderis		Terbol		Overall	
	W[1]	S[1]	W	S	W	S	W	S
FLIP83-13C	2	1	1	15	3	5	1	3
FLIP83-98C	5	11	2	8	6	2	2	1
FLIP83-88C	3	7	5	9	3	4	3	4
FLIP84-70C	3	11	1	4	2	7	1	6
FLIP84-104C	7	2	4	1	5	1	5	1
FLIP84-116C	2	3	1	5	8	8	1	3

1/ W = Winter and S = Spring.

3.2.4. Yield Trials for Spring Sowing

A total of 237, 193 and 229 newly bulked lines were evaluated for yield at Tel Hadya, Jinderis, and Terbol, respectively (Table 3.7). Although a large number of genotypes had exceeded the check numerically, only one line at Tel Hadya and Terbol could supercede the check by significant margin. Analysis of the results for 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.

Agronomic studies have shown that the new genotypes having tolerance to cold and ascochyta blight are suitable for earlier sowing than the normal time of sowing in spring. This practice needs further investigation and adoption.

3.2.5. Large-Seeded Chickpeas

In view of the greater demand by the national programs for the ascochyta blight resistant large-seeded chickpeas, the program for 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 (Table 3.2). Many of the newly bulked lines have seed size exceeding 50 g/100 seeds. Such genotypes will fulfil one of the major demands of many national programs.

Eighteen newly bulked large-seeded lines were evaluated for yield and performance of six best yielding lines is shown in Table 3.8. Their yield ranged from 1033 to 1958 kg/ha and seed size over 40 g/100

Table 3.7. Mean yield performance of newly developed lines during 1985 spring.

Location	Trials conducted	Entries tested	Entries exceeding check[1]	Entries significantly exceeding check[1]	Yield for best entries (kg/ha)	Range for c.v. (%)	Range for L.S.D. at 5%
Tel Hadya (Syria)	14	237	53	1	2092-2225	5.2-15.9	203- 458
Jinderis (Syria)	11	193	4	0	1308-1792	8.2-24.3	237- 540
Terbol	13	229	78	1	2708-4028	14.1-31.8	767-1687

1) ILC 1929.

Table 3.8. Performance of six best large-seeded chickpea entries in the winter sown preliminary yield trial at Tel Hadya, 1984/85.

Entry	Days to flower (No.)	Plant height (cm)	Cold tolerance (1-9 scale)	100-seed wt. (g)	Yield (kg/ha)
FLIP84-19C	133	38	5.0	46	1958
FLIP84-18C	132	40	3.0	44	1792
FLIP84-17C	138	34	5.5	45	1650
FLIP84-1 C	144	31	7.0	43	1375
FLIP84-12C	140	30	7.0	41	1225
FLIP84-2 C	142	33	7.0	40	1033
ILC 482 (check)	136	19	8.0	26	333
SE					180.71
CV (%)					31.01

seeds. 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, they will be provided to the cooperators, who are desirous of having large seeded ascochyta blight resistant lines for winter sowing.

3.2.6. Tall Chickpeas

The growers in the Mediterranean region have preference for tall chickpea for machine harvest. It has been observed that the seed loss in the tall types is minimum compared to conventional bushy type by 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 lines that are high yielding with true kabuli type seed (Table 3.9). The tall lines still lack early maturity and that is where future emphasis will be laid. The plant height shown in Table 3.9 is less than that generally attained by the tall types. The height was mainly reduced due to severe cold.

Thirty-four tall chickpea progenies have been bulked (Table 3.2). Some of these lines have seed size exceeding 40 g/100 seeds. Thus they are not only tall but also large-seeded. A few of them are as early as ILC 482. The later cultivar is high yielding and widely adapted because of early flowering and long reproductive phase. Basic drawback is its susceptibility to severe cold. It is hoped that some of the early maturing, cold tolerant tall chickpeas developed at the center may remove those bottlenecks. K.B. Singh and R.S. Malhotra.

Table 3.9. Performance of six tall chickpea lines in the preliminary yield trial at Tel Hadya, 1984/85.

Entry	Days to flower	Plant height (cm)	Cold tolerance 1-9 scale	100-seed wt. (g)	Seed type	Yield (kg/ha)
FLIP84-20C	136	37	5.5	32	K	1825
FLIP84-43C	138	32	3.0	30	K	1625
FLIP84-46C	137	43	4.5	34	K	1467
FLIP84-22	140	40	6.0	34	K	1275
FLIP82-42	142	39	6.0	32	K	1050
FLIP82-33	139	47	5.5	37	K	975
ILC3279 (check)	141	42	6.0	29	I	1258
SE						
CV (%)						

K = Kabuli; I = Intermediate.

3.2.7. Desi Chickpeas

A small proportion of our resources has been devoted towards development of ascochyta blight resistant desi types, especially suited for Pakistan and north-west India. The crosses were made at the ICRISAT Center and seeds supplied in F_2. During 1984/85, more than 50 promising F_5 progenies have been bulked. They were grown in the off-season nursery during 1985 and if they prove less-photoperiod sensitive, their seeds will be furnished to breeders in Pakistan and ICRISAT for evaluation of their yield and adaptation. K.B. Singh, R.S. Malhotra and ICRISAT based scientists.

3.2.8. 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 and other information to the national programs for on-farm trials in 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).

3.2.8.1. 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 82-236C chickpea lines were compared with spring sown Syrian Local land race. The season being one of the coldest in recent years, ILC 3279 tolerated cold very well and produced higher yield than both FLIP 82-236 C and

ILC 482 (check cultivar). ILC 3279 has been tested in the on-farm trials for four years at 69 locations and produced 1296 kg/ha yield (Table 3.10). It exceeded Syrian Local sown in spring by almost 100%. ILC 3279 has better resistance to ascochyta blight and cold than ILC 482 (Table 3.11). ILC 3279 is a tall genotype and hence better suited for machine harvest. Because of these special attributes, the Syrian Ministry of Agriculture has identified this cultivar for release.

3.2.8.2. Morocco

Three cultivars; namely: ILC 195, ILC 482 and ILC 484; were evaluated during winter in the on-farm trials in Morocco. Due to their suprior performance, the Moroccan Government has decided to issue the seed to the farmers. They have a total of 8.5 tons seed and have requested additional seeds from ICARDA.

3.2.8.3. 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 around 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 demanded 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. On Turkish Government demand, the Center has already furnished one ton seed to the Research Station at Diyarbaker.

Table 3.10. Yield performance (kg/ha) of the chickpea cultivar ILC 3279 in comparison to ILC 482 (check) and Syrian Local in the trials conducted in Syria.

Year	No. of Location	Winter		Spring	% increase of ILC3279 Over Syrian Local
		ILC 482	ILC3279	Syrian Local	
1981/82	23	1128	1632	259	532
1982/83	11	2018	1647	1074	53
1983/84	24	1455	1087	921	18
1984/85	11	688	816	Not tested	-
Average		1322	1296	751	94

Table 3.11. Ancilliary data of ILC 3279 and ILC 482 during the winter season at Tel Hadya.

Entry	Days to 50% flowering	Days to maturity	Plant height (cm)	100-seed weight (gm)	Cold tolerance 1-9 scale	Ascochyta blight reaction 1-9 scale
ILC 3279	136	173	68	29	5.5	3
ILC 482 (check)	124	164	42	29	6.9	5

Scale: 1 = Free, 9 = Dead.

3.2.8.4. Egypt

Three cultivars (ILC 195, ILC 482 and ILC 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 National Scientists.

3.3. Chickpea Diseases and their Control

The 1984/85 season was very unfavorable for the development and spread of ascochyta blight. Due to extremely low temperatures during February and March 1985, spores in the diseased debris were killed. Thereafter, weather became dry and unusually hot, a condition least favorable for ascochyta blight development. Despite repeated spore suspension sprays and sprinkler irrigations, the disease did not develop in epiphytotic form. Consequently, neither germplasm and breeding lines could be properly screened nor meaningful data from the pathological experiments conducted in the field could be collected. The disease not only failed to develop at the experiment stations, but also at the farmers' field in the west Asia and north Africa.

The work on nematode continued in cooperation with the Instituto di Nematologia Agraria, C.N.R., Bari, Italy. Due to severe cold weather, the experiments conducted in the field were partially affected. Results of laboratory and green-house experiments are reported.

3.3.1. Spore Concentration of Ascochyta rabiei and Disease Development

The effect of spore concentrations from 50,000/ml to 7,500,000/ml of race 3 was studied on the disease development in 10 genotypes of chickpeas (Table 3.12). 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 concentration 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 at low as well as at high spore concentrations. There is an indication of 'slow blighting', at least in one genotype (ICC 3996), and it will be interesting to puruse this kind of study.

3.3.2. 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 (Table 3.13). Longer periods of 100% relative humidity increased the disease severity. The threshold period differed in different genotypes. For examples, ILC 182 showed consistently resistant reaction from 0 hr to 30 days, ILC 3279 maintained resistant reaction until 1 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 3.12. Effect of spore concentration (1000/ml) on reaction of chickpea genotypes to race 3 of *Ascochyta rabiei* at Tel Hadya (greenhouse), 1984/85.

Genotype	Blight severity[1/] at different spore concentrations						
	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
LSD (5%)	Genotypes at same level of spore concentration	1.21

1/ Rating scale: 1 = Free; 9 = Killed.

Table 3.13. Effect of 100% relative humidity period on reaction of the chickpea genotypes to race 3 of _A. rabiei_ at Tel Hadya (green-house), 1984/85.

Genotype	Blight severity[1/] at 100% humidity for									
	0hr	8hrs	1 day	5 days	10 days	15 days	20 days	25 days	30 days	Mean
ILC- 182	2.0	2.3	3.3	2.7	4.7	4.3	3.7	3.7	3.3	3.3
ILC- 187	2.0	4.3	4.7	4.3	4.7	6.3	6.0	6.0	6.0	4.9
ILC- 200	2.7	3.3	4.3	4.3	3.3	6.0	6.0	5.0	6.0	4.6
ILC- 215	6.0	6.3	6.3	6.3	7.0	7.0	6.3	8.7	8.7	7.0
ILC- 482	2.7	5.0	5.0	6.0	5.7	6.0	6.0	7.7	8.0	5.8
ILC-1929	7.0	9.0	8.7	9.0	8.0	8.3	9.0	9.0	9.0	8.6
ILC-3279	2.0	3.3	3.0	5.7	5.0	6.0	6.0	6.0	6.0	4.8
ILC-3346	2.3	5.0	5.7	6.0	5.7	6.0	6.0	6.7	6.7	5.6
ILC-3996	2.0	2.0	3.0	2.3	3.0	4.3	5.0	6.0	6.0	3.7
ILC-4935	2.0	5.0	2.7	5.0	4.3	5.7	4.7	6.0	6.0	4.6
Mean	3.1	4.6	4.6	5.2	5.1	6.0	5.9	6.5	6.6	

CV %	Time period	14.93
CV %	Genotypes	13.47
LSD (5%)	Time periods at same level of genotypes	1.16
LSD (5%)	Genotypes at same level of time period	1.14

Rating scale : 1 = Free; 9 = Killed.

3.3.3. Disease Severity and Sporulation of Six Races of *Ascochyta rabiei*

The results are shown in Table 3.14. There seems to be a weak relationship between disease severity and sporulation. 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 1-9 scale. On the other hand, both sporulation and disease severity were high for genotype ILC 1929 with the race 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. The most mild race seems to be race 1. The most agressive one is 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 fortunately is least common in Syria. These lines could be used extensively in resistance breeding program.

3.3.4. Cross protection between two races of *A. rabiei*

The cross protection between the most common race (race 3) and an agressive race (race 6) in Syria was studied (Table 3.15). 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 of the genotypes equalled to the mean reaction of the two races inoculated independently. This year's finding was contrary to the results obtained last year. Therefore, this aspect will be further studied.
R.S. Malhotra, K.B. Singh, M.V. Reddy and M.P. Haware.

Table 3.14. Blight severity and (STY) sporulation (SPN) of six races of ascochyta blight on different chickpea genotypes at Tel Hadya (green-house), 1984/85.

Chickpea genotype	Blight severity (1-9 scale) and sporulation (million spore/g tissues)													
	Race 1		Race 2		Race 3		Race 4		Race 5		Race 6		Mean	
	STY	SPN	STY	SPN	STY	SPN	STY	SPN	STY	SPN	STY	SPN	STY	SPN
ILC -72	3.5	1.0	4.0	1.0	3.5	1.0	3.0	1.0	6.0	1.0	3.5	1.0	3.92	1.0
ILC -182	4.0	1.4	5.0	0.6	5.0	0.8	4.5	0.5	6.5	3.3	4.0	0.6	4.83	1.2
ILC -187	6.5	5.3	6.0	1.8	3.5	1.2	6.0	0.5	7.0	2.8	6.0	0.4	5.83	2.0
ILC -191	6.5	3.1	6.0	1.4	6.0	3.0	5.5	2.2	7.0	5.8	6.0	0.3	6.17	2.6
ILC -200	6.0	4.7	6.0	1.6	6.0	2.2	4.5	1.4	7.0	2.4	4.5	0.2	5.67	2.1
ILC -201	6.0	7.8	6.0	2.5	6.5	2.0	6.0	0.7	7.0	6.7	7.0	0.7	6.42	3.4
ILC -202	6.0	0.8	6.0	1.9	4.5	0.9	4.5	0.7	6.5	0.7	5.0	0.2	5.42	0.9
ILC -482	6.5	20.1	5.5	4.1	6.0	9.3	5.0	2.6	8.5	23.6	8.5	26.9	6.67	14.4
ILC- 484	7.0	19.1	7.0	10.9	6.0	6.8	6.0	1.5	8.0	23.9	7.0	2.3	6.83	10.7
ILC-2380	6.0	4.1	5.0	1.8	6.0	2.4	4.0	0.4	6.0	0.9	3.5	0.3	5.17	1.7
ILC-2506	5.0	1.5	4.5	0.4	4.5	1.3	5.0	0.4	6.0	0.9	4.0	1.0	4.75	0.8
ILC-2956	5.0	1.0	4.5	0.3	5.5	0.7	3.5	1.3	6.0	0.6	2.0	1.0	4.75	0.5
ILC-3279	4.0	0.4	4.0	0.7	4.5	1.2	4.5	0.7	6.0	0.4	5.5	1.0	4.17	0.4
ILC-3346	6.0	2.9	6.0	2.2	6.0	4.8	6.0	0.9	7.0	4.1	5.5	0.2	5.92	2.3
ILC-3803	7.0	3.1	6.0	0.7	6.5	6.0	5.5	8.0	6.5	2.8	5.5	1.0	6.25	3.7
ILC-3856	6.5	2.2	6.0	0.7	6.0	2.5	5.5	1.1	6.5	3.8	5.0	1.0	6.08	1.7
ILC-3864	6.0	3.1	6.0	1.0	6.0	1.8	5.5	1.5	6.5	2.6	6.0	0.2	5.83	1.7
ILC-3866	6.0	7.5	5.5	7.6	6.0	3.5	6.0	0.8	6.5	3.1	5.0	0.2	6.0	2.7
ILC-3868	6.0	3.2	6.0	2.5	5.5	3.3	5.0	0.9	6.0	3.0	3.5	0.2	5.75	3.0
ILC-3870	6.0	0.5	6.0	1.0	6.0	1.6	3.5	0.3	6.0	1.8	5.5	1.0	5.08	1.1
ILC-4421	4.0	0.5	4.0	1.0	6.0	2.3	4.2	1.4	6.0	1.1	5.0	0.7	5.0	1.0
ICC-3996	2.0	1.0	2.5	76.3	8.0	0.9	2.0	1.4	8.0	3.7	5.0	1.0	3.92	1.2
ICC-1929	8.0	43.8	8.5	76.3	8.0	30.5	7.5	11.8	8.0	35.1	7.5	15.1	7.92	35.4
Mean	5.6	5.9	5.5	5.3	5.7	1.7	0.0	1.6	6.6	1.9	5.2	1.6	5.6	4.1

CV (%) Races (Blight Severity)=21.09; Genotypes (Blight Severity)=14.09;
CV (%) Races (Sporulation)=116.34; Genotypes (Sporulation)=192.35.

LSD (5%) STY - races at same genotype level=1.63; genotypes at same race level=1.54;
LSD (5%) SPN - races at same genotype level=15.34; genotypes at same race level=15.48.

Table 3.15. Cross protection between two races of _A. rabiei_, Tel Hadya (greenhouse), 1984/85.

Genotype	Race 3		Race 3		Race 3+Race 6	
	Million spores/g tissue	Blight severity[1/]	Million spores/g tissue	Blight severity	Million spores/g tissue	Blight severity
ILC- 182	0.2	4.3	0.1	4.0	0.5	4.7
ILC- 187	0.2	5.0	0.0	4.0	0.6	5.7
ILC- 200	0.4	5.7	1.3	5.0	1.0	6.0
ILC- 215	69.6	8.3	0.0	9.0	31.3	8.7
ILC- 482	0.3	6.0	0.0	8.0	10.4	7.0
ILC-1920	27.5	8.3	21.1	8.7	23.3	9.0
ILC-3279	0.0	3.0	0.7	5.7	1.0	6.0
ILC-3346	0.7	5.3	0.4	6.0	0.9	6.0
ICC-3996	0.8	3.0	0.3	4.3	1.5	5.7
ICC-4935	1.3	5.3	0.8	6.0	1.2	5.7

CV (%)	Races	7.05
CV (%)	Genotypes	9.69
LSD(5%)	Races at same genotyps level	0.95
LSD(5%)	Genotypes at same race level	0.95

1/ Rating scale: 1 = Free; 9 = Killed.

3.3.5. Studies on Nematodes

3.3.5.1. Survey

Survey was again conducted during this year. Soil and plant samples were collected mostly, from northern Syria and some from the southern and central parts of Syria. The analysis revealed that the 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 thorneii) 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.

3.3.5.2. 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 low benefit and high cost of the treatments, but crop rotation could provide an easy and cheap way to limit yield loss of chickpea. Unfortunately, information on the host range of the nematode, required for suggesting appropriate rotations, is scanty. Therefore an investigation was undertaken in greenhouse at Bari (Italy) to assess the host status of 53 plant species belonging to 12 botanical families and of economic importance in the *Mediterranean* region. The plants were grown in clay pots containing 750cm^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 5g 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 of the nematode. Most of the membres 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 aiming to limit yield losses caused by M. artiellia. Although most of them, such as lentil, oat, sunflower, sugarbeet, cotton and flax, are grown on large areas in many Mediterranean countries.

3.3.5.3. Host range of the chickpea cyst nematode (Heterodera sp.)

In Syria chickpea has been reported to be badly damaged by a species of cyst forming nematode, Heterodera sp., whose host range was not known. Research on the host range of Heterodera sp. was conducted both at Bari (Italy) and ICARDA (Syria). A total of 50 plant species, most of them tested for their host status toward M. artiellia, were also tested for their susceptibility to the chickpea cyst nematode in Bari, Italy. Several plant species were included to achieve additional information on the identification of this cyst-forming nematode, which is being done at Bari. Experimental conditions were 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 two months later. The results confirmed that the host range of the nematode is confined to members of the Leguminosae family and only a few females were collected from roots of carnation, reported to be good host of some populations of H. trifolii, occurring in Mediterranean countries. All Trifolium sp. tested were found not to be host of the nematode, but large numbers of nematodes were collected from roots of chickpea, lentil and pea. Good host were also cowpea and grasspea. 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, by using non-leguminous crops, should be suggested to avoid yield loss of 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 at the rate of 75 cysts/200g soil in the greenhouse. The tested crops comprised food and forage legumes, cereals and others grown in winter, spring and summer seasons. These were 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. (Table 3.16).

Table 3.16. Measurement of cysts/g roots in different crops at Tel Hadya, 1984/85.

Crop	No. of cysts/g roots		
	R I	R II	Mean
Peas	476.74	570.95	523.85
Chickpea	435.71	462.56	449.14
Medic	159.6	197.22	178.41
Lathyrus	150.08	196.56	173.32
Lentil	126.48	131.1	128.79
Phaseolus	31.72	84	57.86
Lupins	27.12	44	35.56
Soybean	35.84	18.88	27.36
Vetch	12	16	14
Barley	3.04	9.6	6.32
Barley	5.6	0	2.8
Sunflower	2.56	2.4	2.48

The other crops showed no infection of cysts, and were non-hosts.

3.3.5.4. 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. artirllia* at Bari. Even though some differences were observed on the reproduction of *M artiellia* on lines of *C. arietinum*, none were resistant to the nematode. All wild species of *Cicer* were highly susceptible to the root-knot nematode.

Green-house screening at ICARDA in 1983/84 of 290 ascochyta blight resistant, newly-developed, kabuli lines revealed that 27 lines were resistant. These lines were put in an advanced screening trial during 1984/85. Out of these, 4 lines showed resistance to cyst nematode. These are FLIP 82-144, FLIP82-215, FLIP 83-11 and FLIP 83-85. At the same time 183 of our newly developed lines (FLIP 84) were screened by using augmented design and adding 3 checks in each block, the checks used were ILC 482 (susceptible), ILC 1929 (susceptible) and ILC 3279 (tolerant). Out of these lines 26 were resistant, having low number of cysts/g roots. They are FLIP 84-2 , 84-7, 84-10, 84-16, 84-19, 84-43, 84-48, 84-61, 84-63, 84-67, 84-79, 84-81, 84-102, 84-104, 84-112, 84-121, 94-124, 84-148, 84-156, 84-169, 84-173, 84-174, 84-176, 84-184, 84-188.

These 26 lines plus 4 lines from the previous screening were screened in an advanced trial, out of which we found 11 lines resistant or tolerant to cyst nematode. They are FLIP 83-85, FLIP 84-7, FLIP 84-43, FLIP 84-61, FLIP 84-63, FLIP 84-67, FLIP 84-81, FLIP 84-104, FLIP 84-112, FLIP 84-124, FLIP 84-184, and FLIP 84-188.

In addition 70 lines from our 1984-85 crossing program were screened in an augmented design which resulted in 7 tolerant lines to cyst nematode. They are ILC 136, ILC 470, ILC 1919, ILC 2506, ILC 4295, FLIP 82-91, and FLIP 83-15. These lines will be retested in the next season. Another screening of wild species was done by using different species, out of 9 lines only one was tolerant, NEWC 7 (Cicer bijugum).

3.4. Chickpea Insects and their Control

3.4.1. Insect populations

In general, leafminer and pod borer populations were lower in 1984/85 season, possibly as a result of very low temperatures in winter. Frost damage to the crop was responsible for 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 the leafminers were continued. The Commonwealth Institute of Entomology has definitely 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 (Figure 3.1). Mining of leaves starts one 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 that due to the second generation as the plant is then more capable of compensating for damage.

3.4.2. Studies on resistance to leafminer

The screening for resistancae to leafminer continued. A total of 1001 cultivars were rated for resistance, distributed as follows:

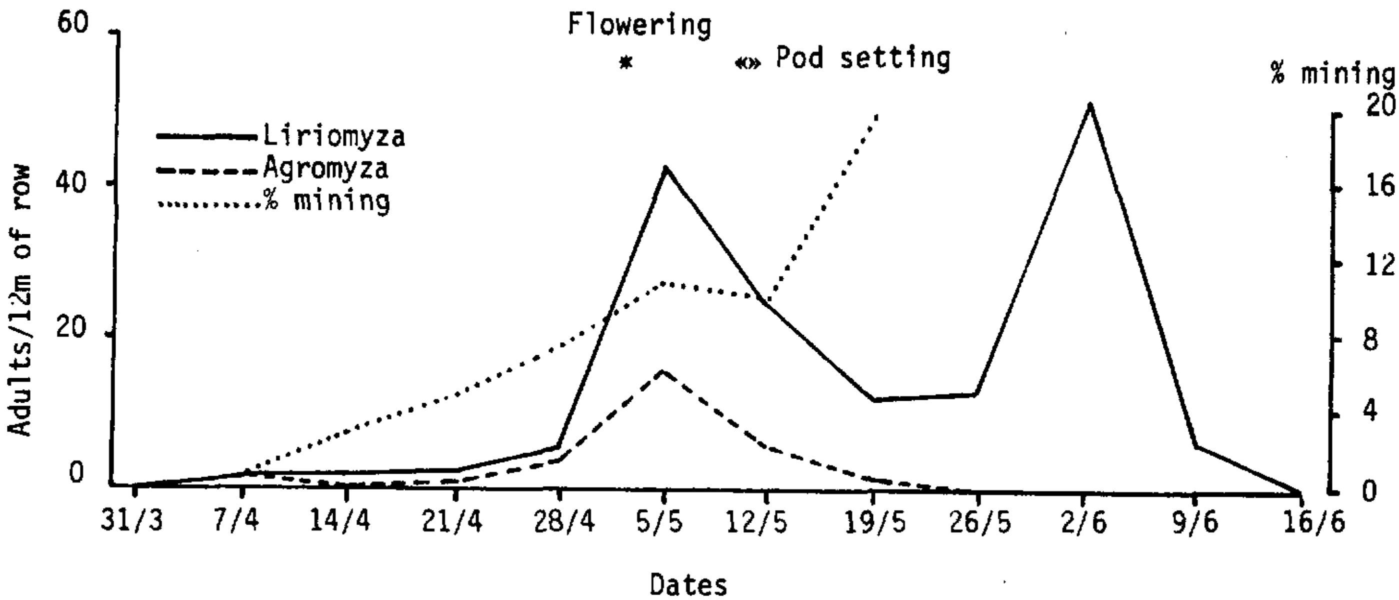


Fig. 3.1.Seasonal fluctuation of adult chickpea leafminers populations and percentage leaflets mined. Tel Hadya, 1984/85.

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 five 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 (Table 3.16.1): duration of flowering, days to maturity, canopy width, seed yield and protein contents. A significant correlation with height does not seem to be supported by previous field experience. The correlations which were more meaningful and tend to corrobarate field observations are those with days to 50% flowering and 100-seed weight. The evidence tends to indicate that late, small-seeded varieties are resistant whereas most early, large-seeded varieties are susceptible or very susceptible. A detailed analysis of the 90 varieties which have been 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 in the presence and in the absence of the insect and the determination of corresponding yield losses in resistant and susceptible genotypes. Figure 3.2 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

Table 3.16.1. Simple correlation coefficients between selected morphological and physiological characters of 101 chickpea genotypes and their reaction to leafminer damage measured in a 1 to 9 visual damage score scale (1 = no damage; 9 = severe damage)

Character	r with damage scores (n = 101)
Days to 50% flowering	-0.477**
Duration of flowering	0.066ns
Days to maturity	-0.049ns
Height	0.247*
Canopy width	0.008ns
Pods/plant	-0.348**
Seeds/pod	-0.252*
Seed Yield	-0.044ns
100 seed weight	0.691**
Protein contents	0.023ns

ns = non significant; * = significant at 5% level;
** = significant at 1% level

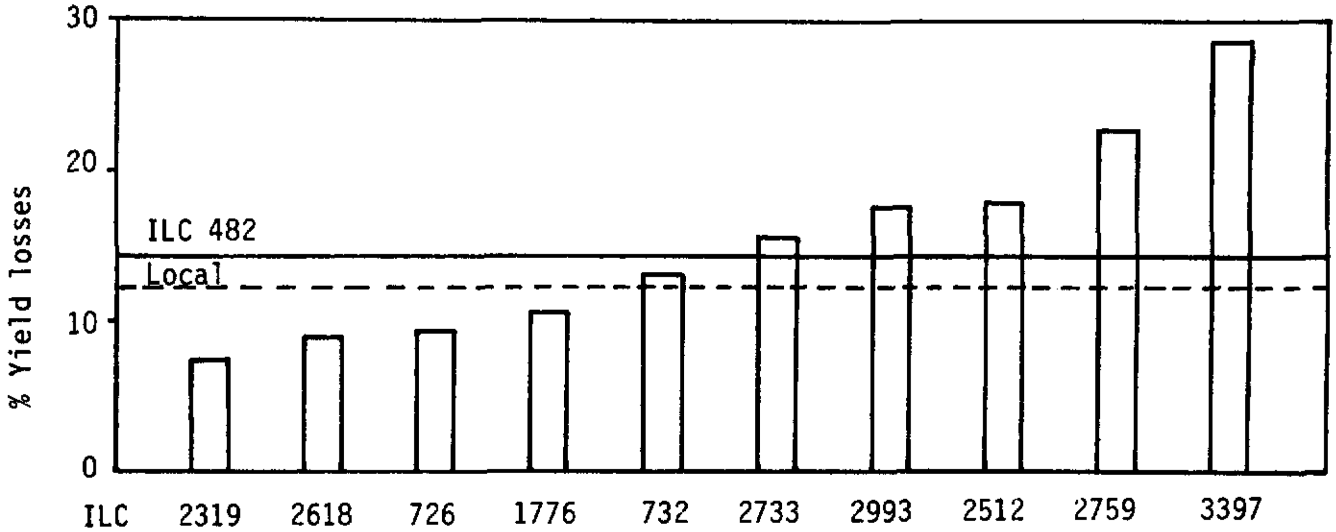


Fig. 3.2. Percentage yield losses due to leafminer in 12 chickpea genotypes selected for varying degrees of resistance to the insect. Means of three seasons (1983-1985), four replications per season.

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 evidence of differential levels of damage in terms of mining and defoliation was obtained. The resistant variety ILC 2319 had consistent less damage and defoliation than the susceptible variety ILC 2512 (Figure 3.3). There are preliminary indications that non-preference for oviposition may be involved but more precise tests under controlled (greenhouse) conditions are needed to reconfirm this. In terms of tolerance as expressed by the percentage yield loss due to the insect, the resistant ILC 2319 significantly outyielded the susceptible check ILC 2512 in the absence of insecticidal protection (Table 3.17). ILC 2319 had smaller 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.

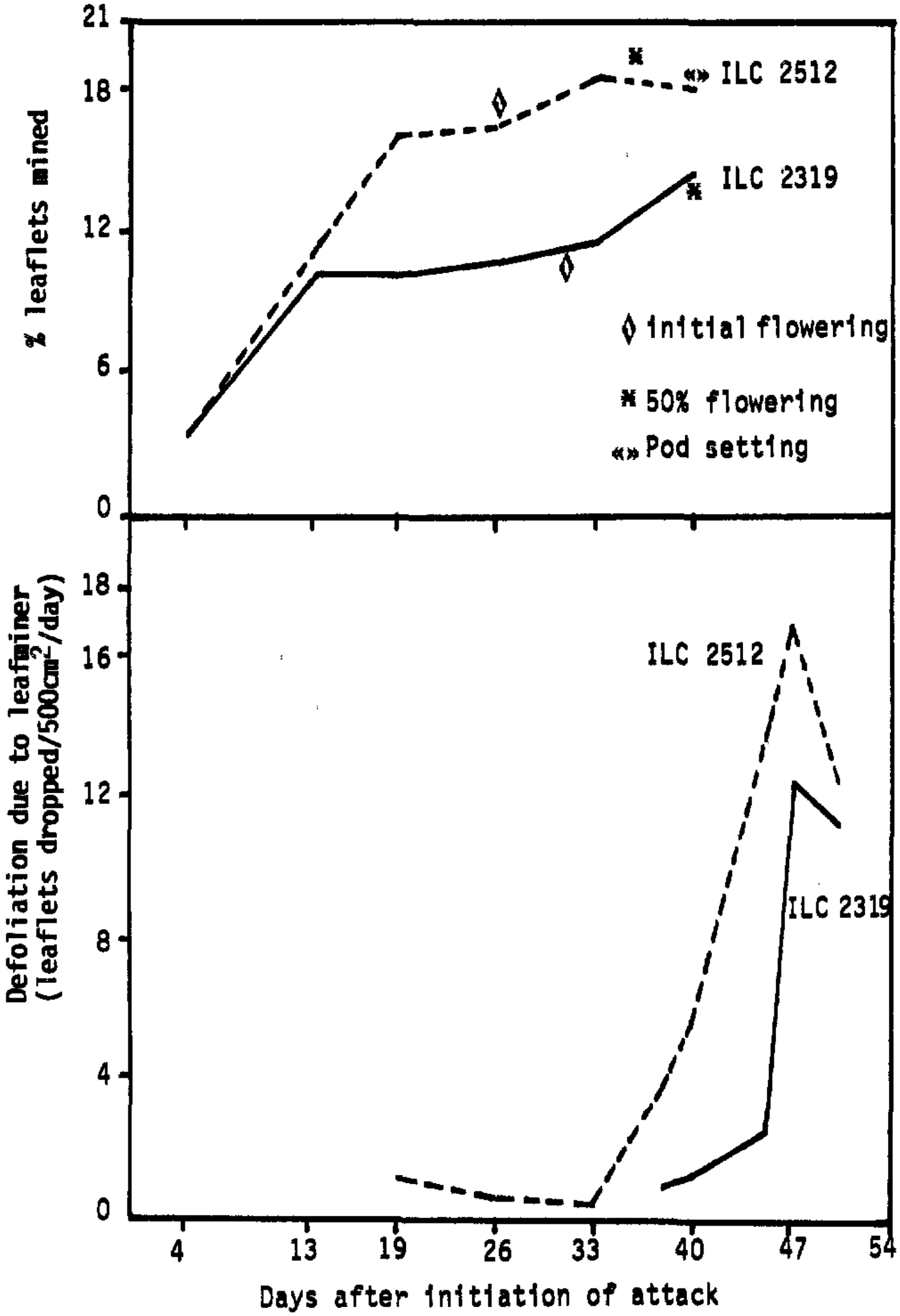


Fig.3.3. Comparative seasonal levels of damage due to leafminer in a resistant (ILC 2319) and a susceptible (ILC 2512) chickpea genotype. Means of four replications. Tel Hadya, 1984/85.

Table 3.17. Effect of different insecticidal regimes on the yields of a chickpea leafminer resistant cultivar (ILC 2319) and a susceptible cultivar (ILC 2512). Means of four replications, Tel Hadya, 1984/85.

Treatment	VDS 1/	Yield (kg/ha)	% Yield 2/ increase
Resistant sprayed 3 times	1.0	1194	6.0
Resistant sprayed 2 times	1.2	1207	7.2
Resistant sprayed once	3.0	1104	0
Resistant never sprayed	4.7	1126	-
Susceptible sprayed 3 times	1.2	1180	15.9
Susceptible sprayed 2 times	2.5	1166	14.5
Susceptible sprayed once	6.2	1134	11.4
Susceptible never sprayed	8.0	1018	-
LSD 5%	1.4	75.8	
CV	27.3	4.5	

1/ VDS = visual damage score in a 1-9 scale

2/ With respect to the unsprayed resistant and susceptible checks.

3.5. Chickpea Microbiology

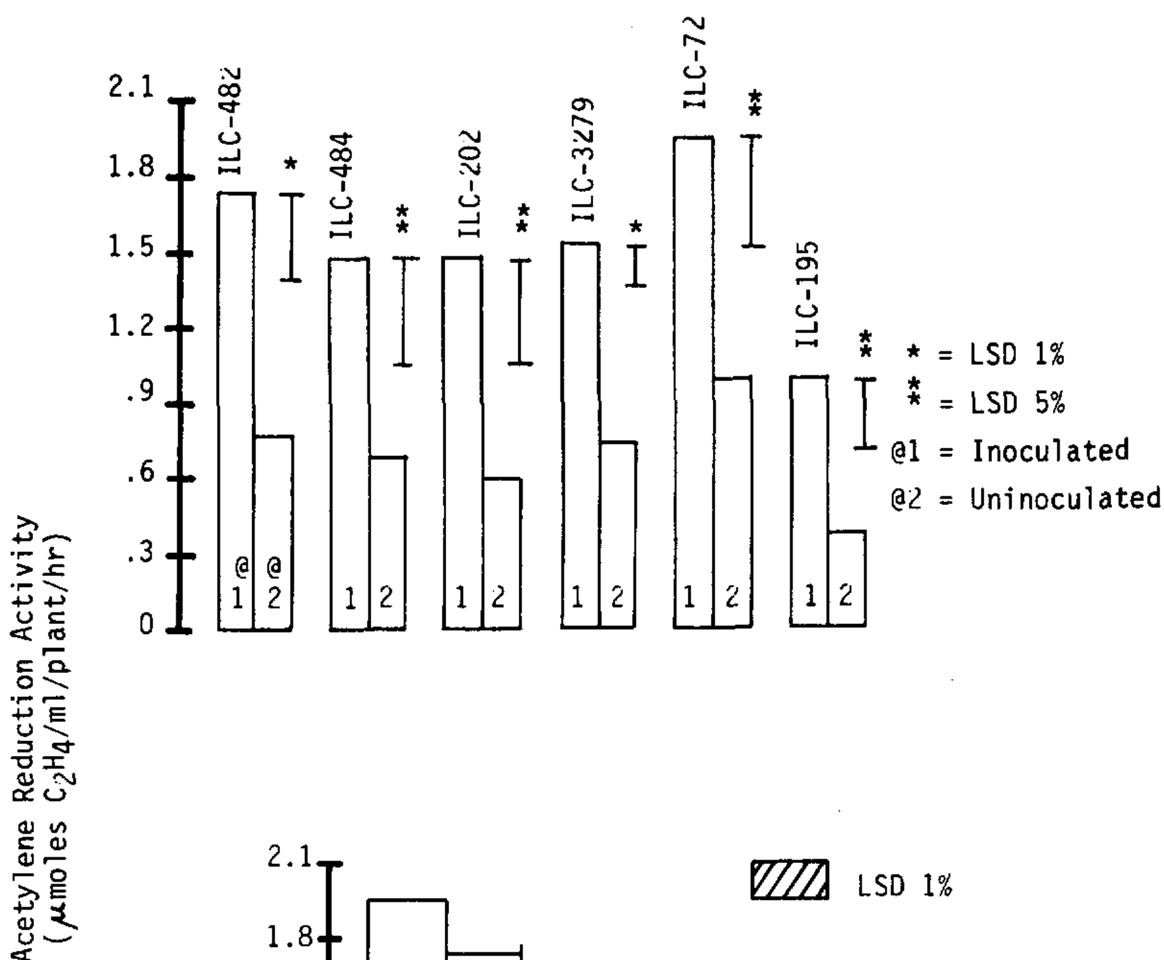
3.5.1. Acetylene Production of Chickpea Cultivars in Relation to Inoculation

The 1984/85 was the second, and final, year of monitoring of acetylene reduction activity (ARA), in six promising lines of chickpeas. The lines monitored were ILC 482, 484, 202, 3279, 72 and 195 and were planted with, and without, inoculation with chickpea specific *Rhizobium*. The field chosen for the 1984/85 trials reported here was chosen specifically as the previous year saw inoculated chickpeas in the same area. 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.

Figure 3.4 shows the effect of inoculation on ARA. Coating of the seed, at time of planting, with a chickpea compatable *Rhizobium* significantly increased its ARA. A comparison of Figures 3.4 and 3.5 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 Figure 3.6.

With the exception of ILC 482 inoculation did not significantly increase grain yields when the two treatments were compared (Figure 3.7). 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 (Figure 3.8). J. Stephens and M.C. Saxena.

Figure 3.4. A comparison of seasonal mean acetylene reduction values of six chickpea lines with and without inoculation.



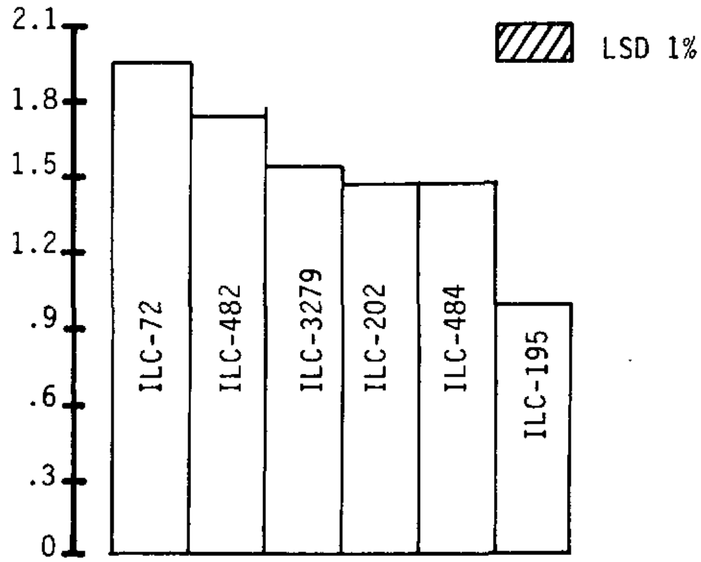


Figure 3.5. A comparison of seasonal mean acetylene reduction values for six chickpea lines treated with inoculation only.

Figure 3.6. A comparison of inoculated and uninoculated treatments for acetylene reduction with time for six chickpea cultivars.

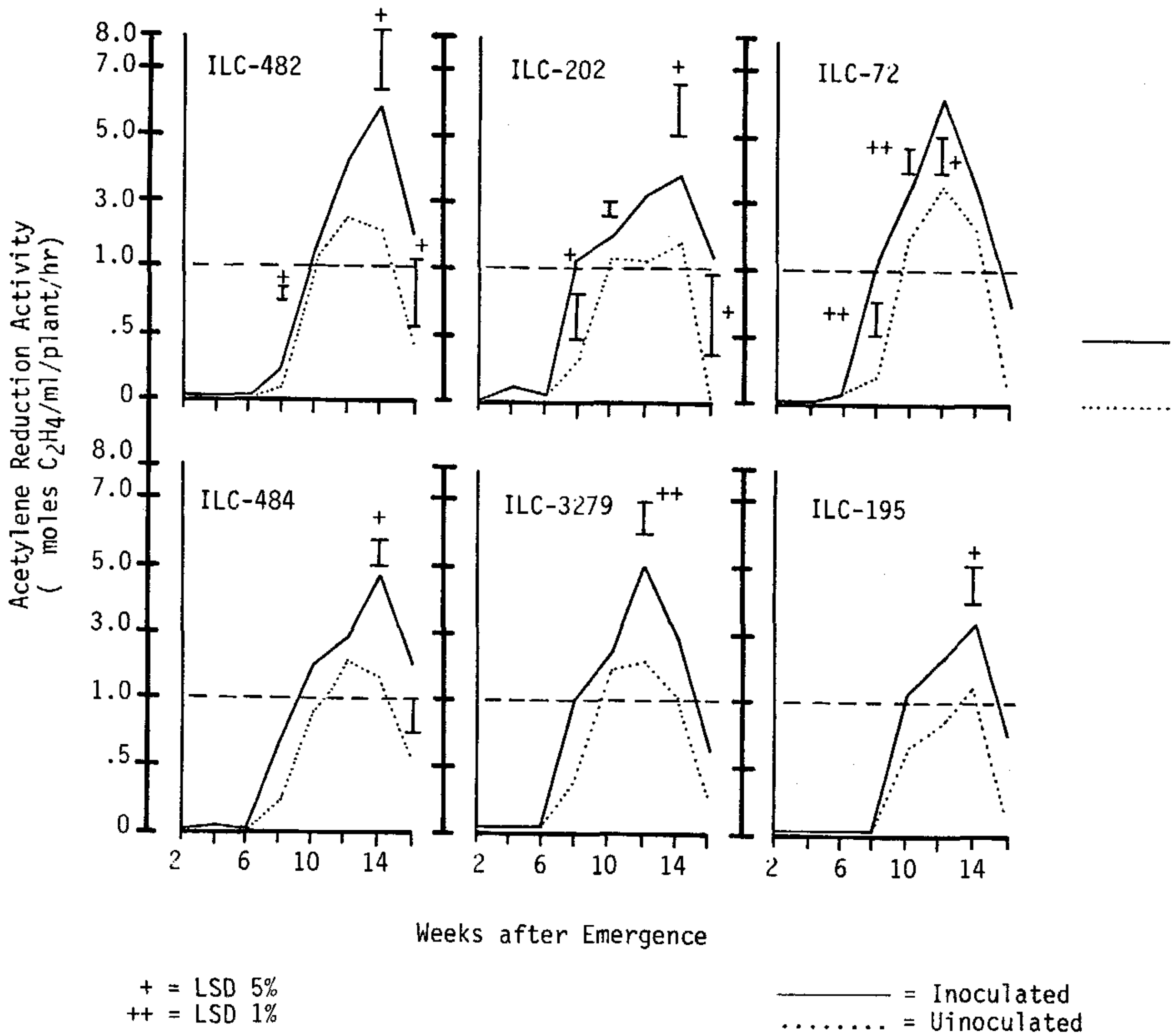


Figure 3.7. A comparison of mean grain yield between inoculated and uninoculated treatments. Inoculated seed was coated with an effective strain of Rhizobium cicer.

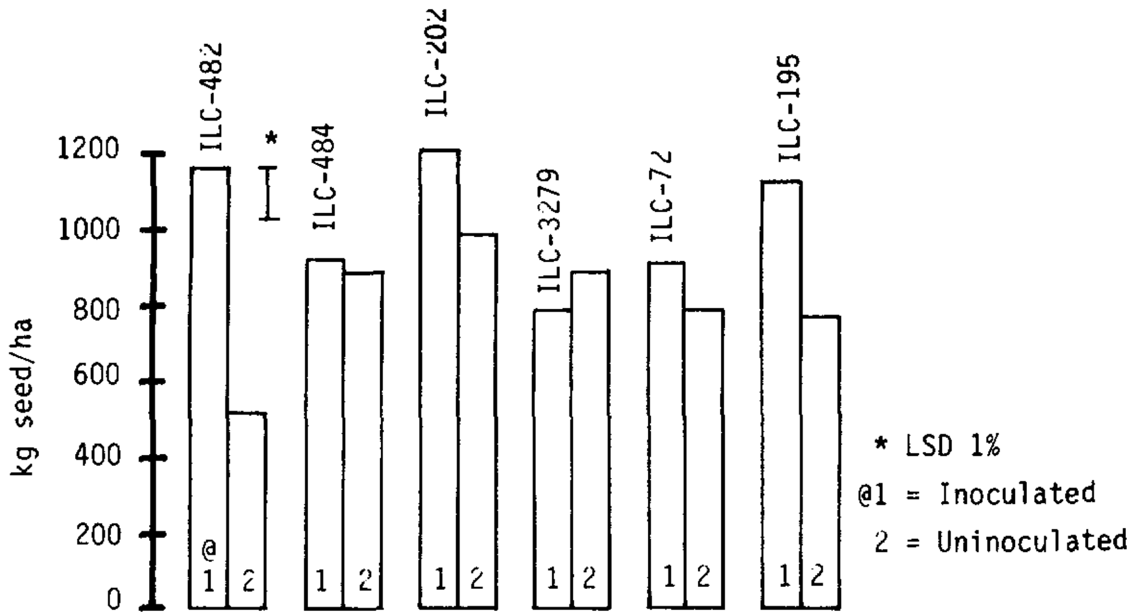
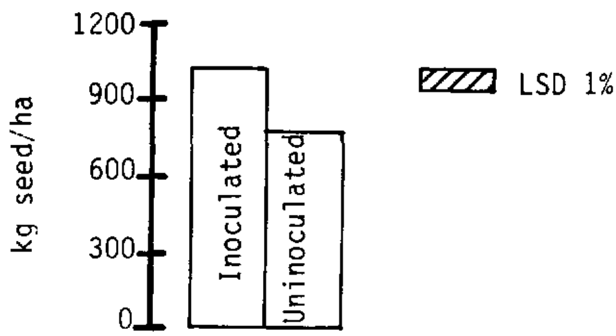


Figure 3.8. A comparison of the total mean yields of six chickpea lines with and without Rhizobium inoculation.



3.5.2. 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. Mycorrhizae are fungi commonly associated with plant roots, which can increase the plant's ability to take up nutrients such as phosphorus and also improve plant water economy.

Those types of mycorrhiza prevalent in Tel Hadya and Breda soils were described and classified. Several pot experiments were carried out in greenhouses at Tel Hadya to investigate mycorrhizal effects on chickpea growth under different conditions.

Elimination of mycorrhiza by soil sterilization prior to sowing resulted in 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 conspicuous when medium levels of phosphorus were given, and was much reduced under very low or very high soil phosphorus conditions. 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.

The mycorrhiza work was carried out with the cooperation of Mr. E. Weber and Mr. E. George from the University of Hohenheim, West-Germany. M.C. Saxena.

3.6. Chickpea Production Agronomy and Crop Physiology

3.6.1. Response of some promising lines to date of sowing

In West Asia and the Mediterranean region chickpeas are normally spring grown, largely due to their susceptibility to ascochyta blight and frost. The reproductive stage of the spring 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 sowing in winter include completion of flowering and pod development before soil moisture becomes limiting and temepratures 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 chikpea varieties: ILC 3279 (standard check), FLIP 82-39 and FLIP 82-236 (new promising lines).

Seed yield ranged between 500 and 1200 kg/ha (Figure 3.9). ILC 3279 gave high seed yield when sown in winter and delaying sowing to March resulted in reduction in yield. Sowing the new lines (FLIP 82-236 anf 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 (Table 3.18), however, unlike ILC 3279, when sowing was delayed until March, there was no significant reductions in seed yield, indicating the suitability of these new lines for mid winter and early spring sowings. All three lines produced high seed when sown in early January.

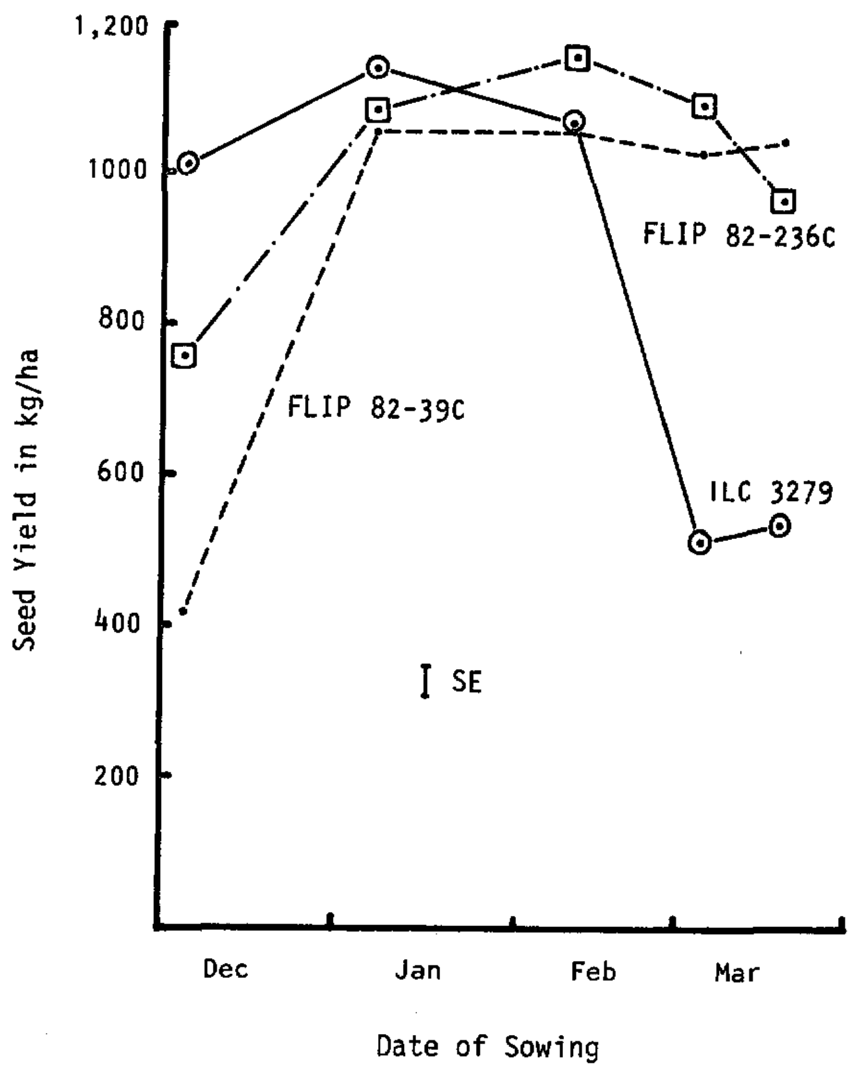


Figure 3.9. Effect of sowing date on yield of three chickpea genotypes.

Table 3.18. Effect of sowing date and variety on total biological yield, harvest index and plant population, Tel Hadya, 1984/85.

Date of sowing	Biological yield kg/ha				Harvest index				Population/m^2			
	ILC 3279	FLIP 82-236C	FLIP 82-39C	Mean	ILC 3279	FLIP 82-236C	FLIP 82-39C	Mean	ILC 3279	FLIP 82-236C	FLIP 82-39C	Mean
3 Dec	2278	1601	799	1559	0.44	0.48	0.52	0.48	24.0	13.4	8.4	15.3
6 Jan	2498	2222	2178	2299	0.46	0.48	0.49	0.47	26.9	25.1	26.4	26.1
5 Feb	2313	2268	1961	2180	0.46	0.51	0.54	0.51	21.1	22.1	18.9	20.7
4 Mar	2092	2083	1899	2025	0.25	0.52	0.54	0.44	20.3	19.7	20.2	20.1
18 Mar	2267	1976	2056	2100	0.23	0.49	0.51	0.41	30.0	29.5	29.6	29.7
Mean for variety	2290	2030	1788		0.37	0.50	0.52		24.5	22.0	20.7	
	LSD		SE	CV	LSD	SE		CV	LSD	SE		CV
Sowing date (S)	355		115	22.0	0.046	0.017		13.6	4.75	1.78		26.0
Variety (V)	186		65.2	13.9	0.032	0.011		11.5	2.06	0.722		14.2
S X V	415		146		0.077	0.022			4.60	1.615		

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 spite of attaining high total biological yield gave low seed yield due to poor partitioning of assimilates to the seeds (Figure 3.10 and Table 3.18).

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 the 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.

3.6.2. Response to Supplemental Irrigation

Little is known about the effects 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. The duration from flowering to maturity for winter sown unirrigated and irrigated and spring sown unirrigated and irrigated were 41, 52, 33 and 44 days respectively. Total dry matter per unit area (Figure 3.11) and photosynthetic area index (Figure 3.12) were both increased by giving irrigation.

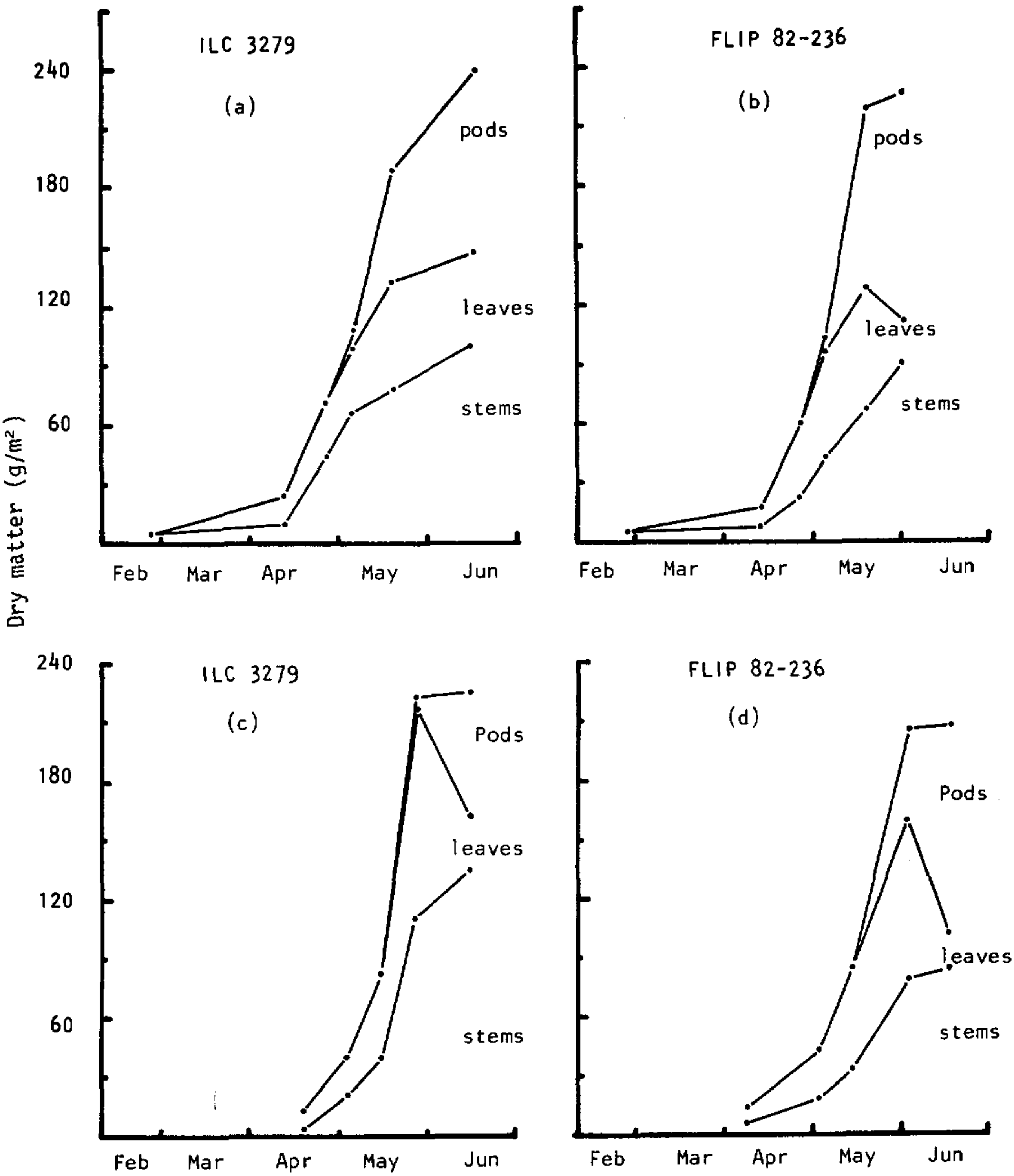


Figure 3.10. Effect of sowing date (a & b = 6.1.1985, c & d = 4.3.1985) on dry matter accumulation and partitioning in ILC 3279 and FLIP 82-236.

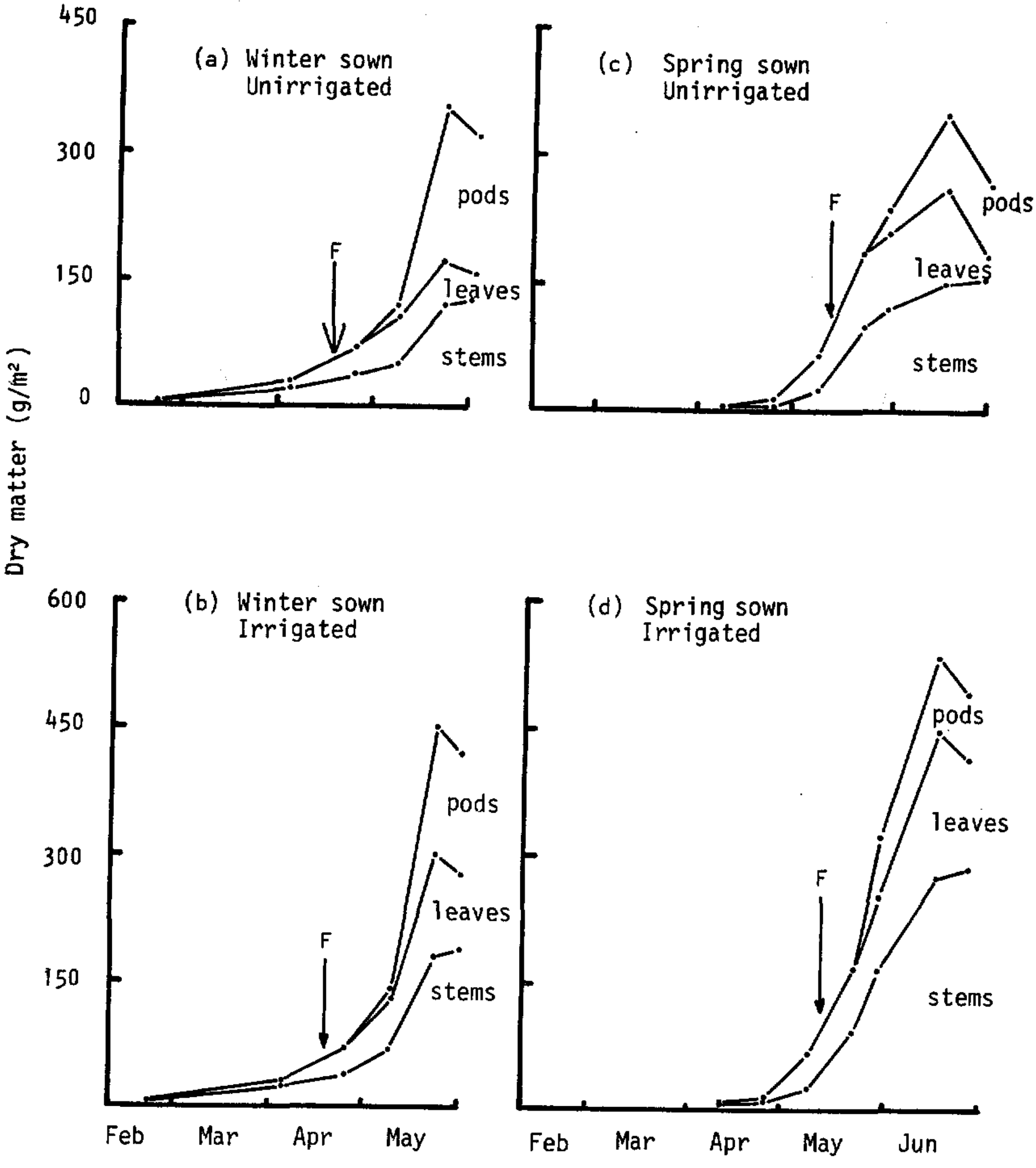


Figure 3.11. The effect of date of sowing and supplemental irrigation on dry matter production and partitioning.

F = Start of flowering

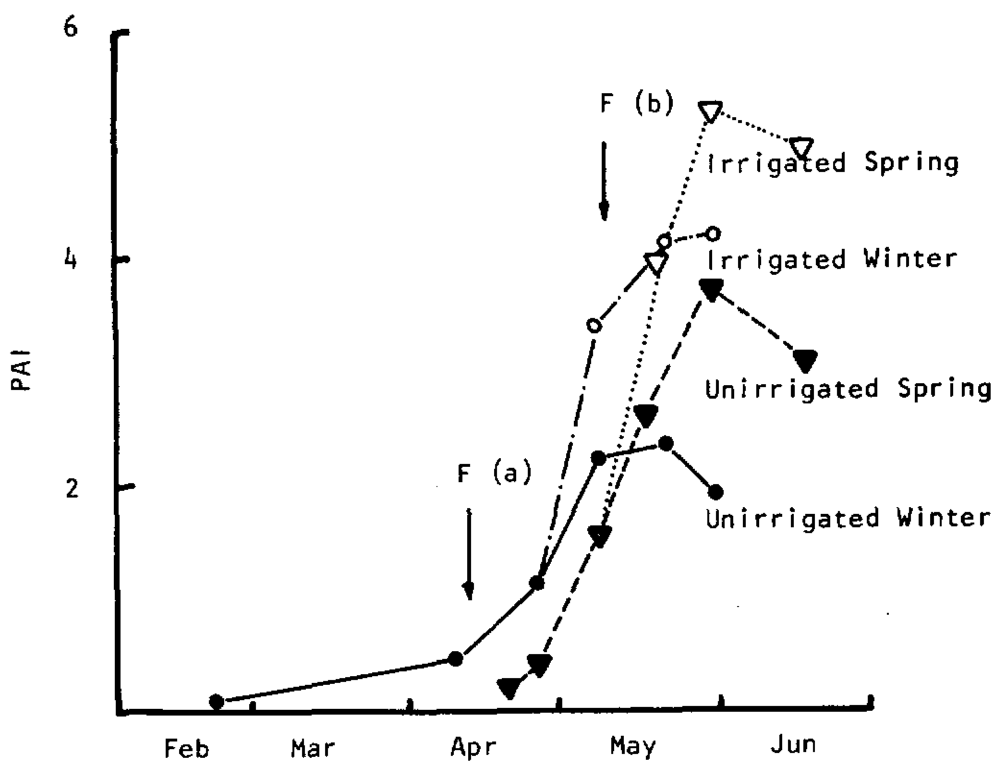


Figure 3.12. The effect of time of sowing and irrigation on photosynthetic area index (PAI)

F = Start of flowering for (a) Winter
(b) Spring sowing

The effects of date of sowing and supplemental irrigation on yields and some of the components are given in Table 3.19. Advancing date of sowing into winter and irrigation 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 bio. yield (r = 0.91) and improved partitioning (increase in harvest index) of dry matter (r = 0.71) to the seeds. Winter sown and irrigated crops attained high biological yield and partitioned a larger proportion of the assimilates to the seeds, hence high seed yields (Table 3.19). 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 encouraged flower abortion.

In conclusion, the study indicates the usefulness of irrigation in both winter and spring sown chickpea line, ILC 3279. If even higher seed yields are to be obtained in spring sowing through irrigation, ivestigations need to be conducted into the improvement in partitioning of the total dry matter to the seeds. With this in mind, the 1985/86 trial will include five extra promising genotypes. S. Silim and M.C. Saxena.

3.6.3. Weed Control

International Weed Control Trial was conducted at Jinderis (Syria) and Terbol (Lebanon) during 1984/85 season. Results are given in Table 3.20. Seed yield reduction due to weeds was 89% and 74% in Jinderis and Terbol respectively. Hand weeding twice as compared with

Table 3.19. 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	Mean	Winter	Spring	Mean	Winter	Spring	Mean	Winter	Spring	Mean
No.Irrigation	1153	557	855	2543	1866	2205	0.46	0.30	0.38	289	309	299
Irrigation	1997	1349	1673	4299	3521	3910	0.47	0.39	0.43	293	268	280
Mean	1575	953		3421	2693		0.46	0.34		291	289	
	LSD	SE	CV%	LSD	SE	CV%	LSD	SE	CV%	LSD	SE	CV%
Sowing date	86.3	25.8	8.2	244.9	73.2	9.6	0.043	0.013	12.6	NS	7.6	10.6
Irrigation	151.8	50.0	15.8	338.8	111.7	14.6	0.044	0.014	14.3	NS	9.1	12.5
Interaction	NS			NS			NS			NS	12.8	

Table 3.20. Effect of different weed control treatments on yields and harvest index of chickpea, Jinderis and Terbol, 1984/85.

Treatments	Jinderis			Terbol		
	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 @ 0.5kg a.i./ha	293	604	0.48	1617	3130	0.52
Tribunil 3.0+Kerb @ 0.5kg a.i./ha	302	615	0.49	1418	2856	0.49
Igran @3.0+Kerb @ 0.5kg a.i./ha	299	596	0.49	1666	3829	0.45
Bladex @0.5+Kerb @0.5kg 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	23.7

repeated hand weeding resulted in 19% increase in yield in Jinderis but in Terbol it reduced yield by 22%. In 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 2.5 kg with Kerb at 0.5 kg a.i./ha were as effective in controlling weeds as hand weeding twice. In Jinderis, all hand weeding treatments were superior to chemical weed control. The reduction in yield in Jinderis with herbicides was due to phytotoxicity of herbicides following crop exposure to severe frost. The most phytotoxic herbicides were Maloran and Tribunil.

The results of 1984/85 season indicate that some herbicides were as effective as hand weeding. However, in areas prone to frost, there is need to screen for phytotoxicity.

4. FOOD LEGUME SEED AND STRAW QUALITY

4.1. General:

Over 14000 tests were performed in the Food legume Quality Laboratory during 1984/85, representing an increase of 14% over 1983//84. These are summarized in Table 4.1.

The near-infrared (NIR) analyzer performed 18366 tests during the period, including protein and total nitrogen in seeds, grains and straws, lysine and wheat hardness. Utilization by programs was as follows: FSP 18%, GRU 16%, CIP 11%, FLIP 51% and Ph.D. students (AUB and FLIP) 3%. At the same time the kjeldahl laboratory performed 11,400 tests of which 12.9% were submitted by CIP, 35% by FLIP, 17% by PFIP and 28% by FSP. The standard error per test of the kjeldahl laboratory had a CV of 0.85 for cereal and food legume grains.

An earlier observation that overnight soaking significantly reduced the cooking time of food legumes was verified by further testing. Cooking times of chickpea, faba bean and lentil were reduced respectively by 62, 72 and 69% by overnight soaking. A further reduction was obtained if sodium bicarbonate was used.

4.2. Chickpea:

Pertinent information concerning early generation evaluation was provided to the 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, and the coefficient of correlation between these two parameters was 0.87, for 3003 entries. Work was completed on a study of the effect of growing location and planting time on protein content, seed size and yield for 207 genotypes

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Table 4.1. 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

at two locations, Terbol and Tel Hadya. Winter planting led to a 78% increase in yield at Tel Hadya and a 44% increase at Terbol, the higher rainfall area. Winter planting reduced protein content by 1% at Tel Hadya and 0.7% at Terbol. Seed size was increased by winter planting at both locations, by 4% at Tel Hadya, and 5% at Terbol. There was no significant difference in protein content between the two locations, but both 100 seed weight and yield were significantly higher at Terbol.

4.3. Faba Bean:

Nearly 1400 lines were tested for the breeders. Protein content was found to be a highly heritable parameter in a study which involved 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 4.2.

4.4. Lentil:

Pertinent data on early generation lines were provided to the breeders. Studies on lentil decortication were continued, and ICARDA received the Tangential Abrasive Dehulling Device (TADD) machine, an instrument 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 were centred on development of

Table 4.2. 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	C.V.
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.

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 on on-farm trials was commenced. This consisted of determinations 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 4.3.

The trials were grown on 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 4.4. Phil Williams, K.B. Singh, L.D. Robertson and W. Erskine.

4.5. Variation in Straw Quality in Lentil, Faba bean and Chickpea

The nutritive values of lentil, chickpea and faba bean straw grown at Tel Hadya, Syria are summarised in Table 4.5. 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 lentils straw was higher than that of chickpea and faba beans; but the neutral detergent fibre means showed chickpea as having the lowest value.

Table 4.3. Quality parameters of straws of advanced lentil genotypes.

Genotype	PCD	NDF	C.P.
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 4.4. Influence of location on lentil straw quality.

Location	PCD	NDF	C.P.
Tel Hadya	45.6	61.8	5.8
Heimo	48.0	58.6	7.5
K.Naseb	50.1	57.7	6.0
Izraa	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 (%)

Table 4.5.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 fibre (%)	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) g digestible organic matter per 100 g dry matter.

The influence of year or time of planting is very much greater than the effects of genotype (Table 4.6). With lentils there were substantial genotype-year interactions. Genotypic effects were non-significant when tested against the genotype-year interaction for digestibility, crude protein content and neutral detergent fibre level, (Table 4.6). With chickpeas the effects of planting time were significant when considered against genotype-season interactions for digestibility, crude protein content and neutral detergent fibre level but genotype effects were non-significant. 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 regarding 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 fibre content (Table 4.7). 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 fibre value is increased, but many of the correlation coefficients are non-significant. 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.

Table 4.6. Significance of genotype differences compared with year or time of sowing.

	Genotype	Year of sowing
Lentils		
Digestibility[1]	NS	XXX
Crude protein (%)	NS	NS
Neutral detergent Fibre (%)	NS	XXX
Ash (%)	NS	XXX
		Time of sowing
Chickpeas		
Digestibility[1]	NS	XX
Crude protein (%)	NS	XXX
Neutral detergent Fibre (%)	NS	XXX
Ash (%)	NS	XXX

1) g digestible organic matter per 100 g dry matter

NS ; $P > 0.05$
XX ; $P < 0.01$
XXX; $P < 0.001$

Table 4.7. Correlation coefficients between straw quality in food legumes and plant characteristics.

	Days to flowering	Days to maturity	Plant height (cm)	Seed yield (kg/ha^{-1})
Lentils (over both 1982 & 1983				
Digestibility[1)]	0.89**	0.89**	-0.67**	0.69**
Crude protein (%)	0.29	0.22	0.0	0.45
Neutral detergent fibre (%)	-0.66**	-0.66**	0.39	-0.44
Ash (%)				
Chickpeas (Winter sowing)				
Digestibility [1)]	-0.09	0.09	0.22	0.42
Crude protein (%)	0.33	0.26	-0.01	0.35
Netural detergent fibre (%)	-0.45	-0.65**	-0.19	-0.33
Ash (%)	0.35	0.27	-0.08	-0.34
Chickpeas (Spring sowing)				
Digestibility [1)]	0.10	0.36	-0.35	0.19
Crude protein (%)	0.51*	0.19	-0.75***	-0.73**
Neutral detergent fibre (%)	-0.36	-0.43	0.60*	0.39
Ash (%)	0.18	0.10	-0.78***	-0.26
Faba beans				
Digestibility[1)]	0.27	-0.36	-0.25	-0.30
Crude protein (%)	0.19	-0.09	0.04	0.08
Neutral detergent fibre (%)	-0.35	0.33	0.12	0.10
Ash (%)	0.34	-0.22	0.10	-0.10

1) g digestible organic matter per 100 g dry matter.

* ; $P < 0.05$
** ; $P < 0.01$
***; $P < 0.001$

Inspite 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 conduct voluntary intake and digestibility studies using animals with food legume straws since these may reveal differences, particularly in voluntary intake, which cannot be accurately assessed in the laboratory. Willie Erskine, Brian Capper, S. Rihawi, L.D. Robertson, K.B. Singh and M.C. Saxena.

5. COLLABORATIVE PROJECTS

5.1. International Testing Program

5.1.1. General

The international nurseries play a significant role in disseminating improved germplasm to cooperators in different countries. We continued coordinating the international testing program between ICARDA and the legume scientists in the national programs. The main thrust continued to be on the identification of superior genotypes with wide adaptation, resistance to diseases, and insect pests, 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 severally affected especially in faba beans. This resulted in 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. The requests received from cooperators were high and we could meet only 79 per cent of their demand (Table 5.1.1). The increasing trend in demand of the 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.

Table 5.1.1. Request and supply of different Food Legume International Nurseries for 1985/86 season.

	Agronomy	Chickpea	Lentils	Faba Beans	TOTAL
Request	121	539	445	377	1482
Dispatch	121	449	351	254	1175

Table 5.1.2. The best five lines across locations in Lentil International Screening Nurseries (LISN), 1984/85.

Rank	Name of Nursrey			
	LISN-L	LISN-S	LISN-E	LISN-T-E
1	81S 30935	FLIP 84-60L	FLIP 84-112L	ILL 112 (78S 26052)
2	FLIP 84-102L	FLIP 84-59L	ILL 4354	FLIP 84-48L
3	FLIP 84-78L	FLIP 84-26L	FLIP 84-29L	FLIP 84-51L
4	FLIP 84-82L	FLIP 84-44L	ILL 4236	FLIP 84-44L
5	FLIP 84-72L	FLIP 84-27L	ILL 3516	ILL 1939

L = Large, S = Small, E = Erect, T-E = Tall Erect.

The international nursery report for the 1982/83 season was distributed to the cooperators with the international nurseries and trials supplied for 1985/86 during August and in September 1985. The results for the 1983/84 season have been analyzed and the report is under preparation. The salient features of 1983/84 results are presented here.

5.1.2. Chickpeas

The yield data for the Chickpea International Yield Trial were reported from 31 locations, and at 6 locations several lines performed significantly better than the local checks. At El Koudia (Morocco), Suleimaniya (Iraq), Islamabad (Pakistan), Al-Ghab (Syria) and Samsun (Turkey), some lines yielded almost double as compared to the respective local checks. The five best entries across locations were ILC 482 (1180 kg/ha), FLIP 82-20 (1139 kg/ha), FLIP 82-9C (1093 kg/ha), FLIP 81-71 (1085 kg/ha) and FLIP 81-24 (1069 kg/ha).

In the Chickpea International Yield Trial-Winter-Mediterranean Region reported from 44 locations, the local check was excelled by a significant ($P \leq 0.05$) margin by some entries at 22 locations: Setif (Algeria); Shandweel (Egypt); Larissa (Greece); Oroumieh (Iran); Capalbio (Italy); Islamabad and Tarnab (Pakistan); Annaceur and Zemamra (Morocco); Cordoba, Jaen and Sevilla (Spain); Hama, Izra'a, Jinderis, and Tel Hadya (Syria); El-Kef, Mateur, Menzel Temine (Tunisia); and Ankara and Samsum (Turkey). Most of the test lines were resistant to ascochyta blight. The five best lines across locations were ILC 482 (2134 kg/ha), FLIP 81-293 (2040 kg/ha), FLIP 81-57W (1951 kg/ha), FLIP 82-40C (1911 kg/ha), and FLIP 82-43C (1904 kg/ha).

In the Chickpea International Yield Trial-Winter-Sub Tropical, a number of lines were superior to the local check at 3 of the 8 locations: Mallawi (Egypt), Tel Hadya (Syria), and El-Kef (Tunisia). On the basis of performance across locations, FLIP 82-28C (1155 kg/ha), FLIP 82-3C (1081 kg/ha), FLIP 81-10 (1077 kg/ha), FLIP 82-63C (1025 kg/ha) and FLIP 81-312 (1011 kg/ha) were the top yielders.

In the Chickpea International Yield Trial-Large Seeded, a number of lines were significantly superior to the local checks at 6 of 28 locations: Toshevo (Bulgaria), Mallawi (Egypt), Suleimaniya (Iraq), Islamabad (Pakistan), La Molina (Peru), and Samsum (Turkey). On the basis of performance across locations, ILC 116 (1378 kg/ha), ILC 136 (1358 kg/ha), ILC 134 (1325 kg/ha), ILC 254 (1302 kg/ha), and ILC 451 (1291 kg/ha) were the top yielders.

Results of the Chickpea Adaptation Trial (CAT) were received from 20 locations in 12 countries. Five entries namely ICC 4918, ILC 1919, ICC 50003, ICC 11525 and ICC 10136 were the top yielders in order of their merit on overall location basis.

In the Chickpea International Screening Nursery at 19 locations, the test lines were among the 10 top yielders at 11 locations. FLIP 82-127, 82-128, ILC 482, 82-167, and 82-225 gave the largest yields across locations.

In the Chickpea International F_3 Trials for Mediterranean (MR) and Sub-Tropical (STR) region, of 8 and 7 locations reporting yield performance, at 3 locations each of the F_3 populations excelled the local checks by a significant ($P \leq 0.05$) margin. The best cross populations across locations in MR were X82TH 168, X82TH 169, X82TH 164, X82TH, and X82TH 88, and in STR were X82TH 77, ILC 3279, X82TH 81, X82TH 78, and X82TH 2.

Results from the Chickpea International Ascochyta Blight Nursery were reported from 17 locations in 12 countries. Out of 71 lines tested, only six lines namely ILC 187, ILC 202, ILC 2956, ILC 3274, ILC 3279 and ILC 3856 were resistant/tolerant across locations. At each individual locations, however, several lines were resistant/tolerant.

The results from Weed Control Trial were reported from 12 locations. Across locations a loss of 41% in seed yield due to weeds was noticed. The most promising weedicide treatments were: Bladex + Kerb at Jubeiha (Jordan); Igran + Kerb at Terbol (Lebanon), Maloran at Faisalabad (Pakistan); Tribunil + Kerb at Gelline (Syria) and Maloran/Igran + Kerb at Elvas (Portugal).

The Chickpea Date of Planting and Plant Population Trial reported from Quetta (Pakistan), Beja (Tunisia), and Terbol (Lebanon) revealed that late plantings and low plant population densities gave lower yields than early plantings with high plant population densities.

From the 9 locations reporting the Fertilizer-cum-Inoculation Trial the response was significant only at 5 locations but it varied. Inoculation with Rhizobium at Mallawi (Egypt), and Inoculation + Phosphate + Potash at Sids (Egypt) and Islamabad and Tarnab (Pakistan) gave significantly superior yields over the control and were the best treatments in these countries.

The Chickpea Iron Efficiency Trial reported from 3 locations using two genotypes, one iron efficient and the other inefficient, revealed that spray of 0.5% ferrous sulphate did not increase the yield though the iron deficiency symptoms were apparently removed.

5.1.3. Lentils

In Lentil International Yield Trial-Large Seeded, some of the lines out-yielded the local check by a significant margin at 16 out of the 26 locations: Salta (Argentina), Graneros (Chile), Sakha (Egypt), Debre Zeit (Ethiopia), Karaj (Iran), Dohuk (Iraq), Terbol (Lebanon), Sidi-Laidi (Morocco), Islamabad (Pakistan), La-Molina and San Lorenzo (Peru), Pulawy (Poland), Beja and El-Kef (Tunisia), Ankara and Izmir (Turkey). On the basis of overall performance across locations, the five best lines included ILL 8 (78S 26002), ILL 20, ILL 857, ILL 4606, and ILL 707 with 1144, 1026, 1015, 984 and 979 kg/ha seed yield, respectively.

The results of Lentil International Yield Trial-Small Seeded revealed that some of the lines significantly out-yielded the local check at 9 out of 18 locations reported: Perico and Salta (Argentina), Mallawi (Egypt), Terbol (Lebanon), Merchouch and Sidi-Laidi (Morocco), Tel Hadya (Syria), Izmir (Turkey), and Sana'a (N. Yemen). The highest seed yield across locations was reported for ILL 112 (78S 26052) which was followed by ILL 9 (78S 26004), ILL 1 (76TA 66005), ILL 1939 and FLIP 84-67L (76TA 271) with 1080, 1015, 994, 989 and 986 kg/ha, respectively.

Seed yield results of four Lentil International Screening Nurseries (LISN) comprising Large (L), Small (S), Early (E), and Tall Erect (T-E) were reported from 23, 16, 17, and 21 locations respectively. The five best lines across locations in the four nurseries are shown in Table 5.1.2.

Results of Lentil International F_3 Trial (LIF_3T) and Lentil International F_3 Trial - Early (LIF_3T-E) were reported from 10 and 8 locations, respectively. In LIF_3T, 4, 4, 2, 1, 1, and 7 populations exceeded the local check in seed yield by a significant margin at Setif (Algeria), Mallawi (Egypt), Terbol (Lebanon), Tel Hadya (Syria), and Ankara and Izmir (Turkey), respectively. However, in LIF_3T-E, two populations at Beja (Tunisia), excelled the local check by a significant margin.

In the Weed Control Trial, weed infestation reduced the yields by about 48 per cent across the locations. From the nine locations reporting results, at seven of the locations some of the weedicide treatments were promising. These included: Gesagard + Kerb in Behtim (Egypt), Chakwal (Pakistan), and Pullway (Poland); Maloran + Kerb in Sakha (Egypt), Jubeiha (Jordan), and Terbol (Lebanon); and Tribunil in Izra'a (Syria).

The Plant Population Trial was reported from New Delhi (India), Terbol (Lebanon) and Quetta (Pakistan). No definite conclusions could be drawn from results of New Delhi and Quetta, however, the results from Terbol indicated absence of any significant differences among different population levels and row spacings.

The Lentil Fertility-cum-Inoculation Trial was reported from 4 locations namely Perico (Argentina), Lahore (Pakistan), Wad Medani (Sudan), and Izra'a (Syria). The results exhibited the absence of any significant response due to the inoculation and fertilizer treatments.

5.1.4. Faba Beans

The International Yield Trial-Large Seeded, reported for yield from 17 locations revealed that some of the test entries were significantly better ($P \leq 0.05$) than the respective checks at Mansoura (Egypt), Terbol (Lebanon), and Ankara (Turkey). The five best lines across the locations were FLIP 83-8FB, Sevilla Giant (ILB 1933), 79SL 48590 (ILB 282), 74TA 22 (ILB 9) and Lattakia Local (ILB 1815) with average yields of 2751, 2518, 2517, 2509 and 2492 kg/ha, respectively.

The results of the Faba Bean International Yield Trial-Large Seeded were received from 21 locations in 16 countries. At five of these locations namely, Saskatoon (Canada), Terbol (Lebanon), Tarnab (Pakistan), Lattakia (Syria) and Ankara (Turkey), some of the test entries exceeded the local check by a significant margin. The best five entries across the locations were 74TA 498 (ILB 360), X77TA 82 (80S 44371), X77TA88 (80S 44539), Giza 3 (ILB 1819), and 78S 49288 (ILB 112) with average seed yield of 1845, 1843, 1834, 1821, and 1792 kg/ha, rspectively.

Results from two Faba Bean International Screening Nurseries (FBISN) namely, Large Seeded (L) and Small Seeded (S) were reported from 16 and 19 locations, respectively. Out of these, at 8 locations for FBISN-L and 12 locations for FBISN-S, at least 10 entries exceeded the respective local checks. The five best entries in FBISN-L were:

ILB 1817 (FLIP 82-45 FB), X77TA 64 (80S 44027), X77TA 31 (80S 43587), X79L 25 (FLIP 82-29 FB), and 77TA 72 (80S 44178); and in FBISN-S were: ILB 1817 (76TA 56267), X77TA 88 (FLIP 82-22FB), X77TA 81 (80S 44358), X75TA 8 (FLIP 82-33FB), and ILB 1820 (Giza 4).

The results for two International F_3 Nurseries ($FBIF_3N$) namely normal ($FBIF_3N$) and early ($FBIF_3N$-E), were reported for yield from 7 and 15 locations, respectively. It was observed that at 5 of the 7 locations reported, the local check ranked 20 or less in $FBIF_3N$, and at least 10 or less at 7 of the 15 locations in $FBIF_3N$-E. The five best populations in $FBIF_3N$ were: S82478, S82147, S82030, S82082 and S82101, and in $FBIF_3N$-E were: S82154, S82029, S82112, S82129 and S82017.

The results from the Faba Bean International Chocolate Spot Nursery indicated that out of the 19 entries tested, only three namely BPL 710, 1179 and 1196 were resistant across all the four locations (Netherlands, Egypt, U.K. and Syria).

In The Faba Bean International Ascochyta Blight Nursery, of the 30 lines tested for resistance in U.K., Canada and Syria, 28 were rated resistant or moderately resistant but two lines namely Giza 4 and Syrian Local showed susceptibility at some locations. It is worth mentioning that some of the lines namely 14986-1, -2, and -3 resistant to chocolate spot were also resistant to ascochyta blight.

The Faba Bean International Rust Nursery was tested in Egypt, Canada and Syria. In Canada three isolates were used, one of which proved to be most virulent and only two lines namely 81-24948-1 and Syrian Local were resistant to this isolate. On the basis of other isolates, seven lines namely Sel. Lat-82-15563-3-A, 81-24948-1, 81-24948-2, 81-24857-1, 81-24694-1, 83-30010, and 83-30094 were resistant or moderately resistant across Syrian, Egyptian and Canadian locations. It is worth mentioning that four of these lines namely Lat 81-24948-1, 81-24948-2, 81-24857-1 and 81-24694-1 were also found resistant to rust in FBIRN in Egypt, Canada and Syria.

The results of Faba Bean International Orobanche Nursery were received from two locations; Douyet (Morocco) and Beja (Tunisia). The number of Orobanche shoots were much lower in most of the test lines as compared with the susceptible checks. The best tolerant sources in Morocco included, BPL 2210, F 331, BPL 1722, and F 402; and in Tunisia, BPL 561, F 402, BPL 1636, and BPL 733.

In Weed Control Trials, reported from 7 locations the differences between different treatments were not significant. The weed population in these trials was not much as supported by average loss of only 13 per cent in yield due to weeds when compared with weed free check.

The Plant Population Trial at Terbol revealed that high plant population density at 60 cm row spacing was best as compared to varying densities at 30, 40 and 50 cm row spacings. Though the trials at Mateur and Menzel Temine (Tunisia) were conducted only using 90, 70 and 50 cm row spacings without varying populations, the best yields were obtained at 50 cm row spacing.

The Fertilizer-cum-Inoculation Trial reported from Perico (Argentina) and Beja (Tunisia) revealed the absence of any response due to variable fertilizer and inoculation treatments in faba beans in these countries.

5.2. ICARDA/IFAD Nile Valley Project

This special project reached the last year of its II three year phase in 1985. The objectives of this project have already been described in the last annual report 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 the Center. A comprehensive six year report of the project is under preparation. The major highlights of the research during the 1984/85 season in the project are described here.

5.2.1. On-Farm Trials in Egypt

On-farm research was carried out in three governorates with farmers participation using large plats 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 neighbouring farmers and extension agents under IFAD Agricultural Development Project in Minia. Twenty-two trials in Minia, 17 in Kafr El-Sheikh, and six in Fayoum governorates were conducted to study the following factors at test and farmers' levels:

Governorate	Test factors				
	Plant Population 1/	Fertilizers 2/	Weed Control 3/	Irrigation 4/	Disease Control 5/
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.

In the Samallot district of Minia, test package including plant population, fertilizers and weed central gave positive and consistant yield increases with an average increase of 960 kg/ha (30.1%) seed and 760 kg/ha (13.8%) straw over farmers' practices at four out of five 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 5.2.1. When irrigation was included as a test variable the yield advantage of the whole test package was relatively lower at 380 kg kg/ha (11.0%)

In Kafr El-Sheikh district, the whole test package increased yield at eight, out of 12 sites, by an average of 940 kg/ha (26.3%) over the 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 kafr El-Sheikh governorate, the whole test package increased yield by about 20% (730 kg/ha) over farmers' practices (Table 5.2.2.).

In Fayoum and Etsa districts, the farmer-managed trials at five, out of six 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 the farmers' practices (Table 5.2.3.).

Table 5.2.1. Average seed and straw yields, gross benefit, variable costs, and net benetif as affected by the test and farmres' 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	S.D.	Yield	S.D.	(EP/ha)	(EP/ha)	EP/ha	S.D.
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	

S.D. = Standard deviation
EP = Egyptian Pound.

Table 5.2.2. 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	S.D.	Yield	S.D.	(SP/ha)	(SP/ha)	SP/ha	S.D.
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	

1/ Plant population, fertilizers, weed control, and disease control.

Table 5.2.3. 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)		Cross benefit	Variable costs	Net benefit	
	Yield	S.D.	Yield	S.D.	(EP/ha)	(EP/ha)	EP/ha	S.D.
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	

1/ Plant population, fertilizers, and weed control.

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 at Giza 402 (tolerant) and Giza 2 (susceptible) cultivars with a test package of high plant population, fertilizer application, Rhizobium inoculation 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.

5.2.2. 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 the general farmers' practices. The test package consisted of early planting, frequent irrigation, and pest control. In addition, 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 neighbouring farm was considered for comparison of the test package with that of farmers' practices. The yields were lower this year in comparison to those in 1983/84 because the season was warmer in 1984/85.

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 5.2.4).

5.2.3. 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 neighbouring farms (general practices) at 20 out of 22 locations. As an 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 the farmers practices with a mean increase of 59% (460 kg/ha). The yield levels were low because of exceptionally

Table 5.2.4. 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 parenthesis are standard deviations.
SP = Sudanese Pound.

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 hectar more than that from neighbouring farms with marginal rates of return of 390% and 974% in Zeidab and Aliab schemes, respectively (Table 5.2.5).

Table 5.2.5. 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
Neighbouring 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

5.3. Collaborative Research with the Syrian National Program

The collaborative applied research with the Syrian Natinal Program (ARC-Douma) in the improvement of faba beans, kabuli chickpea and lentils continued during 1984/85. The work included conduct of yield trials, disease and pest screening nurseries, disease control and agronomy trials and on-farm trials. The details of the on-farm trials conducted on kabuli chickpeas and lentils have been already given in the relevant sections of this report.

5.3.1. Faba Beans

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 wide adaptability in the international yield trials yielded 5500 kg/ha. Averaged over all the test locations lines H15 yielded highest consistently over 1982/83, 1983/84 and 1984/85; Cyprus Imp. was second; and these two genotypes out yielded the rest by a significant margin. Also a rainfed regional yield trial was conducted at Izra, 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 years, 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 land race genotypes during the 1985/86 season.

5.3.2. Lentils

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, 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 the consistency of their performance. Meanwhile, from the on-farm trials conducted over last three years genotype 78S 26002 (ILL 8) came out to be the highest yielding large seeded type, giving an 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 0.5 ha area in two villages will be jointly executed by ARC and ICARDA during the 1985/86 season. This genotypes tends to lodge less than local and is, therefore, better suited for mechanical harvesting.

5.3.3. Kabuli Chickpeas

Unlike in case of 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/form six locations, viz., Izraa, Hama, Gelline, Jableh, Tel Hadya and Jinderis. 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-Izraa, Gelline, Kamishly, El-Ghab, Tel Hadya and Jinderis. The yield 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 Jinderis, again the local check (ILC 1929) gave the highest yield closely followed by ILC 451 and ILC 263. There is a need for evaluation of newer large-seeded lines that have now come out of 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 5.3.1. It is clear that most of the test entries showed high level of tolerance to ascochyta blight.

Agronomic studies investigated 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), at Gelline and Homs, on the performance of local land race 2 chickpeas (Table 5.3.2.). Significant increase in yield occurred 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 now spacing was superior to the narrower one, whereas at Homs where crop was grown with irrigation, there was no difference due to now spacing variable.

Table 5.3.1. Mean ascochyta blight rating (on 1-9 scale, where 1 = free and 9 = dead) 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 disese score
24	2.0 to 3.0
16	3.1 to 4.2
Local check	6.6

Table 5.3.2. Effect of date of sowing and plant population (plants/m^2) on the yield of chickpeas at Gelline and Homs, 1984/85.

Treatments	Yields (kg/ha) Gelline	Homs
Date of sowing		
Winter	1003	1523
Spring	317	682
LSD (5%)	137	569
CV (%)	6.5	16.2
Plant population		
30 plants/m^2	575	965
45 plants/m^2	648	1041
60 plants/m^2	757	1301
LSD (5%)	76	182
CV (%)	10.1	8.3

5.4. ICARDA Tunisia Cooperative Project

In this cooperative project between ICARDA and the Institut National de la Recherche Agronomique de Tunisie (INRAT), a food legume breeder from ICARDA and Tunisian food legume scientists work together to identify superior genotypes and production techniques for all three food legumes with backup from staff at the headquarters in Syria. 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.

5.4.1. 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 heavier yielding lines and the identification of genetic sources of resistance to the prevalent diseases and pests. For diseases this season 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 stabilised by being combined with resistance/tolerance to the major diseases. With the irregularity of natural disease development increased attention has accordingly been given to evolving, where practical, disease screening methods for developing epiphytotic conditions through artificial inoculation. This season 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 neessary for good disease development. It is also planned to develop an orobanche sick plot at Beja, as although infection levels are high the attack in nurseries is rather irregular making effective screening difficult.

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.

In the large seeded breeding program 61 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; yield data on the five heaviest yielding lines across locations in each trial is given in Table 5.4.1.

Table 5.4.1. Seed yield in kg/ha of superior yielding large seeded faba bean lines in three trials at two more locations in 1984/85.

Trial	Line	Locations				
		Beja	Kef	Jendouba	Sejnane	Mean
	ILB 1815-Lebanese L.L.[1/]	2541	1475	4633[2/]		2883
	1814 79S4	2125	2562	3833		2840
	398 76TA 56264	2308	2362	3783		2818
	1814 79S653	3000	1675	3533		2736
IYT-L	1821 Turkish local	2258	2425	3467		2717
	Tunisian local check	1704	992	2867		1853
	SE +	331.3	480.4	297.6		
	CV %	23.7	40.4	14.3		
	BPL 26563	1350	2325	4000	1950	2406
	472	2112	1162	3850	2153	2319
	ILB 1933 seville giant	2375	1662	3925	796	2190
	ILB 1799 79 MB	1687	1712	3350	1800	2137
AYT-L	ILB 1805 Elegant 5 mc	1287	1187	4200	1840	2129
	Tunisian local check	1635	1562	4329	1788	2329
	SE +	432.5	351.1	420.2	98.0	
	CV %	37.0	35.3	15.9	41.2	
	X 79S 72 80S 80028	1200	3287			2244
	171 80S 80135	1812	2950			2381
	70 80S 80026	1837	2600			2219
	ILB 282 76TA 56356	1975	2437			2206
PYT-L	X795 131 FLIP 82-27 FB	1387	2950			2169
	Tunisian local check	1277	2232			1755
	SE +	274.7	403.1			
	CV %	27.5	25.2			

1/ L.L. = Local Large

2/ Values underlined significantly ($P < 0.05$) exceeded the check.

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 (PYT-S) with 21 lines. In all trials a number of lines out-yielded the check at more than one location but none did so significantly; yield data on the three heaviest yielding lines across locations in each trial are given in Table 5.4.2.

During this and the previous two seasons five large seeded and three small seeded lines have been retained in trials at more than one location as overall they have outyielded the local check. Table 5.4.3 gives such yield data, expressed as a percentage of the local check, and for most lines there was a marked within and between season variation at a location for the percentage increase or decrease, although in certain instances this will reflect high coefficients of variation. In spite of this ILB 1217 (Reina Blanca) was the most stable line outyielding the check in five out of six 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.

As a result of the relatively little progress achieved so far an increasing 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

Table 5.4.2. Seed yield in kg/ha of superior yielding small seeded faba bean lines in four trials at two or more locations in 1984/85.

Trial	Line	Locations				
		Beja	Kef	Jendouba	Sejnane	Mean
	ILB 285 78S 48476	2166	1437			1802
	X77 Sd 11 80S 45676	1858	1700			1779
	ILB 33 74TA95	1741	1437			1589
IYT-S	Tunisian local check	1908	525			
	SE $\pm$	325.1	332.9			
	CV %	36.9	37.3			
	X75TA 33 80S 43651	2825	1325	3741	1193	2271
	ILB 269 78S 48821	1891	1708	3783	1470	2213
	1555 Rastatt	2066	1491	3925	1315	2199
AYT-S-1	Tunisian local check	2129	1853	3911	1383	2319
	SE $\pm$	435.5	273.4	259.6	98.1	
	CV %	40.9	29.1	12.6	41.2	
	X 77TA 88 80S 44539	1758	1816			1787
	ILB 382	1908	1441			1675
	470	1883	1291			1587
AYT-S-2	Tunisian local check	2130	1747			1939
	SE $\pm$	257.4	169.4			
	CV %	28.4	19.9			
	X 75TA 33 80S 43651	3587	1750			2669
	X 77TA 81 80S 44388	3625	1575			2600
	X 77TA 60 80S 43971	2962	1950			2456
PYT-S-1	Tunisian local check	2565	1556			2061
	SE $\pm$	374.1	285.2			
	CV %	22.0	25.2			

Table 5.4.3. Seed yield expressed as a percentage of the local check cultivar of five large and three small seeded lines at two locations over three season.

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

Loaction	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 signifiacntly ($P < 0.05$) outyielded the local check cultivar
b/ ND: no data available.

conditions to examine the variation for agronomically useful characters. Also a further range of early generation bulks and progenies from ICARDA base program as well a considerable number of pure line accessions from ICARDA's germplasm collection will be evaluated under local environmental conditions.

5.4.2. 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, and the spring-sown crop can also be severely affected by the disease. Accordingly all the genetic material received from ICARDA has resistance to blight, and 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 symptoms have been observed at experiment stations and on farmers' fields, but this season the incidence was generally lower except in the wilt sick plot at Beja. This aside it is still felt from observations and surveys in previous seasons that this disease is potentially as big a constraint to production as ascochyta blight. Last seasons's report indicated that both a Fusarium spp. and a Verticillium spp. had been isolated from wilt infected plants, and the species have now been identified at Montana State University, U.S.A., 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 the Beja location and a soil problem at the Sejnane location resulted in many missing plots in some trials and statistical analysis has yet to be undertaken. In all the international trials only one entry of the local check cultivar was included and this was not protected against ascochyta bilght through fungicide application. In all other trials there were usually at least two protected and two unprotected entries of the local check, and in presentation of the results the seed yield of the test entries is compared against the former.

A number of lines populations in the international trials yielded more than the local check at one or more locations but none did so significantly. Yield data on the five heaviest yielding lines in the IYT 1 and 2 at two locations are given in Table 5.4.4. In the AYT 1 and PYT 3, however, one line and 15 lines, respectively, significantly out yielded the local check but only at one location; yield data on the top five lines in each trial are given in Table

Table 5.4.4. Seed yield in kg/ha of the five heaviest yielding chickpea lines in an IYT 1 and 2 at Beja and Kef in 1984/85.

	IYT-1				IYT-2		
Line	Beja	Kef	Mean	Line	Beja	Kef	Mean
FLIP 82-101 C	1608	2412	2010	FLIP 82-144 C	1937	2400	2169
128 C	2216	1775	1996	81- 10 C	2066	2108	2087
121 C	2041	1868	1955	312 C	1718	2291	2005
91 C	2016	1818	1917	82-239 C	1818	2008	1913
186 C	1983	1812	1898	261 C	1950	1858	1904
Local check	825[a/]	1406	1116	Local check	1891	1950	1920
SE ±	401.4	261.5		SE ±	245.8	237.9	
CV %	42.9	29.1		CV %	23.3	27.8	

a/ Two replicates severely infected by ascochyta blight.

Table 5.4.5. Seed yield in kg/ha of the five heaviest yielding chickpea lines in an AYT 1 and PYT-3 at Beja and Kef in 1984/85.

	AYT-1				PYT-3		
Line	Beja	Kef	Mean	Line	Beja	Kef	Mean
FLIP 81-293	2575[a/]	2225	2400	FLIP 83-12 C	4175	2175	3175
ILC 484	2212	2012	2112	15 C	3425	2400	2913
482	2412	1725	2069	19 C	3150	2150	2650
FLIP 81-67	2050	2025	2038	45 C	3137	1975	2556
82-27 W	2150	1887	2019	82-259 C	3112	1375	2244
Local check	2081	1244	1663	Local check	2541	2055	2298
SE ±	191.2	282.6		SE ±	111.6	100.4	
CV %	13.4	26.6		CV %	5.9	35.5	

a/ Values underilned significantly ($P < 0.05$) outyielded the local check.

5.4.5. *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 have significantly and consistently outyielded the local check cultivar yield data in Table 5.4.6 for five resistant lines 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 an attack of blight, to benefit the heavier yields of early or winter planting. However, wilt is a problem in both winter and spring planting and with two years' screening of ascochyta resistant material in the wilt sick plot a Beja it has been possible to identify a few lines that have some tolerance to wilt. Data on four ascochyta resistant lines with best combination of seed yield and wilt tolerance over two years are given in Table 5.4.7 and one or more of these 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 the Kef location, and data on the five heaviest yielding lines across locations are given in Table 5.4.8. 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.

Table 5.4.6. Seed yield, expressed as a percentage of local check, of five ascochyta resistant lines tested over three seasosn at Beja and Kef locations.

Line	1982/83		1983/84		1984/85		Mean
	Beja	Kef	Beja	Kef	Beja	Kef	
FLIP 81-56 W	61	112	129	159	63	124	108
41 W	85	67	132	131	107	108	105
57 W	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 5.4.7. Seed yield, expressed as a percentage of the local check, and wilt ratings (WR) of four ascochyta resistant lines at Beja and Kef in 1983/84 and 1984/85.

Line	1983/84			1984/85			Seed Yield	WR
	Seed yield		WR[1/]	Seed yield		WR		
	Beja	Kef	Beja	Beja	Kef	Beja		
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.

Table 5.4.8. Seed yield in kg/ha of the five heaviest yielding chickpea lines at Beja and Kef in 1984/85.

Line	Beja	kef	Mean
ILC 263	3091	615	1853
136	3000	450	1725
165	2891	508	1700
3396	2900	500	1700
254	2825	408	1617
Local check	2475	133	1304
SE ±	196.5	92.1	
CV %	12.8	46.8	

However, in the AYT 2 and 3 there were 20 lines tested that stemmed from single plant selections made in the local cultivar land race 'Amdoun' for resistance to wilt. All these lines have shown a high level of resistance in the wilt sick plot (WSP) at Beja during this and the previous seasons, and in the last two seasons have significantly outyielded the local check by a large margin when grown in replicated trials in the WSP. The 20 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, and in all cases their seed yield did not differ significantly from that of the local check cultivar Amdoun. Data on six lines that have been tested over three years in both wilt infected and wilt free land are given in Table 5.4.9. Since wilt is considered a major constraint to production, and as these lines have proved to be resistant and possess a 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.

In an attempt to develop lines having dual resistance to both 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 of lines in the IYTs showed that 14 and a reasonable to good level of wilt resistance (a rating of 5 or less on a 1 to 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 emphasising the care needed in identifying wilt resistance. Of the 216 ascochyta resistant lines reecived from ICARDA this season 26 were rated 5 or less for wilt.

Table 5.4.9. Wilt rating (WR) and seed yield (kg/ha) and seed weight of six chickpea lines selected out of the 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 for spring planting without ascochyta resistance, such as these in the large seeded international yield trial (IYT1), are also screened in the WSP, and this season 10 lines in the IYT1 had wilt ratings of five or less. In addition to the field screening seedlings of all the lines are screened in the laboratory in a 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 the field for those lines that show symptoms of wilt early in the season, and it is hoped that further refining of the technique in the laboratory will permit an 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 by a locally occuring strain of ascochyta blight. Thirty-six F_4 and 30 F_5 single plants form 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 shown a high level of resistance to wilt and ILC 191 is known to be resistant to blight. 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 undertaken by the base program at ICARDA Aleppo, between ascochyta resistant lines with heaviest yield in Tunisia and wilt resistant Amdoun selections, with the aim of combining dual resistance with a large seed size in a locally well adapted background. As a result of this 23 F_1 and 22 F_2 populations were grown this season in wilt free land at kef. The F_2 populations have been harvested as single plants and around 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.

5.4.3. 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 for the first two years of the program, was found to be lighter yielding than three other local cultivars. Accordingly the heaviest yielding of these last three cultivars, namely, 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, no significant difference was detected between the seed yield 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 (Table 5.4.10). Unfortunately none of these lines showed good mechanical harvest characteristics in that none were particularly erect and all tended to lodge to a certain degree.

Data was reported last year on four lines which over three years of testing had produced a minimum mean increase of 45% over the local check cultivar. These data and those of this season on the four lines are given in Table 5.4.11, and this season the lines were generally lighter yielding than the local check cultivar. This again reflects the problems raised above but over four seasons these lines have given 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.

5.4.4. Agronomic Studies

Agronomic experiments were conducted at Beja and Kef research stations to determine optimum production practices for the three legumes. Factors tested were date of planting, plant population, fertilizer application and weed control. In all studies the best

Table 5.4.10. Seed yield in kg/ha of superior yielding lentil lines and F_4 populations in three trials at Beja and Kef in 1984/85.

Trial	Line	Beja	Kef	Mean
	ILL 1939	2775[a/]	1806	2291
IYT-S	Tunisian local check	1788	2288	2038
	SE ±	262.3	203.6	
	CV %	28.8	21.2	
	ILL 358	2662	1000	1831
	2149	2587	1318	1953
	4062	2100	1500	1800
	FLIP 84 - 56L	1975	1535	1756
PYT-2	- 112L	1937	1487	1712
	- 115L	2112	1168	1640
	Tunisian local check	1287	1620	1454
	SE ±	295.4	211.0	
	CV %	27.9	25.5	
	X 82S - 33	2037	1112	1575
	49	1900	1200	1550
	55	2562	1300	1931
AYT-F_4	61	2287	850	1569
	177	1948	875	1412
	243	2187	562	1375
	Tunisian local check	1250	1104	1177
	SE ±	271.3	242.3	
	CV %	25.1	41.1	

a/ Underlined values significantly ($P < 0.05$) outyielded the check.

Table 5.4.11. Seed yield in kg/ha of four lentil lines over four seasons at Beja, Kef and Jendouba.

Line	Season[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 the 1981/82 season and all lines only tested in the same trial in the 1984/85 season.
2/ Values underlined significantly ($P < 0.05$) outyielded the local check.

adapted local cultivars were used and the crop was protected from pests and diseases.

The date of planting, population and fertilizer application trials were very similar to those conducted in the two past seasons, and as the results obtained this season were very similar to previous ones, which have been fully reported in Tunisia-ICARDA annual reports, only a brief summary of them will be given. For all three legumes seed yield was significantly reduced by delaying planting from early November to late January, and generally showed a linear increase from raising the plant population from 5 to 12 plants/m^2 for lentils. For lentils the results indicated that further raising the plant population might produce an additional yield increase, and this will be examined next season, but there was no such indication for faba beans and chickpeas. No crop showed a significant seed yield response to the application of nitrogen and phosphate, and no difference was observed between applying phosphate as di-ammonium phosphate or as triple super phosphate.

Previous results have shown 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 the Beja and Kef locations, and the results are presented in Table 5.4.12 for faba beans and chickpeas and in Table 5.4.13 for lentils. In all trials there was a significant difference between treatments, and as all the treatments produced a lighter yield than the weed free check, the data are expressed as percentage yield reduction in relation to the check, which is taken as zero. The average reduction across locations and crops owing to weed infestation was 81%, and it was larger at Kef except for faba beans where the high level of orobanche infection at

Table 5.4.12. Seed yield reduction for treatments expressed as a % of the weed free treatment for faba beans and chickpeas at Beja and Kef in the ICARDA weed control trial in 1984/85.

Treatment	Rate, kg/ha a.i.		Faba beans			Chickpeas		
	Faba beans	Chickpeas	Beja	Kef	Mean	Beja	Kef	Mean
Weed free			0	0	0	0	0	0
No weeding			95	78	87	76	93	85
Hand weeding twice			13	20	22	15	30	22
Maloran	1.5	2.5	66	70	68	72	86	79
Tribunil	3.0	3.0	82	61	72	64	90	77
Igran	2.5	3.0	47	64	56	51	82	67
Bladex	0.5	0.5	64	73	69	76	90	83
Bladex	1.0	1.0	56	62	59	72	83	78
Maloran+Kerb	1.5+0.5	2.5+0.5	44	60	52	62	88	75
Tribunil+Kerb	3.0+0.5	3.0+0.5	78	63	71	62	86	74
Igran+Kerb	2.5+0.5	3.0+0.5	29	57	43	52	78	65
Bladex+Kerb	0.5+0.5	0.5+0.5	73	64	69	67	87	77

Beja was a confounding factor. Hand weeding at two 45 day intervals after emergence gave reasonable weed control, except at Kef for lentils and excluding this result gave an average yield reduction of only 19%. No herbicide or combination of herbicides could be considered effective in controlling the weed population with best, namely, Igran + Kerb on faba beans at Beja showing a 29% yield reduction, and this combination was also the best at 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 of Bladex and Tribunil + Kerb showing reductions of 65% and 67% respectively across locations.

The results this season suggest that none of the herbicide treatments would be commercially acceptable. In the two previous seasons, however, some of the treatments proved to be more effective especially at Beja where the weed population is lower, and the three most effective herbicides for each legume over three years and across the two locations are listed in Table 5.4.14. More work, however, is required on examining the effectiveness of new combinations and differing and higher rates of application and this will be undertaken next season.

Table 5.4.13. Seed yield reduction for treatments expressed as a % of the weed free treatment for lentils at Beja and Kef in the ICARDA weed control trial in 1984/85.

Treatment	Rate	Beja	Kef	Mean
Weed free		0	0	0
No weeding		55	86	71
Hand weeding twice		17	47	32
Maloran	1.5	60	80	70
Gesagard	1.5	54	83	79
Tribunil	2.0	55	87	71
Bladex	0.5	71	88	80
Bladex	1.0	47	83	65
Maloran+Kerb	1.5+0.5	57	81	69
Gesagard+Kerb	1.5+0.5	64	74	69
Tribunil+Kerb	2.0+0.5	54	79	67
Bladex+Kerb	0.5+0.5	59	91	75

Table 5.4.14. List of the three most effective herbicides or herbicide combinations over three years of testing for faba beans, chickpeas and lentils.

Faba beans		Chickpeas		Lentils	
Herbicide	rate kg/ha a.i.	Herbicide	rate kg/ha a.i.	Herbicide	rate kg/ha a.i.
Igran	2.5	Tribunil+	1.5	Tribunil+	1.5
		Kerb	0.5	Kerb	0.5
Igran+	2.5	Igran+	2.5	Gesagard+	1.5
Kerb	0.5	Kerb	0.5	Kerb	0.5
Maloran+	1.5	Maloran+	1.5	Maloran+	1.5
Kerb	0.5	Kerb	0.5	Kerb	0.5

6. TRAINING

6.1. Group Training

6.1.1. Food Legumes Residential Course

The Food Legume Improvement Program conducted its residential course at Tel Hadya research station during 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, Yemen Arab Republic).

The course covered practical techniques of the improvement of faba bean, lentils, and kabuli chickpeas. This included field as well as laboratory activities. The syllabus focused on breeding, agronomy, field experimentation, diseases, insects, microbiology, as well as general areas such as farming systems. The main emphasis was a multidisciplinary approach to the improvement of the food legumes while still maintaining individual attention to cater for the needs of national programs. To achieve the latter objective each individual (taking into consideration the academic background and experience) was assigned a small experiment, supervised by a senior scientist. Through this activity the trainees were able to conduct experiment, analyse results, and write reports.

Classroom lectures were given by the Food Legumes Scientists as background information to the field activities. Training reference material, which included publications and visual aids, were provided during the course.

6.1.2. In-Country Course on Food Legumes Improvement in Morocco

The Moroccan Food Legume National Program - INRA - and the Food Legume Improvement Program - ICARDA- jointly conducted the "Food Legume Improvement Training Course" during 11-16 Feb 1985 at Rabat, Morocco. Thirty technicians from 10 research stations in Morocco and Tunisia particiapted in the course.

Instruction in the course was given by seven Moroccan and 2 ICARDA scientists. Lectures, which were general in nature, 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.

6.1.3. National Course on Cereals and Food Legumes Pathology in Syria

The Syrian National Program (ARC), 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) during 21 Apr - 2 May, 1985, at ICARDA's stations, Tel Hadya and Lattakia. The course was attended by 15 training participants from the various Syrian research stations.

Disease aspects of the food legumes and cereal crops were the main theme in the course. These covered biology of pathogens, epidemiology of diseases, and control measures for diseases. Techniques to create epiphytotics and scoring damage in the field and green house were given high priority.

6.1.4. Seed Technology Training Course

The Arab Organization for Agricultural Development (AOAD) and the International Center for Agricultural Research in Dry Areas (ICARDA) conducted the Seed Technology Course during 9-26 September, 1985, at Tel Hadya research station. The course was attended by 19 participants from 9 countries (Syria, Saudi Arabia, Yemen Arab Republic, Peoples Democratic Republic of Yemen, Jordan, Algeria, Iraq, Morocco, and Sudan).

The course covered general aspects of seed technology to include: 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.

6.2. Individual Training

The Food Legume Improvement Program increased the opportunities for individualized training. Eighteen training participants were hosted by the program during 1985. This represents a 50% increase over

1984. The increase in number is accompanied by, diversity in the topics offered as shown in Table 6.1. The participants period of stay ranged from two weeks to seven months.

In this category the training participants varied in academic background as well as working experience. Many conducted experimental research jointly with ICARDA scientists. The rest were trained in skills to the topics shown in Table 6.1. Each topic was addressed in a modullar fashion to include field and laboratory practicals as well as visual aids.

Degree training, where the students register at a university and conduct thesis research at ICARDA research stations, is also shown in Table 6.1.

6.3. Training Reference Material

The program made its first slide-tape audio-tutorial module entitled "Screening Chickpeas for Resistance to Ascochyta blight". This module so far had been used in the 1985 residential course, in-country courses in Morocco and Pakistan, and specialized pathology course at Tel Hadya Research Station. The feed-back from the training participants and the high demand from the 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".

Table 6.1. Participants in individual training at Food Legumes Improvement Program, ICARDA, during 1985.

Training Category	Subject	Duration	Country	No.
Senior Research Fellow	Agronomy/Physiology	7 months	India	1
Training Research Associate	Agronomy/data collection	One month	Sudan	3
	Field experimentation and data collection	Two months	Tunisia	1
	Lentil breeding	Two months	Pakistan	1
		Two weeks	Morocco	1
		One 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	One month	Sudan	1
	Field X laboratory research equipment X crossing techniques	3 months	Ethiopia	1
	Microbiology lab. techniques	One month	Sudan	1
	Entomology	One month	Syria	1
	Faba bean breeding for Orobanche resistance	Four months	Netherlands	1
High Degree:				
Research Scholar(M.Sc.)	Agronomy	Four months	Germany	1
	Pathology	Four months	Afghanistan	1
Research Fellow (Ph.D.)	Agronomy/Physiology	Three years	Syria	1
	Breeding	Three years	Egypt	1
Total				20

7. Publications

7.1. 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.

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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.

7.2. 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 Weeks, University of Damascus, 2-7 Nov. 1985. pp. 16.

Hussein, M.M. and Sherbeeny, M.H. 1985. Faba bean improvement in ICARDA/IFAD Nile Valley Project. Paper presented in 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 in 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 Rainfed Agriculture Information Networks Workshop, March 17-20, 1985, Amman, Jordan.

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Singh, K.B. and Malhotra, R.S. 1985. Inheritance of protein content and other agronomic characters in chickpea. Paper presented in "Sixth Meeting of the EUCARPIA Section - Oil and Protein Crops", June 10-13, 1985, at Junta De Andalucia, Cordoba, Spain.

7.3. Miscellaneous

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