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FOOD LEGUME IMPROVEMENT PROGRAM

Annual Report for 1986

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INTRODUCTION

1. The Food Legume Improvement Program continued its research and training efforts with the objective of improving the productivity and yield stability of faba bean (Vicia faba), lentil (Lens culinaris) and kabuli-type chickpea (Cicer arietinum). Although these crops may appear to be of minor significance in global statistics for agricultural production and trade, or for contributions to the nutrition of mass populations, they are of immense value in the rainfed farming systems of low rainfall areas of the West Asia and North Africa region and areas in many other countries having a Mediterranean type of climate. In such countries there are little alternatives to these crops and they are not only an important source of high quality yet cheap protein in the diets of the people but also provide rich crop residues as animal feed and play a key role in maintaining the productivity of soil through biological nitrogen fixation.

2. ICARDA has world wide responsibility for research on faba beans and lentils and a joint regional responsibility for improvement of kabuli-type chickpea with ICRISAT. The productivity of these crops is limited and unreliable because of the inherently poor yield potential of the landraces currently grown and their susceptibility to damage caused by diseases, insects, nematodes and parasitic weeds on the one hand, and to extremes of weather conditions (cold, heat, drought) on the other. Traditional methods of cultivation including costly manual harvesting are additional factors that reduce profitability for all these crops, but lentil in particular. The Food Legume Improvement Program's research aims to overcome these constraints with increasing efforts to link ICARDA's activities closely with those of national programs so that benefit will reach the farmers as quickly as possible.

3. Research Strategy

The research on each of the food legume crops is organized into a number of projects and it involves a interdisciplinary team of scientists from FLIP and other programs. However, for the convenience of readers the results are presented here by disciplines. The strategy employed to develop improved genetic stocks and cultivars and production technology using the experimental sites available to FLIP and linkages with national programs has already been reported earlier (ICARDA Annual Report 1984). Research at ICARDA's principal research station at Aleppo and its subsites in Syria and Lebanon was complemented by that conducted in the Nile Valley Project in Egypt, Ethiopia and Sudan and in the ICARDA/INRAT cooperative project on food legumes in Tunisia. Stronger linkages were developed with Algeria, Jordan, Morocco, Pakistan and Turkey to achieve this complementarity. As national programs' capacity is increasing to take more responsibility for crop improvement research, FLIP is moving to strengthen its research in those specialised areas where it has a comparative advantage by expanding collaboration with advanced institutions. Of more than 34 collaborative projects of this kind that ICARDA has, 24 involve FLIP.

With the re-establishment of the microbiology section in FLIP in August 1985, after three years activity under Farming Systems Program management, came a new microbiologist and a new focus of activity. The premise on which these activities are based is that the program at ICARDA is the appropriate location to conduct research to unravel the interactions of host genotype, environment, and rhizobia for improved biological nitrogen fixation (BNF) in legumes in the region. To do this it is necessary to utilize the regional network of agronomists, microbiologists, to conduct test nurseries, and to take advantage of the capacity of universities in the developed countries to conduct

research that is appropriate to the program needs. The program aims to develop improved BNF technologies applicable and transferable to national programs and farmers in the region. Towards this overall objective, it will be necessary to define the conditions under which inoculation with Rhizobium is necessary, and to provide the appropriate economical inoculant technology where needed. Selection of superior Rhizobium strains, effective over a large range of crop genetic material and agroclimatic conditions, is a necessary component of this technology. Finally, through a system of regional trials conducted in cooperation with national programs, superior Rhizobium and inoculation technology will be carried to farmers in the region. Thus a stepwise approach is proposed to be adopted (Figure 1), whereby evaluation of the need-to-inoculate is coupled with selection of superior rhizobia strains. A broad range of strain and cultivar combinations will be evaluated in greenhouse trials, with highly effective combinations being tested subsequently in regional field trials. Superior strains will then be combined with improved inoculum production and application technologies as a package for national programs.

4. Staff Changes

The ICRISAT chickpea pathologist position remained vacant. A pathologist from ICRISAT headquarters, however, visited the program during the crop season. A person was identified to fill the position of a legume entomologist. She will join ICARDA in December 1986. A legume breeder-cum-pathologist was appointed, in late 1985, and placed with the Institute of Agriculture Research, Addis Ababa, Ethiopia to strengthen the Highland Pulses Program in Ethiopia, under a World Bank loan to the Ethiopian government. The position of legume scientist in FLIP's North African Regional (NAR) program was filled in July 1986 and the scientist placed with INRA, at Rabat, Morocco. A post-doctoral fellow in lentil breeding at the headquarters and another

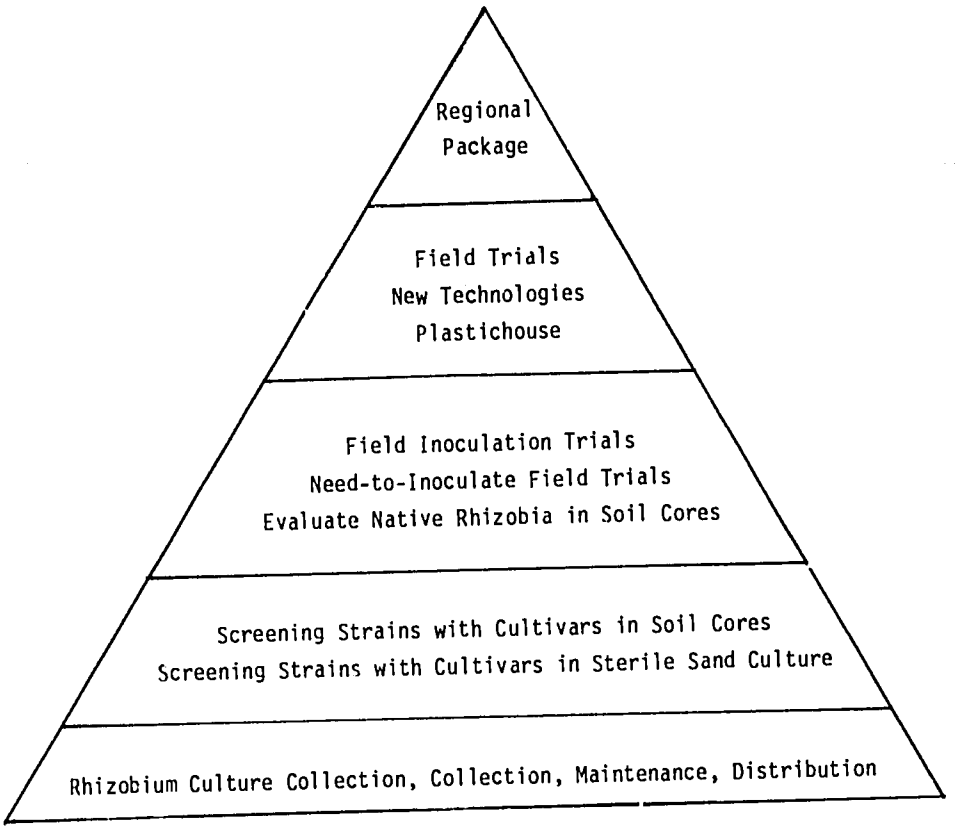

Figure 1. A stepwise approach to the development of a package of improved biological nitrogen fixation technology for food legumes in the ICARDA region.

in plant pathology for the NAR program were appointed. The position of post-doctoral fellow in chickpea breeding and dry-pea improvement have been advertised and will soon be filled. Three visiting research associates from West Germany and a visiting scientist from China joined the program in the later half of 1986. The visiting research associates will carry out their Ph.D. thesis research at ICARDA. The Chinese scientist will work on breeding methods for faba bean improvement. China is the largest producer of faba bean in the world.

5. Research Highlights

In 1985/86 season the winter was mild and the total seasonal precipitation was close to long-term average for Tel Hadya. Therefore, unlike 1984/85, the crops in 1985/86 did not suffer from any major environmental stress. The season was particularly favourable for faba bean because of the mild winter.

The main achievements of the program during the 1985/86 season are summarised below:

5.1. Faba bean

5.1.1. With the evaluation of 840 pure lines accessions (BPL's) for 39 descriptors this season, there was progress in making a germplasm catalogue for faba beans. ICARDA's BPL collection is a unique source of genetic variability in faba bean for breeders from all over the world. Several accessions have high autofertility and higher yield potential than the best adapted checks.

5.1.2. Evaluation of pure line accessions for common diseases led to the identification of 118, 75 and 30 sources, respectively, for the

resistance to chocolate spot, ascochyta blight and rust diseases. Multiple disease resistance was confirmed for the third consecutive year in three selections from the crosses made at ICARDA. Seeds of these will now be distributed to cooperators.

5.1.3. Progress was made in studying the role of phyllosphere in imparting host resistance to chocolate spot disease.

5.1.4. Algeria, Egypt, Tunisia and Yemen Arab Republic have asked for larger quantities of seeds of several of the lines distributed to national programs for further yield testing because of their superior performance this last season. Also faba bean breeders from Denmark, Egypt, Ethiopia, France, Tunisia, Turkey and Yemen Arab Republic have asked for large numbers of breeding lines.

5.1.5. Work to incorporate independent vascular supply trait and determinate growth habit in faba beans made progress, and large seededness was introduced. Selections have seed size up to 1.5 g/seed and 8-10 reproductive nodes, with resultant high yield. At Lattakia their yields were significantly better than best local checks. Clearly there are now good prospects for commercial exploitation of the determinate habit for increased yield and yield stability.

5.1.6. In Sudan on-farm trials in the Nile Valley Project showed that the prospect for economic introduction of faba beans in non-traditional areas south of Khartoum was good. The first year of on-farm trials on faba beans in Ethiopia demonstrated the possibility that substantial increases in yield could be achieved by introducing improved agronomic practices.

5.2. Lentil

5.2.1. Three ICARDA derived lentil lines have been released in North Africa - one in Algeria (Syrie 229) and two in Tunisia (ILL 4400 and ILL 4606).

5.2.2. The key constraint to lentil production in the Near East is the high cost of labour for pulling the crop from the ground. On-farm tests of a harvest package involving improved cultivar and both sowing and harvest methods have been successfully undertaken in northwestern Syria this season. Recommendations for farmers' use are the double-knife cutter bar with a non-lodging cultivar (78S 26002) and a flat seed bed. To transfer the harvest technology to national programs a course on lentil harvest mechanization was held at Tel Hadya with attendance from Algeria, Jordan, Syria, Tunisia and Turkey.

5.2.3. A laboratory technique was perfected to screen lentil lines for tolerance/resistance to the parasitic weed-Orobanche sp., which is known to cause substantial yield reductions in farmers' fields. Screening of ICARDA's lentil germplasm has started using this technique. Studies on integrated control revealed that solarization (by covering the wet soil with clear polyethylene sheet to raise the temperature) effectively reduced Orobanche damage to the crop on a heavily infested soil.

5.3. Kabuli Chickpea

5.3.1. The technology for winter sowing of chickpeas is spreading in the region with the release of ICARDA developed cold tolerant and ascochyta blight resistant chickpea cultivars. Following the work in a joint ICARDA/INRA Tunisia project, Tunisian national program released ILC 3279 and FLIP 83-46C chickpeas for winter sowing in Tunisia. Syria

released ILC 482 (Ghab 1) and ILC 3279 (Ghab 2) for the same purpose. Thus, four countries (Cyprus, Spain, Syria and Tunisia) have released varieties for winter sowing. ICARDA/Tunisia cooperative project also released the first wilt resistant variety Be-Sel-48 for spring sowing.

5.3.2. In addition, many cultivars selected from the ICARDA nurseries are being evaluated in the on-farm trials or in the multilocation trials in a number of countries including Algeria, Cyprus, Egypt, France, Italy, Lebanon, Morocco, Oman, Pakistan, Syria and Turkey.

5.3.3. For the first time very high yielding, early maturing and ascochyta blight resistant lines have been developed for spring sowing, possessing reasonable degree of heat and drought tolerance.

5.3.4. Responding to the needs of the cooperating national programs, lines with large seed size (>40 g/100 seeds) and tall types suitable for mechanical harvesting have been developed and distributed.

5.3.5. Supplemental irrigation during the reproductive phase of crop growth was shown to benefit both winter and spring sown chickpea crops.

5.4. International Testing Network

Nearly 1200 sets of 34 different international nurseries and trials covering the above three food legumes were furnished to 140 cooperators in 52 countries. Demand being larger than the seeds available, we could supply only 86% of the requested nurseries.

5.5. Training

The number of training participants in FLIP during 1985/86 was 102. Of these, 80% were in the group training courses and the remaining as individual trainees for degree or non-degree training programs. Besides organizing an annual residential training course, the program conducted two short courses at the headquarters; one on mechanization of lentil and the other on creation of artificial disease epiphytotics in faba bean. Two in-country training courses were also organized.

5.6. Conferences

The first International Food Legume Research Conference on cool season food legumes (dry-pea, faba bean, chickpea and lentil), held in July 1986 in Spokane, Washington, USA, was sponsored by ICARDA along with three US Universities, USAID and IDRC. A regional workshop on Biological Nitrogen Fixation was organised in April 1986 at Aleppo in collaboration with the Pasture, Forage and Livestock Improvement Program.

1. FABA BEAN IMPROVEMENT

Research on faba bean improvement continued 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 Program. Research on faba bean improvement carried out in the Nile Valley of Egypt, Sudan, and Ethiopia 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, the major effort on the improvement work was assigned to development of genotypes and production and plant protection techniques of faba bean for such an environment.

1.1. Germplasm

The faba bean germplasm collection at ICARDA is maintained in two different forms. The first is the ILB[1] collection which is the original germplasm accessions as received, usually heterogenous, heterozygous populations. This collection is now the responsibility of the Genetic Resources Program. The other collection is a set of inbred lines developed from the ILB collection. These BPL[2] accessions are derived by a process of selfing and single plant progenies to produce

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1) ILB= ICARDA Legume Faba Bean

2) BPL= Faba Bean Pure Line

inbred line sources for use in the breeding program. These lines have the advantage of ease of maintenance, repeatability of evaluations, and they allow genes from different sources to be kept separated so not many are lost by genetic drift. The BPL collection now stands at over 5200 accessions. The work on BPL's is shown in Table 1.1.1.

From this pre-breeding activity 840 BPL's were sufficiently inbred to allow an evaluation trial in the 1985/86 season. These lines were evaluated in a series of 28 experiments with four checks in each. The BPL accessions were evaluated for the IPBGR/ICARDA faba bean germplasm descriptor list. Yield data was adjusted based on the values of the checks in each experiment. The distributions for flowering date, plant height, hundred seed weight, and grain yield are given in Figures 1.1.1, 1.1.2, 1.1.3, and 1.1.4. There were some very high yielding BPL's with the best yield of 7.3 t/ha vs. 6.0 t/ha for the best check (Table 1.1.2). There were 13 BPL's with yields over 6 t/ha; these are very uniform highly inbred lines, with over 6 to 7 cycles of inbreeding using single plant progeny rows. The best lines will be evaluated for yield in 1986/87 and seed will be increased in the screenhouse at ICARDA.

M. El-Sherbeeny and L.D. Robertson.

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 1985/86 season. Work for developing disease resistance included screening and selection within ILR accessions for resistance

Table 1.1.1. Faba Bean Germplasm Lines grown in 1985/86 and planned for the period from 1986/87 to 1987/88.

Stage of development	1985/86	1986/87	1987/88
Increase	1352	680	1300
Cycle 5	483	381	-
Cycle 4	383	576	-
Cycle 3	643	743	-
Cycle 2	1639	-	381
Cycle 1	381	-	-
ILB	-	68	X[1]
Autofertility	840	-	650
Total	5721	2453	2331

1) X=A number of lines may be added.

Table 1.1.2. Performance of the 25 highest yielding pure lines and checks in the BPL evaluation experiments, Tel Hadya, Syria, 1985/86.

BPL	ILB	Origin	Days to 50% flowering	Plant height (cm)	100-seed weight (g)	Grain yield (t/ha)
986	669	Syria	97	102	88	7.25
53	28	Iraq	97	87	126	7.22
1015	784	Iraq	95	110	141	7.01
65	33	Iraq	102	83	126	6.64
52	28	Iraq	100	96	134	6.59
444	276	Lebanon	95	75	129	6.22
46	24	Iraq	95	83	155	6.19
321	195	Turkey	100	98	131	6.18
133	66	U.K.	97	84	105	6.18
393	244	Turkey	98	92	135	6.15
442	275	Lebanon	98	83	129	6.15
1164	923	Tunisia	99	108	107	6.14
22	13	Syria	102	78	155	6.10
596	358	Egypt	105	103	100	6.07
1046	815	Algeria	103	108	100	5.96
999	768	Syria	95	108	136	5.90
1043	811	Morocco	99	106	108	5.89
725	454	Sudan	92	80	100	5.88
379	236	Turkey	102	88	112	5.87
47	25	Iraq	98	93	90	5.85
451	280	Lebanon	95	83	132	5.85
787	518	Afghanistan	116	98	56	5.84
1120	882	Lebanon	99	103	145	5.82
77	38	Iraq	97	92	193	5.76
24	15	Syria	97	94	140	5.75
Syrian L.L.	1814	Syria	94	96	170	5.82
Reina Blanca	1270	Spain	100	82	133	4.22
Lebanese L.S.	1816	Lebanon	98	94	62	4.56
Lebanese L.L.	1817	Lebanon	96	95	165	6.04
L.S.D. (0.05)			2.6	11.7	17.0	1.084
C.V. %			2	11	16	26

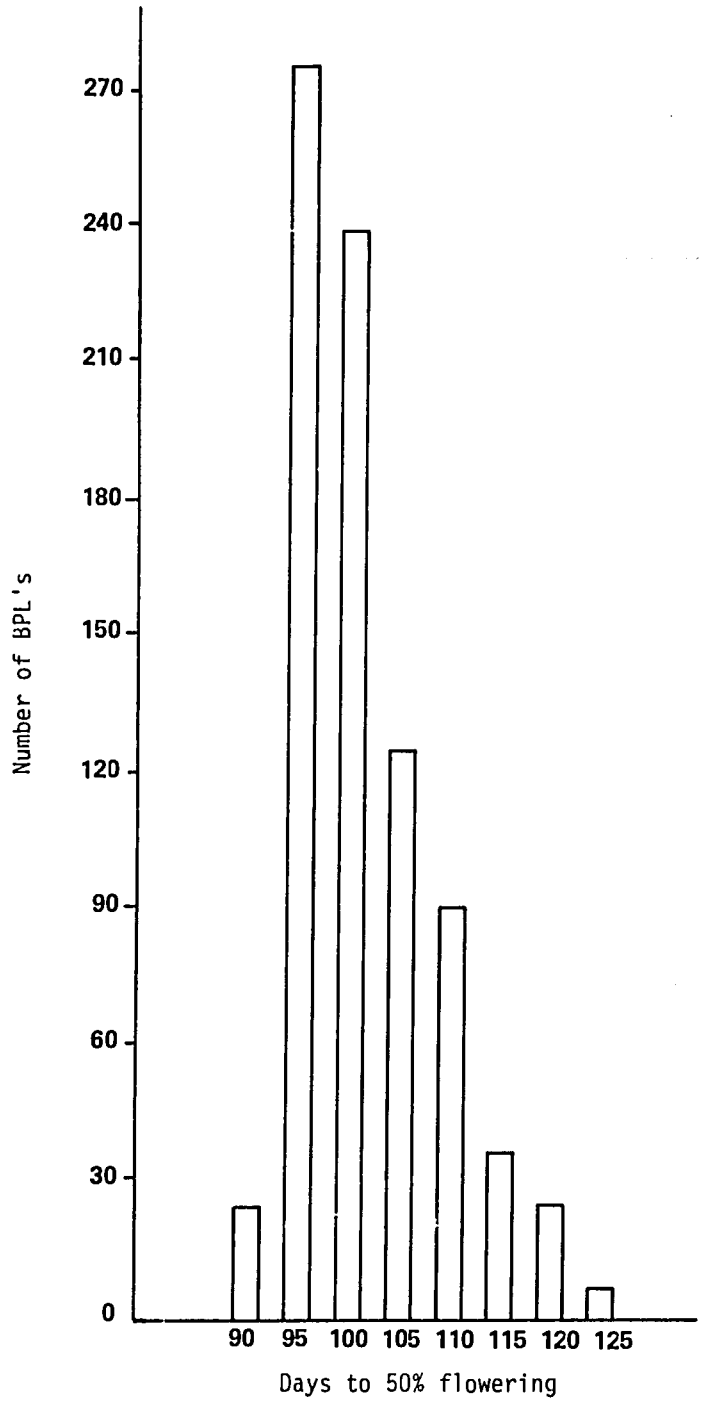


Figure 1.1.1. Frequency distribution for days to 50% flowering in 840 BPL accessions evaluated at Tel Hadya, 1985/86.

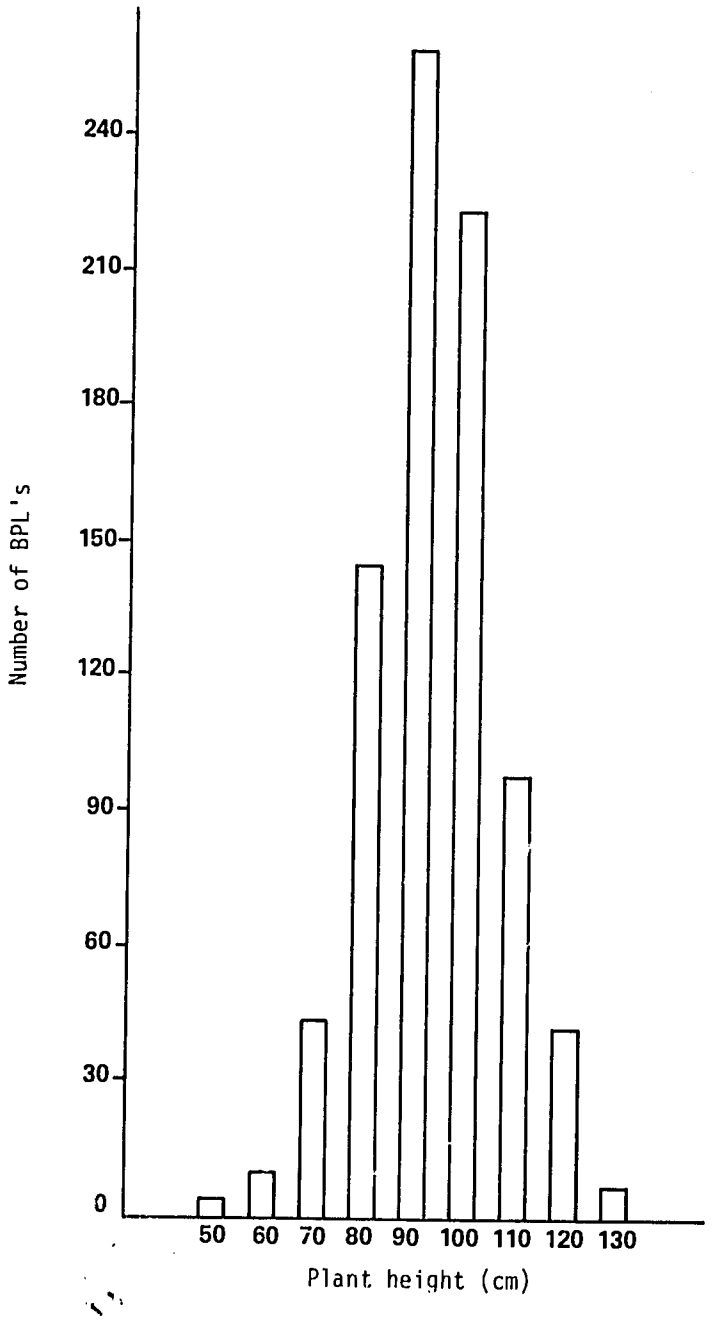


Figure 1.1.2. Frequency distribution of plant height classes in 840 BPL's evaluated at Tel Hadya, 1985/86.

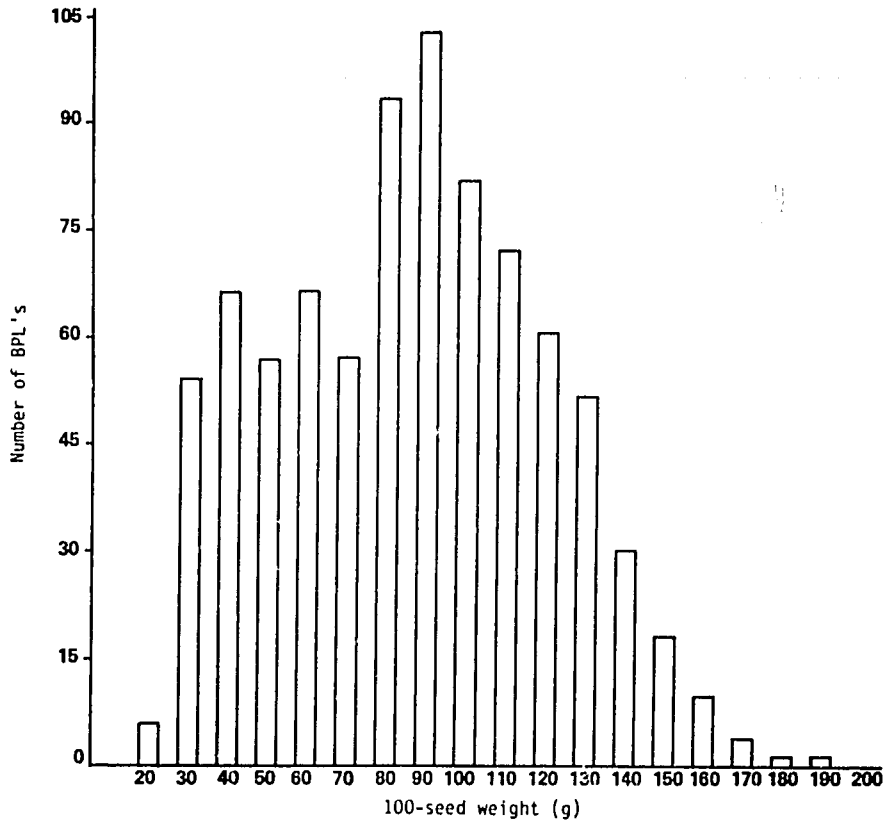
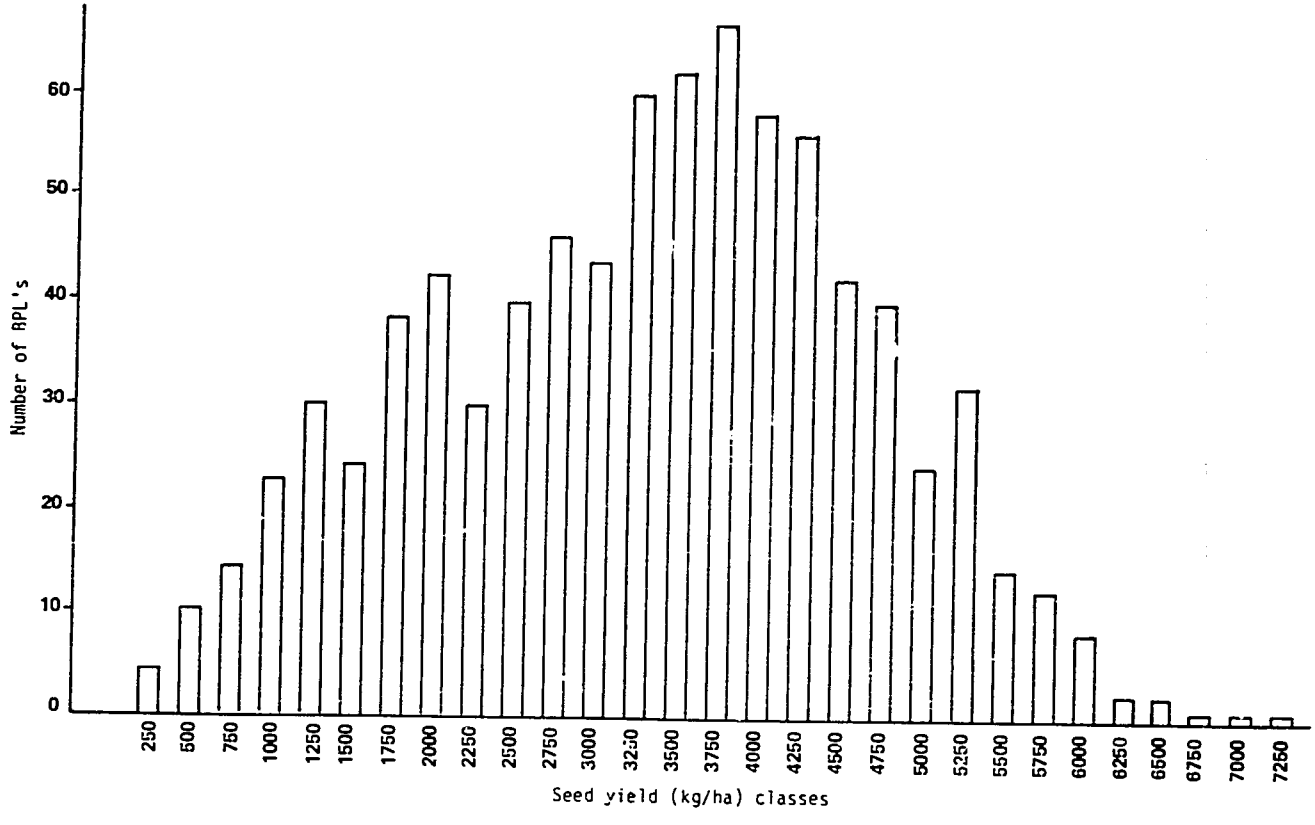


Figure 1.1.3. Frequency distribution of 100-seed weight classes in 840 BPL's evaluated at Tel Hadya, 1985/86.

Figure 1.1.4. Distribution of grain yield for 840 BPL accessions grown at Tel Hadya in the 1985/86 season.



to Botrytis fabae at the disease screening site in Lattakia. However, more emphasis has started to be given in using resistance sources already found. This 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 agro-ecological conditions in the region.

1.2.1.1. Germplasm for Disease Resistance

1.2.1.1.1. Chocolate Spot: For chocolate spot (Botrytis fabae) 132 selections from ILB accessions were rescreened and 118 single plant selections made at Lattakia. These will be rescreened in 1986/87 with further within line selection to purify the resistance. Of 132 selections tested, 64 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 selections.
S.B. Hanounik and L.D. Robertson.

1.2.1.1.2. Ascochyta Blight (Ascochyta fabae): This nursery included selections from BPL accessions from a first screening cycle in the 1983/84 season. Of the 113 selections from 32 BPL accessions tested in 1985/86, 111 were rated 1,3, or 5, with the other 2 rated 7 or 9. In this nursery 75 single plant selections were made for increase in the 1986/87 season (after the 1986 off-season increase) for inclusion in international testing and use in the ICARDA breeding program.
S.B. Hanounik and L.D. Robertson.

1.2.1.1.3. Rust (Uromyces viciae fabae): Of 98 BPL accessions tested, 16 were rated 3 or 5 with the remaining 82 rated 7 or 9. In this nursery 30 single plant selections were made for further evaluation and purification in the 1986/87 season.
S.B. Hanounik and L.D. Robertson.

1.2.1.1.4. Stem nematodes: The stem nematode (Ditylenchus dipsaci) is a destructive seed and soil borne pathogen of faba bean in many parts of temperate regions including the Middle East, North Africa and Europe. Infected seeds and plant debris play an important role in its survival and dissemination. Although the application of some nematicides could provide partial control, their use alone does not represent an effective and practical method of crop protection. Therefore, our attention has been focused on the identification of resistant sources. These efforts resulted in the detection of some sources for resistance to this nematode. Results concerning the evaluation of these sources at ICARDA in 1981 and 1982 and Tunisia in 1984 are shown in Table 1.2.1.

S.B. Hanounik.

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, 1984/85 and 1985/86 for further purification for disease resistance under bee-proof cages. There are now 41 chocolate spot, 25 ascochyta blight, and 28 rust resistant lines purified for four cycles by disease inoculation and single plant selection (Tables 1.2.2, 1.2.3, and 1.2.4). This process will be repeated in 1986/87. This is providing sources of disease resistance for the crossing program and in 1986/87 a diallel will be used to study inheritance of resistance to chocolate spot using these sources of resistance. Additionally, crosses will be made to study the inheritance of ascochyta blight resistance.

S.B. Hanounik and L.D. Robertson.

Table 1.2.1. Faba bean (*Vicia faba*) reactions to *Ditylenchus dipsaci* at different locations.

Entry No.	BPL	Origin	Disease Reaction[a]		
			Syria		Tunisia
			1981	1982	1984
1	1	Jordan	R	R	R
2	11	Jordan	R	R	R
3	12	Jordan	R	R	R
4	21	Syria	R	R	R
5	26	Syria	R	R	R
6	27-1	Syria	R	R	R
7	27-2	Syria	R	R	R
8	63	Iraq	R	R	R
9	88-1	Iraq	R	R	R
10	88-2	Iraq	R	R	R
11	183	Afghanistan	R	R	R
12	40	Syria	R	R	R
13	Syrian local	Syria	S	S	NT[b]
14	Tunisian local		NT	NT	S

[a] R = Resistance denotes 1, 3, or 5, and S = susceptibility denotes 7 or 9 on ICARDA's 1-9 rating scale.

[b] NT = Not tested.

Table 1.2.2. Disease reaction on chocolate spot-resistant inbred lines.

Sel-81-Lat	BPL	Disease rating[1]	Sel-81-Lat	BPL	Disease rating[1]
24640-1	112	5	24948-1B	1179	3
24640-2A	112	5	24948-2	1179	3
24640-2B	112	3	24948-6	1179	3
24694-2	261	3	24950-6	1196	5
24694-3	261	5	24996	1538	7
24694-4	261	5	25005-2	1548	7
24698-1	266	3	25075	1689	7
24701-1	274	5	25087	2749	5
24701-2	274	3	25096	1758	7
24799	461	5	25099	1763	5
24833	658	5	25100	1764	5
24857-1	710	3	25111	1802	5
24857-2	710	3	25114-1	1821	5
24901	1056	5	25114-2A	1821	5
24902	1058	5	25116-2B	1821	5
24948-1A	1179	3	25117	1832	5
Rebaya 40	ILB 365	9			

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

Table 1.2.3. Disease reaction on ascochyta blight resistant inbred lines.

Sel.80-Lat.		BPL	Disease rating[1]	Remarks[2]
70015-1		74	3	MR
70015-2		74	3	MR
70015-4		74	3	MR
14200-1		230	3	MR
14336		365	3	MR
14399		436	3	MR
14427		465	3	MR
14434-1		471	3	MR
14434-2B		471	3	MR
14434-3		471	3	MR
14435-1		472	3	MR
14435-2		472	3	MR
14435-3		472	3	MR
14435-4		472	3	MR
14986-1		266	3	MR
14998-2		646	3	R
14998-3		646	3	MR
15025	ILB	752	3	MR
15035-2		818	3	R
		A-2	3	MR
SEL.82-LAT	10026	2485	3	MR
Giza 4	ILB	1820	9	-

1) Disease readings were made on ICARDA's 1-9 ascochyta blight rating scale.
2) Moderately resistant (MR) and resistant (R) to bean yellow mosaic virus (BYMV).

Table 1.2.4. Disease reaction on rust-resistant inbred lines.

Sel-83-Lat.	BPL	Disease reaction[1]
30008	7	3
30010	8	3
30164-1	260	3
30164-2	260	3
30168-1	263	3
30168-2	263	3
30192	309	3
30244	406	3
30258	417	3
30268-1	427	3
30268-2	427	3
30268-3	427	3
30273	ILB 1814	3
30318	481	3
30332-1	484	3
30332-2	484	3
30328	490	3
30374	522	3
30378-1	524	3
30378-2	524	3
30384-1	530	3
30384-2	530	3
30386	533	3
30388-1	536	3
30388-2	536	3
30394	539	3
Sel-81-Lat. 24857	710	3
Sel-80-Lat. 15563-1A	-	3
Sel-80-Lat. 15563-1B	-	3
Sel-81-Lat. 24948-6	1179	3
Rebaya 40	-	9

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

1.2.1.3. International Disease Screening Nurseries

Seeds of several chocolate spot, ascochyta blight, and rust resistant sources identified in the screening program at Lattakia were included in the Faba Bean International Disease Screening Nurseries. However, results concerning the reaction of entries in these nurseries were not received from all locations.

Although the FBICSN-86 (chocolate spot nursery) was provided for testing in 12 countries, results were obtained only from Syria, Egypt, Canada, and Morocco. Of the 29 entries tested during 1984, 1985 and 1986 in seven countries, only one, BPL 1179 (81 Lat. 24948-2), was rated resistant across all locations including the most virulent isolate B-29 used in Canada to inoculate this nursery under highly disease-inductive-conditions (Table 1.2.5). Although BPL 1179 (81 Lat. 24948-1) and BPL 710 (81 Lat. 24857-1) were also rated resistant across all locations, they were rated susceptible to isolate B-29 in Canada. However, disease reaction of the remainig entries varied considerably among different locations, indicating the possible presence of physiological specialization in the host-pathogen system of chocolate spot. This aspect is discussed in section 1.3.1 later.

Although the FBIABN-86 (ascochyta blight nursery) was provided for testing in 11 countries, no results have yet been received. Results of 1983, 1984, and 1985 indicated the presence of a location-non-specific and a location-specific resistance to A.fabae. Resistant at all locations were BPL 460, BPL 471, ILB 382, 83-30118-1, 83-31616-1, and 83-31818-4; all other lines showed location specific resistance.

Results from the FBIRN-86 (rust nursery) have only been received from Egypt. Results from 1983 through 1985 indicate that BPL 1179 has location-non-specific resistance with other lines showing location-specific resistance. It should be noted that BPL 1179 is also

Table 1.2.5. Chocolate spot reaction of entries of *Vicia faba* in different countries.

Entry No.	Selection	Accessions	Origin	Disease reaction[1]												
				Syria			Egypt			U.K.		Canada[2]		China	Morocco	Qatar
				84	85	86	84	85	86	84	85	B27	B29	85	86	85
1	81 LAT. 24701-2	BPL 274	Holland	R	R	R	R	R	R	NT	S	R	S	R	S	S
2	81 LAT. 24948-1	BPL 1179	Ecuador	R	R	R	R	R	R	R	R	R	S	R	R	R
3	81 LAT. 24948-2	BPL 1179	Ecuador	R	R	R	R	R	R	NT	R	R	R	R	R	R
4	81 LAT. 24857-1	BPL 710	Ecuador	R	R	R	R	R	R	R	R	R	S	R	R	R
5	81 LAT. 24957	BPL 1278	Syria	R	R	R	R	S	R	NT	S	R	R	R	S	S
6	83 LAT. 5007-1		ICARDA	R	R	R	NT	S	NT	NT	S	NT	NT	S	NT	R
7	83 LAT. 5121-1		ICARDA	R	R	R	NT	R	NT	NT	R	NT	NT	R	NT	R
8	S81062-8	FLIP 83-30FB	ICARDA	R	R	R	NT	S	NT	NT	S	NT	NT	R	NT	S
9	S81064-15	FLIP 83-31F3	ICARDA	R	R	R	NT	R	NT	NT	R	NT	NT	R	NT	R
10	S81062-2	FLIP 83-37FB	ICARDA	R	R	R	NT	R	NT	NT	R	NT	NT	R	NT	S
11	S81066-15	FLIP 83-38FB	ICARDA	R	R	R	NT	S	NT	NT	S	NT	NT	R	NT	S
12	S8164-8	FLIP 83-112FB	ICARDA	R	R	R	NT	S	NT	NT	S	NT	NT	R	NT	S
13	81 LAT. 24638-1	BPL 110	U.K.	R	R	R	NT	R	R	NT	NT	R	S	NT	S	NT
14	81 LAT. 24640-1	BPL 112	U.K.	R	R	R	NT	R	R	NT	NT	R	S	NT	S	NT
15	81 LAT. 24640-2A	BPL 112	U.K.	R	R	R	NT	NT	R	NT	NT	R	S	NT	S	NT
16	81 LAT. 24640-2B	BPL 112	U.K.	R	R	R	NT	NT	R	NT	NT	R	S	NT	R	NT
17	81 LAT. 24694-1A	BPL 261	Greece	R	R	R	R	R	R	S	NT	R	R	NT	S	NT
18	81 LAT. 24694-1B	BPL 261	Greece	R	R	R	NT	NT	R	NT	NT	R	S	NT	S	NT
19	81 LAT. 24694-2A	BPL 261	Greece	R	R	R	NT	NT	R	NT	NT	R	S	NT	R	NT
20	81 LAT. 24694-2B	BPL 261	Greece	R	R	R	NT	NT	R	NT	NT	R	S	NT	S	NT
21	81 LAT. 24698-1	BPL 266	Greece	R	R	R	R	R	R	S	NT	R	S	NT	S	NT
22	81 LAT. 24901-2	BPL 1056	Turkey	R	R	R	NT	NT	R	NT	NT	R	S	NT	S	NT
23	81 LAT. 24996	BPL 1538	Netherlands	R	R	S	NT	R	R	NT	NT	R	S	NT	S	NT
24	81 LAT. 25003	BPL 1546	Netherlands	R	R	S	NT	S	R	NT	NT	R	R	NT	S	NT
25	S81077-1	-	ICARDA	R	R	NT	NT	R	S	NT	NT	R	S	NT	S	NT
26	81 LAT, 25111	BPL 1802	Ethiopia	R	R	R	NT	NT	R	NT	NT	R	S	NT	S	NT
27	81 LAT. 25114-1	BPL 1821	Ethiopia	R	R	R	R	R	R	S	NT	S	S	NT	S	NT
28	Rebaya 40	ILB 365	Egypt	S	S	S	S	S	S	S	NT	R	S	NT	S	NT
29	Syrian local large	ILB 1814	ICARDA	S	S	S	R	S	R	S	S	R	S	R	S	R
30	Local check	-	-	NT	NT	NT	S	S	S	S	S	R	S	R	S	S

1. Disease ratings were made on ICARDA's 1-9 rating scale.
2. Reactions in Canada were recorded in moist chambers in 1985 for isolates B27 and B29.

resistant to chocolate spot.

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 (Table 1.2.6). F_2 and F_3 bulks will be supplied in 1987 along with F_2 selections made for disease resistance at ICARDA in the 1986/87 season. Additionally and especially for Sudan, backcrosses to the country parent will be made for some crosses in the 1986/87 season. Selections will also go into progeny rows with lines fed into preliminary yield trials and F_3 bulks to go into the international F_4 nurseries. New single crosses will be made with new resistance sources in the 1986/87 season.
L.D. Robertson and S.B. Hanounik.

1.2.1.5. Resistance to Aphis fabae

Resistance to Aphis fabae in faba beans was screened using 745 BPL accessions 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 4 with 1=very resistant and 4=very susceptible. Of the 745 tested 30 were rated resistant (Table 1.2.7). These lines will be rescreened in 1986/87 with a more detailed study of their resistance.
L.D. Robertson and C. Cardona.

1.2.1.6. Autofertile Inbred Lines

An autofertility evaluation was made for 840 BPL accessions by comparing the number of seeds/plants and pods/plant with tripped and nontripped plants when grown under insect-proof mesh covered

Table 1.2.6. Crosses made for different countries/regions in 1985/86.

Country/ Region	Resistant to								Deter- minate	IVS	Large seed	Total crosses
	Botrytis	Ascochyta	Rust	Virus	Oro- banche	Stem nematode	Root rot	Total				
Ethiopia	16	-	16	-	-	-	-	32	-	-	6	38
China	10	-	6	-	-	-	-	16	14	-	-	30
North Africa	10	10	-	-	4	-	-	24	-	-	8	32
Egypt	10	-	10	10	10	6	-	46	-	4	-	50
Sudan	-	-	-	18	-	-	28	46	-	-	-	46
Syria	5	2	-	-	-	-	-	7	-	-	3	10
Total	51	12	32	28	14	6	28	171	14	4	17	206

Table 1.2.7. Aphid resistance of 740 BPL accessions.

Visual Damage Score[1]	Number of BPL's
1.0-1.5	30
1.6-2.0	56
2.1-2.5	76
2.6-3.0	216
3.1-4.0	367

[1] Where 1=no apparent aphid damage, 2=slight damage, some curling of leaves, 3=heavy damage, curling of leaves, honeydew production, and 4=severe damage, extreme curling of leaves, heavy honeydew production, stunting of plants.

Table 1.2.9. Grain yield, 100-seed weight, flowering date, plant height, and autofertility (seed index) of 15 BPL accessions and four checks grown at Tel Hadya in 1985/86.

Line	Seed index[1]	Grain yield (t/ha)	100-seed weight (g)	Flowering date (days)	Plant height (cm)
BPL 65	0.78	6.64	126	102	83
BPL 52	0.92	6.60	134	100	96
BPL 46	1.13	6.19	156	95	83
BPL 442	0.84	6.15	129	98	83
BPL 22	1.02	6.10	155	102	78
BPL 596	1.39	6.07	101	105	103
BPL 1043	0.82	5.89	108	99	106
BPL 725	0.78	5.88	99	92	80
BPL 47	1.48	5.85	90	98	93
BPL 451	0.78	5.85	132	95	83
BPL 24	0.97	5.75	140	97	94
BPL 571	1.09	5.72	120	95	88
BPL 581	0.83	5.68	76	101	81
BPL 435	1.46	5.64	70	100	88
BPL 68	1.06	5.64	135	97	94
ILB 1814	-	5.82	170	99	96
ILB 1270	-	4.22	133	100	82
ILB 1816	-	4.56	62	98	94
ILB 1817	-	6.04	165	96	95
L.S.D. (5%)	-	1.08	17.0	2.6	11.7
C.V. (%)	-	26	16	2	11

1) Seed index = (number of seed/plant non-tripped)/(number of seeds/plant tripped).

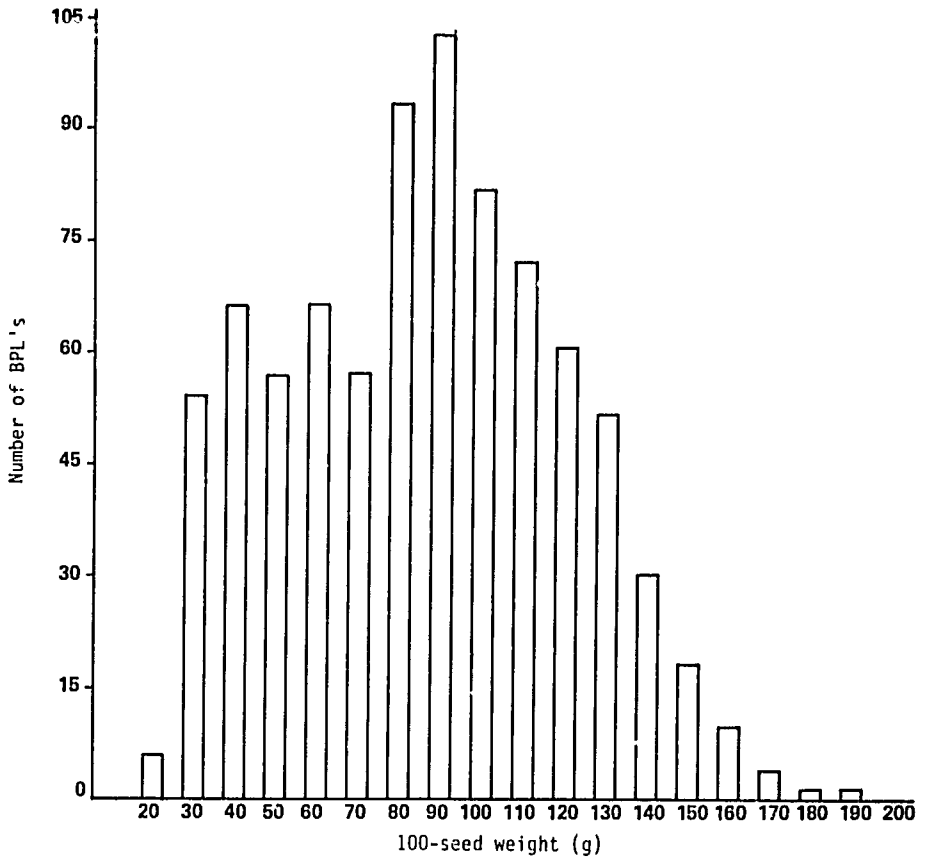


Figure 1.1.3. Frequency distribution of 100-seed weight classes in 804 BPL's evaluated at Tel Hadya, 1985/86.

screenhouses. These lines had been through at least 6 or 7 selfing cycles under insect-proof mesh covered screenhouses. A large variation was seen in the distribution of autofertility (Figure 1.2.1). The correlation between the seeds/plant and pods/plant indices was 0.91**.

Autofertility can be very important when insect pollinators are not present and autostertility can result in severe yield losses. Lines with high autofertility and high yield were found in the 840 BPL accessions tested and they included large seeded lines (Table 1.2.8). There were six lines that exceeded the best check for grain yield with an autofertility index of 0.75. These lines will be tested for yield and autofertility again and be used in the crossing program in 1986/87. L.D.Robertson and M. El-Sherbeeny.

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

Faba beans in most of the ICARDA region are grown where there is adequate rainfall/supplementary irrigation.To obtain high and stable yield, 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 1985/86 season most of the crosses involved at least one parent resistant to a pest (Table 1.2.9). This trend will continue in future.

Crosses were undertaken in the 1985/86 season at Tel Hadya and Lattakia, Syria for several national programs including Ethiopia, Egypt, China, Sudan, and the North African region. Disease resistant crosses have been already discussed (Table 1.2.6). Additionally,

Table 1.2.9. Number of crosses made for various traits or reasons in the 1985/86 season and planned for 1986/87 (excluding alternative plant types).

	Number of crosses	
	1985/86	1986/87
Ascochyta fabae resistance	60	50
Botrytis fabae resistance	60	50
Uromyces fabae resistance	20	20
Multiple disease resistance	20	40
Protein percentage	10	-
Earliness	-	20
Yield	-	-
National Programs	204	120
Total	374	300

crosses were made with determinate lines, IVS (independent vascular supply) lines, and lines such as Reina Blanca and New Mammoth which show good adaption in many of the above countries. This crossing will continue in 1986/87 with backcrosses to the country parent also included in the crossing flock.

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 1.2.2. This scheme makes use of an off-season nursery at Shawbak, Jordan at the F_1 and F_4 progeny row (increase to 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 within the F_2 populations (at Tel Hadya for yield and at Lattakia for disease resistance) and F_3 progeny rows grown where selections are made for yield, frost resistance and disease resistance, with these selections going to Lattakia as F_4 progeny rows where selections are made for increase for preliminary screening nurseries (PSN). Lines are then advanced through PSN's and preliminary, advanced and international trials using multilocation testing. Brassica napus is used for pollination control in trials. This reduces the inter-mixing of genotypes 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.

In replicated yield trials the highest yield at Tel Hadya in the 1985/86 season was 5.72 t/ha compared to only 2.5 t/ha in the 1984/85 season where frost severely reduced yields. Replicated yield trials of 879 lines were conducted at Tel Hadya under irrigated conditions during the 1985/86 season (Table 1.2.10). There were 354 entries that

Figure 1.2.2. **The Faba Bean Breeding Program at ICARDA.**

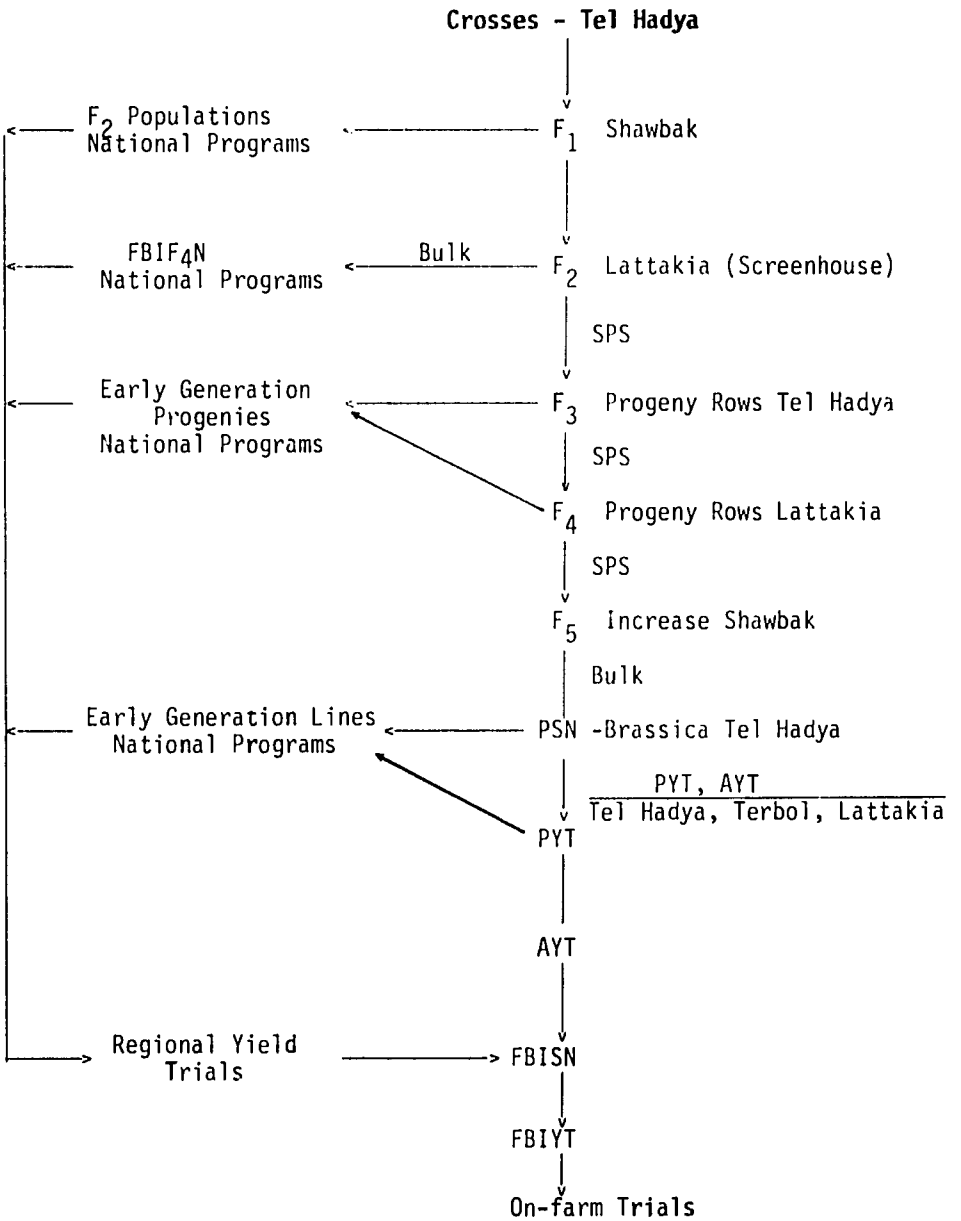


Table 1.2.10. Results of faba bean yield trials grown at Tel Hadya, Syria during the 1985/86 season.

Trial	No. of test entries	No. of lines exceeding best check		Grain Yield (kg/ha x000)					Checks
		total	significantly (P=0.05)	Trial(s) mean	Best line mean	Best check mean	L.S.D. check vs. line (5%)	C.V. (%)	
FBIYT-L	16	1	0	4.80	5.44	5.23	.760	11.4	ILB 1814
FBIYT-S	16	8(13)[1]	0(5)[1]	4.96	5.61	5.18(4.73)[2]	.698	10.2	ILB 1814, ILB 1819
FBISN-L	31	1	0	3.32	3.79	3.78	.588	13.0	ILB 1814, ILB 1270
FBISN-S	56	7	0	3.33	4.29	3.78	.827	18.3	ILB 1814, ILB 1270
FBEYT-L	69	5	0	3.00	3.74	3.50	.638	19.3	ILB 1814
FBEYT-S	45	20(36)	0(0)	3.29	4.10	3.45(3.03)	1.047	23.0	ILB 1814, ILB 1816
FBAYT-L	96	34	0	3.05	3.89	3.21	.695	16.8	ILB 1814, ILB 1817
FBAYT-S	45	1(10)	0(1)	2.82	3.60	3.48(3.04)	.499	13.0	ILB 1814, ILB 1816
FBPYT-L	288	104	12	4.16	5.72	4.34	.617	14.3	ILB 1814, ILB 1817
FBPYT-S	141	69(91)	9(14)	4.14	5.60	4.14(3.97)	.954	21.5	ILB 1814, ILB 1816
FBPYT-Disease	76	7(48)	1(4)	3.30	4.58	3.82(3.19)	.754	16.9	ILB 1814, ILB 1816
FBAYT-Rainfed	21	(2)	0(0)	1.06	1.44	1.34(1.30)	.241	16.6	ILB 1814, ILB 1816

1. Number of lines exceeding the best small seeded check or significantly greater than the best small seeded check.
2. Best small seeded check mean.

exceeded the best check (or best small seeded check in small seeded trials) and 36 of these were significantly better than the check at the 5% probability level.

At Terbol, Lebanon a total of 758 lines were yield tested in the 1985/86 season with the highest yield reported being 6.36 t/ha (Table 1.2.11). There were 311 lines that outyielded the best check (or best small seeded check in small seeded trials) with 32 lines significantly better at the 5% probability level.

A total of 1786 F_2 single plant selections were made in the 1985/86 season which will be grown in F_3 progeny rows during the 1986/87 season. From F_3 progeny rows a total of 1951 selections were made for F_4 progeny rows and 677 selections were made from preliminary yield trials which will go to F_4 progeny rows in 1986/87. There were 716 selections from F_4 progeny rows for preliminary screening nurseries large and small in 1986/87. There were 87 selections from the preliminary yield trial (disease) for F_4 progeny rows and 139 selections for the preliminary screening nursery (disease) for the 1986/87 season.

From PSN-L-86 192 selections were made for the 1987 PYT-L and from the PSN-S-86 and PSN-Disease-86 96 selections were made for the PYT-S in 1987.

Ninty-six lines from the preliminary yield trials (large, small, and disease) were selected for advanced yield trials in 1986/87. From advanced yield trials 45 lines were selected.
L.D. Robertson.

Table 1.2.11. Results of faba bean yield trials grown at Terbol, Lebanon during the 1985/86 season.

Trial	No. of test entries	No. of lines exceeding best check		Grain Yield (kg/ha x000)					Checks
		Total	significantly (P=0.05)	Trial(s) mean	Best line mean	Best check mean	L.S.D. check vs. line (5%)	C.V. (%)	
FBIYT-L	16	6	0	4.21	5.15	4.39	.996	17.1	ILB 1814
FBIYT-S	16	11	2	4.95	5.85	4.90	.814	11.9	ILB 1814, ILB 1819
FBISN-L	31	17	1	5.03	6.14	5.04	1.088	15.8	ILB 1814, ILB 1270
FBISN-S	56	35	2	5.20	6.19	5.15	.921	10.0	ILB 1814, ILB 1270
FBEYT-L	69	42	6	4.79	5.37	4.69	.646	11.7	ILB 1814
FBEYT-S	45	12	0	4.18	4.92	4.59	1.063	12.7	ILB 1814, ILB 1816
FBAYT-L	96	24	1	4.84	6.36	5.15	1.163	14.4	ILB 1814, ILB 1817
FBAYT-L	288	71	7	4.89	6.25	6.26	.628	10.2	ILB 1814, ILB 1817
FBPYT-S	141	11(93)[1]	3(13)[1]	4.47	5.70	5.16(4.16)[2]	.952	16.2	ILB 1814, ILB 1816

1. Number of lines exceeding the best small seeded check, or significantly greater than the best small seeded check.

2. Best small seeded check mean.

1.2.2.2. Disease Resistance

The major disease resistance work, as mentioned earlier, was carried out at Lattakia. At this location environmental conditions are conducive for the development of natural epiphytotics. But in order to ensure proper screening, artificial epiphytotics were developed.

In 1985/86 the new system of screening most F_2 populations for disease resistance was started at Lattakia. These selections will be grown at Tel Hadya in 1986/87 in F_3 progeny rows and selections made for F_4 progeny rows to be screened for disease resistance at Lattakia. Selections from these F_4 progenies will again go to Shawbak, Jordan for an offseason increase and then to Tel Hadya for F_6 PSN's. This system of selection is shown in Figure 1.2.2. This means most of the crosses in Table 1.2.9 will be grown at Lattakia for disease screening.

Ascochyta blight: Various sources of resistance were used to make 60 crosses for ascochyta blight in 1985/86 and these will be screened in 1986/87 at Lattakia. At Lattakia 45 F_2 populations were planted and 765 single plant selections were made for F_3 progeny rows to be grown in Tel Hadya in 1986/87. The bulk of selections of each cross will be increased to produce F_4 bulks for the 1987/88 international F_4 nursery.

Selections from 8 F_2 populations grown in 1984/85 were grown in F_3 progeny rows and 228 single plant selections were made for F_4 progeny rows to be grown at Tel Hadya in 1986/87.

Nine F_5 selections were grown from one cross between BPL 470 and ILB 37. This nursery was severely affected by BYMV and the eight selections seemed highly resistant to both BYMV and ascochyta blight. These were increased in the 1986 off-season and will be tested in a PYT in 1986/87.

Chocolate spot: Chocolate spot resistant sources were used for making 60 crosses which will be screened for resistance in 1986/87 at Lattakia. Chocolate spot resistance was screened for in 43 crosses at Lattakia in 1985/86 and 222 single plant selections were made for F_3 progeny rows at Tel Hadya in 1986/87. Additionally, the bulks of the selections will be increased at Tel Hadya to provide seeds for the $FBIF_4N$-88. The low ratio of resistant to susceptible plants observed in the 43 populations was apparently due to some viral infections which rendered plants less resistant to chocolate spot.

From 68 F_3 progeny rows grown in Lattakia, selected from 13 F_2 populations in 1984/85 for chocolate spot resistance, 174 single plant selections were made for chocolate spot resistance to be grown in F_4 progeny rows in 1986/87 at Tel Hadya.

In 31 F_6 progeny rows selected from 14 F_4 progenies, followed by an off-season increase, 22 selections were made and increased in the 1986 off-season for inclusion in a PYT in 1986/87 at Tel Hadya.

Rust: 20 crosses were made in 1985/86 and these will be screened for rust resistance in 1986/87 at Lattakia. From 14 F_2 populations 112 single plant selections were made for rust resistance to grow in F_3 progeny rows at Tel Hadya in 1986/87. Additionally, the bulk of the selections will be increased at Tel Hadya to provide seeds for the $FBIF_4N$-1988.

Durable disease resistance

Considerable evidence is available today on the presence of several races and pathogenic variations in B.fabae, A. fabae, and U. viciae fabae. In an attempt to suppress the effects, or to prevent the build-up of such destructive races, genes from plants that seemed to

have different mechanisms of resistance (disease escape, tolerance, or hypersensitivity) were combined. These efforts resulted, so far, in the development of F_6 progenies with durable resistance and greater yield compared to the susceptible cultivars Rebaya 40 and Giza 4 under the conditions of this test at FLIP's sub-site in Lattakia.

F_6 Bot x Bot: This nursery consisted of 24 F_6 progenies selected from F_4 progenies of 17 different crosses made in 1983 between several chocolate spot resistance sources, after an off-season increase. Of the 24 progenies tested 16 were rated 1, 3 or 5, with the remaining 8 rated 7 or 9. In this nursery 36 single plant selections were made (Table 1.2.12). Seeds from these selections will be planted in 1986-1987 for further purification and to produce enough seeds for preliminary yield trials.

F_6 Asco. x Asco: This nursery consisted of 65 F_6 progenies selected from F_4 progenies of 31 crosses made in 1983 between several ascochyta blight resistant sources, after an off-season increase. All of the 65 progenies were rated 1 or 3 compared to the local check which was rated 7 or 9. In this nursery 77 single plant selections were made (Table 1.2.13). Seeds from the best 16 selections were planted during the 1986 off-season to provide enough seeds for international evaluation and also for preliminary yield trials in 1986-1987. It should be noted that selections made for resistance to ascochyta blight were apparently also resistant to bean yellow mosaic virus as well as chocolate spot which occurred naturally in this nursery in 1985/86.

Multiple disease resistance

Faba bean fields have frequently been affected by combinations of different diseases, such as chocolate spot and rust in Egypt, chocolate spot and ascochyta blight in northern Europe, or chocolate spot,

Table 1.2.12. Chocolate spot reaction of entries in the F_6 Botrytis X Botrytis Nursery-Durable Resistance.

Sel.86-Lat.	Cross No.	Parents		Disease reaction[1]	
		Male	Female	CS	BYMV
2-1	L83101	BPL 710-2	BPL 1179	R	R
3-1	L83102	BPL 710-1	BPL 1179	R	MR
5-1	L83103	BPL 1278	BPL 1179	R	MR
5-2	L83103	BPL 1278	BPL 1179	R	MR
5-3	L83103	BPL 1278	BPL 1179	R	R
6-1	L83103	BPL 1278	BPL 1179	R	R
6-2	L83103	BPL 1278	BPL 1179	R	R
6-3	L83103	BPL 1278	BPL 1179	R	R
8-1	L83103	BPL 1278	BPL 1179	R	R
8-2	L83103	BPL 1278	BPL 1179	R	R
8-3	L83103	BPL 1278	BPL 1179	R	MR
9-1	L83104	BPL 1821	BPL 1179	R	MR
17-1	L83107	BPL 1179	BPL 261	R	R
17-2	L83107	BPL 1179	BPL 261	R	R
18-1	L83108	BPL 261	BPL 266	R	R
20-1	L83109	BPL 1196	BPL 266	R	R
23-1	L83111	BPL 1821	BPL 266	R	MR
27-1	L83114	BPL 1179	BPL 1390	R	R
27-2	L83114	BPL 1179	BPL 1390	R	R
27-3	L83114	BPL 1179	BPL 1390	R	MR
29-1	L83114	BPL 1179	BPL 1390	R	R
30-1	L83114	BPL 1179	BPL 1390	R	R
32-1	L83114	BPL 1179	BPL 1390	R	R
32-2	L83114	BPL 1179	BPL 1390	R	R
32-3	L83114	BPL 1179	BPL 1390	R	MR
33-1	L83115	BPL 1196	BPL 1390	R	MR
33-2	L83115	BPL 1196	BPL 1390	R	R
33-3	L83115	BPL 1196	BPL 1390	R	MR
33-4	L83115	BPL 1196	BPL 1390	R	MR
35-1	L83116	BPL 1278	BPL 1390	R	R
35-2	L83116	BPL 1278	BPL 1390	R	MR
35-3	L83116	BPL 1278	BPL 1390	R	MR
36-1	L83117	BPL 1179	BPL 1821	R	R
36-2	L83117	BPL 1179	BPL 1821	R	R
36-3	L83117	BPL 1179	BPL 1821	R	MR
	Rebaya 40	BPL 1179	BPL 1821	S	S

1) Chocolate spot (CS), and bean yellow mosaic virus (BYMV) reactions were recorded on ICARDA's scales where R, MR and S denote resistant, moderately resistant, and susceptible reactions, respectively.

Table 1.2.13. Ascochyta blight reaction of entries in the F_6 Ascochyta X Ascochyta Nursery - Durable Resistance.

Sel.86-Lat.	Cross No.	Parents		Disease reaction[1]		
		Male	Female	AB	CS	BYMV
2	L83118	ILB 37	BPL 2485	R	MR	MR
3-1	L83118	ILB 37	BPL 2485	R	MR	MR
3-2	L83118	ILB 37	BPL 2485	R	MR	MR
4-1	L83119	ILB 37	BPL 435	R	MR	MR
6-1	L83120	ILB 37	BPL 460	R	MR	R
6-2	L83120	ILB 37	BPL 460	R	MR	MR
6-3	L83120	ILB 37	BPL 460	R	R	R
6-4	L83120	ILB 37	BPL 460	R	MR	MR
8-1	L83123	ILB 37	15563-3	R	MR	MR
8-2	L83123	ILB 37	15563-3	R	MR	MR
8-3	L83123	ILB 37	15563-3	R	MR	MR
9-1	L83123	ILB 37	15563-3	R	R	R
9-2	L83123	ILB 37	15563-3	R	R	R
9-3	L83123	ILB 37	15563-3	R	MR	MR
11-1	L83124	BPL 2485	ILB 37	R	MR	MR
11-2	L83124	BPL 2485	ILB 37	R	MR	MR
11-3	L83124	BPL 2485	ILB 37	R	R	R
13-1	L83125	BPL 2485	BPL 460	R	MR	R
13-2	L83125	BPL 2485	BPL 460	R	R	MR
14-1	L83126	BPL 2485	BPL 471	R	MR	MR
16-1	L83127	BPL 2485	BPL 472	R	R	R
16-2	L83127	BPL 2485	BPL 472	R	MR	MR
17-1	L83127	BPL 2485	BPL 472	R	R	R
17-2	L83127	BPL 2485	BPL 472	MR	MR	MR
18-1	L83127	BPL 2485	BPL 472	R	MR	MR
19-1	L83127	BPL 2485	BPL 472	R	MR	MR
21-1	L83129	BPL 2485	BPL 818	R	MR	MR
23-1	L83129	BPL 2485	BPL 818	R	MR	MR
24-1	L83131	BPL 435	BPL 2485	R	MR	MR
26-1	L83131	BPL 435	BPL 2485	R	R	R
27-1	L83132	BPL 435	ILB 37	R	MR	MR
27-2	L83132	BPL 435	ILB 37	R	R	R
28-1	L83133	BPL 435	BPL 472	R	R	R
29-1	L83135	BPL 460	BPL 2485	R	R	R
31-1	L83135	BPL 460	BPL 2485	R	R	R
32-1	L83135	BPL 460	BPL 2485	R	MR	MR
33-1	L83136	BPL 460	ILB 37	R	MR	MR
34-1	L83136	BPL 460	ILB 37	R	MR	MR
39-1	L83140	BPL 460	BPL 266	R	MR	MR
41-1	L83141	BPL 460	15563-3	MR	MR	MR
41-2	L83141	BPL 460	15563-3	MR	MR	MR
44-1	L83142	BPL 471	BPL 2475	R	R	MR
44-2	L83142	BPL 471	BPL 2485	MR	R	R
44-3	L83142	BPL 471	BPL 2485	R	R	MR

Table 1.2.13. (Cont'd.)

Sel.86-Lat.	Cross No.	Parents		Disease reaction[1]		
		Male	Female	AB	CS	BYMV
46-1	L83143	BPL 471	ILB 37	R	MR	MR
47-1	L83143	BPL 471	ILB 37	R	MR	MR
47-2	L83143	BPL 471	ILB 37	R	MR	MR
48-1	L83145	BPL 471	BPL 460	MR	MR	R
48-2	L83145	BPL 471	BPL 460	R	MR	MR
54-1	L83149	BPL 472	BPL 2485	R	MR	MR
54-2	L83149	BPL 472	BPL 2485	R	MR	MR
58-1	L83149	BPL 472	BPL 2485	R	MR	MR
58-2	L83149	BPL 472	BPL 2485	R	MR	MR
58-3	L83149	BPL 472	BPL 2485	R	MR	MR
58-4	L83149	BPL 472	BPL 2485	R	MR	MR
59-1	L83149	BPL 472	BPL 2485	R	R	R
59-2	L83149	BPL 472	BPL 2485	R	R	R
61-1	L83150	BPL 472	BPL 471	R	MR	MR
61-2	L83150	BPL 472	BPL 471	R	MR	MR
62-1	L83150	BPL 472	BPL 471	R	MR	MR
67-1	L83151	BPL 472	BPL 435	R	MR	MR
67-2	L83151	BPL 472	BPL 435	R	MR	MR
68-1	L83152	BPL 472	BPL 266	R	MR	R
68-2	L83152	BPL 472	BPL 266	R	MR	MR
71-1	L83152	BPL 472	BPL 266	R	MR	MR
72-1	L83153	BPL 266	BPL 2485	R	MR	MR
72-2	L83153	BPL 266	BPL 2485	R	MR	MR
72-3	L83153	BPL 266	BPL 2485	R	MR	MR
76-1	L83155	BPL 266	BPL 471	R	MR	MR
77-1	L83156	ILB 37	15563-3	R	MR	MR
77-2	L83156	ILB 37	15563-3	R	MR	MR
78-1	L83158	BPL 2485	BPL 818	R	MR	MR
78-2	L83158	BPL 2485	BPL 818	R	MR	MR
78-3	L83158	BPL 2485	BPL 818	R	MR	MR
78-4	L83158	BPL 2485	BPL 818	R	MR	MR
81-1	L83159	BPL 471	BPL 818	R	R	R
81-2	L83159	BPL 471	BPL 818	R	MR	MR
	Giza 4	-	-	S	S	S

1) Ascochyta blight (AB), chocolate spot (CS), and bean yellow mosaic virus (BYMV) reactions were recorded on ICARDA's 1-9 scoring scales where R, MR, and S denote resistant, moderately resistant, and susceptible, respectively.

ascochyta blight and rust in the Middle East. Losses due to these combinations are greater compared to those caused by individual diseases. Therefore, our efforts were focused on the detection and development of new lines with multiple disease resistance. These efforts resulted in the detection of new sources with resistance to two or three diseases. Genes from these sources were combined, and F_6 progenies showed better resistance to complex disease conditions compared to local cultivars (Table 1.2.14). Seeds from these materials were increased during the 1986 off-season for preliminary yield trials and international evaluation in regions known to suffer from such complex disease problems.

Yield Testing of Disease Resistant Lines

In 1985/86 77 disease resistant lines were yield tested in preliminary yield trials and 15 were selected for advanced yield trials. From the preliminary screening nurseries 59 disease resistant lines were selected for preliminary yield trials in 1986/87. In Table 1.2.15 it can be seen that there has been progress in developing high yielding lines with disease resistance.

A total of 482 entries from the Faba Bean International, Preliminary, and Advanced Yield Trials were tested for disease reaction at FLIP's sub-site in Lattakia. These nurseries were inoculated separately with B. fabae, A. fabae, and U. viciae fabae, then evaluated for disease reaction. Although none of the entries was resistant to all of the three pathogens used for inoculation, these evaluations revealed the presence of 88, 214 and 42 entries with moderate resistance to chocolate spot, ascochyta blight and rust, respectively.
L.D. Robertson and S.B. Hanounik.

Table 1.2.14. Multiple disease resistance of certain faba bean germplasm lines and F_6 famililies.

Accession or cross	Origin or parents	Disease reaction[a]														
		Chocolate spot			Ascochyta blight			Rust			Alternaria spot			Stem-phylium		
		84	85	86	84	85	86	84	85	86	84	85	86	84	85	86
BPL 1179	Ecuador	R	R	R	NT[b]	NT	NT	R	R	R	R	R	R	R	R	R
BPL 710	Ecuador	R	R	R	NT	NT	NT	R	R	R	R	R	R	R	R	R
BPL 266	Greece	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
L82003-2	261X472	R	R	R	R	R	R	NT	NT	NT	NT	NT	NT	NT	NT	NT
L82004-1	261X74	R	R	R	R	R	R	NT	NT	NT	NT	NT	NT	NT	NT	NT
L82005-1	472X710	R	R	R	R	R	R	R	R	R	NT	NT	NT	NT	NT	NT
L82007-2	460X710	R	R	R	R	R	R	R	R	R	NT	NT	NT	NT	NT	NT
L82009-2	A2X1179	R	R	R	R	R	R	R	R	R	NT	NT	NT	NT	NT	NT
L82010-3	15563X1179	R	R	R	NT	NT	NT	R	R	R	NT	NT	NT	NT	NT	NT
L82011-2	15563X710	R	R	R	NT	NT	NT	R	R	R	NT	NT	NT	NT	NT	NT
ILB 1814	Syrian local	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
ILB 1821	Egyptian local	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
ILB 365	Egyptian local	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S

[a] R = resistance denotes 1, 3, or 5 and S = susceptibility denotes 7 or 9 on ICARDA's 1-9 scoring scale.
[b] NT = not tested.

1.2.2.3. Adaptability of Faba Beans to Environments

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, W.Germany) 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 were grown in 1985/86 to produce the base population for selection. This will be planted for the first selection cycle both at Tel Hadya, Syria and Hohenheim in W.Germany.

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 1986 and those planned for 1987 for national programs are listed in Table 1.2.16. 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, Aquadulce and New Mammoth with wider adaptability have been requested.

Additionally, F_3 progenies and lines from preliminary and advanced yield trials have been sent to natinal programs for selection in different environments. Populations and lines of this type distributed for the last two years are listed in Table 1.2.17.

Table 1.2.15. Grain yield and flowering date of some lines selected for disease resistance and yield.

Line	Grain yield (t/ha)	Flowering date (days)	Resistant to
L83116-39	4.59	105.7	Botrytis, BYMV
L83131-35-2	4.[illegible]4	103.7	Botrytis, ascochyta, BYMV
L83145-62-1	4.13	103.7	Botrytis, ascochyta, BYMV
L83152-89-3	3.95	103.3	Botrytis, ascochyta, BYMV
82LAT.30047-1-(1-1)	3.89	108.7	Ascochyta
S83135-5	3.87	103.0	Ascochyta
L83156-96	3.86	108.0	Botrytis, ascochyta, BYMV
S83135-6	3.80	99.3	Ascochyta
ILB 1814	3.82	106.2	Susceptible
ILB 1816	3.19	105.8	Susceptible
Test entry mean	3.28	105.8	
L.S.D. (5%)	0.754	5.8	
C.V. (%)	16.9	3.4	

Table 1.2.16. Crosses made for various countries or regions in 1986 and planned for 1987.

Country/Region	No. of Crosses	
	1986	1987
Egypt	50	20
Ethiopia	38	20
Sudan	46	30
China	30	40
North Africa	32	20
Syria	10	10
Total	206	140

Table 1.2.17. Distribution of F_2 and F_3 bulks and early generation lines to national programs in 1985 and 1986.

Year	Country	No. of lines/crosses	Type of Material
1985	Yemen	6	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	Reina Blanca mass selections
1985	China	100	Determinate lines
1986	Egypt	1	ILB 1270, 100kg
1986	Egypt	28	IVS lines
1986	Egypt	183	Small seeded lines
1986	Egypt	457	Determinate lines
1986	Turkey	86	Determinate lines
1986	Turkey	136	Large seeded lines
1986	Turkey	10	Lines for increase and yield trials
1986	Algeria	6	Lines for multilocation testing
1986	France	76	Determinate lines
1986	Denmark	70	Determinate lines
1986	Ethiopia	600	F_4 Progenies,1 large-seeded ILB
1986	Sudan	4	Landraces for mass selection
1986	N. Yemen	16	Multilocational testing of Elite lines
1986	N. Yemen	2	FLIP 84-14FB, FLIP 84-41FB for On-farm Trials

Material has been used directly and through selection within bulks and lines by breeders on site. In Egypt several lines have been selected for advanced yield trials and many for preliminary trials and nurseries. A request has been met for a large quantity of seed of 'Reina Blanca' and seed of a mass selection for smaller seed size within this has also been provided. In Ethiopia approximately 70 F_4 progenies have been selected from progenies provided by ICARDA which are adaptable and have large seed size, at least three times the seed size of the local. These also have cream color which is preferred over the local dark seed color. One line, New Mammoth, has been identified from ICARDA nurseries which is well adapted in Ethiopia and has the advantage of large cream color seed. In Turkey eleven lines were identified from a screening nursery and a request met for a replicated trial and seed for increase. From ICARDA international trials 59 lines were identified for multilocational testing in Tunisia. Also, 73 lines have been requested for further testing in Tunisia based on a special screening nursery provided. A request has been met for seed for multilocational testing of 16 lines in North Yemen. Also requested were two lines, FLIP 84-14FB and FLIP84-41FB, for on-farm trials in the 1986/87 season.
L.D. Robertson.

1.2.3. Cultivars for Low-Rainfall Environments

Efforts have been made in the past 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. In the 1985/86 season work on rainfed faba bean breeding was being phased out and only one trial, the FBAYT-Rainfed-86 was grown. Two lines exceeded the checks, but not significantly. This work will be discontinued in 1986/87. L.D. Robertson.

1.2.4. Development of Alternative Plant Type Faba Bean Genetic Stocks and Breeding Methology

1.2.4.1. 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 120 this season (Table 1.2.18). These were increased in the off season and F_2 populations will be screened for determinate plants in the 1986/87 season. Increased emphasis is being given to crosses for disease resistance with determinate lines and for straw strength. From F_2 populations 1727 determinate selections were made which will be grown in F_3 determinate progeny rows in 1986/87. These included 235 selections from F_2 disease resistant determinate populations which will be grown at Lattakia for disease resistance selections. From F_3 determinate progeny rows 477 selections were made for F_4 progeny rows, with 104 from disease resistant determinate crosses which will be grown at Lattakia for disease screening. Also, 200 F_3 determinate bulks were harvested for disease resistance screening at Lattakia in 1986/87. Selections from F_4 determinate progeny rows and PYT's for determinate PSN's in 1986/87 numbered 400. There were 290 selections from F_3 progeny rows which were increased in the offseason nursery and will be included in a PSN-determinate or PYT-determinate based on seed supply.

Selections were made in progeny rows and nurseries and trials for plants with larger seeds and reduced branching and more podded nodes/branch. Also increased straw strength was selected for and will receive a higher priority in selection and in the crossing program.

Replicated yield trials were conducted with 237 determinate lines in preliminary yield trials at Tel Hadya and Lattakia (Table 1.2.19). In the advanced yield trial at Lattakia four determinate lines exceeded the indeterminate check. In the advanced and preliminary yield trials at Tel Hadya there were determinate lines not significantly less than the best indeterminate check, ILB 1814. The highest determinate yield was 4.44 t/ha, the highest determinate yield recorded to date. It is hoped to plant most determinate yield trials earlier for the 1986/87 season. For 1985/86 they were late planted because of delay in receiving seed from the offseason.
L.D. Robertson.

1.2.4.2. Independent Vascular Supply Lines (IVS)

These are lines where each flower in a receme has an independent vascular supply, the result of which is that all flowers in a raceme produce pods and flower shedding is greatly reduced. These IVS lines were grown at ICARDA in 1984/85 for the first time and twenty 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 made in 1986 are given in Table 1.2.18.

From populations grown in 1984/85 from seed received from Durham several selections were made and increased in the offseason nursery and grown in an early generation yield trial. Two lines gave yields of 3.82 and 3.24 t/ha versus 3.85 t/ha of the normal check ILB 1814.

Table 1.2.18. Determinate and IVS Crosses made in 1986 and planned for 1987.

Cross Type	Determinate		IVS	
	1986	1987	1986	1987
Yield	81	80	10	15
Botrytis	10	30	-	15
Ascochyta	4	15	-	5
Rust	-	20	-	5
Closed Flower	10	10		
Determinate x IVS	(15)[1]	(15)[1]	(15)[1]	(15)[1]
Total	120	170	25	55

1 Listed both determinate and IVS totals.

Table 1.2.19. Results of determinate yield trials grown at Tel Hadya and Lattakia, Syria in 1985/86.

Trial	No. of lines	No. of lines exceeding check	Grain Yield (t/ha)					Checks
			Trial mean	Best line mean	Best check mean	L.S.D. check vs line (5%)	C.V. %	
AYT-Det-1, Date 1	15	0	2.89	3.23	3.55	0.549	24.4	ILB 1814
AYT-Det-1, Date 2	15	0	2.63	2.91	3.58	0.549	24.4	ILB 1814
AYT-Det-1, Lattakia	15	4	2.50	3.10	2.69	0.805	19.3	ILB 1814
AYT-Det-2	45	0	2.46	2.96	4.03	0.895	22.5	ILB 1814, ILB 1816
PYT-Det	237	0(5)[1]	2.69	4.23	4.57	0.500	18.0	ILB 1814, ILB 1816
PYT-Det, Lattakia	237	0(1)[1]	2.54	4.44	5.06	0.746	23.2	ILB 1814, ILB 1816

[1] Exceeding small seeded check (ILB 1816).

From populations grown for IVS and other crosses 522 selections were made for progeny rows and for the best selections an increase was made in the offseason so that an early generation trial can be conducted.

L.D. Robertson.

1.2.4.3. Yield Components with Determinate Populations

In 1984/85 yield component data was taken on ten plants of each of three replications of 15 determinate populations. Analysis was done using path coefficients to determine direct and indirect effects in 19° using the total plant data as a bulk determinate population.

The largest variabilities were with seed yield/plant, pods/plant, seeds/plant, and podded nodes/plant while 10 seed weight, seeds/pod, and pods/podded nodes showed a smaller variability (Table 1.2.20). The largest correlations with yield were with pods/plant, seeds/plant and podded nodes/plant (Table 1.2.21). The correlations of 10 seed weight with other yield components were small and of no consequence. Correlations among pods/plant, seeds/plant and podded nodes/plant were large. Table 1.2.22 shows the direct and indirect effects for yield of the various component traits. Seeds/plant was the only yield component with a high correlation with yield through a direct effect; the high correlations of pods/plant and podded nodes/plant with yield were mostly through the indirect effect of seeds/plant. It seems the effect of seeds/pod and also of pods/podded node is minimal and therefore selection for pods/plant would be an effective selection criteria, as shown previously with F_2 populations of indeterminate faba beans.

Table 1.2.20. The mean, range and C.V. for determinate plants planted in the first week of November, 1984 for yield and yield components.

Trait	Mean	Range	C.V. (%)
Pods/Plant	6.5	21	55.9
Seeds/Plant	12.6	42	58.5
Podded Nodes/Plant	5.6	16	53.4
10 Seed Weight (g)	7.7	14.13	29.0
Seeds/Pod	2.0	4.2	34.5
Pods/Podded Node	1.2	2.0	22.6
Seed Yield/Plant (g)	10.2	33.57	61.3

Table 1.2.21. Correlations among yield and yield components for determinate plants planted in the first week of November, 1984 (d.f.=408).

Trait	Pods/ plant	Seeds/ plant	Podded nodes/ plant	10 Seed weight	Seeds/ pod	Pods/ podded node	Seed yield/ plant
Pods/plant	1.00	.81**	.94**	-.08	-.16*	.21*	.74**
Seeds/plant		1.00	.80**	-.10*	.36**	.09	.90**
Podded nodes/plant			1.00	-.05	-.12*	-.08	.74**
10 seed weight				1.00	-.06	-.11*	.24**
Seeds/pod					1.00	-.13*	.33**
Pods/podded node						1.00	.06
Seed yield/plant							1.00

Table 1.2.22. Direct and indirect effects of yield components on yield with determinate plants planted the first week of November, 1984.

Trait	Pods/ plant	Seeds/ plant	Podded nodes/ plant	10 Seed weight	Seeds/ pod	Pods/ podded node	Correlation with seed yield
Pods/plant	.0029	.6536	.1187	-.0282	-.0116	.0089	0.744**
Seeds/plant	.0024	.8049	.1006	-.0345	.0267	.0038	0.904**
Podded nodes/plant	.0027	.6423	.1261	-.0171	-.0085	-.0036	0.742**
10 seed weight	-.0002	-.0829	-.0064	.3353	-.0042	-.0045	0.237**
Seeds/pod	-.0005	.2914	-.0146	-.0191	.0737	-.0055	0.325**
Pods/podded node	.0006	.0724	-.0106	-.0355	-.0096	.0425	0.060

1.3. Faba Bean Diseases

1.3.1. Studies on Races in Botrytis fabae

Although different isolates of B.fabae may differ considerably in their virulence, there are no reports on the existence of physiological races in the pathogen. However, in the multi-location testing of several chocolate spot resistant sources by ICARDA it was observed that some lines showed location- specific resistance whereas others exhibited location- non-specific resistance. Therefore, efforts were made to study the race situation in B.fabae and to differentiate lines with broad-based resistance from those that possess narrow-based resistance.

Sixty isolates of B.fabae from northern Syria were evaluated for their virulence on Syrian Local Large faba bean and based on the frequency distribution (Fig. 1.3.1) of virulence eight isolates representing the whole range (A20, B7, B9, B47, A13, B44, B1 and B6) were selected. These were used separately to inoculate six faba bean lines, BPL 710, 1196, 1179-1, 1763, 1821, and ILB 1814, of which the first three showed location- non-specific resistance and the remaining three a location- specific resistance to chocolate spot. In tests repeated twice BPL 710, 1196 and 1179-1 revealed no significant ($P = 0.01$) interaction, whereas BPL 1763, BPL 1821 and ILB 1814 showed significant ($P = 0.01$) interaction with different isolates of B.fabae (Table 1.3.1). Thus BPL 710, BPL 1196 and BPL 1179-1 seem to carry genes for a broad-based horizontal resistance.

Based on their virulence on BPL 1763, BPL 1821 and ILB 1814, the eight isolates of B.fabae can be grouped into four classes, each with a distinct disease pattern (Table 1.3.1). Isolates A20, B7, B9 and B47, which can be distinguished from B6 by using BPL 1763 and from A13, B44 and B1 by using BPL 1821, could represent race 1. Isolates A13 and B44, which can be distinguished from B6 by using BPl 1763 or BPL 1821

Table 1.3.1. Chocolate spot reaction of *Vicia faba* at different locations and to different isolates of *Botrytis fabae*.

Faba bean line	Origin	Disease reaction[1]														
		Locations[2]							Isolates from Syria[3]							
		Syria		Egypt		England		Netherlands	A20	B7	B9	B47	A13	B44	B1	B6
		1982	1983	1982	1983	1982	1983	1983	Race 1				Race 2		Race 3	Race 4
BPL 710	Ecuador	R[4]	R	R	R	R	R	R	HR	HR	HR	HR	HR	HR	HR	HR
BPL 1196	Spain	R	R	R	R	R	R	R	HR	HR	HR	HR	HR	HR	HR	HR
BPL 1179-1	Ecuador	R	R	R	R	R	R	R	R	R	R	R	R	HR	HR	HR
BPL 1763	Ethiopia	R	R	R	R	S	S	S	R	R	R	R	R	R	R	HS
HBPL 1821	Ethiopia	R	R	R	R	S	S	S	R	R	R	R	HS	HS	S	R
ILB 1814	Syria	S	S	R	R	S	S	S	HS	HS	HS	HS	R	R	HS	S
ILB 365	Egypt	S	S	S	S	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT

1) Disease reactions at different locations, and to different isolates were recorded on ICARDA's chocolate spot scales for field and detached leaf tests, respectively.
2) Field evaluations in different geographical regions.
3) Detached leaf evaluation in the laboratory using isolates from different part in Syria.
4) Reactions recorded on ICARDA's 1-9 scoring scales where HR, R, S, and HS denote highly resistant, resistant, susceptible, and highly susceptible, respectively. NT denotes not tested.

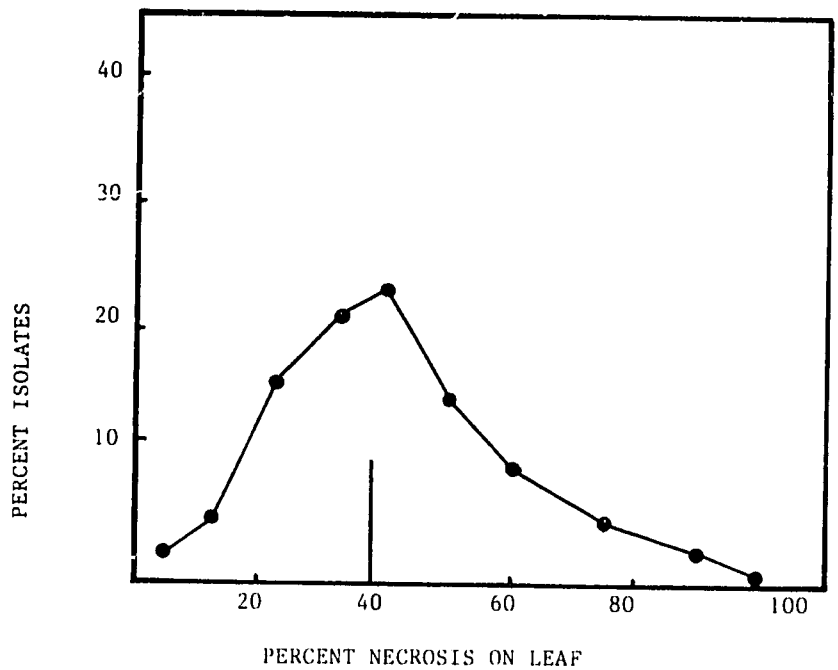


Figure 1.3.1. Frequency distribution of virulence among 60 isolates of Botrytis fabae from Syria, on the faba bean line ILB 1814 (mean necrosis = 40%, standard deviation = 18.8, range about mean 2.86 - 77, and variance = 355.10), employing the detached leaf test.

and from B1 by using ILB 1814, may represent race 2. Isolates B1, and B6, which can be distinguished from each other by using BPL 1763 and BPL 1821 can be designated to represent race 3 and race 4, respectively.

The resistance reaction of BPL 1763, BPL 1821, and ILB 1814 in Egypt and susceptibility in England and The Netherlands (Table 1.3.1) indicates that races 1, 2, 3 and 4 are more common in Northern Europe than in the Middle East. A detailed race survey is planned for 1986/87 in Egypt. If the present inference that race 1, 2, 3 and 4 are not present in Egypt is confirmed by the survey, it should be possible also to use genes for vertical resistance in BPL 1763, BPL 1821 and ILB 1814 along with genes for horizontal resistance in BPL 710, BPL 1196 and BPL 1179-1 which are being currently used effectively.

Surveys in Syria indicated that races 1, 2, 3 and 4 are common in Tartous, Akkar, Tel Kalakh and Homs area, but not in Lattakia area.

1.3.2. Host-Pathogen Interactions in B.fabae

Although it is known that the invasion of faba bean tissue by B.fabae or B.cinerea activates the production of high levels of phytoalexins, reports on passive mechanisms of resistance that may occur at the phyllosphere level, before invasion of the leaf tissue, are fragmentary. Therefore phyllosphere effects of chocolate spot-resistant and -susceptible faba bean lines on the germination of spores and germtube development of B.fabae were studied. Such studies could help in (i) providing useful information on mechanism of resistance, (ii) developing an in vitro technique for resistance screening, (iii) providing a method for studying the inheritance of resistance, and (iv) developing a biological control of chocolate spot disease.

Healthy leaves from the 6th node were collected from field grown plants of the chocolate spot-resistant (BPL 710 and BPL 1179) and susceptible (R 40) faba bean lines. They were gently washed in water. Another set was surface disinfected for 2 minutes in 10% Chlorox solution (0.5% sodium hypochlorite) then washed similarly with water. Washings from the first set were used to permit the study of the effect of water soluble substances, and the epiphytotic micro-organisms on the spore germination and germ-tube elongation of B.fabae, whereas those from the second set were used to study of the effect of water soluble substances only. Spores of the fungus were harvested from a 12-day old faba bean-dextrose-agar (FDA) culture and incubated at 20°C separately in petri dishes containing leaf washings. After 48 hrs. the percent spore germination and the length of germtubes were measured.

Washings from the intact leaves of the chocolate spot-resistant lines suppressed spore germination (Figure 1.3.2) and germtube growth (Figure 1.3.3) of B.fabae significantly when compared to the washings from the leaves of susceptible line. Washings of Chlorox- treated leaves gave less dramatic effects suggesting that epiphytotic micro-organisms played a role, in addition to the water soluble diffusates, in the phyllosphere effect exhibited by the resistant lines. In order to separate the effects of epiphytotic micro-organisms and their by-products from the effects of leaf diffusates, there is a need to grow the plants in aseptic conditions in gnotobiotic chambers. This will be done in 1986/87. Also, efforts will be made to assess the scope of using this method in routine screening of genotypes for resistance to B.fabae.

1.3.3. Chemical Control of B.fabae and U.viciae fabae

In vitro efficacy of different concentrations of four fungicides (Folpet, Mancozeb, Vinclozolin and Procymidone) on spore germination

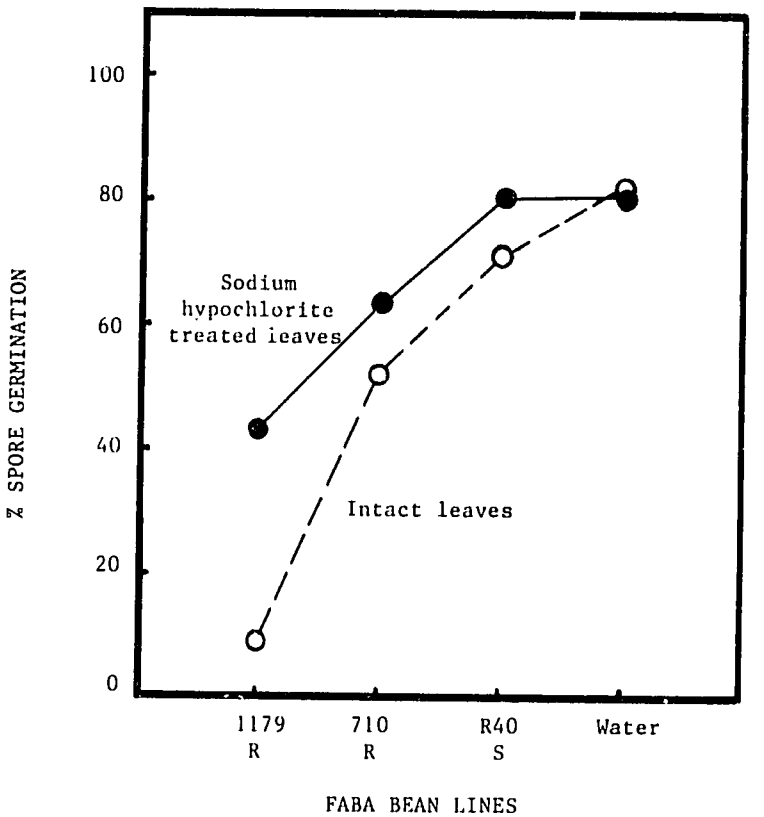


Figure 1.3.2. The phyllosphere effect of intact and sodium hypochlorite-treated leaves of resistant (R) and susceptible (S) lines of Vicia faba, on spore germination of spores of Botrytis fabae.

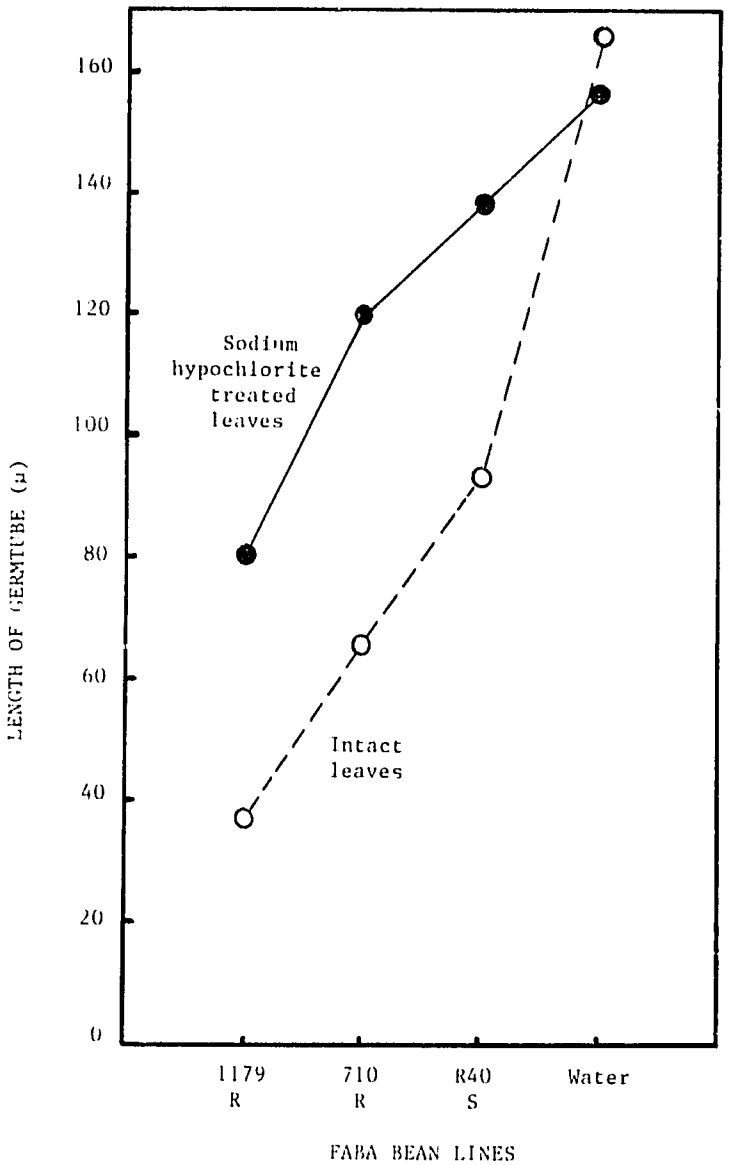


Figure 1.3.3. The phyllosphere effect of intact and sodium hypochlorite-treated leaves of resistant (R) and susceptible (S) lines of *Vicia faba*, on the germtube development of *Botrytis fabae*

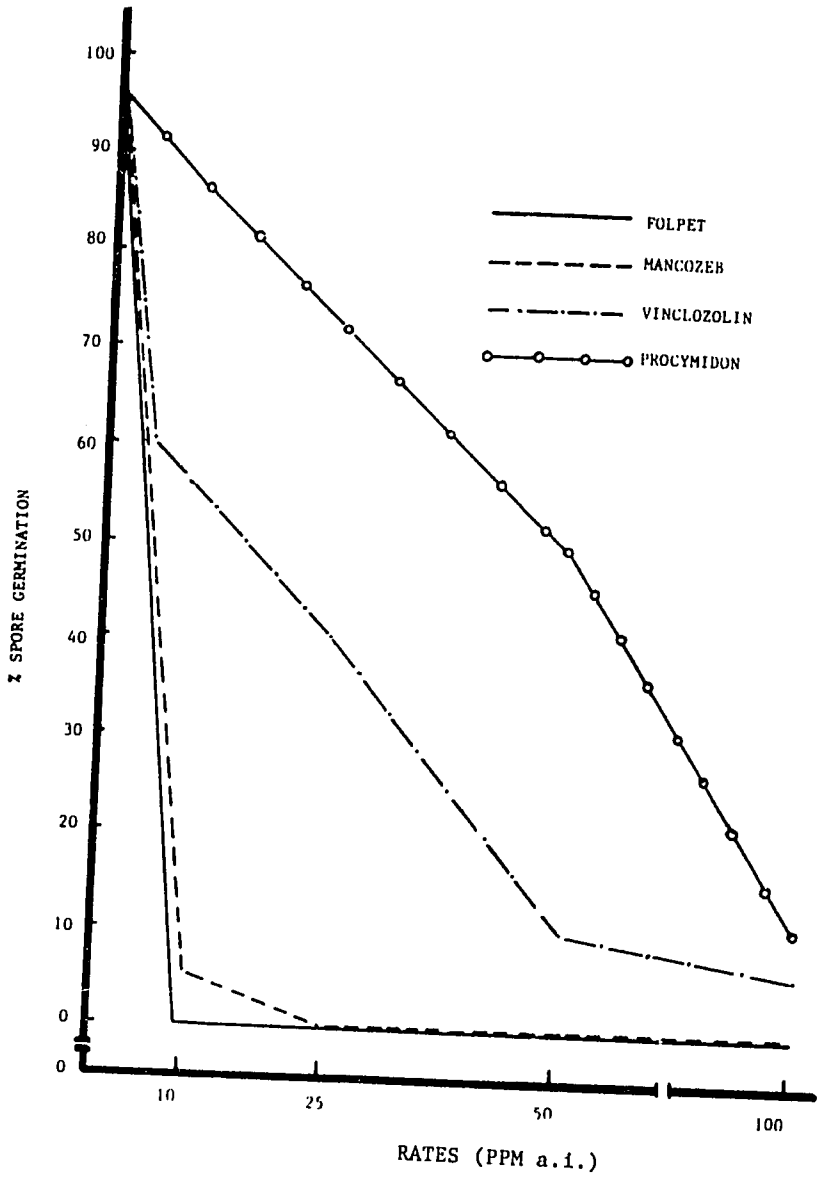


Figure 1.3.4. Spore germination of Botrytis fabae as affected by different fungicides.

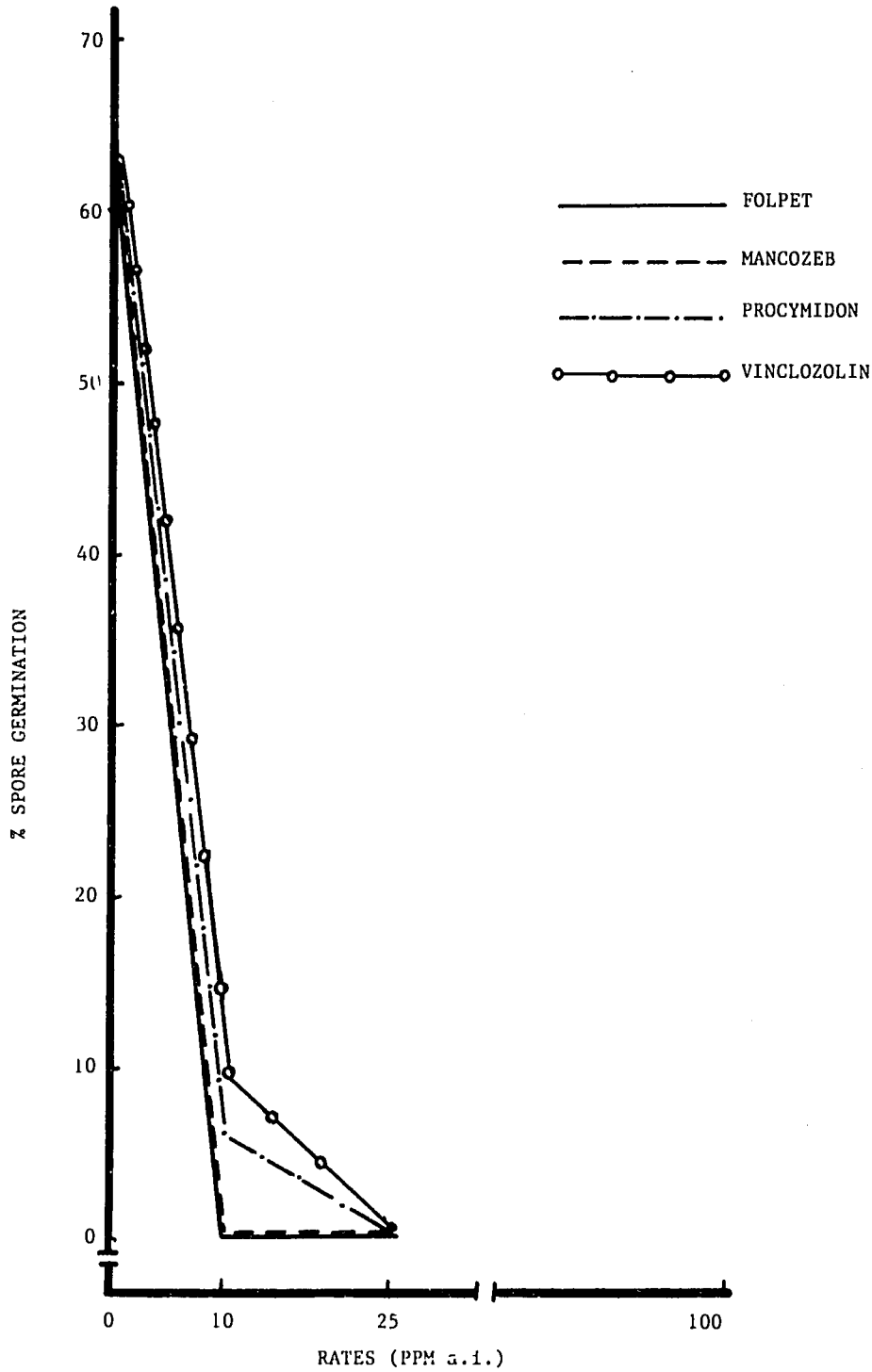


Figure 1.3.5. Spore germination of Ascochyta fabae as affected by different fungicides.

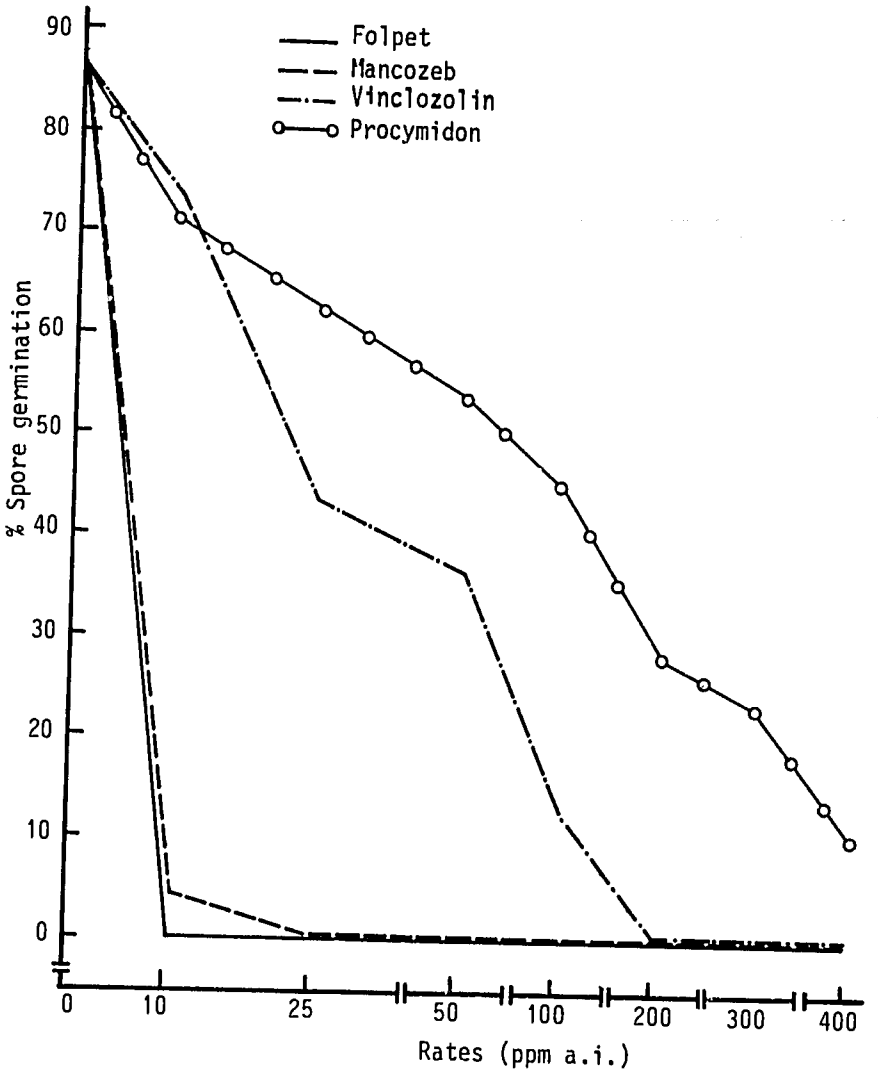


Figure 1.3.6. Spore germination of Uromyces viciae fabae as affected by different fungicides.

and germtube elongation of Botrytis fabae, Ascochyta fabae, and Uromyces viciae fabae was investigated to assess the prospects of their field effectiveness in controlling these diseases. Spores of B.fabae and A.fabae were harvested from 12-day old FDA cultures whereas those of U.viciae fabae were collected from naturally infected faba bean leaves. A spore suspension of $5x10^5$ spores/ml was obtained for each pathogen. Fungicides were dissolved in distilled water to prepare series of concentrations to cover the rates recommended for use in the field and 2.9 ml of each was added to 0.1 ml of the spore suspension of each pathogen in a petri dish, which were then incubated at 20^0C for 48 hours. Percent spore germination and germtube length were measured after 48 hrs.

Folpet was significantly (P = 0.05) more effective in inhibiting spore germination and germtube elongation of B.fabae, A.fabae and U.viciae fabae than the rest of fungicides. Effect of different sets of chemicals on spore germination of the three pathogens are shown in Figures 1.3.4, 1.3.5 and 1.3.6. Because of significant superiority of Folpet and Mancozeb in controlling the spore germination and germtube elongation, these chemicals will be field evaluated during 1986/87.
Dr. S.B. Hanounik.

1.3.4. Virology

Research on virology was conducted in close cooperation with the Institute of Plant Protection (IPO) at Wageningen, The Netherlands. The work included virus surveys in the region, evaluation of faba bean germplasm for bean leaf roll virus and bean yellow mosaic virus resistance, testing international increases of faba bean for seed-borne virus and production of antisera for three legume viruses. The salient features of these studies are presented here. Details of these studies are contained in the report of the Genetic Resources Program.

1.3.4.1. Virus Survey

A total of 589 faba bean samples with virus-like symptoms were collected from Egypt, Lebanon, Morocco, Sudan, Syria and Tunisia. Among the sap-transmissible viruses, bean yellow mosaic virus was the most prevalent in all the countries surveyed except Tunisia where broad bean mottle virus was the most prevalent virus. The incidence of each virus in the countries surveyed is shown in Table 1.3.2. Based on visual observations in the field, bean leaf roll virus was the most prevalent in most countries surveyed.

Dr. K. Makkouk

1.3.4.2. Germplasm screening for BYMV resistance

At Tel Hadya, Syria 672 faba bean lines were evaluated for their resistance to BYMV using mechanical inoculation. Plants were inoculated twice with the virus, 2 and 5 weeks after sowing the seeds, and were evaluated 3 weeks after the second inoculation. Nineteen lines showed good level of BYMV resistance and these lines will be re-evaluated during the next growing season (1986/1987).

1.3.4.3. Germplasm screening for BLRV resistance

A total of 386 faba bean lines were evaluated for their resistance to BLRV at Lattakia, Syria. All plants were artificially inoculated with BLRV using a mixture of the aphid vectors Aphis fabae and Aphis craccivora. Over 100 single plant selections resistant to BLRV were made and increased during the summer of 1986, and will be re-evaluated during the next growing season (1986/1987).

Drs. K.M. Makkouk, L.D. Robertson and S.B. Hanounik.

Table 1.3.2. Viruses identified in faba bean samples collected from Egypt, Lebanon, Morocco, Sudan, Syria and Tunisia during 1985/86.

Country	No. of samples tested	Number of field samples which contained							
		BBMV	BBSV	BYMV	PSBMV	CMV	PEMV	BBWV	BBTMV
Egypt	70	5	4	49	10	11	7	4	0
Lebanon	44	0	6	4	1	0	*	*	*
Morocco	7	1	0	1	0	0	*	*	*
Sudan	254	45	19	145	3	6	5	1	1
Syria	145	6	36	67	30	*	2	0	0
Tunisia	69	41	8	8	9	13	2	1	0
TOTAL	589	98	73	274	53	30	16	6	0

BBMV = broad bean mottle virus
BBSV = broad bean stain virus
PSBMV= pea seed-borne mosaic virus
BYMV = bean yellow mosaic virus
CMV = cucumber mosaic virus
BBWV = broad bean wilt virus
PEMV = pea enation mosaic virus
BBTMV= broad bean true mosaic virus
* = not tested

1.3.4.4. Detection of seed-borne viruses

Since some of the viruses which infect faba beans are seed-borne, procedures were developed for the detection of broad bean stain virus (BBSV) and broad bean true mosaic virus (BBTMV). International increases of faba bean were subjected to very strict roguing (twice) during the growing season in addition to weekly insecticidal spray for beetle control. Seed lots obtained were tested for the presence of BBSV and BBTMV and only those which proved to be virus free were forwarded to the collaborators.
Drs. K.M. Makkouk and L.D. Robertson.

1.4. Faba Bean Insects and their Control

Studies on the comparative economic importance of Sitona weevils and aphids were continued and critical periods and damage levels for appropriate aphid control were identified.

1.4.1. Insect Control Recommendations

Based on previous results Sitona spp. and the aphids are considered to be the main pests of faba beans. In order to separate yield losses due to Sitona spp. and aphids at different plant growth stages control of Sitona with Carbofuran at planting and aphid control at preflowering and pod setting with Primicarb were compared. In general the Sitona spp. infestaion was very low in all treatments, since the highest nodule damage found was only 6.4% (Table 1.4.1). However, high infestations with Aphis fabae were found, which thereby confirmed last years results that these are the key pest in faba beans. The application of Primicarb at preflowering stage to control the early

Table 1.4.1. Damage levels and seed yields of fab. beans (Syrian Local Medium, ILB 1813) by selective control of Sitona spp. and aphids. Tel Hadya, 1985/86.

Treatments*	Aphids VDS (1-4)	Sitona % ND (nodules damaged)	Seed yield kg/ha	Seed yield % increase
Control of Sitona spp. + early aphids + late aphids	1.3	0.6	2306	50.0
Control of Sitona spp. + early aphids	2.0	0.6	2444	52.8
Control of early aphids	2.0	1.6	2234	48.3
Control of Sitona spp. + late aphids	3.4	0	2141	46.1
Control of late aphids	4.0	1.4	1325	12.9
Control of early + late aphids	1.3	6.4	2601	55.6
Control of Sitona spp.	3.5	0.2	2189	47.3
Check	4.0	2.1	1154	
L.S.D. (5%)			512.9	
C.V. (%)			17.02	

* Sitona spp. control: Carbofuran G 20 kg/ha (1 kg a.i./ha) applied at sowing. Aphid control: Primicarb 0.15 kg a.i./ha.

aphids resulted in the highest yield increases of 48% to 55%. Therefore it was not of importance whether Sitona spp. were controlled or not. The yield increase of 47% in the case of Sitona spp. control must be due to some other factors, since nodule damage in the check was extremely low as well. Overall one early preflowering application of Primicarb without any control of Sitona spp. turned out to be most effective.

Since aphids are the most important insect pest of faba beans but might be controlled by just one chemical application, reliable and practicable recommendations for the proper timing of the treatment need to be developed. Therefore critical damage and/or infestation levels for aphid control were determined. The timing of one spray was based upon visual damage score (VDS) (scale 1-4; 1=no aphids; 4=severe damage) and infestation (scale 1-5; 1=no aphids; 5=many colonies of aphids). The highest yield was achieved with full protection, followed by spraying once at a VDS of 2, or when 5% of stems were infested (Figure 1.4.1). The yield losses of these treatments were 17.6% and 18.4% respectively. These results illustrate that either the VDS or infestation levels might be used for timing the insecticide application, and with proper timing one application is sufficient for aphid control.

1.4.2. Host Plant Resistance

Screening for resistance to aphids continued with 844 Bean Pure Line (BPL), which were planted in the plastichouse and infested with aphids. Using the visual damage score (1-4) 55 BPL lines rated 1-1.9 VDS. The aphid populations were then raised to very high levels, so that all lines received high infestation scores. None turned out to be resistant, but the best 5 lines will be selected and rescreened in the plastichouse.

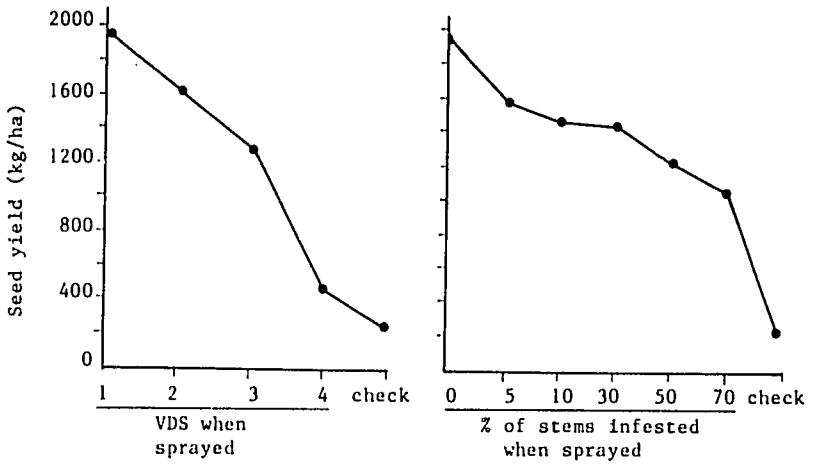


Figure 1.4.1. Effect of scheduling insecticidal spray based on visual damage score (VDS; 1 = no damage, 4 = heavy damage) or percentage stem infection by aphids on seed yield of faba bean, Tel Hadya 1985/86.

Table 1.4.2. Effect of an artificial infestation with *Lixus algirus* on seed yield in faba beans. Tel Hadya, 1985/86.

Treatments	% stems infested	No. of stems lodging/13.5 m^2	Seed yield	
			kg/ha	% increase
No infestation	5	109	2193	3.78
Infestation with 3 pairs/m^2	44	150	2110	
L.S.D. (5%)			662.6	
C.V. (%)			8.8	

1.4.3. Economic Importance of Stemborer, Lixus algirus

Studies on the pest status of the stemborer were continued with results shown in Table 1.4.2. Even an infestation with 3 pairs/m^2 did not cause significant yield loss, which indicates that L.algirus is not an economic pest of faba bean in this region and the experiments can be terminated.

1.5. Faba Bean Crop Physiology, Agronomy and Microbiology

1.5.1. Water Use-Efficiency in Faba Bean Genotypes Selected for Low Rainfall Environment

In environments where rainfall is low, faba bean growth is restricted and this results in inadequate ground cover and high evaporative losses. At a given population, one way of reducing evaporation from the bare ground and increasing the amount of intercepted radiation and thus improving the productivity and water-use efficiency is to narrow the inter-row spacing. As from 1983/84, therefore, a trial was initiated using faba bean genotypes that had performed well under low rainfall to investigate the yield performance and water-use efficiency at two populations (22 and 44 plants/m^2) and two row spacings (22.5 and 45 cm). The trial was repeated in 1985/86. Soil moisture changes were monitored in selected treatments using the neutron probe.

Seed yield did not vary significantly among genotypes; however, as in 1984/85, faba bean line 80S 44367 gave the lowest seed yield (Table 1.5.1). Substantial yield increases were obtained by either reducing row spacing from 45cm to 22.5cm or increasing plant population from 22 to 44/m^2; and a combination of narrow row spacing and high plant population gave the highest yields (Table 1.5.2) which was

Table 1.5.1. Means for seed yield (SY), total biological yield (TBY) and harvest index (HI) of different faba bean genotypes, Tel Hadya.

Genotype	Yield (kg/ha)		
	SY	TBY	HI
80S 64214	1375	2237	0.62
80S 43856	1297	2151	0.60
80S 44358	1370	2234	0.61
80S 45057	1348	2277	0.60
80S 44815	1215	2224	0.55
80S 44367	1145	1851	0.62
80L 90121	1455	2413	0.61
ILB 1814	1399	2555	0.54
L.S.D. (5%)	NS	343	0.033
S.E.	75.5	122.1	0.012
C.V. (%)	19.7	18.9	6.9

Table 1.5.2. Means for seed and total biological yields for sowing at 2 row spacings, R (45 and 22.5 cm), and two populations, P (22 and 44 plants/m^2).

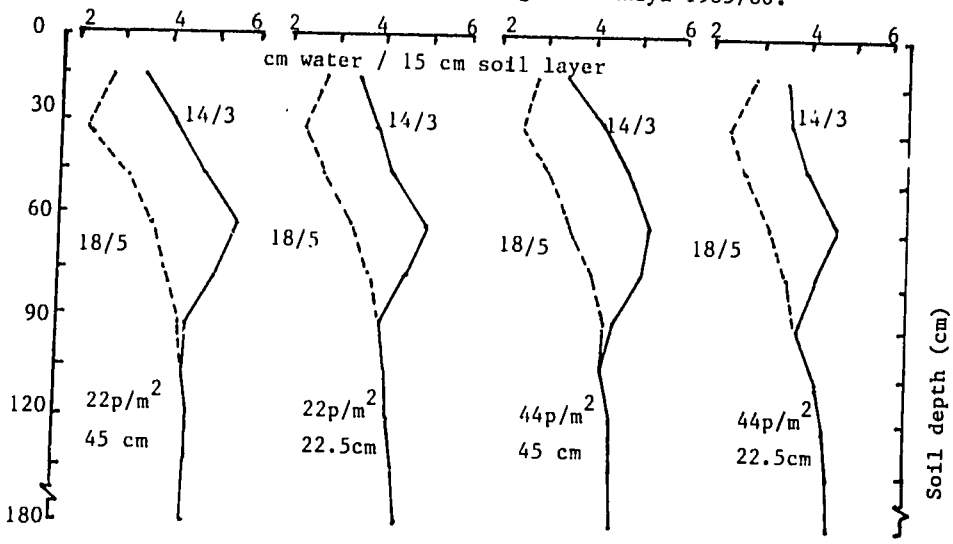
Population/m^2 (kg/ha)	Seed yield (kg/ha)			Total Biological Yield (kg/ha)		
	45cm	22.5cm	Mean	45cm	22.5cm	Mean
22 plants	805	1502	1154	1335	2504	1920
44 plants	1240	1754	1497	2020	3111	2566
Mean	1023	1628		1677	2808	
	(R)	(P)	R X P	(R)	(P)	R X P
L.S.D. (5%)	106.1	106.1	150.0	171	171	NS
S.E.	37.8	37.8	53.4	61.1	61.1	86.4
C.V. (%)		19.7			18.9	

Table 1.5.3. Seed yield, evapotranspiration (ET) and water-use efficiency of ILB 1814 at 22 and 44 plants/m^2 and at 22.5 and 45cm row spacing, and for seven other genotypes at 22 plants/m^2 and 45cm row spacings. Tel Hadya rainfed (316 mm), 1985/86.

Genotype	Population and row spacing combination	Seed yield (kg/ha)	Et (mm)	Water-use efficiency (kg/ha/mm Et)
80S 64214	P_1R_1	973	232.9	4.18
80S 43856	P_1R_1	882	227.1	3.88
80S 44358	P_1R_1	809	220.9	3.66
80S 45057	P_1R_1	729	228.7	3.18
80S 44815	P_1R_1	701	227.6	3.08
80S 44367	P_1R_1	678	220.0	3.08
80L 90121	P_1R_1	910	241.3	3.77
ILB 1814	P_1R_1	762	243.6	3.13
ILB 1814	P_1R_2	1817	239.4	7.59
ILB 1814	P_2R_1	1451	242.1	5.99
ILB 1814	P_2R_2	1566	253.8	6.17

R_2 and R_1 = 22.5 and 45cm row spacing respectively
P_1 and P_2 = 22.0 and 44 plants/m^2 respectively.

Figure 1.5.1. Soil moisture extraction along the profile at maximum recharge (14.3.1986) and at maturity (18.5.1986) for ILB 1814 as affected by plant population and row spacing. Tel Hadya 1985/86.



consistent with the results of the last two seasons. The increase in seed yield was mainly through increase in total biological yield ($r = 0.97$).

Table 1.5.3 gives seed yield, evapotranspiration and water-use efficiency for eight genotypes at selected population and row spacing combinations. Genotypes 80S 64214, 80S 43856, 80S 44358 and 80L 90121 were more efficient in their water use than other genotypes. In ILB 1814 both narrow row spacing and high plant population resulted in improved water use efficiency. The soil moisture profile extraction was not influenced much by treatments (Figure 1.5.1).

1.5.2. Growth, Dry Matter Build-up and Yield of Faba Bean Genotypes of Differing Plant Types

In favourable environments, yield potential of a crop is determined largely by its efficient utilization of light for dry matter production and a favourable partitioning of dry matter between the economic yield and the rest of the plant. In conventional faba bean plant type the high percentage of flower and pod shed results in poor partitioning of the total dry matter to the seeds. To overcome the problem a number of new plant types with either determinate growth habit or independent vascular supply to each flower (IVS) are being developed. However, little is known about the pattern of dry matter build up and partitioning in these. An investigation was therefore undertaken to study assimilate build-up and partitioning differences between the conventional indeterminate lines (ILB 1814, ILB 1816 and Giza 3), an independent vascular supply (IVS6), and a determinate (FLIP 84-230) line.

The number of nodes/plant was small at the beginning of the season, increased steadily to a maximum, then declined slightly

(Figure 1.5.2b). ILB 1814, ILB 1816, Giza 3 and IVS 6 achieved increase in number of nodes/plant through indeterminate growth habit while FLIP 84-230 produced more branches/plant (Figure 1.5.2a). This suggests that the advantage of determinate habit of growth in FLIP 84-230 may be lost because of production of large number of branches/plant, particularly at reproductive phase. Planting at high plant density resulted in suppression of branching. Photosynthetic area index (PAI), percentage intercepted radiation and dry matter production followed the same pattern; low at the beginning of the season and increased to a maximum (Figures 1.5.2 c & d; 1.5.3). Dry matter production was associated with intercepted radiation. ILB 1814 which achieved high PAI intercepted a high percentage radiation and produced large total dry matter and FLIP 84-230 had low PAI, intercepted less radiation and produced low amount of dry matter. The dry matter partitioning to leaves, stems and reproductive parts is given in Figure 1.5.3. All genotypes showed similar pattern in dry matter partitioning except during later stages of sampling where IVS 6 partitioned less amounts of assimilates to the reproductive parts. Seed yields were similar in all genotypes except for IVS 6 which was significantly low (Table 1.5.4). Low seed yield in IVS 6 was largely due to Orobanche infestation occurring in early reproductive growth in this late genotype. FLIP 82-230, in spite of attaining low total biological yield, achieved seed yield comparable to conventional Mediterranean lines (ILB 1814, ILB 1816, and Giza 3) through improved partitioning. The study was affected by infestation by Orobanche and will be repeated in 1986/87 season to follow in particular reproductive growth.

1.5.3. Photothermal Regulation of Flowering in Faba Beans

Selection of genotypes well adapted to the environment in which they are grown is key to realizing their full yield potential. Work on

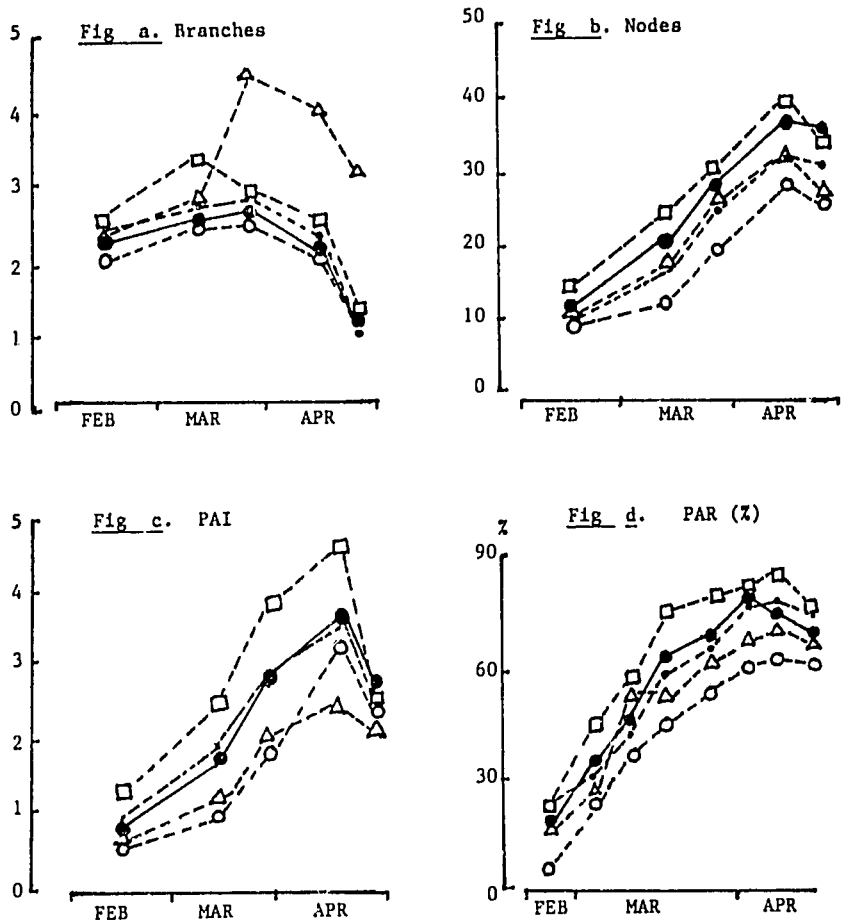


Figure 1.5.2. Genotypic differences in faba beans for: (a) number of primary branches/plant; (b) total nodes/plant; (c) photosynthetic area index; and (d) photosynthetically active radiation interception (%) in 1985/86.

IVS 6 — FLIP-84-230 — ILB 1814 — GIZA 3 — ILB 1817

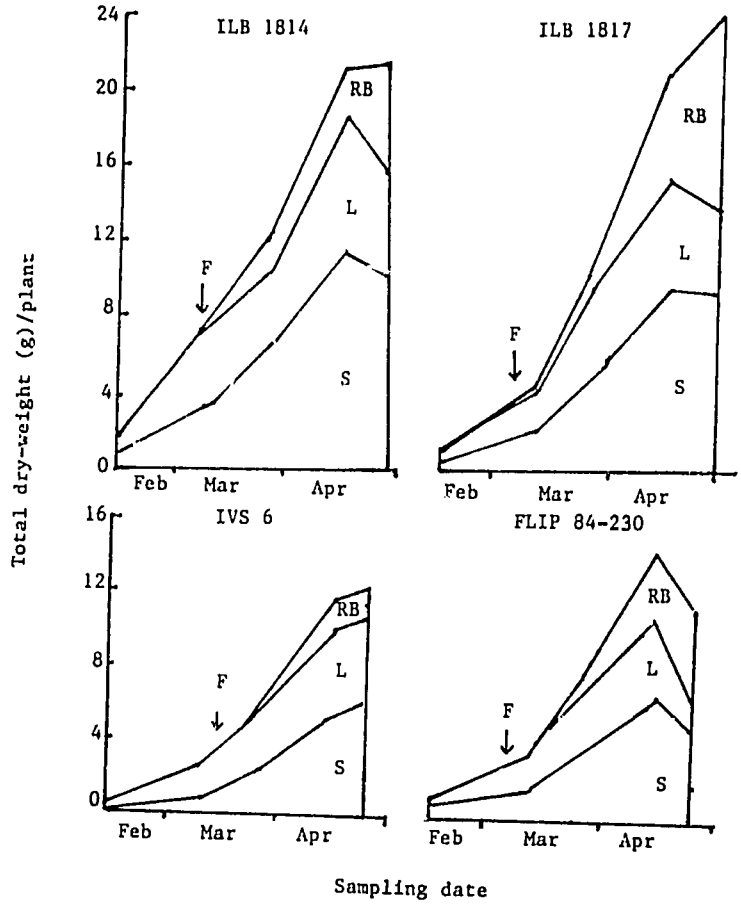


Figure 1.5.3. Dry-matter accumulation in different plant parts in four genotype of faba bean in 1985/86. S= stem; L= Leaves; RB= reproductive bodies. Arrow with 'F' shows start of flowering.

Table 1.5.4. Yield (kg/ha), harvest index and Orobanche damage score in faba bean genotypes of different plant types, Tel Hadya 1985/86.

Genotype	Yields (kg/ha)		Harvest index	Orobanche damage score*
	Seed	Total biological		
IVS 6	1441	3159	0.43	5.6
FLIP 84-230	2208	3021	0.79	4.9
ILB 1814	2683	5632	0.48	3.8
Giza 3	2814	5393	0.52	3.5
ILB 1816	2842	5205	0.55	4.0
L.S.D. (5%)	1003	1624	NS	NS
S.E.	325	527	0.10	0.54
C.V. (%)	9.3	13.3	12.6	11.5

* Score for Orobanche damage:
1 = no damage
9 - complete crop kill

Table 1.5.5. Relationship between progress to flowering (1/f) and mean temperature (t) and photoperiod (p) for six faba bean genotypes, Tel Hadya 1985/86; 'a' is constant, 'b' is partial regression coefficient of progress to flowering on t and c is partial regression coefficient on P.

Genotype	a	b	c	R^2
Zeidab	-0.000941	0.001243	0.000098	0.769
Aquadulce	0.001385	0.000871	0.000132	0.712
Syrian local large	0.002537	0.000869	0.000055	0.748
Lebanese local large	0.000569	0.000921	0.000193	0.721
Giza 4	-0.001444	0.001248	0.000154	0.940
Violette di Policoro	0.001047	0.000924	0.000139	0.777

other grain legumes (e.g. lentils, chickpeas, soybeans) under controlled environmental conditions have indicated their sensitivity to photoperiod and thermal regimes. The results showed that progress towards flowering is linearly related to mean temperature and photoperiod with little interaction between these two variables. Since no such information was available for faba bean a study was initiated at the Plant Environment Laboratory in the University of Reading, UK in a collaborative project with funding from ODA. Results are awaited. However, in order to test the response under actual field condition, a study was conducted during 1985/86 season with six faba bean genotypes from different geographical regions (Table 1.5.5). Various photothermal regimes were obtained by using extended days of 16h vs natural day length (the photoperiod ranged from 9 to 13h) and by staggering sowing from November 1985 to March 1986.

The model for predicting progress towards flowering (1/f) is described by the following equation (Roberts, Hadley and Summerfield, 1985*):

$1/f = a + bt + cp$, where f is number of days from planting to first open flower, t is mean temperature, p photoperiod, and a , b and c constants.

Using the data from this field trial, values for constant a and regression coefficients b and c for each genotype were calculated and are given in Table 1.5.5. The results confirmed that progress towards flowering in faba bean was also influenced by temperature and photoperiod. Separate simple linear regressions for each genotype were studied for progress towards flowering on mean temperature ($1/f = a+bt$) or photoperiod ($1/f = a+bp$). The results showed that rate of progress towards flowering was influenced mainly by mean temperature (R^2 were

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Roberts, E.H., Haldey, P. and Summerfield, R.J., 1985. Effects of temperature and photoperiod on flowering in chickpeas (Cicer arietinum L.) Annals of Botany 55, 881-92.

0.768, 0.707, 0.751, 0.688, 0.922 and 0.763 for Zeidab, Aquadulce, Syrian local large, Lebanese local large, Giza 4 and Violette di Policoro, respectively). The small response to photoperiod was largely due to the narrow range of photoperiod achieved. The extended photoperiod of 16h had very low illuminance (results in lentil indicate that minimum illuminance to influence progress towards flowering is 500 lux, while in this study the illuminance achieved ranged from 75 to 350 lux). Hence this aspect will be investigated again in 1986/87 using higher light intensity.

1.5.4. Weed Control in Faba Bean

Crop yield loss because of weeds and effect of some selective herbicides and herbicide combinations on the grassy and broad leaved weeds was studied at Tel Hadya in a weed control trial (details in Table 1.5.6). The weedy plots yielded only 37% of the seed yield obtained from weed-free plots. Yield level in general was low because the crop was unirrigated. A combination of cyanazine or terbutryne with pronamide applied as pre-emergence spray resulted in adequate control of weeds and resulted in seed yields equal to those from plots kept weed-free by hand weeding (Table 1.5.6). Other tested herbicides were not as effective.

Dr. M. Pala

1.5.6. Faba Bean Microbiology

With the movement of microbiology section to the Food Legume Program, a limited number of experiments were conducted for selection of improved Rhizobium strain - cultivar combinations with increased nitrogen fixation capacity.

Table 1.5.6. Effect of weed control on seed yield of faba bean and on weed dry weight, Tel Hadya, 1985/86.

Treatment	Rate of appln. (kg a.i./ha)	Time of appln.	Seed yield (kg/ha)	Weed dry weight (kg/ha)
Weedy check			274	1659
Weed-free check			744	171
Cyanazin + pronamide	1.0 + 0.5	Pre-em.	854	428
Terbutryne + pronamide	2.0 + 0.5	Pre-em.	808	483
Dinoseb acetate + fluazifabbutyl	1.0 + 0.5	Post-em.	635	336
Codal	2.0	Pre-em.	543	1085
Secbumetron	0.25	Pre-em.	437	1578
Carbetamid	1.5	Pre-em.	360	921
AC 252-214	0.2	Pre-em.	300	1388
AC 252-214	0.2	Emerg.	417	681
AC 252-214	0.15	E.Post-em.	108	1218
Fomesafen	0.2	E.Post-em.	129	2133
Fomesafen	0.2	M.Post-em.	102	1379
Fomesafen	0.2	L.Post-em.	164	2322
L.S.D. (P=0.05)			184	811
C.V. (%)			30	50

There were two basic types of experiments. The first involved evaluation of 15 prominent cultivars for response to inoculation with a single Rhizobium strain (ICARDA strain 65, isolated in Libya), compared to uninoculated treatments. The second experiment evaluated response of a single cultivar (Lebanese Local Small) to inoculation with six separate strains of rhizobia compared to an uninoculated control. The primary criteria for response to inoculation in both experiments were yield components.

Over the mean of 15 cultivars screened, there was no response to inoculation with a single strain of Rhizobium over the uninoculated control. Some individual lines, however, did respond. Lines Giza 402, FLIP 82-25FB, FLIP 84-240FB, and Lebanese Local Large gave 200-400 kg/ha higher, though insignificant, grain yields with inoculation. Lines 39MB (a selection from Aquadulce), 79S4, ILB 3188, and ILB 1814 gave decreased, but insignificant, grain yields when inoculated. Inoculation significantly decreased grain yield in line FLIP 82-29FB. Biological yields followed similar patterns.

In the trial screening for inoculation effects from six Rhizobium strains, there were no significant yield differences between treatments inoculated and the uninoculated control on Lebanese Local Small. It must be noted that in this experiment final yield was severely restricted by drought, but no significant differences between treatments were detected at any stage of crop growth.

These results are to be expected, for Tel Hadya soils contain large numbers of indigenous rhizobia effective with faba bean. In addition, cultivars are selected throughout the breeding program based on yield performance utilizing the native soil rhizobia for nitrogen fixation. Under these conditions, it will be unlikely that a significant inoculation response will be obtained with randomly chosen strains.

In the coming season a stepwise approach to strain selection using a number of prominent cultivars in several soils will be adopted. A broad range of strain and cultivar combinations will be tested in plastichouse experiments, with superior combinations being evaluated subsequently in the field.

Dr. D. Beck

2. LENTIL IMPROVEMENT

Considerable progress was made in developing improved production practices, cultivars, and genetic stocks of lentils with high and stable seed yields adapted to the three main agroecological regions of production, with maintained seed quality and nitrogen-fixing ability, and with the additional specific characters for each region, namely: (i) high altitude region (above 1000m elevation) - cold tolerance to allow winter sowing and attributes for mechanical harvest (tall, nonlodging growth habit and pod retention and indehiscence), (ii) middle- to low-elevation region around the Mediterranean Sea - attributes for mechanical harvest, maintained straw quality and yield, tolerance to Orobanche and Heterodera sp., resistance to vascular wilt, and tolerance to drought stress during the reproductive growth period, and (iii) lower latitudes region (Indian subcontinent, Ethiopia, and Sudan) - phenological adaptation to the warm, short-photoperiod environment, and resistance to rust, vascular wilt, and ascochyta blight.

2.1. Development of Lentil Cultivars and Genetic Stocks

2.1.1. Breeding Scheme

During the last season we made 333 crosses. Most of the crosses (73%) were targeted for the Mediterranean middle-low elevation region (Table 2.1.1). There were 78 crosses made specifically for the lower latitude region; this represents 23% of the crosses. In the future we expect to reduce the proportion of crosses for the Mediterranean region and increase the emphasis on early flowering material targeted toward the lower latitudes, in view of the importance of lentil production in Bangladesh, Ethiopia, India and Pakistan. Only 11 crosses were made to recombine cold tolerance with high yield for the high elevation areas. This region represents less than 10% of the lentil production area in the developing world.

Table 2.1.1. Lentil crossing block 1985-1986 showing target regions, aims of recombinations and number of crosses made.

Region	Aims of recombination	No. of crosses
High elevation	Cold tolerance x High yield	11
	Total	11
Mediterranean (Low-medium elevation)	Large seeds: High yield x Mechanical harvest	93
	Small seeds: High yield x Mechanical harvest	113
	High yield : Large seeds x Small seeds	4
	L. orientalis x High yield	6
	Crosses for Jordan national program	24
	Crosses for Tunisia national program	4
	Total	244
Lower latitudes	Wilt resistance x High yield	25
	High yield: Small seeds x Large seeds	34
	Crosses for Bangladesh national program	19
	Total	78

The material from crosses directed towards the three target regions are handled in three streams, as described in last Annual Report (ICARDA, 1985), within a bulk-pedigree system of breeding.
Dr. W. Erskine

2.1.2. Development of Methodology for Dihaploid Production

The lentil breeding program utilizes bulk breeding from the F_2 to the F_4 generation and then uses a pedigree system (ICARDA 1985). In the cooperative program with the University of Manitoba, Canada funded by the International Development Research Centre, Ottawa, we are developing the methodology for dihaploid production in lentils. The production of dihaploids brings complete homozygosity in one step, whereas self pollination following a cross between pure lines allows a progressive but slow return to homozygosity over many generations. Since no selection is practiced prior to F_4 generation, the production of dihaploids by anther culture from F_1 plants promises to speed up the breeding cycle from a cross through to selection.

The project aims to define the conditions for the induction and recovery of haploid plantlets from cultured anthers and microspores. Chromosome doubling can then be undertaken to produce dihaploids. To date, calli have been developed from anther tissue, but haploid callus emanating from the culture of microspores has not yet been detected. Large differences between genotypes in the cultureability of their anthers have been found, as is the case in most species. Although some calli are greening and produce chlorophyll, the differentiation into plantlets still remains a problem.
Drs. D. Palmer and W. Tai (University of Manitoba) and W. Erskine.

2.1.3. Yield Trials

Selections from the breeding program are tested both in preliminary and advanced yield trials in three locations contrasting in their rainfall namely Breda (annual average rainfall:281mm), Tel Hadya (ann. average rainfall:328mm). and Terbol (ann. average rainfall c.550mm).

This season the top yields recorded at both Tel Hadya and Breda were in excess of 2 tons seed/ha (Table 2.1.2). The overall location means for the three test sites were 1.6 tons/ha at Terbol, 1.3 tons/ha at Tel Hadya and at Breda 0.7 tons/ha. The location means were always higher than the check mean yield, indicating clearly that most of the test entries were yielding more than the checks. Thus, amongst the small-seeded entries the percentages of entries yielding significantly ($P \leq 5\%$) more than the check at Terbol, Tel Hadya and Breda were 36, 21 and 35% respectively. Many other entries merely ranked above the check in seed yield but did not exceed the check by a significant margin. Such entries represented 28, 35 and 35% of all the test entries at Terbol, Tel Hadya and Breda, respectively (these percentages exclude those entries outyielding the check significantly).

Amongst the large-seeded material in yield trials the story is similar, and the percentage of entries yielding significantly ($P \leq 5\%$) above the check were 55, 30 and 2% at Terbol, Tel Hadya and Breda, respectively. A further 18, 39 and 33%, respectively, merely ranked above the check. This indicates that there are many high yielding lines emanating from the breeding program, and a substantial number of these lines are outyielding the checks in all three locations. We propose to add one large-seeded improved check (78S 26002) and one small- seeded improved check (78S 26013) to the trials next season.

Table 2.1.2. Results of yield trials (advanced, preliminary and regional) conducted for large-(L) (>4.5g/100 seeds) and small-(S) seeded selections at Tel Hadya and Breda in Syria and Terbol in Lebanon during the 1985/86 season.

	Tel Hadya		Breda		Terbol	
	L	S	L	S	L	S
Number of yield trials	9	10	2	7	3	4
Number of test entries[1]	211	230	51	166	78	88
% of entries sig. ($P<0.05$) exceeding check[2]	30	21	2	35	55	36
% of entries ranking above check (excluding above)	39	35	33	35	18	28
Yield of top entry (kg/ha)	2008	1999	1564	1121	2097	2192
Check mean yield (kg/ha)	1141	1249	720	649	1532	1515
S.E. check mean +/-[3]	42.8	43.7	81.9	17.8	48.3	47.2
Location mean (kg/ha)	1315	1305	834	714	1683	1628
C.V. (%)	19.5	21.2	27.8	4.2	9.9	11.6

1. Entries are common over locations
2. Large seeded check=ILL 4400 (Syrian Local L.); small-seeded check = ILL 4401 (Syrian Local S.)
3. A pooled analysis of large-seeded and small-seeded trials was done for each site.

2.1.4. On-Farm Trials and Regional Trials in Syria

During the last season we continued the search for high yielding large and small seeded lentil lines with the Syrian National Program through regional trials and on-farm trials. There are two regional trials, large-seeded and small-seeded, which contain the best lines from the ICARDA base program. They were grown at five research stations in Syria; Idleb, Heimo and Gelline belonging to the Syrian Government and Breda and Tel Hadya run by ICARDA.

In the large seeded regional yield trial the location means varied from 915 kg/ha in Breda, the driest site, up to 2.3 tons/ha at Heimo. The national check, Kurdi 1, yielded less than the trial mean in four out of the five locations and ranked 17 out of 24 entries on the basis of mean yield overall. The highest yielding line ILL 4354 gave a mean seed yield of 1648 kg/ha, which was 33% higher than the yield of the national check which yielded a mean of 1242 kg/ha seed.

A similar picture was given by small-seeded regional yield trial, with Breda location again giving the lowest mean yield, whereas at Heimo a trial mean of 2.2 tons/ha was obtained. The national check for small seeds was Hurani 1, which yielded an average of 1367 kg/ha seed. However, it ranked 15 out of 24 entries on the basis of seed yield and the best entry ILL 5858 gave a mean yield of 1601 kg/ha.

The best entries from the regional trials are included in on-farm trials as the next stage of testing. This season we concluded a series of on-farm trials initiated during 1982-83 season on small-seeded lentils. The 1985-86 on-farm trials were conducted at nine sites in a randomized block design with two replications. The national check Hurani 1 yielded 993 kg/ha seed overall, in contrast to the two ICARDA lines 78S 26013 and 76TA 66088 which yielded 1281 and 1243 kg/ha

Table 2.1.3. Mean seeds yield (kg/ha) of small-seeded lentil on-farm trials in Syria from 1982 to 1986.

Selection	ILL	Season				Mean over all sites	Rank
		1982/83	1983/84	1984/85	1985/86		
78S 26013	16	1054	990	931	1281	1054	1
76TA 66088	223	877	1076	978	1243	1049	2
Hurani 1	2130	823	855	998	993	938	3
Number of sites		6	7	13	9	35	
C.V.(%)		25.4	23.7	17.7	14.3	17.5	
Standard error ±		73.2	60.0	34.5	38.0	30.5	

respectively (Table 2.1.3). This year both ICARDA lines were confirmed as resistant to vascular wilt (Fusarium oxysporum f.sp. lentis) on farmers' fields.

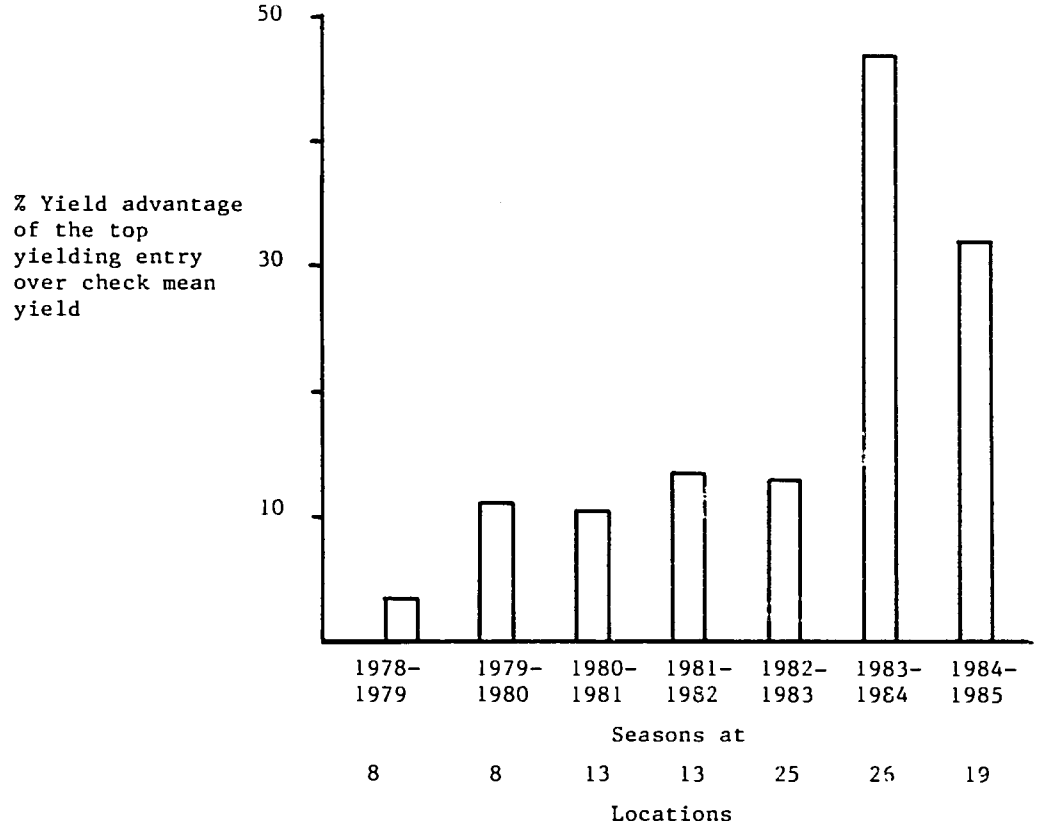
A summary of the results over the four seasons shows that over a total of 35 sites 78S 26013 yielded an average of 1054 kg/ha in contrast to the local check Hurani 1 which gave 938 kg/ha. The other ICARDA line, 76TA 66088, also yielded more than the check (1049 kg/ha). Both lines have a reduced tendency to lodge than the local, so their mechanical harvest is facilitated. The lines will be grown on a larger area next season as pre-release multiplication, and they will be submitted to the Syrian variety release committee.
Dr. W. Erskine

2.1.5. Yield of International Trials in Comparison with a Long-Term Check

Each year the international trials are distributed around the world and on the basis of the results obtained lines are either retained or rejected as an entry in next seasons' international trial. A long-term check has been retained in each trial to monitor the results and assess the progress in selection for yield of the ICARDA base program. The results reflect the yield potential of the entries on an international stage with the number of data sets analyzed annually reaching to 26 locations.

In the Lentil International Yield Trial-Large Seeded, the long-term check is Syrian Local Large (ILL 4400). In the 1978-79 trial the top yielding entry only gave 3.5% more average yield over all sites than the check (Figure 2.1.1). In the next four years' trials the yield advantage of the top yielding entry over ILL 4400 rose to 10-14%. In the last two years' results the yield advantage over the check of

Figure 2.1.1. The yield advantage, expressed as a percentage, of the top yielding entry in the Lentil International Yield Trial - Large seeded over the check (ILL 4400) means used internationally over the number of locations indicated on the x-axis over different seasons.



the best entry has now risen to over 30%. This recent rise reflects the inclusion of lines into the international trials which emanate from crosses made at ICARDA, whereas previously the entries comprised selections from germplasm. Taken overall, the increasing yield advantage of the best entry over the long-term check ILL 4400 illustrates clearly the response to selection for yield undertaken by the ICARDA breeding program measured internationally.
Drs. W. Erskine and R. S. Malhotra

2.1.6. Use of ICARDA Lentils by National Programs

ICARDA lentils were used on an increased scale by national programs during the season 1985/86 (Table 2.1.4). A total of five lentil lines from ICARDA have now been released by national programs as cultivars. Syrie 229 is now released in Algeria, and ILL 4400 and ILL 4606 have been released in Tunisia following their extensive testing by the joint Tunisia/ICARDA food legume project. These three lines are in addition to NEL 358 released in Ethiopia in the previous year, and ILL 481 released in Canada as a green-manure crop.

Several other lines have now been tested extensively by national programs and are either about to be submitted for or are under registration. In Turkey, which is now the largest lentil producing country in the world, G.D. Pull 2 (ILL 467) and G.D. Kirimize 3 (ILL 4399) have now been tested successfully for three years in S.E. Anatolia. Two lines are undergoing registration in Spain. In Syria 78S 26002 (ILL 8) will be brought before the varietal release committee. This season in the village project, which was part of the cooperative program with the Ministry of Agriculture, 78S 26002 was tested against local in a 0.5 ha sowing at Talref'at. The result showed a yield superiority of 48% by 78S 26002 over the local cultivar.
Drs. W. Erskine and R.S. Malhotra.

Table 2.1.4. Names of ICARDA lentil lines released by national programs together with the number of additional lines in pre-release multiplication.

Africa	Algeria	Syrie 229
	Morocco	1
	Tunisia	ILL 4400 and ILL 4606
West Asia	Lebanon	2
	Syria	3
	Turkey	2
Nile Valley	Ethiopia	NEL 358
Indian sub-continent	India	1
	Pakistan	1
South America	Argentina	4
North America	Canada	ILL 481
Europe	Spain	2

2.1.7. Genetic Variation of Lodging

Although lentils are now harvested by hand in the Middle East, research is focused on mechanizing their harvest. Yield losses from a mechanical harvest increase with lodging. For example, the seed yield advantage of a non-lodged selection over the lodged landrace increased from 9% with a hand harvest to 39% with harvest by a double-knife cutter bar.

We studied the genetic, environmental, and genotype- environmental variation of the lodging of 242 lines grown at three locations

contrasting in rainfall. There was no lodging at the dry site, Breda, where a total of only 1.5 t/ha biomass was harvested. In contrast the lodging scores (scale 1 to 5, with 1 = no-lodging and 5 complete lodging) were 2.3 and 2.4 at the two wetter sites, where the mean total biological yields exceeded 3t/ha. The broadsense heritability of lodging across sites was 0.41 $\pm$ 0.046.

In a separate trial of 25 genotypes in one location, detailed morphological measurements were made to relate to lodging scores. Path analysis revealed that genotypes with thick stems lodge least. Since lodging can only be scored on a plot basis, selection of single plants with thick stems may assist progress in breeding for a non-lodging habit.

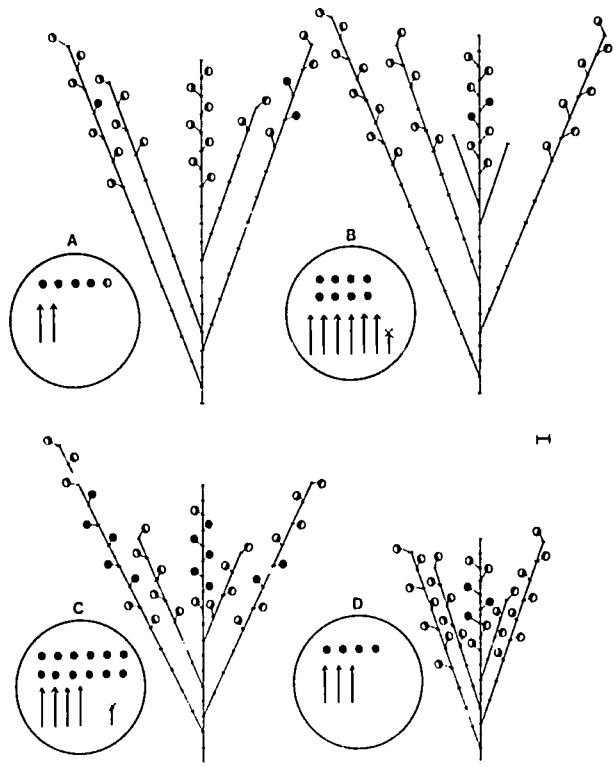
The path analysis also showed a low direct effect of seed and straw yield in loding, suggesting that increased yields are not always linked to increased lodging. In this regard high yielding lines with a non-lodging habit have now been found.

2.1.8. Genetic Variation in Growth Habit

Last year we reported a study of the genetic variation in growth habit of 25 contrasting genotypes (ICARDA, 1985). Growth habit is of particular importance, because it determines the ease with which a mechanized harvest can be undertaken. Thus, whereas a tall, un-lodged crop can be harvested mechanically with low losses; a short and lodged canopy will result in heavy losses with a mechanized harvest. The study was repeated last season.

Although the variability within the crop in growth habit is continuous, striking differences between genotypes are evident in Figure 2.1.2, illustrating schematically the habits of four genotypes.

Figure 2.1.2. Diagrams of four lentil genotypes A = ILL 468 (Chile), B = ILL 922 (Turkey), C = ILL 4354 (Jordan), D = ILL 4605 (Argentina) based on the mean of 40 plants. The scale is indicated by a 2cm bar. Main stem height and average node length are to scale. The average node number on the main stem subtending the 1st, 2nd, 3rd etc. primary branches is shown, as is the average nodal position of pods on the main stem and primary branches. The number of secondary and tertiary branches are displayed in a circle beside each genotype. The following symbols are used ⊖ half pod, ● whole pod, + node on main stem or primary branch, ↑ secondary branch, and ↑ tertiary branch.



Overall the seed yield was distributed within the canopy as 17.6% on the main stem, 48.9% on the primary branches, and 33.4% on secondary branches. The average nodal positions of pods bearing this yield are also shown in Figure 2.1.2.

The study showed that the tall genotypes are constructed along different architectural plans; they varied in the number of branches, canopy spread, and lodging susceptibility, for example. Because this genetic variation is probably determined by different genes, several contrasting sources of extreme height should be crossed in breeding for height, as this would increase the possibility of transgressive segregation for height and possibly result in further diversity in growth habit.

Dr. W. Erskine and Mr. W.J. Goodrich.

2.1.9. Measurement of Hybrid Vigour

The successful exploitation of hybrid vigour requires firstly an economic level of vigour and secondly a viable system of hybrid seed production. In the absence of any information on hybrid vigour in lentils measured at crop density, we evaluated 50 different hybrids and their parents for hybrid vigour at Tel Hadya. The parents spanned a wide range of diversity in the crop and originated from a total of 15 countries. A split-plot design was used with two replications and with crosses as main plots and generations (parents and F_1) as sub-plots. The experiment was sown at crop density (200 seeds/m^2) with guard plants of a common line to border all F_1 plants.

For grain yield/plant heterosis from the mid-parent value averaged 19.4% over all 50 crosses (Table 2.1.5). However, the high standard error of this value reflected the very considerable variation from cross to cross in hybrid vigour, and, consequently, the average for

Table 2.1.5. The mean mid-parent value and F_1 generation over 50 crosses together with the average heterosis from mid-parent and from better parent for five traits in the 1984-85 season.

Character	Mid-parent mean	F_1 mean	Heterosis from mid-parent (%)	Heterosis from better parent (%)
Grain yield/plant (g)	0.7	0.8	+19.4 ± 12.94	+4.9 ± 10.28
Biological yield/plant (g)	1.7	2.0	+16.2 ± 10.09	+4.5 ± 8.77
Time to flower (d)	95.9	95.3	-0.6 ± 0.31	0.8 ± 0.35
Plant height (cm)	21.1	23.6	+11.6 ± 0.39***	2.4 ± 2.06
100 seed weight (g)	3.27	3.27	0.0 ± 2.33	-13.7 ± 2.66***

*** $P<0.001$

mid-parent value was not judged significantly greater than zero at 5% probability level. The mean value for grain yield per plant for heterosis above the better parent was 4.9%, but again this was not significantly greater than zero.

Amongst the other characters, there was no significant average hybrid vigour over crosses for time to flower. For plant height there was significant hybrid vigour from the mid-parent value for increased height, but it did not reach the level of the better parent, on average. For 100 seed weight there was no significant hybrid vigour from the mid-parent value. A significant negative value for heterosis from the better parent, in view of the previous sentence, merely indicates that the larger-seeded parent, on average, had significantly larger seeds than the mid-parent value. The experiment will be repeated.

Dr. W. Erskine

2.1.10. Genetic Variation in Response to Irrigation

In Egypt, before the construction of the Aswan Dam, lentils were grown on moisture retained in soil from the annual flood of the Nile. Irrigation became widely available when the high dam was constructed, but Egyptian lentils are ill-adapted to extra irrigation. Most introductions to Egypt come from rainfed areas with similar adaptation. This study, conducted by a Ph.D. student with financial support from the Nile Valley Project, was designed to estimate the genetic variation in lentils in response to irrigation in order to develop a selection metholodology for irrigated conditions.

The study was conducted during both the 1984/85 and 1985/86 seasons with 34 diverse accessions from the lentil germplasm collection in five environments at three locations: (1) Tel Hadya, unirrigated;

Tel Hadya, one supplementary irrigation (50mm before flowering), Tel Hadya, two supplementary irrigations (50mm before flowering and again before pod filling), (2) Breda, without irrigation, and (3) Terbol, without irrigation.

The season 1984-85 was wetter at all sites than the following season with, for example, 373 and 316 mm rain received in the two seasons respectively in Tel Hadya. Consequently the trial means at Breda and Tel Hadya (unirrigated) were 599 and 2195 kg/ha in 1984/85, but in the following season the trial means had dropped to 531 and 1931 kg/ha respectively, representing declines in yield of 11 and 12%. Interestingly, however, the rainfall distributions of the two years contrasted with only 14mm being received during April and May 1985 in contrast to 52mm in the corresponding period the following year, with the result that irrigation during this pod-filling period led to a response in yield of 28% in 1984/85 and a lower response of only 10% in 1985/86 despite the lower seasonal rainfall total.

There was a highly significant genotype x year interaction, and also a significant genotype x environment interaction which was explained by joint regression analysis. Another example of the different linear responses of genotypes to variable soil moisture levels is given in the section 'study of drought tolerance and moisture use in lentil genotypes'.
Mr.A. Hamdi (University of Durham, U.K.) and Dr. W. Erskine

2.1.11. Screening for Resistance to Vascular Wilt

Vascular wilt (Fusarium oxysporum f.sp. lentis) is a major fungal pathogen of lentils both around the Mediterranean Sea and also in the Indian sub-continent. Last season we estimated from a survey in N. Syria that vascular wilt accounted for an overall reduction in seed

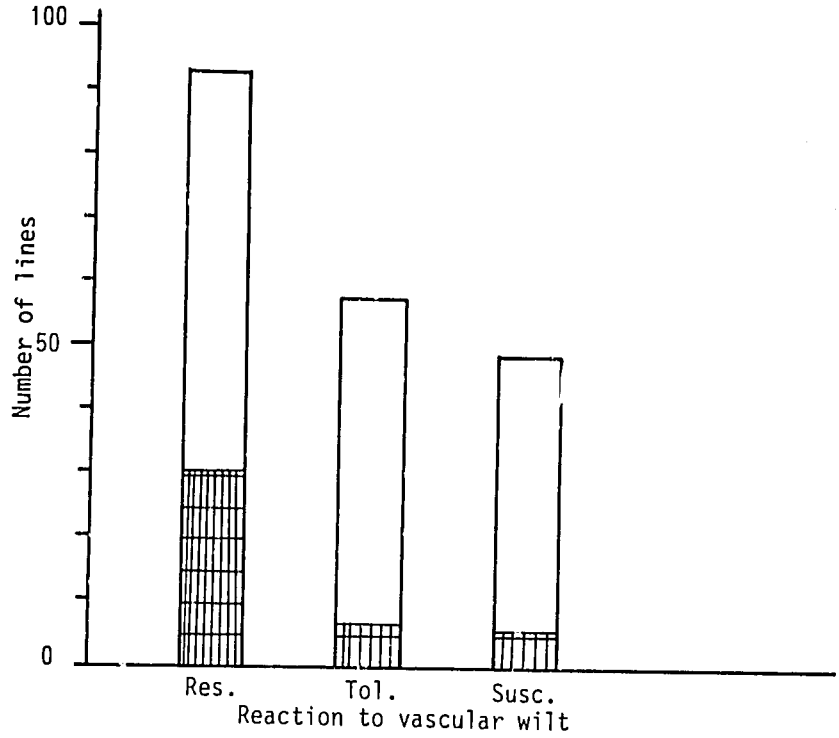


Figure 2.1.3. The reaction to vascular wilt of 209 lines in yield trials in the field at Tel Hadya during 1985/86 season. The number of large seeded lines is indicated by the barred area, and small seeded entries comprise the clear area.

yield on farmers' fields of 12% (Baya'a, Erskine and Khoury, 1986). This season a higher incidence of wilt was observed in Syria, probably because the adequate early-season rain was followed by a dry April leading to severe plant stress during reproductive growth.

Field screening for resistance to vascular wilt was possible in nine replicated trials at Tel Hadya. In these trials there were at least 10% of plants killed in one of the plots of the susceptible local check (ILL 4401), indicating sufficient soil inoculum for screening. Overall 209 lines were screened for their reaction to vascular wilt in comparison to the check, and 93 lines or 44.4% were completely resistant with no wilted plants in any plot. There were 49 lines (23.4%) which were either equally or more susceptible to wilt than Syrian Local Small (ILL 4401); the remaining 67 lines (32.1%) showed a tolerant reaction exhibiting some wilt but always at a lower incidence than the check (Figure 2.1.3).

The 209 lines comprised 44 large-seeded and 165 small-seeded lines, and the comparison of results in the groups is interesting. The large-seeded group had almost double the frequency of resistant lines (70.5%) than the smaller-seeded group (36.4%), and half the frequency of susceptible lines (13.6%) compared to the microsperma types (26.1%). Clearly more attention will have to be paid to selecting small-seeded resistant material than large-seeded lines.
Dr. W. Erskine

2.2. Lentil Harvest Mechanization

Mechanization of lentil harvest in the Middle East is a major research goal of FLIP, because lentil areas are declining due to increased labor costs for harvest in comparison to world lentil prices. Research on lentil harvest mechanization has been intensified at ICARDA following a

grant from the International Development Research Centre, Canada. The major trial conducted at Tel Hadya in the 1984/85 season gauged the minimum change from traditional agronomy needed for the successful operation of two harvesting machines. The results showed that the double-knife cutter bar performed well only on soil which was flattened either by sowing with a seed drill or by a bar dragged behind the ducksfoot cultivator, which was covering broadcast seed. The cutter bar worked best on an un-lodged cultivar. The angled blade system was most successful on a traditional broadcast and ridged crop irrespective of the cultivar.

During the 1985/86 season we moved to farmers' fields to test the two harvest systems under the optimal agronomic conditions found in the previous season in five locations in N. Syria. The agronomic and economic results are summarized in Table 2.2.1. We studied the effects of two methods of soil flattening, seed drilling and the use of a bar using a set of seven treatments (Table 2.2.1). The bar increased yields of seed and straw from a hand harvest by a non-significant margin, indicating that if a field is broadcast and then covered with a bar it can be harvested either by hand, with no loss in return compared to the traditional system of sowing without a bar, or by cutter bar.

Under low output price conditions (SL 1.87/kg seed and SL 0.88/kg straw), only treatment alternatives 6 and 4 were undominated, i.e. they are rational economic options (Table 2.2.1). Both these treatments include seed drilling and mechanical harvest by cutter bar. Between these two treatments, the extra expenditure required to grow the improved variety 78S 26002 (ILL8) instead of local seed had a high marginal rate of return (175%); thus every extra Syrian Lira spent would be repaid to create SL 1.75 net benefit.

We tested different mechanization costs (high and low levels of costs and efficiencies of performance of the machines) but they did not

Table 2.2.1. Mean seed and straw yields (kg/ha) and net revenue over variable costs (SL/ha) in five on-farm trials on lentil harvest mechanization in N. Syria during 1985-86 season. Net revenue is calculated for both high and low output costs.

Treatment No.	Sowing method	Cultivar	Harvest method	Mean seed yield (kg/ha)	Mean straw yield (kg/ha)	Net revenue (low output price) (SL/ha)	Net revenue (high output price) (SL/ha)
1	Broadcast	Local	Hand (Control)	998	2312	2785	4651
2	Broad.+bar	Local	Hand	1164	2406	3178	5506
3	Broad.+bar	Local	Cutter bar	942	1659	2710	4490
4	Drilled	Local	Cutter bar	937	1866	3059	4943
5	Broad.+bar	78S 26002	Cutter bar	1066	2003	3100	5033
6	Drilled	78S 26002	Cutter bar	1107	1798	3223	5333
7	Broadcast	Local	Angled blades	798	1845	2559	4079
	C.V. (%)			21.8	22.6		
	SE ±			49.0	100.6		

alter the ranking economically of the treatments. We then looked at a high output price (SL 3.8/kg seed, SL 1.0/kg straw) which did change the economic rank order of treatments. Treatment 2 (broadcast + bar, local seed, hand harvest) came at top with 5506SL/ha net benefit followed by treatment 6 (Drilled, 78S 26002 seed, cutter bar harvest). Under these price conditions the reduction in yield losses, particularly of seed, due to mechanization becomes a crucial factor in attracting farmers to adopt lentil harvesting by cutter bar. It is significant that the cutter bar can also harvest many other crops (cereals, and forage and other food legumes). We will concentrate on testing the cutter bar further in larger plots in farmers' fields next year.

The angled blades tended to mix soil with the plant material and were inconsistent in performance agronomically. Consequently their performance measured economically was poor. A changed design will be tested inside Tel Hadya next season.

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2.3. Lentil Straw Quality

Although lentil seed is the primary yield of the crop, the straw or residues following threshing are an important livestock feed in the Near East. Over the past few seasons we have studied the genotypic, genotype-season, and seasonal variation in straw quality and quantity (ICARDA, 1984 and 1985). The importance of seasonal differences in straw quality and the presence of a significant genotype x season interaction are now clear, as is the relative unimportance of genetic variation in straw quality. In an attempt to understand some of the above variability we harvested by hand samples from a trial of six elite lines in two replicates at Tel Hadya for subsequent (painstaking) separation of the crop residue into the four component plant parts:

Table 2.2.2. The distribution within lentil straw of four plant parts and their respective quality attributes.

	Distribution (%)	Digestibility (g/100g dry matter)	Protein (%)	Fibre (NDF) (%)	Lignin (%)
Leaves	38.1	66.2	8.6	29.2	7.0
Pod walls	22.8	48.3	6.3	49.7	11.4
Branches	34.3	39.8	3.6	60.2	19.6
Roots	4.7	25.9	6.2	71.4	24.0
L.S.D. (5%)	1.25	3.48	0.46	1.90	1.40

1) roots 2) branches 3) pod walls and peduncles 4) leaves (petiole, rachis and leaflet).

There were highly significant differences between the plant parts in their distribution within the straw, and also in the quality of the components measured; in vitro digestibility, protein content, neutral detergent fibre content, and lignin content (Table 2.2.2). The high proportion of pod walls was due to the crop's high harvest index. Leaves were the most digestible component, followed by pod walls and then branches and finally roots. The digestibility data of the plant parts are confirmed by the negative association of digestibility with both fibre and lignin contents.

The six lines differed in their relative distribution of the plant parts. Thus Kurdi 1 and 78S 26002 lines had a lower proportion of leaves than the other lines and a higher proportion of branches. Since variety x plant part interactions were non-significant for the quality characters digestibility, and protein and lignin content, the major reason for differences between varieties in overall straw quality is different distribution of the plant parts within the straw. Differences between seasons in straw quality may possibly be explained in the same way, by differences in the dry matter distribution between component plant parts.

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2.4. Lentil Insects and their Control

Studies on the development of control recommendations for insect pests affecting lentils were continued. The experiments concentrated on a further evaluation of the economic importance of the Sitona spp. complex and the efficiency of insecticides to control this pest.

2.4.1. Insect Control Recommendations

Based on the results of the previous season an experiment was set up to partition yield losses between Sitona spp. (mainly Sitona lineatus and Sitona crinitus) and foliar insects (aphids and thrips). Total insect control through granular insecticide (carbofuran) applications at planting and 2 foliar sprays with methidathion at preflowering and midflowering gave a non-significant yield increase of 27.5% (Table 2.4.1). When only Sitona spp. were controlled yield increased by 15.5%, whereas yield response to aphid control (2 aphid sprays with pirimicarb) was 10.2%, and to thrips control (2 foliar sprays with formathion) 11.0%. Although no significant differences were found this season, the results showed the same tendency as in previous years and thereby confirmed the findings that Sitona spp. are the key pest in lentils.

2.4.2. Economic Importance of Sitona spp.

To evaluate the economic feasibility of Sitona spp. control under farmers' conditions damage levels and seed yields were studied at 7 different locations in northern Syria using 2 levels of carbofuran treatment. At Maara (Idelib) the highest infestation of 87% nodules damaged was found, and at Sowan the lowest of 18% nodules damaged (Table 2.4.2). Because of high variability the yield increases resulting from carbofuran treatments were non-significant. This experiment however indicated that with the lower dosage of carbofuran, which was only half of the recommended rate, the control achieved was equivalent. To further determine the economic importance of Sitona spp. in lentils in relationship to meteorological data this experiment will be conducted at 3 locations with different climatic conditions the next season.

Table 2.4.1. Effect of different insecticide regimes on *Sitona* spp. weevil damage levels, foliar insect pest populations, and yields of Syrian Local Large lentil, Tel Hadya, 1985/86.

Treatments	*Sitona* spp. % nodules damaged	Foliar insects/600cm^2 Accum. no. of 5 counts Aphids	Thrips	Seed yield kg/ha	% increase
Complete control[1]	20.2	50	132	1906	27.5
Control of *Sitona* spp.[2]	0.7	481	180	1727	15.5
Control of aphids[3]	85.0	60	169	1649	10.2
Control of thrips[4]	69.0	25	113	1665	11.0
Check	72.0	510	181	1496	

1 Carbofuran G 5% 20 kg/ha at planting, 2 foliar sprays Supracid 40% (methidathion) 2cc/l.
2 Carbofuran G 5% 20 kg/ha at planting.
3 Two foliar sprays with Primor 50% pirimicarb w/w 0.5 g/l.
4 Two foliar sprays with Anthio 33% formathion 1cc/l.

Table 2.4.2. Effect of chemical treatments on Sitona spp. damage levels and seed yield of Syrian Local Large lentil at 7 locations in northern Syria, 1985/86.

Location	Treatment[1]	% nodules damaged	Seed yield kg/ha	% increase	C.V. (%)	LSD (5%)
Maara	C 20	7	1551	73	8.8	468
	C 10	28	1272	41		
	Check	87	896			
T. Rafaat	C 20	1	1736	34	16.4	1123
	C 10	9	1747	35		
	Check	53	1298			
Souran	C 20	5	1113	25	6.8	298
	C 10	2	1016	14		
	Check	18	893			
Atareb	C 20	0	548	24	21	442
	C 10	1	480	3		
	Check	24	465			
Breda	C 20	3	557	9	3.8	91
	C 10	1	611	19		
	Check	39	514			
T. Hadya	C 20	2	1609	18	20.9	1359
	C 10	1	1565	15		
	Check	61	1358			
Afes	C 20	17	736	7	15.1	466
	C 10	13	731	6.6		
	Check	38	687			

1) Carbofuran 5% G at 20 kg/ha (C20) and 10 kg/ha (C10) applied at planting.

Table 2.4.3. Damage and population levels of *Sitona* spp. and seed yield of Syrian Local Large lentil at different treatment levels of carbofuran G 5%, Tel Hadya, 1985/86.

Carbofuran treatment	Visual damage score (1-9)	% leaflets damaged	% nodules damaged	Neonate adults per 1500cc soil	Seed yield kg/ha
20 kg/ha	1.4	4	15	1	1700
15 kg/ha	1.4	6	4	1	1807
12 kg/ha	1.4	4	2	2	1804
10 kg/ha	1.7	6	10	7	1869
8 kg/ha	1.6	5	9	6	1890
5 kg/ha	1.6	4	11	8	1869
2 kg/ha	1.8	9	25	26	1708
Check	2.1	12	96	29	1810

Table 2.4.4. Effect of early and late planting and carbofuran[1] treatment on *Sitona* spp. damage levels at different locations in northern Syria, 1985/86.

Location	% nodules damaged				C.V. (%)	LSD (5%)
	Early planting		Late planting			
	No treatment	Carbofuran	No treatment	Carbofuran		
Taom	67.1	8.4	21.9	11.7	44.7	26.3
Noaman	42.8	0.4	49.1	0.4	22.3	11.6
Em-hosh	58.4	0.9	25.4	0.0	42.2	20.1
Kafer Antones	72.1	16.1	22.1	0.6	73.3	45.4
Suqilbiyeh	23.4	8.4	28.4	9.9	37.7	14.8
Dowair	19.8	9.3	15.3	6.2	55.6	15.8

1) Carbofuran 5% G 20 kg/ha.

2.4.3. Control of Sitona spp.

The effect of 8 treatment levels of carbofuran on the Sitona spp. infestation and damage was studied in another experiment, whereby the critical level of nodule damage inducing economic loss could be established. Unfortunately part of the trial was lost because of flooding, but the results obtained still indicate that application of even half or one quarter of the recommended dosage leads to reduced Sitona spp. infestation and damage levels (Table 2.4.3). In cooperation with the weed control group the effects of 2 planting dates (early and late) with and without carbofuran treatment were studied at 6 locations in northern Syria. Generally the plots sown in December showed less nodule damage than those sown in early November (Table 2.4.4). High Sitona spp. infestations of 67.1 and 72.1% nodule damage were found only in 2 locations, when lentils were planted early without carbofuran treatment. It appears that early planting of lentils can increase Sitona spp. infestations necessitating a control treatment.

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2.5. Lentil Crop Physiology, Agronomy and Microbiology

2.5.1. Photothermal Regulation of Flowering in Lentils

One of the major factors responsible for narrow adaptability of most of the lentil genotypes is their sensitivity to photoperiod and thermal regime. Under controlled environmental conditions, more precise information on this aspect of adaptation has been generated*. Results have indicated that progress towards flowering (1/f) is linearly

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* Summerfield, R.J., Roberts, E.H., Erskine, W. and Ellis, R.H. 1985. Effect of temperature and photoperiod on flowering in lentils (Lens culinaris Medic.) Annals of Botany 56:659-671.

related to mean temperature (t) and photoperiod (p) with little interaction between the latter two variables. In order to test this model under actual field condition, a study was conducted in the field during 1985/86 season to investigate the response of six lentil genotypes from different geographical regions (Table 2.5.1) to various photothermal regimes as obtained by using extended days of 16h vs normal days, in which the photoperiod ranged from 9 to 13h and by staggering planting from November 1985 to March 1986. The model for describing progress towards flowering (1/f) is described by the equation: $1/f = a + bt \pm cp$, where a, b and c are constants. The outcome of fitting this equation to the flowering data for individual genotypes is in Table 2.5.1. The results show that progress towards flowering is influenced by temperature and photoperiod. Separate simple linear regressions for each genotype were carried out for progress towards flowering vs mean temperature ($1/f = a + bt$) and photoperiod ($1/f = a + bp$) and the results showed that the rate of progress towards flowering was influenced mainly by mean temperature (R^2 were 0.793, 0.846, 0.824, 0.780, 0.495 and 0.829 respectively for ILL 9, ILL 1744, ILL 2501, ILL 4400, ILL 4349, ILL 4605). The small response to photoperiod was probably due to the narrow range of photoperiod achieved. The extended photoperiod of 16h had very low illuminance which varied from 75 to 350 lux, whereas the minimum illuminance to influence progress to flowering in lentil is now reported to be 500 lux. This may also explain the low coefficient of determination for ILL 4349, which is adapted to the long day environments of North Africa.

Drs. S. Silim, M. C. Saxena and W. Erskine.

Table 2.5.1. The regression of progress to flowering (1/f) on mean temperature (t) and photoperiod (p) for each of the six lentil genotypes, Tel Hadya 1985/86.

Genotype	a	bt	cp	R^2
ILL 9	-0.010278	0.001388	0.000522	0.873
ILL 1744	-0.006758	0.001390	0.000293	0.870
ILL 2501	-0.009182	0.001499	0.000365	0.856
ILL 4400	-0.009542	0.001314	0.000458	0.867
ILL 4349	-0.019285	0.000837	0.001303	0.676
ILL 4605	-0.003991	0.001244	0.000198	0.839

2.5.2. Study of Drought Tolerance and Moisture Use in Lentil Genotypes

Response of diverse genotypes of lentils to total seasonal moisture supply was investigated by growing under rainfed conditions at Tel Hadya (316 mm seasonal rainfall) and Breda (218 mm seasonal rainfall) and also at Tel Hadya under two additional levels of moisture supply through supplemental irrigations (i. one irrigation of 50 mm at flowering, and ii. three irrigations (in all 150 mm) starting at flowering stage). Soil moisture studies were conducted on nine genotypes to determine evapotranspiration and water-use efficiency under rainfed conditions in Tel Hadya.

Averaged over all genotypes, both seed and total biological yields were closely related to total seasonal moisture supply (Table 2.5.2). At each level of moisture supply both seed and total biological yields varied significantly among genotypes. In the lowest level of moisture supply (Breda, 218 mm rainfall), the highest yielders were ILL 4354,

Table 2.5.2. Effect of total seasonal moisture supply on seed and total biological yields (kg/ha) of diverse lentil genotypes sown in Breda and Tel Hadya, 1985/86.

Genotype	Origin	Seed yield (kg/ha)					Biological yield (kg/ha)				
		Breda	Tel Hadya				Breda	Tel Hadya			
		Rainfed (218mm)	Rainfed (315mm)	One Irr. (366mm)	Three Irr. (466mm)	Mean	Rainfed (218mm)	Rainfed (316mm)	One Irr. (366mm)	Three Irr. (466mm)	Mean
ILL 8	Jordan	453	1238	1838	2358	1811	1679	3759	4451	6463	4891
ILL 9	Jordan	498	1213	1582	1726	1507	1631	4279	4838	7403	5507
ILL 16	Jordan	346	1212	1328	1625	1388	1300	3954	4697	6358	5003
ILL 101	Syria	186	1024	1790	1319	1377	670	3253	4770	6614	4879
ILL 223	Iran	316	1377	1453	1964	1598	1116	4401	4537	7197	5378
ILL 470	Syria	271	1135	1565	2204	1635	1081	3126	3874	5958	4319
ILL 793	Egypt	152	509	167	622	533	762	2995	4215	5668	4293
ILL 1861	Sudan	204	990	1392	1470	1284	1098	3621	4408	6044	4691
ILL 4349	USSR	112	281	641	607	510	920	2376	3899	5038	3771
ILL 4354	Jordan	561	1468	1379	2147	1665	1497	4350	3881	6612	4948
ILL 4400	Syria	235	1096	1223	1237	1185	786	3244	4876	7065	5062
ILL 4401	Syria	232	999	1160	1534	1231	1259	3801	4194	6546	4847
ILWL 7			184	208	371	254		1056	1442	2340	1613
Mean		297	979	1233	1476		1150	3401	4160	6100	
			Moisture(M)	Genotype(G)	MxG			Moisture(M)	Genotype(G)	MxG	
L.S.D. (5%)		144	199	241	446		343	472	398	810	
S.E.		50.3	57.4	86.1	149.1		169	137	142	273	
C.V. (%)		33.9	33.7	24.3			20.8	21.6	10.8		

Table 2.5.3. Total evapotranspiration (Et) and water-use efficiency (WUE, kg/ha/mm) for total biological yield (TBY) and seed yield (SY) for different lentil genotypes under rainfed conditions at Tel Hadya, 1985/86.

Genotype	Date of maturity	Et (mm)	WUE (kg/ha/mm)	
			TBY	SY
ILL 8	May 9	253.4	14.83	4.89
ILL 9	May 9	264.5	16.18	4.59
ILL 16	May 12	236.6	16.71	5.12
ILL 101	May 9	263.1	12.36	3.89
ILL 223	May 9	243.8	18.05	5.65
ILL 470	May 9	261.0	11.98	4.35
ILL 793	May 10	275.4	10.88	1.85
ILL 4349	June 14	244.7	9.71	3.93

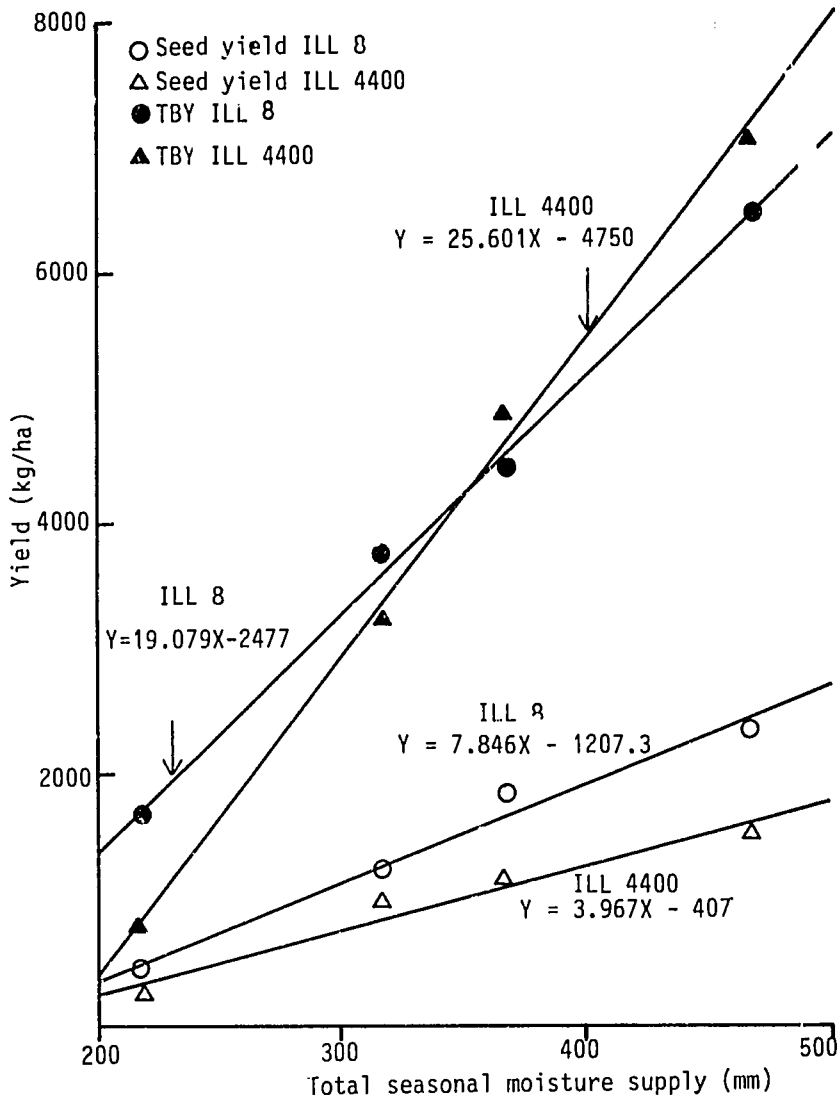

Figure 2.5.1. Relationship between total seasonal moisture supply with seed yield and biological yield of ILL 8 and ILL 4400 lentil genotypes, 1985/86.

cm water/15 cm soil layer

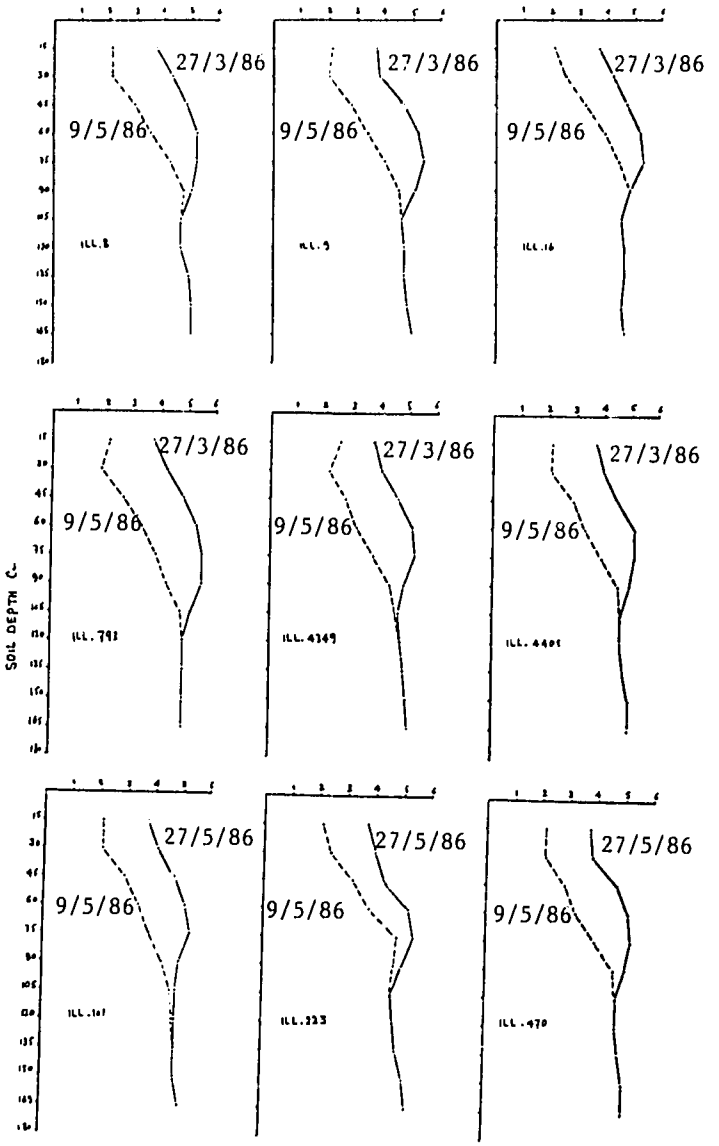

Figure 2.5.2. Soil moisture content in different soil layers (cm water/15 cm soil layer) at highest recharge and at physiological maturity of some contrasting lentil genotypes under rainfed condition, Tel Hadya, 1985/86.

ILL 8 and ILL 9 (Table 2.5.2). Under rainfed condition in Tel Hadya (316 mm rainfall) high yields were obtained from ILL 4354, ILL 223, ILL 8, ILL 9 and ILL 16 (Table 2.5.2). There were variations in response to moisture supply among genotypes. For example in seed yield, ILL 8 was very responsive and ILL 4400 unresponsive whereas in total biological yield the reverse was observed (Figure 2.5.1).

Soil moisture profiles at maximum recharge and at maturity for nine genotypes are given in Figure 2.5.2. Genotypes ILL 101 and ILL 793 extracted water from deeper soil profile than other genotypes. In the first 90 cm of the soil profile, ILL 4400, ILL 4349, ILL 470 and ILL 8 extracted greater amount of soil moisture than other genotypes (Figure 2.5.2). ILL 9, ILL 16 and ILL 470 had the highest water use efficiency in terms of total biological yield, and in terms of seed yield ILL 8, ILL 16 and ILL 223 had the highest water use efficiency (Table 2.5.3).

This study has indicated variations among genotypes in their response to moisture supply. For example in terms of seed yield, ILL 8 and ILL 4354 perform well under low rainfall regime and are very responsive when moisture supply is increased whereas ILL 4400 is unresponsive to increased moisture supply.
Drs. S. Silim and M. C. Saxena.

2.5.3. Effect of Exogenous Application of Growth Regulator on Yield of Lentils

Genetically lentil is capable of producing greater seed yields than are harvested in fields today. The number of pods at maturity is less than 50% of the total number of flowers produced. Generally the later formed flowers do not develop filled pods. It is possible that there is competition between pods for assimilates and possibly for some

endogenous growth regulators and pods formed later are at a disadvantage. A trial was initiated to investigate the potential of exogenous application of plant growth regulator planofix (naphthylacetic acid, NAA) on yield of lentil. Times of application were: one application (at start of flowering, April 1), two applications (one each at start of flowering and 100% flowering, April 1 and 8 respectively), and three applications (one each at start of flowering, 100% flowering and 100% pod set, April 1, 8 and 16 respectively). Four concentrations of NAA were used: 0, 10, 20, and 30 ppm. The rate of NAA and time of application had no significant influence on yields (Table 2.5.4). This therefore suggests that endogenous growth regulator may not be limiting and is not the cause of pod drop or non-filling. It is possible that pod filling was limited by the supply of assimilates.
Drs. S. Silim and M. C. Saxena.

2.5.4. Response of Lentil to Plant Population and Row Spacing

The effect of four plant population densities (100, 200, 300 and 400 plants/m^2) and four row spacings (20, 30, 40 and 50 cm) on lentils were studied in Tel Hadya and Breda. At both locations, both seed and total biological yields were significantly increased with increase in plant population (Table 2.5.5). Varying row spacings, however, had no significant influence on both seed and total biological yields except in Tel Hadya where sowing at narrow row spacing increased seed yield significantly (Table 2.5.5). Seed yield obtained at Tel Hadya (316 mm rainfall) was about six times that of Breda (218 mm rainfall) and total biological was about triple. Seed yield increase obtained in some treatments was largely due to production of large total dry matter, large number of seeds/unit area and improved partitioning of assimilates to the seeds, respective correlation coefficients being 0.81, 0.47 and 0.21 for Tel Hadya and 0.85, 0.45, and 0.26 for Breda.
Drs. S. Silim and M. C. Saxena.

Table 2.5.4. The effect of rate and frequency of application of growth regulator planofix (naphthylacetic acid) on seed and total biological yields (kg/ha) of lentils, Tel Hadya 1985/86.

Rate of NAA (PPM)-R	Seed yield (kg/ha)				Total biological yield (kg/ha)			
	No. of applications (A)				No. of applications (A)			
	One	Two	Three	Mean	One	Two	Three	Mean
0 (control)	2074	2011	2076	2054	4934	4802	4870	4868
10	2033	2020	2011	2021	4651	4735	4740	4722
20	2033	2066	2079	2060	4733	4886	5078	4899
30	1950	1955	2101	2002	4651	4651	5125	4811
Mean	2023	2013	2067		4752	4770	4953	

	(A)	(R)	AxR	(A)	(R)	AxR
L.S.D.(5%)	NS	NS	NS	NS	NS	NS
S.E.	45.3	31.1	65.1	130.4	87.5	185.1
C.V. (%)	8.9	5.3		10.8	6.3	

Table 2.5.5. Effect of row spacing and plant population on yield of lentil, Tel Hadya and Breda, 1985/86.

Treatment	Tel Hadya (ILL 223)		Breda (ILL 4401)	
	Seed yield (kg/ha)	Total biol. yield (kg/ha)	Seed yield (kg/ha)	Total biol. yield (kg/ha)
Row spacing (cm)				
20	2168	5502	353	1738
30	2083	5566	368	1914
40	1831	5044	359	1991
50	1692	4735	353	1909
S.E.	85	248	12.8	58.4
C.V.(%)	17.5	19.0	14.3	12.4
Population/m^2				
100 plants	1642	4008	254	1307
200 plants	1976	5293	354	1809
300 plants	2048	5494	405	2154
400 plants	2108	6052	418	2281
S.E.	65	136	19.9	83.7
C.V.(%)	13.3	10.4	22.3	17.7

2.5.5. Effect of Height of Cut on Yield of Lentils

As part of a major effort at ICARDA to mechanize lentil harvest, a trial which was initiated during 1984/85 season was repeated in 1985/86 to investigate the effect of height of cut (ground level, 5 cm and 10 cm above ground) as compared to hand pulling on loss of seed and straw yields of three lentil lines of different plant stature: ILL 8 (erect and non-lodging), ILL 4400 (local genotype that lodges) and ILL 554 (erect and late maturing). Cutting was carried out using a 'Hege forage harvester'. Because of lack of significant interaction between height of cut and genotype, results are presented mostly as means of main effects.

The effect of height of cut on straw yield is given in Table 2.5.6. Significant reductions in straw yields were obtained when crop was cut at ground level, 5 cm or 10 cm above ground as compared to hand pulling, representing respectively 20.7%, 44.3% and 47.9% reductions. Reductions in seed yield were 10.8%, 22.0% and 15.4% respectively for cutting at ground level, 5 cm and 10 cm above ground. This study as in previous year has shown that the mechanical harvesting of lentil by cutter bar results in some losses in both seed and straw and loss in straw increased with increase in height of cut. Seed yield loss was largely due to pod drop and straw loss was due to roots and lower section of the stem being left in soil.

2.5.6. Weed Control

2.5.6.1. International Weed Control Trial

Lentils because of their small stature do not grow tall and do not build up a protective canopy to prevent establishment of weeds. Large

Table 2.5.6. Main effects of height of cut and genotypes on seed total biological and straw yields (kg/ha).

Treatment	Yields (kg/ha)		
	Seed	Total biological	Straw
a. Harvesting			
Hand pulling (control)	1387	4762	3375
Cut 0 cm above ground	1237	3915	2678
Cut 5 cm above ground	1082	2962	1881
Cut 10 cm above ground	1174	2931	1757
S.E.	63	164	141
C.V.(%)	17.9	15.5	20.2
b. Genotype			
ILL 8	1820	4410	2590
ILL 4400	1209	3814	2605
ILL 554	631	2704	2073
S.E.	38	131	116
C.V.(%)	12.4	14.4	19.1

yield losses are therefore incurred following weed infestation. As part of International Weed Control Trial, studies were conducted in 1985/86 at Breda (northern Syria) and Terbol (Lebanon) to assess the losses in yield due to weeds and identify promising pre-emergence herbicides for weed control in lentils.

Weed infestation at both locations was high (Table 2.5.7). At Breda 88.8% of the weeds were narrow leafed, mostly barley volunteers. Herbicides reduced the level of weed infestation. At Breda pre-emergence application of Gesagard at 1.5 kg a.i./ha, Gesagard at 1.5 kg with 0.5 kg a.i./ha Kerb, Maloran at 1.5 kg with 0.5 kg a.i./ha Kerb, Tribunil at 2.0 kg with 0.5 kg a.i./ha Kerb and Bladex at 0.5 kg with 0.5 kg a.i./ha Kerb gave very good control of weeds with no significant difference in yield when compared with the best hand weeding treatment (Table 2.5.7). At Terbol hand weeding was superior to chemical weed control giving significantly higher grain yield (Table 2.5.7).
Drs. S. Silim, M. C. Saxena and R. S. Malhotra.

2.5.6.2. Evaluation of New Herbicides

Effect of weeds on crop yield loss and the role of some new selective herbicides on weed control and crop yield was studied at Tel Hadya using Syrian Local Small lentil cultivar ILL 4401). Weeds caused 63% reduction in seed yield (Table 2.5.8). Post-emergence application of dinoseb acitate + fluazifabbutyl appeared to be the best herbicide treatment resulting in a seed yield statistically at a par with that from hand weeded weed-free check. Cyanazine + pronamide as pre-emergence spray was the next best combination (Table 2.5.8). AC 252-214 herbicide caused serious crop stunting.
Drs. M. Pala and S. Silim.

Table 2.5.7. Seed and total biological yields (kg/ha) of lentils and total dry weights of weeds (kg/ha) at crop maturity. Breda and Terbol 1985/86.

Treatment	BREDA (kg/ha)					TERBOL (kg/ha)		
	Lentil seed yield	Lentil total biological yield	Broad leafed weeds	Narrow leaf weeds	Total weeds	Lentil seeds yield	Lentil total biological yield	Total weeds
Weedy check	33	338	298	2363	2660	30	1074	9823
Repeated hand weeding (weed free)	178	1345	26	197	223	1853	5157	-
Weeded 40 and 80 days after emergence	358	1771	16	64	80	1425	5066	-
Maloran 1.5 kg a.i./ha pre-emergence	231	1292	122	1187	1309	689	3099	5060
Gesagard 1.5 kg a.i./ha pre-emergence	241	1361	71	287	324	157	2841	5159
Tribunil 2.0 kg a.i./ha pre-emergence	115	854	122	1349	1470	434	2516	6647
Bladex 0.5 kg a.i./ha pre-emergence	125	794	168	1676	1845	180	1743	8135
Bladex 1.0 kg a.i./ha pre-emergence	171	1095	154	1028	1182	438	2558	6350
Maloran 1.5 kg + Kerb 0.5 kg a.i./ha	236	1491	71	168	239	891	3458	1687
Gesagard 1.5 kg + Kerb 0.5 kg a.i./ha	317	1456	76	67	143	258	2298	5457
Tribunil 2.0 kg + Kerb 0.5 kg a.i./ha	366	1667	191	99	290	416	2476	3770
Bladex 0.5 kg + Kerb 0.5 kg a.i./ha	346	1567	163	267	430	116	1449	7639
L.S.D. (5%)	98	258	119	521	498	368	1065	2140
S.E.	34.2	90	41.5	181	173.3	128	370	744
C.V. (%)	30.2	14.4	69.0	49.8	40.8	44.6	26.3	29.9

Table 2.5.8. Effect of weed control on seed yield of lentil and on weed dry weight, Tel Hadya, 1985/86.

Treatment	Rate of appln. (kg a.i./ha)	Time of appln.	Seed yield (kg/ha)	Weed dry weight (kg/ha)
Weedy check			550	1168
Weed-free check			1481	43
Cyanazine+pronamide	0.5+0.5	Pre-em.	1018	473
Terbutryne+pronamide	2.0+0.5	Pre-em.	990	472
Dinoseb acetate + fluazifabbutyl	1.0+0.5	Post-em.	1079	379
Codal	1.5	Pre-em.	876	1068
Secbumetron	0.2	Pre-em.	782	669
Carbetamid	1.5	Pre-em.	456	760
AC 252-214	0.15	Pre-em.	189	1327
AC 252-214	0.15	Emerg.	301	391
AC 252-214	0.1	E.Post-em.	143	501
Fomesafen	0.2	E.Post-em.	928	515
Fomesafen	0.2	M.Post-em.	697	506
Fomesafen	0.2	L.Post-em.	903	1005
L.S.D. (P=0.05)			422	939
C.V. (%)			41	92

2.5.7. Microbiology

With the movement of microbiology section to the Food Legume Program, a limited number of experiments were conducted for selection of improved Rhizobium strain - cultivar combinations with increased nitrogen fixation capacity.

There were two basic types of experiments. The first involved evaluation of 15 prominent cultivars for response to inoculation with a single Rhizobium strain (ICARDA strain 19, isolated in Syria), compared to uninoculated treatments. The second experiment evaluated response of a single cultivar (Syrian Local Large) to inoculation with six separate strains of rhizobia compared to an uninoculated control.

Over the mean of 15 cultivars tested, there was no yield response to inoculation with a single strain of Rhizobium over the uninoculated control. Some individual lines, however, did show response to inoculation though these responses were insignificant. ILL 1939 showed a slight grain yield depression when inoculated. ILL 4401 (Syrian local small) gave a slight increase in grain yield, and a nearly significant increase of 500 kg/ha straw yield when inoculated. Differences between inoculation treatments of other lines were insignificant, with inoculation producing slight decreases or increases in straw and grain yield depending on the cultivar.

In the trial screening for inoculation effects from six Rhizobium strains on Syrian Local Large, there were no significant yield differences between the treatments inoculated and the uninoculated control. However, five strains showed a significant increase in total crop N over the control at harvest, giving 5-10 additional kg N/ha.

These results are to be expected, for Tel Hadya soils contain large numbers of indigenous rhizobia effective with lentil. In addition, cultivars are selected throughout the breeding program based on yield performance utilizing native soil rhizobia for nitrogen fixation. Under these conditions, it will be unlikely that a significant inoculation response will be obtained with randomly chosen strains.

In the coming season a stepwise approach to strain selection using a number of prominent cultivars in several soil types will be adopted. A broad range of strain and cultivar combinations will be tested in plastichouse experiments, with superior combinations being evaluated subsequently in the field.

Dr. D. Beck.

3. KABULI CHICKPEA IMPROVEMENT

The kabuli chickpea project is a joint venture with ICRISAT, India and is operated from ICARDA which acts as a world center for its improvement. The kabuli chickpea is mainly grown as a spring-sown crop in the Mediterranean region of West Asia, North Africa and Southern Europe. Mexico and a few South American countries, such as Chile, Colombia and Bolivia, grow kabuli type chickpea. This type occupies a small portion of chickpea area in the Indian subcontinent. In addition, it is grown in a limited area in Australia, western United States of America and the Union of Soviet Socialist Republics.

Large-seeded chickpea is preferred in the Americas and Spain, medium-seeded in the Mediterranean region and small-seeded in rest of the world. Major improvement in yield is expected by adopting winter sowing in West Asia and North Africa using ascochyta blight and cold tolerant germplasm and improved production technology. Cultivars responsive to irrigation, and resistant to wilt and root-rot, are required for countries in the Indian subcontinent, Nile Valley and the Americas. The program at ICARDA is devoted to improving germplasm and production technologies to augment the research effort of the national programs.

3.1. Breeding

The year 1986 was good for chickpea breeding in many ways. A number of lines chosen from international nursery have been released as cultivars by national programs and many others are potential candidates for release in futur . Ascochyta blight resistanc lines with large seeds and tall stature developed at the center have been furnished to cooperators. In view of the demand from host country, Syria, screening for resistance to cyst nematode has begun in collaboration with the Istituto di Nematologia Agraria, C.N.R., Bari, Italy. Also screening lines responsive to irrigation was initiated this year. Germplasm screening is continuing for resistance to wilt in collaboration with the Tunisian National Program, and for tolerance to cold with the Turkish National Program.

Dr. K.B. Singh.

3.1.1. Release of Cultivars by National Programs

The main objective of the chickpea improvement program is to strengthen the breeding effort of national programs. One of the ways we aim to fulfill this objective is through the supply of international nurseries. The progress is reproduced below:

Year	Type of Nursery	Sets furnished	Countries covered
1977/78	2	34	15
1986/87	11	497	48

We have developed different nurseries to meet specific demands of national programs. Demands have increased almost 15-fold in eight years because cooperating countries have found the material useful to their programs. By October 1986, nine lines had been selected and released as cultivars in four countries (Table 3.1.1). Further, there are at least 14 lines which may be released in the near future.

Analysis of the cultivars selected by the national programs reveals interesting information. First, all cultivars have been released for winter sowing in the Mediterranean region. This suggests that winter sowing is being accepted as a means of increasing yield in the region. Second, all the cultivars selected by national programs from ICARDA supplied material have resistance to ascochyta blight and tolerance to cold. Third, many of the cultivars are tall. Fourth, none of the cultivars have been chosen for spring sowing in the Mediterranean region or winter sowing in the sub-tropical region. The requirement for spring season is early maturity, large seed size and adaptation for irrigated conditions, especially in sub-tropical region. In future development of germplasm, while maintaining emphasis on winter sowing, adequate attention will also be given for spring sowing

in the Mediterranean region and for winter sowing in the subtropical region.
Dr. K.B. Singh.

3.1.2. Breeding Strategy

The strategy for generating kabuli chickpea germplasm is shown schematically in Figure 3.1.1. Although there may be scope to improve the strategy, the present one is serving well if judged by the demand of the international nurseries and utilization of the germplasm by the national programs.

When the program was established during 1977/78, two major weakness noticed in chickpea production in West Asia and North Africa were low yield and instability in production. The problem of low yield can be solved greatly by adopting winter sowing. Attempt has been made to incorporate resistance to physical stresses (cold and iron deficiency) and biotic stresses (ascochyta blight, leaf miner, cyst nematode, and Orobanche). Also an effort is made to reduce the photoperiod sensitivity. It is hoped that reduced photoperiod sensitivity and resistance to various stresses will add stability in production. Half the effort is devoted to generate germplasm for winter sowing, one-fourth to spring sowing, and the remaining to three special projects, namely large-seeded type, tall type and desi type.
Dr. K.B. Singh.

3.1.3. Screening Germplasm

The program has identified ascochyta blight as a major limiting factor in chickpea production in west Asia and north Africa. Cold tolerance assumes a great significance for winter sowing. Leaf miner causes yield reduction up to 20 per cent. Sporadic damage from cyst nematode and fusarium wilt has been reported. Screening germplasm for

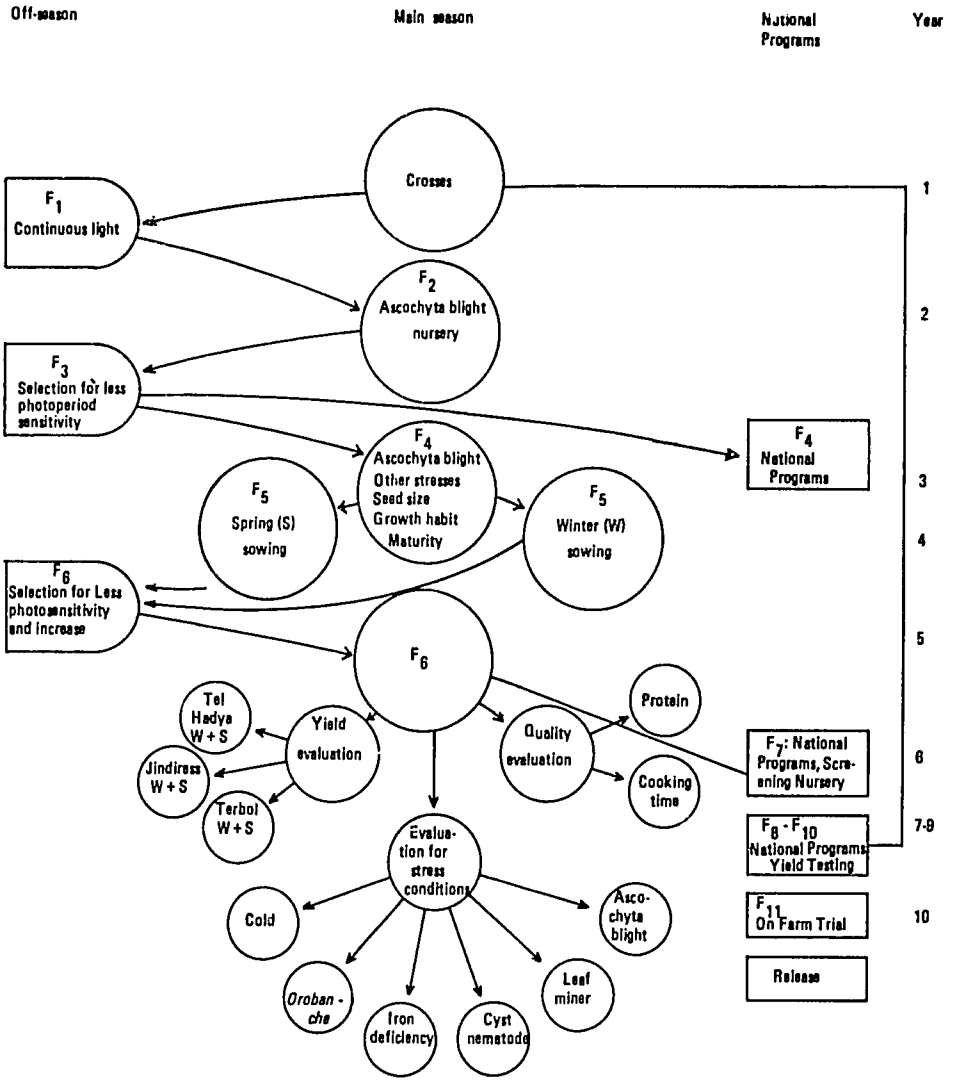

Fig. 3.1.1. The selection and testing scheme for the kabuli chickpea germplasm development at ICARDA.

resistance to different stresses and incorportating genes for resistance in high yielding genotypes is, therefore, a major goal of the program.

3.1.3.1. Physical and Biotic Stresses

Ascochyta blight: Search for resistance to ascochyta blight (Ascochyta rabiei (Pass.) Lab.) began during 1978. Several sources of resistance have been identified. Most are late in maturity, and have pea-shaped seed with light cream to light pink color. All of them seem to have origin in the USSR, whether they were obtained directly or via other countries. Among the germplasms of the desi type, accessions with high level of resistance at vegetative stage have been found, but none has resistance at podding stage. Our effort is continuing to identify additional sources of resistance to find a true desi type or a true kabuli type resistant to ascochyta blight. We screen our germplasm against a mixture of races 1 to 4.

During 1985/86, 690 germplasm accessions were screened and 18 lines found promising. These will be evaluated in the advanced screening next season. With these, more than 15,000 germplasm accessions have been evaluated for their reaction to the blight.
Drs. K.B. Singh & M.V. Reddy.

Cold tolerance: Screening for cold tolerance started soon after it became clear that winter sowing produces substantial increase in yield. This effort was increased when many lines were killed because of cold during 1981/82 which had a severe winter. Planting during early October provides an opportunity to screen germplasm to cold, however, screening for cold in field is not always possible because some years turn out to be warmer than normal. Limited experience suggests that proper evaluation of germplasm should be possible two of every five years or one of every three years. Attempts to develop a reliable

laboratory screening technique have not been successful because of lack of desired temperature control.

Due to seasonal fluctuations, a line is considered tolerant if found tolerant in two cold seasons. On this criterion, we have evaluated 2433 germplasm lines in the past six years and have found 11 lines tolerant and 36 lines moderately tolerant (Table 3.1.2). More than 50% originated from India (17 lines) and Pakistan (8 lines), another 17 lines from the Mediterranean region and the remaining from Chile. The pedigree, origin, seed type and weight of tolerant lines are shown in Table 3.1.3. We now have confidence that screening for cold tolerance can be done at Tel Hadya farm. We have tried to screen material at a much cooler site in temperate region, but it is felt that the winter is too severe to permit any worthwhile screening for the Mediterranean region. Drs. K.B. Singh, R.S. Malhotra and M.C. Saxena.

Leaf miner: Of 340 new germplasm lines screened, two were rated 4 on a 1-9 scale, 10 rated 5 and the remainder between 6 and 9. Sixty-three lines found tolerant/resistant in previous seasons were sown for reconfirmation. Twenty-two lines were found resistant and 41 tolerant. The severity of leaf miner during 1985/86 was higher than other years.

Though we have resistant lines, the progress in breeding leaf miner resistant lines has been slow. Our approach has been to cross ascochyta blight resistant lines with those resistant to leaf miner and screen the F_2 plants first for ascochyta blight and then for leaf miner. Recovered plants have resistance to ascochyta blight, but are not resistant to leaf miner. Earlier, when we attempted to select material resistant to leaf miner first, no leaf miner resistant plants were recovered from the F_2 populations, but some tolerant plants were selected.

Dr. K.B. Singh.

Table 3.1.1. Lines selected from ICARDA's chickpea international nurseries and released as cultivars by national programs through October 1986.

Country	Cultivars released
Syria	Ghab 1 (ILC 482)
	Ghab 2 (ILC 3279)
Cyprus	Yialousa (ILC 3279)
Spain	Fardon (ILC 72)
	Zegri and Atalaya (ILC 200)
	Almena ILC (2548)
	Alcazaba ILC (2555)
Tunisia	ILC 3279
	FLIP 83-46C

Table 3.1.2. Screening chickpea germplasm accessions tolerance of cold at Tel Hadya, Syria, 1981/82 to 1985/86.

Reaction to (scale 1-9)[1]	No. of accessions	Percent of total
1	0	0.0
2	0	0.0
3	11	0.4
4	36	1.5
5	468	19.2
6	296	12.2
7	524	21.5
8	965	39.7
9	133	5.5
Total	2433	100.0

1. Rating: 1 = free; 5 = intermediate; 9 = killed.

Table 3.1.3. Pedigree, origin, seed type, and seed size of the cold tolerant chickpea lines.

Genotype	Pedigree	Origin	Rating[1]	Seed type	100-seed weight (g)
ILC 668	NEC 1706	Iran	3	K	22
ILC 794	12-071-03725	"	3	K	29
ILC 1071	12-190-04098	"	3	K	41
ILC 2487	Bakoda Dhaki	India	3	K	16
ILC 2505	JG 19	India	3	K	9
ILC 3081	Sample 30	Pakistan	3	K	17
ILC 3287	EC 1455	Pakistan	3	K	23
ILC 3470	CA-83	Spain	3	K	29
ILC 3598	PRSP-576	India	3	K	23
ILC 3599	PRSP-609	India	3	I	23
ILC 3789	PR-4401	India	3	I	20

1. Rating: 3 resistant

Cyst nematode: This year, screening for cyst nematode (Heterodera ciceri) included 312 lines. Though many lines showed resistance to cyst nematode, the results were not reliable due to very high number of cysts per g of soil and infestation by Rhizoctonia sp. More systematic screening has been planned for next year in cooperation with the Istituto di Nematologia Agraria, C.N.R., Bari, Italy.
Drs. N. Greco, and M. di Vito (Bari) and K.B. Singh.

Multifactor resistance: ascochyta blight and cold: During 1985/86, 355 newly bred lines were evaluated for resistance to ascochyta blight and cold. Ninety lines were found resistant to ascochyta blight and 91 to cold. A majority of them were resistant to a single stress, but ten of them were resistant to both (Table 3.1.4). It may be pointed out that in most years only 'tolerance' to both would be adequate. Of course, a combination of resistance to one stress and tolerance to other will be better. Lines found resistant to both stresses will be used extensively in hybridization program because besides resistance they have larger seed and a few of them were early in maturity and medium-tall.

3.1.3.2. Response to Irrigation

Generally, the kabuli chickpea type is irrigated in the Indian subcontinent, the Nile Valley, and Mexico. Also in the Mediterranean region, a small percentage of chickpea area is irrigated. In order to cater to the needs of such areas, 151 genotypes were evaluated for response to irrigation. These genotypes were grown with supplemental irrigation and rainfed.

An efficient implementation of supplemental irrigation requires scheduling by consumptive use with the quantity of water required for continued plant growth based on minimal demand. For supplemental irrigation of chickpea, a total of three irrigations were added during

Table 3.1.4. Chickpea lines found resistant to both ascochyta blight and cold at Tel Hadya, 1985/86.

Entry Name	Reaction[1] to		Days to	Plant	100-seed
	Blight	Cold	Fl. (no.)	ht. (cm)	weight(g)
FLIP 83-7C	MR	R	104	52	40
FLIP 83-49C	MR	R	106	50	33
FLIP 84-109C	MR	R	100	36	35
FLIP 83-112C	R	R	102	38	26
FLIP 85-47C	R	R	104	46	33
FLIP 85-79C	MR	R	100	41	35
FLIP 85-83C	MR	R	107	39	33
FLIP 85-86C	R	R	104	43	45
FLIP 85-99C	MR	R	103	50	36
FLIP 85-124C	MR	R	106	47	35
ILC 482 (check)	T	T	98	38	30
ILC 3279(check)	R	R	107	58	30

1. R = resistant; MR = moderately resistant; T = tolerant.

the 1985-86 season as scheduled by daily water balance computations of rainfall and pan evaporation. Each irrigation was applied by sprinklers as 50mm the first day and 40mm the following day for a total of 90mm to refill the soil profile to field capacity at the rooting depth. Seasonal rainfall at Tel Hadya was 315mm. Therefore, the total amount of water applied to the study site by irrigation and rainfall was 585mm.

One hundred forty-seven lines out of 151 responded to irrigation and 92 of them produced significantly higher yield when irrigated. Nineteen lines produced more than 3000kg/ha on irrigation, the highest being 3690kg/ha. On the other hand, in rainfed condition only two lines yielded more than 3000kg/ha and the highest yield was 3127kg/ha. The mean yield of all the 151 lines with irrigation was 2736kg/ha as against 1940kg/ha without irrigation. Thus 796kg/ha or 42% more yield was produced by irrigation over rainfed. Higher yield due to irrigation occurred from longer reproductive period, heavier biological yield and more pods per plant. Irrigation reduced the 100-seed weight, harvest index, the number of primary and secondary branches, and protein content in seed. Overall production of protein was higher per unit area because of substantially higher seed yield.
Drs. K.B. Singh & E. Perrier.

3.1.4. Winter Sowing

Chickpea is spring-sown in the Mediterranean region but by sowing in early winter, the chickpea production can be substantially increased. Winter sowing has two major prerequisites: (1) tolerance to cold and (2) resistance to ascochyta blight. In the past eight years ICARDA has developed ascochyta blight and cold tolerant germplasm suited for winter sowing.

Some common trials were sown at three sites (Tel Hadya, Jindiress and Terbol), in two seasons (winter and spring) and for three years (1983/84, 1984/85 and 1985/86). Seventy-two entries were evaluated during 1983/84 and 96 entries during 1984/85 and 1985/86. As regards weather conditions, 1984/85 winter was one of the coldest in the last 50 years and spring of 1983/84, especially in Tel Hadya, was the driest. Tel Hadya is the driest of the three sites, Terbol the wettest and Jindiress the intermediate, with long term average seasonal rainfall of 320, 575 and 475 mm, respectively.

The seed yield is summarized in Figure 3.1.2. The winter-sown trials over the three seasons produced mean yield of 1953 kg/ha and the spring-sown gave 1243 kg/ha. Thus winter-sown produced 49 per cent more yield than spring-sown trials. The lowest yield at any given year at any site during winter was 967 kg/ha, whereas the lowest yield during spring was 168 kg/ha. Clearly a yield of 168 kg/ha is uneconomical. Thus winter-sown chickpea is expected to produce high and stable yield.
Dr. K.B. Singh.

3.1.5. Segregating Material

We made 498 crosses. The break-up of these was: 360 crosses for ICARDA breeding program; 82 crosses for Tunisian, Lebanese, Jordanian, South Dakota (USA), and Italian programs; and 56 crosses for a Ph.D. student. Included in 360 crosses were 126 crosses for germplasm development for winter and spring sowing, 106 for large-seeded type, 25 for tall types, 25 for early type, 20 for desi type, 10 for high biological yield, 10 for cold tolerance, 10 for leaf miner and ascochyta blight resistance, 10 for ascochyta blight and fusarium wilt resistance, and 18 for genetic studies. The F_2 seeds were produced from F_1 plants sown in the off-season with artificially extended photoperiod.

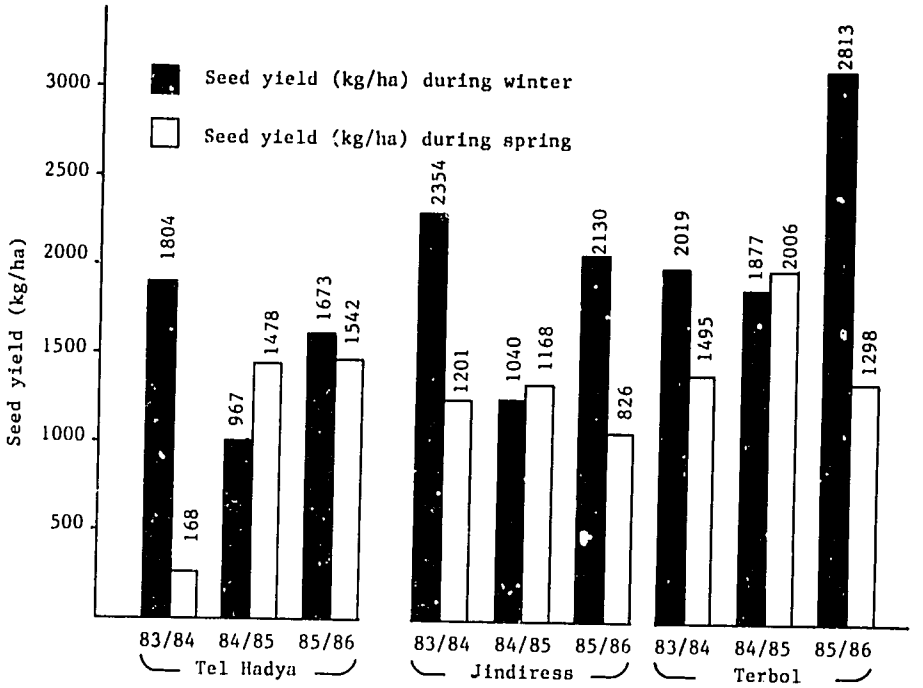

Figure 3.1.2. Mean seed yield of 72, 96, and 96 entries grown during winter and spring of 1983/84, 1984/85 and 1985/86, respectively at three sites.

During the 1985/86 season 10,026 progeny rows were grown and 12,730 single plants selected between the off-season and main season. The off-season is mainly used to discard highly photoperiod sensitive lines in F_3 generation. The main season is used for positive selection for ascochyta blight resistance and negative selection for cold tolerance, iron deficiency and Orobanche. The selection for maturity, growth habit and seed characters are made in F_4 progenies.

Three hundred and sixty-three promising and uniform progenies were bulked during the main season and grown in the off-season for selection of less photoperiod sensitive lines and for seed increase. Two hundred and three lines or 56% of the progenies were selected as less photoperiod sensitive lines; others were rejected as they did not mature.
Drs. K.B. Singh and M.V. Reddy.

3.1.6. Yield Trials during Winter and Spring

A large number of lines which have been developed in the past year were evaluated for yield at three locations in two seasons (Table 3.1.5). Many lines have exceeded the check cultivars and yield levels are continuously being upgraded. There has been better progress for spring sowing this year. Early maturing lines appear to perform well during spring.
Dr. K.B. Singh.

3.1.7. Large-seeded Type

Twenty-two newly bred lines were evaluated for yield and other traits during 1985/86 and the performance of five large seeded (> 40 g/100 seeds) lines is shown in Table 3.1.6. Of course, improvement will be required for higher level of resistance to ascochyta blight, earliness, and yield, although many cooperators will accept these large-seeded

Table 3.1.5. Yield performance of newly developed lines during winter and spring at Tel Hadya and Jindiress (Syria) and Terbol (Lebanon), 1985/86.

Location	Entries tested	Entries exceeded checks	Entries significantly exceeded checks (P=0.05)	Range of highest yields (kg/ha)	Range for CV (%)
Winter sowing					
Tel Hadya	306	120	2	1341-2726	10.5-40.3
Jindiress	196	54	6	2174-2846	8.9-16.6
Terbol	240	43	0	3015-3801	5.9-16.3
Spring sowing					
Tel Hadya	218	46	35	1694-2424	7.3-17.5
Jindiress	152	93	5	1007-2147	13.7-21.3
Terbol	174	75	13	1630-1988	12.0-19.7

Table 3.1.6. Mean performance of five best large-seeded type lines in the Preliminary Yield Trial at Tel Hadya, 1985/86.

Entry Name	Days to fl.	Plant height (cm)	Seed yield kg/ha	100-seed wt. (g)	Reaction[1] to Blight	Reaction[1] to Cold
FLIP 85-6C	111	50	940	45	T	R
FLIP 84-12C	106	37	1063	42	T	T
FLIP 85-2C	113	37	575	52	T	R
FLIP 85-43C	105	43	1341	42	T	R
FLIP 85-4C	112	41	765	49	T	R
ILC 482	98	33	1071	29	T	T
ILC 3279	109	50	1035	30	R	R
Trial mean	107	42	895	44		
C.V. (%)	2.20	7.11	32.36	4.55		
S.E.±	1.67	2.11	204.84	1.40		
L.S.D. (5%)	4.90	6.18	599.35	4.11		

[1] R = resistant, T = tolerant.

lines even if they are at par or a bit lower yielding than the medium-seeded type because of strong consumers' preference and higher selling price. The new material seems to have higher level of resistance to ascochyta blight and is earlier maturing.
Dr. K.B. Singh.

3.1.8. Tall Type

The chickpea plant has a bush type growth habit. Tall type was perhaps developed through natural mutation and was first grown as a commercial crop in the Central Asian Region of the USSR. These tall types were generally late in maturity and had pea-shaped seed of light cream to light pink color. From the USSR they have spread to other places. These tall types are easy to machine harvest and perhaps can be tailored to yield higher than bush type.

During 1985/86, 44 new tall types were evaluated for yield and other traits at Tel Hadya and Terbol. The results of the five best tall types are presented in Table 3.1.7. There has been major improvement in new tall types over the original USSR line (ILC 3279) for seed type and size as preferred by growers and consumers. Efforts have been increased to improve yield and earliness. The new material coming out of the project is earlier in maturity and has the same level of resistance to ascochyta blight and cold as that of ILC 3279.
Dr. K.B. Singh.

3.1.9. Desi Type

A small portion of our resources was devoted to develop ascochyta blight resistant desi type for countries like Pakistan where such type is primarily grown and blight is endemic. During 1985/86, newly developed lines were evaluated for yield and other characters and results from the ten best lines are presented in Table 3.1.8. Many

Table 3.1.7. Mean performance of five best tall lines in the Preliminary Yield Trial at Tel Hadya and Terbol during winter, 1985/86.

Entry Name	Days to fl.	Plant ht.(cm)	Seed yield (kg/ha) Tel Hadya	Terbol	Mean	100-seed wt. (g)	Reaction[1] to Blight	Cold
FLIP 84-22C	108	55	1583	2825	2204	36	4	5
FLIP 84-46C	109	55	1434	2785	2135	36	5	3
FLIP 85-16C	101	54	1841	2785	2313	44	5	2
FLIP 85-18C	107	58	1503	2761	2132	40	5	2
FLIP 85-19C	105	54	2000	2825	2413	39	6	2
ILC 3279	109	54	1214	3000	2107	28	3	3
ILC 482	98	36	1400	3011	2208	30	5	4
Mean	105	49	1417	2941	2179	37		
C.V. (%)	1.12	7.27	23.45	7.75	15.6	5.27		
S.E. ±	0.83	2.54	234.97	161.15	198.06	1.38		
L.S.D. (5%)	2.44	7.42	687.53	771.52	729.53	4.05		

1. Scale for blight and cold rating:
   1 = free; 5 = tolerant; 9 = killed.

Table 3.1.8. Mean performance of 10 best desi lines in the Preliminary Yield Trial at Tel Hadya during winter, 1985/86.

Entry Name	Days to flowering	Plant height (cm)	Seed yield (kg/ha)	100-seed weight (g)	Seed color[2]	Reaction[1] to blight	Reaction[1] to cold
FLIP 85-21C	98	37	1789	24	LB	4	2
FLIP 85-38C	102	40	1646	20	YB	4	3
FLIP 85-24C	101	32	1269	19	YB	4	3
FLIP 85-39C	102	33	1309	19	YB	3	3
FLIP 85-25C	100	39	1746	28	LB	3	3
FLIP 85-26C	102	39	1337	28	LB	4	6
FLIP 85-40C	99	39	1702	28	YB	3	4
FLIP 85-27C	102	38	1678	28	LB	3	5
FLIP 85-28	98	40	1615	25	LB	3	5
FLIP 85-31C	102	55	1853	34	LB	3	5
ILC 482	98	36	1623	30	Beige	5	4
ILC 3279	109	56	1071	29	Beige	3	2
Mean yield	101	41	1550	25			
C.V. (%)	0.96	6.38	16.64	3.92			
S.E. ±	0.69	1.83	182.46	0.68			
L.S.D. (5%)	2.01	5.34	533.88	1.99			

1. Scale for blight and cold ratings: 1 = free; 5 = tolerant; 9 = killed
2. LB = light brown; YB = yellow brown

lines yielded more than ILC 482, the best local kabuli check, had resistance to both ascochyta blight and cold, and possessed acceptable seed color in contrast to the black seed coat of most of the desi lines earlier identified. Also, seed size of most of the lines is greater than is normally found in the desi type. These desi lines will be furnished to cooperators in blight prone areas.

We have bulked 56 promising F_5/F_6 lines. When these lines were grown in the off-season nursery from June to October, 22 of them did not mature because they were highly photoperiod sensitive. It has been observed that lines which do not mature during June-October planting do not perform well during spring planting in the Mediterranean region or winter planting in the subtropical region. We have selected many promising plants from F_2 to F_5 generation which will be grown as progeny rows next season. Also we have made 20 crosses to generate additional material.
Dr. K.B. Singh.

3.1.10. On-farm Trial

3.1.10.1. Syria

The on-farm trial in chickpea was started in Syria during 1979/80 to compare the performance of winter sowing with traditional spring sowing, jointly by the Agriculture Research Center (ARC) of the Ministry of Agriculture and Agrarian Reform, Syria, and ICARDA. These trials over the years have shown that winter sowing is possible with only ascochyta blight and cold tolerant cultivars; that winter-sown chickpea produces more seed (25 to 125 per cent depending upon rainfall, temperature and location); and that winter-sown crop can be machine harvested. The major achievement of this collaborative effort has been the release of 'ILC 482' and 'ILC 3279' named, respectively, 'Ghab 1' and 'Ghab 2'. These cultivars have been released by the

Ministry of Agriculture and Agrarian Reform due to high and stable yield (Table 3.1.9). On an average, winter-sown Ghab 1 produced 100 per cent more than Syrian land race sown during spring and Ghab 2 produced 60 per cent more yield.
Dr. K.B. Singh and Dr. Walid Taweel.

3.1.10.2. Morocco

The on-farm trial continued in Morocco with chickpea cultivars ILC 195, ILC 482 and ILC 484.

3.1.10.3. Tunisia

Based on multilocation testing of several cultivars, Tunisian national program has released ILC 3279 and FLIP 83-46C. The seeds of these cultivars will be multiplied and large scale demonstration organized during next season.

3.1.10.4. Turkey

The Turkish national program has organized on-farm trials in different regions to introduce winter sowing of chickpea. The lines being currently tested are ILC 195/2, NEC139/2, ILC 201, and ILC 482. They have also increased large quantity of seed of ILC 195/2 and ILC 482.

3.1.10.5. Algeria

The program has identified ILC 3279 for on-farm demonstration plots and ILC 190, ILC 191, and ILC 482 for on-farm verification trials.

3.1.10.6. Oman

Chickpea line ILC 237 has been chosen for on-farm trial.

3.1.10.7. Lebanon

The line ILC 482 has been tested in the on-farm trial for several years. The farmers are convinced with its performance and it may be released soon.

3.1.10.8. Other Countries

Egypt and Pakistan have chosen lines from the international nurseries and included them either in the on-farm trials or multilocation trials. Since the seed multiplication activities are not strong in some countries, ICARDA has assisted them by providing foundation seed.
Dr. K.B. Singh.

3.1.11. Purification of Pure Lines for Cold Tolerance

The 1984/85 season was one of the coldest in recent years. ILC 482 and ILC 3279, which are evaluated tolerant and resistant to cold respectively in the past season, suffered severely. However, in large plots of these cultivars there were plants that not only survived, but also were productive. Five hundred such plants were selected from each of ILC 482 and ILC 3279. Seeds were sown in plant-rows in cold and ascochyta blight nurseries. Ascochyta blight developed in epiphytotic form, but winter was mild.

Fortunately, there were two plants in ILC 482 that were resistant to both cold and ascochyta blight, and there were many in ILC 3279 that were resistant to both (Table 3.1.10). It is proposed to repeat the evaluation for one more season, before developing new versions of ILC 482 and ILC 3279.
Dr. K.B. Singh

3.2. Chickpea Diseases and their Control

Though many diseases infect chickpea plant, ascochyta blight (Ascochyta rabiei (Pass.) Lab.) causes maximum damage in West Asia and North Africa. It has been observed that the control of the disease through fungicide is uneconomical. Other means of control have been found to be unsatisfactory. The most effective and practical method of control

Table 3.1.9. Summarized results of the on-farm trials jointly conducted by Agriculture Research Center, Ministry of Agricultrure and Agrarian Reform, and ICARDA from 1978/79 to 1985/86 in Syria.

Year	No. of locations	Seed yield (kg/ha)	
		ILC 482	ILC 3279
1979/80	18	1839	
1980/81	21	1724	
1981/82	12	1255	1632
1982/83	24	2018	1647
1983/84	15	1455	1088
1984/85	11	688	817
1985/86	13	2007	1602
Mean		1569	1357

Table 3.1.10. Evaluation of 500 plant-rows of ILC 482 and ILC 3279 for cold and ascochyta blight at Tel Hadya, 1985/86.

Reaction	ILC 482		ILC 3279	
	Cold[a]	Ascochyta blight[b]	Cold	Ascochyta blight
Resistant	107	2	461	277
Intermediate	277	65	11	204
Susceptible	116	433	28	19

[a] Screening was done by advancing planting date by eight weeks to early October.

[b] Evaluation was done in the field, where epiphytotic conditions were created using a mixture of race 1, 2, 3, and 4 of *A. rabiei*.

is through the use of resistant cultivars. Therefore ascochyta blight resistance work receives major emphasis. The other diseases of some importance are fusarium wilt and root-rot. They assume importance in Tunisia, Spain and Mexico. Some collaborative work is in progress with the first two countries. Unfortunately, the post of chickpea pathologist remained vacant throughout the season and research work was carried out by chickpea breeder with consultation and support from the former Chickpea Pathologist, Dr. M.V. Reddy.

3.2.1. Screening Chickpea Lines Resistant to Races of Ascochyta Blight

Six races numbered 1 to 6 have been identified from Syria and Lebanon. Races 1 to 3 were found widely distributed and races 4 to 6 were less common. A total of 1069 lines, including 943 kabuli germplasm, 76 desi germplasm and 50 newly bred FLIP entries, were evaluated against six races individually. Screening was done in two steps: (i) preliminary and (ii) advanced. In preliminary screening, the entries were evaluated at seedling stage in flats. Promising lines were evaluated until maturity with each entry grown in pots using three replications. Concentration of spore suspension spray was 200,000 spores/ml. Spraying was done at seedling stage in preliminary screening, whereas it was done at seedling stage and again at podding in advanced screening. The evaluation was done in plastic house between November 1985 and April 1986, where favorable temperature and humidity conditions were maintained.

Results of screening 1069 genotypes are shown in Table 3.2.1. Forty-seven, 27, 29, 8, 13, and 4 genotypes were resistant to race 1, 2, 3, 4, 5, and 6, respectively. It indicates that races 1 to 3 were mild and races 4 to 6 were aggressive. Twelve genotypes were found resistant to at least three races (Table 3.2.2). Three lines, namely ILC 202, ILC 3856 and ILC 5928, had resistance to five races. Obviously these will be more useful to the breeding program.
Drs. K.B. Singh & M.V. Reddy.

Table 3.2.1. Screening chickpea lines' resistance to six races of Ascochyta rabiei at Tel Hadya, 1985/1986.

Scale[1]	Reaction of accessions to					
	Race 1	Race 2	Race 3	Race 4	Race 5	Race 6
1	0	0	0	0	0	0
2	0	0	1	0	1	0
3	20	9	2	1	6	2
4	27	18	26	7	6	2
5	25	2	15	2	1	0
6	154	74	199	37	75	37
7	76	75	298	51	84	95
8	31	16	173	19	15	52
9	736	875	355	955	881	881
Total	1069	1069	1069	1069	1069	1069

1. Scale: 1 = free; 5 = tolerant; 9 = killed

Table 3.2.2. Chickpea lines showing resistance to three or more races of Ascochyta rabiei at Tel Hadya, 1985/86.

	Resistance[1] to race					
	1	2	3	4	5	6
ILC 72	R	R	R	R	S	S
ILC 190	R	S	R	S	R	S
ILC 201	R	R	S	R	R	S
ILC 202	R	R	R	R	R	S
ILC 482	R	R	S	S	R	S
ILC 2506	R	R	S	R	S	R
ILC 2956	R	S	R	S	R	R
ILC 3279	R	S	R	R	R	S
ILC 3856	R	R	R	R	S	R
ILC 5928	R	R	S	R	R	R
FLIP 83-48C	R	R	R	S	R	S
ICC 3996	R	R	R	S	S	S

1. R = resistant, S = susceptible.

3.2.2. Estimation of Yield Loss

The yield loss due to ascochyta blight was determined in a set of 20 lines, including resistant, tolerant and susceptible genotypes. Split plot design with protected and diseased treatments as main plots and genotypes as sub-plots with three replications was adopted. No disease was noticed in plots where disease was controlled by chlorothalonil (Bravo 500), whereas disease developed in epiphytotic form in plots which were artificially inoculated with a mixture of race 1 to 4 prepared in the laboratory. The results are shown in Table 3.2.3.

In another experiment, loss in yield due to blight was estimated in a set of lines rated mainly as resistant or moderately resistant. A susceptible check, ILC 1929, was included for comparison. The design and treatments were the same as in the previous experiment. The effect of fungicide spray and spore suspension spray was also similar to that of the previous experiment. The results are presented in Table 3.2.4. Yield loss in the resistant kabuli type was virtually nil, whereas there was some loss in yield in the resistant desi type. It is known that resistance in the desi type is weak at podding stage which might be reflected in loss of yield. There was considerable yield loss in moderately resistant types, especially in desi type, and heavy loss in yield in the susceptible types. This year's results are in accord with the results obtained during 1982/83 and 1983/84.
Drs. M.V. Reddy and K.B. Singh.

3.2.3. Integrated Control of Ascochyta Blight

Earlier studies have shown that chemical control of ascochyta blight in susceptible lines is uneconomical, but it could be useful in a tolerant line that is resistant at vegetative stage and susceptible at podding stage. Two field trials were conducted during winter and spring using

Table 3.2.3. Yield loss in chickpea due to ascochyta blight at Tel Hadya during winter, 1985/86.

Blight reaction of genotypes	Seed type	No. of entries	Average yield (kg/ha) Healthy	Diseased	% Increase/ decrease
Resistant	Kabuli	10	1881	1937	+ 2.9
	Desi	3	2424	1775	-26.8
Moderately resistant	Kabuli	2	2091	1474	-29.5
	Desi	1	2298	1355	-41.0
Susceptible	Kabuli	4	2082	321	-84.6

C.V. (%) main plot (disease)	15.65
C.V. (%) sub plot (genotypes)	28.34
S.E. ± main plot means	35.95
S.E. ± sub plot means	205.82
L.S.D. (5%) main plot means	218.77
L.S.D. (5%) sub plot means	579.53

Table 3.2.4. Estimation of yield loss in resistant, moderately resistant and susceptible lines of chickpea during winter season at Tel Hadya 1985/86.

Blight reaction of genotypes	Seed type	No. of entries	Average yield (kg/ha) Healthy	Average yield (kg/ha) Diseased	% Increase/ decrease
Resistant	Kabuli	11	2657	2744	+3.27
	Desi	6	2392	2747	+14.8
Moderately resistant	Kabuli	2	2527	1858	-26.5
Susceptible	Kabuli	1	2521	76	-97.0

C.V. (%) main plot (disease)	20.42
C.V. (%) sub plot (genotypes)	16.45
S.E. ± main plot means	66.98
S.E. ± sub plot means	170.65
L.S.D. (5%) main plot means	407.61
L.S.D. (5%) sub plot means	480.48

tolerant cultivar ILC 482. Disease was created by spreading diseased debris and spraying with spore suspension developed in the laboratory. One and two sprays of chlorothalonil (Bravo 500) were given at different stages of crop growth. The results are shown in Table 3.2.5 and 3.2.6 for winter and spring sowing. One spray at either pre-flowering, flowering or early podding was sufficient to eliminate pod infection in spring-sown crop, whereas two sprays at pre-flowering and flowering stage or flowering and early podding stage were required for winter-sown crop. Further, chemical spray not only reduced pod infection but also seed infection. In spring-sown crop the seed infection was brought to zero which will be highly desirable for the production of disease-free seed. The findings of this year are in close conformity with the earlier findings.
Drs. M.V. Reddy and K.B. Singh.

3.2.4. Association of Plant Height with Pod Infection by Ascochyta Blight

Generally, pod infection by ascochyta blight in chickpea is slight in tall, resistant genotypes. To determine whether it is environmental or genetic, an experiment was conducted using five genotypes with tall growth habit and three with bushy growth habit. The height of tall genotypes was reduced by bending them with rope. In general, there was no major difference in pod infection in bushy types. In tall types, there was no difference in some, but major difference was noticed in others (Table 3.2.7). It is planned to repeat the trial to arrive at a definite conclusion.
Drs. M.V. Reddy and K.B. Singh.

Table 3.2.5. Effect of foliar spray of chlorothalonil on ascochyta blight severity and yield of chickpea cultivar ILC 482 at Tel Hadya during winter, 1985/86.

Treatment[1]	Blight severity on vegetative parts	Percent pod infection	Yield (kg/ha)	Percent seed infection
1 spray in VS	3.7	75.7	2432	9.7
1 spray in FS	3.7	73.2	3068	11.8
1 spray in EPS	3.0	35.1	3128	5.2
1 spray in LPS	4.7	69.9	2358	8.1
2 sprays VS + EPS	2.0	12.1	3628	2.2
2 sprays FS + EPS	2.0	6.2	3555	0.6
2 sprays EPS + LPS	3.3	31.1	3412	2.2
Complete protection	2.0	10.1	3457	0.7
2 sprays based on epidemiology data	2.0	12.0	3239	4.3
No spray (Control)	4.3	73.8	2582	8.5
S.E. ±	0.41		304	
L.S.D. (5%)	1.203		902.47	
C.V. (%)	22.9		17.0	

1. VS = vegetative stage, FS = flowering stage, EPS = early podding stage, LPS = late podding stage.

Table 3.2.6. Effect of foliar spray of chlorothalonil on ascochyta blight severity and yield of chickpea cultivar ILC 482 at Tel Hadya during spring, 1985/86.

Treatment[1]	Percent pod infection	Yield (kg/ha)	Percent seed infection
1 spray in VS	3.2	2523	0
1 spray in FS	0.3	2845	0
1 spray in EPS	5.8	2456	0
1 spray in LPS	16.6	2129	1.3
2 sprays VS + EPS	0.6	2517	0
2 sprays FS + EPS	0.2	1887	0
2 sprays EPS + LPS	3.4	2187	0.3
Complete protection	0.2	2442	0
2 sprays based on epidemiology data	1.0	2494	0
No spray (control)	15.7	2081	0.2
Mean	4.69	2356	0.18
S.E. ±		217.13	
L.S.D. (5%)		645.14	
C.V. (%)		16.0	

1. VS = vegetative stage, FS = flowering stage, EPS = early podding stage, LPS = late podding stage.

Table 3.2.7. Effect of plant height on pod infection of ascochyta blight in a set of chickpea genotypes at Tel Hadya, 1985/86.

Genotype	Growth habit	Plant height (cm)[a]		Pod infection (%)	
		reduced height	normal height	reduced height	normal height
ILC 72	Tall	52.0	56.0	41.9	37.1
ILC 194	Bush	44.0	42.0	66.8	67.5
ILC 196	Tall	44.0	58.0	35.0	48.1
ILC 202	Tall	44.0	50.0	51.0	43.5
ILC 482	Bush	41.0	41.0	89.2	82.9
ILC 484	Bush	43.0	41.0	82.4	66.4
ILC 2956	Tall	49.0	59.0	59.3	30.3
ILC 3279	Tall	48.0	58.0	49.3	61.7
Mean		46.0	51.0	59.4	54.7

C.V. (%) main plot (plant height)	69.4		83.4	
C.V. (%) sub plot (genotypes)	7.4		25.8	
S.E. ± main plot means	6.8		9.7	
S.E. ± sub plot means	6.2		6.2	
L.S.D. (5%) main plot means		41.5		59.1
L.S.D. (5%) sub plot means		8.7		17.4

a) The height of tall genotypes was reduced by bending with rope.

Table 3.2.8. Reaction of some chickpea genotypes to race 3 of *A. rabiei* in seedling and adult stage in plastichouse experiment at Tel Hadya, 1985/86.

Chickpea genotype	Blight severity on 1-9 scale	
	Seedling stage	Adult plant stage
ILC 72	3.0	2.7
ILC 78	5.0	6.0
ILC 194	3.0	4.3
ILC 195	2.7	3.7
ILC 196	2.7	3.7
ILC 202	2.7	3.0
ILC 482	3.0	3.3
ILC 743	6.0	6.3
ILC 1929	6.7	7.0
ILC 3279	2.7	2.7
Mean	3.7	4.3
C.V. (%) main plot (stage)	19.49	36.56
C.V. (%) sub plot (genotypes)	28.12	20.38
S.E. ± main plot means	0.11	0.24
S.E. ± sub plot means	0.30	0.30
L.S.D. (5%) main plot means	0.45	0.45
L.S.D. (5%) sub plot means	0.86	0.86

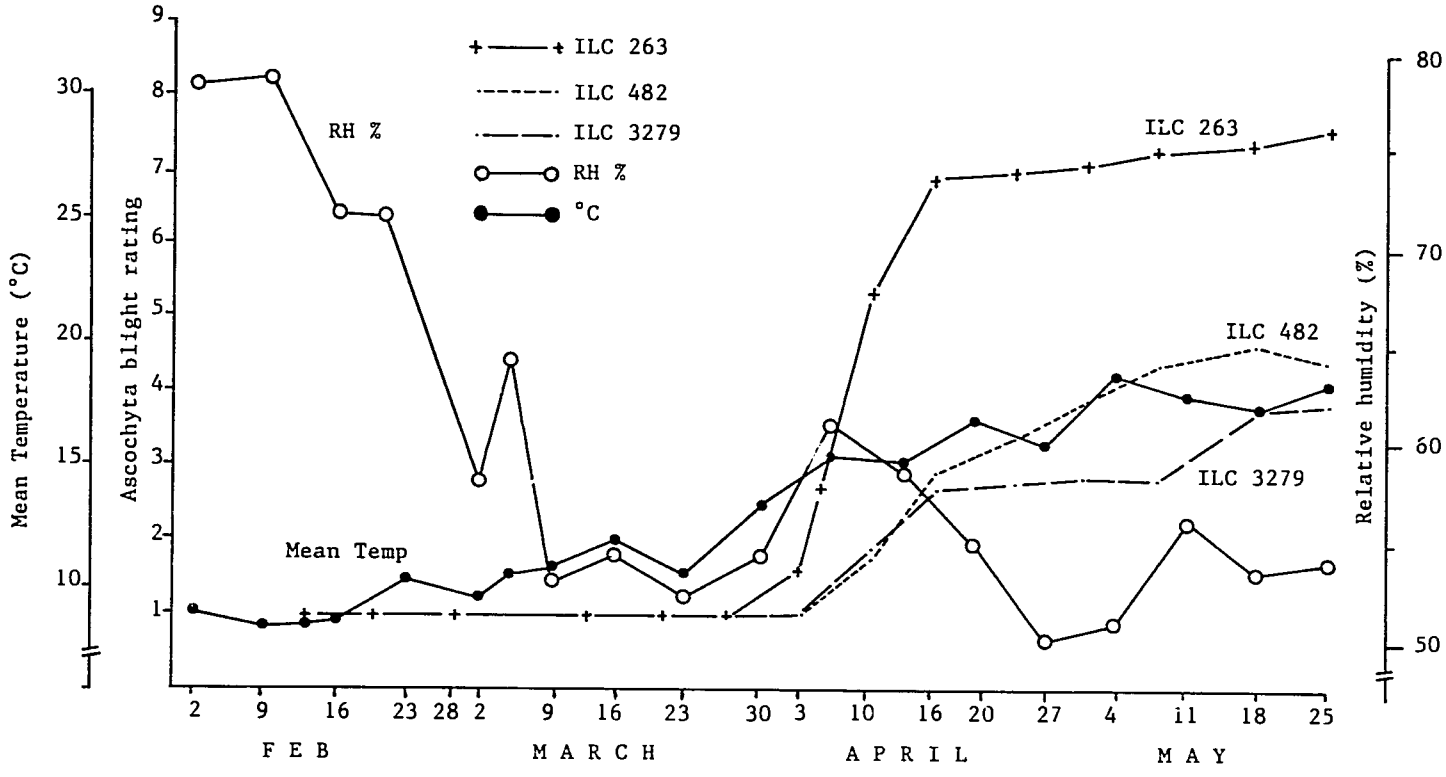

Figure 3.2.1. Ascochyta blight severity in 3 cultivars of chickpea in relation to temperature and relative humidity during 1985/86, Tel Hadya.

3.2.5. Relationship between Seedling and Adult Plant Reaction to Ascochyta Blight

Ten genotypes having resistant and susceptible reaction were evaluated by infecting plants with race 3 of A. rabiei at seedling and adult stage in the plastichouse. Some interesting results have been obtained (Table 3.2.8). Only in one genotype (ILC 72) was the disease rating less at seedling stage, in one other genotype (ILC 3279) it was the same, and in the remaining eight it was more at adult plant stage. This suggests that the plant at seedling stage is more tolerant than at adult stage.

3.2.6. Epidemiology of Ascochyta Blight

The relationship of temperature and relative humidity with the development of ascochyta blight was examined in the field for the third year in 1985/86. Results were similar to those of 1982/83 and 1983/84. Blight build-up was rapid when the mean temperature was above 10 ^{o}C and mean relative humidity more than 60% (Figure 3.2.1). These conditions existed in the first week of April during 1986. The susceptible line (ILC 263) was rated 8 when sown during winter and 7 when sown during spring. The 1985/86 season was not favorable for blight disease, hence the disease started late and even the susceptible was not completely killed.

Dr. M.V. Reddy.

3.3. Chickpea Insects and their Control

Since leafminers, primarily Liriomyza cicerina (Randomil), are the key pest of chickpea in the ICARDA region, studies on control methods and host plant resistance were continued. In addition, the occurrence of pod borer (Heliothis spp.) and damage caused were surveyed.

3.3.1. Chemical Control

In winter- and spring-planted chickpeas the importance of leafminer damage at different crop growth stages was measured and critical periods of control determined. As is shown in Table 3.3.1 no significant yield increases with control could be found, which stands in contrast to previous years. Also there were no consistent tendencies in winter and spring planted chickpea as far as time of treatment was concerned. Although yield increases achieved were about the same in winter and spring plantings, leafminer populations were found to be higher in the spring plantings, which is also indicated by the higher visual damage score (VDS) in all treatments. In contrast the pod borer Heliothis spp. occurred in higher numbers and caused more damage in winter plantings. In the untreated check 11.8% pods were damaged in the winter-planted versus 2.8% in the spring-planted chickpea.

3.3.2. Host Plant Resistance

The screening of chickpea genotypes for resistance to the leafminer involved 250 germplasm, 80 breeding lines, 76 lines for reconfirmation and 31 accessions in ILM, international leafminer nursery. Of the 76 reconfirmed lines 10 rated 3 and 25 received 4 on the 1-9 visual damage scale and can be considered to be resistant. Five lines of the 31 ILM accessions rated 3 and 17 lines rated 4. These will be tested further next season.

To measure the differential yield losses caused by leafminers in susceptible and resistant chickpea genotypes, 15 genotypes previously selected for varying degrees of resistance were grown with and without protection. Since this trial was damaged

Table 3.3.1. Effect of chemical control (Nuvacron 3 cc/l) of leafminer at different crop growth stages on the visual damage scores (VDS) and seed yield of winter- and spring-planted chickpeas (ILC 482), Tel Hadya, 1985/86.

Treatments	Winter-planted			Spring-planted		
	VDS (1-9)	Seed yield kg/ha	Seed yield % increase	VDS (1-9)	Seed yield kg/ha	Seed yield % increase
1 spray at:						
Preflow. + flow. + postflow.	1.1	2330	15.9	2.3	1487	16.4
Flow. + postflow.	2.1	2281	13.0	2.8	1535	20.1
Preflow. + postflow.	2.1	2385	18.2	2.9	1339	4.8
Preflow. + flow.	1.0	2356	16.7	2.5	1412	10.5
Preflowering	2.7	2224	10.2	3.4	1335	6.0
Flowering	2.3	2211	9.6	2.9	1506	17.8
Postflowering	2.3	2304	14.2	3.2	1410	10.3
Check	3.3	2218		3.8	1278	
S.E.	0.10	78.0		0.15	86.5	
C.V. (%)	9.4	7.0		10.9	12.5	

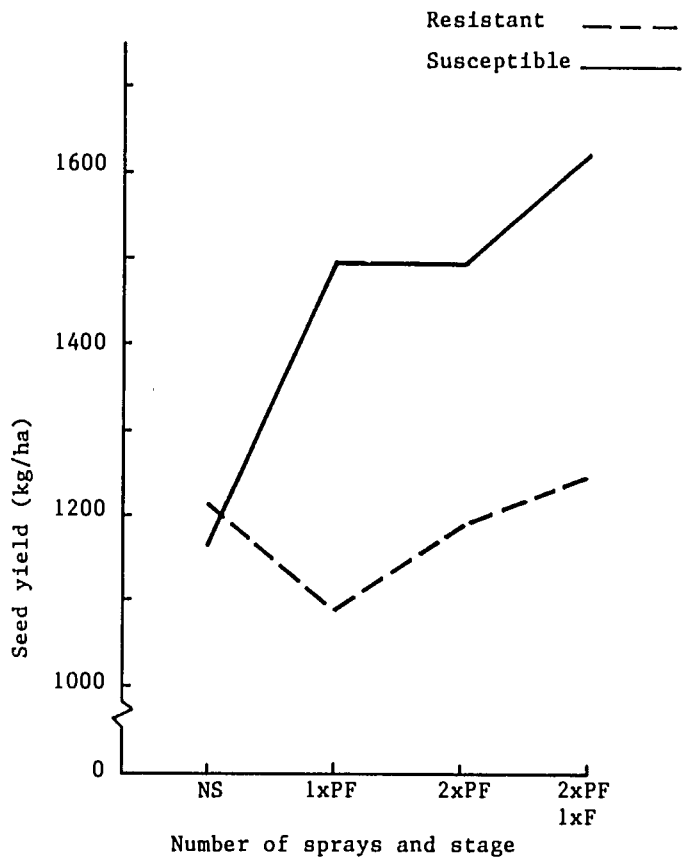

Figure 3.3.1. Seed yield of a susceptible and a resistant chickpea genotype as affected by spraying Nuvacron 40% (3ml/l) at different stages of crop growth.
NS = no spray; 1 = spray once; 2 = spray twice;
PF = pre-flowering stage; F = flowering stage.

by flooding, it will be repeated in 1986/87.

The varieties previously found to be susceptible (ILC 2512) and resistant (ILC 2319) showed significantly different yield increases when receiving chemical treatment(s) for leafminer control (Figure 3.3.1). In the susceptible ILC 2512 seed yield increased by 38.8% when 3 insecticide applications were made, compared to an increase of only 2.6% in the resistant ILC 2319. Both two and one chemical treatments caused yield increases of 27.9% in the susceptible and even a yield decrease of 1.9% and 10% in the resistant line. These results show that the susceptible line possesses high-yielding capacities but requires protected conditions, whereas the resistant line will be superior when non-protected.
Entomology and K.B. Singh.

3.4. Chickpea Crop Physiology, Agronomy and Microbiology

3.4.1. Response of Some Promising Lines of Chickpea to Date of Sowing

A study initiated in 1984/85 was repeated in 1985/86 at Tel Hadya and Terbol to investigate the effect of a range of winter and spring sowing dates (7 December, 7 January, 3 February, 16 February, 5 March and 18 March) on performance of some promising chickpea cultivars. Four cultivars were used: ILC 3279, ILC 482 (standard checks), FLIP 82-39C and FLIP 82-236C (new promising lines).

Seed yield in Tel Hadya in 1985/86, unlike 1984/85, did not vary significantly among genotypes and interaction between date of sowing and genotypes was nonsignificant. Seed yield was, however, significantly affected by date of sowing. Earliest date of sowing (7 December) gave the highest seed yield and there was progressive reduction in yield with delay in planting (Figure 3.4.1). In Terbol, seed yield was higher than Tel Hadya and the date of sowing effect was

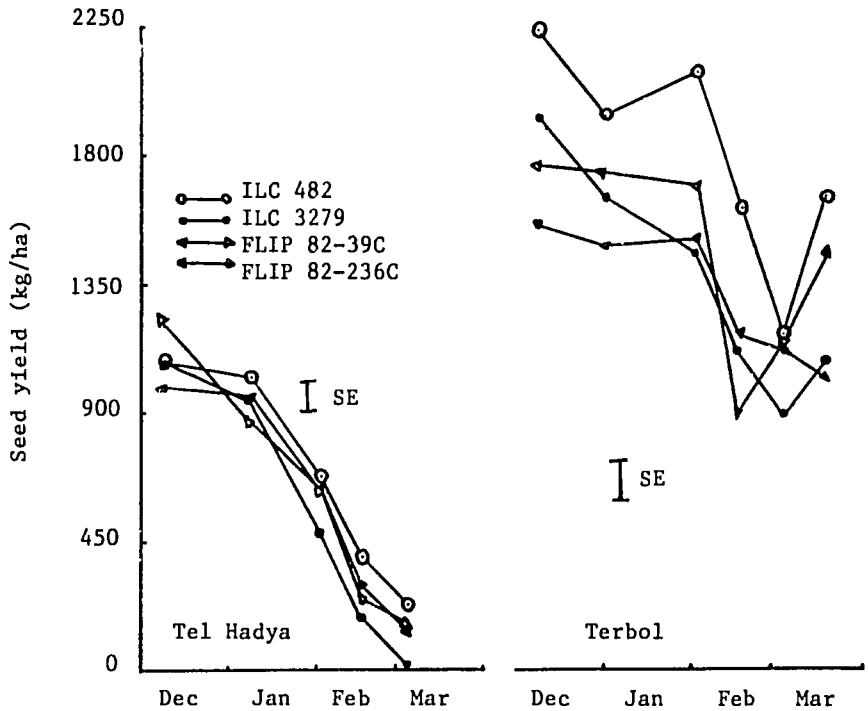

Figure 3.4.1. Effect of date of sowing on seed yield of four chickpea cultivars at Tel Hadya and Terbol, 1985/86.

similar to that at Tel Hadya except that yield from the last date of sowing (18 March) was higher than that from March 5, probably because the late sown crop benefited from the late rains in May at Terbol. ILC 482 was the highest yielding genotype because the winter was mild this year.

The major factor that appeared to have determined seed yield in Tel Hadya was plant stand. There was progressive but significant reduction in plant stand/unit area with delay in sowing and this resulted in significant reduction in maximum leaf area index achieved and in turn resulted in lower total biological yield. In Terbol the attainment of high seed yield with early sowing was again associated with the attainment of high total biological yield (r = 0.82), high harvest index (r = 0.72) and high plant stand/unit area (r = 0.62).
Drs. S. Silim and M.C. Saxena.

3.4.2. Response of Winter and Spring Sown Chickpeas to Supplemental Irrigation

Little is known about the effect of supplemental irrigation on winter- and spring-sown chickpeas under Mediterranean conditions. A trial initiatd in 1984/85 season to investigate the role of supplemental irrigation (one each at flowering and pod set) on ILC 3279 sown in winter and spring, was repeated in 1985/86 but with six genotypes (ILC 482, ILC 3279, FLIP 81-57W, FLIP 81-293, FLIP 84-19 and FLIP 84-80). Sowing was done on 3 December 1985 and 24 February 1986.

Winter-sown crops flowered earlier than spring- with ILC 482 and FLIP 81-293 flowering first and ILC 3279 last (Table 3.4.1). Supplemental irrigation extended reproductive period of both winter and spring sowings (Table 3.4.1) and caused significant increase in percentage of radiation intercepted (Figure 3.4.2). In addition, winter sown crop intercepted more radiation than the spring sown.

Table 3.4.1. Date of 100% flowering and number of days from 100% flowering to physiological maturity of chickpea cultivars as affected by date of sowing and moisture supply, Tel Hadya, 1985/86.

Treatments		Winter Sowing		Spring Sowing	
		Date of 100% flowering	Days from flowering to maturity	Date of 100% flowering	Days from flowering to maturity
ILC 482	rainfed	10.4.86	33	10.5.86	26
ILC 482	irrigated	10.4.86	44	10.5.86	37
ILC 3279	rainfed	17.4.86	35	16.5.86	31
ILC 3279	irrigated	17.4.86	44	16.5.86	40
FLIP 81-57W	rainfed	16.4.86	33	15.5.86	26
FLIP 81-57W	irrigated	16.4.86	41	15.5.86	35
FLIP 81-293	rainfed	10.4.86	42	11.5.86	31
FLIP 81-293	irrigated	10.4.86	47	11.5.86	40
FLIP 84-19	rainfed	15.4.86	33	13.5.86	28
FLIP 84-19	irrigated	15.4.86	41	13.5.86	34
FLIP 84-80	rainfed	17.4.86	38	15.5.86	30
FLIP 84-80	irrigated	17.4.86	40	15.5.86	34

Table 3.4.2. Effect of sowing date and moisture supply on yield, Tel Hadya, 1985/86.

Moisture Supply	Seed yield (kg/ha)			Biological yield (kg/ha)			Plant population/m^2		
	Winter	Spring	Mean	Winter	Spring	Mean	Winter	Spring	Mean
Rainfed	1559	884	1221	4347	2576	3462	29.3	19.6	24.3
Irrigated	2431	1522	1997	7218	4102	5660	28.6	18.6	23.6
Mean	1995	1203		5783	3339		28.9	18.9	
	L.S.D.(5%)	S.E.	C.V.(%)	L.S.D.(5%)	S.E.	C.V.(%)	L.S.D.(5%)	S.E.	C.V.(%)
Sowing date	589	131	56.7	1090	242	36.8	6.0	1.9	38.7
Moisture	228	66	28.6	639	185	28.1	NS	0.5	13.6
Interaction	NS	147		1255	304		NS	1.4	

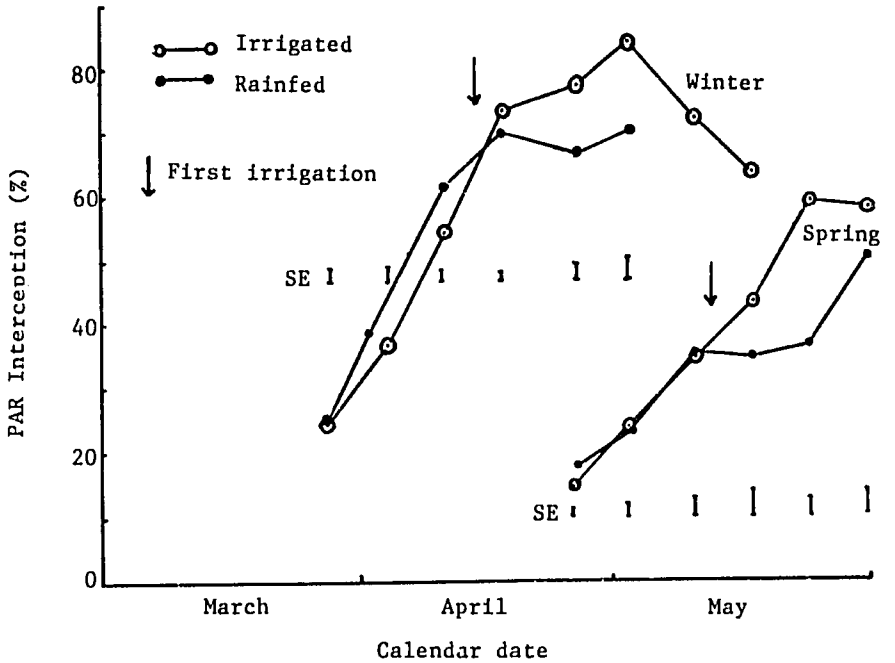

Figure 3.4.2. The effect of supplementary irrigation on interception of photosynthetically active radiation (PAR) by winter and spring sown crop of chickpea (mean of 5 genotypes), Tel Hadya, 1985/86.

The interactions between date of sowing, moisture supply and genotype were nonsignificant. Consequently the main effects are presented in Table 3.4.2. Fifty six percent and 72% seed yield increases were obtained in winter and spring sowings, respectively, following irrigation. Winter sown and irrigated crop intercepted high percentage radiation over a long period, and this contributed to production of large total dry matter. The poor stand in spring sown crop was a result of dry spell experienced at sowing.

The study as in 1984/85 has indicated the usefulness of supplemental irrigation in winter and spring sown chickpea.
Drs. S. Silim and M.C. Saxena.

3.4.3. Performance of Spring Sown Chickpea Genotypes under a Moisture-supply Gradient

A study was initiated during 1985/86 season to investigate the potential of line-source sprinkler as a tool for applying irrigation gradient across the field to identify genotype differences in response to moisture supply. Total moisture supply given above seasonal precipitation was 320mm near the sprinkler and no irrigation (0mm) farthest from sprinkler. In all, nine levels (300, 200, 220, 180, 140, 100, 60, 20, 0mm) of moisture supply above 316 mm of seasonal precipitation were achieved (Figure 3.4.3). Sixteen genotypes were used in the study including a few entries from ICRISAT that have shown promise in their studies on terminal drought.

Time to 100% flowering and physiological maturity varied among genotypes. ICC 10991, ICC 10448 and ILC 1929 were early in flowering, followed by ICC 11051, JG 74 and ILC 482; ILC 3279 flowered last. Irrigation at the highest level extended reproductive growth by delaying maturity (Table 3.4.3). ILC 482 was earliest to mature followed by ICC 10991, K 850, ILC 1919 and ILC 1929; again ILC 3279 matured last.

Table 3.4.3. Dates of flowering and physiological maturity of chickpea genotypes sown in spring and grown under rainfed[1] condition and maximum irrigation[2]. Tel Hadya, 1985/86.

Genotype	Date of % flowering	Dates of physiological maturity	
		rainfed treatments	maximum irrigation (300m)
V_1 = ICC 10991	1.5.1986	5.6.1986	11.6.1986
V_2 = K 850	8.5.1986	5.6.1986	12.6.1986
V_3 = ICC 11051	4.5.1986	7.6.1986	15.6.1986
V_4 = JG 74	3.5.1986	8.6.1986	30.6.1986
V_5 = P 1329	8.5.1986	5.6.1986	13.6.1986
V_6 = ICC 10448	1.5.1986	6.6.1986	15.6.1986
V_7 = ILC 16	4.5.1986	4.6.1986	15.6.1986
V_8 = ILC 262	10.5.1986	10.6.1986	19.6.1986
V_9 = ILC 482	4.5.1986	3.6.1986	7.6.1986
V_{10} = ILC 629	12.5.1986	9.6.1986	19.6.1986
V_{11} = ILC 1919	8.5.1986	6.6.1986	10.6.1986
V_{12} = ILC 1929	1.5.1986	10.6.1986	22.6.1986
V_{13} = ILC 1930	6.5.1986	4.6.1986	22.6.1986
V_{14} = ILC 3279	16.5.1986	18.6.1986	27.6.1986
V_{15} = FLIP 82-39C	10.5.1986	7.6.1986	14.6.1986
V_{16} = FLIP 82-236C	10.5.1986	8.6.1986	16.6.1986

1 = 316 mm seasonal precipitation
2 = 300 mm of irrigation on top of seasonal precipitation.

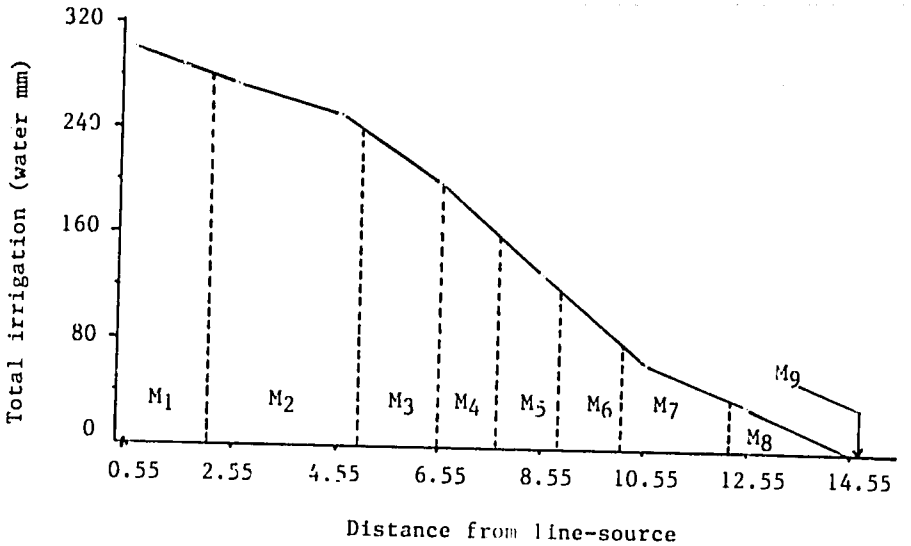

Figure 3.4.3. Amount of total irrigation water received at different distances from the line source. M_1 to M_9 are moisture supply classes, with M_1 having a mean supply of 300 mm of irrigation water and M_9 no irrigation at all.

Table 3.4.4. Effect of moisture supply[1] on yield and harvest index of spring sown chickpeas, Tel Hadya, 1985/86. Mean of 16 genotypes.

Amount of Irrigation (mm)	Seed yield (kg/ha)	Total biological yield (kg/ha)	Harvest Index
300	2077	5567	0.38
260	1962	5285	0.38
220	1858	5020	0.38
180	1792	4696	0.39
140	1752	4254	0.42
100	1606	3510	0.47
60	1563	3265	0.49
20	1244	2558	0.50
0	1133	2369	0.48
S.E.	32.7	83.8	0.011
C.V. (%)	13.6	14.3	17.1

1. Moisture supply above 316 mm rainfall

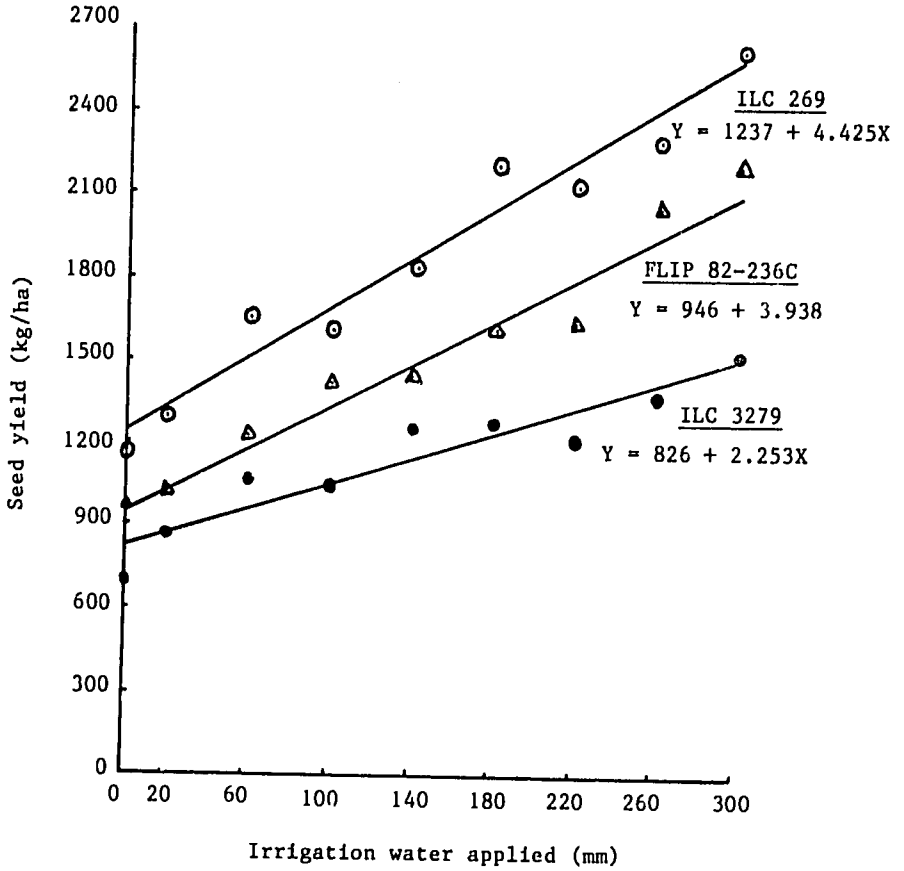

Figure 3.4.4. Relationship between irrigation water supply and seed yield of three selected chickpea genotypes, Tel Hadya, 1985/86. Total seasonal precipitation was 316 mm.

Seed yield was affected significantly by moisture supply. Under rainfed condition, seed yield was very low and increased with progressive increase in moisture supply (Table 3.4.4). Total biological yield also increased. There was, however, significant reduction in harvest index with increase in moisture supply. Genetic differences in response to moisture supply were evident, but were not large enough to reach level of significance at P = 0.05. As an example, ILC 629 and FLIP 82-236C were most responsive and ILC 3279 least responsive to irrigation (Figure 3.4.4). In conclusion, the line-source sprinkler system appears promising for screening genetic differences in chickpea for moisture requirement.
Drs. S. Silim and M.C. Saxena

3.4.4. Weed Control

Effect of controlling weeds by mechanical means or by herbicides was studied in a trial on winter-sown chickpea using cultivar ILC 482. Weeds reduced seed yield by 67% (Table 3.4.5). Pre-emergence application of cyanazine + pronamide proved the most effective weed control treatment. This was closely followed by terbutryne + pronamide combination applied as pre-emergence spray. Fomesafen and AC 252-214 caused phytotoxicity and showed poor weed control.
Drs. M. Pala and S. Silim.

3.4.5. Microbiology

3.4.5.1. Rhizobial studies

There were two basic types of experiments. The first involved evaluation of 15 prominent cultivars for response to inoculation with a single Rhizobium strain (ICARDA strain 192, isolated in Morocco),

Table 3.4.5. Effect of weed control on seed yield of chickpea and on weed dry weight, Tel Hadya, 1985/86.

Treatment	Rate of appln. (kg a.i./ha)	Time of appln.	Seed yield (kg/ha)	Weed dry weight (kg/ha)
Weedy check			277	1943
Weed-free check			838	182
Cyanazin + pronamide	1.0 + 0.5	Pre-em.	1040	190
Terbutryne + pronamide	2.0 + 0.5	Pre-em.	956	252
Dinoseb acetate + fluazifabbutyl	1.0 + 0.5	Post-em.	770	511
Codal	2.0	Pre-em.	661	883
Secbumetron	0.25	Pre-em.	480	1219
Carbetamid	1.5	Pre-em.	381	1530
AC 252-214	0.2	Pre-em.	200	912
AC 252-214	0.2	Emerg.	33	497
AC 252-214	0.1	E.Post-em.	26	1455
Fomesafen	0.2	E.Post-em.	61	1776
Fomesafen	0.2	M.Post-em.	165	1553
Fomesafen	0.2	L.Post-em.	301	1427
LSD (P=0.05)			133	466
CV (%)			21	31

compared to uninoculated treatments. The field used in this experiment was inoculated 3 years previously with a different strain. The second experiment evaluated response of a single cultivar (ILC 482) to inoculation with six separate strains of rhizobia compared to an uninoculated control. This experiment was conducted on a field previously uninoculated, containing low numbers of indigenous chickpea rhizobia. The primary criteria for response to inoculation in both experiments were yield components.

Over the mean of 15 cultivars tested, there was no response to inoculation with a single strain of Rhizobium over the uninoculated control. Some individual lines did show response to inoculation, though these responses were insignificant. Line ILC 35 expressed a 400kg/ha decrease in seed yield with inoculation, while line ILC 3279 when inoculated gave 600kg/ha greater seed yield than the uninoculated control. Other cultivars behaved in a manner similar to these two, but varied to a lesser extent from the uninoculated control. These differences indicate the importance of cultivar-strain interaction with use of inoculants.

In the field screening for inoculation effects from six Rhizobium strains, there were significant yield differences between treatments inoculated and uninoculated on ILC 482. Strain No. 192, used in previous years in ICARDA-produced chickpea inoculants, showed no significant final yield difference over the uninoculated control. Strain Nos. 183 and 191 however produced a significantly higher yield than the uninoculated control or strain 192. The control gave the lowest grain yield of all treatments, but control plants had the highest total protein content.

These type of cultivar-strain combination differences will be exploited after further evaluation in an organized selection program during the next year.

3.4.5.2. Studies on VA-Mycorrhiza

Studies on the mycorrhizal relationship of chickpea, as also of lentil, were continued in 1985/86. It was observed that both chickpeas and lentils, like many other crop plants, are able to form a symbiosis with vesicular-arbusclar mycorrhizal- (VAM-) fungi in their roots. A root colonization of VAM-fungi (Figure 3.4.5) might increase the ability of the host plant to absorb mineral nutrients and take up water under stressful environments.

Field studies concerning mycorrhiza were carried out at three locations in Northern Syria (Tel Hadya, Jib Kas and Breda), differing in rainfall, soil type and cropping history. A high number of mycorrhizal spores could be recovered from the top soil and the prevalent systems will be described. A study of the root systems of chickpea and lentil was undertaken at the same sites, and all roots were found to be heavily infected with VA mycorrhiza - 40 to 90% of the total root length was infected by VAM- fungi.

VAM can improve the phosphate nutrition of chickpea plants, but application of phosphatic fertilizer can alter the plant- fungus relationship. This came out from a pot-culture experiment conducted in a plastichouse at Tel Hadya, where effect of inoculation with VA mycorrhiza was studied at varied levels of soil phosphate on chickpea cultivar ILC 482 in sterile soil. VAM- inoculation increased plant dry weight three times with no phosphate applied, five times with low level of phosphate (6 ppm P) and only two- fold at the higher phosphate level (24 ppm P). The soil was very low in available phosphorus. The infected plants showed not only better growth and total phosphate uptake, but also increased phosphorus contents.

Mr. Eckhard George, Mr. Edwin Weber (University of Hohenheim) and Dr. M.C. Saxena.

Figure 3.4.5. Chickpea root showing mycorrhizal infection. Arbuscules, vesicles, internal and external hyphae, external spores - including an empty spore, and several entry points can be seen. Sample was taken from roots of a potted plant of ICC 482 chickpea grown with 6 ppm P appled to pot.

4. OROBANCHE STUDIES

Orobanche spp. is an important angiospermic parasite affecting the productivity of faba bean, lentil, chickpea and pea in several areas in the West Asia and North Africa Region. The incidence is particularly high in faba beans and lentils. Hence studies were initiated on developing integrated control of the parasite for faba bean and lentil crops. The work was conducted in close collaboration with the University of Hohenheim with special funding from GTZ, Federal Republic of Germany. Some of the studies were conducted in collaboration with the Royal Tropical Institute, Amsterdam, and the Agricultural University, Wageningen, The Netherlands.

4.1. Effect of Soil Solarization on Orobanche spp. Infestation in Faba Beans and Lentils.

Soil solarization involves covering wet soil during the hot season with transparent polyethylene (PE) to increase soil temperature to levels lethal to soilborne pests. Beside a temperature effect, a shift in microbial population and changes in chemical and gas composition levels maintained by PE mulch are considered to be involved in disease control. Orobanche seeds may possibly be destroyed directly by heat or indirectly by microbial activity after the seeds have been weakened by sublethal heating.

In 1985/86 season a trial was conducted in a naturally infested field at Tel Hadya. Before mulching the soil with transparent PE, the field was cultivated and sprinkler irrigated to field capacity. Four mulching periods were tested; 0, 10, 20 and 40 days in 4 reps. Without any soil tillage half of each plot was sown with faba bean (ILB 1813) and half with lentil (ILL 4400) at the end of October. The trial was also used to monitor weed and nematode populations.

Temperature in 5, 10 and 15 cm soil depths was measured continuously during the experiment. At 5 cm depth the daily soil temperature maxima of the covered soil reached between 52-55 ^{o}C and lasted for around one hour in the late afternoon. The maximum temperature in the upper layer of the PE-covered soil was 12-15 ^{o}C higher than in the uncovered soil (Figure 4.1).

Number of Orobanche per m^2 in faba bean and lentil was decreased by more than 90% after 40 days solarization while the seed yield was increased by more than 50% in faba bean and more than 70% in lentil (Figure 4.2, 4.3).

All weed species grown in the plots were recorded and the species controlled determined. After 20 and 40 days of solarization only two species (Coronilla scorpioides, Scorpiurus muricatus) were dominant in contrast to 5 species (Coronilla scorpioides, Phalaris paradoxa, Scorpiurus muricatus, Sinapis arvense, Vaccaria pyramidata) in the control. Number of weed species and weed dry weight was decreased, the latter by about 80-90%. The cover ratio of weeds measured in percent of soil covered was reduced in both crops to less than 1% after 40 days of solarization (Table 4.1 and 4.2).

To evaluate the nematode population in the soil, samples up to 15 cm depth were taken from each plot and nematodes extracted were classified and counted (Table 4.3). Also the root nematode Pratylenchus thornei on faba bean was very well controlled (Table 4.4).

Drs. J. Sauerborn and M.C. Saxena.

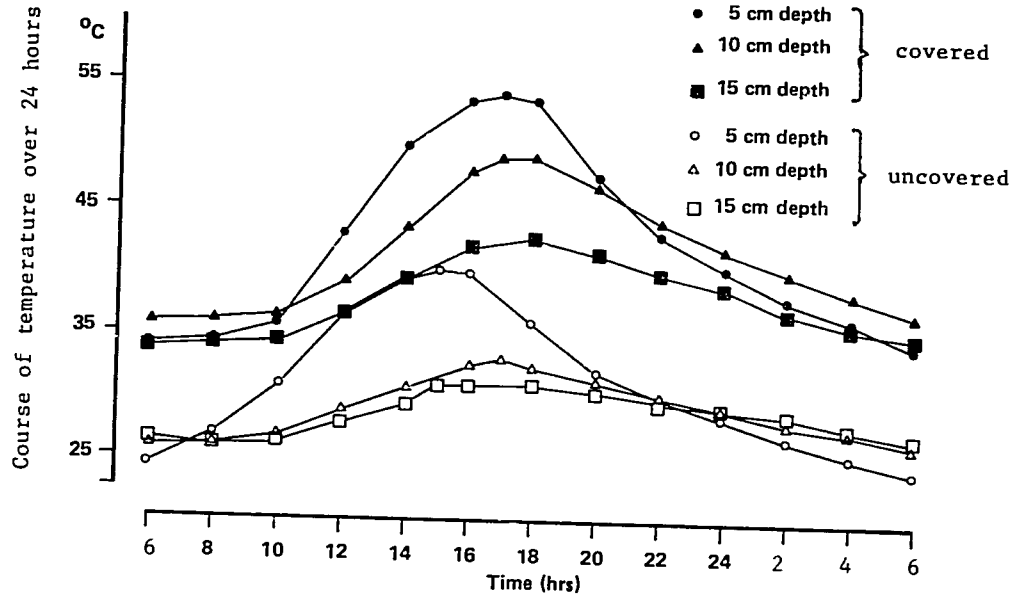

Figure 4.1. Daily course of temperatures of PE-covered and uncovered soil at several depths(recorded 14 Aug 1985).

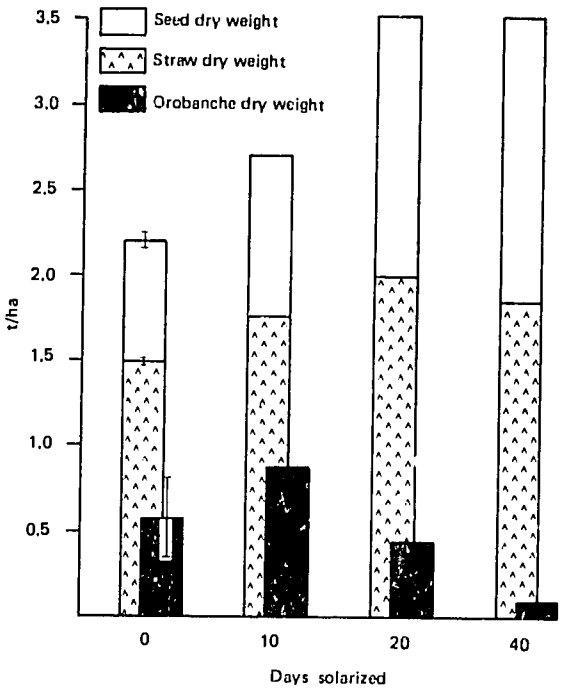

Figure 4.2. Effect of solarization on Orobanche spp. and faba bean yield - Tel Hadya 1985/86.

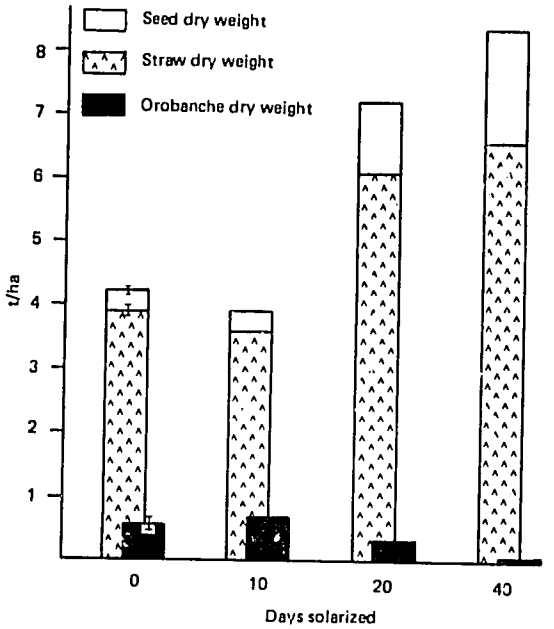

Figure 4.3. Effect of solarization on Orobanche spp. and lentil yield - Tel Hadya 1985/86.

Table 4.1. Effect of solarization on weeds in faba bean - Tel Hadya 1985/86.

Duration of solarization (days)	*Coronilla scorpioides* (no./m^2)	*Phalaris brachyst.* (no./m^2)	*Scorpiurus muricatus* (no./m^2)	*Muscaria racemosa* (no./m^2)	*Sinapis arvensis* (no./m^2)	Other weeds (no./m^2)	Weeds total (no./m^2)	Weeds dry weight (g/m^2)	Monocots dry weight (g/m^2)	Dicots dry weight (g/m^2)	Cover ratio (%)
0	32.00	13.00	2.00	2.00	3.25	22.25	76.50	98.75	22.25	76.50	32.50
10	17.00	34.75	12.75	0.25	0.00	9.50	80.25	123.25	73.75	49.50	30.00
20	14.75	0.00	11.00	1.50	0.00	0.00	27.25	23.00	0.00	23.00	0.33
40	25.75	0.00	5.50	1.00	0.00	0.00	29.75	16.25	0.00	16.25	0.33
S.E. of Mean	4.18	9.79	4.59	0.94	0.38	3.14	13.14	30.04	24.48	18.14	6.17
L.S.D.(5%)					1.20	10.06	42.03				19.72
C.V.(%)	37.40	164.01	117.44	158.94	92.31	79.24	49.18	92.00	204.00	87.83	76.90
Significance	ns	ns	ns	ns	*	*	*	ns	ns	ns	*

Table 4.2. Effect of solarization on weeds in lentil - Tel Hadya 1985/86.

Duration of solarization (days)	Coronilla scorpioides (no./m^2)	Phalaris brachyst. (no./m^2)	Scorpiurus muricatus (no./m^2)	Other weeds (no./m^2)	Weeds total (no./m^2)	Monocots dry weight (g/m^2)	Dicots dry weight (g/m^2)	Weeds dry weight (g/m^2)	Cover ratio (%)
0	4.75	3.75	3.25	24.25	36.00	13.25	108.75	122.00	42.50
10	16.25	35.00	2.25	13.25	66.75	80.00	17.50	97.50	25.00
20	31.25	0.00	9.50	7.25	48.00	0.00	15.50	15.50	13.75
40	19.50	0.00	5.25	0.00	22.25	0.00	8.25	8.25	0.50
S.E. of Mean	3.73	9.53	4.43	4.88	12.20	20.06	13.04	23.04	3.78
L.S.D.(5%)	11.91			15.60			41.70	73.68	12.09
C.V.(%)	41.53	196.73	175.08	87.20	56.43	172.13	69.54	75.76	36.98
Significance	*	ns	ns	*	ns	ns	*	*	*

Table 4.3. Number of nematodes in 500 cm^3 of soil after soil solarization (soil samples taken up to 15 cm depth in 4 reps.).

Nematodes	Duration of solarization (days)			
	0	10	20	40
Pratylenchus sp.	270	32	32	0
Helicotylenchus sp.	270	0	0	0
Tylenchus sp.	54	0	16	0
Tylenchorhynchus sp.	36	0	0	0

Table 4.4. Influence of soil solarization on *Pratylenchus thornei* on faba bean at flowering stage.

Duration of solarization (days)	*Pratylenchus thornei* (no./10 g root)
0	166
10	16.5
20	3.8
40	0.3
S.E.	15.32
C.V.(%)	65.72
L.S.D.(5%)	49.01
Significance	*

4.2. The Effect of Different Sowing Dates on the Development of Orobanche spp. on Faba Bean and Lentil.

Farmers delay the sowing of the crop as a common cultural method for controlling Orobanche spp. in the region. The object of the experiment was to study the effect of sowing date on the development of Orobanche, especially the very early subterranean stages, the infestation level and biomass of the parasite and the yield of the crop. Two varieties of faba bean (ILB 1813, Giza 402) and lentil (ILL 4400, ILL 2581) were sown in a naturally infested field at Tel Hadya in 3 replications, at five sowing dates between October 15 and December 17. Once a week host plants were dug up starting at the time the first Orobancne attachments were expected (25 days after emergence). After the roots were washed the plants were studied, the dry matter of host and parasite and the number of Orobanche attachments, divided into different growth stages were established. Delay in sowing the Syrian Local faba bean variety resulted in a decrease in biomass while the seed yield was initially increased. Highest yield was observed when the crop was sown in the beginning of December. Further delay resulted in a decrease. For the Egyptian variety Giza 402 this was less clear but this might be due to the frost damage to these plants at the early sowing dates (Figure 4.4). For lentils the delay in sowing caused initially an increase, but later a decrease, in biomass. Both varieties did not give any seed yield due to Orobanche infestation, at the first sowing date (Oct. 15). Highest yield was observed when the crop was sown in mid-November (Figure 4.5). Dry weight of Orobanche was significantly decreased in both crops with later sowing dates (Figure 4.4., 4.5).

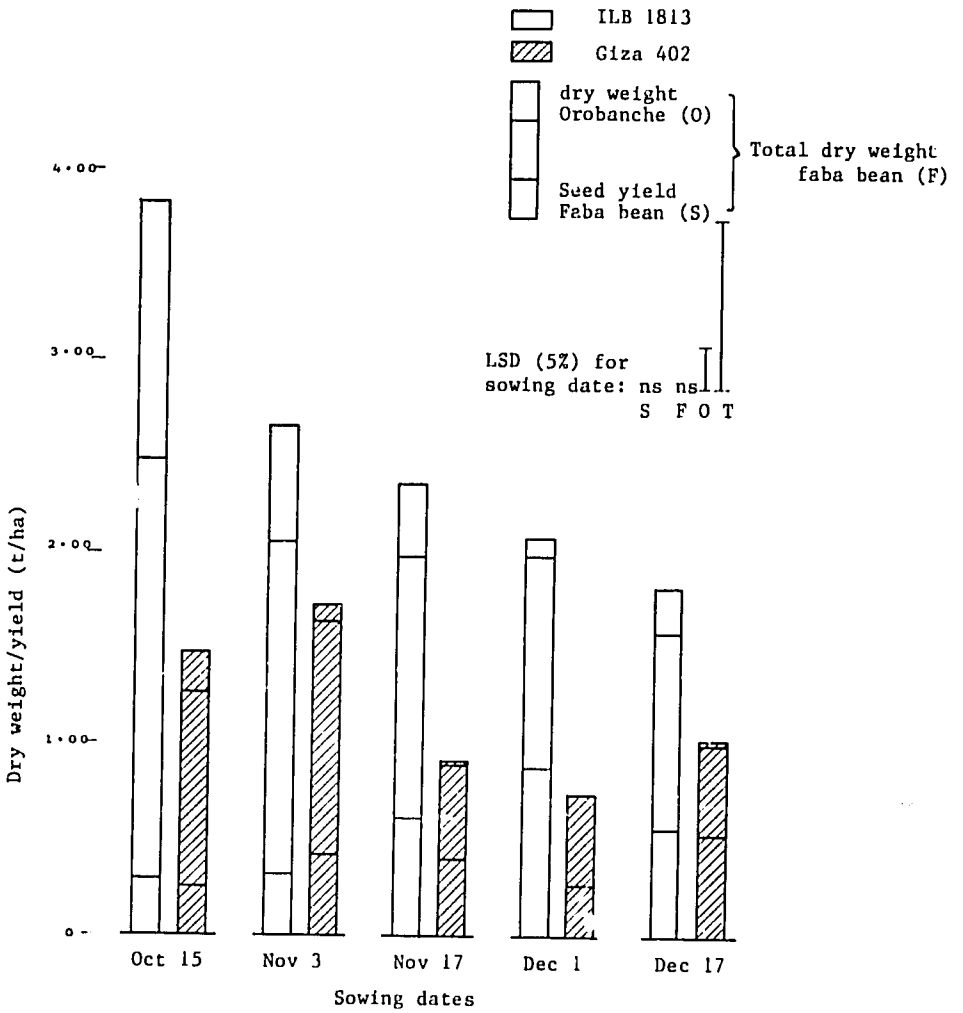

Figure 4.4. Effect of sowing date on Orobanche spp. dry weight and yield of two faba bean varieties - Tel Hadya 1985/86.

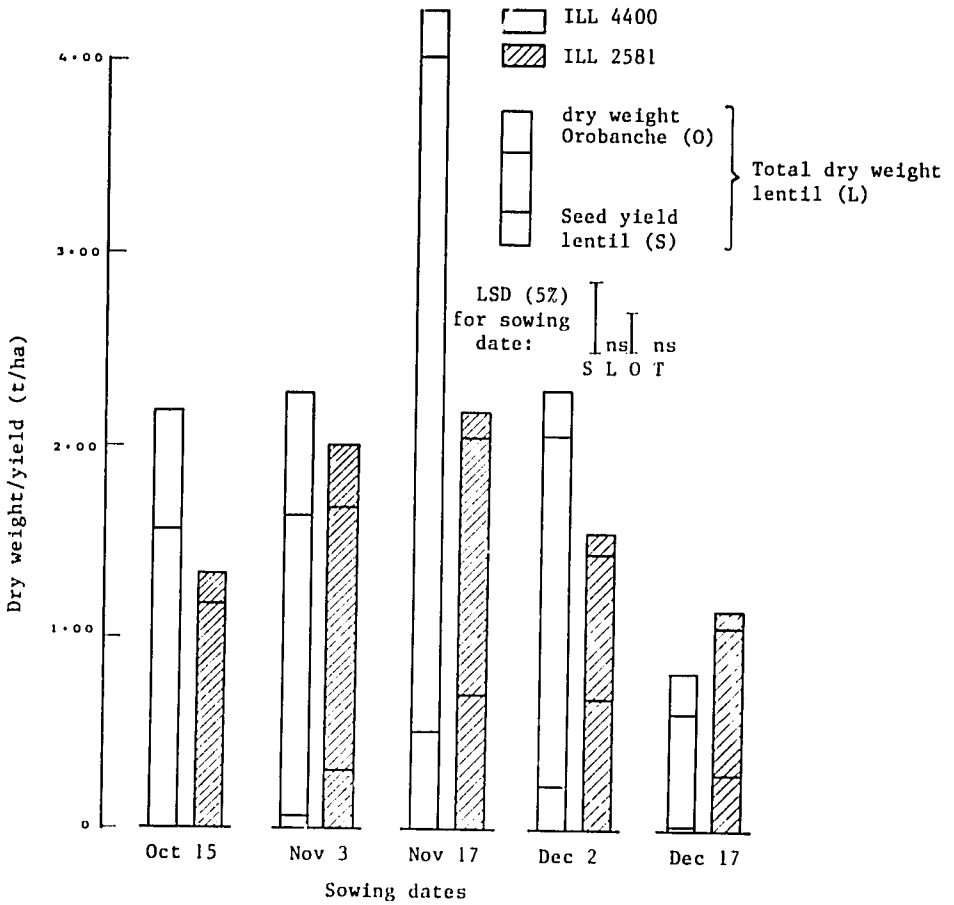

Figure 4.5. Effect of sowing date on Orobanche spp. dry weight and yield of two lentil varieties - Tel Hadya 1985/86.

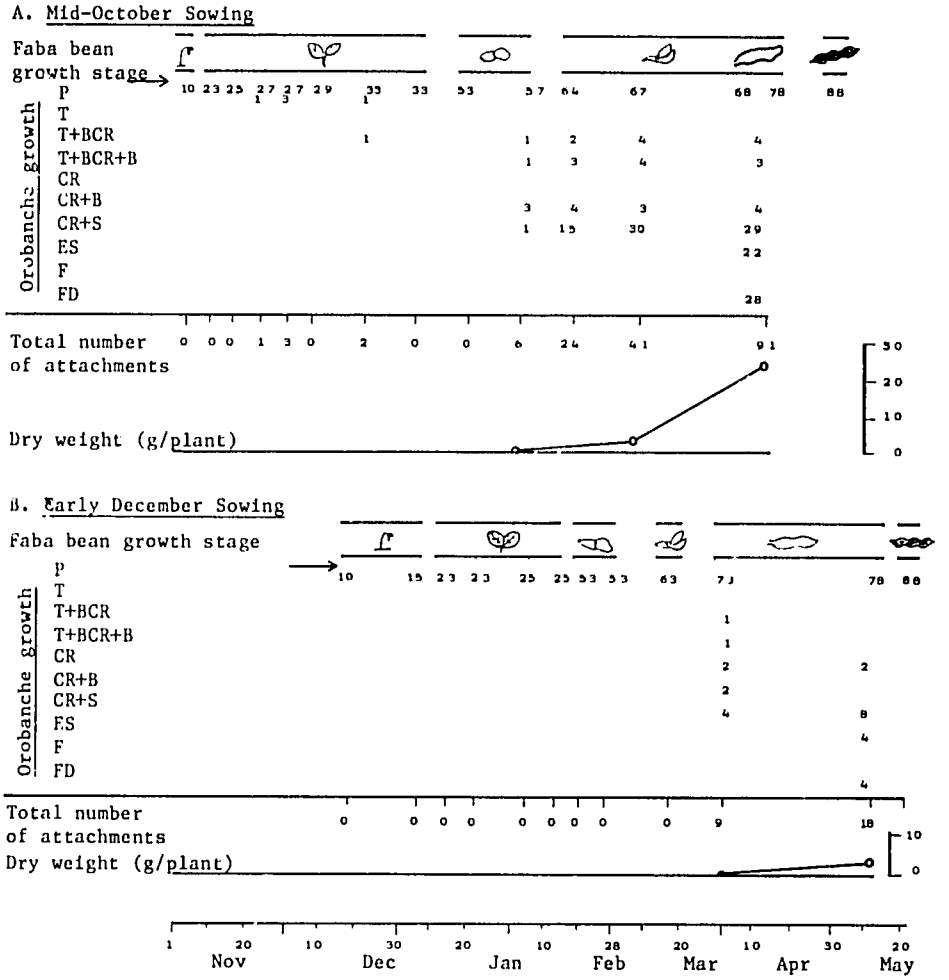

Figure 4.6. Development of faba bean (ILB 1813) and Orobanche spp. as affected by date of sowing.
P = procaulome; T = tubercle; BCR = beginning of crown roots; CR = crown roots; B = bud; S = shoot; ES = emerged shoot; F = flowering; FD = fruit development.

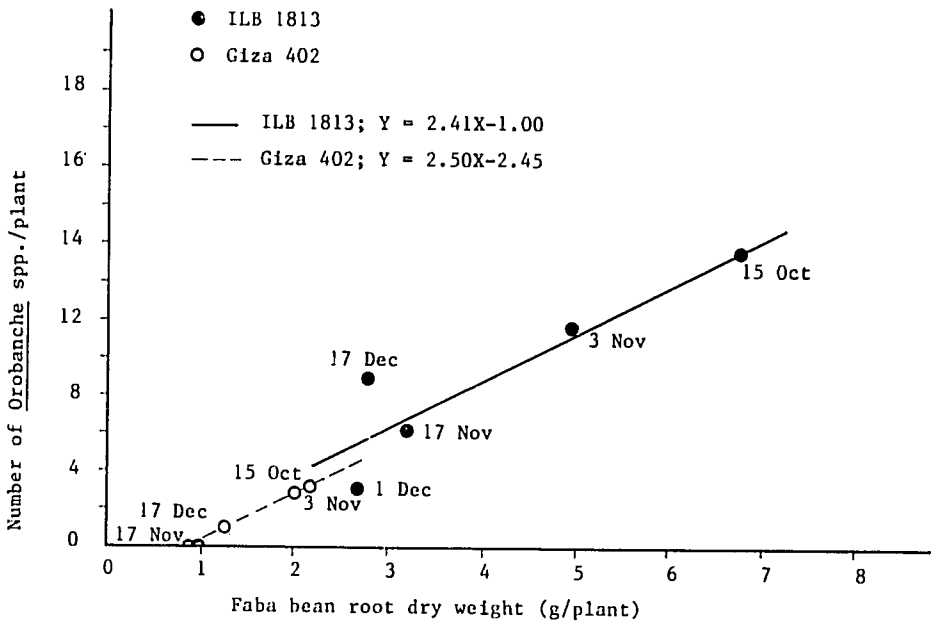

Figure 4.7. Relationship between root dry-weight of faba bean and number of Orobanche spp. attachments, Tel Hadya 1985/86. Data from 5 sowing dates between 15 Oct and 17 Dec 1985.

The development of faba bean and Orobanche is shown in Figure 4.6. The first Orobanche attachments (procaulomes) were found by end of November when the crop was sown in mid-October. In time there was an increase in the number of attachments and naturally, development of the older Orobanche growth stages. Orobanche emerged in mid-March.

On the Syrial local faba bean sown in the beginning of December, the first Orobanche attachments were observed end of March, (probably there were already some attachments before). First shoots appeared above the soil in mid-April, when faba bean had already formed pods.

A close relation between root dry weight of faba bean and the number of Orobanche attachments was found (Figure 4.7). From this graph it can be inferred that the low level of Orobanche infestation on Giza 402 was mainly due to the smaller root system.

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1.3. Chemical Control of Orobanche spp.

4.3.1. Evaluation of New Herbicides in Faba Bean and Lentil

A trial to study the chemical control of Orobanche spp.in faba bean and lentil were conducted in Tel Hadya. In the lentil control plots the Orobanche infestation reached 0.5 t/ha. Three herbicides were tested, Imazaquin (Scepter), Glufosinate (Basta) and Glyphosate (Lancer) in 4 replications. All of them were applied post emergence twice at several doses, at tubercle to bud stage of Orobanche development and 15 days thereafter. The herbicides were sprayed with a knapsack sprayer at a volume of 400 l/ha.

Lancer in faba bean reduced the number of Orobanche per m^2 by 69-83% but no increase in yield could be observed. Scepter controlled Orobanche up to 100% while seed yield was decreased by 22% because of phytotoxicity. Basta did not prove effective at all. High rate of Orobanche infestation in this treatment when compared with the treatment Lancer 2X was associated with yield loss of up to 43% (Table 4.5). In lentils all herbicides showed quite heavy phytotoxicity but again Basta failed to control Orobanche spp.

Scepter appears to be an interesting chemical which will be studied in more detail in further experiments.

4.3.2. Application of Lancer at several Sowing Dates of Faba Beans

A second chemical control trial was conducted to look at the effect of different sowing dates on the efficacy of herbicide (Lancer) application in faba bean (ILB 1813). Delay in sowing as well as Lancer application decreased significantly the number of Orobanche per m^2. In the 4th sowing date the total number of Orobanche was decreased by 80%, seed yield was increased by 92%. Two times herbicide application controlled the number of Orobanche by 63% and increased seed yield by 46% (Table 4.6). The interaction of the two factors was non significant for all the attributes studied except the number of Orobanche shoots per faba bean plant, which was significantly reduced by herbicide application in the first two dates of sowing but not in the remaining three sowing dates.

Obtaining more stable and effective control of Orobanche by the use of glyphosate is possible if the tolerance of faba bean to glyphosate is increased. Collaboration is being sought in this regard with some of the Centers working on biotechnology, and we hope a program will soon be developed.

Table 4.5. Evaluation of herbicides to control Orobanche spp. in faba bean - Tel Hadya 1985/86.

Herbicides (kg a.i./ha)	Seed yield (t/ha)	Straw yield (t/ha)	Total biol. yield (t/ha)	Orobanche dry weight (t/ha)	Orobanche (no./m^2)	% Orobanche dry weight of total biomass (%)
1 Control water	1.08	5.01	7.18	0.29	20.50	3.81
2 Control hyspray	1.17	4.82	7.15	0.14	14.00	1.86
3 Scepter 0,04 1x	0.84	3.19	4.86	0.00	0.00	0.00
4 Scepter 0,04 2x	0.53	3.76	4.82	0.00	0.00	0.00
5 Scepter 0,08 1x	0.39	4.10	4.88	0.02	0.31	0.45
6 Scepter 0,08 2x	0.14	3.27	3.56	0.00	0.00	0.00
7 Basta 0,04 1x	0.95	4.15	6.05	0.21	22.75	3.38
8 Basta 0,04 2x	0.62	3.82	5.06	0.32	44.00	7.68
9 Basta 0,06 1x	0.75	3.21	4.71	0.28	25.50	6.01
10 Basta 0,06 2x	0.70	3.15	4.54	0.16	15.00	3.51
11 Lancer 0,08 1x	0.95	3.38	5.27	0.04	6.50	0.78
12 Lancer 0,08 2x	1.07	4.36	6.50	0.02	3.50	0.32
S.E. of Mean	0.11	0.53	0.65	0.05	8.19	1.34
L.S.D.(5%)	0.32	-	1.87	0.14	23.55	3.85
C.V.(%)	29.50	27.57	24.10	81.29	129.21	115.55
Significance	*	ns	*	*	*	*

Table 4.6. Role of Lancer application and different sowing dates of faba bean (ILB 1813) in affecting Orobanche spp. infestation and crop yield. Tel Hadya 1985/86.

Treatments	Orobanche (no./m^2)	Orobanche (no./plant)	Orobanche (t/ha)	Seed yield (t/ha)	Straw yield (t/ha)
Glyphosate (kg a.i./ha):					
0	31.60	3.11	0.53	0.58	2.01
0,08 x 2	11.60	1.20	0.11	0.84	1.64
S.E.	13.83	1.52	0.13	0.27	0.46
C.V.(%)	64.05	70.47	42.00	37.64	25.0
L.S.D.(5%)	10.61	1.16	0.10	0.21	0.35
Significance	*	*	*	*	*
Sowing dates:					
15 October (1)	42.00	4.38	0.75	0.52	2.33
30 October (2)	27.33	2.80	0.33	0.74	2.33
15 November (3)	21.11	1.97	0.27	0.69	1.53
30 November (4)	8.33	0.83	0.12	0.99	1.50
15 December (5)	9.17	0.78	0.12	0.60	1.45
S.E.	13.83	1.52	0.13	0.27	0.46
C.V.(%)	64.05	70.47	42.00	37.64	25.00
L.S.D.(5%)	16.78	1.84	0.16		0.55
Significance	*	*	*	ns	*
Combinations of sowing date and herbicide:					
Date / Herbicide					
1 / 0	61.33	6.33	1.33	0.33	2.49
2 / 0	45.33	4.67	0.60	0.36	2.06
3 / 0	25.67	2.33	0.38	0.72	1.97
4 / 0	7.67	0.67	0.10	0.93	1.98
5 / 0	18.00	1.53	0.24	0.55	1.57
1 / 0.08 x 2	22.67	2.43	0.18	0.70	2.16
2 / 0.08 x 2	9.33	0.93	0.07	1.11	2.59
3 / 0.08 x 2	16.67	1.60	0.16	0.68	1.09
4 / 0.08 x 2	9.00	1.00	0.14	1.06	1.03
5 / 0.08 x 2	0.33	0.02	0.07	0.66	1.33
S.E.	13.83	1.52	0.13	0.27	0.46
C.V.(%)	64.05	70.47	42.00	37.64	25.00
L.S.D.(5%)		2.60			
Significance	ns	*	ns	ns	ns

4.3.3. On-farm Evaluation of Glyphosate in Faba Bean

Application of Glyphosate 2 times at the rate 0.08 kg a.i. per ha appears to be currently the most effective treatment. However the timing and the number of Glyphosate applications necessary for Orobanche control, and the optimum herbicide dose at which high efficiency is combined with low phytotxicity depends on climatic conditions, Orobanche growth stage, infection level and vigour of faba bean plants. An on-farm trial was, therefore, conducted at 5 different locations in northern Syria to evaluate the practice under farmers' conditions.

Two of the 5 locations had to be abondoned because in one (Al Mintar) the faba beans were wiped out by Rhizoctonia sp. while in the other (Jableh) the rose beetle (Epicometis) sp. destroyed all the faba bean flowers. The beetle also damaged Orobanche. Data for Orobanche infestation at Jable have, however, been included in Figure 4.8, because at this site the infestation was very high. The rest of results are only of Al Bab, Homs (Farhanie), Idlib and, as a reference, Tel Hadya. In all the four sites a good control of Orobanche (between 80 to more than 90%) was attained using two time Glyphosate application (Figure 4.8). At Jable, there was some control in the beginning, but at a later stage there was no difference between treated and non-treated plots (Figure 4.8). Seed yield was increased at Al Bab and Idlib but not in Homs and Tel Hadya (Figure 4.9). In Homs orobanche attacked the crop very late so that faba bean plants were not damaged, i.e. no yield reduction could be observed. This might be due to the environmental conditions and the late sowing of the crop.

In general, Lancer controlled Orobanche well but did not lead to an increase in seed yield. This might be because of the phytotoxicity of the product. Chlorosis of the youngest leaves, leaf drop and

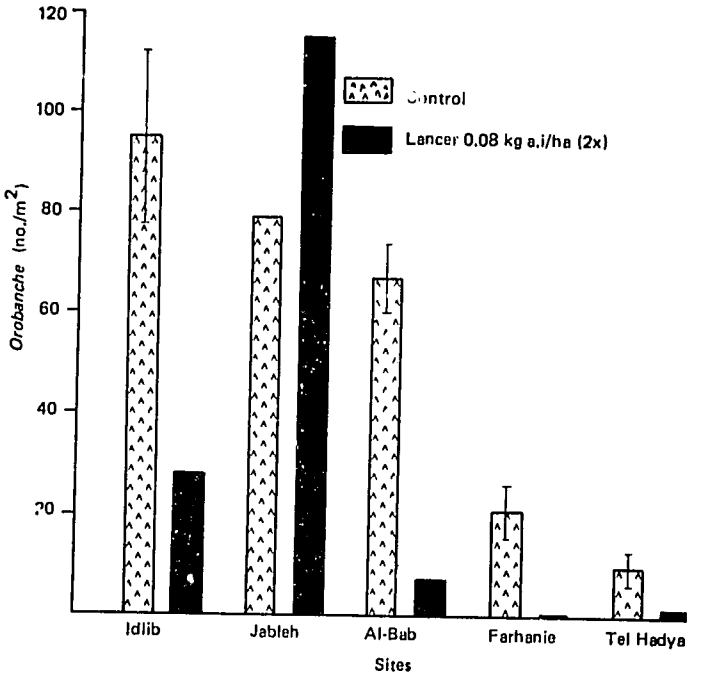

Figure 4.8. Effect of Lancer (Glyphosate) application on Orobanche spp. at different sites in Syria.

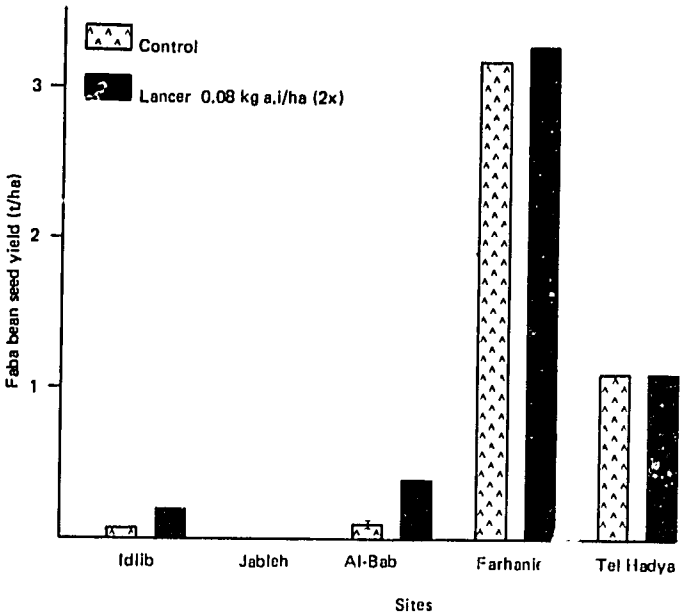

Figure 4.9. Effect of Orobanche spp. control by Lancer (Glyphosate) on seed yield of faba bean at different sites in Syria.

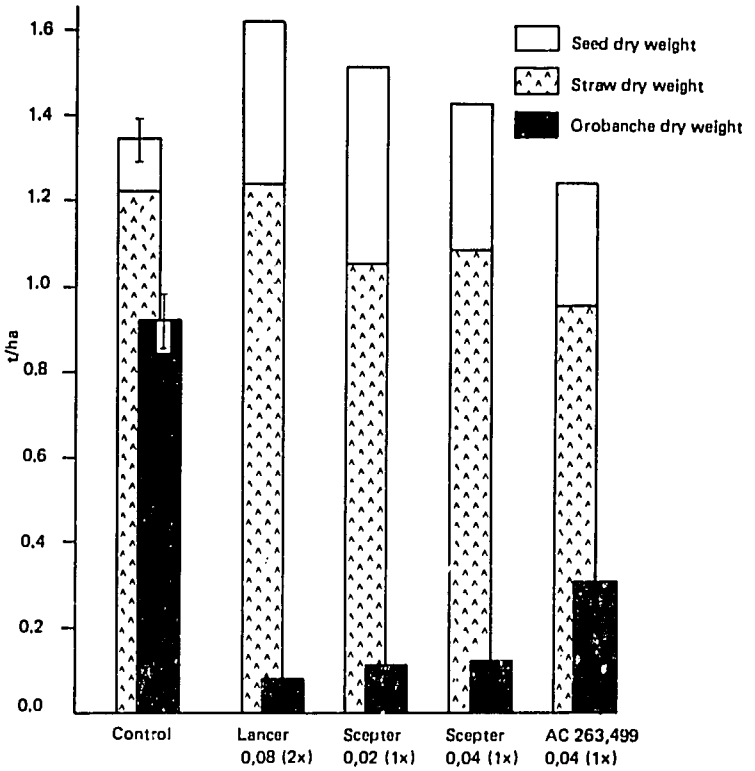

Figure 4.10. Effect of herbicide application in faba bean (SLL) on Orobanche spp. at Al-Bab 1985/86.

sometimes loss of whole plant were observed at all locations. More research on rate and time of application of Lancer under different environmental conditions is needed to effect an efficient control measure.

At Al Bab Scepter and AC 263,499 were tested beside Lancer for Orobanche control. Scepter at a dosage of 0.02 kg a.i./ha controlled Orobanche to nearly the same extent as Lancer, and seed yield was in both treatments the same (Figure 4.10). These results show the possibility of identifying herbicides other than Lancer to control Orobanche spp.

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4.4. Single Plant Selection for Orobanche Resistance in the Population Giza 402

Giza 402 has been developed as a faba bean cultivar having tolerance to Orobanche spp. Because of out-crossing, however, there is large variability in the tolerance of the plants in the population of Giza 402. In order to identify plants that show no or reduced Orobanche infestation, this study has been started. During the 1985/86 season 495 faba bean plants (Giza 402) were grown in single plastic pots (10 ltr) in the field. The pots were filled with a mixture of soil and sand (3:1 weight proportion) and inoculated with 0.5 g Orobanche seeds. To prevent out-crossing, the plants were covered by a screen mesh. Twenty eight plants were found to be free of Orobanche above the ground. After the roots were washed each of these plants showed between 1 to 10 early Orobanche attachments. The number of faba bean plants infested by emerged Orobanche is given in Table 4.7.

Table 4.7. Number of faba bean plants (Giza 402) infested with *Orobanche crenata*.

No. of Orobanche: (emerged)	0	1	2	3	4	5	6	7	8	9	10	>10
No. of faba bean plants infested:	28	40	74	72	69	60	42	28	21	17	14	30

Table 4.8. Effect of *Orobanche* infestation on yield components of faba bean plants (Giza 402).

Orobanche per plant	*Orobanche* dry weight (g/plant)	Pods per plant	Seed yield (g/plant)
0	0.00	3.40	3.81
1	0.98	3.76	3.09
2	2.16	3.64	3.44
3	2.36	3.84	3.66
4	2.92	3.36	3.14
5	2.76	2.96	3.10
6	3.50	2.08	2.11
7	3.51	2.24	2.16
8	5.50	1.72	1.92
9	7.04	1.96	1.85
S.E. of Mean	0.41	0.33	0.37
L.S.D.(5%)	1.13	0.92	1.03
C.V.(%)	66.51	57.08	65.76
Significance	*	*	*

With an increasing number of Orobanche shoots per plant the number of pods and the seed yield per plant decreased significantly (Table 4.8). Yield loss ranged between 4 and 51% depending on the number of Orobanche shoots per plant. On an average, one Orobanche shoot resulted in 28.6% yield loss.

The seeds of the plants which did not show any emerged Orobanche shoot at the time of harvest were grown during off-season at Bab-Janneh to multiply seeds for further investigations.

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4.5. Weed Survey of Faba Bean Fields in Syria with Special Reference to Orobanche spp. and Cuscuta spp.

In 1986 faba bean fields in Syria were surveyed for weeds including the parasitic weeds Orobanche spp. and Cuscuta spp. The survey was carried out along the Euphrates river from Raqqa to Abu Kamal and north east of Aleppo (Kafr Antoon, Al Bab, Kuwayres). In total 38 fields were checked for the parasitic weeds, while 23 fields were surveyed for the general weed flora. Weeds were collected to identify the species present. To analyse the weed flora in the field the relative area of ground covered by total vegetation and by individual species was estimated using a %-scale (0-100). To estimate the Orobanche infestation level in the field again a %-scale (0-100) was used where 0 = no faba bean plant infested; and 100 = 100% of the faba bean plants infested.

The frequency percentage (f) value was computed as follows:

$$f = 100 \times \frac{n}{m}, \text{ where}$$

n = number of fields, in which the respective species were found; and
m = total number of fields surveyed.

Table 4.9: Frequency and average cover of common weeds in faba bean fields along the Euphrates river (12 fields surveyed), 1986.

Species	Frequency (%)	Species	Average cover (%)
Melilotus indica	83	Melilotus indica	17.6
Avena sterilis	75	Phalaris brachystachyos	7.4
Polygonum aviculare	75	Erigeron Linifolius	7.3
Phalaris brachystachyos	67	Lolium perenne	6.0
Sonchus oleraceus	67	Convolvulus arvensis	5.3
Setaria viridis	58	Setaria viridis	4.1
Chenopodium album	50	Cynodon dactylon	3.1
Convolvulus arvensis	50	Polygonum aviculare	3.1
Cuscuta sp.	50	Sonchus oleraceus	3.1
Lolium perenne	50	Avena sterilis	3.0

Table 4.10. Frequency and average cover of common weeds in faba bean fields NE of Aleppo (11 fields surveyed).

	Frequency (%)		Average cover (%)
Convolvulus arvensis	91	Orobanche crenata	3.2
Amaranthus blitoides	82	Sinapis arvensis	2.9
Descurainia sophia	82	Descurainia sophia	2.6
Phalaris brachystachyos	82	Coriandum sativum	2.4
Orobanche aegyptiaca	76	Melilotus indica	2.4
Avena sterilis	73	Fumaria asepala	2.0
Chenopodium vulvaria	73	Polygonum aviculare	2.0
Galium tricorne	73	Chenopodium vulvaria	1.9
Polygonum aviculare	73	Convolvulus arvensis	1.9
Orobanche crenata	71	Avena sterilis	1.8
Amaranthus retroflexus	64	Amaranthus blitoides	1.8
Chenopodium album	64	Phalaris brachystachyos	1.8
Sinapis arvensis	64	Triticum aestivum	1.5
Torilis leptophylla	64	Convolvulus althaecides	1.2
Coriandrum sativum	55	Amaranthus retroflexus	1.0
Cuscuta sp.	55	Diplotaxis erucoides	0.8
Euphorbia spp.	55	Euphorbia spp.	0.8
Melilotus indica	55	Orobanche aegyptiaca	0.8
Vaccaria pyramidata	55	Fumaria parviflora	0.7

All the surveyed fields were in the stage of ripeness, and had been irrigated and once or twice weeded.

Along the Euphrates river Orobanche was not found in the fields. Also the farmers mentioned Orobanche only as a common weed in tomatoe and/or potatoe but not in legume crops. Cuscuta was found in 6 of 21 fields (=30%). In the region northeast of Aleppo Orobanche crenata and O.aegyptiaca were found in 71 and 76% of the surveyed fields, respectively. Cuscuta spp. were present in 55% of the fields. The infestation level for these fields was 21% (0,5-100%) for Orobanche crenata and 3% (0,5-30%) for O. aegyptiaca.

The frequency value gives the percentage of samples in which the species concerned appeared. Frequency values > 50% were found for 10 species in the Euphrates valley, and for 19 species in northeastern Aleppo province. Most of the species with a high frequency value had also a high degree of coverage (Table 4.9 and 4.10).

It is worth noting that most of the fields were used by the farmers to collect the weeds as fodder for their animals. Fields which were already harvested were grazed by cows and horses, which indicates the importance of crop and weeds as a basis for fodder.

Drs. J. Sauerborn and M.C. Saxena

4.6. A Rapid Test to Screen Lentil (Lens culinaris Med.) under Laboratory Conditions for Susceptibility to Orobanche

Field screening for resistance (low emergence frequency) has been found very problematic due to several reasons. Non uniform distribution of Orobanche seeds in the field greatly reduces the effectiveness of selection. Changing environmental conditions from year to year make it

difficult to compare the results from several years.

Because of the problems caused by variability of soil infestation and the interference of environmental factors in the development of the parasite, a laboratory screening test was developed at ICARDA. Under standardized conditions large numbers of plants can be rapidly screened.

Lentil seeds grown in petridishes, filled with attapulgus clay between glass microfibre filterpaper, where Orobanche seeds are uniformly distributed next to the lid of the petridish. The method allows observations of Orobanche development during crop growth. After 35 days of incubation at 25/20 ^{o}C (day/night 12 hrs. light) the root system of the host plant can already be evaluated or Orobanche susceptibility by counting the Orobanche attachments. This test is now used to evaluate the lentil germplasm.

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5. STUDIES ON NEMATODES

Investigations on nematodes of chickpea and lentil were initiated in 1982 in cooperation with the Istituto di Nematologia Agraria - C.N.R., Bari, Italy. Soon it was realized that a cyst forming nematode Heterodera sp., the root-knot nematode Meloidogyne artiella, and the root lesion nematode Pratylenchus thornei were the most damaging nematodes frequently encountered in Northern Syria. Therefore, investigations have continued in 1985/1986 to identify the cyst nematode, to give more insight on the biology of this nematode and of M.artiellia, to estimate crop losses caused by infestation of the cyst nematode, to control P.thornei, and to search for chickpea lines or cultivars resistant to the root-knot nematode. Detailed report is separately available, hence only major highlights have been summarized here.

5.1. Description of New Species

Second stage juveniles, males, females, and cysts of the cyst nematode infecting chickpea in Syria were studied at Bari with the aid of both light and scanning electron microscopy and the morphometrics of the nematode when compared with those of closely related species revealed that the nematode is a new species. It has been described as Heterodera ciceri sp.n (Volvas, Greco and di Vito, 1985) and article published.

5.2. Development of H.ciceri and Meloidogyne artiellia on Chickpea

Second stage juveniles of Heterodera ciceri invaded roots of chickpea soon after plant emergence both in winter- and spring-sown plots. Females of the nematode were first observed on 19 March and on 10 April, for chickpea sown in winter and in spring, respectively, while

cysts were formed by 4 April and 16 April, respectively. Root knot nematode (M. artiellia) also invaded roots of chickpea in winter and females and egg masses of the nematode were observed by early and late March, respectively. Only one generation per year occurs for both nematode species. No diapause of M.artiellia eggs was observed and the nematode survives during dry and hot summer months both as eggs or juveniles; 20% of the nematode population at harvest still occur the following autumn.

5.3. Crop Loss Assessment with H. ciceri in Chickpea and Lentil

Chickpea tolerates populations of H. ciceri < 1 egg/cm^3 of soil, but yields are reduced by 50% or completely lost when populations of the nematode are 16 eggs/cm^3 of soil or exceedes 64 eggs/cm^3 soil, respectively (Figure 5.1). Lentil was less susceptible to H. ciceri with a tolerance limit of 2.5 eggs/cm^3 soil and maximum losses of 50% observed (Figure 5.1). The nematode reproduced better on chickpea than on lentil.

5.4. Chemical Control of Pratylenchus thornei on Chickpea

Two trials were conducted, one with winter-sown and the other with spring-sown chickpea ILC 482, to test the efficacy of Aldicarb in controlling the root lesion nematode (Pratylenchus thornei). Good control, as assessed by number of P. thornei extracted from roots and by the appearance of the roots, was obtained by using 10 kg a.i./ha of the chemical at sowing or in 2 splits (5 kg at sowing + 5 kg in early spring), or in 3 splits (5 kg at sowing + 2.5 kg in early spring + 2.5 kg in late spring). Yield differences due to treatments were significant only in the spring-sown trial where respective yields were

1.33, 1.62 and 1.52 t/ha for one, two- and three-split applications of Aldicarb as against 0.98 t/ha for untreated check.

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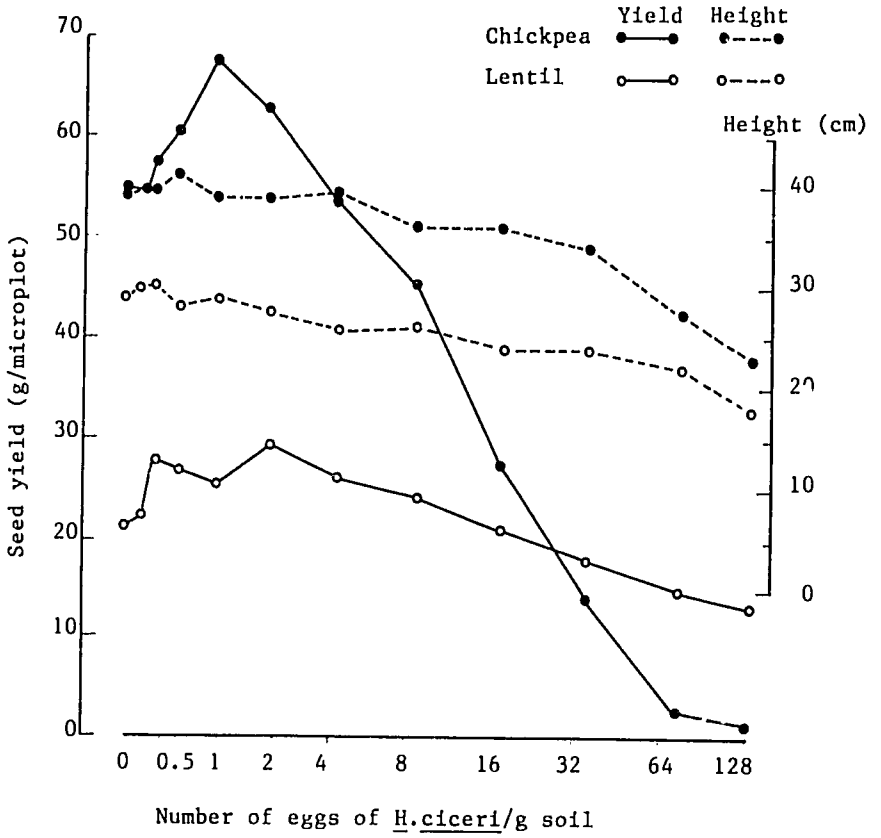

Figure 5.1. Effect of level of infestation of H.ciceri in soil on the plant height and seed yield of lentil (ILL 4401) and winter sown chickpea (ILC 482).

6. COLLABORATIVE PROJECTS

6.1. ICARDA/IFAD Nile Valley Project on Faba Bean

The 1985/86 season was the first year of the third phase of this project which now covers Ethiopia in addition to Egypt and Sudan. Research work had, as usual, a very heavy 'on-farm' emphasis with parts of resources and efforts devoted to the back-up research. In case of the program in Egypt and Sudan, there was increased interaction betweeen the project scientists and the extension workers in providing support to the production programs being executed in the areas falling in the recommendation domain of the ICARDA/IFAD Nile Valley Project (NVP).

6.1.1. Program in Egypt

6.1.1.1. Pilot Demonstration Plots in El-Minia and Fayoum

NVP scientists cooperated with the staff of the Agricultural Development Projects in El-Minia and Fayoum in extending to the farmers the faba bean production package developed in the NVP. In El-Minia, the demonstration plots occupied 297 ha involving 385 farmers in 94 villages across the nine districts. Yield estimates of demonstration farmers in contrast to those of farmers outside the demonstration showed an average increase of 420 kg/ha (12%) in seed yield and 510 kg/ha (9%) in straw yield. The recommended package included seed rate, fertilizer application, weed control, early sowing, use of Orobanche tolerant faba bean cultivar Giza 402, and aphid control. Farmers in demonstration area were provided, through village cooperatives on credit, the certified seed of Giza 402, fertilizers and Igran herbicide.

Besides the above demonstration plots, nearly the entire faba bean area (about 100 ha involving 197 farmers) in two villages - Kom Lofe (North Minia) and Derwa (South Minia) was also chosen for demonstration of the recommended package. Here the average seed yield increase was about 450 kg/ha (13.5%).

The average profitability (net benefit as % of total cost) was 77 and 66% respectively, for the 'demonstration' and 'outside the demonstration' farmers in the nine districts in El Minia. In the two 'whole village' demonstrations the profitability of the recommended package was 107% as against 82% for the traditional practices.

In Fayoum governorate five demonstrations were conducted, one each of about 2.1 ha in five districts. The average seed yield increase with the package was 0.79 t/ha (31.6%) and straw yield 1.40 t/ha (373%).

Associated studies revealed that poor seed bed preparation and inadequate soil coverage over the seed were responsible for poor productivity of faba bean in farmers fields. These aspects would be studied in detail in the coming season so that simple and economic methods are identified.

6.1.1.2. Pilot Demonstration of Orobanche Control in El-Minia and Kafr El-Sheikh Governorates

Five demonstration plots (1.5 ha each) in El-Minia and two in Kafr El-Sheikh governorate were laid-out by NVP researchers to show the importance of integrated control of Orobanche by using parasite tolerant cultivar Giza 402 and use of Lancer (glyphosate) at 179 cm^3 in 500 l water per hectare at flowering and a repeat of the spray 15 days later. Optimum levels of fertilizer and seed rate were used. Seed

yield increased by 1.79 t/ha (194.6%) and Orobanche dry-weight decreased by 63% with the recommended practices, in El-Minia. In Kafr El-Sheikh, the average increase in seed yield was 1.91 t/ha (96%) and reduction in Orobanche dry weight by 98.5%.

The profitability of the recommended package was 290% against 33% for farmers' own practice in El-Minia. In Kafr El-Sheikh, the respective profitability values were 149 and 42%.

Associated socio-economic studies on the management of Orobanche using this package by farmers themselves on 52.5 ha area in El-Minia revealed that shortage of sprayers, supplying small quantity of glyhposate from large containers and lack of even-spray may prove serious constraints to the use of glyphosate. A well planned and well organized program would be needed to disseminate the technique amongst farmers, who are convinced of its economic benefit.

6.1.1.3. Researcher-Managed On-farm Trials on Method of Sowing in El-Minia and Kafr El-Sheikh Governorates

Three trials were conducted in each of El-Minia and Kafr El-Sheikh governorates in which farmers method of sowing was compared with a test method involving use of rotavator to cover the broadcasted seed. The need arose because the farmers' method gave inadequate plant stand, in spite of optimum seeding rate, because of excessive soil coverage when chisel plough was used (in El-Minia) or inadequate seed coverage and high seeding costs when sown by dibbling in untilled soil (in Kafr El-Sheikh). Test method in El-Minia involving use of rotavator (instead of chisel ploughing) for seed-bed preparation, seed broadcast followed by rotavation again to cover seed gave 29.9% higher seed yield and 17.5% higher straw yield over the farmers' method. The overall profitibility was increased by 32.3% . In Kafr El-Sheikh the relative

increase was of smaller magnitude, 7.9% for seed yield and 9.9% for over-all profitability.

6.1.1.4. Back-up Research

Research was conducted in the field of agronomy, genetic improvement, pathology, entomology, microbiology, Orobanche control, soil fertility and plant nutrition, water management, mechanization and nutritional quality. Results are contained in the Proceedings of the VII Annual Coordination Meeting held at Addis Ababa, 23-27 Sept 1986. Hence only a few major findings have been presented here.

In a weed control study conducted at 5 sites covering the governorates of Kafr El-Sheikh and Fayoum Igran (terbutryne) at 2.5 kg a.i./ha or Gesagard (prometryne) at 2.5 kg a.i./ha as preemergence application proved more economic than hand weeding with marginal rates of return being Egyptian Lira 14.5, 10.2 and 6.3 per E.L. spent on the respective weed control treatments in Kafr El-Sheikh and E.L. 4.56, 9.48 and 0.88 in Fayoum.

In back-up research on breeding, performance of 9 breeding lines derived from a cross (Giza 3 x ILB 938) was evaluated for disease resistance (chocolate spot and rust) and yield. Line 461/845/83 ranked first in resistance to chocolate spot and sixth in resistance to rust with these rankings being significantly better than the disease reaction of Giza 3 and susceptible check Rebaya 40. At the same time, this line gave 51.4% higher yield than Giza 3. Seed of this line and other sister lines are being multiplied for wider testing before release, because of their high yield and chocolate spot resistance.

6.1.2. Program in Sudan

6.1.2.1. Pilot Production-cum-Demonstration Program in Sayal Agric. Scheme, in Northern Region.

A package of three recommended practices (early sowing, frequent irrigation and pest control) was demonstrated in a pilot demonstration-cum-production program conducted for the first time in Sayal agricultural scheme in the Northern Region, as had been previously done in the Aliab and Zeidab scheme areas. Ten plots, ranging in size from 2 to 4.6 ha, were selected to represent the two major sections of the Sayal scheme with a total of 50 farmers participating to cover an area of 29.4 ha. Yield from these plots was compared with the yields of the neighbouring farmers. Yield gains with the recommended package ranged from 454 kg to 1574 kg/ha (25.4% and 172.6% respectively). Economic evaluation indicated that adoption of the package was highly profitable with an average increase in net profit of Sudanese Pounds 2445/ha. These results are in confirmity with those obtained for Aliab and Zeidab schemes.

6.1.2.2. Pilot Production-cum-Demonstration Plots in the New Areas in Sudan

A high potential of faba bean cultivation in the new areas had been well demonstrated over a 3-year period in the yield maximization trials conducted at Gezira, Rahad and New Halfa research stations. In continuation of these efforts to extend faba bean cultivations to the new areas a total of ten farmers from Gezira, Rahad and New Halfa were helped to grow the crop each in an area of 0.42 ha following the production package developed in the NVP at the Gezira Research Station, Wad Medani. Average seed yields were 2030, 1234 and 981 kg/ha respectively at Gezira, Rahad and New Halfa. Economic analysis showed

that average net returns were Sudanese Pound 4325, 2114 and 1091/ha, respectively, which were higher than from several other crops that are commonly grown in these areas. It is clear, therefore, that expansion of faba bean cultivation in these new areas is possible and it can meet the need of a leguminous food crop in the rotations currently being practiced by the farmers.

6.1.2.3. On-farm Evaluation of Chemical Control of Bruchids and its Demonstration in the Nile Province

Work in the previous season had established the efficacy of store disinfection with insecticides and the value of subsequent seed fumigation with aluminium phosphide in controlling insect depredation of faba bean during storage in the Northern Province, in Selaim Besin. Two educational campaigns were carried out in Selaim to demonstrate to farmers the necessity of store hygiene. The acceptance was immense, the farmers participating in the campaign rose from 16 in the first year to 43 in the second. This year commercial store protection by extension workers in Selaim and an independent service agent served over 120 farmers and protected close to 1000 tons of faba beans in Selaim.

Following the above achievement, the evaluation and demonstration activities were taken up in the Nile Province during the 1985/86 season. On-farm evaluation of three chemicals - Folithion, Baythroid, and Satisfar, for store disinfection followed by fumigation using aluminum phosphide (Phostoxin) was done at Zeidab, Aliab and Shendi. Neighbouring stores were used for comparison of the benefit from the treatment. Results are shown in Table 6.1. The net benefit values represent the difference in faba bean prices between September (Sudanese Pound 2857/t) and harvest time (Sudanese Pound 2524/t) less costs of storage treatment. In the case of untreated stores the

September faba bean price was assumed to decrease proportional to the level of seed infestation by bruchids. The advantage of storage sanitation was convincingly demonstrated.

In another study, underground pit storage system was evaluated at Selaim and Hudeiba. Cost of underground pit storage per t of faba bean came to Sudanese Pound 49 in Selaim and Sudanese Pound 45 in Hudeiba. Based on these costs, the net benefit of storage in underground pits was compared with traditional storage practiced by the farmers in the two areas. The net-benefit from pitstorage exceeded that from traditional storage by Sudanese Pound 542/t in Selaim and Sudanese Pound 870/t in Hudeiba, because in the pit storage there was no infestation whereas in the traditional storage the level of infestation was 17.25% in Selaim and 32.35% in Hudeiba. Farmers traditionally store their produce in jute bags stacked on the ground.

Improvement in sack storage was also evaluated. Jute bags when lined with 30 gauge polyethylene and produce fumigated with Postoxin before closing the bags resulted in a net benefit of Sudanese Pound 266/t in contrast to a net loss of Sudanese Pound 359/t when storage was done in jute bags because the seed infestation by bruchids was 22.8% in the latter as compared to nearly no infestation in the farmer treatment. The cost of the treatment was about Sudanese Pound 55 per t of faba bean.

These studies have demonstrated the significance of simple storage practices that can result in significant improvement in economics of faba bean production to the farmers in the Nile Province.

Table 6.1. On-farm evaluation of chemical control of bruchids in the Nile Province, 1985/86. All costs and benefits (bn.) are in Sudanese Pounds per ton of faba bean.

Treatment and location	Treated store			Untreated neighb. stores			Diff. in net bn.
	Gross bn.	Treat. cost	Net bn.	% infest.	Expected price	Net bn.	
Folithion (Zeidab)	333	15	318	11.25	2538	12	306
Folithion (Aliab)	333	15	318	18.50	2329	-195	513
Folithion (Shendi)	333	15	318	9.75	2578	54	264
Baythroid (Aliab)	333	11	322	21.50	2243	-281	603
Satisfar (Shendi)	333	15	318	14.33	2448	-76	394
Satisfar (Aliab)	333	15	318	7.25	2650	126	192
Mean			319			-60	379

6.1.2.4. Farmer-managed On-farm Trials in Northern Region

The package of improved production pratices that was developed earlier was evaluated in new sites in the Nile and Northern Province this year. There were 8 sites in Hagar Al Asal, 8 in Basabeir and 4 in Sayal in Nile Province and 6 sites in Selaim and 7 in Burgeig in Northern Province. The improved package of management consisted of early planting, frequent irrigation and pest control. At Selaim and Burgeig weed control was also included. Grain yield increases of 1065, 1553, 832 and 305 kg/ha with improved package over the traditional farmers practice were obtained at Hegar El Asal, Basabeir, Sayal and Selaim, respectively; the increases being significant and economic. Sensitivity analysis indicated the stable nature of the profitability.

Grain yield response to improved package at Burgeig was not significant because of increased bird damage to flowers in the early-sown crop.

6.1.2.5. Survey of Faba Bean Marketing in Sudan

A survey of faba bean marketing channels in Sudan was carried out in 1985 covering main production areas in northern Sudan and main urban consumption areas-Atbara, Khartoum and Medani. The objectives were to identify the channels of marketing, calculate the marketing costs and margins for different agents in the system, to estimate capacity, costs and losses in storage at various levels and to determine the potential for increasing faba bean farmers' income through establishing marketing cooperatives. The results of this study form the M.Sc. thesis of Mr. Fuad S. Yousif of the University of Gezira, Sudan. The study highlights the small share that farmer currently gets from the price paid by consumer for faba bean. It is suggested that storage of produce at farm level would increase this share. Alternatively, forming a marketing cooperative by the faba bean farmers could also improve farmers' profit.

6.1.2.6. Back-up Research

Back-up research covering different disciplines was carried out with particular emphasis on faba bean improvement for new areas in Sudan south of Khartoum. Progress was made in identifying superior genotypes, irrigation practices, insect control and weed control. Mechanization of seeding and harvesting was also investigated and available machines modified for faba bean.

6.1.3. Studies in Ethiopia

6.1.3.1. Survey of Major Faba Bean Producing Areas in Central Zone of Ethiopia

An exploratory survey of the major faba bean producing areas in the central zone of Ethiopia was conducted to identify and prioritize major faba bean production problems so that future research may focus on them. A total of 100 farmers were interviewed in Menagesha, Selale and Yerer - Kereyu zones of Shoa Province. This province accounts for 60.7% of total faba bean area and 37.4% of total production in the country. As perceived by sample farmers, the major limiting factors in faba bean production were diseases and pests, namely, chocolate spot, rust, African ballworm and aphids. Beacuse of high instability in the yield, farmers did not use much input. They, however, recognized the value of the crop in their crop rotation.

6.1.3.2. Evaluation of Faba Bean Production Package on Farmers Field

On-farm trials were conducted at five sites each in Ada district in Yerer-Keryu zone (1950 to 2000m elevation) and Wolmera district in Menagesha zone (2300 to 2500m elevation). It was planned to test seven factors of production at 'improved' and 'farmers' level in a set of nine treatment combinations. One of the treatment combinations had all the factors at 'improved level' and another all at 'farmers level'

In Ada district the mean seed yield with all factors at 'improved level' was 2193 kg/ha as against 1369 kg/ha obtained from the treatment combination with all factors at 'farmers level' Further analysis of the treatment combinations revealed that improved variety (Kasa), application of fertilizer (100 kg/ha diammonium phosphate) and

mechanical weeding (at 30 and 45 days after sowing) were the main factors causing the improvement in yield. Early sowing also proved beneficial.

In Wolmera district only three treatment combinations were tested because of limitation of technical man-power. The yield levels were lower there than in Ada district. As an average of five sites, the seed yield with 'improved' package was 1.4 t/ha as against 0.7 t/ha with the 'farmers' practice.

It is proposed to test only four factors namely date of sowing, variety, fertilizer and weed control in the 1986 season.

6.1.3.3. Back-up Research

As in Egypt and Sudan, back-up research was carried out in Ethiopia in the field of germplasm evaluation and improvement, diseases and insect control, microbiology and nutritional quality. Details are given in the Proceedings of the VII Coordination Meeting of the NVP.

Germplasm evaluation is done at Bekoji, Debre Zeit and Denbi research stations of the accessions maintained by the Plant Genetic Resources Center of Ethiopia (PGRC), and some 349 accessions have been evaluated in the past. During 1985, 492 faba bean introductions from ICARDA were evaluated at Holetta Research Center, and 479 individual plants selected on the basis of good pod-bearing habit, disease tolerance and lodging resistance.

Possibility of growing an off-season nursery of faba bean at Holetta Research Center was explored, by planting the crop in mid January 1986. Prolonged unusually high rainy period from March to early June extended the growing season and delayed maturity. This will

have to be further explored in the coming season.

In order to identify high yielding faba bean varieties, National Variety Trial (NVT) and a Preliminary National Variety Trial (PNVT) were conducted at several locations. Six entries (Coll 2/77, -165/77, -47/78, 289/77 and PGRC/E027141) out yielded standard check (CS 20 DK) by a margin of 200 kg seed or more. Based on the results of 3 years of testing of entries in NVT five entries have been identified (Coll 1/77, -2/77, -47/77, -111/77 and KS 20/78) for verification trials so that one or more of them could be released.

Screening of 69 local and exotic germplasm for resistance to chocolate spot at Kulumsa and Ambo stations revealed that only four lines (PGRC/E -27113, -27296, New Mammoth, PGRC/E -27113) were tolerant, remaining being moderately to highly susceptible. Screening for rust resistance at Denbi station led to the identification of two entries (Coll 1/78 and 78-S-49892) as tolerant. In 1986, ICARDA's International Disease Nurseries have been evaluated and several lines have shown promise.

A survey of insect pests associated with faba bean revealed that African Ballworm (Heliothis armigera Hb.) was the most important field pest. In storage, Collosobruchus chinensis L. and C. masculatus F. were major pests, the former being of particular economic significance. In an experiment to control this pest, use of 2ml of vegetable oil per kg seed was found to be as effective as seed treatment with chemicals Pirimiphosmethyl, Lindane, Folithion and Danfin. Untreated seeds showed 92.7% damage at the end of nine months of storage under artificial infection with bruchids whereas with the treated seed the damage was less than 1%.

6.2. International Testing Program

The main thrust of the international testing program continued to be the identification of superior genotypes with resistance to diseases and insect pests, and other stresses, and acceptable seed quality, and the development of an optimum package of practices for food legumes for different environments. The nurseries were further diversified as per the feed-back from national programs. To satisfy the demand for mechanical harvesting of chickpea in the Mediterranean region, a regional yield trial of tall lines was formulated (CIYT-W-MR-T) and supplied for the first time for winter sowing. Another chickpea nursery to identify the stable sources of tolerance to cold was developed and distributed to locations which experience severe cold during winter. Similarly for the cooperators from the countries in the southern latitudes a special Faba Bean Regional Yield Trial (FBRYT-SL) was developed and distributed. As sufficient information has been generated from the dates of planting-cum-population trials these have been terminated effective 1986.

For the 1986/87 season, we supplid 1209 sets of 36 different nurseries and trials to 140 cooperators in 52 countries. Despite furnishing such a large number of nurseries, we could meet only 85% of the total requests received.

Some of the national programs namely Algeria, Turkey, Tunisia, Morocco, Sultanate of Oman, Lebanon and Egypt demanded large quantities of seeds of the superior lines identified from the ICARDA supplied materials for final evaluations or for varietal release. Wherever possible the demand was met to help the national programs to transfer their results to farmer's fields quickly.

Two new varieties in chickpeas, namely ILC 3279 and FLIP 83-46C and two in lentils, namley ILL 4400, and ILL 4604, were identified from the food legume international nurseries by the Tunisian national

program for general cultivation in Tunisia. Similarly ILC 482 (Ghab 1) and ILC 3279 (Ghab 2), the two varieties identified by the Syrian national program, have been released for general cultivation in Syria.

To study the adaptation of faba bean lines in the Faba bean International Yield Trial-Large seed (FBIYT-L-84) and Faba bean International Yield Trial-Small seed (FBIYT-S-84) the phenotypic stability analysis based on Eberhart and Russel (1966) model was done. Four characters (seed yield, plant height, days to flowering and days to maturity) were analysed. In both the trials significant differences among entry means and locations were observed for all the characters. G x E interactions were present for all characters. The partitioning of G x E interaction showed that both linear and non-linear portions were significant and important for seed yield with a preponderance of linear portion. Thus using linear regression, only seed yield was predictable under the differing environmental conditions. Five entries each, 'Aquadulce', 'Seville giant', 76TA 56246, 79SL 48590, and 74TA 22 from FBIYT-L-84, and FLIP 83-1F, FLIP 83-7F, 78S 49228, 80S 44371 and 78S 48476 from FBIYT-S-84 were most stable.

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6.3. ICARDA TUNISIA COOPERATIVE PROJECT

In the cooperative project between ICARDA and the Institut National de la Recherche Agronomique de Tunisia (INRAT), Tunisian and ICARDA food legume scientists identified superior genotypes and production techniques for all three food legumes. In addition to backup support from staff at the headquarters in Aleppo, ICARDA-sponsored consultants visited the program during the season. Disease work was conducted jointly with the Institut National de l'Agronomique (INAT) while field

verification of important findings was done in cooperation with Office des Cereales. The main climatic feature of the 1985/86 season was drought which affected both breeding and agronomic results.

6.3.1. Faba Bean Breeding Program

Emphasis on faba bean breeding was on selecting high yielding genotpypes and identifying durable resistance to common pests namely Botrytis fabae, Ascochyta fabae, Orobanche spp. and stem nematode (Ditylenchus dipsacis).

6.3.1.1. Development of High Yielding Cultivars

In spite of evaluating 277 entries in international, advanced, and preliminary yield trials, only a few entries exceeded the local check significantly (Table 6.3.1). Of the superior genotypes identified, PAM-1 from Italy and Paleolo from Spain yielded 35% and 39% more than the local check, respectively. ICARDA selections 80S-43856, 80S-43238 and FLIP 83-106FB outyielded the local check at Beja by 31%, 33% and 40%, respectively. The relatively poor performance of F_4 and F_5 population trials was disappointing and might be attributed to the limited adaptation of the exotic parents. However, the adaptation problem is expected to be solved through the single plant selections made from 841 rows (1 m each) of F_2 populations which originated from 19 crosses involving local landraces. These selections were made on the basis of large pods, prolific yield and autofertility. In addition, out of 1100 entries evaluated in unreplicated nurseries, 255 yielded numerically higher than local checks and these will be in replicated preliminary yield trials next season.

Table 6.3.1. Performance of faba bean in trials at various locations and seed yield of superior entries in kg/ha and as percentage of local check at Beja, 1985/86.

No. of trials and locations	No. per type and per location	No. of tested entries	No. of entries exceeding local check	No. of entries exceeding local check significantly	Performance of superior entries at Beja: Trials and entries	Yield (kg/ha)	% of local check
International (IYT)	4	81			EJW-EEC		
-Beja	4	81	27	4	Brocal	3306	128
					VT-1	3332	129
					PAM-1	3487	135
					Paleolo	3590	139
					Local check	2583	100
					S.E.	441.7	
					C.V.(%)	16.6	
Advanced (AYT)	9	141			FBAYT-S2		
-Beja	9	141	60	3	FLIP82-19FB	3669	109
-Kef	8	127	65	1	80S-43977	3719	110
-Oued Meliz	3	54	34	0	80S-44358	3763	111
-Ras Rajel	1	8	3	0	Local check	3382	100
					S.E.	419.1	
					C.V.(%)	14.2	
Preliminary (PYT)	3	55			FBPYT-S2		
-Beja	3	55	27	6	ILB 2858	3090	119
-Kef	1	22	11	0	80S-43859	3116	120
					FLIP83-114FB	3142	121
					80S-43856	3402	131
					80S-43238	3454	133
					FLIP83-106FB	3636	140
					Local check	2597	100
					S.E.	324	
					C.V.(%)	11.2	

6.3.1.2. Screening for Resistance to Major Pests

In screening for tolerance to Orobanche spp. no striking results were obtained, although clear variation was observed in number of Orobanche per plant and adaptation (Table 6.3.2). It was apparent that there was no relationship between yield and tolerance levels to Orobanche. BPL 2062 seemed promising in both tolerance level and yield (Table 6.3.2).

Screening for resistance to Botrytis fabae was done under artificial epiphytotic conditions in a plastic tunnel. The susceptible check had a score of 6.2 in a 1 to 9 scale while most of the introduced germplasm in FBICSN showed a resistant reaction. More virulent strains of the pathogen will be used in the future.

Artificial epiphytotic for Ascochyta fabae could not be developed effectively probably due to high temperature. Thus screening for resistance was not possible. Next season, greater emphasis will be on solving problems in developing effective epiphytotics.

Stem nematode screening was done under natural infestation at Krib. Because of drought, the infestation level was low, non-uniform and rather late thus results were inconclusive. However, ratings of 51 locals averaged 4.3 on 1 to 9 scale (1 resistant and 9 highly susceptible) while 110 of the tested entries were rated 3 or less. Future screening will be done under controlled conditions as well.

6.3.2. Chickpea Breeding Program

The chickpea program is divided in two major sub-programs, winter and spring chickpeas. Emphasis on winter types was increased with the aim of developing chickpea types suitable both for winter and spring sowing. All trials of winter chickpeas were grown in 4 locations:

Beja, Kef, Oued Meliz and Ras Rajel. Spring chickpea trials were evaluated in 1 to 4 locations including Bou Salem. As expected because of stand problem, spring chickpea trials had generally higher C.V. values than winter chickpeas. The superiority of winter chickpeas over spring chickpeas was again confirmed. With 4 varieties averaged over 4 locations, winter planting outyielded spring planting by more than 250%.

Table 6.3.2. Seed yield and number of Orobanche spikes per plant of some faba bean test entries in FBION-86.

Entry	No. of Orobanche/plant	Yield(kg/ha)
Giza 402	0.43	250
BPL 2062	0.45	733
Syrian Local Large	1.90	900
Tunisian Local (x)	2.09	667

6.3.2.1. Development of High Yielding Winter Chickpeas

In winter sown chickpeas, Ascochyta blight was serious and thus about 97% of the tested entries of international trials exceeded the susceptible local check in yield and about 73% of those entries were significantly superior (Table 6.3.3). In Advanced Yield Trials at Beja, these values were 76% and 36% in the same order. However, ascochyta blight did not develop at Oued Meliz and only 14 lines were significantly better yielders than the local check in international trials; none was significantly superior in Advanced Yield Trials.

Of particular interest in CIYT-MR-86 were FLIP 82-128C and FLIP 83-47C which outyielded the local check by 83% and 74% respectively, at Beja and by 20% and 9% at Oued Meliz in the same order. In CIYT-STR-86, 5 entries (FLIP 82-150C, FLIP 82-239C, FLIP 83-22C, FLIP 83-50C and ILC 482) exceeded the best local check by 11% and the average of local checks at Oued Meliz by 32% to 49%. To identify dual purpose (winter and spring) types, CIYT-SP-86 was grown in winter and 3 entries (FLIP 83-26C, FLIP 83-26C, FLIP 83-53C and ILC 482) did equally well in Beja and Oued Meliz where yield increases over the local checks averaged 21%, 28%, and 28%, respectively.

In each of the 5 Advanced Yield Trials a number of lines were significantly better yielders than the local check (Table 6.3.3). In CAYT-W-E, 7 lines (FLIP 81-79C, FLIP 81-312C, FLIP 83-13C, FLIP 83-46C, FLIP 83-60C, FLIP 83-100C and ILC 482) outyielded the check by 33% to 49% at Beja. Of particular interest in CAYT-W1, were FLIP 81-003 and ILC 484 each of which yielded 2.9 t/ha compared to 1.99 t/ha for Ascochyta - protected local and 1.40 t/ha for unprotected locals. In CAYT-W3, FLIP 82-239C and ILC 482 outyielded the average of local checks (1.8 t/ha) by 12%. In CAYT-W4, 13 entries significantly exceeded the local checks with yield increases between 20-30%.

Unreplicated international nurseries evaluated 113 introductions out of which 89 at Beja, 31 at Kef and 7 at Oued Meliz outyielded the local checks.

6.3.2.2. Development of High Yielding Spring Chickpeas

In spring sown chickpeas no heavy disease infestation was observed. Contrary to winter chickpeas, only a few lines were significantly better yielders than the local Amdoun (Table 6.3.4). Of particular interest are ILC 116, ILC 135 and ILC 2587 which exceed the local check (0.76 t/ha) by 66% to 84%. In advanced yield trials, Amdoun selections

Table 6.3.3. Performance of winter chickpea in trials at various locations and seed yield in kg/ha and as percentage of local checks at Beja and Oued Malez, 1985/86.

Type of trials and locations	No. of trials	No. of tested entries	No. of entries exceeding local check	No. of entries exceeding local check significantly	Performance of superior entries at Beja and Oued meliz[1]				
					Trials and entries	Beja		Oued Meliz[1]	
						Yield(kg/ha)	%of local(x)	Yield(kg/ha)	%of local(x)
International (IYT)	3	69			CIYT-MR				
					FLIP82-128C	2213	184	2461	120
-Beja	3	69	67	49	FLIP83-47C	2188	132	2850	139
					Local check	1204	100	2047	100
-Kef	3	69	10	1	S.E.	313		286	
-Oued Meliz	3	69	49	14	C.V.(%)	15.2		16.6	
-Ras Rajel	3	69	24	7	CIYT-STR				
					FLIP82-150c	2612	193	3712	149
					FLIP82-239C	2363	175	3300	132
					FLIP83-22C	2487	184	3328	133
					FLIP83-50C	2087	154	3395	136
					ILC 482	2668	197	3457	139
					Local check	1352	100	2495	100
					S.E.	356		398	
					C.V. (%)	16.9		18.2	
Advanced (AYT)	5	107			CAYT-W-E				
-Beja	5	107	81	29	FLIP81-79C	2367	133	2803	108
					FLIP81-312C	2650	149	3031	117
-Kef	5	107	12	0	FLIP83-13C	2387	134	3137	121
					FLIP83-46C	2388	134	2709	105
-Oued Meliz	5	107	61	0	FLIP83-60C	2506	141	2621	101
					FLIP83-100C	2425	136	2718	105
-Ras Rajel	5	107	65	32	ILC 482	2593	146	2509	97
					Local check	1782		2589	
					S.E.	378		533	
					C.V.(%)	18.1		19.9	

Table 6.3.3. (cont'd.)

Type of trials and locations	No. of trials	No. of tested entries	No. of entries exceeding local check	No. of entries exceeding local check significantly	Performance of superior entries at Beja and Oued meliz[1]			
					Trials and entries	Beja Yield(kg/ha)	Beja %of local(x)	Oued Meliz[1] Yield(kg/ha)	Oued Meliz[1] %of local(x)
Advanced (continued)					CAYT-W1				
					FLIP81-003	2983	172	2020	102
					FLIP81-004	2800	161	2168	109
					FLIP81-068	2675	154	2208	111
					Protected local[2]	1995		2112	
					Unprotected local[2]	1483		1867	
					Local mean (x)	1739		1987	
					S.E.	450		248	
					C.V.(%)	22.2		16.0	
					CAYT-W2				
					FLIP82-34W	2587	130	1950	69
					FLIP82-87C	2762	138	2904	103
					ILC 482	2102	105	[illegible]	106
					Local check	1995		[illegible]	
					S.E.	384		370	
					C.V.(%)	18.8		14.0	
					CAYT-W3				
					FLIP81-144C	2363	131	2493	107
					FLIP82-239C	2325	129	2537	109
					ILC 482	2319	129	3227	139
					Local check	1801		2324	
					S.E.	335		902	
					C.V.(%)	17.2		31.5	

1. Ascochyta did not develop
2. Against Ascochyta blight

(in CAYT-SP1) outyielded Local Amdoun significantly by 35% to 45% at Beja (selections Se-Be-11, Se-Be-119 and Se-Be-120) and by 15% to 25% at Ben Salem (selections Se-Be-107 and Se-Be-122). In addition, these selections have large seed with complete resistance to Fusarium and Verticilium wilt which cause very serious yield losses. In CAYT-SP3, ILC 263 and Se-Be-FTA 29 (Fusarium tolerant Amdoun, FTA, selections) outyielded local Amdoun by 52% and 65%, respectively, at Beja and by 33% and 29% at Oued Meliz. ILC 482 which was also used as a check in spring trials performed poorly at Beja and Ban Salem but fairly good at Oued Meliz (Table 6.3.4).

6.3.2.3. Screening for Disease Resistance

Two major diseases of chickpeas in Tunisia are ascochyta blight and wilt complex. Yield losses can reach 100% when a susceptible cultivar is grown in an infested field. Thus the major objective is to identify resistant germplasm for utilization in the breeding program with the ultimate aim to develop high yielding cultivars combining resistance for both pathogens.

All advanced yield trials and CISN were screened for ascochyta blight under field and laboratory conditions. Disease epiphytotic was developed by artificial inoculation. In the laboratory, screening was done at the seedling stage under controlled conditions using a mixutre of 3 isolates from Beja, Kef and Mateur. Field ratings were generally higher than those of the laboratory. One MSc. thesis project on the genetics of resistance to Ascochyta was presented at INAT. Details on Ascochyta work will be included in the annual report of ICARDA-Tunisia Cooperative Project.

In the wilt complex, both Fusarium oxysporum and Verticillium alboatrum are very serious pathogens of chickpeas. In a field survey, the

frequency of V. alboatrum was about 61% diseased plants of spring chickpeas over the last 3 years. At Beja wilt-sick-plot, where screening is done for both pathogens simultaneously, a total of 1231 entries were screened in 26 trials and/or nurseries. A high level of resistance was shown in 178 lines giving 0-20% incidence (Table 6.3.5). The line FLIP 83-60C of CIABN-A was resistant to the wilt complex and at the same time had 5.9 rating (tolerant) for ascochyta blight. Results from ICRISAT wilt disease nursery indicated the possibility of having a different race in Tunisia than that identified in ICRISAT. However, this needs to be confirmed using a set of differential hosts in a pot experiment.

6.3.2.4. Variety Release

Three improved chickpea genotypes proved to be superior over several years of testing and thus were identified for release to farmers:

i. 'Be-Se-48' is a wilt resistant cultivar recommended for spring sowing. In 1985/86, it outyielded the local check by 25% and 14% at Beja and Ban Salem, respectively. Yield increases of more than 20% were obtained in previous seasons. Seed size is large (49 g/100 seed compared to 44 g/100 seed for local Amdoun). Be-Se-48 is completely resistant to wilt but highly susceptible to ascochyta blight, and therefore is strictly recommended for spring sowing.

ii. 'FLIP 83-46C' is recommended for winter sowing, being fairly resistant to ascochyta blight and a good yielder. On a 1 to 9 scale for resistance scoring, it was rated 3.75 and 2.6 under field and laboratory conditions, respectively, when using a mixture of isolates. In the 1985/86 season it outyielded the local by 11% at 2 locations while in previous seasons yield increases were more than 20%. Seed size is medium (32 g/100 seeds).

Table 6.3.4. Performance of spring chickpea in trials at various locations, with seed yield of superior entries in kg/ha and as percentage of local Amdoun at 3 locations, 1985/86.

Type of trials and locations	No. of trials	No. of tested entries	No. of entries exceeding local check	No. of entries exceeding local check significantly	Performance of superior entries at 3 locations						
					Trials and entries	Beja		Oued Meliz		Bou Salem	
						kg/ha	%of local	kg/ha	%of local	kg/ha	%of local
International (IYT)											
-Beja	2	39	21	3	LIYT-L						
					ILC 116	1269	166	925	89		
-Kef	1	23	6	NA[1]	ILC 135	1338	175	853	82		
					ILC 2587	1417	185	945	90		
-Oued Meliz	1	23	16	1	ILC 482[2]	450	59	185	181		
					Local Amdoun	764		1046			
-Ras Rajel	1	23	18	0	S.E.	311		358			
					C.V.(%)	32.8		29.3			
Advanced (AYT)					CAYT-SP1						
-Beja	6	129	78	5	Se-Be-11	1675	140	1578	116	1000	115
					Se-Be-48	1500	125	1921	141	987	113
-KEF	3	69	34	NA	Se-Be-107	1458	123	1515	111	1083	125
					Se-Be-119	1738	145	1781	131	856	98
-Oued Meliz	4	78	41	0	Se-Be-120	1625	135	1593	117	931	107
					Se-Be-122	1306	109	1421	104	893	103
-Ras Rajel	3	69	25	9	ILC 482[2]	612	51	1750	128	887	102
					Local Amdoun	1200		1364		871	
-Bou Salem	1	23	16	2	S.E.	265		362		130	
					C.V.(%)	20.9		22.0		13.9	
					CAYT-Sp[3]						
					ILC 263	1438	152	1918	133		
					Se-Be-FIA-29	1563	165	1862	129		
					ILC 482[2]	756	80	1421	98		
					Local Amdoun	947		1445			
					S.E.	395					
					C.V. (%)	36.1					

1. NA: not analysed due to a large number of missing plots.
2. ILC 482 used as a check also.

Table 6.3.5. Summary of wilt screening at Beja wilt sick plot during 85/86 season.

Trial	Total number of lines	Number of lines/wilt incidence		
		0-20%	21-50%	51-100%
ICARDA Nurs.	512	76	58	378
ICRRWN	51	49	1	1
CAYT-E-W	27	0	2	25
CAYT-W1	25	0	1	24
CAYT-W2	25	0	6	19
CAYT-W3	25	0	1	24
CAYT-W4	25	0	0	25
CIYT-W-MR	24	0	0	24
CIYT-W-STR	24	0	1	23
CIYT-Sp	24	0	3	21
CISN-W	53	4	6	43
CISN-Sp	40	3	4	32
CISN-W 85	16	0	3	13
CISN-Sp 85	14	0	4	10
CIABN. A	41	1	0	39
CIABN-B	51	0	0	51
CILMN	26	0	4	22
CAYT-Sp1	23	12	5	6
CAYT-Sp2	23	0	3	20
CAYT-Sp3	21	2	6	13
CAYT-Sp4	22	18	3	1
CIYT-L	24	0	2	22
F6	44	12	0	32
F5	17	0	0	17
F4	21	1	5	15
PF/Hors prog.	33	0	1	32
Total	1231	178	119	932

iii. 'ILC 3279' is recommended for winter sowing. It is tall (suitable for mechanical harvesting), and fairly resistant to Ascochyta blight (3.5 to 5.0 field ratings and 2.3 laboratory rating). It yielded consistently as much as the local check under disease-free conditions but the local is 100% susceptible to Ascochyta. Being relatively small seeded (30 g/100 seeds), it is recommended for usage in pastry and coffee blending. Since it showed 100% kill for wilt disease complex, it is strictly recommended for wilt-free areas.

6.3.3. Lentil Breeding Program

The main objective in lentil breeding is to develop genotypes with high yield, good adaptation, and tall erect growth habit to facilitate harvesting.

6.3.3.1. Development of High Yielding Cultivars

A total of 245 entries including early and advanced segregating populations were evaluated in international, advanced, and preliminary yield trials. Though several entries outyielded the local checks numerically at all locations, only 3 genotypes at Beja, one at Oued Meliz, and 50 at Kef were significantly superior in yield (Table 6.3.6). Since results from Kef were considered with reservation due to soil heterogeneity and excessive drought (200 mm poorly distributed), only 1.1% of the tested entries were significantly superior. The main reason for such poor performance is the narrow adaptation of lentils. To overcome this adaptation problem, more local landraces need to be included in the hybridization program with 3-way crosses involving these landraces as recurrent parents. The few superior entries showed considerable yield advantages over the local checks (Table 6.3.6), but this superiority was not consistent over locations. No erect types

were identified and the four semi-erect entries identified had lodging and relatively low yield.

In international trials, though only one entry (ILL 5728) was significantly superior at Oued Meliz, a few entries showed a wide adaptation and yielded slightly more than the local checks at two or more locations (Table 6.3.6).

Of particular interest in advanced yield trials were the entries FLIP 114 L and FLIP 8456 L, which yielded 32% and 36% respectively, more than the check at Beja. The same lines were better yielders than the local check by 11% at Oued Meliz. ILL 4606 and FLIP 84-84L were superior in yield across locations, indicating a wide range of adaptation.

In preliminary yield trials, FLIP 84-43L yielded 20% and 49% more than the local checks at Beja and Kef, respectively. In addition to yield trials, 4 non-replicated nurseries having 252 different entries were evaluated in 4 locations. A total of 108 entries outyielded the local checks at various locations. Superior lines will be evaluated in preliminary yield trials next season.

6.3.3.2. Variety Release

Two lentil genotypes were recommended for release after showing good and consistent performance over several seasons. The first is ILL 4606 which originated from Nablus. It is small seeded (*Microsperma* type) with 4.46 g/100-seed weight. It has been a consistently better yielder than the local Oueslatia. In 1985/86, it was superior at 3 locations with 14%, 24%, and 5% more yield than the local at Beja, Kef, and Oued Meliz, respectively. In the previous 3 seasons, these differences averaged 8%. ILL 4606 has no major disease problem though is

Table 6.3.6. Performance of lentil in yield trials at various locations and seed yield of superior entries at Beja and Oued Meliz. 1985/86.

Type of trials and locations	No. of trials	No. of tested entries	No. of entries exceeding local check	No. of entries exceeding local check significantly	Seed yield (kg/ha) of superior entries at Beja and Oued Meliz					
					Trial and entry	Location Beja	Location Oued Meliz	Trial and entry	Location Beja	Location Oued Meliz
International (IYT)										
-Beja	3	69	15	0	LIYT-L			LIYT-S		
					ILL5666	2525	1977	ILL1939	2575	2246
					ILL5582	2-74	2300	ILL5728	2501	2269
-Kef	3	69	36	11	Local check	2216	[illegible]	ILL5729	2469	2125
					S.E.	197	[illegible]	Local check	2316	2100
-Oued meliz	2	46	6	1	C.V.(%)	9.0	[illegible]	S.E.	288	361
								C.V.(%)	14.2	20.8
Advanced (AYT)										
-Beja	4		31	2	LIYT-L1			LAYT-L3		
					ILL4606	2038	1846	FLIP114L	2156	2240
-Kef	4	88	39	25	Local check	1718	1757	FLIP8456L	2237	2068
					S.E.	281	336	Local check	1634	2407
-Oued Meliz	4	88	11	0	C.V.(%)	16.2	22.9	S.E.	360	323
								C.V.(%)	20.8	20.0
					LAYT-L2					
					FLIP84-84L	2343	2290			
					Local check	2105	2167			
					S.E.	317	544			
					C.V.(%)	16.4	28.3			
Preliminary (PYT)										
-Beja	4	88	40	1	LPYT-L2			LPYT-L4		
					FLIP84-45L	2250		FLIP84-43L	2016	
-Kef	4	88	31	14	Local check	1673		Local check	1617	
					S.E.	277		S.E.	288	
					C.V.(%)	16.0		C.V.(%)	18.2	
					LPYT-L3					
					FLIP84-42L	1881				
					Local check	1584				
					S.E.	271				
					C.V.(%)	17.9				

susceptible to lodging. Seed color is light olive green which is appealing to local consumers.

The second variety is ILL 4400 which originated in Syria. It is large seeded (Macrosperma type) with seed size of 5.93 g/100 seeds compared to 5.67 g/100 seeds for local large. The yield of ILL 4400 was consistent over years and outyielded the local by 4% on the average. Altough the yield advantages of either of the two released varieties is not high, their release will increase the genetic diversity of lentil cultivars grown in Tunisia and thus reduce hazards of genetic vulnerability.

6.3.4. Agronomic Practices

Studies on cultural practices were done at 4 locations: Beja, Oued Meliz, Kef, and Ben Salem. These included date of sowing, population density, and weed competition, and control in all three food legumes as well as winter vs. spring sowing test on chickpeas.

6.3.4.1. Date of Sowing x Population Density

Results of 1985/86 for both date of sowing and population density were generally in agreement with those of previous years. The first 4 planting dates, staggered about 15 days between October 15 to December 1, had no significant effect on the yield of faba beans and lentils at 3 locations under dryland conditions. Delayed rain contributed at least in part to these results. The fifth date at mid-December was rather late in both crops, and more so in faba bean large where yield was reduced by 50% at Beja. Results under supplementary irrigation (5 irrigations totalling 170 mm) at Oued Meliz showed a similar trend. Averaged over 4 population densities, faba bean yield ranged between

3.0 t/ha to 3.5 t/ha for the first 4 dates while the fifth date yielded 2.9 t/ha. In spring chickpeas, planting dates between January 30 and March 4 gave similar yields even under supplementary irrigation (3 irrigations totalling 100 mm) at Oued Meliz. Sowing dates of March 17 and April 1 reduced yield by 73% and 76%, respectively, compared to early sowing at Beja. At Oued Meliz, March 21 and April 10 sowings reduced yield by 35% and 48%, respectively.

Results on plant population indicated that the three food legumes responded positively to increased population density even under low rainfall conditions. However, yield differences were not as striking as those of previous years with more effective rainfall. Under dryland conditions at Beja and Kef, yield increases due to high population density were 20% and 50% in lentils, 74% and 239% in faba bean small, and 64% and 93% in faba bean large, respectively. The increase was 36% in spring chickpeas at Beja. At Oued Meliz, with supplementary irrigation, the response to high planting density was of higher magnitude in spring chickpeas and lentils (Table 6.3.7). A yield level of 8.15 t/ha was obtained in faba beans with the highest density planted on November 1.

6.3.4.2. Weed Competition and Control

Early or late weed infestations caused considerable yield losses in all three food legumes. Crops unweeded for 12 weeks after emergence resulted in daily yield losses of 15.9 kg/ha, 14.7 kg/ha and 19.3 kg/ha for faba bean small, lentils and spring chickpeas, respectively, at Beja. At the same location, late weed infestation reduced yield by 116.7 kg/ha, 53.3 kg/ha, and 287.5 kg/ha for these crops in that order. At Oued Meliz under supplementary irrigation, such losses were 1455 kg/ha for faba beans, 960 kg/ha for lentils, and 1970 kg/ha for chickpeas.

Table 6.3.7. Yield (t/ha) response to the highest and lowest population density at Oued Meliz, 1985/86.

Crop	Lowest populations		Highest populations		% increase over
	pl./m^2	yield	pl./m^2	yield	lowest desity
Faba bean small	NA[1]	2.93	54.0	6.20	59
Lentils	42.0	0.77	167.0	1.84	139
Spring chickpeas	6.9	1.14	24.0	3.04	167

1. NA =not available

Herbicides Igran, Kerb, Maloran, Gesagard, and Tribunil at various rates and combinations gave only partial weed control. There is a need to test other herbicides. Hand weeding twice (45 and 90 days after emergence) is an effective method to recommend to farmers until an economical and practical weed control schedule is identified.

6.3.4.3. Winter vs. Spring Sowing of Chickpea

These trials continued to confirm the superiority of winter sowing of chickpeas in 12 locations: Kef area (3), Mateur (1), Ras Rajel (1), Goublat area (3), Zaghoua (1), Beja (1), Mangel Tamime (1), Krib (1) and Oued Meliz (1). Data were available from the last four locations only. They indicated that winter sowing increased yield, on the average, by 259% over spring sowing (Table 6.3.8.). Averaged over 4 locations, the highest yielder was ILC 482, compared to local check, FLIP 81-56W, and ILC 3279 (Table 6.3.9.).

6.3.5. Special Project on Applied Biotechnology

Treatment with Agrobacterium rhizogenes increased germination by 12% in petri dishes in faba beans, soybeans and peas. Both leaf area and dry weight were increased, as well as root-to-shoot ratio because of prolific roots. Though the mechanism involved in increasing germination is not known, phytohormones being produced by the Agrobacterium may be a cause. Better root proliferation is likely to increase the moisture availability from soil profile in the dry areas and may thus increase productivity. Agrobacterium may therefore have a good potential in drought tolerance and in the improvement of stand in spring chickpeas by making moisture more available. However, the advantages of Agrobacterium treatment need to be verified under field conditions in faba beans, chickpeas, and lentils, which will be done in the coming season on this collaborative project with Montana State University and INAT.

Tunisian National Program Scientists.

Table 6.3.8 Mean yield of winter- and spring- sown chickpeas at four locations averaged over four varieties, 1985/86.

Location	Yield (kg/ha) and Planting Season		
	Winter (early Dec.)	Intermediate (mid Feb.)	Spring (early April)
Beja	1836	873	532
Manzel Temim	1088	786	30
Krib	1123	1183	693
Oued Meliz	2738	2012	635
Mean	1696	1214	472
%of Spring planting	359	235	100

Table 6.3.9. Mean yield of winter- and spring- sown chickpea varieties averaged over four locations, 1985/86.

Location	Yield (kg/ha) and Planting Season		
	Winter (early Dec.)	Intermediate (mid Feb.)	Spring (early April)
FLIP81-56W	1635	1260	484
ILC 482	1868	1183	479
ILC3279	1537	1164	409
Local check	1745	1248	517
Mean	1696	1214	472

7. TRAINING

7.1. Group Training

7.1.1. Food Legume Residential Course

The Food Legume Improvement Program conducted its annual residential course at Tel Hadya research station from 1 March - 19 June, 1986. The course was attended by 23 trainees from 12 countries (Table 7.1).

The participants were trained in research skills for the improvement of faba bean, lentil, and kabuli chickpea. Emphasis was on practical field and laboratory activities focusing on multidisciplinary and team approach. Within this general frame individual elements of training were also given to some trainees to cater to the needs of their national programs. To achieve this each trainee was assigned to a specific requested area supervised by a senior scientist.

The trainees were also exposed to such areas as farming systems approach to research, seed production, and report writing. In addition, the trainees organized field days and presented seminars related to the field experimentation in which they were involved. This was done with the objective of enhancing communication abilities.

7.1.2. Lentil Harvest Mechanization Training Course

Lentil harvesting by hand is become increasingly expensive in all the countries bordering the Mediterranean sea because the cost of labour is mounting faster than the price of lentil. The Food Legume Improvement Program as part of its effort in approaching this problem conducted the "Lentil Harvest Mechanization Course" from 11 to 22 May, 1986, at Tel Hadya. The course was attended by eight trainees from Turkey, Syria, Jordan, Algeria, and Tunisia.

Table 7.1: Participation in group training in the Food Legume Improvement Program, 1986.

Type of Training	Duration	Countries	No.
A. Residential			
Food Legume Improvement	3 months 2.3-5.6.1986	China, Egypt, India, Iran, Iraq, Jordan, Morocco, Pakistan, Sudan, Syria, Turkey, N. Yemen	23
B. Short-Courses			
- Food Legume Disease Epiphytotics	4-18.3.1986	Syria, Tunisia.	5
- Lentil Harvest Mechanization	11-22.5.1986	Algeria, Jordan, Syria, Tunisia, Turkey	8
C. In-Country Courses			
- Hybridization Techniques	6-16.1.1986	Sudan	8
- Food Legume improvement-Tunisia	13-20.4.1986	Algeria, Morocco, Tunisia.	24
- Seed Production	15-30.3.1986	Egypt, Ethiopia, Sudan	34
D. Training Workshops			
- Cereals & Food Legumes Breeding Strategies for Moisture limited Environments	11-13.5.1986	Syria	6
		Total	108

Topics covered in the course focused on breeding and agronomy in relation to harvest mechanization of lentils. Harvest machinery (cutterbar, angled blades) were covered in relation to setting, operation, and maintenance. Alternative machines for lentil harvest and threshing were also briefly covered. The course also covered on-farm trials of lentil harvest mechanization and related economic analysis. The presentations and demonstrations were complemented by practical work.

As part of training follow-up, the Food Legume Improvement Program will provide technical advise on request to the course participants who will start on-farm trials of lentil harvest mechanization in their own countries.

7.1.3. Disease Epiphytotics and Identification of Resistant Sources in Food Legume

The Food Legume crops in West Asia and North Africa are affected by many diseases which may cause high losses under disease conducive conditions. To strengthen the capabilities of the national programs in combating these diseases the Food Legume Improvement Program conducted the "Disease Epiphytotics and Identification of Resistance Sources in Food legumes", during 4-18 March, 1986, at at FLIP sub-site at Lattakia, Syria. The course was attended by five participants from Syria and Tunisia.

Both theoretical and practical aspects were stressed in the course. However, more emphasis was placed on the practical aspects covered by field and laboratory practicals.

Techniques in isolation, purification, identification, and sporulation of major fungal pathogens were covered. Techniques for

fast screening of germplasm for disease resistance were also covered. Management of faba bean disease nurseries was included with major emphasis on artificial inoculation in the field.

7.1.4. Food Legume Hybridization Techniques In-country Course

The Agricultural Research Corporation (ARC) of Sudan and the Food Legume Improvement Program conducted jointly the "Hybridization Techniques Course", during 6-16 January 1986, at Shambat Research Station, Khartoum, Sudan. The course, financed by the ICARDA/IFAD Nile Valley Project, was attended by eight research technicians from various research stations in Sudan. Sudanese and ICARDA scientists jointly instructed the trainees in management of a crossing field and efficiently crossing faba bean flowers. This course was a good example where a national program shared with ICARDA the planning and management of a training course. The success rate in crosses made by the trainees was taken as the measure for the success of the course.

7.1.5. Food Legume Improvement In-Country Course in North Africa

This was the second course in a series to be conducted by the Food Legume Improvement Program in North Africa. The course was conducted at INRA in Tunisia, during 12-20 April, 1986. The course was regional in nature and was attended by 16 trainees from Algeria, Tunisia, and Morocco. Eight members of extension staff from Tunisia also attended for two days. Instructors in the course were from Tunisia, Algeria, Morocco, and ICARDA. The program of the course covered various aspects of food legume improvement with emphasis on both theory and practical. The course served as a forum for strengthening network activities among the 3 North African countries involved. This was acheived during the course and in the informal discussion meeting held immediatetly at its termination.

7.1.6. Seed Production Course, Egypt

The Fourth Seed Production Course organized by ICARDA was held in Egypt from 15-30, March, 1986; 50% of the time was spent at the Central Administration for Seed, Giza and 50% at the Mubarak Mechanization Center, Sakha. It was sponsored by ICARDA/IFAD Nile Valley project, ICARDA Seed Production Project (DGIS/GTZ), and Central Administration for Seed, Ministry of Agriculture and Food Security, Egypt.

Six participants from Ethiopia, 6 participants from Sudan and 22 participants from Egypt attended the course. Topics covered in the course included the main elements of a seed program and practical excercises on purity, germination, viability, moisture, certification, variety identification, and seed health. The course was used as a forum to strengthen the network among seed technology specialists through presentation of seed program in Egypt, Sudan, Ethiopia, India, and Kenya. This course was the first regional in-country seed production course offered by ICARDA.

7.1.7. Cereal and Food Legume Breeding Strategies for Moisture Limited Environments Training Workshop

ICARDA and the National Research Program in Syria joined their efforts through a Collaborative Research Project to improve the productivity of food crops in Syria. Breeding is an important component of this project. The Cereal and Food Legume Improvement Program at ICARDA, at the request of the Syrian National Program, conducted a training workshop on "Cereal and Food Legume Breeding Strategies for Moisture-Limited Environments" from 11-13 May, 1986, at Aleppo, Syria.

The workshop which was attended by six Syrian Scientists provided a forum for exchange of scientific information in the field of cereal and food legumes breeding. Better definition of major constraints, revision of major current breeding methods and strategies for improving these methods were attempted.

7.2. Individual Training

The Food Legume Improvement Program continued its policy of increasing opportunities for individualized training of research workers from national programs. Topics covered, duration, countries, and numbers of participants are shown in Tables 7.2 and 7.3.

Training plans for this category were developed to suit the needs of each participant. The majority of the trainees (70%) received non-degree oriented training in specific research skills. Degree oriented training witnessed an increase in number and involved students registering at various universities to complete course requirements whereas thesis work was done either wholy or partially at ICARDA research stations. In a few cases thesis work was done elsewhere and this was limited to ICARDA-National Program Collaborative Projects.

Table 7.2: Participation in individual-degree training in the Food Legume Improvement Program, 1986.

Discipline	Degree	University	Countries	No.	Duration
Thesis at ICARDA					
Virology	M.Sc.	Damascus	Syria	1	2 years
Part of Thesis at ICARDA					
Breeding	M.Sc.	Amman	Jordan	1	1 month
Breeding	M.Sc.	A.U.B.	Lebanon		1 week/
			Bangladesh	4	1 month
Pathology	M.Sc.	Gezira	Sudan	1	3 months
Thesis elsewhere					
Breeding	Ph.D.	Durham/UK	Ethiopia	1	3 years
Breeding	M.Sc.	France	Algeria	1	2 years
Breeding	Ph.D.	Reading/UK	Tunisia	1	3 years
			Total	10	

Table 7.3: Participation in individual non-degree training, with the Food Legume Improvement Program, 1986.

	Topic	Range of Duration	Countries	No.
1.	Agronomy	One month - 3 months	Sudan, Morocco, Tunisia, Ethiopia, N. Yemen.	9
2.	Breeding	Two weeks - 6 months	Ethiopia, W. Germany Algeria, Turkey	5
3.	Pathology	One month - 6 months	Egypt, Sudan, Ethiopia Morocco, Syria.	5
4.	Entomology	One month	Sudan, Syria	3
5.	Orobanche	Six months - 9 months	Germany, Netherlands	2
6.	Microbiology	Three months	Ethiopia	1
7.	Quality	Two weeks	Turkey	1
			Total	26

8. PUBLICATIONS

8.1. Journal Articles

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9. STAFF LIST

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Nawal Saroukhan	Secretary
Hasna Boustani	Secretary
Mary Bogharian	Secretary
Ibrahim Mustafa	Driver
Naaman Ajanji	Driver
Abdullah el Khaled	Stores Attendant
Hussein Humeidi	Farm Labourer
Hikmat Alloush	Farm Labourer
Ahmed el Halabi	Farm Labourer
Asaad Omar Darwish	Attendant I - Driver
Ali Deeb Zahlout	Guard (Lattakia)
Kokab Hammoud	Office Attendant (Lattakia)

* Left during the year.