FOOD LEGUME IMPROVEMENT PROGRAM

Annual Report for 1990

ICARDA

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International Center for Agricultural Research in the Dry Areas
P.O. Box 5466, Aleppo, Syria

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1. INTRODUCTION

1.1. GENERAL

The Food Legume Improvement Program (FLIP) aims at encouraging and supporting national efforts in West Asia and North Africa (WANA) and other developing countries, in improving the productivity and yield stability of kabuli chickpea, lentil, faba bean and dry pea. We therefore continued our activities on crop improvement research, training and information dissemination on these cool season food legumes. In line with Center's strategy of paying more attention to the drier areas, research efforts on faba bean improvement were reduced and efforts were increased on those legumes that are better adapted to the drier environments.

Researchers from FLIP and other research programs in ICARDA worked on specific research projects in multidisciplinary teams. Wherever possible, full involvement of national program scientists was also enlisted. Work on kabuli chickpea was done jointly with the International Crop Research Institute for Semi-Arid Tropics (ICRISAT). We worked very closely with the national programs in Algeria, Egypt, Ethiopia, Iran, Iraq, Jordan, Libya, Morocco, Pakistan, Sudan, Syria, Tunisia, and Turkey in developing and supporting local coordinated legume improvement programs, enlisting participation of all major institutions engaged in research on cool season food legumes. This is being done to harness the complementarity of research efforts, avoid duplication and optimise the use of resources available for research at national level.

We expanded our contacts with the national programs in the countries outside WANA as well. Collaboration with researchers in China, eastern Europe, India and the USSR increased because of their interest in our mandate crops. We continued collaborating with institutions in the industrialized countries for basic research and for the application of biotechnological tools in crop improvement research.

Much of our crop improvement research on kabuli chickpea, lentil and dry pea was carried out at ICARDA's principal research station at Tel Hadya. Other subsites in northern Syria (Breda, Jinderess) and in the Beka'a valley of Lebanon (Terbol) were also used. Work on faba bean improvement was mainly done at the Douyet research station of INRA, Morocco where the FLIP faba bean breeder and pathologist are located since September 1989.

The weather conditions during the 1989/90 season at various research sites are depicted in Figures in Section 11. In general, the season was drier than the long-term average at all the test sites. This affected the crop growth and yield adversely. At Tel Hadya, it was one of the driest and coldest seasons in the last 14 years, with total seasonal precipitation being only 233.4 mm and the minimum temperature falling below the freezing point on 56 days. A severe cold spell during the middle of March (minimum temperature -8.9°C on 17 March) when winter-sown crops were in the stage of rapid growth, caused wide-spread cold damage and material in several experiments was completely lost. Although the value of this rather unusual cold spell for routine screening and selection was limited, it did permit identification of a few chickpea lines that could withstand such low temperatures. Since the precipitation was sub-normal, chickpea could effectively be screened for drought tolerance at Tel Hadya and lentil at Breda.

Advancement of breeding material by an additional generation during summer was conducted at Terbol research station for kabuli chickpea, at Bab-Janeh (Syria) for lentil and at Annaceur (Atlas mountains, Morocco) for faba bean. Possibility of raising a summer nursery of lentil at Terbol and Kaarim sites in Lebanon was also studied. Research sites of several national programs were also used for strategic joint research on the development of breeding material with specific resistance to some biotic stresses because of the presence of 'hot-spots' there.

1.2. ACHIEVEMENTS

A summary of the major achievements of the program in research, training and network activities during the 1989/90 season is given below:

1.2.1. Kabuli Chickpea

Yields of kabuli chickpea are low and unstable in WANA. Improvement is possible on both these aspects through the adoption of winter sowing in the low altitude regions. As an average of several yield trials conducted at three locations over last seven years (1983/84 to 1989/90), winter-sown crop gave 67% higher yield than spring sowing. For the genotypes in the top 10% yielding group, the increase due to winter sowing was 134%. The area under winter sowing is increasing in WANA, where 27 cultivars have been released so far for winter sowing. During the 1989/90 season five cultivars were released: 'Jubeiha 1' and 'Jubeiha 2' in Jordan, 'Janta 2' in Lebanon, and 'Dalma 89' and 'Tabavo 89' in Turkey. Adoption and impact studies have been started in Morocco and Syria.

NARSs continued to make good use of ICARDA enhanced germplasm. More than 15000 lines were furnished to NARSs in 47 countries in 1989/90. In 11 countries, 40 lines were identified for on-farm trials or pre-release multiplication.

To stabilize chickpea productivity, considerable emphasis was laid on breeding for resistance to various biotic and abiotic stresses. Evaluation continued for Ascochyta blight, Fusarium wilt, leaf miner, cyst nematode, cold and drought resistance in cultivated as well as wild Cicer species, and new sources of resistance were identified. A highly cold tolerant mutant of ILC 482 was identified which could withstand -8.9°C temperature in the middle of March. Also line ILC 3470 showed promise. These lines will be used in the breeding program. Studies on the genetics of cold tolerance revealed that the selection for this trait should be done during late generations. A screening technique for drought tolerance based on sowing the crop in the third week of March has been found effective in identifying genotypic differences for this trait.

Wild Cicer spp. have proved to be the only sources of resistance to seed beetle and cyst nematode and they have better tolerance to cold and Ascochyta blight than the cultivated species. Hence, efforts on inter-specific crossing were continued. Karyotype study of Cicer spp. has helped in developing some understanding of the cross-incompatibility of certain interspecific combinations. Successful cross could be made between C. arietinum and C. bijigum for the first time, and this has given hope for introgression of some desirable characteristics from the wild species into the cultivated chickpea.

Collaborative studies with the University of Frankfurt have helped in identifying non-radioactive probes for DNA fingerprinting for genetic characterization of chickpea lines as well as different isolates of Ascochyta rabiei fungus. This will eventually help in increasing the efficiency of our efforts in breeding chickpea resistant to this disease.

The cold and dry weather conditions during 1989/90 did not permit good field screening of breeding material for Ascochyta blight. Hence most of the work was done in the green-house and growth chamber. Screening of various breeding lines and promising germplasm against a mixture of six Ascochyta rabiei isolates revealed that lines ILC 6189 and FLIP 87-509C were resistant and FLIP 84-91C was moderately resistant. A certain degree of cross-protection was observed in some lines.

Host-plant resistance of ILC 5901 chickpea to leaf miner was confirmed, and seems to be associated with high malic acid concentration in the exudate. Neem-seed extract proved to be a safe, cheap and effective agent to control leafminer in chickpea. Use of olive oil + salt to treat the seeds provided a good protection to chickpea from seed beetle (Collosobruchus chinensis) in the storage.

Studies on improving the symbiotic nitrogen fixation in chickpea revealed that the soil-core method to determine need for inoculation was more accurate than Rhizobium population estimates alone in the soils of northern Syria. Evaluation of symbiotic effectiveness using sterile hydroponic N-free system gave the most accurate estimates of soil rhizobia populations and assessment of the need for inoculation. There was a strong cultivar x strain interaction in affecting symbiotic N_2-fixation. Fixation was highly affected by available moisture supply. It increased as the moisture supply increased from 280 mm to 499 mm. Also the percentage of total plant nitrogen coming from symbiosis increased with increasing moisture supply.

1.2.2. Lentil

We continued our lentil breeding strategy targetted to different agroecological regions with emphasis on yield potential, drought tolerance, plant architecture for mechanized harvest and resistance to important diseases (Fusarium wilt, Ascochyta blight, rust) and parasite (*Orobanche crenata*). Over 300 simple crosses were made and handled by bulk-pedigree system using off-season generation advancement. A new nursery containing rust resistant sources was launched.

The season being extremely dry, it permitted identification of breeding material with drought tolerance. The progress made was evident from the fact that several breeding lines ranked above best checks in this dry season. Considerable progress was made in screening for resistance to Fusarium wilt. A wilt-sick plot had been developed and a methodology for screening developed based on delayed sowing. Two lines (ILL 298 and 6435) were identified giving resistant reaction against Fusarium wilt at both seedling and adult stage. Also, highly resistant sources were identified in wild species - *Lens culinaris* ssp. *orientalis*, *L. nigricans* ssp. *nigricans* and *L. nigricans* ssp. *ervoides*. One line of cultivated species (ILL 5588) was identified as resistant to both wilt and Ascochyta blight. In our attempts to exploit wild *Lens* spp. in crop improvement, we developed a hydroponics system to have a year-round supply of vigourous plants of wild and cultivated species with profuse flowering necessary for wide crossing. Studies on the protocol for *in vitro* culture of embryo/ovules were continued.

Use of a line-source sprinkler system at Breda has permitted identification of lentil genotypes that perform well under drought, but are able to respond to increased moisture supply as well. Early growth and seedling vigour have proved to be good criteria in predicting genotype performance under droughty conditions but if there is a late frost, as occurred this season, the significance of these traits is reduced and cold tolerance becomes an additional important trait. Study on screening for cold tolerance showed that it can be done at an intermediate elevation (600-800 m) by sowing the crop early to predispose it to damage from cold in most years.

The national programs in different lentil production regions continued making good use of ICARDA enhanced germplasm. Five lines were released by NARSs in 1989/90 for general cultivation ('Jordan Lentil 3' in Jordan, 'ILL 4605' in Morocco, 'Mansehra 89' in Pakistan and 'Erzurum 89' and 'Malazgirt 89' in Turkey). Several others have been selected for on-farm multi-location trials and pre-release multiplication in WANA. In the southern latitudes, good use is being made of ICARDA enhanced material in Pakistan, India, Nepal, Bangladesh and Ethiopia. Australia, Canada, Chile and China have also made selections from ICARDA material.

We continued transferring the technology of lentil harvest mechanization to the NARSs. In 1989/90, the General Organization of Agricultural Mechanization of Syria encouraged the farmers in Kameshly to grow lentil on 80,000 ha following the technology earlier demonstrated in collaboration with ICARDA. Because of dry weather conditions, the crop growth was poor and mechanized harvest could only be done using swathe-mower. Nearly 25% of the total area in Kameshly was harvested by this method. The seed yield losses ranged from 4.7%-8.6% with swathe-mower as compared to hand harvest.

Research on <u>Rhizobium</u> and <u>Sitona</u> weevil control were carried out to increase the symbiotic nitrogen fixation in the wheat-based cropping system. Twenty-one lentil <u>Rhizobium</u> strains were tested for their symbiotic efficiency with three Jordanian lentil cultivars using an aseptic N-free hydroponic gravel culture system. Strain LE 867 from Turkey was found to be consistently superior, although strain LE 835 and 843 from Jordan were also good. These strains will be further evaluated for inoculation studies. The N_2-fixation was highly affected by total seasonal moisture supply. As the moisture supply increased from 180 mm to 376 mm the percentage of total plant nitrogen derived from fixation increased from 36% to 77%.

Seed treatment of lentil with a low dose (12ml/kg seed) of Promet was as effective as the use of 20 kg/ha of carbofuran (5%G) in controlling <u>Sitona</u> larvae damage and in increasing lentil yield over untreated check. The yield of symbiotically fixed nitrogen increased because of <u>Sitona</u> control although the percentage of total plant N coming from symbiosis was not affected. Superiority of Promet seed treatment was also established in the on-farm trials. Visual damage score was related well with the oviposition and larval damage to nodules.

1.2.3. Faba bean

Most of the faba bean improvement research was conducted at the Douyet research station, Fes, Morocco. The most significant development was the identification of three selections (18035, 18009, and 18015) of faba bean with high resistance to Orobanche crenata and almost 100% higher yield than the susceptible check (Aquadulce). On-farm verification, conducted on a few sites only because of limited seeds, confirmed this superiority. The seed multiplication of these lines has been started.

Use of ICARDA enhanced faba bean material by the national programs has continued. Iran and Portugal have released cultivars. Egypt is ready to release Reina Blanca and a selection from chocolate spot resistant cross. In Ethiopia, a cross bulk has been purified and is in pre-release multiplication. FLIP 86-146FB is in on-farm trials in China for relay cropping with cotton. In Tunisia, lines 80 S80028, S82113-8 and S82033-3 have been selected for pre-release multiplication because of their high and stable productivity under droughty conditions. A small seeded line (FLIP 83-106 FB) has also been identified for seed multiplication in Tunisia.

Crosses have been made and trait specific genetic stocks developed to meet the specific needs of the national programs, particularly those of North Africa, for seed size, adaptation, and resistance to

Orobanche, chocolate spot, Ascochyta blight, rust and stem nematode.

Testing of inbred liens with known differential disease reaction to races of Botrytis fabae and Ascochyta fabae since 1986 in Algeria, Egypt, France, Italy, Morocco, Syria, Tunisia and has permitted characterization of pathogenic races in the Mediterranean region. This will help in developing suitable control strategies for each country using appropriate sources of host-plant resistance.

On-farm evaluation of different insecticides for the control of Bruchus dentipes showed that methyl parathion (Metyphon EC 50, 1 ml/l) was most effective. Two sprays, one at early pod setting and second 10 days later, were needed.

1.2.4. Dry Peas

Of 348 accessions collected from different parts of the world, 50 high yielding selections were retained for evaluation of their adaptation to dry areas of WANA. In the Adaptation Trial conducted at Tel Hadya, Jinderess and Terbol, Accession No. 21 was identified as widely adapted. Some accessions showing high tolerance to cold were also identified. Agronomic studies on plant population with pea genotypes of differing leaf morphology under rainfed and assured moisture supply conditions revealed that the optimum plant population for conventional leaf types was 36 plant/m^2 whereas for leafless types it was 80 plants/m^2.

1.2.5. Orobanche Control

Studies were carried out on various individual control methods with a view to develop integrated control. Host-plant resistance studies with six different forage legume species revealed large inter- and intraspecific variation in susceptibility to the parasite. Wide crossing may, therefore, provide scope for transferring resistance to species in which it is currently lacking. Preliminary studies on dry peas also revealed large genotypic differences in Orobanche susceptibility.

The dry and cold weather during 1989/90 was not very conducive for the growth of Orobanche. Hence several trials gave inconclusive results. Fosamine was identified as a new herbicide for Orobanche control in faba bean and imazathapyr proved effective in dry peas. Studies on biological control of Orobanche using Phytomyza orobanchia fly or Ulocladium atrum fungus demonstrated that the efficacy of these control measures was highly dependent on the weather condition and the 1989/90 season was not conducive for these biological control agents.

1.2.6. International Testing Program

This program is a vehicle for dissemination of genetic materials and improved production practices, in the form of international trials and nurseries, to national programs. A total of 1030 sets of 45 different nurseries were distributed to 130 cooperators in 54 countries for the 1990/91 season. The nurseries were further diversified and specifically targetted to different areas and included more sources of resistance to various stress factors and specific traits rather than the finished cultivars.

In case of faba bean only a limited number of nurseries with specific characteristics including determinate growth habit and sources of disease and pest resistance were distributed. Regional yield trials were specifically developed and distributed for North African countries from the Douyet, Morocco base as a part of the faba bean research network in the Magreb.

1.2.7. Nile Valley Regional Program

This was the second year of this special project dealing with research, transfer of technology and training, to improve the production of cool season food legumes in Egypt, Ethiopia and Sudan. On-farm trials with improved production package gave economic increases in yield of all the legumes. Back-up research helped in developing breeding material with improved resistance to diseases, insect-pests, and the parasite Orobanche and in developing more economical and efficient production techniques for evaluation on farmers' fields. Adoption studies were carried out to monitor the progress and obtain feed-back on the problems being faced by the farmers. Support activities, including production of seeds of improved cultivars, were also taken up. All the planned activities were successfully conducted, which reflects the maturity of the national programs.

1.2.8. North African Regional Program

Cooperation with the national programs in Algeria, Libya, Morocco, and Tunisia expanded during 1989/90. Several selections of ICARDA enhanced breeding lines and segregating populations out-yielded the local checks by significant margins in the multilocation testing of faba bean, chickpea, and lentil. A number of lines were identified for pre-release multiplication and a few released. North African Regional Trials and Nurseries were developed with responsibility for their coordination resting with one of these countries. Thus trials on faba bean were coordinated by Morocco, on chickpea by Tunisia and on lentil by Algeria. The regional food legume scientist based at Fes, Morocco, provided the necessary technical back-stopping.

In Algeria, several rust-resistant determinate faba bean lines were selected with high yield potential. Lines yielding significantly higher than best local check were selected from the International Pea Adaptation Trial. In winter chickpea, performance of ILC 482 and ILC 3279 continued to be promising, but new lines were also identified, e.g. FLIP 83-98C. Seeds of FLIP 81-293 C and FLIP 81-57 W were multiplied for release in western Algeria. In case of lentil seeds of FLIP 86-20L were multiplied for release in eastern Algeria.

In Libya, the program is relatively younger. Faba bean lines FLIP 86-119 FB and ILB 1814 proved promising. Also Reina Blanca, Turkish Local and ILB 1954 performed well. Weeds were a serious problem in faba bean fields, but could be effectively controlled by using pre-emergence application of cyanazine and pronamide. Early sowing (between 15 Oct & 1 Nov) with 22.2 plant/m^2 plant population was optimum. In chickpea, Ascochyta blight was a problem and five lines with tolerance to the disease were selected. Weed control in chickpea was effectively achieved through the use of pre-emergence application of Igran. Need for inoculation with Rhizobium was evident at all the chickpea test sites. In the yield trials on lentil four entries (78 S26002, FLIP 84-76L, FLIP 84-81L and FLIP 84-148 L) were found promising.

In Morocco, more than 1000 single plants were selected in the segregating progenies of faba bean under artificially induced epiphytotics of Ascochyta blight, chocolate spot and rust. Several lines with high resistance to Orobanche and high yield were identified. In chickpea, lines FLIP 84-79C and FLIP 84-93C were included in the catalogue trial and their seed multiplication was started. Lines FLIP 83-47C, 83-48C and 84-92C were identified as having broadbased resistance to Ascochyta blight. On-farm demonstration and monitoring of adoption for winter chickpea technology was continued in collaboration with DVP/DVRA using cultivar ILC 195. Amongst the lentil lines, ILL 4605 was released because of its resistance to rust and good seed quality. Also lines L24 and L56 were released. ILL 6002, 6209 and 6212 maintained their rust resistance for the third consecutive year of rust epidemic. Verification trials were started using five promising lentil lines.

In Tunisia, identification of faba bean lines able to tolerate drought was a major achievement. Selections were made from segregating populations of faba bean for resistance to chocolate spot and Ascochyta blight. Reina Blanca and FLIP 83-106B were identified as potential candidates for release. In the evaluation of chickpea lines FLIP 84-92C and FLIP 84-79C continued to show better performance than the checks. A number of F_6/F_7 progenies have been selected for dual resistance to wilt and Ascochyta blight. FLIP 83-47C and FLIP 84-92C have been identified for pre-release multiplication as dual season (winter and spring) cultivars. Lentil again showed good adaptation to dry areas in Tunisia and line 78S 26002 confirmed its superiority across locations and is being considered for release to farmers.

1.2.9. Training and Networking

Training and networking activities were continued to strengthen the research skills in the national programs. Group training at ICARDA headquarters included the 'Food Legume Residential Course', and a short course each on 'Insect Control', 'Biology and Control of Orobanche', 'Breeding Methodologies', 'Virology' and 'Application of Biotechnology in Food Legume Improvement'. Group training was also conducted through sub-regional and in-country training courses in the conduct of which the national program scientists also participated. These were the courses on 'Faba bean Improvement' and 'Agronomy of Winter Chickpea' in Morocco, 'Field Inspection of Diseases in Seed Multiplication' in Algeria, 'Lentil Harvest Mechanization' in Jordan, 'Breeding Methodology' in Turkey and 'General Food Legume Improvement' in Iran.

In addition several individual non-degree training participants visited the program and participated in various research activities working closely with the program scientists. A total of 242 participants, including 16 students registered for M.Sc. or Ph.D. degree, benefited from these training activities.

FLIP assisted the national programs in the operation of national food legume networks in Algeria, Libya, Morocco, Tunisia, Egypt, Ethiopia, Jordan, Pakistan, Sudan, Syria and Turkey. In addition, regional networks in North Africa, Nile Valley and West Asia were supported. The 'International Nurseries and Trials Network' supported the food legume improvement research in all the developing countries where these legumes are important. In addition, two disciplinary networks were operated: one on 'Biological Nitrogen Fixation' and the other on 'Aphid Control'.

Information dissemination was given high priority and the results of research conducted by the program scientists were disseminated through papers published in Journals, or presented in various conferences, program reports and special publications. FABIS and LENS newsletters served as vehicle for quick dissemination of information by the national program scientists.

In view of the importance of various biotic and abiotic stresses in affecting the productivity and yield stability of cool season food legumes, an International Conference was convened by the program in Ravello, Italy. The proceedings of the conference are to be published.

2. KABULI CHICKPEA IMPROVEMENT

The kabuli chickpea improvement is a joint program with ICRISAT Center, India. The main aim of the program is to increase and stabilize kabuli chickpea production in the developing world. Of the four main regions where chickpea is grown, the Mediterranean region and Latin America produce mostly kabuli type chickpea. Five to ten percent of the area in the other two main production regions (Indian subcontinent and East Africa) is also devoted to the kabuli type. Kabuli chickpea is also grown in high elevation areas (>1000 m above sea level) in West Asia, especially in Turkey, Iraq, Iran, and Afghanistan, and in North Africa in the Atlas mountains. Ascochyta blight and Fusarium wilt are two major diseases of chickpea. Leaf miner in the Mediterranean region and pod borer in other regions are major insect pests. Kabuli chickpea is mainly grown as a rainfed crop in the wheat-based farming system in areas receiving between 350 mm and 600 mm annual rainfall in the West Asia and North Africa (WANA) region. In Egypt and Sudan and parts of South Asia, West Asia and Central America, the crop is grown with supplemental irrigation.

In West Asia and North Africa, where the crop is currently spring-sown, yield can be increased substantially by advancing sowing date from spring to early winter. There are indications that increasing plant density and reducing row width might increase yield significantly, especially during winter sowing. Winter sowing also allows the chickpea crop to be harvested by machine. Major efforts are underway to stabilize chickpea productivity by breeding cultivars resistant to various stresses, such as diseases (Ascochyta blight and Fusarium wilt), insect pests (leaf miner and pod borer), parasites (cyst nematode and Orobanche crenata Forsk.), and physical stresses (cold and drought). Efforts are also underway to collect basic information for generating input-responsive cultivars, especially those which respond to application of phosphate and water.

During 1990, several collaborative projects operated. In the project "Development of chickpea germplasm with combined resistance to Ascochyta blight and Fusarium wilt using wild and cultivated species", four Italian institutions collaborated with ICARDA. The screening for cyst nematode was carried out in association with the Istituto di Nematologia Agraria, C.N.R., Bari, Italy. Fusarium wilt resistance screening was done in association with INRAT, Tunisia and the Department de Patologia Vegetal, Cordoba, Spain. Screening for tolerance of cold was done in cooperation with agricultural research institutes in Turkey. Genetics of phosphate uptake was investigated in association with the University of Hohenheim, Federal Republic of Germany (FRG). A program on mutation breeding was conducted jointly with the Nuclear Institute for Agricultural Biology, Faisalabad, Pakistan. The University of Saskatchewan, Canada is collaborating in studies of genetic diversity in kabuli chickpea. Studies on mechanism of drought and cold resistance and some aspects of biological nitrogen fixation are being conducted in collaboration with INRA, Montpellier, France. Studies on leaf miner resistance and application of restriction fragment length polymorphism (RFLP) in characterizing chickpea genotypes and Ascochyta rabiei isolates are carried out in collaboration with the University of Frankfurt, F.R. of Germany.

2.1. Chickpea Breeding

Main objectives of the breeding are (1) to produce cultivars and genetic stocks with high and stable yield, (2) to develop segregating populations and material for crossing programs to support National Agricultural Research Systems (NARSs), and (3) to conduct strategic research to support work on germplasm improvement. Specific objectives in the development of improved germplasm for different regions are:

1. Mediterranean region: (a) winter sowing: resistance to Ascochyta blight, tolerance of cold, suitability for machine harvesting, medium to large seed size (40% of resources); (b) spring sowing: cold tolerance at seedling stage, resistance to Ascochyta blight and Fusarium wilt, tolerance of drought, early maturity, medium to large seed size (30% of resources);
2. Indian subcontinent and East Africa: resistance to Ascochyta blight and/or Fusarium wilt, drought tolerance, early maturity, small to medium seed size, response to supplemental irrigation (15% of resources);
3. Latin America: resistance to Fusarium wilt, large seed size (5% of resources);
4. High elevation areas: spring sowing, cold tolerance at seedling stage, resistance to Ascochyta blight, terminal drought tolerance,

early maturity, and medium to large seed size (10% of resources).

2.1.1. Use of Improved Germplasm by NARSs

2.1.1.1. International nurseries and trials

During 1990, more than 15,000 chickpea entries including breeding lines were furnished to 47 countries (Table 2.1.1). Sixty-three percent of the material was provided to NARSs in the WANA region, 12% to other developing countries and remaining 25% to developed countries. Fifty-two percent of material furnished to developed countries was for the joint research projects with ICARDA.

Drs. K.B. Singh, R.S. Malhotra and M.C. Saxena.

2.1.1.2. On-farm trials

During 1989/90, five newly bred lines, namely FLIP 83-47C, FLIP 83-48C, FLIP 83-71C, FLIP 83-98C, and FLIP 84-15C, were evaluated in Syria against a standard check, Ghab 1, at 18 locations in collaboration with the Directorate of Scientific Agricultural Research, Douma. Four trials failed due to extremely low rainfall, below 200 mm. Two lines, FLIP 84-15C and FLIP 83-98C yielding 1503 kg and 1493 kg ha^{-1}, respectively, were only marginally superior to the check, Ghab 1 (1463 kg ha^{-1}). But the 100-seed weight of FLIP 84-15C is 45 g against 28 g of Ghab 1 and FLIP 83-98C has better resistance to Ascochyta blight and cold than Ghab 1. The program has been involved in the on-farm trial activities with many other NARSs in West Asia and North Africa.

NARS scientists and Dr. K.B. Singh.

Table 2.1.1. Number of entries furnished in the form of internationa yield trials and nurseries and breeding lines during 1990

Country	Trial and nursery		Breeding line (No.)	Total entry (No.)
	No. of sets of Trial/nursery	No. of entries		
Algeria	37	1154	15	1169
Australia	7	185	3	188
Austria	3	91	–	91
Belize	3	75	–	75
Brazil	4	92	–	92
Bulgaria	4	135	–	135
Canada	–	–	490	490
Chile	5	121	–	121
China	5	135	233	368
Colombia	2	46	–	46
Cyprus	5	189	–	189
Egypt	12	374	–	374
Ethiopia	8	247	–	247
Fed. Rep. Germany	–	–	12	12
France	11	384	18	402
Greece	3	75	–	75
India	14	513	149	662
Iran	21	668	6	674
Italy	14	465	1	466
Japan	–	–	1	1
Jordan	25	762	14	776
Kenya	1	30	–	30
Lebanon	6	184	–	184
Libya	7	229	–	229
Malawi	3	95	–	95
Mexico	2	46	–	46
Morocco	19	557	–	557
Namibia	1	23	–	23
New Zealand	1	29	–	29
Oman	1	23	–	23
Pakistan	14	543	87	630
Peru	7	209	–	209
Poland	1	40	–	40
Portugal	5	144	–	144
Qatar	1	49	–	49
Saudi Arabia	2	79	–	79
Senegal	1	23	–	23
Spain	19	586	1000	1586
Srilanka	2	78	–	78
Sudan	3	102	–	102
Swaziland	2	46	–	46
Syria	33	965	–	965
Tunisia	35	1194	–	1194
Turkey	59	1842	103	1945
U.K.	1	40	10	50
USSR	–	–	11	11
Yemen	2	46	–	46
Total	411	12,913	2153	15,066

2.1.1.3. Pre-release multiplication of cultivars by national programs

Forty lines have been identified in recent years from the international nurseries by scientists in 11 countries for pre-release multiplication and/or on-farm testing (Table 2.1.2), because of appropriate seed size, plant height and phenology, and tolerance to cold and Ascochyta blight.

NARS Scientists and Dr. K.B. Singh.

Table 2.1.2. Chickpea lines identified for pre-release multiplication and on-farm testing by NARSs in recent years.

Country	Line
Afghanistan	FLIP 84-145C, FLIP 81-293C, FLIP 81-57W.
Algeria	FLIP 81-57W, ILC 190.
Cyprus	FLIP 85-10C.
Egypt	ILC 202, FLIP 80-36C.
Iraq	FLIP 81-269C, FLIP 82-142C, FLIP 82-169C, ILC 482, ILC 3279.
Lebanon	FLIP 85-5C, FLIP 84-15C.
Libya	ILC 484, FLIP 84-92C.
Morocco	FLIP 82-150C, FLIP 82-152C, FLIP 83-47C, FLIP 83-48C, FLIP 84-92C.
Syria	FLIP 82-150C, FLIP 83-47C, FLIP 83-48C, FLIP 83-71C, FLIP 83-98C, FLIP 84-15C.
Tunisia	FLIP 83-47C., FLIP 84-92C.
Turkey	FLIP 83-31C, FLIP 83-77C.FLIP 85-13C, FLIP 85-14C, FLIP 85-15C, FLIP 85-60C, 87AK 71112, 87 AK 71113, 87 AK 71114, 87 AK 71115.

2.1.1.4. Release of cultivars by NARSs

NARSs in 14 countries have selected 31 lines and have released them as cultivars (Table 2.1.3): 27 for winter sowing and two for spring sowing in the Mediterranean region and 2 for winter sowing in more southerly latitudes.

NARS Scientists and Dr. K.B. Singh.

Table 2.1.3. Kabuli chickpea cultivars released by different NARSs.

Country	Cultivars released	Year of release	Specific features
Algeria	ILC 482	1988	High yield, wide adaptation
	ILC 3279	1988	Tall, high yield
Cyprus	Yialousa (ILC 3279)	1984	Tall
	Kyrenia (ILC 464)	1987	Large seeds
France	TS1009 (ILC 482)	1988	Released by TOP SEMENCE
	TS1502 (FLIP 81-293C)	1988	Released by TOP SEMENCE
Italy	Califfo (ILC 72)	1987	Tall
	Sultano (ILC 3279)	1987	Tall
Lebanon	Janta 2 (ILC 482)	1989	High yield
Jordan	Jubeiha-2 (ILC 482)	1990	High yield, wide adaptation
	Jubeiha-3 (78 S 26002)	1990	High yield
Morocco	ILC 195	1987	Tall
	ILC 482	1987	High yield, wide adaptation
Oman	ILC 237	1988	High yield
Portugal	Elmo (ILC 5566)	1989	High yield
	Elvar (FLIP 85-17C)	1989	High yield
Spain	Fardan (ILC 72)	1985	Tall, high yield
	Zegri (ILC 200)	1985	Mid-tall, High yield
	Almena (ILC 2548)	1985	Tall, high yield
	Alcazaba (ILC 2555)	1985	Tall, high yield
	Atalaya (ILC 200)	1985	Mid-tall, high yield
Sudan	Shendi (NEC2491/ILC 1335)	1987	High yield
Syria	Ghab 1 (ILC 482)	1986	High yield, wide adaptation
	Ghab 2 (ILC 3279)	1986	Tall, cold tolerant
Tunisia	Chetoui (ILC 3279)	1986	Tall
	Kassab (FLIP 83-46C)	1986	Large seeds, high yield
	Amdoun 1 (Be-sel-81-48)	1986	Large seeds
Turkey	Gunei Sarisi (ILC 482)	1986	High yield, wide adaptation
	Damla 89 (FLIP 85-7C)	1990	High yield, large seed
	Tasova 89 (FLIP 85-135C)	1990	High yield, large seed

All cultivars are resistant to Ascochyta blight and were released for winter sowing, with the exception of Amdoun 1 which is resistant to Fusarium wilt and released for spring sowing, and ILC 237 and Shendi which are intended for use under irrigation. In Turkey, ILC 482 was released for spring sowing.

2.1.2. Screening for Multiple Stresses

2.1.2.1. Land races

Screening of germplasm lines was initiated in 1978 for Ascochyta blight (Ascochyta rabiei [Pass.] Lab.), in 1979 for cold, in 1981 for leaf miner (Liriomyza cicerina Rond), in 1982 for seed beetle (Callosobruchus chinesis L.), in 1986 for cyst nematode (Heterodera ciceri Vovlas, Greco et Di Vito), in 1987 for Fusarium wilt (Fusarium oxysporum Schlecht. emnd Synd f.sp. Ciceri [Padwik] Snyd. & Hans) and in 1989 for drought. The number of lines evaluated between 1978 and 1990 for different stresses are shown in Table 2.1.4. Resistant sources have been identified for Ascochyta blight, Fusarium wilt, leaf miner, and cold. But no source of resistance was found for seed beetle and cyst nematode. Resistant sources have been freely shared with NARSs and are used in crossing blocks.

Drs. K.B. Singh, S. Weigand, M.C. Saxena, R.S. Malhotra, O. Tahhan (ICARDA), N. Greco and M. Di Vito (Italy), R. Jimenez-Diaz (Spain).

Table 2.1.4. Reaction of chickpea germplasm accessions to some biotic and abiotic stresses at Tel Hadya between 1978 and 1990.

Scale	Ascochyta blight	Fusarium wilt	Leaf miner	Seed beetle	Cyst nematode	Cold
1	0	0	0	0	0	0
2	0	2	0	0	0	0
3	16	0	0	0	0	15
4	17	26	8	0	0	120
5	1049	57	201	0	0	657
6	361	155	509	164	620	502
7	1838	251	1167	185	881	723
8	1223	584	8	1551	0	1796
9	11443	1547	3538	3253	4449	2165
Total	15947	2636	5478	5153	5950	5978

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

Table 2.1.5. Reaction of germplasm accessions of wild Cicer spp. to biotic and abiotic stresses at Tel Hadya, Syria during 1987/88, 1988/89 and 1989/90.

Scale[a]	Blight		Wilt[c]		Leaf miner		Seed beetle		Cyst nemat.		Cold	
	No.	species[b]	No.	species	No.	species	No.	species	No.	species	No.	species
1	0	0	72	1,4,5,6,7	0	0	20	1,3,4,5,7	2	6	0	0
2	5	5,6	0	0	15	2,5,8	12	1,5,6,7	0	0	66	1,4,7
3	63	1,3,5,6	7	1,5,7	36	1,4,5,6	4	1,7	15	1,6,7	17	1,4,5,7
4	2	4,6	15	1,5,6,7	25	1,4,5,6,7	3	1,6,7	4	1	28	1,4,6
5	25	1,4,5,6,7	6	5,6,7	28	1,5,6,7	2	3,5	11	1,7	8	5,6
6	14	1,5,6,7	4	5,6	9	6,7	8	1,5,7	6	1,8	4	5,6
7	12	1,2,4,5,7	4	6	6	1,5,7	18	2,4,5,7	9	5,7,8	7	5,6
8	2	1,3	0	0	0	0	53	2,5,6,7,8	30	1,5,6,7,8	18	5,8
9	8	5,7,8	5	6	2	1	10	5,6,8	103	2,3,4,5,6,7	36	3,5,6,8
Total	131		113		121		130		180		184	

(a) Scale: 1 = free; 5 = intermediate; 9 = killed.
(b) Species code: 1 = C. bijugum; 2 = C. chorassanicum; 3 = C. cuneatum; 4 = C. echinospermum; 5 = C. judaicum; 6 = C. pinnatifidum; 7 = C. reticulatum; 8 = C. yamashitae.
(c) Evaluation for wilt was done at Istituto Sperimentale per la Patologia Vegetale, Rome.

2.1.2.2. Wild Cicer species

Evaluation of eight annual wild Cicer species continued for the third year to identify sources of resistance to different stresses. The highest susceptibility rating from the three years evaluation of a line has been taken as the actual rating for that line. The results are summarized in Table 2.1.5. Sources of resistance were found for six stress factors, including Ascochyta blight, Fusarium wilt, leaf miner, seed beetle, cyst nematode, and cold. Wild species were the only source of resistance so far found for seed beetle and cyst nematode and had higher level of resistance than the cultivated species for Ascochyta blight, Fusarium wilt, leaf miner, and cold. The most important species for resistance to different stress factors was C. bijugum, while C. yamashitae was the least important. There is a need to evaluate the existing collections to other important stresses and to collect additional accessions for evaluation.

Drs. K.B. Singh, S. Weigand, M.C. Saxena, R.S. Malhotra, O. Tahhan (ICARDA), A. Porta-Puglia, N. Greco and M. Di Vito (Italy).

2.1.2.3. Breeding lines

Most of the breeding lines developed at the Center have been evaluated for eight stresses, including Ascochyta blight, Fusarium wilt, leaf miner, Collosobruchus chinensis, cyst nematode, cold, iron deficiency, and herbicide toxicity. Complete evaluation has been done for five stresses, namely Ascochyta blight, leaf miner, Callosobruchus chinensis, Cyst nematode, and cold. Sources of resistance have been found for all stresses except for cyst nematode and Callsobruchus chinensis in breeding lines. Results of screening of land races and breeding lines are shown in Figs 2.1.1. to 2.1.8.

Drs. K.B. Singh, S. Weigand, G. Bejiga, R.S. Malhotra, O. Tahhan, M.C. Saxena (ICARDA), N. Greco, M. Di Vito (Italy), S. Jana (Canada).

2.1.2.4. Listing of resistance

Sources of resistance identified for Ascochyta blight, Fusarium wilt, leaf miner, and cold in cultivated species are listed in Table 2.1.6. These have been used in breeding programs at ICARDA and elsewhere and resistant cultivars bred. Due to differential disease race-patterns, some lines found resistant at ICARDA were susceptible elsewhere.

Sources of resistance in wild Cicer species for Ascochyta blight,

Table 2.1.6. Sources of resistance to biotic and abiotic stresses identified between 1978 and 1990.

Stress	Source of resistance
Ascochyta blight	ILC 72, ILC 182, ILC 187, ILC 200, ILC 2380, ILC 2506, ILC 2956, ILC 3279, ILC 3856, ILC 4421, ILC 5586, ILC 5902, ILC 5921, ILC 6043, ILC 6090, ILC 6188.
Fusarium wilt	ILC 54, ILC 240, ILC 256, ILC 336, ILC 487.
Leaf miner	ILC 316, ILC 992, ILC 1003, ILC 1009, ILC 1216, ILC 2622, ILC 5594, ILC 5901.
Cold	ILC 794, ILC 1071, ILC 1251, ILC 1256, ILC 1444, ILC 1455, ILC 1464, ILC 1875, ILC 3465, ILC 3470, ILC 3598, ILC 3746, ILC 3747, ILC 3791, ILC 3791, ILC 3857, ILC 3861, Mutant of ILC 482.

N.B. No source of resistance was found for seed beetle and cyst nematode.

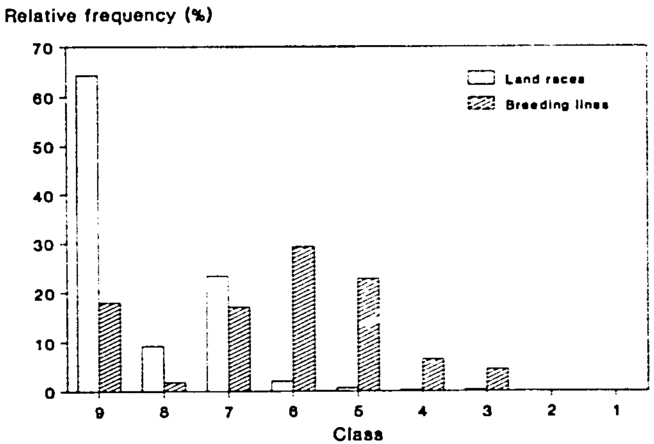

Fig. 2.1.1. Bar chart for Ascochyta blight resistance.

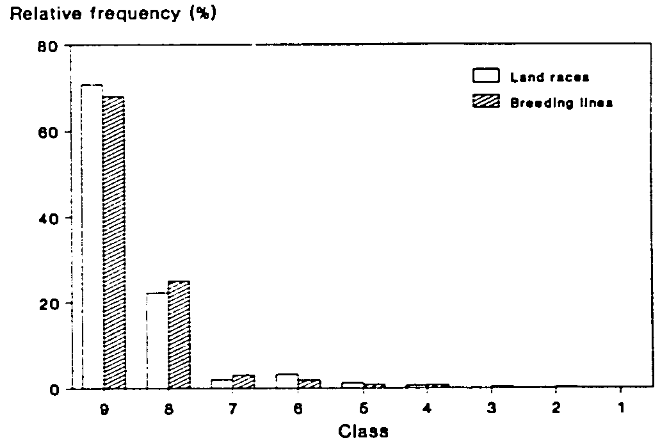

Fig. 2.1.2. Bar chart for Fusarium wilt resistance.

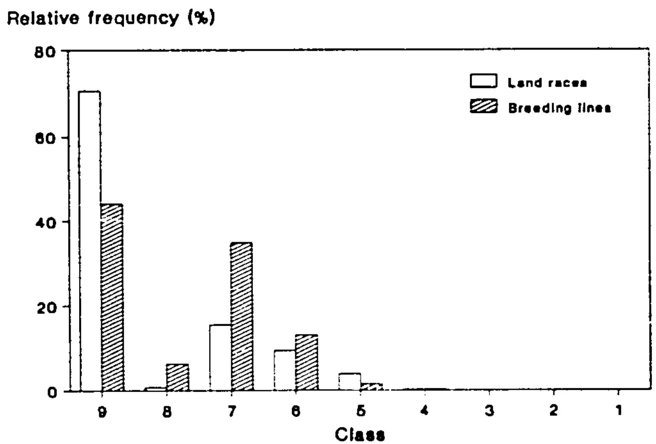

Fig. 2.1.3. Bar chart for leaf miner resistance.

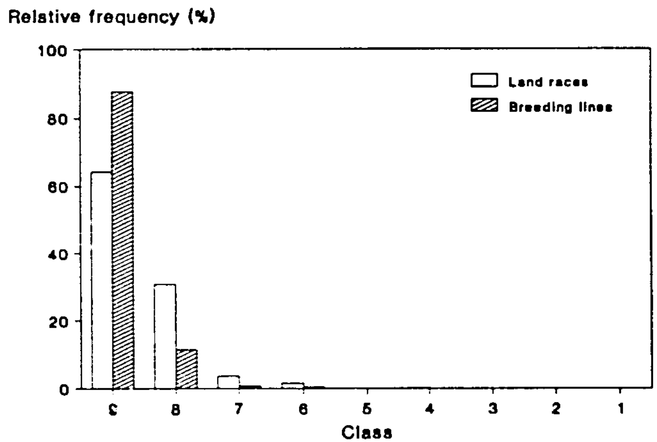

Fig. 2.1.4. Bar chart for bruchid resistance.

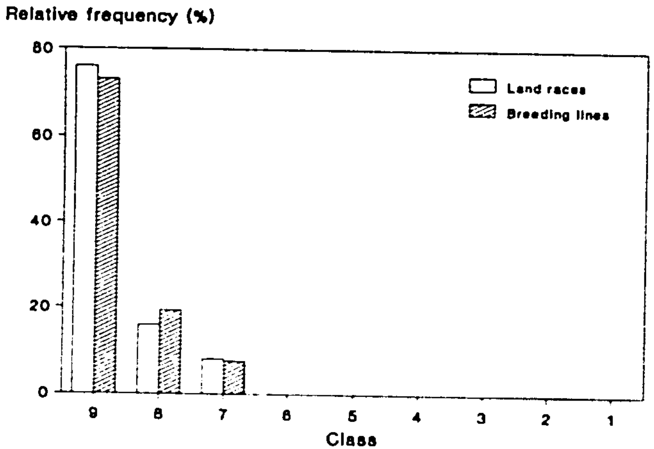

Fig. 2.1.5. Bar chart for cys' nematode resistance.

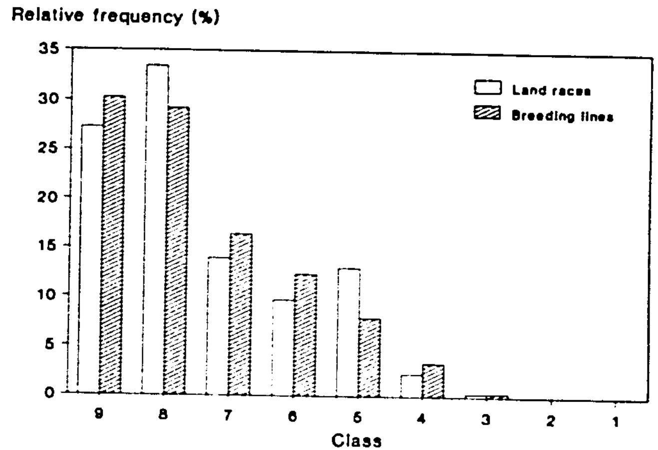

Fig. 2.1.6. Bar chart for cold tolerance.

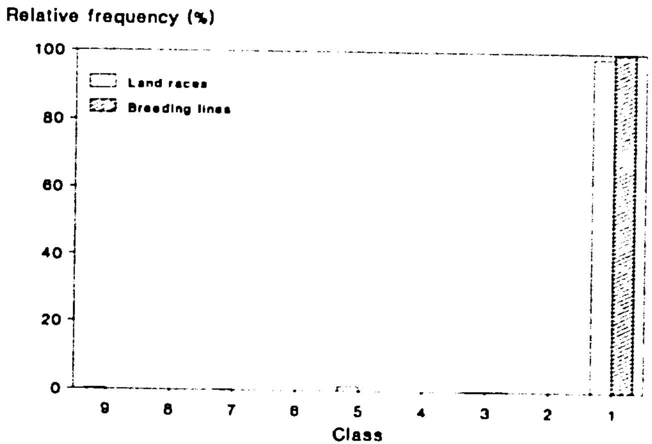

Fig. 2.1.7. Bar chart for iron deficiency tolerance.

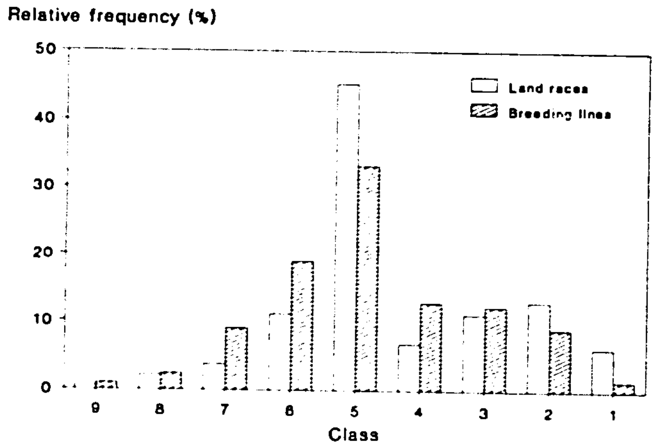

Fig. 2.1.8. Bar chart for herbicide tolerance.

Fusarium wilt, leaf miner, seed beetle, cyst nematode, and cold are given in Table 2.1.7. Efforts are underway to transfer genes for resistance for cold and cyst nematode from wild to cultivated species. Dr. K.B. Singh.

Table 2.1.7. Sources of resistance (rating 1 or 2 on a 1-9 scale) in wild *Cicer* species to biotic and abiotic stresses.

Stress	Source of resistance
Ascochyta blight	*C. judaicum*: ILWC 30-2, ILWC 30/S-1, ILWC 31/S-1; *C. pinnatifidum*: ILWC 30-1.
Fusarium wilt	*C. bijugum*: 20; *C. echinospermum*: 4; *C. judaicum*: 31; *C. pinnatifidum*: 6; *C. reticulatum*: 11. Out of these: *C. bijugum*: ILWC 7-1, ILWC 8-3, ILWC 32-2; *C. echinospermum*: ILWC 35/S-1, ILWC 39; *C. judaicum*: ILWC 4/3, ILWC 20/S-1, ILWC 46; *C. pinnatifidum*: ILWC 22-2, ILWC 29/S-2; *C. reticulatum*: ILWC 21-14, ILC 36/3.
Leaf miner	*C. chorassanicum*: ILWC 23/3; *C. cuneatum*: ILWC 37/7; *C. judaicum*: ILWC 4/1, ILWC 4/3, ILWC 4/4, ILWC 20/3, ILWC 20/S-2, ILWC 31-2, ILWC 33/S-9, ILWC 33/S-10, ILWC 37/S-2, ILWC 41/1, ILWC 43/1, ILWC 46; *Cicer yamashitae*: ILWC 3-2.
Callosobruchus chinensis	*C. bijugum*: ILWC 7-1, ILWC 7/S-5, ILWC 7/S-11, ILWC 7/S-12, ILWC 7/S-14, ILWC 7/S-17, ILWC 7/S-18, ILWC 8-3, ILWC 34/S-1; *C. cuneatum*: ILWC 37/7; *C. echinospermum*: ILWC 35/S-1, ILWC 35/S-3, ILWC 39; *C. judaicum*: ILWC 3-1/2, ILWC 33/S-6, ILWC 33/S-8, ILWC 33/S-10, ILWC 38/S-2, ILWC 46; *C. reticulatum*: ILWC 21-1/1.
Cyst nematode	*C. bijugum*: ILWC 7-1, ILWC 7-2, ILWC 7-4, ILWC 7/S-1, ILWC 7/S-3, ILWC 7/S-4, ILWC 7/S-5, ILWC 7/S-11, ILWC 7/S-12, ILWC 7/S-14, ILWC 7/S-15, ILWC 7/S-17; *C. reticulatum*: ILWC 21-1-3/2; *C. pinnatifidum*: ILWC 212, ILWC 213, ILWC 226, ILWC 236.
Cold tolerance	*C. bijugum*: ILWC 7-1, ILWC 7-2, ILWC 7-4, ILWC 7/S-1, ILWC 7/S-3, ILWC 7/S-4, ILWC 7/S-5, ILWC 7/S-11, ILWC 7/S-12, ILWC 7/S-13, ILWC 7/S-14, ILWC 7/S-15, ILWC 7/S-17, ILWC 7/S-18, ILWC 8-4, ILWC 8/S-1, ILWC 8/S-3, ILWC 32-2, ILWC 42/1, ILWC 42/2;

2.1.3. Germplasm Enhancement

The main objective of this project is to develop superior germplasm for use in the breeding programs of NARS and ICARDA. The emphasis is on cold tolerance, Ascochyta blight resistance, combined resistance to cold and Ascochyta blight, and tall stature.

2.1.3.1. Cold

F_2, F_3 and F_4 generations of crosses between cold tolerant lines of diverse origins were grown during 1989/90. The season being extremely cold, there was severe winter killing. Nevertheless, 701 plants were selected. M_3 plants of ILC 3279 line were killed. However, one mutant of ILC 482 was found to be highly tolerant to cold; its tolerance will be tested again.

Dr. R.S. Malhotra and K.B. Singh.

2.1.3.2. Ascochyta blight

Plants grown in F_2 from crosses made between blight resistant lines were killed due to cold. In mutated material (M_3) of ILC 3279, the disease did not develop. Eight new crosses have been made.

Dr. K.B. Singh.

2.1.3.3. Combined resistance to cold and Ascochyta blight

Five thousand and twenty-six F_2 plants of 15 crosses were grown in cold and Ascochyta blight nursery and 79 plants were found tolerant to cold. Of these 77 plants also tolerated blight which was not severe due to drought and cold. In F_4, 27 out of 460 progenies were resistant to cold. Ninety-five F_4 plants resistant to cold and blight were selected. Ten more crosses to combine cold and Ascochyta blight were made.

Dr. K.B. Singh and R.S. Malhotra.

2.1.3.4. Tall stature

Six crosses between tall lines of diverse origins and types have been made and F_2 seeds produced.

Drs. K.B. Singh and Geletu Bejiga.

2.1.4. Development of Improved Germplasm for Wheat-based Systems.

2.1.4.1. Bulk-pedigree method for breeding cold, Ascochyta blight and drought tolerant chickpeas

In the Mediterranean region chickpea is generally grown as a spring-sown crop. Major requirements of the crop are early maturity and terminal drought tolerance and resistance to Ascochyta blight. Research conducted at ICARDA has shown that advancing sowing date by two to four weeks to early spring in the high elevation areas or to late winter in the low elevation areas of the Mediterranean region improves the seed yield substantially. But the sowing can only be advanced with genotypes tolerant to cold at the seedling stage. We have developed a bulk-pedigree method to breed cold, Ascochyta blight and drought tolerant chickpea, which is shown schematically in Fig. 2.1.9.

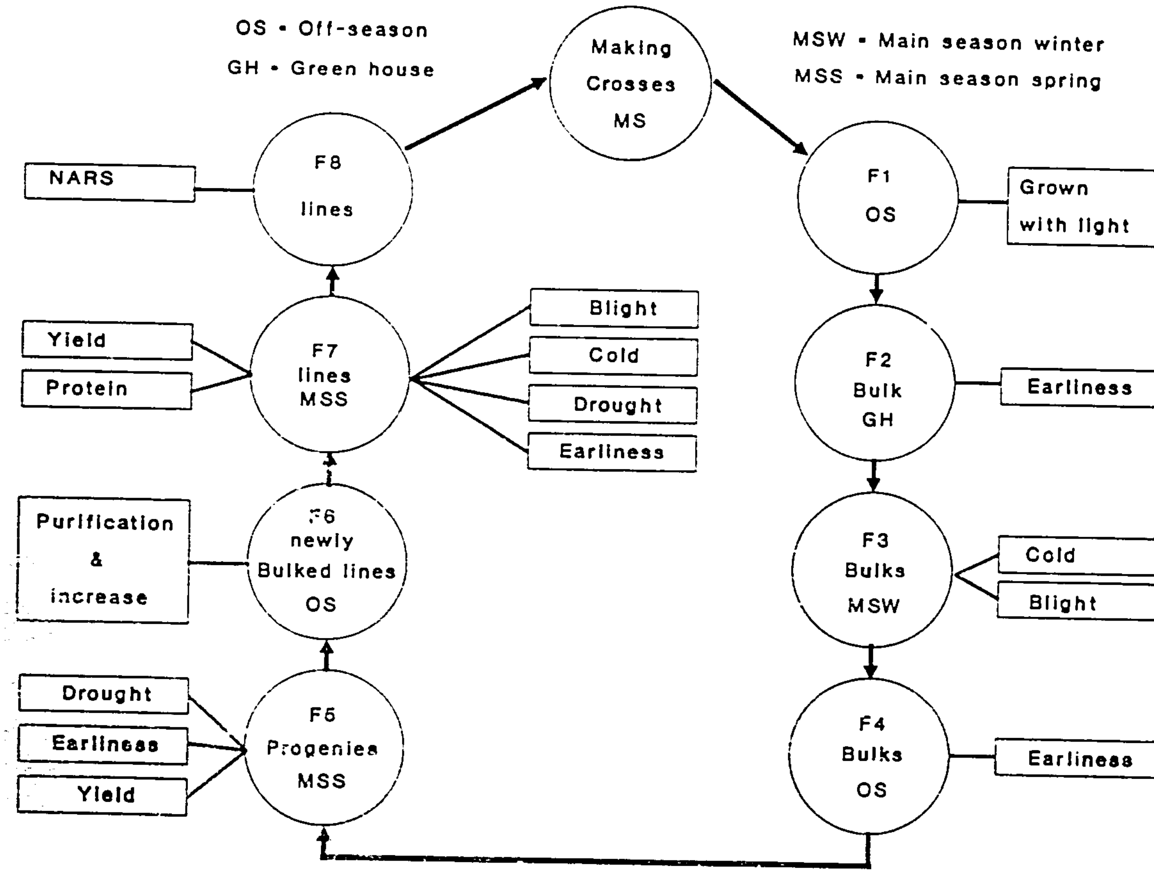

Figure 2.1.9. Bulk-pedigree method for breeding cold, Ascochyta blight and drought tolerant chickpeas.

Taking advantage of the off-season and greenhouse facilities, new cold, Ascochyta blight and drought tolerant lines are bred in a period of four years. As early-maturity lines tolerate or escape drought we select for early maturity. Selection for tolerance to Ascochyta blight and cold (at seedling stage) is done first in the early generation (F_3) and finally in the advanced generation (F_7). For drought, selection is made in F_5 and F_7, mainly through earliness and yield under droughty conditions.

Drs. K.B. Singh and G. Bejiga.

2.1.4.2. **Segregating generations**

During the 1989/90 season, 645 crosses were made, of which 268 were grown in the off-season during 1990. F_2, F_3 and F_4 bulks were grown in the period between the off-season and main season (Table 2.1.8). About 15,000 progeny rows were grown during winter and spring seasons. A total of 318 promising and uniform F_5 and F_6 progenies were bulked. These bulked lines were grown in the off-season for seed increase and purification.

The 1989/90 season being unusually cold, nearly 80% of the segregating material (F_2 to F_6) was killed by frost. Since the temperatures continued to be low for most of March (with lowest temperature reaching -8.9½C on 17 March) and April was hot and dry, the development of Ascochyta blight was poor and the material could not be effectively screened for the disease.

Dr. K.B. Singh.

Table 2.1.8. Chickpea breeding material grown at Tel Hadya during winter and spring and at Terbol during off-season, 1989/90.

Generation	No. of bulk/ progeny grown	No. of plants selected	No. of bulked progenies
F_0	645	-	-
F_1	268	-	-
F_2 Bulk	361	-	-
F_3 Bulk	367	262	-
F_3 Progeny	838	416	-
F_4 Bulk	114	2975	-
F_4 Progeny	7837	3456	32
F_5 Progeny	2943	1162	43
F_5 Progeny (Large)	412	278	15
F_5 Progeny (Tall)	729	836	23
F_6 Progeny	1183	-	120
F_6 Progeny (Large)	423	-	18
F_6 Progeny (Tall)	614	-	67
Total:			
$F_2/F_3/F_4$ bulks	842		318
$F_3/F_4/F_5/F_6$ progeny	14979	9385	

2.1.4.3. Yield performance of newly bred lines

Two hundred and eighty-six newly-bred lines were evaluated for yield at three locations (Tel Hadya, Jinderess and Terbol) and in two seasons (winter and spring). Several lines were superior in yield over the check, though only a few were significantly better (Table 2.1.9). Although the 1989/90 season was the coldest and driest in recent years, many lines sown during winter yielded more than 2 t ha^{-1} at Terbol (317 mm total rainfall) and over 1 t ha^{-1} at Tel Hadya (233.4 mm) and Jinderess (333 mm). Yields were low for spring-sown material, especially at Tel Hadya, but several lines exceeded the standard check (23 significantly). Because of severe drought, coefficients of variation were higher than in the previous seasons.

Dr. K.B. Singh.

Table 2.1.9. Performance of newly developed lines during winter and spring at Tel Hadya, Jinderess and Terbol, 1989/90.

Location and season	No. of trials	Entries: Tested	Entries: Exceeding check	Entries: Significantly exceeding check	Yield: Mean of location	Yield: Mean of highest yield (kg ha^{-1})	Range for: C.V. (%)	Range for: LSD (P=0.05) (Kg ha^{-1})
Tel Hadya								
-Winter	13	286	164	83	496	917	13-48	161-268
-Spring	13	286	50	15	308	507	6-29	53-186
Jinderess								
-Winter	13	286	149	15	993	1471	17-29	315-598
-Spring	13	286	55	6	657	887	13-27	177-375
Terbol								
-Winter	13	286	69	1	1701	2226	6-29	234-879
-Spring	13	286	21	2	627	920	10-27	155-432
Overall								
-Winter	13	286	-	-	1063	-	-	-
-Spring	13	286	-	-	531	-	-	-

2.1.4.4. Development of large-seeded, tall, early maturity and spring types

NARSs need large-seeded chickpeas to satisfy consumers preference, tall type for machine harvesting and early type for spring sowing and low rainfall areas. Lines meeting these specific needs have been bred and the best are shown in Table 2.1.10. For example, FLIP 89-19C combines tall stature, large-seed, early maturity, and high yield. FLIP 89-35C, FLIP 89-63C, FLIP 89-86C and FLIP 89-101C, being 30-40% higher yielding and 2 to 10 days earlier in flowering than ILC 482, may perform better in areas having a short growing season.

Dr. K.B. Singh.

2.1.4.5. Dual season cultivar

Chickpea is traditionally grown as a spring-sown crop in WANA, but winter sowing is being introduced because of better yield potential. Development of dual season cultivars will permit farmers to sow the same cultivar any time from early winter to spring depending upon the nature of the cropping system. We have examined results of preliminary yield trials conducted at three locations, both winter and spring, and have identified lines which have nearly the same ranking in the two seasons (Table 2.1.11). However, the majority of lines behave differently. A few examples are shown in the same Table. The difference in performance is due to the disparate requirements for cultivars sown in winter and spring. For example, cultivars would need cold tolerance and medium maturity for winter sowing, whereas for spring sowing drought tolerance and early-maturity are required.

Dr. K.B. Singh.

Table 2.1.10. Performance of some promising lines of large-seeded and early-type chickpea at 3 locations during winter and of spring-type during spring, 1989/90.

Lines	Grain yield (kg h^{-1}) Tel Hadya	Jinderess	Terbol	Mean	100 sd. weight (g)	Days to 50% flowering	Height (cm)
Large-seeded type							
FLIP 89-5C	725	1346	1592	1221	38	135	37
FLIP 89-8C	562	1119	1556	1079	43	142	39
FLIP 89-11C	814	1314	1635	1254	38	145	35
FLIP 89-19C	657	1462	1921	1347	43	135	41
ILC 482	284	1113	2222	1206	25	135	31
Trial mean	426	988	1537	984			
SE	76.7	170.6	168.2				
C.V. (%)	25.4	24.4	15.5				
LSD (P<0.05)	224.6	499.2	492.2				
Early type							
FLIP 89-35C	798	1200	1946	1315	29	132	38
FLIP 89-63C	952	1460	2016	1476	27	128	33
FLIP 89-86C	965	1544	2063	1524	23	134	40
FLIP 89-101C	863	1219	1937	1340	29	136	33
ILC 482	438	883	1905	1075	24	138	30
Trial mean	678	1156	1756	1197			
SE	89.3	164.0	145.0				
C.V. (%)	18.6	20.1	11.6				
LSD (P<0.05)	261.4	480.1	424.4				
Spring type							
FLIP 89-63C	413	752	681	615	20	54	21
S 89158	487	646	629	587	21	53	22
S 89281	589	603	623	605	36	50	26
ILC 1929	494	535	719	583	29	55	22
Trial mean	347	652	612	537			
SE	46.1	64.7	76.4				
C.V. (%)	18.8	14.1	17.7				
LSD (P<0.05)	135.1	189.5	223.7				

Table 2.1.11. Seed yield of lines which performed well either in winter or spring or both at three locations, 1989/90.

Season	Winter				Spring				Mean of 2 seasons
	Tel Hadya	Jinderess	Terbol	Mean	Tel Hadya	Jinderess	Terbol	Mean	
Dual season-PYT-E									
FLIP 89-63C	952	1460	2016	1476(3)	413	752	681	615(1)	1046(2)
FLIP 89-101C	863	1219	1937	1340(4)	406	779	639	608(3)	974(4)
FLIP 89-106C	1300	1157	2175	1544(1)	386	749	614	583(7)	1064(1)
Winter-PYT-E									
FLIP 89-68C	916	1749	1348	1338(5)	140	632	389	387(23)	863(13)
FLIP 89-86C	965	1544	2063	1524(2)	224	676	426	442(21)	983(3)
FLIP 89-105C	849	1187	1968	1335(6)	344	649	645	546(16)	941(6)
Spring-PYT-E									
FLIP 89-125C	184	1121	1714	1006(22)	379	643	720	581(9)	794(21)
S 89251	316	778	1556	883(23)	314	732	793	613(2)	748(22)
S 89281	2	721	1198	640(24)	589	603	623	605(4)	623(24)
ILC 482	438	883	1905	1075(9)	370	624	583	526(17)	801(19)
Mean	678	1156	1756	1197	347	652	612	537	
C.V. (%)	18.6	20.1	11.6		18.8	14.1	17.7		
S.E	89.3	164.0	145.0		46.1	64.7	76.4		
LSD (P<0.05)	261.4	480.1	424.4		135.1	189.5	223.7		

N.B. Figures in parenthesis show rank of the line in a trial of 24 entries.

2.1.4.6. Winter sowing

A comparison of spring versus winter sowing has been made over seven years (1983/84 to 1989/90) at three sites (Tel Hadya, Jinderess and Terbol), using common breeding lines (testing between 72 and 384 lines). The winter cold of 1984/85, 1988/89 and 1989/90 was more severe than in normal years and the spring of 1983/84, 1988/89, and 1989/90 (especially at Tel Hadya) was much drier than normal years.

The seed yield data in Fig. 2.1.10 showed that winter-sown trials on average produced 1567 kg ha^{-1} against 939 kg of spring-sown trials, giving 66.9% or 628 kg ha^{-1} more yield. The yield differences between winter and spring were larger during dry seasons than for normal seasons. During an abnormally cold year (1984/85), yields of winter-sown trials were lower than spring-sown trials. But this trend was reversed during the 1988/89 and 1989/90 seasons which were also very cold, because of deliberate selection for better cold tolerance since 1984/85. Breeders usually select the top 10% for further evaluation and possible release; this ten percent top yielders in winter sowing produced 134.0% or 1256 ha^{-1} more than the mean yield produced in spring over seven years. Obviously, there is a big advantage of winter sowing over spring.

The adoption of winter chickpea in the region is gradually increasing (Table 2.1.12). The primary limitation is the availability of seed, which is being addressed by the national programs.

Dr. K.B. Singh.

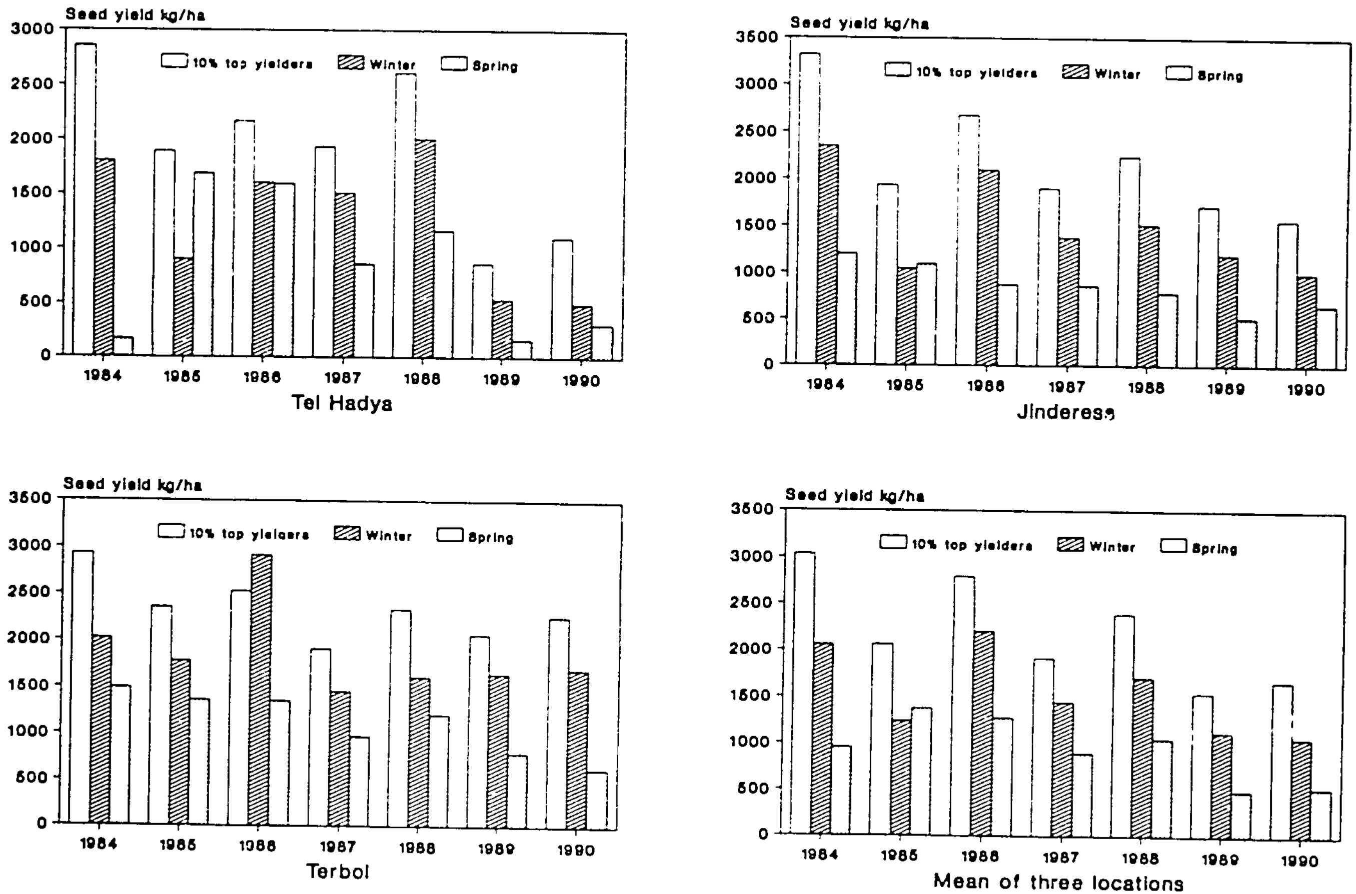

Figure 2.1.10. Mean seed yield (kg ha^{-1}) of chickpea grown in winter (,) and spring ( ) at three locations (Tel Hadya, Jinderess and Terbol) and seven years.

Table 2.1.12. A rough estimation of adoption of winter chickpea in the Mediterranean environment.

Country	Estimated area (ha)		
	1987/88	1988/89	1989/90
West Asia			
Cyprus	500	1000	1500
Jordan	-	2	20
Lebanon	-	5	50
Syria	500	1000	5000
Turkey	10	100	250
North Africa			
Algeria	100	150	300
Morocco	40	100	500
Tunisia	15	100	500
Europe			
France	-	15	200
Italy	-	25	100
Portugal	-	20	250
Spain	-	20	250
North America			
U.S.A. (California)	200	400	1250
Total	1365	2937	10020

2.1.4.7. Role of cold tolerant genotypes in winter chickpea technology

Although it is known that genotypes require cold tolerance for winter sowing in the Mediterranean region, the relationship between cold tolerance and yield in winter sowing has not been quantified. The 1989/90 season was very cold. Therefore, results of seed yield and cold tolerance obtained from 12 trials including four advanced yield trials (AYT) and eight preliminary yield trials (PYT) were examined. Each of the 12 trials comprised 24 newly bred genotypes. They were sown in randomized block design with two replications in the first week of December 1989 at Tel Hadya, Jinderess and Terbol. The plot size was 4 rows of 4 meter lenght for AYTs and 2 rows of 4 meter length for PYTs. The plots were fertilized at the rate of 50 kg P_2O_5 ha $^{-1}$. Herbicide was used to control weeds and fungicide was sprayed to protect the crop from Ascochyta blight. The same set of trials was spring-sown during the first week of March 1990 at three locations.

Observations were recorded on cold tolerance and seed yield; the analysis of variance for these traits was significant at Tel Hadya. The mean cold ratings for 12 trials at Tel Hadya varied from 5.19 to 7.75 on a 1-9 scale, where 1 = free and 9 = killed, indicating that there was considerable damage to the chickpea crop. Several lines failed to produce any yield because all plants were killed.

Mean seed yield of 12 trials during winter and spring is shown in Table 2.1.13. In two trials, AYT-E1 and AYT-E2, seed yield in winter was less than spring, whereas in the remaining ten trials yields in winter were higher. Yields of 288 entries in 12 trials sown in winter at Tel Hadya were 508 kg ha^{-1} as compared to 303 kg ha^{-1} in spring, giving an increase of 68%. At Terbol, where cold effect on the crop was negligible, the mean yield in winter was 1633 kg ha^{-1} as compared 614 kg ha^{-1} in spring, giving an increase of 165%. Yield levels at Tel Hadya were low because of severe cold in winter and an extreme terminal drought in spring.

Table 2.1.13. Mean seed yield (kg ha^{-1}) of four advanced yield trials (AYTs) and eight preliminary yield trials (PYTs) at three locations (TH = Tel Hadya, Jin = Jinderess, Ter = Terbol) in two seasons (W = winter and S = spring) during 1989/90.

	Main yield kg ha^{-1}											
	AYT-E1	AYT-E2	AYT-1	AYT-2	PYT-L	PYT-T1	PYT-T2	PYT-E1	PYT-E2	PYT-1	PYT-2	PYT-3
TH-W-mean	161	396	640	492	426	632	618	678	597	489	465	504
S.E.	58.0	59.31	70.28	93.21	76.77	60.61	56.223	89.35	91.44	74.09	75.78	55.78
C.V.	48.2	21.19	15.52	18.18	25.49	13.55	12.87	18.63	21.7	21.4	23.04	15.69
LSD	160.9	173.5	205.54	184.95	224.62	177.33	164.5	261.43	267.5	246.8	221.7	163.5
TH-S-mean	474	412	231	380	210	251	203	347	309	329	254	239
S.E.	21.85	18.25	25.87	20.34	22.77	26.50	34.10	46.17	63.44	56.84	23.48	46.19
C.V.	6.5	6.27	15.84	7.56	15.33	14.96	23.8	18.8	29.02	14.41	13.1	27.35
LSD	63.9	53.39	75.69	59.52	66.62	77.54	99.8	135.1	185.6	166.31	68.7	135.16
JIN-W-mean	890	875	1205	983	988	1062	1104	1156	1058	869	952	873
S.E.	107.64	162.80	149.42	149.51	170.62	201.39	186.27	164.08	183.78	174.91	139.11	107.57
C.V.	16.9	26.31	17.54	21.5	24.42	26.81	23.87	20.1	24.6	28.5	20.7	17.43
LSD	314.96	476.4	437.21	437.47	499.24	598.26	545.04	480.1	537.7	511.8	407.0	314.8
JIN-S-mean	781	644	719	715	626	662	639	652	664	647	641	590
S.E.	78.50	123.93	127.99	81.44	75.80	94.80	60.37	64.78	70.81	65.23	84.95	71.78
C.V.	14.1	27.19	25.16	16.11	17.11	20.26	13.4	14.1	15.1	14.3	18.7	17.2
LSD	229.7	362.6	374.51	238.3	221.8	277.4	176.7	189.5	207.2	190.9	248.6	210.01
TER-W-mean	1730	924	1920	1839	1537	1737	1659	1756	1837	1468	1654	1533
S.E.	79.86	300.27	85.13	118.95	168.23	109.78	127.52	145.04	117.06	298.31	130.51	193.62
C.V.	6.53	22.07	6.27	9.15	15.5	8.94	10.87	11.68	9.013	28.7	11.2	12.88
LSD	233.68	878.6	249.1	348.04	492.2	321.23	373.12	424.4	342.5	872.9	381.9	408.5
TER-S-mean	739	705	491	738	503	577	492	612	649	674	615	577
S.E.	64.56	57.08	63.80	52.80	92.71	62.99	62.97	76.44	62.83	118.33	80.32	64.60
C.V.	12.4	11.46	18.35	10.13	26.1	15.5	18.1	17.7	13.7	24.8	18.5	15.85
LSD	188.9	167.0	186.7	154.5	271.3	184.3	184.2	223.7	183.8	346.2	235.01	189.01

Correlation coefficient between cold tolerance and seed yield in winter at Tel Hadya was r = -0.830 with a range of -0.604 to -0.885 in different trials (Table 2.1.14), confirming that cold tolerance is a prerequisite for winter sowing of chickpea in the Mediterranean region.

Drs. K.B. Singh, R.S. Malhotra and M.C. Saxena.

2.1.4.8. Breeding for high yield and wide adaptation

Chickpea cultivars are known to have narrow adaptation. Factors influencing adaptation of a genotype are not well understood. However, it is known that genotypes with resistance to diseases and reduced sensitivity to temperature and photoperiod are generally more widely adapted. At ICARDA, a number of lines possessing Ascochyta blight resistance and cold tolerance were developed. These lines have been evaluated for yield and other attributes in the Mediterranean environment including West Asia, North Africa and southern Europe. Two lines, namely ILC 482 and ILC 3279, proved useful in several countries and have been released as cultivars (Table 2.1.3).

ILC 482 is an introduction from Turkey. The original collection, Acc. No. 26780-68, was a mixture which was purified and assigned the number ILC 482. Evaluation at ICARDA revealed that it had field resistance to Ascochyta blight, high yield and moderate tolerance to cold. It is a medium-duration line requiring 134 days to flowering and 181 days to maturity when sown during winter under Tel Hadya conditions. It has a typical bushy growth habit with a height of 50 cm. It is high in shoot biomass with over 50% harvest index.

Table 2.1.14. Analysis of variance for seed yield at Tel Hadya during winter 1989/90 and correlation between seed yield and cold.

Source of variation	DF	AYT-E1	AYT-E2	AYT-1	AYT-2	PYT-L	PYT-T1	PYT-T2	PYT-E2	PYT-E2	PYT-1	PYT-2	PYT-3
Entry	23	** 0.625	** 2.880	** 3.605	** 2.151	** 3.651	** 2.828	** 1.565	** 3.214	** 3.716	** 2.673	** 4.116	** 2.736
Rep.	1	** 0.750	NS 0.33	NS 0.083	** 1.688	NS 0.021	NS 0.083	NS 2.083	** 0.521	NS 0.521	** 0.333	* 2.083	** 0.521
experimental error	23	0.141	0.290	0.214	0.209	0.369	0.195	0.214	0.257	0.303	0.130	0.159	0.301
Correlation between SYLD and CT		-0.8025	-0.8847	-0.7912	-0.7623	-0.8694	-0.7294	-0.6042	-0.8493	-0.8699	-0.7992	-0.8345	-0.8087

SYLD = Seed yield, CT = Cold tolerance.
* Significant at P=0.05; ** significant at P=0.01; NS not significant.

It is a medium-seeded line (100-seed weight 29g) with 21.8% protein content. In 1979/80 it was evaluated in the Chickpea International Yield Trial Winter (CIYT-W) and proved to be high yielding and widely adapted in many countries. Based on its performance, it has been released in Algeria, France, Jordan, Lebanon, Morocco, Syria, and Turkey under the names ILC 482, TS 1009, Jubeiha - 2, Janta 2, ILC 482 Ghab 1, and Guney Sarisi 482, respectively.

ILC 3279 is an introduction from the USSR. The original accession, Step-noz 1, was a mixture and was separated in two lots. Tall type was assigned ILC 3279 and bushy type ILC 200. Evaluation at ICARDA revealed that it was resistant to Ascochyta blight, high yielding and cold tolerant. It is a late-maturity line (taking 149 days to flower and 183 days to mature) when sown during winter under Tel Hadya conditions. It has a tall growth habit with a height of 70 cm. It is high in shoot biomass and has harvest index of 40%. It is a medium-seeded line (100 seeds weight = 28g) with 21.5% protein content. It was first included in the Chickpea International Yield Trial-Winter (CIYT-W) in 1979 and since then it has been evaluated widely in the CIYT-W. This line proved medium yielding and widely adapted. Because of tall stature it is possible to combine harvest. It has been released in Algeria, Cyprus, Italy, Jordan, Syria, and Tunisia under names ILC 3279, Yialousa, Sultano, Jubeiha-3, Ghab 2, and Chetoui, respectively.

From the release of ILC 482 in seven countries and ILC 3279 in six countries, we can identify some attributes for the wide adaptability of a chickpea cultivar: (1) Tolerance of cold and Ascochyta blight; (2) medium maturity and medium seed size; and (3) suitability for machine harvest.

Dr. K.B. Singh.

2.1.5. Genetic Studies

2.1.5.1. Gene action for cold tolerance in chickpea

Six crosses were investigated using combining ability and generation mean analyses for reaction to cold tolerance in chickpea (Cicer arietinum L.). The combining ability variances revealed the significance of both the additive and non-additive gene effects with preponderance of dominance. The generation mean analysis revealed the presence of genic interactions besides additive and dominance gene effects. Among the interactions, additive x additive and dominance x dominance with duplicate epistasis were present. Cold tolerance was dominant over susceptibility to cold. Selection for cold tolerance would be effective in later generations when dominance is reduced after a few generations of selfing. This is being followed and in the early generation only a negative selection is exercised.

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2.1.5.2. Characterization of chickpea growing environments

Cluster analysis was used as a tool to classify chickpea growing environments into zones. Data on days to flowering and seed yield for two chickpea international yield trials during 1985-86 and 1986-87 were used for the present study. The GENSTAT hierarchal, agglomerative clustering program was employed with correlation coefficient as the distance measure and single linkage as the clustering strategy. Results revealed that by characterization of the genotype by location, interaction within a cluster/zone was minimized, and only key sites from each cluster need to be used for initial evaluation of a large number of breeding materials. These selected materials from each zone should then provide an opportunity for selection of material for specific adaptation.

Drs. R.S. Malhotra and K.B. Singh.

2.1.5.3. Genotype-environment interactions for protein content

Genotype-environment interactions for protein content was investigated in 116 lines. This study indicated that protein content was about the same during winter and spring. The heritability estimate for protein content was low. Stability analysis exhibited the presence of g x e interaction, and non-linear component of g x e interaction was significant and important. The study suggested that selection for genotypes with high protein content and stable performance should be possible through multilocation testing. No association of protein content with ten morphoagronomic characters included in this study was found.

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2.1.5.4. Diversity and multivariate association of response to three stress conditions in a world collection of chickpea

In an evaluation of the response of over 6300 kabuli chickpea accessions to Ascochyta blight, leafminer, cold, and 23 other characters there were considerable regional differences. Diversity was lower for the stress-response traits than for other characters. Accessions from West Asia, which consisted mainly of advanced breeding lines from ICARDA, had the highest frequency and diversity for resistance to Ascochyta blight, and those from South Asia for leaf miner resistance and low temperature tolerance. Worldwide, days to flowering had the highest diversity index. Bivariate log-likelihood ratio tests showed the strongest association of each of the three stress-response traits with seed yield, biological yield and harvest index. Excluding these three yield variables, a group of four characters with strong bivariate association with each stress-response trait was chosen for the discrete multivariate loglinear analysis. The four characters in each group were selected from the following six morpho-phenological characters: growth habit, canopy width, seed size, plant height, pod dehiscence, and days to flowering. The simplest log-linear model for each group consisted of both two-and three-factor association terms, but no independent factors. The six morpho-phenological characters identified by the association analyses might be important for increasing overall response of kabuli chickpea to its three major stresses: Ascochyta blight, leaf miner and low temperature.

Drs. S. Jana and K.B. Singh.

2.1.5.5. Karyotype study of Cicer species

Karyotype analyses of eight annual Cicer species, including C. arietinum, C. echinospermum, C. reticulatum, C, bijugum, C. judaicum, C. pinnatifidum, C. cuneatum, and C. yamashitae, was completed jointly by ICARDA, SCSG (Stazione Sperimentale di Granicoltura per la Sicilia, Caltaglorone, Italy) and University of Napoli. Similarity in the karyotypes of the three species C. arietinum, C. reticulatum, and C. echinospermum indicates a crossability group and explains as to why it has been possible to cross them. These three species are different than the remaining five species. It will be difficult to introgress genes between these two groups. In the second group, similarity was found between C. bijugum and C. judaicum and to some extent C. pinnatifidum. Therefore, they may be crossable among themselves which has now been realized at ICARDA. C. cuneatum and C. yamashitae were different from each other and the previous two groups. Out of the basic eight chromosomes in Cicer species, the major difference lies in the first and second chromosomes in length and presence of secondary constriction.

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2.1.6. Strategic Research

2.1.6.1. Study of P-efficiency of chickpea

Cultivation of chickpea in the Mediterranean area often takes place in locations with low levels of available phosphorus (P) in the soil. Chickpea is traditionally sown in spring and is recognized to have a high P-efficiency. The proposed introduction of winter sowing would increase the yield because much of the crop growth would occur in the more humid season avoiding heat and drought stress at the end of the growing period. The greater production of dry matter is expected to increase demand for total P. Therefore, in winter it is possible that P-deficiency could prove to be a limitation for yield on P-limiting soils.

It is often not possible to compensate P-deficiency by soil amendments for economic reasons; as an alternative, breeding for high P-efficiency could be a solution.

Eight distinct lines of kabuli type chickpea were crossed in a diallel fashion. Parents and their progenies (F_2-plants and F_2-derived lines in F_4) were grown at Tel Hadya in a low-P soil. Two P-levels (with, without 75 kg P_2O_5 ha^{-1}) and two sowing times (winter, spring) were used during the growing seasons of 1986/87 and 1987/88 seasons which differed greatly in annual rainfall.

The following conclusions were drawn from this study.

1. A low level of available P may prove as a yield limiting factor for chickpea in winter sowing, in a location where the yield of a spring sown crop may not be affected by this limitation.
2. High P-level x genotype and high P-level x genotype x year interactions for seed yield in winter sowing were demonstrated. Because of this it will be useful to develop a breeding and testing

method comprising use of different P-levels and testing over several years, to obtain P-efficient pure lines for winter sowing.

3. Yield limitations due to P-deficiency in chickpea were found to vary from location to location as well as from year to year at the same location. Therefore, it is not recommended to breed distinct cultivars for low and for high P- environments, but rather to breed for cultivars with adaptation to a variety of P conditions.

4. Selection for improved phosphorus use characteristics is not expected to cause unfavourable correlated responses with agronomic traits.

5. Strong correlation between the productivity of the parents and that of their progenies suggests the usefulness of careful evaluation of potential parents before initiating a crossing program. The results of this study are reported in detail as a Ph.D. Thesis of the University of Hohenheim, F.R. of Germany.

   Dipl. Ing. Agr. Th. Bambach (Germany), Prof. Dr. P. Ruckenbauer (Austria) and Dr. K.B. Singh (ICARDA).

2.1.6.2. Studies on drought tolerance

Chickpea is considered to be a drought tolerant crop, but little research has been conducted on Kabuli chickpea in a Mediterranean environment. A line-source sprinkler system is being used to evaluate genotypic dufferences, but a screening technique is necessary that permits evaluation of a large number of germplasm and breeding material for tolerance to drought. Since the crop experiences terminal drought, it was thought worthwhile to test the effect of delayed spring-sowing to accentuate the stress effects to permit identification of genotypic differences in drought tolerance. An experiment with four sowing dates, 28 Feb. (D1) (normal sowing date), 10 Mar. (D2), 20 Mar. (D3) and 30 March (D4) and 25 genotypes varying in maturity, plant height, seed size, and seed yield, was conducted at Tel Hadya during 1990. Due to limitation of seed, the plot size was small (4 rows 2.5 m long, 30 cm apart). Randomized complete block design was used with three replications for each date. Observations were collected on 15 morphological, phenological and seed characters. In addition, the amount of soil moisture was determined at sowing, and plant count at emergence and maturity, percent of emergence, and canopy temperatures at late vegetative, flowering and pod filling stages were recorded.

Mean performance of genotypes for 14 characters at each date are shown in Table 2.1.15. There was a gradual reduction in the performance for all characters with delay in sowing from first to fourth date. Mean seed yield of 25 genotypes on four dates of sowing are given in Table 2.1.16. Some genotypes such as FLIP 87-59C, ICC 14197, and ICC 14218 produced good yield on all four dates of sowing. On the contrary, some genotypes such as FLIP 85-142C, ILC 72 and ILC 3279 produced some yield on the first date of sowing, but virtually no yield was produced on the fourth date of sowing. The former group of genotypes was early in maturity while the later group was late in maturity.

Table 2.1.15. Mean performance of different characters on four dates of planting during 1990.

Characters	Dates of planting				
	D1	D2	D3	D4	Overall
Days to flowering	60	57	55	51	56
Plant vigour*	2.2	2.4	2.8	2.7	2.5
Ground cover (%)	64	58	33	37	48
Days to maturity	99	95	94	87	94
Plant height (cm)	25.5	25.6	23.2	24	24.6
Primary branches	2.9	2.8	2.7	2.6	2.8
Secondary branches	7.8	7.7	3.7	3.7	5.7
Pod number	11.5	13	8	7.8	10.1
No. of filled pod	10.4	11.8	7.1	7.2	9.1
% of filled pod	90	90	80	80	85
Hundred-seed weight (g)	29.3	29.2	25.7	24.2	27.1
Seed yield (kg ha^{-1})	1065	920	587	551	781
Shoot biomass (kg ha^{-1})	2525	2333	1788	1869	2129
Harvest index (%)	41.3	39.2	32.5	29.4	35.6

* Vigour score rating scale: 1 = very good, 5 = poor.

Correlation coefficients were estimated between seed yield and 13 variables on all four dates (Table 2.1.17). Seed yield was significantly correlated with earliness (flowering and maturity), plant vigour and harvest index in all four dates of sowing. Correlation of seed yield with 100-seed weight, % filled pods, % of ground cover and plant height was high only in the later dates (D4 and D3). On the other hand, shoot biomass was highly associated with seed yield on only the first date of sowing. Characters such as number of primary and secondary branches had no influence on seed yield.

Table 2.1.16. Yield performance in four dates of sowing during 1990. Data in the paranthesis indicate rank.

Entry	Yield kg ha^{-1} (Rank)				
	D1	D2	D3	D4	Overall
ILC 72	485(24)	130(25)	11(24)	7(24)	158(24)
ILC 3279	570(23)	365(23)	76(23)	37(22)	262(23)
FLIP 85-142	339(25)	150(24)	3(25)	6(25)	124(25)
FLIP 86-12	702(20)	522(22)	98(22)	9(23)	333(22)
ICCV 88504	602(21)	619(21)	530(16)	380(18)	532(20)
ICCV 88512	787(19)	661(19)	419(18)	356(19)	556(19)
ILC 1929	1439(3)	1276(2)	948(3)	737(8)	1100(4)
ILC 482	1215(11)	1033(13)	661(13)	444(16)	838(14)
ILC 1919	1043(15)	863(16)	524(17)	652(12)	770(15)
FLIP 87-5	1281(9)	1126(11)	776(10)	704(10)	972(10)
FLIP 87-7	1213(12)	1200(5)	778(9)	833(6)	1006(8)
FLIP 87-8	1341(7)	989(14)	713(11)	754(7)	949(11)
FLIP 87-51	1420(5)	1144(9)	1020(1)	728(9)	1078(5)
FLIP 87-58	1409(6)	1157(8)	635(14)	887(5)	1022(7)
FLIP 87-59	1435(4)	1420(1)	935(4)	1004(2)	1199(1)
FLIP 87-80	824(18)	854(17)	309(21)	257(21)	561(18)
FLIP 87-85	1294(8)	1096(12)	833(6)	943(4)	1042(6)
ILC 710	1278(10)	1159(7)	781(8)	470(15)	922(12)
ILC 830	909(17)	961(15)	543(15)	517(14)	732(16)
ILC 1130	1020(16)	1135(10)	689(12)	604(13)	862(13)
ILC 1141	1200(13)	833(18)	369(20)	441(17)	711(17)
ILC 1687	58[illegible](22)	633(20)	385(19)	352(20)	489(21)
ILC 1748	1113(14)	1237(4)	965(2)	694(11)	1002(9)
ICC 14197	1611(1)	1176(6)	893(5)	1007(1)	1172(2)
ICC 14218	1507(2)	1263(3)	789(7)	963(3)	1131(3)
Mean	1065	920	587	551	781
SE±	122.17	101.00	83.81	57.68	42.50
C.V (%)	19.87	19.01	24.72	18.12	9.43
LSD (P=0.05)	347.34	287.17	238.29	163.98	120.84

Table 2.1.17. Correlation of seed yield with other variables on four dates of planting at Tel Hadya in Spring 1990.

Variable	Date of sowing			
	D1	D2	D3	D4
Days to flowering	-0.7540	-0.8359	-0.7735	-0.8407
Plant vigour	-0.6565	-0.6426	-0.6296	-0.7218
Ground cover (%)	0.4442	0.5630	0.7012	0.6235
Days to maturity	-0.6880	-0.7760	-0.7705	-0.8368
Plant height	-0.3632	-0.5901	-0.5011	-0.5073
Primary branches	-0.1690	-0.0832	-0.1401	-0.2640
Secondary branches	0.0511	0.1147	-0.3268	-0.1024
Pod number	0.2049	0.4451	0.4757	0.4662
Filled pod	0.1994	0.4122	0.4631	0.4596
% Filled pod	0.1072	0.2050	0.5601	0.6466
Shoot biomass	0.7512	0.5901	0.5412	0.3400
Seed yield	-	0.7027	0.7068	0.7423
Harvest index	0.8537	0.8428	0.8781	0.9391
Hundred-seed weight	0.4985	0.2996	0.6216	0.8606

It can be concluded from this study that sowing on March 30 or 20 can be effective in distinguishing drought susceptible lines from the tolerant ones. Considerations must be given to earliness, seed weight, and plant vigour at early stages of growth, and percent ground cover in selecting genotypes tolerant of drought.

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2.1.6.3. Study on plant ideotype

The chickpea plant in the present form is inefficient in utilization of additional inputs (nutrients and water). The short stature of the plant makes it difficult to harvest by machine. As a result, improvement in seed yield has been limited, harvesting is handled manually and farmers with resources are leaving chickpea cultivation. Therefore, there is need to tailor the chickpea plant such that it may utilize inputs efficiently and could be harvested by machine. We selected from breeding material five different plant types, tall stature, long fruiting branches, tree type, bushy, and prostrate. In each class, three genotypes were chosen with nearly the same maturity period. They were sown during winter (first week of December) with three replications at two row spacings (30 cm and 45 cm apart). The plot size was 6 rows of 4 m long.

Observations were recorded on seed yield and 12 characters. The tree type group produced the highest seed yield (2793 kg ha^{-1}) followed by long fruiting branch group (2783 kg ha^{-1}) and bushy type group (2696 kg ha $^{-1}$) (Table 2.1.18). The prostrate types produced the lowest yield (1367 kg ha^{-1}). Groups with taller plants (tall type and long fruiting branches) produced more seed yield at narrower row spacing, whereas other three groups produced more yield at wider row spacings. A few characters, such as canopy width, number of secondary branches, and pod number were influenced by row spacing. The study needs to be repeated to draw conclusions on the plant ideotype.

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Table 2.1.18. Seed yield and other attributes as influenced by different plant type and row spacing at Tel Hadya, Syria, 1989/90.

Character	Tall type			Postrate			Tree type			Long fruiting			Bushy type		
	30 cm	45 cm	Mean	30 cm	45 cm	Mean	30 cm	45 cm	Mean	30 cm	45 cm	Mean	30 cm	45 cm	Mean
Days to flowering	138	138	138	139	140	140	130	130	130	130	130	130	132	130	131
Days to maturity	176	177	177	176	177	177	173	174	174	173	173	173	175	175	175
Plant height (cm)	51	51	51	19	18	19	36	38	37	44	47	46	37	40	39
Stem Length (cm)	56	56	56	44	46	45	41	44	43	49	51	50	42	46	44
Nodules/main stem	24	25	25	21	25	23	21	22	22	20	24	22	20	21	21
Canopy width (cm)	26	35	31	57	68	63	29	39	34	27	36	32	30	40	35
Primary Branches/plant	3.3	3.4	3.4	4.3	4.3	4.3	4.3	4.1	4.2	4.2	3.8	4	4.3	4.3	4.3
Secondary Branches/plant	5.2	7.4	6.3	4.3	6.0	5.2	4.1	5.9	5	4.3	6.2	5.3	4.9	6.3	5.6
Pods/plant	21	29	25	21	27	24	18	25	22	20	24	22	28	41	35
Seeds/plant	19	26	23	12	21	17	18	27	23	16	24	20	25	38	32
Biomass yield(kg/ha)	6347	5574	5961	4708	4694	4701	5949	6003	5976	6833	6120	6477	5514	5815	5665
Seed yield (kg/ha)	2505	2188	2347	1331	1403	1367	2768	2819	2794	2933	2634	2784	2610	2781	2696
100-Seed weight (g)	31	30	31	29	28	29	31	29	30	34	33	34	30	29	30

2.1.6.4. Interspecific hybridization

2.1.6.4.1. 10 x 10 diallel cross: A 10 x 10 diallel cross including reciprocals with eight wild *Cicer* species and two cultigens (kabuli: ILC 482 and desi: CAM 67) was made. Out of 90 possible cross-combinations, 21 set 401 pods producing 480 seeds (Table 2.1.19). Contrary to common belief, crosses with the kabuli type produced more seeds than with the desi type. *C. reticulatum* was a good pollen parent. Generally, F_1 seeds were produced from the known crossable combinations, *C. arietinum* with *C. echinospermum* and *C. reticulatum*, and *C. echinospermum* with *C. reticulatum*. Success has been reported from a few more cross combinations, although their validity is not known. Nevertheless, success in producing hybrid seeds in *C. arietinum* x *C. bijugum* is very encouraging because no success between such cross-combination has been reported by other researchers.

Table 2.1.19. Seed set in a 10 x 10 diallel cross made at Tel Hadya, Syria, 1989/90.

Female/Male	A-K	A-D	B	E	J	P	R	Total
C. arietinum (A)K	-	55	19	51	0	3	79	207
C. arietinum (A)D	43	-	16	38	0	0	52	149
C. bijugum (B)	6	3	-	2	0	0	3	14
C. echinospermum (E)	20	10	0	-	0	0	7	37
C. judaicum (J)	0	2	0	0	-	0	0	2
C. pinnatifidum (P)	0	0	0	0	0	-	0	0
C. reticulatum (R)	40	26	0	1	0	4	-	71
Total	109	96	35	92	0	7	141	480

N.B. - = No cross was made
D = desi, K = kabuli

2.1.6.4.2. Backcrosses: In F_2 populations of interspecific crosses involving cultivated species, some plants were promising but resembled more their wild parent. A few plants were backcrossed with the cultivated species to recover cultivated species with some useful genes from wild species. A total of 206 back-crossed seeds have been produced.

2.1.6.4.3. Morpho-physiological characterization and evaluation of plants in F_2s: Selected plants from crosses between C. arietinum x C reticulatum (AR), C. reticulatum x C. arietinum (RA), C. arietinum x C. echinospermum (AE), and C. echinospermum x C. arietinum (EA) were evaluated for 15 characters. While data are still being analyzed, the results showed that yields were higher in RA, AE and EA than the cultigen, but it was lower in AR. Plant sterility was noticed in most interspecific crosses. It was highest in AE (44%), followed by RE (33%), ER (16%) and EA (14%). In the future, causes for sterility will be investigated and an attempt will be made to develop male sterility.

2.1.6.4.4. Evaluation of 7 x 4 top cross: Seven wild Cicer species were crossed with four cultivated lines and 56 crosses including reciprocals were produced during 1988/89. Though seeds were produced in many cross combinations, true F_1 seeds were produced in only 16 crosses (Table 2.1.20). Data were recorded on 15 characters, but only yield is presented in Table 2.1.20. Yields were higher when cultivated species were used as females than when wild species were used as females. Yields also differed due to differences in cultigens. Hence to realize higher yield, cultivated species may be used as female and also different varieties may be used to identify the best cross combination.

Table 2.1.20. Mean per yield (g) per plant in F_1 crosses between Cicer species at Tel Hadya, Syria, 1989/90.

Cross	ILC 482	ILC 3279	FLIP 82-150C	FLIP 85-120C	Mean
C. arietinum x C. echinospermum	12.0	17.1	8.5	16.4	13.5
C. echinospermum x C. arietinum	9.8	8.4	6.2	8.4	8.2
C. arietinum x C. reticulatum	27.5	22.1	20.4	30.4	25.1
C. reticulatum x C. arietinum	19.6	13.9	12.1	18.0	15.9
Mean parents yield	19.7	15.4	11.8	18.3	

2.1.6.4.5. Yield potential: Five percent superior yielding plants in four F_2 populations of cross combinations AE, EA, RA, and AR were selected and F_3 generation was grown at Terbol. During 1990/91 the 136 selected plants will be grown and evaluated for yield potential.

2.1.6.4.6. Mixed pollination: An attempt was made to pollinate four wild Cicer species with a mixture of pollen grains collected from eight cultigens (ILC - 195, -464, -482, -3279, FLIP 82-150C, 83-46C, 84-15C, 85-5C). Success was obtained by crossing C. echinospermum and C. reticulatum. Also, some success was obtained by crossing C. bijugum but no success was obtained by crossing with C. pinnatifidum (Table 2.1.21). However, genuineness of crossed seeds with C. bijugum will be evaluated next season.

Table 2.1.21. Success in interspecific hybridization by mixed pollens from eight parents at Tel Hadya, Syria, 1989/90.

Cross	Flowers pollinated	Seed set	% of seed set
C. bijugum x C. arietinum	76	8	10.5
C. echinospermum x C. arietinum	167	39	23.4
C. arietinum x C. reticulatum	193	25	13.0
C. pinnatifidum x C. arietinum	79	0	0.0
Total	515	72	14.0

2.1.6.4.7. 9 x 9 diallel: A 9 x 9 diallel cross among nine annual cicer species was made. Seeds from crosses C. judacium x C. pinnatifidium were obtained for the first time but no seeds were obtained from their reciprocal (Table 2.1.22).

Dr. K.B. Singh and Mr. B. Ocampo.

Table 2.1.22. Success in a 9 x 9 diallel cross between Cicer species at Tel Hadya, Syria, 1989/90.

Cross	Flowers pollinated	Seed set	% of seed set
C. arietinum x C. reticulatum	50	37	74
C. reticulatum x C. arietinum	65	5	8
C. arietinum x C. echinospermum	37	25	68
C. echinospermum x C. arietinum	31	1	3
C. reticulatum x C. echinospermum	55	3	5
C. echinospermum x C. reticulatum	46	14	30
C. judacium x C. pinnatifidum	3	2	67
C. pinnatifidum x C. judacium	7	0	0
Total	294	87	30

2.1.7. Protein Content in Newly Developed Lines

The 1989/90 season was both abnormally cold and dry. The season had 56 days below zero temperature against average of 33 days and 233 mm rainfall against normal of 328 mm. Winter-sown crop suffered severely due to -8.9½C temperature on 17 March 1990, whereas spring-sown crop was not affected by cold. Both winter and spring-sown crop suffered drastically from drought and seed yield was much lower than previous seasons. Yields of winter-sown trials remained higher than spring-sown trials. Mean protein content in seed of entries grown in winter was 22.39% which was in the normal range (Table 2.1.23). But protein content of entries grown in spring was 26.09% which was much higher than the protein content recorded in winter-sown entries. In the past, such difference was never noticed, but in other crops moisture stress is known to decrease yield and increase the level of protein content in seed. This increase in protein content needs investigation.

Table 2.1.23. Mean protein content (%) in ten preliminary yield trials (PYTs) grown during winter and spring at Tel Hadya, Syria, 1989/90.

Name of trial	No. of entries		Protein content(%)		C.V. (S.E.)			
	Winter	Spring	Winter	Spring	Winter		Spring	
PYT-E1	23	24	21.88	221	3.07	(0.471)	3.62	(0.691)
PYT-E2	24	24	21.72	26.68	2.91	(0.446)	2.3	(0.438)
PYR-T1	24	24	22.1	26.93	2.73	(0.426)	1.73	(0.330)
PYT-T2	24	23	22.74	26.46	3.30	(0.531)	2.72	(0.509)
PYT-1	24	24	22.54	24.39	3.95	(0.631)	2.81	(0.484)
PYT-2	24	23	22.33	25.96	3.79	(0.598)	1.31	(0.446)
PYT-3	24	24	22.49	26.69	4.28	(0.680)	1.92	(0.362)
PYT-4	22	24	22.54	25.57	2.29	(0.364)	3.59	(0.649)
PYT-5	10	11	22.79	24.03	3.443	(0.555)	1.73	(0.308)
PYT-L	24	24	22.74	26.98	3.31	(0.533)	2.84	(0.542)
Total/Mean	223	225	22.39%	26.09%				

N.B. E = Early, T = Tall, L = Large

2.2. Application of Biotechnology

2.2.1. DNA Fingerprinting

In cooperation with the University of Frankfurt, F.R. of Germany, we extended the use of oligonucleotide probes for DNA fingerprinting in plants. We analyzed the intra- and interspecific genetic variability within the genus Cicer and the major pathogen of chickpea, Ascochyta rabiei. The results of research during 1989/90 are summarized as follows:

1. All simple sequences tested (CA-, CT-, GATA-, GACA-, GTG-, GGAT-and TCC-multimers) are present and repetitive to various extents.
2. The complexity of the fingerprint patterns obtained strongly depends on the sequence motif used for hybridization. Fig. 2.2.1 demonstrates that hybridization of $(GATA)_4$ to restriction enzyme-digested chickpea DNA exhibits highly variable patterns for different accessions, whereas $(GACA)_4$ and $(GGAT)_4$ show limited heterogeneity, and $(GTG)_5$ provides no accession-specific information at all.
3. The optimal combination of probe and species has to be determined empirically for each case. Using different probes, species-, variety- or individual-specific patterns can be obtained. In case of chickpea, $(GATA)_4$ and $(GACA)_4$ are promising as accession-specific probes.
4. The banding patterns are somatically stable as shown in Fig. 2.2.2 and are inherited in a codominant Mendelian manner and segregate in the F2 generation as shown in Fig. 2.2.3.
5. Different pathotypes of fungus Ascochyta rabiei used for resistance

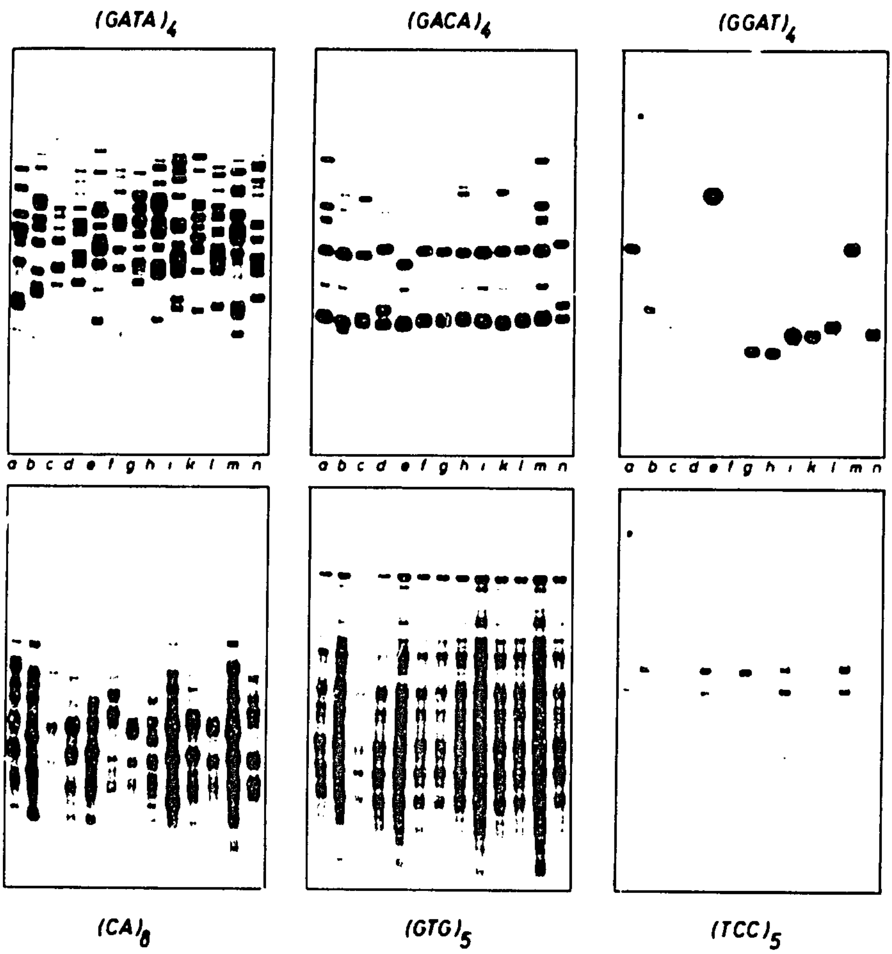

Figure 2.2.1. Different oligonucleotide probes reveal various levels of intraspecific polymorphism within chickpea. DNA from thirteen chickpea accessions derived from our chickpea germplasm collection were screened for genetic polymorphisms by in-gel-hybridization with the ^{32}P-labeled oligonucleotide probes. Digestion was performed with Taq I. Positions of molecular weight markers are given in kilobases.

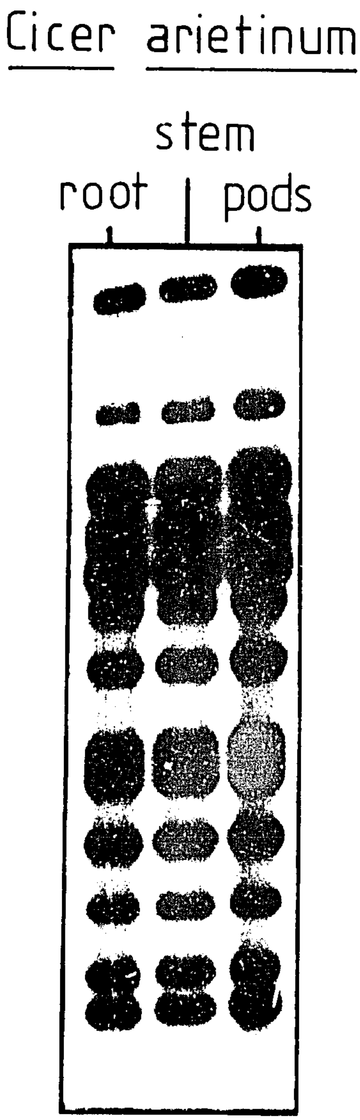

Figure 2.2.2. DNA of roots, stem and pods of a single plant of chickpea line ILC 3475 was extracted, TaqI digested and probed with $(GATA)_4$. The DNA fingerprints do not reveal any difference between the different plant tissues analyzed and indicate somatic stability.

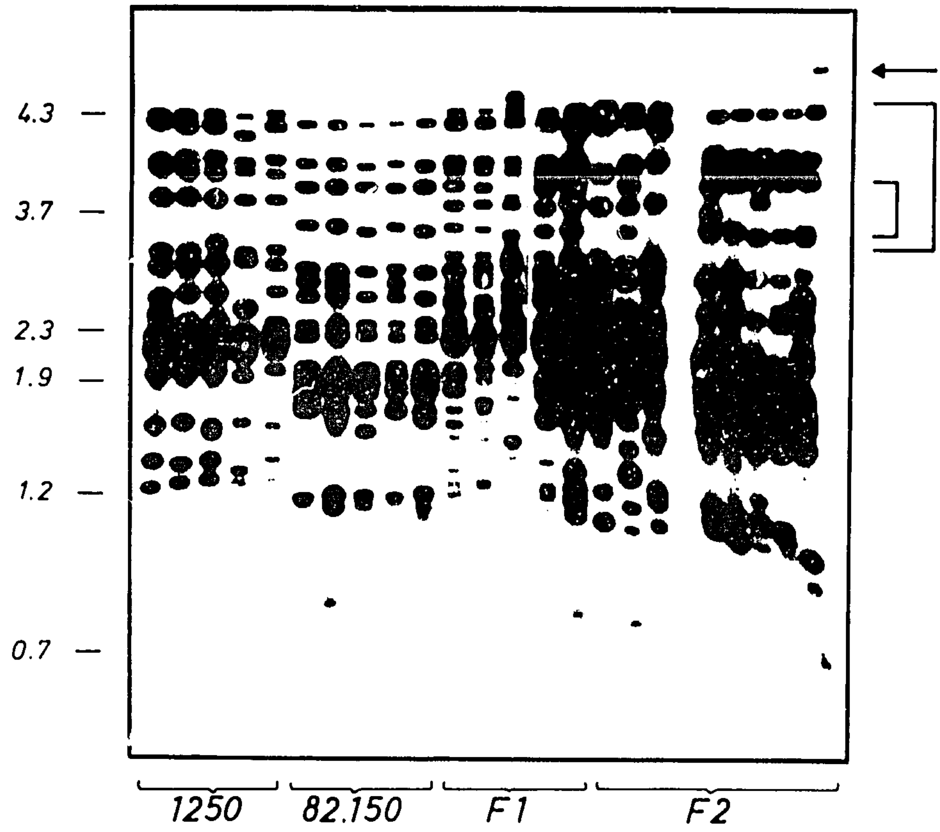

Figure 2.2.3. Segregation of parental differences in $(GATA)_4$ detected Taq I-fragments in F1 and F2 individuals of chickpea. Chickpea material used includes:
1250: 5 individuals from accession ILC 1250; 82-150: 5 individuals from accession FLIP 82-150; F1: 5 individuals from ILC 1250 x FLIP 82-150; and F2: 8 individuals from the offspring of selfed F1 plants. Total DNA was purified from leaves of individual plants, and digested with Taq I. After electrophoretic separation of the fragments, the gel was dried and hybridized to a 32P-labeled $(GATA)_4$ oligonucleotide probe. Molecular weight markers are indicated in kilobasepairs. Bars connect linked fragments. The arrow indicates a fragment present in neither parent and may possibly represents a mutated allele.

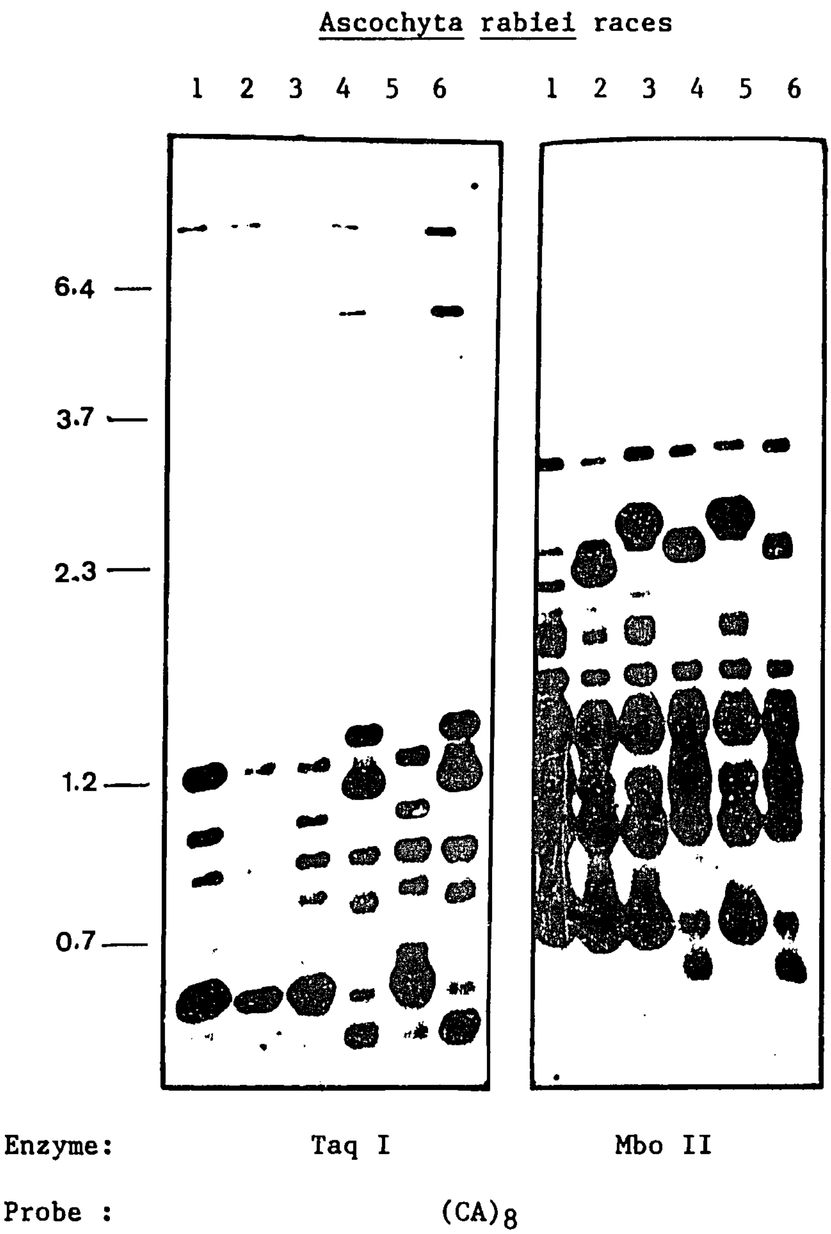

Figure 2.2.4. Pathotyping different races of Ascochyta rabiei by oligonucleotide fingerprinting. DNA was isolated from single-spore- derived mycelia of 6 different fungal isolates held at ICARDA representing 6 races differing in the level of pathogenicity against chickpea. After digestion with Taq I or Mbo II fungal DNA was electrophoresed and in-gel-hybridized to the $(CA)_8$ oligonucleotide. Four different patterns were obtained, as shown by Race 1, Race 2, Races 3 & 5, and Races 4 & 6. Positions of molecular weight markers are given in kilobases.

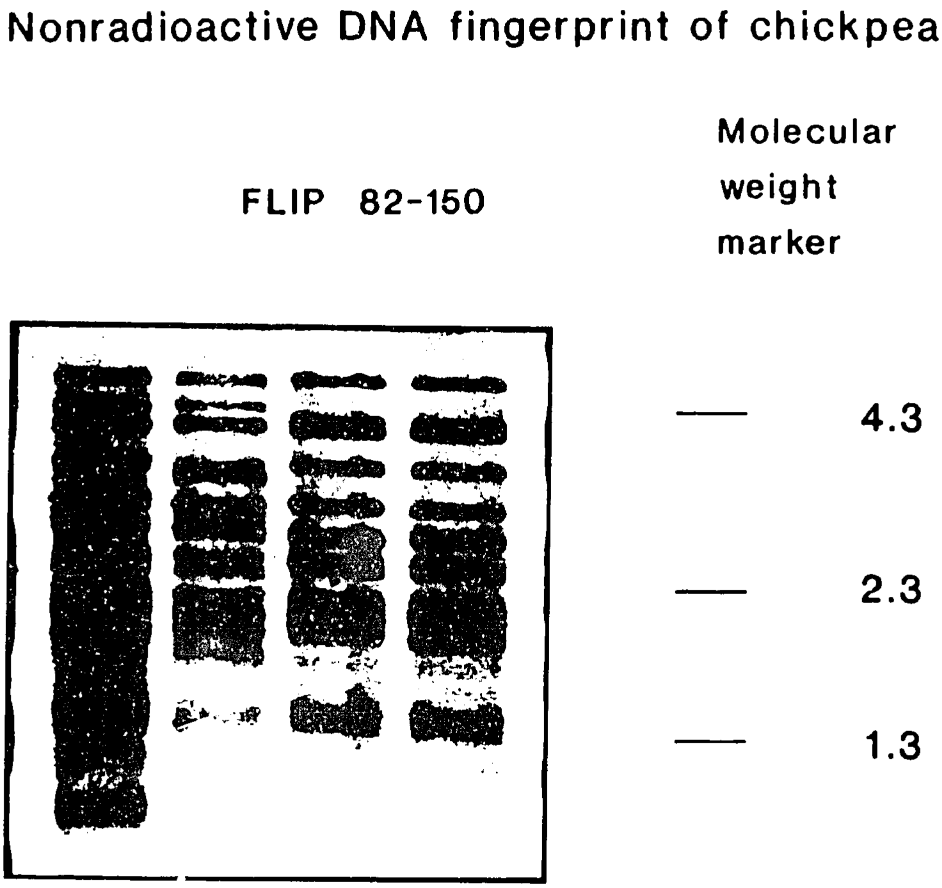

Figure 2.2.5. Nonradioactive fingerprinting of 4 plants of FLIP 82-150. Total DNA of lyophilized leaves and stems was extracted with a modified CTAB method and digested with Taq I. DNA fragments were separated according to size by 0.8% agarose gel electrophoresis. After a modified Southern transfer to a nylon membrane the material was probed with the non-radioactive digoxigenin-labeled oligonucleotide probe $(GATA)_4$. Positions of molecular weight markers are given in kilobases.

screening in chickpea at ICARDA can be distinguished by their fingerprint patterns as shown in Fig. 2.2.4.

6. Non-radioactive digoxigenin-labeled oligonucleotides can be applied for DNA fingerprinting in chickpea as shown in Fig. 2.2.5.

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2.2.2. DNA Transfer Studies

Our earlier studies had shown that Agrobacterium tumefaciens could be used as a gene vector for transformation in chickpea (FLIP Annual Report 1987). Research is being done in the Department of Agronomic Science and Plant Genetics of the University of Naples, Italy, in a collaborative project with ICARDA, on developing a suitable method for DNA transfer including the use of A. tumefaciens.

In a cocultivation experiment using A. tumefaciens strain carrying the helper plasmid pGV2260 and the binary vector p35GUSINT and ungerminated excised embryos of chickpea cultivars 'Sultano' and 'Principe', explants showing GUS (glucuronidase) expression were obtained, but the percentage was low (7% in 'Sultano' and 18% in 'Principe'). Microscopic examination of GUS^+ plants revealed that transgenic cells were located in the subepidermical and meristematic layers of the stem. Because of this, the selection of transformed tissues and regeneration of plants from these would pose a problem and would need further study.

Studies were also carried out on the direct plasmid DNA transfer using plasmid pPL1 (R. Penza and M. Leone, unpublished results) which carries GUS-INT gene from p35 GUS-INT, and ungerminated excised embryos of both chickpea cutlivars mentioned above. The frequency of embryo transformation was even lower than in the previous experiment and was obtained only in 'Principe', and the expression again was chimaeric.
Drs. G. Bile, C. Coduti, E. Filippone and F. Saccardo, Naples, Italy.

2.3. Chickpea Pathology

Chickpea suffers from several diseases in the ICARDA region, but Ascochyta blight is the most important. A major emphasis is therefore given to identify durable and stable sources of resistance to Ascochyta blight in germplasm for use in the hybridization program. Of the other diseases Fusarium wilt and other soil-borne diseases are most common in North Africa. Screening for wilt resistance is carried out in cooperation with national programs in Tunisia and Spain. Stunt (bean leaf roll) virus is present throughout the region.

The objectives of chickpea pathology research at ICARDA are to: (1) screen chickpea germplasm for identification of sources of resistance to Ascochyta blight by using field screening technique; (2) combine efforts with chickpea breeders towards development of high yielding and cold and Ascochyta blight resistant chickpea cultivars; (3) share the resistant material with national programs through cooperative research and nurseries; (4) monitor the presence of pathogenic variability in Ascochyta rabiei; (5) study the epidemiology of Ascochyta blight; (6) collect information on other chickpea diseases in the WANA region through field surveys; and (7) develop cooperative work with national programs.

2.3.1. Screening for Ascochyta Blight Resistance

2.3.1.1. Field screening

Six races of A. rabiei have been identified from Syria and Lebanon. Since only a few lines were found resistant to races 5 and 6, earlier screening of germplasm and breeding lines was carried out against a mixture of only four races (1 to 4). Subsequently the breeding program used lines resistant to race 5 and race 6 in crosses. It was observed that many lines susceptible to races 5 and 6, individually, were resistant against a mixture of races 1 to 6. The germplasm lines, wild species and breeding material are now evaluated against a mixture of 6 races since the 1988/89 season (Table 2.3.1). In 1989/90, spore suspension prepared by mixing equal amount of spores of six races was sprayed to create artificial epiphytotics in the field. The disease started well, but when temperature on 17 March 1990 dropped to -8.9°C the disease development stopped; the second fortnight of March continued to be cold. The nursery was again sprayed with spore suspension four times in April but sudden warm and dry weather did not permit disease development. Cold killed nearly 80% of the material in the nursery. The disease development in the remaining 20% of the material was poor and unreliable. Of the 256 germplasm lines evaluated, only one was found moderately resistant (rating 4), another one had intermediate reaction rating (5), and the remaining 254 lines had a ratings between 6 and 9. The moderately resistant line will be re-evaluated next season.

Table 2.3.1. Chickpea material screened in the Ascochyta blight nursery at Tel Hadya, Syria, 1988/89, using a mixture of races 1 to 6.

Material	No. of entries
F_2 populations	328
F_3 bulks	121
F_3 progenies	609
F_4 progenies	7850
F_5 progenies	2741
F_6 progenies	1188
New germplasm lines	256
Resistant desi and kabuli entries	290
IYT, AYT, PYT lines	1284
ILC 482 selections	26
Wild species accessions	174
CIABN	60

2.3.1.2. Comparison of growth chamber and greenhouse screening

Screening of germplasm and breeding lines to Ascochyta blight at ICARDA is usually done in the field. But more reliable results can be obtained under controlled conditions (greenhouse and growth chamber). Therefore, an experiment using 60 lines was conducted in the field, green house and growth chamber to make relative comparisons. Two replications were used. The material was sprayed with a mixture of six races. Since the material was destroyed by cold in the field, this trial was discarded. In the greenhouse plants were sprayed with spore suspension twice, once at seedling stage and again at initial podding stage and were allowed to grow to maturity. In the growth chamber, the material was inoculated at seedling stage.

Table 2.3.2. Evaluation of 60 lines for resistance to a mixture of races 1 to 6 of A. rabiei in growth chamber and green house at Tel Hadya, Syria, 1989/90.

	Growth chamber		Green house	
Scale	No. of accessions	% of total	No. of accessions	% of total
1	0	0.0	0	0.0
2	0	0.0	1	1.7
3	1	1.7	0	0.0
4	8	13.3	0	0.0
5	15	25.0	11	18.3
6	24	40.0	26	43.3
7	11	18.3	16	26.7
8	1	1.7	5	8.3
9	0	0.0	1	1.7
Mean rating	5.48		6.08	
S.E. of mean	0.588		0.632	
C.V. (%)	15.178		14.706	
L.S.D. ($P \leq 0.05$)	1.665		1.788	

Disease rating was done on the seedling in the growth chamber and on the adult plants in the greenhouse. The results are presented in Table 2.3.2. The mean rating in the green house was 6.1 on a 1-9 scale (1 = no disease; 9 = complete kill) against a mean rating of 5.5 in the growth chamber. The correlation between the disease ratings was r=0.5218. This suggests that screening of chickpeas in greenhouse until podding stage was as reliable as that in the growth chamber. In this study a highly resistant breeding line, FLIP 87-509C, was identified whose rating needs to be confirmed.

2.3.1.3. Evaluation of wild Cicer species to Ascochyta blight

One hundred and seventy-one accessions of eight wild Cicer species were evaluated in the greenhouse against a mixture of races 1 to 4 and a mixture of races 1 to 6 following the standard procedure. There were two replications and the higher rating of the two was assigned to the accession. The results are presented in Table 2.3.3. Whereas a large number of accessions were resistant at seedling stage, only eight accessions were resistant against a mixture of races 1 to 4 and three against a mixture of races 1 to 6 at the adult stage.

2.3.1.4. Screening of breeding lines for resistance to Ascochyta blight

All breeding lines found resistant in field screening against a mixture of races 1 to 4 in the past were evaluated in the greenhouse against mixtures of races 1 to 4 and races 1 to 6. Surprisingly none was found resistant, except FLIP 84-91C, which was moderately resistant to a mixture of races 1 to 4 and had an intermediate reaction to a mixture of races 1 to 6. This study suggests that greenhouse screening is too rigorous and highly favorable to pathogen development.

Table 2.3.3. Reaction of wild *Cicer* species to mixture of Ascochyta blight races 1 to 4 and races 1 to 6 at different stages in the green house at Tel Hadya, Syria, 1989/90.

Scale	Mixture of 4 races		Mixture of 6 races	
	Seedling	Adult	Seedling	Adult
	No. of accessions			
1	0	0	0	0
2	83	0	29	0
3	0	0	0	0
4	3	8	1	3
5	34	46	13	12
6	20	72	26	46
7	21	31	31	39
8	6	10	12	13
9	4	4	62	61
Total	171	171	174	174

2.3.1.5. Reevaluation of kabuli lines found resistant in the field screening

Screening of over 5000 kabuli germplasm accessions against Ascochyta blight in the field revealed 31 resistant lines. These were evaluated in the greenhouse against a mixture of four races and six races by permitting the plants to grow until podding stage. Standard inoculation procedure was followed. Results are presented in Table 2.3.4. Two lines, ILC 200 and ILC 6043, were found moderately resistant to a mixture of four races and ILC 6189 was found resistant to a mixture of six races. After reconfirmation in the field these three lines will be used in the breeding program.

2.3.1.6. Reevaluation of desi lines found resistant in the field screening

Screening of over 12,000 desi germplasm accessions against Ascochyta blight in the field in the past identified 690 lines resistant or moderately resistant. They were evaluated in the greenhouse in the same way as the kabuli germplasm (2.3.1.5). Results are presented in Table 2.3.5. Only ICC 4290 was found resistant to a mixture of four races, and ICC 94 was found resistant to a mixture of six races. These lines will be used in breeding program.

Table 2.3.4. Reaction of kabuli chickpea germplasm lines, identified as resistant in the field, to a mixture of four and six races of *Ascochyta rabiei* in the greenhouse, at Tel Hadya, Syria 1989/90.

Scale	Mixture of four races at				Mixture of six races at			
	Seedling		Adult stage		Seedling		Adult stage	
	No. of accession	% of total	No. of accessesion	% of total	No. of accession	% of total	No. of accession	% of total
1	0	0.0	0	0.0	0	0.0	0	0.0
2	0	0.0	0	0.0	1	3.2	0	0.0
3	1	3.2	0	0.0	0	0.0	1	3.2
4	2	6.5	2	6.5	1	3.2	0	0.0
5	10	32.3	10	32.3	1	3.2	0	0.0
6	8	25.2	8	25.2	2	6.5	1	3.2
7	6	19.4	7	22.6	6	19.4	6	19.4
8	2	6.5	2	6.5	7	22.6	7	22.6
9	2	6.5	2	6.5	13	41.9	16	51.6

Table 2.3.5. Reaction of desi chickpea germplasm lines identified resistant in the field to a mixture of four and six races of *Ascochyta rabiei* in the greenhouse, at Tel Hadya, Syria 1989/90.

Scale	Mixture of four races at				Mixture of six races at			
	Seedling		Adult stage		Seedling		Adult stage	
	No. of accession	% of total	No. of accessesion	% of total	No. of accesseion	% of total	No. of accession	% of total
1	0	0.0	0	0.0	0	0.0	0	0.0
2	1	0.1	0	0.0	0	0.0	0	0.0
3	6	0.9	1	0.1	0	0.0	0	0.0
4	6	0.9	1	0.1	4	0.6	1	0.1
5	65	9.5	17	2.5	17	2.5	14	2.0
6	191	29	220	32.1	70	10.1	72	10.4
7	173	25.3	199	29.1	153	22.1	155	22.4
8	175	25.5	178	25.9	92	13.3	95	13.7
9	68	9.9	69	10.0	354	51.3	353	51.2

2.3.1.7. Reevaluation of breeding lines found resistant in field screening

Evaluation of 1168 breeding lines in the field in the past identified 169 lines as resistant. These lines were evaluated in the greenhouse like kabuli and desi germplasm accessions (Section 2.3.1.4). Results are presented in Table 2.3.6. One line, FLIP 84-79C, was found resistant and six lines moderately resistant to the mixture of four races. FLIP 84-91C was found moderately resistant to a mixture of six races. These lines could be used in the breeding program.

Dr. K.B. Singh and Ms. Siham Kabbabeh.

Table 2.3.6. Reaction of resistant desi chickpea germplasm lines identified in the field to a mixture of four and six races of Ascochyta rabiei in the greenhouse, at Tel Hadya, Syria 1989/90

Scale	Mixture of four races at				Mixture of six races at			
	Seedling		Adult plant		Seedling		Adult plant	
	No. of accession	% of total	No. of accessesion	% of total	No. of accesseion	% of total	No. of accession	of total
1	0	0.0	0	0.0	0	0.0	0	0.0
2	4	2.4	0	0.0	0	0.0	0	0.0
3	2	1.2	1	0.6	0	0.0	0	0.0
4	13	7	6	3.6	3	1.8	1	0.6
5	62	36.7	36	21.3	2	1.2	3	1.8
6	63	33	84	49.7	9	5.3	8	4.7
7	15	8.9	31	18.3	57	33.7	55	32.5
8	4	2.4	5	3.0	55	32.5	55	32.5
9	6	3.6	6	3.6	43	25.4	47	28

2.4. Chickpea Entomology

Studies focused on the development of different control methods for chickpea leafminer (Liriomyza cicerina), the effect of cultural methods and different times of insecticide application on podborer infestation as well as the evaluation of methods for protection of seeds in storage.

2.4.1. Chickpea Leafminer

2.4.1.1. Yield loss assessment

Leafminer damage and yield losses were measured at two on-farm locations (Alkamiye and Al Ghab) in spring-sown and at Tel Hadya in winter- and spring-sown chickpea. Because of the low rainfall and late frost, yields in general were low, especially at Tel Hadya, and were not affected by leafminer control (Fig. 2.4.1). One spray of Thiodan 35 (2 cc/l) at flowering and two sprays at preflowering and flowering stages significantly reduced the percent mining in spring-sown crop at all locations with no difference between one or two sprays. Compared to previous years leafminer infestations were not as severe; only at Alkamiye was the percent mining high. In the winter-sown chickpea the percent mining was slightly lower than in the spring-sown crop.

In the beginning, middle and end of May, 10 chickpea shoots were collected from the check plots, placed in the laboratory and the number of emerging leafminers and parasitoids counted. The highest number of parasitoids emerged from the shoots collected at Tel Hadya; 20, 121 and 392 parasitoids were obtained at the 3 dates, respectively. Thus, towards the end of the season the parasitization rate increased tremendously and it would be worthwhile to study possibilities to enhance the parasitoid populations and use them as biological control agents earlier in the season.

2.4.1.2. Chemical control of leafminer

The effectiveness of neem (Azaderichita indica) extract applications (5 sprays of a solution consisting of 0.5 kg seeds/10 l water, at a rate of 500 l/ha on 12 and 23 April, 1, 9 and 17 May 1990) for leafminer control was studied in comparison with 2 sprays of Thiodan (2 cc/l at 500 l/ha) at preflowering and flowering (23 April and 9 May). Check plots were sprayed 5 times with water (500 l/ha) on the same dates as

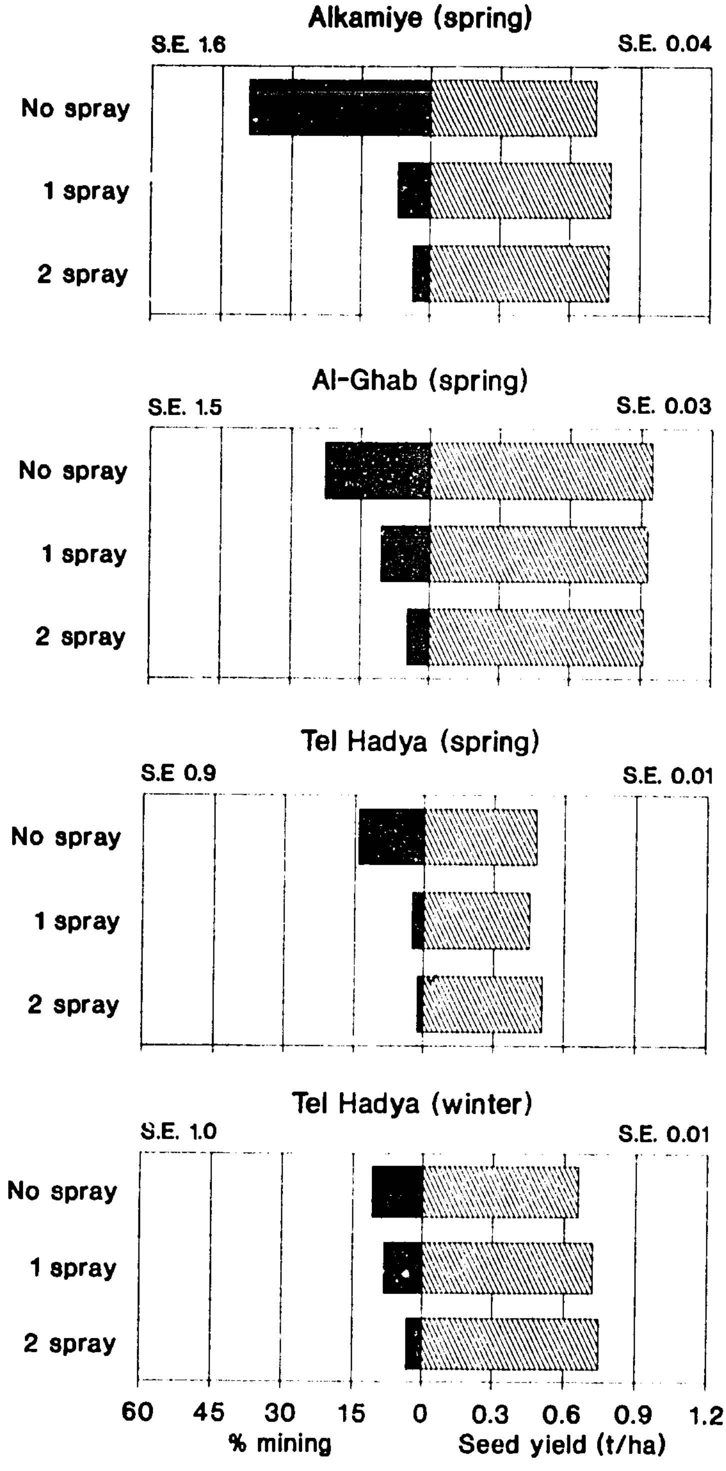

Figure 2.4.1. Effect of insecticide application (Thiodan 35, 2 cc /l) on leafminer infestation and seed yield in chickpea at Tel Hadya and farmers fields, 1989/90.

the neem extract. The percent mining was significantly lower in the neem and Thiodan sprayed than water sprayed plants (Table 2.4.1). At the first sampling date the neem extract was almost as effective as Thiodan in reducing the leaf mining, but on the second date the effectiveness was less. The neem extract application, like Thiodan spray, slightly increased seed yield, but because of the low rainfall yields were low and no significant differences were obtained.

Table 2.4.1. Effect of 5 applications of neem extract as compared to 2 sprays of Thiodan on leafminer infestation on 1 and 16 May 1990 and seed yield in chickpea, Tel Hadya, 1989/90.

Treatment	% mining on 1 May	% mining on 16 May	Seed yield kg/ha
Neem extract	13.2	13.2	408.1
Thiodan	11.2	3.2	423.6
Water	21.7	21.9	385.4
S.E.	1.6	2.5	18.5
LSD (P<0.05)	5.4	8.7	N.S.

2.4.1.3. Host plant resistance to leafminer

In addition to continuing the screening of chickpea germplasm, some previously selected, promising chickpea lines were studied to further relate the degree of resistance to the extent of damage and response to chemical control. Four chickpea lines in winter, and 8 lines in spring together with the susceptible check (Syrian Local ILC 1929) were grown without and with the protection of 1 and 2 insecticide applications of Thiodan 35, 2 cc/l). Yields were low and inconsistent, especially in spring sowing.

Leafminer infestations were monitored by placing water filled trays between chickpea rows to collect the larvae dropping from the leaves to the soil for pupation. In the winter-sown chickpea the total number of larvae per tray varied between 60 and 80 in ILCs 316, 655 and 1216, compared to a total of only 10 larvae in ILC 5901 (Fig. 2.4.2). The relatively low number of larvae found in the Local was due to severe frost damage of the plants. One insecticide application greatly reduced the number of larvae in all chickpea lines, except ILC 5901.

In spring-sown plots without insecticide application the total number of larvae was highest in ILC 5655 and Local with a mean of 81 and 100 larvae per tray (Fig. 2.4.3). In ILCs 316, 394, 655, 1048, 1216 and 3828 the mean number of larvae was significantly lower and varied between 26 and 44 larvae per tray. The number of larvae in ILC 5901 was again extremely low, with only a total of 3 larvae per tray found over the whole season. These results confirm that ILC 5901 has some mechanisms of resistance against leafminer.

In the preliminary studies on possible mechanisms of resistance the analysis of leaf exudates by HPLC revealed higher amounts of malic acid in the exudates of ILC 5901 than in the susceptible ILC 3398 and Local (ILC 1929). The role of the leaf exudates as a resistance

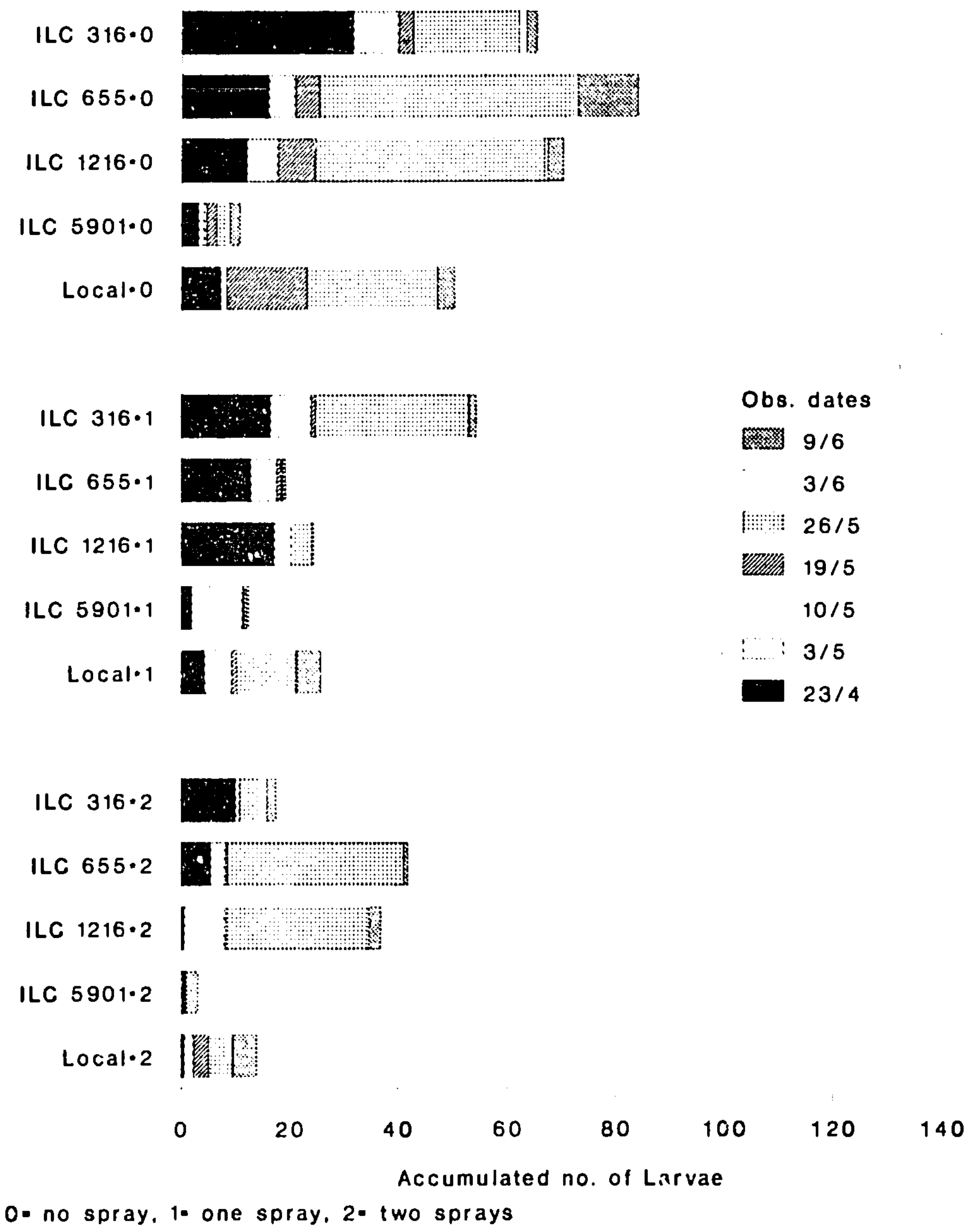

Figure 2.4.2. Cummulative number of weekly collected larvae of leafminer per tray in different winter sown chickpea lines with and without insecticide application (Thiodan 35, 2 cc /l), Tel Hadya, 1989/90.

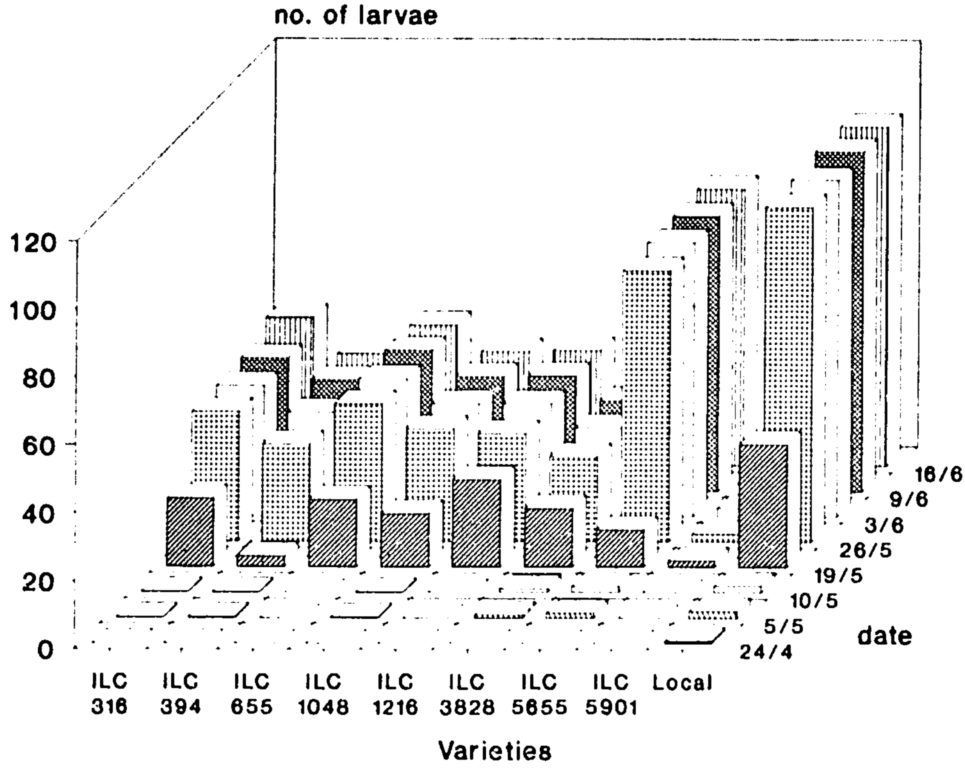

Figure 2.4.3. Mean number of weekly accumulated leafminer larvae per tray in 9 spring sown chickpea lines, Tel Hadya, 1989/90.

mechanism and their effect on leafminer has to be studied further.

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2.4.2. Chickpea Podborer

At Izraa Research Station in southern Syria experiments on some aspects of integrated control of podborer were continued. Monitoring by pheromone traps revealed that both species, Helicoverpa armigera and Heliothis viriplaca, emerged in early April and reached a peak in late April. H. viriplaca disappeared after mid-May, whereas H. armigera had two more peaks and remained present until harvest. Podborer populations and infestation this season were lower than in the last season.

In the experiment on the effect of 5 sowing dates on podborer infestation in 3 chickpea cultivars (Ghab1, Ghab 2, Local) the highest pod damage was found in the December sown chickpea (13 to 12 %) (Table 2.4.2). In the late sowing dates pod damage was only 6 to 8 percent, except for Ghab 2, which because of its late maturity at the March sowing date only had few number of pods and therefore the percent pod damage was high. In all cultivars the yield was highest in the first 2 sowing dates. At all sowing dates the yield of Ghab 2 was lower than those of Ghab 1 and Local, mainly due to its late maturity.

Table 2.4.2. Effect of 5 sowing dates on podborer infestation and grain yield of 3 chickpea cultivars, Izraa, 1989/90.

Sowing date	% pod infestation				Yield kg/ha			
	$Ghab_1$	$Ghab_2$	Local	Mean	$Ghab_1$	$Ghab_2$	Local	Mean
1 Dec. 1989	13.43	13.15	12.55	13.04	850.1	685	845.3	793.5
26 Dec. 1989	11.68	11.4	11.33	11.47	906.5	604.8	765.1	758.8
20 Jan. 1990	9.33	8.83	8.25	8.8	842	488	660.1	663.3
14 Feb.	7.7	9.67	7.4	8.26	490.3	220.7	551.7	420.9
10 March	6.35	21.28	5.35	11	206.1	69.9	229	168.3
Mean	9.69	12.86	8.98		659	413.6	610.2	

LSD ($P<0.05$):		
Dates	1.66	7.64
Cultivars	1.35	15.74
Two dates at different cultivars'	2.89	19.64

In the experiment on the effect of plant density the lowest pod damage was found at the lowest plant density of 20 plant/m_2 and the highest at the highest plant density of 50 plants/m in all 3 chickpea cultivars (Table 2.4.3). This conforms with the results of last season. The number of larvae per 5 plants and per m^2 increased with increasing plant density. The yield was highest at the density of 25 plants/m in all cultivars and lowest at the highest density for Ghab 1 and Local and at 3.3 plants/m^2 for Ghab 2.

Table 2.4.3. Effect of plant density on poborer infestation and grain yield of 3 chickpea cultivars, Izraa, 1989/90.

Plant density (plants/m^2)	% Pod infestation				Yield kg/ha			
	Ghab$_1$	Ghab$_2$	Local	Mean	Ghab$_1$	Ghab$_2$	Local	Mean
20	9.53	9.35	10.2	9.69	809.36	58.43	708.73	725.39
25	12.5	11.78	13.58	12.62	820.7	726.25	744.48	763.81
33.3	13.2	14.83	14.85	14.29	679.18	609.75	711.6	666.84
50	17.22	17.73	18.45	17.8	608.78	655.73	638.9	634.47
Mean	13.11	13.42	14.27		792.42	662.54	700.93	

LSD (P<0.05):		
Plant density	0.62	31.43
Cultivars	1.09	36.29
Two plant density treatments at different cultivars	1.42	59.29

To determine the best time of insecticide application to control podborer Thiodan 35 (6 cc/l) was sprayed at 6 different dates in Ghab 2 and Local cultivars. In the Local the insecticide application on 25 April resulted in the lowest pod damage of 3.7% and highest yield of 1003 kg/ha as compared to 12 percent pod damage and 777 kg/ha yield in the untreated check (Fig. 2.4.4). In Ghab 2 the lowest pod infestation (4.9%) and highest yield (923 kg/ha) were found in the later application date (6 May) because of its late maturity. Unlike last season the best time of application did not correspond with flowering stage of the crop, but was delayed to podsetting. This can be related to the later increase of podborer population this season. As the number of larvae per plant was low this season varying between 0.6 and 1.6 on different dates this could not be used as indication for the time of insecticide application. From the two seasons results it can

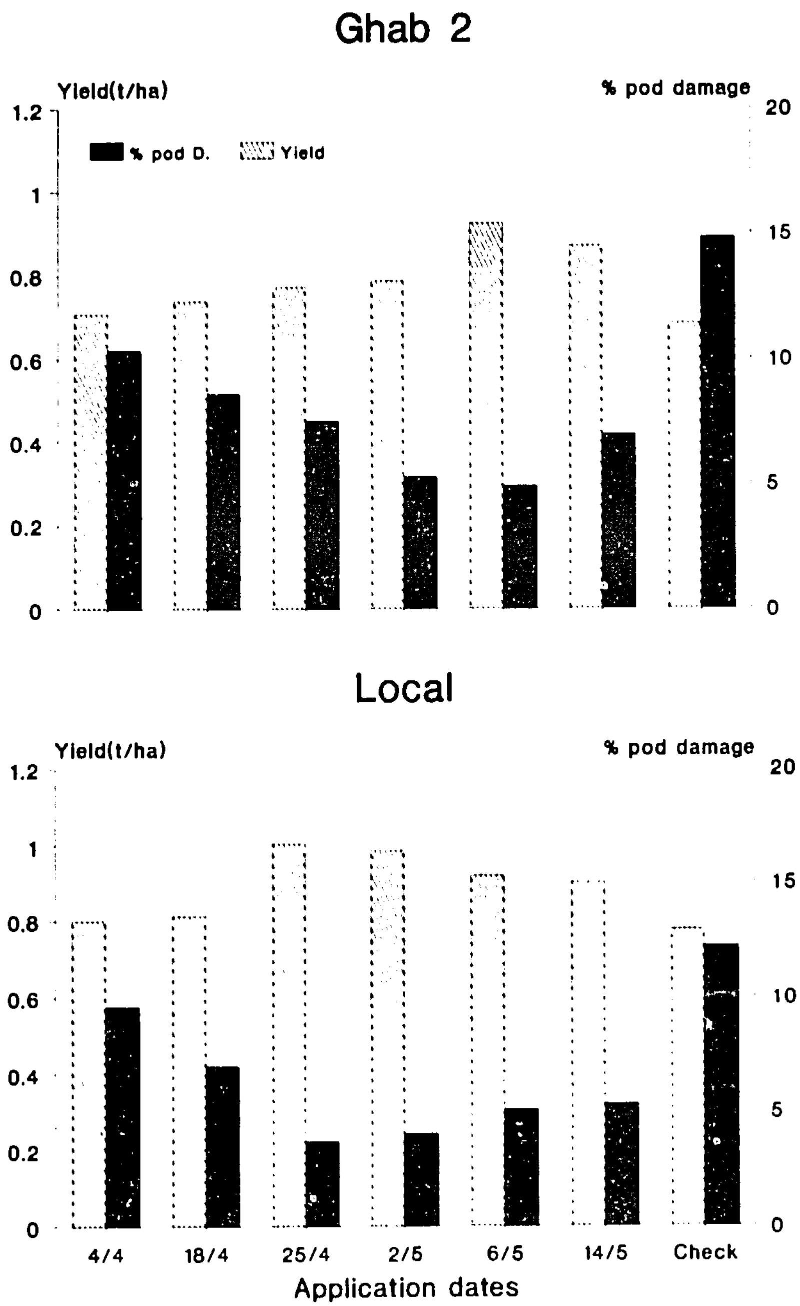

Figure 2.4.4. Effect of date of insecticide application (Thiodan 35, 6 cc /l) on seed yield and pod damage of 2 chickpea cultivars, Izraa, 1989/90.

be concluded that the pheromone trap catches and the phenological stage of the crop considered together would give the best indication for the critical time of insecticide application.

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2.4.3. Aphids

The relation between the pH of leaf washings and infestation with Aphis craccivora found last season was further studied to determine whether the pH contributes to resistance to aphids. Chickpea plants of genotypes ILC 316, 655 and 6104 (resistant) and the susceptible mutant 15040 were grown in the plastichouse and artificially infested with 5 adult A. craccivora per plant at 4 different growth stages (early vegetative, late vegetative, flowering and podsetting). Starting 1 week after infestation the number of aphids per plant was counted on 3 plants of each genotype in weekly intervals until maturity. On the same date the 3 plants were harvested. After determining the fresh weight of different plant parts these were submerged separately in 40 ml de-ionized water and shaken for 10 sec to get leaf washings of which the pH was measured. The relation between the pH of the leaf washings and number of aphids per plant could be described by an exponential regression line (Fig. 2.4.5). Above a pH of 5 the number of aphids per plant increased exponentially. The pH was higher (between 5 and 6) in the mutant 15040, which also had extremely high aphid infestations, whereas in all other genotypes the pH was lower (between 3.5 and 4.5) and the number of aphids was low. These results confirm that the pH of

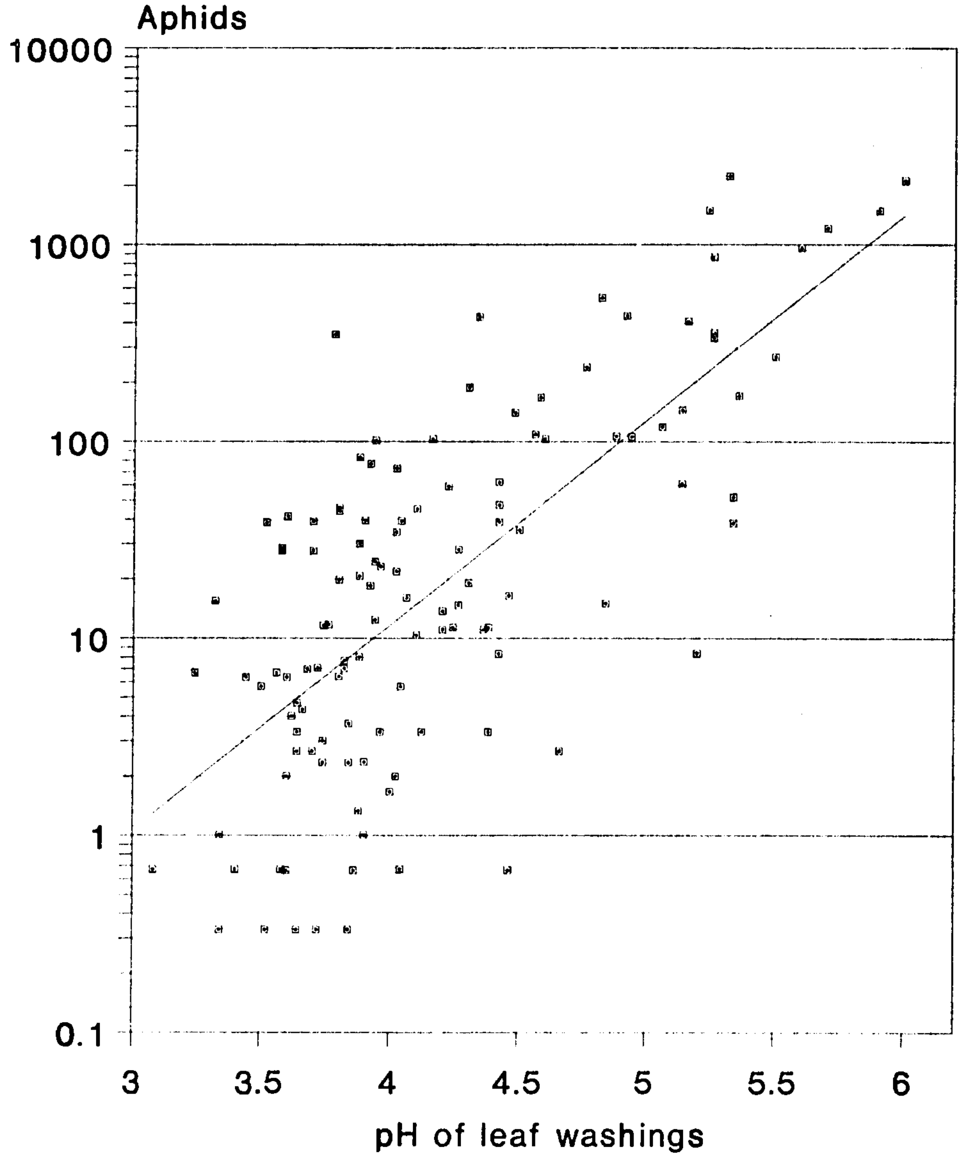

Figure 2.4.5. Regression line describing the relation between pH of chickpea leaf washing and number of <u>Aphis</u> <u>craccivora</u> per plant. Each value is the mean of 3 plants of 4 genotypes at one sampling date.

leaf washings, i.e. the composition of the leaf exudates, is an important factor determining the resistance/susceptibility of chickpea to aphids.

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2.4.4. Protection of Chickpea Seeds in Storage

A number of traditional methods of seed protection were tested for their effectiveness in comparison with 2 insecticides, Actelic (1.0 and 0.5 g/kg seed) and K-Othrin (0.5 g/kg seed). Seeds of chickpea cv ILC 482 were mixed with the following substances (per kg seed):

Salt, 20g	Red chilli, 20g
Olive oil + salt, 5ml+20g	Red chilli + salt, 20g+20g
Garlic, 10g	Defleh, 10 leaves
Garlic + salt, 10g+20g	Kina, 10 leaves
Onion, 20g	Fig, 10 leaves
Onion + salt, 20g+20g	Water, 10ml

Every 3 months 50 seeds were infested with each 4 of female and 4 male C. chinensis and the number of progeny per female and percent infestation counted after 1 month. The insecticides and olive oil + salt treatments showed a high level of effectiveness in controlling the damage. Even 10 months after the treatment the insecticides gave 100% protection (Fig. 2.4.6). In the olive oil + salt treatment only 9.4 and 3.6 percent of the seeds were infested after a period of 8 and 10 months, respectively as against 100% infestation in check. Salt alone was not effective. The seeds treated with olive oil and salt are now

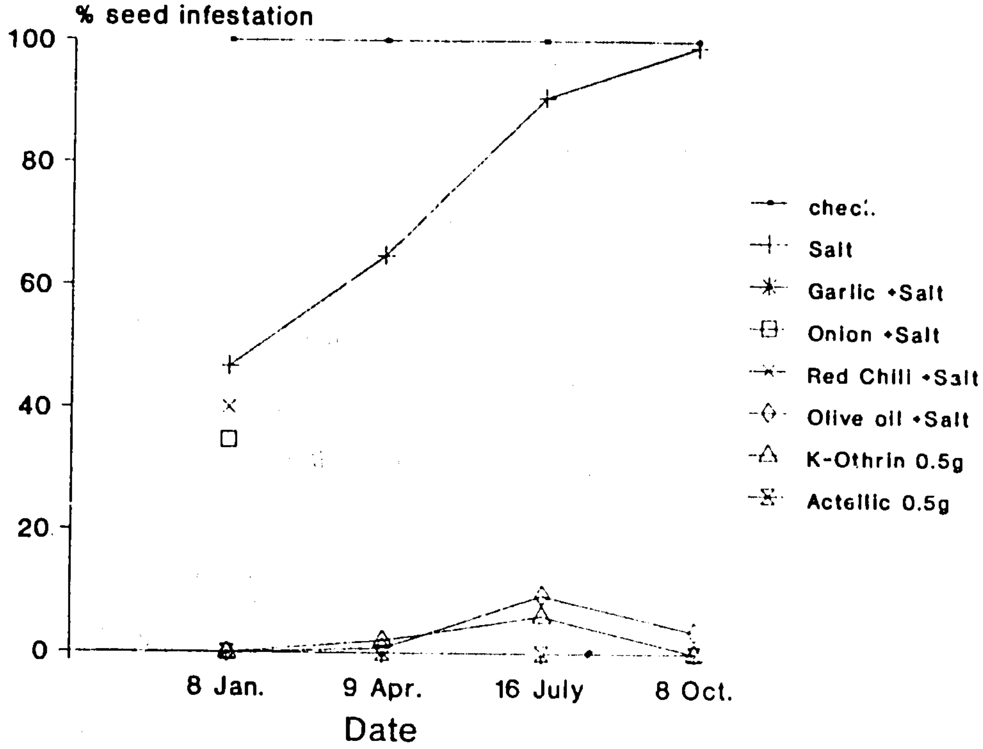

Figure 2.4.6. Effect of two insecticides and alternative treatments on the percent seed infestation with <u>Callosobruchus chinensis</u> in stored chickpea.

being tested for their cookability and any possible negative effects on nutritional quality.

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2.5. Chickpea Biological Nitrogen Fixation

2.5.1. Evaluation of Need for Inoculation in Selected Syrian Soils

Inoculation of chickpea can have a large impact on yield, where native rhizobial populations are low in number or ineffective with introduced cultivars. Evaluation of the necessity for inoculation therefore forms an important component of strategy in N_2 fixation improvement, as it allows the investigator to focus efforts in those areas where response to inoculation with improved strains is most likely.

The absence of a native rhizobial population nodulating chickpea will indicate that inoculation is needed. However, ICARDA research has shown that specific strain-cultivar interactions occur in chickpea, and necessity for inoculation may also exist where introduced cultivars cannot express their full capability for N_2 fixation in symbiosis with native rhizobial populations which have developed in coadaptation with local landraces. It is therefore necessary to evaluate both the presence (population size) and the symbiotic (N_2 fixing) effectiveness of native rhizobia with introduced cultivars to determine whether inoculation is merited.

Most probable number estimations of native rhizobial populations were performed on soils collected from 17 sites in N. Syria, utilizing chickpea grown aseptically in gravel-vermiculite substrate in large test tubes. The proportion of nodulated plants at increasing soil dilutions indicates the relative number of rhizobia nodulating chickpea, but does not indicate symbiotic effectiveness of these rhizobia. A more sophisticated methodology, employing aseptic, N-free, hydroponic gravel culture was developed, where seedlings inoculated with soil dilutions were grown for longer duration. This method allows evaluation of both the size and the symbiotic effectiveness (SE) of the native rhizobia, by comparing total N or dry matter production in the rhizobia treatments with fully N-fertilized controls.

Existing facilities and manpower in most national legume research programs in the region, however, do not allow for sophisticated evaluations of native rhizobial populations or their effectiveness; many programs are unable even to conduct consistent most probable number technique measurements of soil rhizobial populations under aseptic conditions. Therefore, a simple agronomic method to determine potential response to inoculation, utilizing crop yield response to nitrogen fertilizer in soils as an indication of necessity for inoculation, was also conducted in the greenhouse using intact soil cores from the same 17 sites in N. Syria. Soils in the cores are relatively undisturbed, providing a physically and microbiologically intact portion of the field for rhizobia and plant growth studies. The soil core experiments had in common an uninoculated treatment receiving no N fertilizer and a treatment of 120 kg N ha^{-1} applied as split dose at sowing and early flowering. Some experiments in addition included Rhizobium strain treatments utilizing strains selected for maximum N_2 fixation with the concerned cultivars in aseptic hydroponic culture. These soil core experiments were harvested at early pod-fill, and plant dry weight and N contents were determined.

The combined results of the four methods for 17 sites, shown in Table 2.5.1, indicate the value of each separately and in combination with the other methodologies. Sites are ranked by SE as determined in N-free hydroponic culture; the rhizobial population at Jinderess was most effective in N_2 fixation (producing 77% of plant dry matter obtained in the control receiving 100 mg N pot^{-1}), while at Breda the absence of rhizobia was expressed as the lowest measured SE Both population (MPN) and soil core data support the SE rankings, especially at the extremes of symbiotic effectiveness (high and low). Some exceptions, in particular at those sites with SE values near 50%, are however evident. Native rhizobial populations in soils from Deir Sawan and Beftamoun were large, but displayed moderate SE; effectiveness data was supported by a large plant response to N application in soil cores. Native populations at Mourek and Tal Sahhan were low and gave moderate effectiveness values, but chickpea plants did not respond to N application or inoculation in soil cores. The small native population in Tel Hadya field C-6 was not effective, and plants responded significantly to N application and inoculation. At Banias and Al Howeiz, large response to N applications were not observed, though SE values were very low.

Table 2.5.1. Evaluation of need to inoculate at 17 locations in Syria, using four methods to evaluate number and effectiveness of native rhizobial populations and response to N application and inoculation with superior strains.

Location	Symbiotic+ effectiveness	MPN population cells g^{-1} soil	N response‡ %	Inoc resp‡ %
Jinderess	77	4300	-8	-5
Alkamiyeh	70	5900	-1	-5
Sheikh Yousef	66	3100	-2	-
Afrin	62	6500	2	6
Tal Sahhan	57	10	-4	-6
Deir Sawan	54	3000	68	-
Mourek	54	100	-2	-5
Beftamoun	52	31000	72	-
Taftanase	48	0	43	22
Deir Kaak	47	0	22	-
Tel Hadya	46	40	87	53
Tamanaa	43	0	87	87
Salameyeh	40	6	72	-
Hamdaneyeh	38	0	64	45
Banias	38	0	17	-
Al Howeiz	36	10	19	-
Breda	33	0	88	89

+ Effectiveness of native strains in plant dry matter production under N-free conditions, as proportion of 100 mg N pot^{-1} control.
‡ Total plant response (%) of N-fertilized or inoculated treatments over unfertilized, uninoculated controls in intact soil cores.

Population, as determined by the MPN technique, was alone not an adequate indicator of the potential inoculation response. Data from soil core experiments presented here confirms earlier findings (FLIP 1988 Annual Report), where plant response to N and to inoculation in soils were closely correlated, implying that simple tests for response to N can indicate potential for response to inoculation with selected strains. Symbiotic effectiveness, evaluated using the hydroponic N-free system, gave a very reproducible and accurate estimation of necessity for inoculation and, in addition, gave accurate estimations of soil rhizobia populations. In this methodology evaluation results from hydroponic SE testing were generally well supported by N response data in soil cores, with the exception of some sites having intermediate SE values. Because soil core studies can be conducted without special facilities, this method is recommended for survey of need to inoculate in chickpea.

Dr. D. Beck.

2.5.2. Strain-Cultivar Interaction for Symbiotic Efficiency in Chickpea

Data from field and greenhouse experiments conducted during the last 3 years with a range of improved chickpea cultivars and rhizobia strains nodulating chickpea have shown that strain-cultivar specificity for N_2 fixation in Kabuli chickpea exists. In field experiments using a range of cultivars and 3 serologically-distinct strains, differences in strain nodule occupancy, seed yield, crop N yield, percentage of N derived from fixation (%Ndfa), and N fixed were significant for cultivar, strain and the interaction (see 1989 Annual Report).

The degree of interaction between cultivars and strains is most apparent under aseptic N-free conditions using a hydroponic system in the greenhouse, where all plant N is obtained from the seed and N_2 fixation. In several such experiments, the ICARDA chickpea collection of 110 isolates/strains were evaluated for N_2 fixation performance with

6 cultivars, with the objective to select superior strains for further studies in inoculation response.

Although strains #36 and #39 (selected previously for international inoculation response trials) show the best performance across cultivars, the most efficient strain for each cultivar may be different (Table 2.5.2). Strain #36 has high-moderate SE on ILC 482, ILC 5396, and ILC 6327, but compared to the most effective strain has low SE with ILC 195, ILC 3279 and ILC 6281. Strain #39 has low SE on ILC 482, but relatively high SE with ILC 3279. Only strain #38 gave highest SE on more than one cultivar, but fixation was relatively low with cultivars ILC 482, ILC 5396, and ILC 6281. Strains #36, #38, and #39 are commercial strains, obtained from USA collections of the Nitragin Co. or USDA-ARS in Beltsville, MD. Strains #69, #86, and #92 were obtained from field isolations in Turkey, France and Syria, respectively.

This interaction between strains and cultivars for N_2 fixation efficiency, in addition to a similar interaction for competition and nodule formation (unpublished data), complicates the approach to wide-scale inoculation of chickpea cultivars, especially where new improved cultivars are being released on a regular basis. Two strategies may be used to increase N_2 fixed by the chickpea crop. Selection of cultivars for high N_2 fixation with a broad range of rhizobia reduces the need for inoculation with specific strains; in these trials cultivar ILC 6281 had the highest SE while ILC 3279 was the least effective fixer with a range of strains (Table 2.5.2). This approach, however, may fail where native strains are absent or ineffective. Alternatively, mixtures of highly effective strains may be used as inoculants. This approach works with some cultivars, but is dependent on strain-cultivar interaction for competitiveness in nodule formation. Investigations into these aspects of host-strain specificity are continuing.

Dr. D. Beck.

Table 2.5.2. Symbiotic efficiencies (SE) of 6 superior rhizobia isolates on 6 diverse chickpea cultivars, as evaluated under aseptic N-free hydroponic system in the greenhouse.

Cultivar	Symbiotic efficiency rating+ Strain designations #36	#38	#39	#69	#86	#92	Mean of 110 strains
Cultivar mean	70	69	70*	66	68	60	43
ILC 195	61	60	61	67	84*	66	44
ILC 482	80*	59	58	42	57	46	38
ILC 3279	30	55*	47	40	34	33	29
ILC 5396	83	71	72	86	79	89*	48
ILC 6281	81	102*	85	85	73	63	55
ILC 6327	86	68	97*	76	81	64	45

+ Symbiotic efficiency (SE) calculated as:

$$SE = \frac{\text{Total shoot nitrogen of strain treatment}}{\text{Total shoot N of 100 mg N pot}^{-1}\text{ control}} \times 100$$

* Indicates the strain with highest SE for each cultivar.

2.5.3. Effect of Moisture on N_2 Fixation in Spring-sown Chickpea

Earlier studies have shown that spring-sown chickpea, under the rainfed environment of the Tel Hadya area, obtained only a small proportion of its nitrogen from biological nitrogen fixation. During 1986-87 and 1987-88 seasons, the spring-sown crop at Tel Hadya fixed only 38% (9 kg ha^{-1}) and 18% (7 kg ha^{-1}) of total N, respectively, in contrast to 70-80% (88-127 kg ha^{-1}) fixed by the winter-sown crop.

During the 1988-89 season, an experiment utilizing the line-source sprinkler and ^{15}N microplots was conducted in cooperation with the legume physiologist to determine the effects of variable moisture supply on N_2 fixation in 6 spring-sown chickpea lines. The material tested included 4 kabuli-type lines (3 of Mediterranean origin and 1 ICARDA cross) and 2 desi lines from ICRISAT. These cultivars were part of a group of 20 cultivars tested for drought tolerance, water use efficiency and yield response to increase in moisture supply (see FLIP annual report, 1989, pp 107-116).

Cultivar ICC 4958 was earliest in maturity, and had the highest seed yields and water use efficiency (WUE) at all moisture levels (Table 2.5.3). Poor adaptation in cultivar FLIP 85-4C was indicated by late maturity, no seed production under the low moisture regime, and low seed yield but high biological yield production with high moisture. The cultivars of Mediterranean origin (ILC 1919, 1929, and 1930) performed similarly at each moisture level; the Indian cultivar ICC 10448 produced seed yields similar to these cultivars but lower biological yields with a lower water use efficiency. In general, the results showed that low moisture stress tolerance of cultivars could be estimated by their time to flowering (earliness) and seed yield potential (under high moisture).

Table 2.5.3. Characteristics and yields of six spring-sown chickpea cultivars under low (280 mm) and high (499 mm) moisture regimes. Tel Hadya, 1988-89.

	Driest treatment					Wettest treatment			
	Days to	Yield		WUE+ for		Yield		WUE for	
Cultivar	flower	SY	BY	SY	BY	SY	BY	SY	BY
ILC 1919	54	257	1337	1.59	8.25	1885	4553	5.29	12.55
ILC 1929	52	175	1013	1.11	6.41	1943	4713	5.26	12.85
ILC 1930	56	83	852	0.54	5.51	1822	4613	5.10	12.84
FLIP 85-4C	62	0	1092	0	63	598	6513	1.54	14.62
ICC 4958	48	635	1310	4.12	8.49	2467	5410	41	14.07
ICC 10448	56	205	781	1.37	5.23	1688	3777	4.71	10.22

+ WUE = water use efficiency, in kg/ha/mm evapotranspiration for seed and biological yields.

The two cultivars producing the highest total nitrogen yields at all moisture levels were FLIP 85-4C and ICC 4958 (Figure 2.5.1). High N production in FLIP 85-4C can be related to late maturity; longer duration of N uptake and N_2 fixation processes prior to partitioning of photosynthates to pod filling resulted in N yields 30 kg ha^{-1} higher than the next best cultivar in treatments receiving supplementary moisture. Cultivar ICC 10448 produced lowest total N at all moisture levels. The 3 Mediterranean cultivars behaved in a similar manner, producing 27-35 kg N ha^{-1} at low moisture, 56-63 kg N ha^{-1} at moderate moisture and 85-100 kg N ha^{-1} under the high moisture regime.

The proportion of N derived from N_2 fixation (%Ndfa) increased with increasing moisture, indicating that moisture was limiting fixation at the lower levels (Figure 2.5.1). Levels of %Ndfa between cultivars at each moisture level were similar, with 16-23% (mean 19%) at 290 mm, 38-46% (mean 41%) at 407 mm, and 60-69% (mean 64%) at 499 mm moisture. Fixation efficiency at the high moisture level corresponds favorably with that measured over 2 seasons in 8 cultivars of winter-planted kabuli chickpea, where average %Ndfa was 65%. In this experiment, symbiotic efficiency was highest in cultivar ICC 4958 at all moisture levels, with 23, 46 and 69 %Ndfa at low, medium and high levels of moisture, respectively. The other Indian cultivar, ICC 10448, had the lowest %Ndfa at all moisture levels.

Excluding cultivar FLIP 85-4C, quantities of N fixed did not vary much between cultivars at each moisture level (Figure 2.5.1); cultivar averages for each moisture level were 5, 24, and 59 kg N ha^{-1} for low, medium and high moisture regimes, respectively. The largest differences between cultivars at a given moisture level were observed in the two Indian cultivars, where N fixed in ICC 4958 exceeded that in ICC 10448 by 13 and 18 kg ha^{-1}, or 29 and 22%, respectively, at the moderate and high moisture levels.

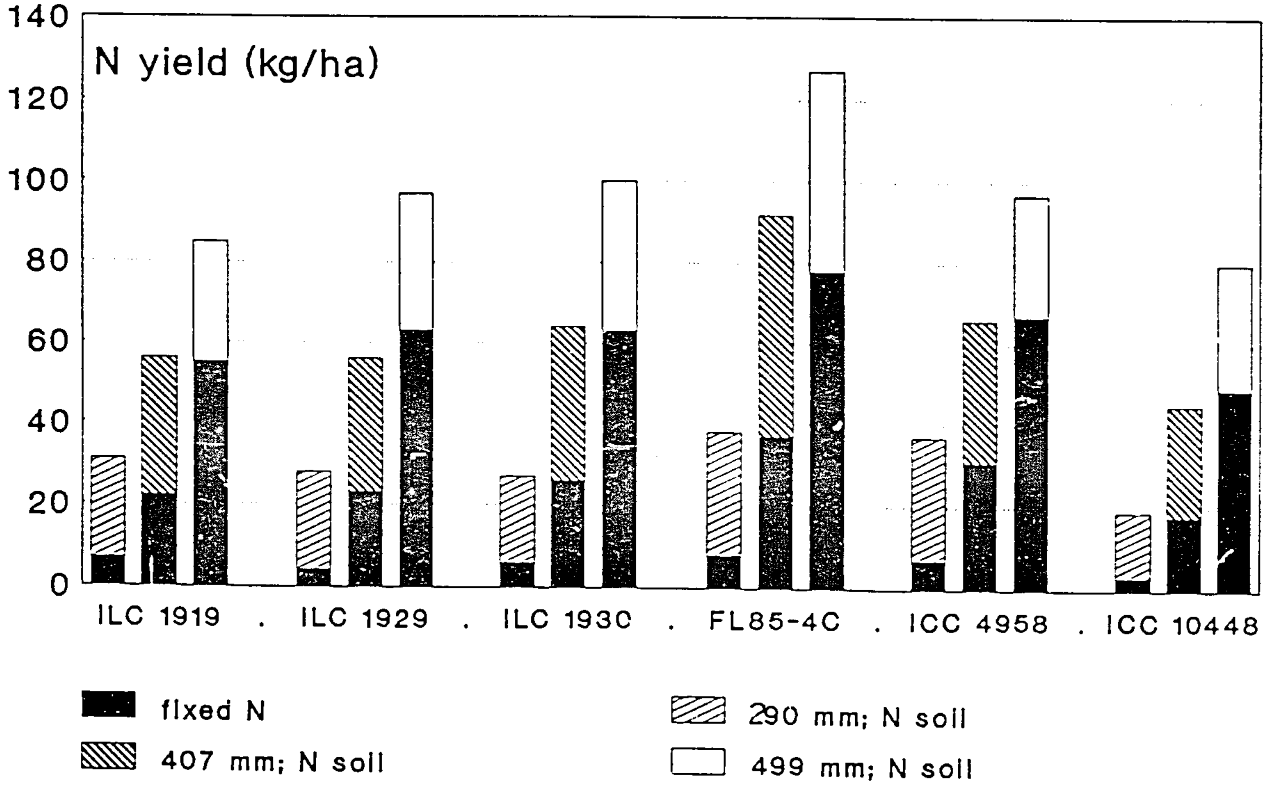

Figure 2.5.1. Nitrogen yield and source in 6 chickpea cultivars grown at 3 moisture levels. High, moderate and low levels correspond to 290, 407 and 499 mm. Tel Hadya, 1988/89.

In Fig. 2.5.1, the top portion of each bar represents the quantity of plant N derived from the soil; the bottom (black) portion of the bar represents quantities of N from fixation. The average quantities of soil N utilized by the crop at the different moisture levels was 24, 37 and 35 kg N ha^{-1} for low, medium and high moisture, respectively. These values approximately represent the total amount of N removed from the soil by the crop, assuming removal of seed and straw from the field at harvest, but neglect N input from roots and nodules.
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2.6. Chickpea Physiology and Agronomy

2.6.1. Response of diverse genotypes to varying moisture supply

The long-term average seasonal precipitation at Tel Hadya being 328 mm, it is a good site for studying the response of spring sown chickpea to varying levels of moisture supply created in the post-rainy period by line-source sprinklers. Genotypes tolerant to drought as well as those that respond well to additional moisture supply can be identified.

Studies were continued at Tel Hadya in the 1989/90 season when total seasonal rainfall was 233.4 mm, using 25 diverse chickpea genotypes sown in spring. Nine moisture supply levels could be created with the lowest being 233.4 mm (rainfed) and the highest 458.4 mm (rain + supplemental irrigation).

Averaged over all the genotypes, the yield decreased as the moisture supply reduced (Table 2.6.1). The seed yield was more sensitive to decrease in moisture supply than the total biological yield because variations in moisture supply were created in the reproductive phase when rainfall had nearly stopped. The harvest index also decreased as the moisture supply decreased.

In a few selected genotypes, access tubes were put to measure soil moisture extraction and compute total water use in the extremes of the moisture supply treatments. The data are presented in Table 2.6.2. ICC 4958 gave nearly highest values for total evapotranspiration (Et) under both moisture supply conditions, and highest water use efficiency (WUE) for seed yield. ILC 1930 was next. ILC 1919, on the other hand gave high WUE at highest moisture supply, but had low value under rainfed situation. Thus, it was possible to identify genotypic differences in water use efficiency under various moisture supply conditions and this information could be of value in breeding genotypes with better WUE.

Although the yield of all the 20 genotypes was linearly related to moisture supply, there were significant differences in their response, as reflected by differences in the slope and the intercept (Table 2.6.3) of the regression lines relating mean yield (average over 4 replications) and moisture supply. ILC 1929 had highest slope and lowest intercept indicating that it could respond well to increased moisture supply but would suffer greatly when moisture supply was limited. On the other hand ILC 1272, ICCL 82001, and ICC 10449 had higher intercept and low slope indicating a measure of tolerance to drought but an inability to respond to increased moisture supply. Intermediate group was represented by lines such as ICC 4958 with reasonably high slope and intercept. Such lines should be of particular interest for spring-sowing in the areas of variable and unpredictable rainfall, as is common in parts of nothern Syria.

Table 2.6.1. Effect of total seasonal moisture supply on the mean performance of 20 chickpea genotypes sown in spring at Tel Hadya, 1989/90.

Moisture supply (mm)	Seed yield (kg/ha)	Total biological yield (kg/ha)	Harvest index
458.4	2173	4774	0.47
428.4	1744	3945	0.44
398.4	1722	3838	0.46
368.4	1232	2953	0.42
338.4	1032	2554	0.41
308.4	784	2111	0.38
278.4	708	1967	0.37
248.4	652	1763	0.38
248.4	652	1763	0.38
233.4	604	1755	0.35
S.E.	45.0	85.3	0.01
LSD (P<0.05)	88.2	162	0.02
C.V. (%)	24.0	18.91	19.7

Table 2.6.2. Seed yield (SY), total biological yield (TBY), total seasonal evapotranspiration (E_t) and water use efficiency (WUE) of some selected chickpea genotypes sown in spring at Tel Hadya, 1989/90, under rainfed (233.4 mm) and highest moisture supply (458.4 mm) through supplemental irrigation.

Chickpea genotype	Rainfed					Supplementally irrigated				
	SY (kg/ha)	TBY (kg/ha)	Et (mm)	WUE (kg/ha/mm) SY	WUE (kg/ha/mm) TBY	SY (kg/ha)	TBY (kg/ha)	Et (mm)	WUE (kg/ha/mm) SY	WUE (kg/ha/mm) TBY
ILC 262	579	3026	191.1	3.03	15.83	2514	5228	425.8	5.90	12.28
ILC 1272	865	1985	192	4.39	10.07	1843	3981	398.4	4.63	9.99
ILC 1930	760	2039	192.0	3.96	10.72	1668	5658	430.0	3.88	13.16
ILC 85-4C	304	1978	184.6	1.65	10.72	1668	5658	430.0	3.88	13.16
ICC 4958	962	1872	201.1	4.78	9.31	2661	5347	440.8	6.04	12.13
ICC 10991	533	1375	188.8	2.82	28	1949	3181	394.2	4.94	8.07
Annigeri	695	1312	185.4	3.75	08	1796	3369	373.9	4.80	9.01
ILC 1919	539	1361	201.4	2.68	6.76	2503	4853	421.4	5.94	11.52

2.6.2. Genotypic Characterization for Winter Sowing

Identification of growth and phenological characters that may predict the performance of a genotype would be of help in the breeding program. A study was therefore carried out at Tel Hadya and Jinderess to relate various growth and phenological parameters with the performance of 25 diverse chickpea genotypes sown in winter (21 Dec. 1989). The season was cold and dry at Tel Hadya and the rainfall at Jinderess was also subnormal. Hence the yield levels were low at both the locations. At Tel Hadya, the crop suffered greatly because of cold stress in the month of March. Study at Jinderess was not as intensive as at Tel Hadya because of logistic reasons.

Table 2.6.3. Relationship between total seasonal moisture supply (mm) with the yield (kg/ha) of chickpea.

Genotype	Seed yield			Total biological yield		
	Intercept	Slope	R^2	Intercept	Slope	R^2
ILC 100	-1360	4873	0.95	-1897	15.1423	0.96
ILC 262	-1528	8.2762	0.90	-2004	14.7925	0.93
ILC 464	-1396	8.2892	0.93	-1736	15.1904	0.97
ILC 613	-1516	8.3749	0.88	-2383	16.6674	0.94
ILC 629	-1568	8.2985	0.92	-1627	13.9758	0.92
ILC 1272	-456	4.9812	0.81	-539	9.7829	0.91
ILC 1929	-1946	10.6051	0.91	-2999	18.8173	0.90
ILC 1930	-1273	9844	0.90	-1438	13.4829	0.94
FLIP 83-2C	-1409	8340	0.93	-1836	14.3887	0.91
FLIP 84-80C	-1316	6.6629	0.93	-2106	14.5868	0.87
FLIP 85-4C	-1267	5.9523	0.90	-2325	16.4654	0.93
FLIP 85-49C	-1197	5.5295	0.95	-1328	12.5525	0.98
ICC 4958	-988	6147	0.90	-1907	14.6316	0.90
ICC 10991	-851	5.6170	0.90	-1051	9.1339	0.92
ICC 10448	-104	2.5113	0.92	-425	6.0799	0.94
ICCL 82001	-398	4.9380	0.93	-680	9.3658	0.91
Annigeri	-460	4.2563	0.77	-858	9540	0.79
K 850	-1431	4437	0.92	-2215	13.2460	0.92
ILC 1919	-1513	8.1696	0.94	-2507	15.0040	0.95
FLIP 82-73C	-1687	8.3691	0.94	-2495	14445	0.90

The relationship between various growth and phenological parameters with the yield of chickpea is shown in Table 2.6.4 for Tel Hadya and Table 2.6.5. for Jinderess. At Tel Hadya (Table 2.6.4) in contrast to the previous season, early shoot vigour and dry weight accumulation showed little relationship with the seed yield and it was only with April observations that positive and significant relationships were observed. This was because of the cold spell that occurred in the month of March. The cold damage score on 21 March, 9

April and 22 April showed highly significant negative correlation with the seed, straw and total biological yield. Plants showing higher early vigour were severely damaged by cold so that vigour score from 1 to 25th March showed a negative correlation with the yields. Percent ground cover early in the season was a better indicator of the crop performance as it showed highly significant positive correlations with yield. Phenological attributes showed high correlation with the yield and the seed yield decreased as the days to flowering and maturity increased. This confirms the need for an early maturity type for a dry site like Tel Hadya, where season tends to end rather fast because of terminal heat and drought.

At Jinderess (Table 2.6.5) where only the phenological attributes were studied, days to emergence showed a significant negative correlation with the yield. Days to flowering and podding showed weak relationship and days to maturity a significantly positive relationship with seed yield. This contrasts with the results from Tel Hadya, and emphasises the need for specific attributes for chickpea cultivars for different ecological regions.

Study at Tel Hadya has further shown that for the unpredictable environmental conditions of cold and drought, it is not just one character but an architecture of characters that have to be considered to predict the performance of a genotype.

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Table 2.6.4. Correlation of various characters with the seed yield, straw yield and total biological yield of rainfed winter chickpea, Tel Hadya, 1989/90 (based on 25 genotypes, 4 replications).

Character (mean value)	Correlation coefficient with		
	Seed yield	Straw yield	Total biol. yield
1. Shoot dry wt(g/⅓m row) at 25.2. (0.64g)	0.0652	0.5072**	0.4387**
2. Shoot dry wt(g/⅓m row) at 11.3. (1.67g)	0.0495	0.5148**	0.4383**
3. Shoot dry wt(g/⅓m row) at 24.3. (3.02g)	0.1527	0.6354**	0.5788**
4. Shoot dry wt(g/⅓m row) at 2.4. (4.05g)	0.2913**	0.8308**	0.7946**
5. Shoot dry wt(g/⅓m row) at 16.4. (8.84g)	0.2419**	0.7943**	0.7446**
6. Shoot dry wt(g/⅓m row) at 30.4. (18.37g)	0.3685**	0.7926**	0.7955**
7. Shoot dry wt(g/⅓m row) at 10.5. (24.41g)	0.4102**	0.7286**	0.7607**
8. Vigour score on 1.3. (3.0 on 1-5 scale)	-0.1119	-0.4248**	-0.3910**
9. Vigour score on 12.3. (2.76)	-0.1746	-0.5555**	-0.5230**
10. Vigour score on 25.3. (2.68)	-0.2610**	-0.6836**	-0.6626**
11. Vigour score on 5.4. (2.16)	0.5491**	0.3071**	0.4758**
12. Vigour score on 18.4. (2.16)	0.6564**	0.2658**	0.4866*8
13. Vigour score on 29.4. (2.23)	0.6641**	0.2396*	0.4685**
14. Ground cover% on 1.3. (10.6%)	0.1342	0.3089**	0.3062**
15. Ground cover% on 12.3. (19.1%)	0.1824	0.6420**	0.5965**
16. Ground cover% on 25.3. (31.5%)	0.2044*	0.6915**	0.6457**
17. Ground cover% on 5.4. (34.7%)	0.5422**	0.8296**	0.8971**
18. Ground cover% on 18.4. (43.9%)	0.5593**	0.8403**	0.9129**
19. Ground cover% on 29.4. (51.7%)	0.5665*	0.8414**	0.9168**
20. Cold damage score on 21.3. (ø41.3%)	-0.2966*	-0.7764**	-0.7526**
21. Cold damage score on 9.4. (ø38.1%)	-0.3391**	-0.8342**	-0.8172**
22. Cold damage score on 22.4. (on 1-9 scale)	-0.3782**	-0.8189**	-0.8160**
23. Days to flowering (122 days)	-0.4994**	-0.2811**	-0.4342**
24. Days to podding (135 days)	-0.4949**	-0.1175	-0.2996**
25. Days to maturity (148 days)	-0.4738**	-0.0538	-0.2391*
26. Harvest index (0.4081)	0.3238**	-0.8167**	-0.5294**

2.6.3. Root Studies

Spring chickpea depends on stored soil moisture, the availability of which in turn depends on the ability of the root system to extract it. In 1988/89 we explored the differences in the rooting depth of a few selected genotypes, used for drought tolerance and water use efficiency studies, by examining their moisture extraction pattern (FLIP Annual Report 1989: p. 113-114). There were large variations in the maximum depth of water extraction amongst the genotypes. To see whether genotypic differences can be identified by differences in early root growth, a pot culture study using polyethylene tubes was conducted in the greenhouse and root and shoot growth measured up to 47 days after emergence on weekly basis. The results are shown in Fig. 2.6.1.

Table 2.6.5. Correlation of various characters with the seed yield, straw yield and total biological yield of rainfed winter chickpea, Jinderess, 1989/90 (based on 25 genotypes, 3 replications).

Character (mean value)	Correlation coefficient with		
	Seed yield	Straw yield	Total biol. yield
1. Days to emergence (39.4 days)	-0.2496**	-0.3819**	-0.3612**
2. Days to flowering (108.9 days)	-0.0844	0.2079**	0.1054
3. Days to podding (123 days)	-0.0898	0.3787**	0.2186*
4. Days to maturity (145.4 days)	0.4895**	0.6938**	0.6712**
5. Harvest index (0.4643)	-0.0023	-0.7399*	-0.5006**

Root weight and root volume differences between the genotypes were quite conspicuous fairly early in the growth cycle and paralleled the shoot weight at most of the stages (Fig. 2.6.1). ILC 262, ILC 1272, ILC 1929, ILC 1930, ICC 82001 and FLIP 85-4C showed faster rate of root growth than the others and achieved higher root weight and root volume by the end of 47 day. These genotypes also had deeper soil moisture

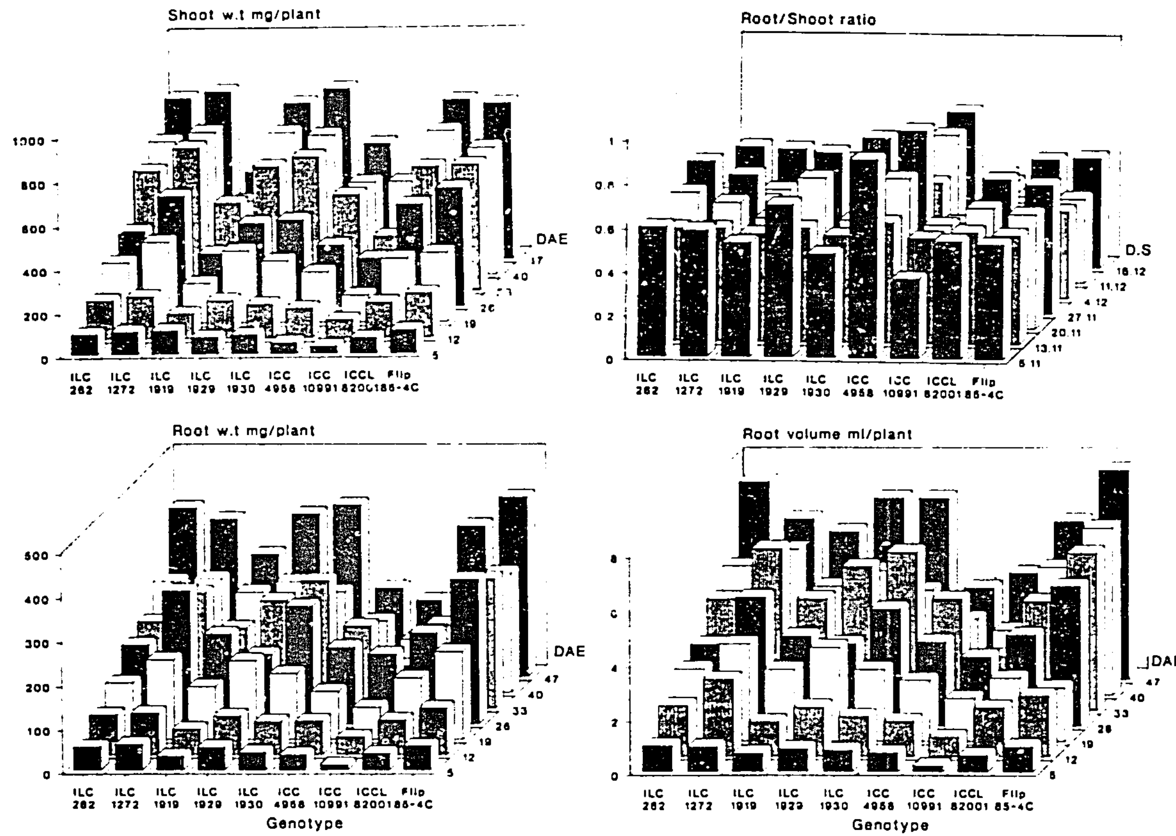

Figure 2.6.1. Differences in the root growth, shoot dry weight and root/shoot dry weight ratio in 9 different-chickpea genotypes in plastic tubes grown for 47 days after emergence in green-house, 1989.

extraction in the field study in 1988/89 except FLIP 85-4C and ILC 262. ICC 4958, which showed deeper extraction of moisture in 1988/89 field study, did not show in pot culture a very high rate of root-growth but it had higher root/shoot dry weight ratio than rest of the genotypes.

The study has shown that early root growth studies can be useful in identifying genotypes which have differential root-growth and moisture extraction patterns later in the season.

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2.6.4. Studies on some Agronomic Requirements of Winter Chickpea Cultivars in Northern Syria

Syrian national program has released Ghab 1 and Ghab 2 chickpea cultivars for their 'B' (rainfall less than 350 mm) and 'A' (rainfall more than 350 mm) zones, respectively, following a series of on-farm trials. These cultivars are being grown with agronomic practices similar to those used for the local cultivars. The Syrian national program, in collaboration with FLIP, conducted a field experiment at various research stations during the 1989/90 season to study the response of these cultivars to row spacing and plant populations. Ghab 1 was grown at Izraa and Ghab stations, and at Gelline and Heimo Ghab 2 chickpea was used. Sowing was done on 16 Dec, 28 Dec, 17 Jan and 20 Dec., respectively. The yield data are shown in Table 2.6.6.

Seed yields tended to be highest at: the lowest plant density of 30 plants/m^2 in 45 cm row spacing at the driest site, Izraa; 45

plants/m^2 in 30 cm row spacing at Heimo and Gelline; and there was no effect of various plant population and row spacing combinations at El Ghab. The study clearly shows that the plants can adjust well to variations in population at a more favourable site such as Ghab, but at drier sites increased population beyond 45 plants/m^2 causes yield reduction perhaps by accentuating the moisture stress.

Syrian National Program Scientists, ARC, Douma.

Table 2.6.6. Yield (kg/ha) of newly released winter chickpea cultivars as affected by row spacing and plant population at different research stations in nothern Syria, 1989/90.

Treatment		Location (total seasonal rainfall in mm)							
Row spacing		Izraa (232.4)		Heimo (319.7)		Gelline (326.6)		Ghab (465)	
(cm)	Plants/m^2	TBY	SY	TBY	SY	TBY	SY	TBY	SY
30	30	2135	840	2940	870	3209	904	4200	2511
	45	1914	720	3287	961	3933	1029	4654	2746
	60	2448	740	3691	849	3793	850	4758	2718
	75	2350	789	3624	918	3928	639	3926	2718
45	30	2059	887	3382	883	3187	735	4072	2380
	45	2014	846	3175	940	3502	710	4245	2530
	60	2215	754	3497	923	3593	660	4222	2447
	75	2266	757	3551	949	3479	545	4376	2517
Mean		2175	791	3393	911	3578	764	4307	2572
S.E.		109.1	32.5	151.2	22.1	97.3	44.2	291.8	102.1
LSD (P=0.05)		320.9	95.6	444.7	65.1	286.2	129.9	NS	NS
C.V. (%)		10.0	8.2	8.91	4.8	5.4	11.5	13.5	7.9

3. LENTIL IMPROVEMENT

Average lentil yields are low because of poor crop management and the low yield potential of landraces. In S. Asia and E. Africa diseases are also a major constraint to production. Accordingly, an integrated approach to lentil improvement is being pursued at ICARDA covering the development of both improved production technology and genetic stocks. A high priority has been placed on transfering to national programs the results of research on lentil harvest mechanization systems to reduce the high cost of harvesting by hand in the West Asia and North Africa region. Agronomic research to develop improved production practices is conducted in coordination with the Farm Resource Management Program, and is extended to the region via the International Testing Network. Increasing the biologically-fixed nitrogen in the wheat-based cropping system is the aim of activities in *Rhizobium* research and *Sitona* weevil control.

3.1. Lentil Breeding

Lentil breeding at ICARDA focuses on three contrasting agro-ecological regions. The importance of the regions in terms of lentil production and the allocation of resources in breeding are summarized together with the respective breeding aims in Table 3.1.1.

Table 3.1.1. Major target agro-ecological regions of production of lentil together with the allocation of resources in breeding and key breeding aims.

Region	% of lentil area in developing countries	% of resources	Key characters for recombination
Mediterranean low to medium elevation	24	75	Biomass (seed + straw), attributes for mechanical harvest, wilt resistance, drought tolerance
S. Asia and E. Africa	51	20	Seed yield, early maturity, resistance to rust, Ascochyta and wilt
High elevation	14	5	Biomass, winter hardiness, attributes for mechanical harvest

3.1.1. Base Program

3.1.1.1. Breeding scheme

The breeding program is divided into streams directed toward the three target agro-ecological zones mentioned above. A description of the scheme of breeding was given in the ICARDA Annual Report 1985.

Approximately 300 simple crosses are made annually and handled in a bulk-pedigree system using off-season generation advancement. Segregating populations targeted for the different regions are distributed with emphasis placed on relevant constraints, providing breeding material for national programs for selection and cultivar development <u>in</u> <u>situ</u>. In the Mediterranean area selection for response to varied moisture supply is conducted at ICARDA stations in Lebanon and Syria. Lines and segregating populations with specific characters are supplied through the International Testing Network.

3.1.1.2. Yield trials

Selections from the breeding program for West Asia and North Africa are tested in preliminary and advanced yield trials at three locations varying in their annual average rainfall, namely Breda (long-term average annual rainfall total 281 mm) and Tel Hadya (328 mm) in Syria and Terbol (545 mm) in Lebanon. During the 1989/90 season the rainfall was considerably below the long-term average at all sites with 183, 233, and 317 mm received up to harvest at Breda, Tel Hadya and Terbol, respectively. Additionally, severe cold (-8.9½C on March 17, 1990) strongly affected plant growth at Tel Hadya and Breda. Yields followed the rainfall gradient with mean yields of biomass at Terbol, Tel Hadya and Breda of 3.9, 1.6, and 0.4 t/ha, respectively. The combined effect of drought and cold in March was so severe at the Breda site that there was no recovery or seed yield. Mean seed yield at Terbol, the wet site, was 1541 kg/ha, whereas at Tel Hadya the mean seed yield was 611 kg/ha.

A summary of the results of the yield trials is given in Table 3.1.2. For seed yield the percentages of lines significantly outyielding the best check were 11 and 42% at Terbol and Tel Hadya, respectively. Another 36 and 44% of the total lines tested at Terbol and Tel Hadya, respectively merely ranked above the best check. The results for biomass follow the general pattern shown by those for seed yield. The 1989/90 season being particularly dry and cold it is of interest that many lines ranked above the best check at all sites under these extreme conditions.

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Table 3.1.2. Results of the lentil yield trials for seed (S) and biomass (B) yields (kg/ha) at three contrasting rainfed locations; Terbol (Lebanon), Tel Hadya and Breda (Syria) during the 1989/90 season.

Location	Terbol		Tel Hadya		Breda
	S	B	S	B	B
Number of trials	10	10	13	13	2
Number of test entries*	202	202	269	269	44
% of entries sig. (P<0.05) exceeding best check**	10.9	5.0	42.4	33.8	11.4
% of entries ranking above best check (including above)	47.0	35.2	85.9	70.2	36.4
Yield of top entry (kg/ha)	2208	5879	1229	2942	516
Best check yield (kg/ha)	1597	4020	465	1390	416
Location mean (kg/ha)	1541	3876	611	1580	383
Range in C.V. (%)	6-12	6-11	15-33	14-22	8-9
Mean advantage of lattice over RBD (%)	8	4	13	10	-

* Entries common over locations.

** Large-seeded checks: ILL 4400 long-term, Idleb 1 improved; Small-seeded checks: ILL 4401 long-term, 78S26013 improved.

3.1.1.3. International nurseries

The lentil international breeding nurseries have evolved from the stage of provision of yield trials and diversified to the supply of an additional wide range of crossing blocks/resistant sources and segregating populations for each of the three major target agro-ecological regions of production (Table 3.1.3).

Table 3.1.3. Lentil international breeding nursery program showing target regions and type of material for distribution.

Type of nursery	Mediterranean low-med. elevation	Lower latitudes	High elevation
Crossing blocks/ Resistance sources	Tall nursery Large seeded nursery Small seeded nursery Wilt nursery*	Ascochyta blight nursery Early nursery Rust nursery**	Cold tolerant nursery
Segregating populations	F_3 nursery- large seeded* F_3 nursery- small-seeded*	F_3 nursery- early	F_3 nursery cold tolerant*
Yield trials	Small-seeded trial Large-seeded trial	Early trial	

* Launched 1989/90. ** Launched 1990/91.

This year a rust resistance nursery was launched to compliment the existing nurseries of disease resistant sources for vascular wilt (*Fusarium oxysporum* f.sp. *lentis*) and Ascochyta blight (*Ascochyta lentis*).

3.1.1.4. Screening for vascular wilt resistance

Vascular wilt caused by Fusarium oxysporum f. sp. lentis is the major fungal disease of lentil in the Mediterranean region. Screening for resistance continued this year in the plastic house using the method developed in the 1987/88 season (FLIP Annual Report 1988).

A total of 98 lines of cultivated lentil were screened for their reaction to wilt at the seedling stage in the 1989/90 season. The lines were rated on a 1-9 scale with rating 1 = resistant and rating 9 = all plants killed. Eleven lines representing 11.2% of lines screened gave ratings < 3, and a further 34 lines, comprising 35% of all lines, rated between 3 and 5. The most resistant lines in this seedling test will be re-screened in an adult-stage screening trial next season.

The 26 most resistant lines in the seedling test of the 1988/89 season were screened this year in pots infested with the causal organism to evaluate their performance at a different, later stage of growth. The 26 lines had all rated < 5 at the seedling stage. It was noticed that most were susceptible at the adult stage when screened in pots, and only two lines - ILL 298 and ILL 6435 - scored below 5 in the adult screening. The check was highly susceptible in both trials. The relationship between the score at the seedling stage and the score at the adult stage is illustrated in Figure 3.1.1. These resistant lines have been shared with national programs in the international nursery-Lentil International Fusarium Wilt Nursery.

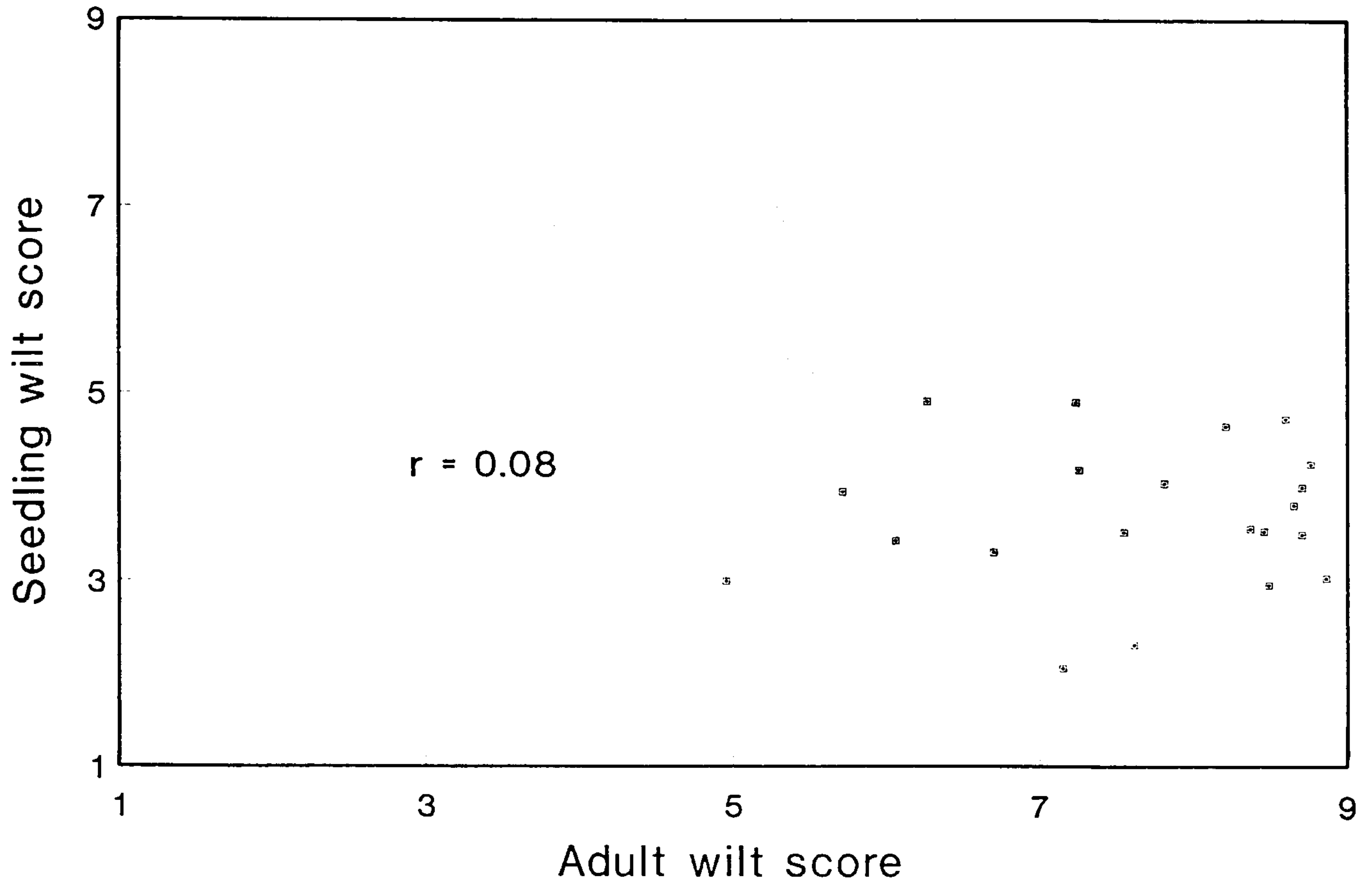

Figure 3.1.1. Relationship between seedling and adult wilt ratings on a 1-9 scale.

Screening was also initiated this year on the reaction of wild lentils to vascular wilt. A total of 221 accessions of wild lentil, comprising Lens culinaris subsp. orientalis, L. culinaris subsp. odemensis, L. nigricans subsp. nigricans, L. nigricans subsp. ervoides, and Vicia montbretii (syn. Lens montbretii) from nine countries, were tested. The screening was done in the plastic house at the seedling stage in trays containing soil artificially infested with Fusarium oxysporum f.sp. lentis. Covariance analysis, using the repeated susceptible check score, showed highly significant differences among accessions in their reaction to wilt. Adjusted mean disease scores ranged from 0.8 to 8.3 with a mean of 4.6. The taxa differed significantly in their average disease rating with all accessions of L. culinaris subsp. odemensis showing susceptibility to wilt (Table 3.1.4). There was a greater range in reaction within the other groups, for example, the most resistant and the most susceptible accessions were found in L. culinaris subsp. orientalis. Resistant accessions were also found within both subspecies of L. nigricans. The ten most resistant accessions were four from L. culinaris subsp. orientalis, four from L. nigricans subsp. nigricans and two from L. nigricans subsp. ervoides (Table 3.1.5). The country of collection had a significant effect on disease reaction in these three sub-species.

In addition to screening in the plastic house, we have tried to develop a methodology for screening in the field in a wilt-infected area. Selection in the field allows seed of individual selected plants to be harvested, whereas culture in the plastic house does not often allow seed collection. The date of sowing has been found to affect

Table 3.1.4. Range, mean and coefficient of variation (%) of 221 accessions of wild lentil for vascular wilt reaction.

Species name	No. of accessions	Range	Mean	CV (%)
L. culinaris subsp. orientalis	109	0.8-8.3	4.8	34.9
L. culinaris subsp. odemensis	17	4.3-8.0	6.2	17.7
L. nigricans subsp. nigricans	30	0.9-7.3	4.0	39.3
L. nigricans subsp. ervoides	63	1.4-7.1	4.3	31.2
V. montbretii	2	3.3-5.1	4.2	21.7
Overall	221	0.8-8.3	4.6	46.4

Table 3.1.5. Disease score (covariance adjusted) for vascular wilt reaction of the best ten accessions of wild lentil.

Accession number (ILWL)	Species	Country of collection	Adjusted mean score
196	L. culinaris subsp. orientalis	Syria	0.8
79	L. culinaris subsp. orientalis	Turkey	0.9
27	L. nigricans subsp. nigricans	Yugoslavia	0.9
17	L. nigricans subsp. nigricans	France	1.3
230	L. culinaris subsp. orientalis	Syria	1.4
56	L. nigricans subsp. ervoides	Yugoslavia	1.4
15	L. nigricans subsp. nigricans	France	1.6
30	L. nigricans subsp. nigricans	Spain	1.7
194	L. culinaris subsp. orientalis	Syria	1.9
292	L. nigricans subsp. ervoides	Turkey	1.9

strongly the incidence of vascular wilt in India. This was also our experience at Tel Hadya in a naturally-infested field in the 1986-87 season (FLIP Annual Report 1987) with 400 germplasm accessions sown at two dates (December 19, 1986 and February 2, 1987). Wilt damage, measured as the percentage of wilted plants in a plot, was 0.6% in the December sowing and 9.3% in the delayed sowing. The range in response among accessions was greater in the late sowing (0-100% wilted plants) than in the December sowing (0-10% wilted plants). This suggested that screening for wilt reaction was best conducted on late-sown plants.

We investigated the effect of sowing date further in the 1989/90 season by sowing in wilt sick plot 20 genotypes varying in their reaction to wilt at monthly intervals from November to February. The season contrasted with that of 1986/87 because severe cold (-8.9°C), which was experienced on March 17, 1990, damaged the early-sown plants so severely that it was not possible to distinguish cold damage from wilt damage (see Section 3.1.1.8). Additionally, only a total of 23 mm of rain fell in March and April 1990, whereas 76.1 mm were received in the equivalent period in 1987. The overall mean of wilt incidence in 1990 was 22%, but differences between the wilt damage at different sowing dates were not significant (Figure 3.1.2). Clearly, it is only in some years that there is an advantage of late sowing in February over earlier sowing in order to screen lentils for vascular wilt reaction. The disease reaction of the 20 lines ranged from 5.5% wilted plants with ILL 5588 to a maximum of 49.5% wilted plants in the susceptible line ILL 244. ILL 5588 is also resistant to Ascochyta blight and represents a case of multiple resistance in lentil.

Drs. W. Erskine and B. Bayaa (Aleppo University).

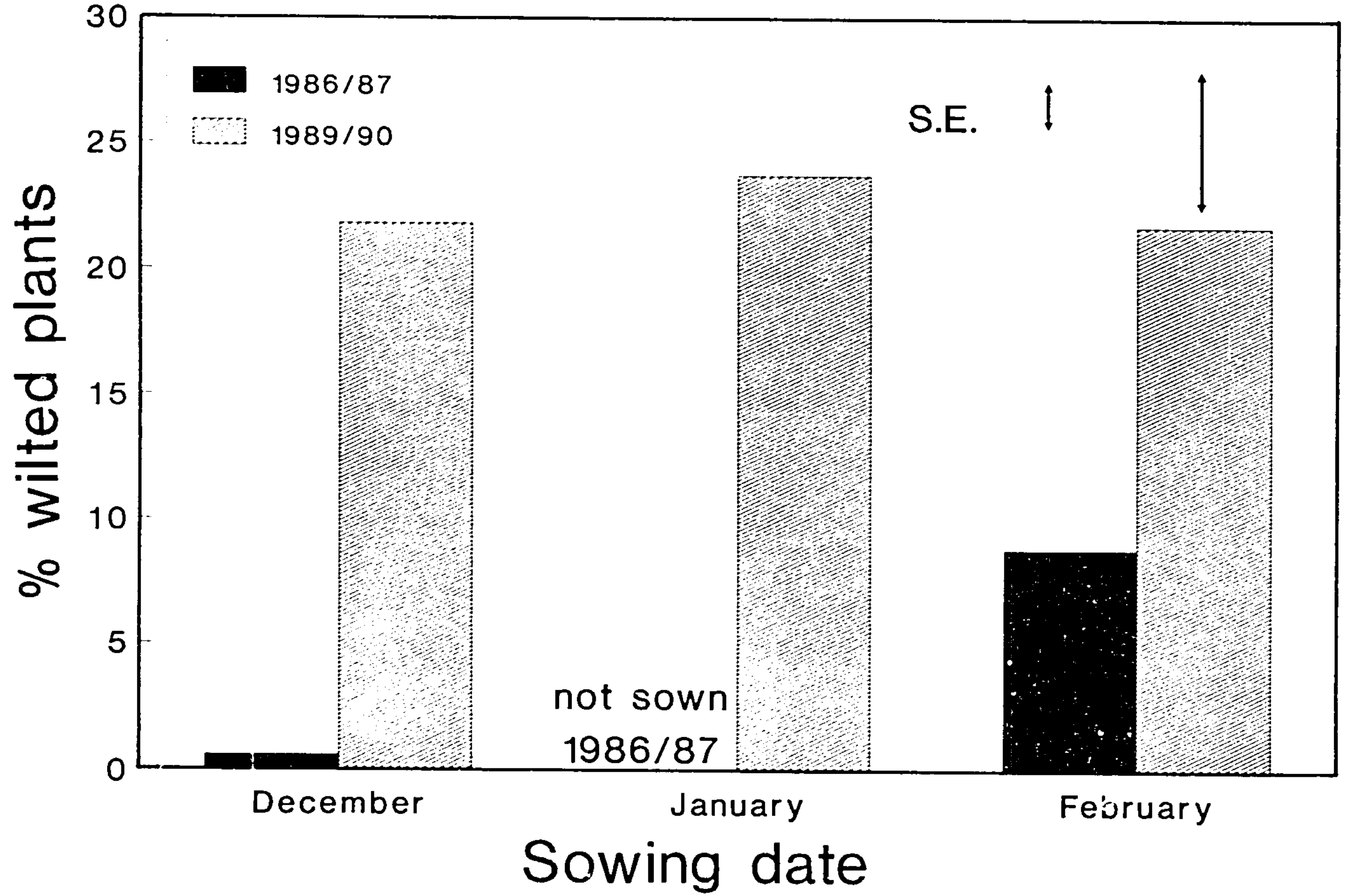

Figure 3.1.2. Sowing date effects on wilt incidence in the 1986/87 and 1989/90 seasons at Tel Hadya.

3.1.1.5. Screening for resistance to Orobanche

Broomrape (Orobanche spp.) is a major cause of yield loss in lentil in some Mediterranean countries. One approach to Orobanche control is through the use of host-plant resistance. Variability within the crop to Orobanche attack is low and no resistance has been identified despite extensive screening of germplasm. We have, therefore, started to explore wild Lens species for sources of resistance. A total of 54 accessions of wild lentil, comprising 37 accessions of Lens culinaris subsp. orientalis, eight of L. culinaris subsp. odemensis, nine of L. nigricans subsp. nigricans, and eight of L. nigricans subsp. ervoides, have been screened using the petri-dish technique for Orobanche. None of the accessions showed a resistant reaction and we will screen additional wild germplasm next season.

Drs. K.-H. Linke and W. Erskine.

3.1.1.6. Allozyme and morphological variation and outcrossing in lentil germplasm

A major emphasis has been laid at ICARDA on studying the variation in germplasm of the cultigen as the key to future crop improvement. A study of qualitative variation was undertaken to complement previous research on quantitative characters with the aim of estimating outcrossing using a multilocus model and quantifying the variation in isozymes and morphological traits to allow modelling of the effects of forming 'core collections' of germplasm. A core collection is a representative sample of a larger germplasm collection, made to facilitate the use of the collection.

In the last report we focused on the results of germplasm from Turkey (FLIP Annual Report 1989). Now, however, the study has been completed in USA and results are available from the analysis of a total of 105 accessions of germplasm from Chile, Greece, and Turkey. The survey of variation covered a total of 1048 plants for three loci of morphological traits, 17 known isozyme loci and one putative isozyme locus - amylase (Amy).

able 3.1.6. Mean number of alleles per locus, mean percentage of polymorphic loci over loci and populations, the mean number of multilocus genotypes per population, mean multilocus diversity index (H_j) over populations in the three countries. Standard errors are in parentheses.

	Chile	Greece	Turkey
Mean number alleles/locus	1.20 (0.13)	1.19 (0.09)	1.18 (0.11)
Mean % of polymorphic loci	21.4 (17.7)	17.7 (7.4)	17.5 (10.1)
Mean no. multilocus genotypes/pop.	3.7 (1.98)	4.5 (1.88)	3.8 (1.91)
Mean multilocus diversity value/pop (H_j)	0.530(0.267)	0.664(0.140)	0.532(0.247)

The average proportion of polymorphic loci per population (P) was 0.19 and the range over populations was from 0 - 0.42. There were no significant differences between the countries in variability either in the proportion of polymorphic populations or the average number of alleles per locus over loci and populations (Table 3.1.6). The history of lentil cultivation in Chile is short and post Columbus in comparison to its ancient cultivation in Greece and Turkey. However, the variation in germplasm from Chile was equal to that within Greek and

Turkish material measured as an average over loci and on a multilocus basis. This implies rapid differentiation and adaptation to a wide range of habitats following the introduction of the crop to Chile or the repeated introduction of different genetic variation.

The level of outcrossing is central to the breeding system and population structure of a species. There has been an earlier measurement of outcrossing rate in lentil from Washington State, USA showing a level of less than 0.08% based on the marker locus cotyledon colour (yc) and a second estimate of 0.9% outcrossing estimated from diverse germplasm grown in Syria based on the aspartate amino-transferase plastid locus (Aat-p). Isozymes are inherited codominantly and heterozygotes are directly identifiable allowing estimates of outcrossing. Although previous single-locus estimates of outcrossing tend to underestimate the true rate of outcrossing by failing to account for non-discernible outcrossing between similar genotypes, this does not explain the observed high outcrossing rate of 6%, based on nine loci, found in Chilean germplasm, an order of magnitude above previous estimates. Outcrossing rates in germplasm from Turkey and Greece were lower at 2-3%. All accessions studied were maintained in the United States Department of Agriculture Western Regional Plant Introduction Station germplasm collection for over twenty years. Sections of the collection are regrown annually at Pullman, Washington State, USA and differences between countries in outcrossing rates probably reflects year to year variation in insect activity. The lentil flower is normally cleistogamous and an insect vector is required to effect cross-pollination. A search for the causal vector insect is now warranted, particularly as problems in maintaining varietal purity during seed multiplication have recently been encountered in Washington.

An important feature of the variability uncovered by the germplasm survey is that the genotypic state at a given locus often depends on the genotypic state at other loci. Of the 36 tests of independence of the allelic distribution of pairs of nine polymorphic loci, a total of 21 showed significant departures from random association of alleles at pairs of loci. The linkage between many of these loci has already been tested, and the only known linkage between these loci is between epicotyl colour (gs) and aspartate amino-transferase (Aat-p), explaining only a small fraction of the associations found. These results indicate a complex multilocus organization of lentil populations. A single multilocus genotype was found in 10.2% of all plants. Studies on other predominantly self-pollinating species, both wild and cultivated, are increasingly giving evidence that adaptative changes occur not only through changes in allelic frequency but also through the reorganization of allelic ingredients into new multilocus allelic combinations adapted to specific habitats. These associations can develop between unlinked or loosely-linked loci in inbreeders because they have not broken up each generation by recombination, in contrast to outbreeders which have a less highly structured multilocus organization.

The data from the survey of qualitative variation in germplasm were used to test different sampling strategies for core collection formation. Differences between the sampling strategies - random, stratified on the basis of groups with sample size constant and proportional to group size - were non-significant in number of alleles captured at P=0.05. However, there was an indication that stratified sampling was more effective than random sampling, agreeing with theoretical expectations.

Drs. W. Erskine and F.J. Muelhbauer (USDA/ARS, Pullman, USA).

3.1.1.7. Comparison of response to moisture supply of landrace and improved cultivars

In lowland Mediterranean environments lentil is usually sown between the 300-400 mm rainfall isohytes in the months of December and January. From March until maturity in May, the crop experiences increasingly strong solar radiation, a rapid rise in maximum temperature, a decrease in rainfall, and high evaporative demand. Drought stress increases during this period, which coincides with the phase of reproductive development in the crop, and as a consequence yields are frequently low.

The overriding importance of moisture availability in determining lentil yield in a lowland Mediterranean environment is illustrated for two cultivars in Figure 3.1.3, which shows the seed yields of the cultivars plotted against the total seasonal rainfall from 29 environments over 8 seasons in trials with the Syrian Ministry of

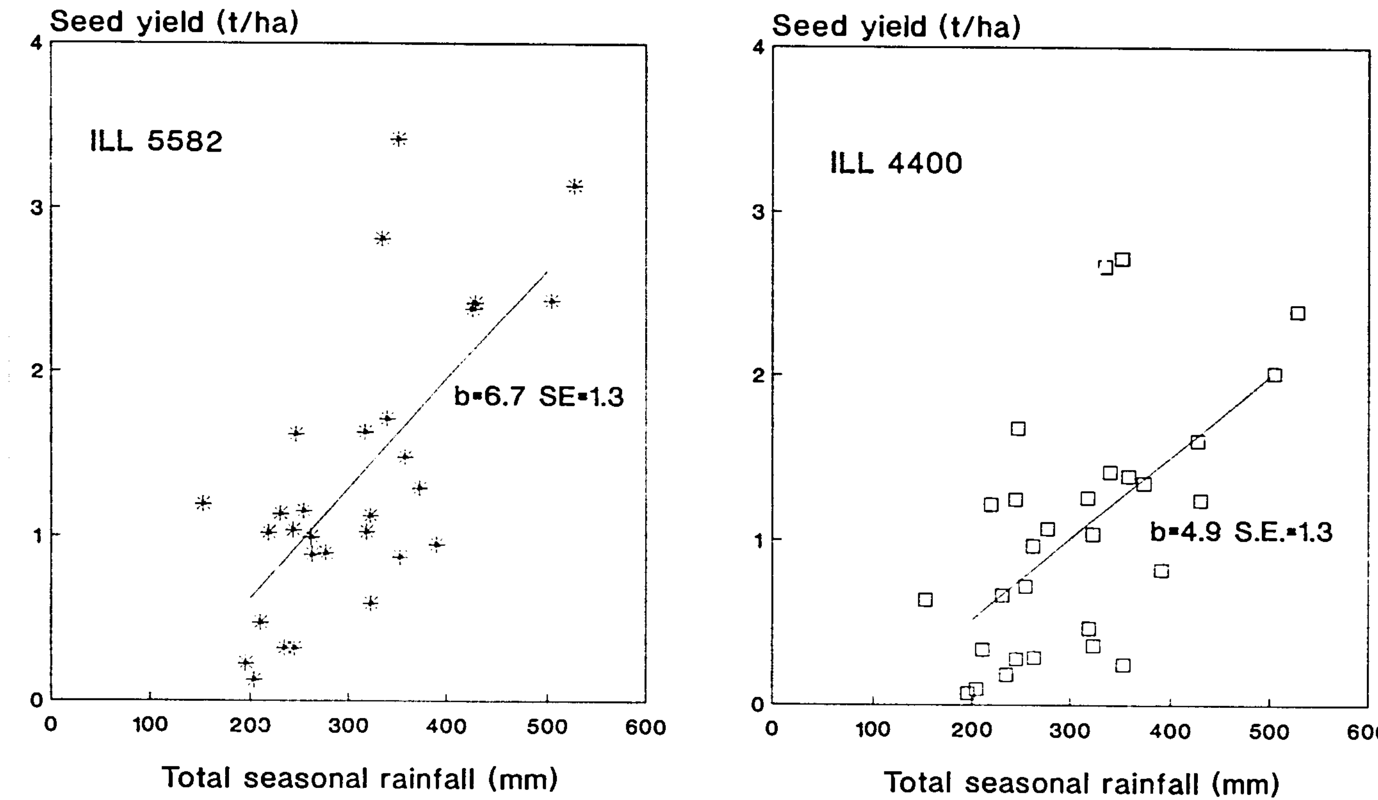

Figure 3.1.3. Seed yield response of two lentil lines to total seasonal moisture supply in 29 variety verification trials between 1981 and 1989 in Syria.

Agriculture. The cultivars were ILL 4400 - a landrace - and 'Idlib 1' (ILL 5582), a selection recently released in Syria. The experiment comprised verification trials on both farmers' fields and research stations in a randomized block design with two replications and a plot size of 40 m^2 over the seasons 1981/82 to 1988/89. Locations were distributed in the main production areas of lentil in Syria namely the Provinces of Aleppo, Idlib and Hama in the North-West, the South-West, and Hassake in the North-East. The distance between the farthest sites is over 500 km. Linear regressions of total seasonal rainfall on to seed yield accounted for 34% of the overall variation in seed yield for ILL 4400 and 47% for 'Idlib 1'. When the regressions were re-run using the total rainfall falling in the months of November through March, the percentages of seed yield accounted for by rainfall rose to 41% for ILL 4400 and 55% for 'Idlib 1' (Figure 3.1.4).

The selection 'Idlib 1' (ILL 5582) emanates from the breeding program at ICARDA, which routinely uses simultaneous yield tests at sites spread along a rainfall cline spanning that of major lentil producing areas of west Asia (sew Section 11). The retrospective analysis of the response to selection for seed yield in rainfed environments in Syria showed that the newly released cultivar 'Idlib 1', with a slope of 8.2±1.4, had a greater response to increased moisture availability than landrace cultivar ILL 4400 with a slope of 6.1±1.4. This shows that selection for yield under rainfed conditions using test sites varying in mean rainfall has resulted in a response in increased water-use efficiency.

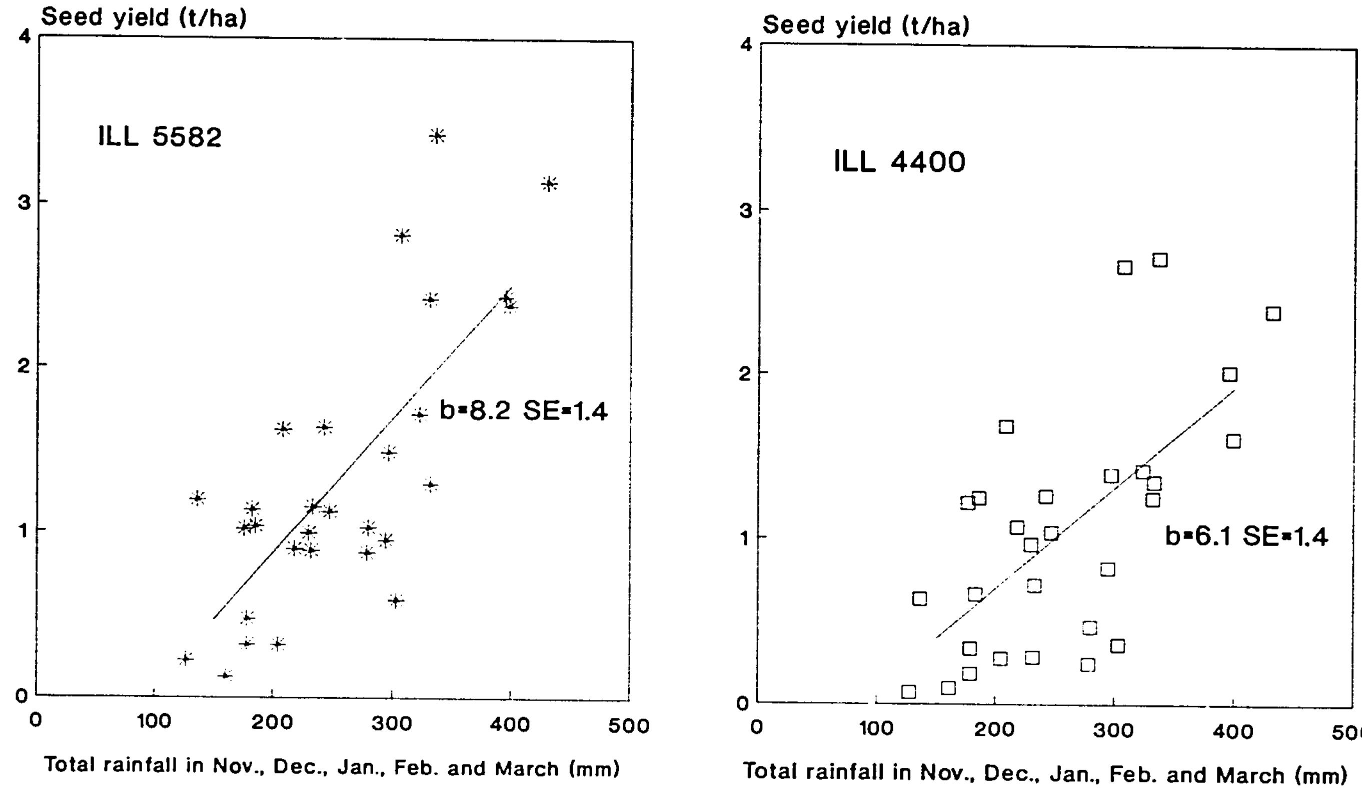

Figure 3.1.4. Seed yield response of two lentil lines to total moisture supply between November and March in 29 variety verification trials between 1981 and 1989 in Syria.

Drs. W. Erskine and M.C. Saxena, and Mr. F. el Ashkar (ARC, Douma, Syria).

3.1.1.8. Cold damage to lentil sown on different dates

During both March 1985 and 1990 cold spells occurred at Tel Hadya following a period of warm weather, during which lentil growth was vigorous. Specifically, the temperature was -9.5°C on March 3, 1985 and -8.9°C on March 17, 1990. This presented an opportunity to study the effect of cold on lentil genotypes sown on different dates.

In the 1984-85 season a total of six genotypes were grown in the field at four sowing dates (Nov. - Jan.) with and without supplementary lighting for a photoperiod of 18hrs. In 1989-90 a total of 20 genotypes were sown at monthly intervals from November through February.

Cold damage varied markedly depending on the sowing date and, hence, age of the crop. Early sown plants (November) were severely hit and cold damage decreased with each successive sowing date (Figure 3.1.5). We used a 1-9 scale to measure cold damage with 1= no damage and 9= >90% of leaves killed. Supplementary light increased the susceptibility to cold primarily because plants given extra light were substantially taller than those growing under normal light at the time of the cold spell (Figure 3.1.6). Supplementary light had also increased the number of nodes on the main stem at this stage of growth.

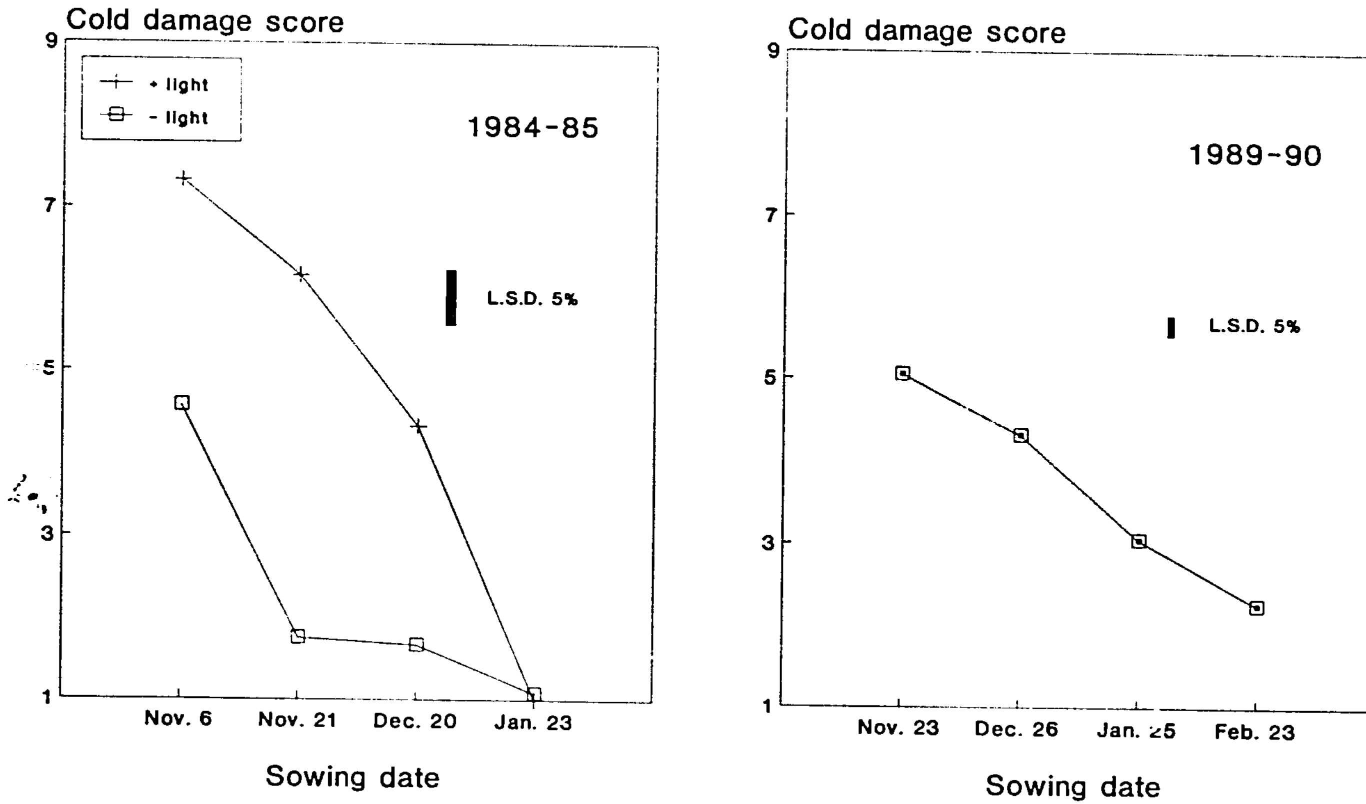

Figure 3.1.5. Cold damage score measured on a 1-9 scale on lentil sown at different dates at Tel Hadya in the 1984/85 and 1989/90 seasons. In 1984/85 supplementary lighting (18h photoperiod) was added.

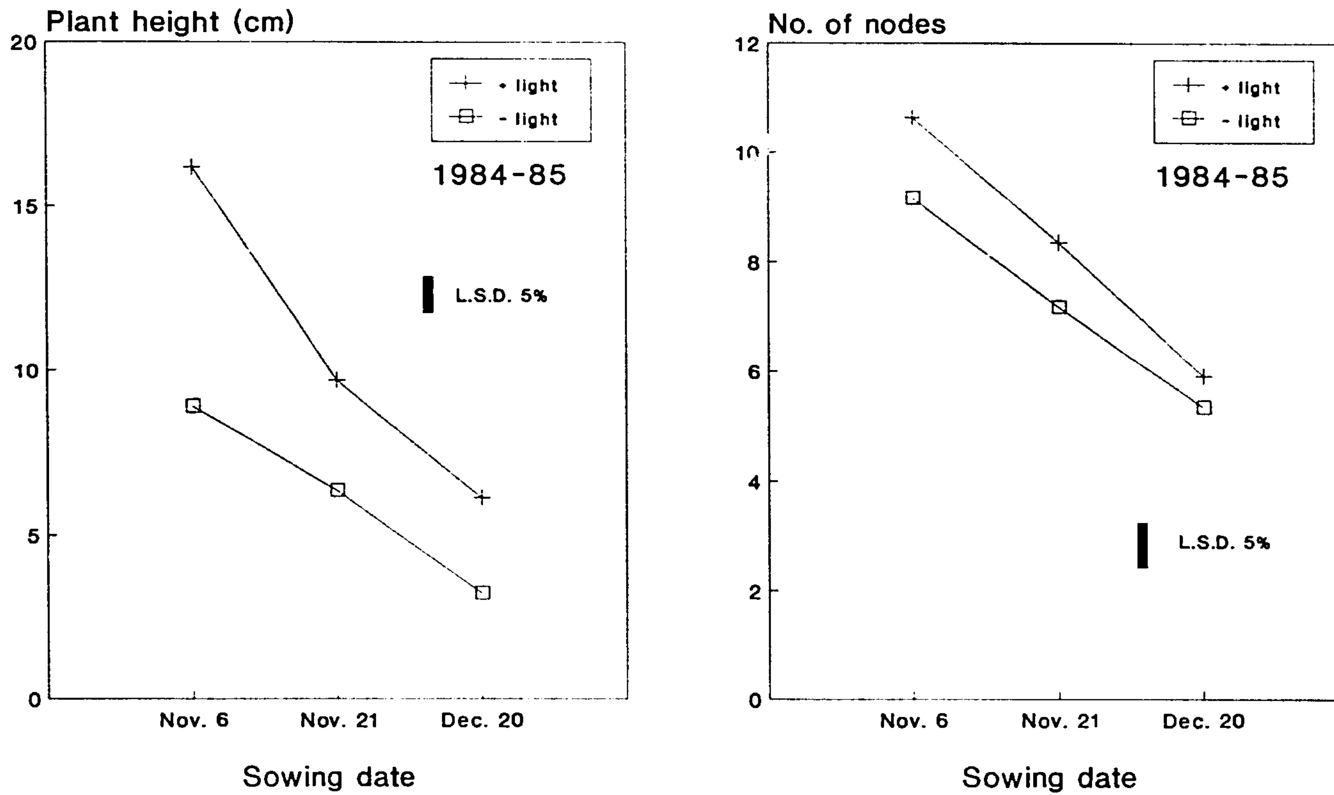

Figure 3.1.6. Plant height (cm) and number of nodes per plant of lentil plants at the time of cold damage and sown at different dates at Tel Hadya in the 1984/85 and 1989/90 seasons. In 1984/85 supplementary lighting (18h photoperiod) was added.

Genotypic effects were highly significant in both seasons and considerably larger than the sowing date - genotype interaction. In the 1984-85 season, genotypes originating from warm growing areas such as ILL 4605 from Argentina, ILL 1744 from Ethiopia and ILL 2501 from India, were more susceptible than those from cooler production areas, such as ILL 4400 from Syria. A similar wide range in susceptibility to cold was found in the 1989-90 season.

Cold spells in March are relatively common but unpredictable in the lowland Mediterranean region and natural selection on landraces has produced material with sufficient cold tolerance for these areas. However, the thrust to replace spring planting with winter sowing at high elevations (>1000m) necessitates the search for highly cold tolerant genotypes. The effect of cold on the different sowing dates suggests that early sowing at an intermediate elevation (600-800m) may be a method to screen for cold reaction, because it will predispose the crop to damage from cold in most years.

Drs. M.C. Saxena and W. Erskine.

3.1.2. Use of Germplasm by NARSs

3.1.2.1. Advances for the Mediterranean region

The ICARDA base program provides segregating populations and breeding lines to national programs in North Africa and West Asia for elevations below 1000m around the Mediterranean Sea. To date, more use has been made of lines than segregating populations and very few crosses are made in the region outside ICARDA.

Table 3.1.7 lists lentil lines released as cultivars or selected for pre-release multiplication by NARSs.

In Syria the line 78S26013 (ILL16) will be submitted to the Variety Release Committee on the basis of its improved grain yield of 16% over the local check, superior resistance to Fusarium wilt and its standing ability, an important attribute in harvest mechanization. This will be the first red-cotyledon lentil registered in the country. Additionally, ILL 5883, another red cotyledon lentil from Jordan is in the last stage of testing prior to release in Syria.

'Jordan 3' (78S26002) was released in 1990 in Jordan; it had been released earlier in Syria.

In North Africa two lines, FLIP84-103L and 78S26002, have been identified by the national program for pre-release multiplication in Tunis as a supplement to 'Neir' and 'Nefza' already released. In Algeria the national program registered 'Balkan 755' and 'ILL 4400' during 1989 and both ILL 468 and ILL 1889 were selected for pre-release multiplication.

Lentils in Morocco suffered a severe attack of rust for the third successive season and much of the crop was destroyed on farmers' fields. ILL 4605 was released in 1989 on the basis of its resistance to rust. Three other lines ILL 6002, ILL 6209 and ILL 6212 with resistance to rust are now entering their second year in the cataloque trials, and ILL 6001 will be entered into these trials in the forthcoming year on the basis of its yield and rust resistance.

National Agricultural Research Systems.

Table 3.1.7. Lentil lines released as cultivars (underlined) or in pre-release multilplication by NARSs.

Mediterranean region	
Algeria	Syrie 229, Balkan 755, ILL 4400, ILL 468, ILL 1889, FLIP 86-20L
Iraq	78S26002, 78S26013
Jordan	Jordan 3
Lebanon	Talya 2
Morocco	ILL 4605, ILL 6002, ILL 6209, ILL 6212
Syria	Idlib 1, 78S26013, ILL 5883
Tunisia	Neir, Nefza, FLIP 84-103L, 78S26002
Turkey	Firat'87
High elevation area	
Turkey	Erzurum'89, Malazgirt'89, 1066-1
S. Latitudes	
Egypt	ILL 4605
Ethiopia	ILL 358
Nepal	ILL 2578, ILL 4402, ILL 4404
Pakistan	Manserha'89, ILL 2573, ILL 5677, ILL5865
Others	
Australia	FLIP 84-80L
Canada	Indianhead
Chile	Centinela-INIA
China	FLIP 87-53L
Ecuador	INIAP 406

3.1.2.2. Advances for southern latitude region

This region comprises the Indian sub-continent and Ethiopia where an early flowering habit is required together with resistance to rust, ascochyta blight and wilt. The importance of foliar pathogens contrasts with other major areas of lentil production.

There are three strong lentil breeding programs in Pakistan with two in Faisalabad and the remaining program in Islamabad. Over the last five years ICARDA has worked closely with these programs in joint selection as the focus of a thrust to broaden the genetic base of lentils in South Asia. As a result the national yield trial 1989/90 of Pakistan contained a total of 10 test entries with five entries from Ayub Agriculture Research Institute, Faisalabad and one line from National Agriculture Research Institute, Islamabad, all of which are local selections from ICARDA-supplied crosses. Two other lines in the national trial are renamed ICARDA lines from Nuclear Institute of Agricultural Botany; the remaining two lines comprise the local check and 'Manserha 89' (ILL 4605) released during last season. 'Manserha 89' has combined resistance to lentil rust and Ascochyta blight as well as a high yield potential in the wetter parts of the production area in Pakistan.

The major production problem in Bangladesh addressable through breeding is rust. We have been making targeted crosses for Bangladesh of rust resistance sources with the local susceptible cultivar 'L5' in the base program at Tel Hadya. Selections have now been made in

Bangladesh of adapted rust resistant plants in the F_3 generation from this material.

During the 1989/90 season ILL 4605 was included in every crossing block in India on the basis of its large seed and combined resistance to rust and Ascochyta blight.

Nepal grows more than 100,000 ha of lentil spread between the Terai area adjacent tc India and the Mid-Hills. The lines ILL 4402 and ILL 4404 are in farmers' field trials, where they out-performed the local check 'Simrik'; they are also in pre-release multiplication.

In Ethiopia 'NEL 358' is being distributed to farmers who have renamed it 'Chelo', meaning tolerant. Several other lines have been identified by the National Program with resistance to rust and a good seed type.

National Agricultural Research Systems.

3.1.2.3. Advances for high altitude region

The high altitude region primarily consists of those regions of Iran and Turkey where lentil is normally grown as a spring crop because of the severe winter cold. The national program of Turkey has clearly demonstrated that winter-sown lentil has a higher yield potential than the spring-sown crop providing there is sufficient winter-hardiness in the cultivar. The line 1066-1, a single plant selection made at Eskisehir from ILL 854, is a large-seeded, red-cotyledon line that is being considered for release for winter sowing. During the last season two lentil cultivars were released for cultivation in highland areas in the spring by the program at Erzurum, Turkey. They are 'Erzurum 89' (ILL 942) a large seeded, yellow cotyledon line and 'Malazgirt 89' (ILL 1384) a small seeded, red cotyledon line.

National Agricultural Research Systems.

3.1.2.4. Advances in other areas

In Australia the line FLIP84-80L is being released in the State of South Australia. 'Indian head' (ILL 481) has been released in Saskatoon, Canada as green manure crop. ILL 5588 and ILL 5684 are in use as sources of resistance to Ascochyta blight, the key pathogen of lentil in Canada. The national program of Chile has recently registered 'Centinela-INIA' (74TA470) as a new cultivar on the basis of its rust resistance. Another source of rust resistance was released in Ecuador in 1988 as 'INIAP-406' (ILL 4605). China has identified FLIP-87-53 L for Qinghai region.

National Agricultural Research Systems.

3.2. Wide Crossing in Lentils

The genetic variability available in such wild relatives of lentil as <u>Lens</u> <u>nigricans</u> subsp. <u>nigricans</u> and <u>Lens</u> <u>nigricans</u> subsp. <u>ervoides</u>. cannot be currently used for improving the cultivated species because of crossability barriers. The use of ovule-culture and embryo-rescue techniques is being tried to overcome these barriers.

To meet the need for vigorous plants with a large number of flowers for crossing, a hydroponics system was perfected and used. Three accessions of L. nigricans subsp. nigricans (ILWL 14, ILWL 18 and ILWL 25) and L. nigricans subsp. ervoides (ILWL 129, ILWL 134-1 and ILWL 185) in addition to one accession of L. culinaris (ILL 8) were used. The seeds were allowed to germinate on Jiffy-7 plates and were later transfered to perforated plastic cups fixed on water bottles containing full strength Hoagland's solution and supplied with air from small aquarium pumps in addition to lignt and temperature regimes as shown in Table 3.2.1.

The wild species showed excellent vigour and produced a large number of flowers and seed (Table 3.2.2). More than 400 pollinations in all combinations were done (Table 3.2.3) on these plants. The outcome was 70 rudimentary pods that eventually turned yellow and died after 15-20 days development. The average size of the hybrid pods was 3-4 times smaller than that of a selfed one of similar age. Twenty one ovules only isolated from the hybrid pods showed no further develoment when subcultured (Table 3.2.4). Some callus growth was observed. Few weeks later only one hybrid callus regenerated to give 3 shoots, but failed to root even when subcultured on a high NAA concentration medium. More work is needed to perfect a protocol that may permit interspecific hybridization using embryo/ovule rescue technique.

Dr. F. Weigand and Mr. H. Mashlab.

Table 3.2.1. Temperature and light regimes for growing cultivated and wild lentil the plants.

Age of plant	Temp. °C		Light	
	Day	Night	Hours	Intensity (uE)
First 6 weeks	18	12	12	400
7-14 weeks	20	15	14	400
15 weeks-Maturity	24	18	16	400

Table 3.2.2. Branches, pods and seeds produced per plant.

Accession No.	No. of main branches	Pods/plant	Seeds/plant
L. nigricans subsp. nigricans			
ILWL 14	42	540	716
ILWL 18	75	918	1353
ILWL 25	66	891	1224
L. nigricans subsp. ervoides			
ILWL 129	33	65	942
ILWL 134-1	83	3081	4039
ILWL 185	31	704	1110

Table 3.2.3. Crosses of wild with cultivated subspecies.

	No. of pollinations	No. of pods
L. nigricans subsp. ervoides (male)	65	16
L. nigricans subsp. ervoides (female)	102	0
L. nigricans subsp. nigricans (male)	87	18
L. nigricans subsp. nigricans (female)	152	36

Table 3.2.4. Media type and composition used for *in vitro* culture.

Purpose	Medium
Ovule-culture	MS + 1.2 uM IAA 2.3 uM Zeatin 1.5 uM GA3
Embryo-culture	MS + 1.2 uM IAA 2.3 uM Zeatin
Shoot regeneration	MS + 1.2 uM NAA 4.0 uM Zeatin
Rooting	MS + 25 uM NAA

3.3. Lentil Harvest Mechanization

Lentil harvest is the major production problem in the Mediterranean region because of the high cost of harvest labour. Systems of mechanization have been developed to decrease the cost of production of the crop. They include: 1) a lentil puller for use with existing cultivars and production practices, 2) mowers on a flattened seed-bed preferably with a non-lodging cultivar, and 3) combine harvesters on a well-prepared seed-bed sown with a tall, non-lodging cultivar. Following extensive research on lentil harvest mechanization at ICARDA, we are now emphasizing the transfer of the technology to national programs.

In Kameshly, the major area of lentil production of Syria, about 80,000 ha of lentil were sown in 1989 and approximately 25% were harvested by swathe-mower in 1990. Farmers prepared their land for machine harvesting by preparing the seed-bed with a plough and a disc-harrow, sowing with a seed drill and then rolling after sowing, following the guidance of the General Organization of Agricultural Mechanization. In contrast to previous seasons when combine harvesters were also used directly for lentil harvest, in 1990 only swathe-mowers were utilized because they allow straw collection and the price of straw was particularly high in this unfavorably dry and cold season.

Field losses from hand harvest and machine harvest by swathe-mower and combine harvester were measured on farmers' fields as part of a joint project with the General Organization of Agricultural Mechanization, Syria on the economics of lentil machine harvest. A total of 45 samples from 15 hand-harvested fields showed that losses on the bare ground accounted for 3.0% ± 0.39% of the potential seed yield, which averaged 1.41 t/ha. The potential straw yield of the samples averaged 3.1 t/ha, of which hand harvest left an average of 3.8% ± 0.45% losses on the field.

Losses from the swathe-mower were estimated on 12 farmers' fields in a total of 36 samples. The mean potential yield of the crop was 1.24 t/ha seed and 2.82 t/ha straw. The average loss of seed on the bare ground was 4.7% ± 0.97%; the range in losses on the bare ground was from 0-22%. Under the swathe, the seed losses were higher at an average of 8.6% of potential yield. The average stubble height was 14.0cm ± 0.95 with a range of from 8 - 30cm.

Harvest by combine harvester results in the loss of almost all straw. It was possible to take 12 samples from only a single farmer's field because of the high straw price this year. The potential yields of seed and straw were 1.23 and 2.06 t/ha and the average seed loss from the combine was 20.9% ± 5.25%. The mean stubble length from the combine was 13.4cm, similar to the height of the swathe-mower harvest.

3.4. Lentil Biological Nitrogen Fixation

3.4.1. Strain Selection for Improved N_2 Fixation in Jordan Lentil Cultivars

A large strain screening experiment was conducted to select the most efficient N_2 fixing Rhizobium strains for the major improved Jordan lentil cultivars, Jordan 1, Jordan 2 and Jordan 3. A total of 21 lentil rhizobia strains were tested with these cultivars for symbiotic effectiveness (SE) using an aseptic N-free hydroponic gravel culture system in the greenhouse. The strains for evaluation were chosen from the ICARDA collection of over 300 lentil rhizobia isolates, based on their high SE in previous screening. Included with these strains were the 4 best Jordanian strains in the ICARDA collection, isolated from Irbid (LE 850), El Shamahba (LE 843), Madaba (LE 838) and Juobel (LE 835). Symbiotic effectiveness was evaluated as:

$$SE = \frac{\text{Shoot dry weight of strain treatment}}{\text{Shoot dry wt. of 100 mg N pot}^{-1}\text{ control}} \times 100$$

In the experiment, variation due to cultivars was not significant, but variations due to strain and strain-cultivar interactions were significant at P<0.01 and P<0.05 levels, respectively. Performance of the Jordanian strains was variable according to cultivars, except for LE 850, which was relatively ineffective. The 3 best strains for each cultivar and across cultivars are shown in Table 3.4.1.

Table 3.4.1. Symbiotic effectiveness (SE) of most promising strains with 3 released Jordanian lentil lines. Strain sources are given.

Cultivar	Strain designations	SE	Source
Jordan 1	LE 735	114	Syria
	LE 843	114	Jordan
	LE 715	113	Syria
Jordan 2	LE 898	99	Turkey
	LE 893	97	Turkey
	LE 867	96	Turkey
Jordan 3	LE 804	112	Egypt
	LE 867	108	Turkey
	LE 835	100	Jordan
Cultivar mean	LE 867	100	Turkey
	LE 804	95	Egypt
	LE 893	93	Turkey
	Mean of 21 strains	71	

Though variability was observed from cultivar to cultivar, strain LE 867 was consistently superior, and should be further evaluated for effectiveness in the field. The high effectiveness of strains 835 and 843, of Jordanian origin, suggests that native rhizobial populations from El Shamahba and Juobel are capable of high N_2 fixation, and that inoculation in these areas is not necessary. These results confirm earlier survey work in which a large proportion of lentil rhizobia isolates from Jordan were found to be highly effective. However, strain LE 850 from Irbid had low N_2 fixing effectiveness with all three cultivars; if this strain is representative of the area, lentil N fixation may be improved through inoculation with selected superior strains.

Dr. D. Beck.

3.4.2. Effect of Variable Moisture on N_2 Fixation in Lentil

During the 1988/89 season, an experiment utilizing the line-source sprinkler and ^{15}N microplots was conducted at Breda in cooperation with the legume physiologist to determine the effects of variable moisture supply on N_2 fixation in 6 lentil lines. The material tested included local landraces and breeding lines from ICARDA. These genotypes were part of a group of 25 cultivars tested for drought tolerance, water use efficiency and yield response to increase in moisture supply (see FLIP Annual Report, 1989, pp 147-159).

Table 3.4.2. Characteristics and yields of six lentil cultivars under low (180 mm) and high (376 mm) moisture regimes. Breda, 1988-89.

		Driest treatment				Wettest treatment			
	Days to	Yield		WUE^{+} for		Yield		WUE for	
Cultivar	flower	SY	BY	SY	BY	SY	BY	SY	BY
ILL 4400	120	157	511	1.68	5.46	1441	3347	5.11	11.86
ILL 4401	120	83	589	0.87	6.20	1226	3235	4.32	11.40
ILL 5582	114	169	674	1.84	7.33	1494	3454	5.30	12.25
ILL 5604	123	130	587	1.39	6.29	1376	3263	4.82	11.42
ILL 5782	114	165	707	1.81	7.76	1231	3139	4.34	11.08
ILL 6004	114	283	815	3.06	8.82	1374	2981	4.88	10.59

$^{+}$ WUE Water use efficiency, in kg/ha/mm evapotranspiration for seed and biological yields

Cultivars ILL 5582, 5782 and 6004 were earliest in maturity, and had the highest yields and water use efficiencies (WUE) at the lowest moisture level (Table 3.4.2). Cultivar ILL 6004 had the highest water use efficiency at lowest moisture (180 mm). ILL 5582 had highest yields and WUE at the highest moisture level (376 mm).

Although cultivar ILL 5582 gave a good biological yield at the lowest moisture level, its total N yield was lowest of all cultivars at low moisture with only 10 kg N ha^{-1} (Figure 3.4.1). Cultivar ILL 6004 at the low moisture supply had the highest biological and N yields with 19 kg N ha^{-1}. The average N yield at this moisture level was 14 kg N ha^{-1} across cultivars. Nitrogen yields at the moderate moisture level (330 mm) ranged from 46 to 69 kg N ha^{-1}; ILL 5604 had the highest N yield. At high moisture (376 mm), N yields ranged from 71 to 94 kg N ha^{-1} (mean 80 kg ha^{-1}). Although cultivar ILL 5582 had highest yields and WUE at high moisture, N yield was below average with 78 kg N ha^{-1}. ILL 5604 had the highest N yield, ILL 5782 the lowest.

The proportion of N derived from N_2 fixation (%Ndfa) in lentil cultivars doubled from an average 36% at lowest moisture to 72% at moderate moisture, indicating that moisture was limiting fixation at the lower level (Figure 3.4.1). Levels of %Ndfa between cultivars at each moisture level showed no significant differences, with 35-38% at 290 mm, 71-73% at 330 mm, and 76-78% at 376 mm moisture. The lack of variation in N_2 fixation capacity of cultivars which responded quite differently, in terms of yield, to moisture availability suggests that

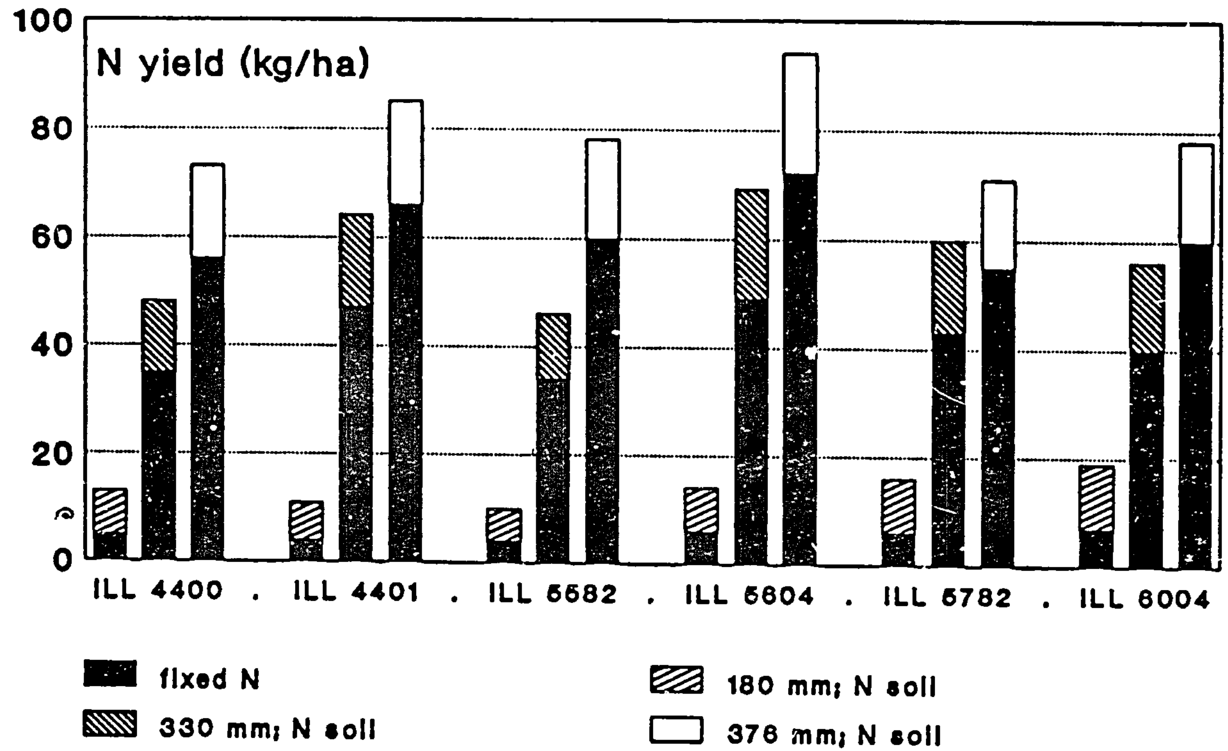

Figure 3.4.1. Nitrogen yield and source in 6 lentil cultivars grown at 3 moisture levels. High, moderate and low levels correspond to 180, 330 and 376 mm Breda.

the fixing system in lentil is an uncomplicated one. Symbiotic efficiency was improved only slightly to an average of 77% at the highest moisture level, implying that the symbiotic system was near maximum efficiency. Data from previous studies, where lentil cultivar ILL 8 gave 69-75 %Ndfa at 358-523 mm rainfall, supports this.

Differences in protein contents of the cultivars at maturity affected the total quantities of N_2 fixed in each. Cultivar ILL 5604 had average biological and seed yields and %Ndfa at high moisture, but because of higher protein content had the largest quantity of N_2 fixed at 72 kg N ha^{-1} (cultivar mean was 61 kg ha^{-1}). Cultivar ILL 5782 had lowest N_2 fixed at high moisture, with 55 kg ha^{-1}.

Further investigations of moisture effects on N_2 fixation in lentil will utilize the line-source sprinkler to observe more closely the direct relationship between moisture availability and fixation.
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3.5. Lentil Physiology

Identifying genotypes that can withstand drought but are, at the same time, capable of benefiting from additional moisture is an important crop improvement objective in lentil. Use of a line-source sprinkler at Breda site, which has a long-term average rainfall of 274.2 mm, provides a good scope for such evaluation (FLIP Annual Report 1988/89).

3.5.1. Responses of Genotypes to Varying Soil Moisture Supply

Studies were continued during the 1989/90 season at Breda, where the seasonal precipitation was only 184.6 mm, using 25 diverse lentil genotypes. Using line-source sprinkler after the termination of the main rainy period to supplement total seasonal rainfall, six different moisture supply levels were studied. Because of cold and suboptimal rainfall, the crop growth was rather restricted and the yield levels were low.

The effects of six moisture supply levels on the seed yield, total biological yield and harvest index are shown in Table 3.5.1. As the moisture supply decreased from a total seasonal value of 319.6 mm, the yield decreased. As in case of chickpea, the reduction in seed yield was much higher than in the total biological yield, because of poorer partitioning of dry matter into the reproductive bodies with decreasing moisture supply.

Table 3.5.1. Effect of total seasonal moisture supply (rainfall, and supplementary irrigation) on the mean performance of 25 diverse genotypes of lentil at Breda, 1989/90.

Total seasonal moisture (mm)	Seed yield (kg/ha)	Total biological yield (kg/ha)	Harvest index
184.6	14	291	0.05
199.6	18	288	0.07
229.6	74	470	0.14
259.6	233	910	0.23
289.6	485	1633	0.28
319.6	649	2027	0.31
S.E.	18.7	44.2	0.008
LSD (P<0.05)	36.7	86.7	0.105
C.V. (%)	53.9	33.4	32.3

There were large differences in genotypes in their response to increasing moisture supply, although the relationship in general was linear. The regression of yields on the total seasonal rainfall using mean yields (of 4 replications) of each genotype is shown in Table 3.5.2. Lentil genotypes ILL 5863, 6049, 4401, 5860 and 5754 showed a large response to increased moisture supply but low intercept, suggesting that they would make very good use of increased moisture supply, but would suffer greatly under drought. On the other hand, there are genotypes such as ILL 6004, 6035, 4349 and 5994 which have higher intercept but low slope of the regression line and would thus be performing well under restricted moisture but would not make best use of increased moisture supply. Combining the characteristics of these two groups of genotypes by crossing may result in higher and stable yielding lentil genotypes for the dry environments common in the lentil growing areas of Syria.

3.5.2. Genotype Characterization

A detailed study of the growth and phenological characters of the 25 diverse genotypes of lentil was carried to investigate the possibility of predicting the yield performance of rainfed lentil under Tel Hadya conditions. The genotypes used were the same as in the line-source sprinkler study at Breda. The sowing was done on 2 Dec. 1989. The correlation coefficients for various characters with seed yield, straw yield and total biological yield are shown in Table 3.5.3.

Seed yield was positively correlated with the seedling vigour 53 days and 59 days after sowing, but the relationship with this character weakened when the period of cold spell occurred. The yield was significantly and negatively correlated with the cold damage score recorded on 21 March '90. Ground cover and shoot dry weight early in the season showed negative relationship because the faster growth early in the season made the plants more susceptible to the cold in the middle of March. However, the straw yield and total biological yield was generally positively correlated with the early shoot dry matter.

Table 3.5.2. Relationship between total seasonal mositure supply (mm) with the yield (kg/ha) of lentil.

	Seed yield (kg/ha)			Total biological yield (kg/ha)		
Genotype	Intercept	Slope	R^2	Intercept	Slope	R^2
ILL 5754	-1502	7.4793	0.92	-3123	17.4117	0.96
ILL 5989	-836	4.2628	0.95	-2096	12.1167	0.91
ILL 5991	-774	3.9176	0.91	-2095	11.5843	0.93
ILL 5994	-580	2.9907	0.97	-1564	9.3664	0.97
ILL 6011	-916	4.5887	0.91	-2217	12.3291	0.92
ILL 1939	-863	4.3772	0.94	-2502	13.5456	0.94
ILL 5715	-1272	6.6387	0.96	-3144	14.6605	0.96
ILL 5775	-1332	6.6272	0.92	-3093	16.9089	0.93
ILL 5860	-1487	7.5249	0.92	-2407	14.3366	0.89
ILL 5863	-1763	9.0106	0.93	-3730	20.4528	0.93
ILL 6049	-1501	7.7224	0.96	-2898	16.3388	0.94
ILL 6004	-460	2.2857	0.90	-1557	8.5861	0.89
ILL 6024	-787	3.9216	0.91	-2096	11.3017	0.91
ILL 6035	-467	2.3293	0.92	-1604	9.0093	0.95
ILL 4403	-831	4.2241	0.95	-2130	11.2860	0.94
ILL 5782	-699	3.6214	0.94	-1749	10.5571	0.94
ILL 2126	-722	3.6208	0.93	-2564	14.5547	0.95
ILL 5604	-1083	5.4968	0.92	-3052	16.4177	0.92
ILL 4605	-697	3.4237	0.86	-2152	11.3027	0.87
ILL 5582	-1102	5.5711	0.94	-2882	15.9078	0.94
ILL 5586	-1044	5.3551	0.96	-2514	13.9626	0.95
ILL 4349	-471	2.4172	0.95	-2664	13.6042	0.92
ILL 4354	-800	4.0939	0.93	-2248	12.3527	0.93
ILL 4400	-902	4.5154	0.91	-2604	14.9651	0.95
ILL 4401	-1440	7.3056	0.95	-2980	16.8477	0.96

Table 3.5.3. Coefficients of correlation of various growth and phenological traits with the yield of rainfed lentil at Tel Hadya 1989/90 (Based on 25 genotypes and 4 replications).

Character (mean values)	Seed yield	Straw Yield	Total biological yield
Vigour on 24.1 (3.01 on 1-5 scale)	0.2696**	0.0706	0.1683
Vigour on 6.2 (2.942)	0.2017*	-0.0256	0.0670
Vigour on 1.3 (2.738)	0.1110	-0.0859	-0.0172
Vigour on 11.3 (2.510)	0.0962	-0.2063*	-0.1141
Vigour on 21.3 (2.501)	0.1382	-0.2542*	-0.1321
Vigour on 2.4 (2.34)	-0.0077	-0.5392**	-0.4088**
Vigour on 18.4 (2.359)	-0.1532	-0.6047**	-0.5202**
Cold damage 21.3 (36.79%)	-0.2096*	-0.5385**	-0.4946**
% ground cover on 24.1 (11.51%)	-0.3628**	-0.1483	-0.2666**
% ground cover on 6.2 (17.34%)	-0.1370	-0.0846	-0.1226
% ground cover on 1.3 (27.8%)	-0.1633	0.1076	0.0111
% ground cover on 11.3 (43.5%)	-0.1468	0.2467*	0.1228
% ground cover on 21.3 (53.7%)	0.1241	0.4125**	0.3633**
% ground cover on 2.4 (67.5%)	0.2089*	0.6567**	0.5832**
% ground cover on 18.4 (74.9%)	0.3156**	0.7541**	0.7021**
Shoot dry weight on 23.1 (0.0019 g/½m)	-0.0818	0.1952	0.1118
Shoot dry weight on 6.2 (0.0394 g)	-0.3394**	0.2428*	0.0376
Shoot dry weight on 1.3 (0.1049 g)	-0.1937	0.4174**	0.2311*
Shoot dry weight on 12.3 (0.1945 g)	-0.2379*	0.2360*	0.0758
Shoot dry weight on 21.3 (0.3073 g)	0.0051	0.5002**	0.3784**
Shoot dry weight on 31.3 (0.4916 g)	0.1742	0.5574**	0.4937**
Shoot dry weight on 12.4 (0.7339 g)	0.3479**	0.7110**	0.6834**
Shoot dry weight on 20.4 (0.9365 g)	0.3089**	0.5778**	0.5665**
Leaf-size on 18.4 (1.63)[1]	-0.2076*	0.3006*	0.1374
Leaf colour on 18.4 (3.08)[2]	0.2960**	-0.2105*	-0.0317
Leaf hairiness on 18.4 (2.60)[3]	-0.2282*	-0.0167	-0.1102
Days to start of flowering (120.5 days)	-0.1767	0.2088*	0.0815
Days to start full flowering (124.3 days)	-0.1864	0.2886**	0.1374
Days to start of podding (135.3 days)	-0.1970	-0.0465	-0.1192
Days to start full podding (139.6 days)	-0.2675**	-0.1451	-0.2235*
Days to start of maturing (147.9 days)	-0.2045*	0.1668	0.0380
Days to start full maturity (153.7 days)	-0.2320**	0.1705	0.0291
Total biological yield (2274 kg/ha)	0.7218**	0.9194**	
Seed yield (603.3 kg/ha)		0.3913**	

[1] 1-3 scale, 1= small leaf; 3= large leaf
[2] 1-5 scale, 1= dark green, 5= pale green
[3] 1-5 scale, 1= very hairy; 5= without hairy growth
* Significant at P<0.05; ** Significant at P<0.01

There was a negative correlation between the leaf size and the seed yield. Lighter green colour and hairy surface were associated with higher grain yield. Days to podding and days to maturity were negatively associated with the seed yield emphasising the need for earliness in the lentil genotypes under the dry environment of Tel Hadya (total seasonal rainfall 233.4 mm) this season.

3.5.3. Root Studies

Differences in the rooting pattern affect the amount and timing of availability of water to a crop, and can be an important mechanism in drought tolerance. Differences in the root growth of some selected genotypes were observed in a pot study in greenhouse in 1988/89 (FLIP Annual Report, 1989). To confirm the results, studies were repeated during the 1989/90 season. The results on shoot dry weight and root length, root volume and root dry weight are presented in Fig. 3.5.1. As in the previous season ILL 4400, ILL 4401, ILL 5582 attained higher root volume, length and dry weight than others. ILL 6004 which made faster early growth invested lesser dry weight in the root system.

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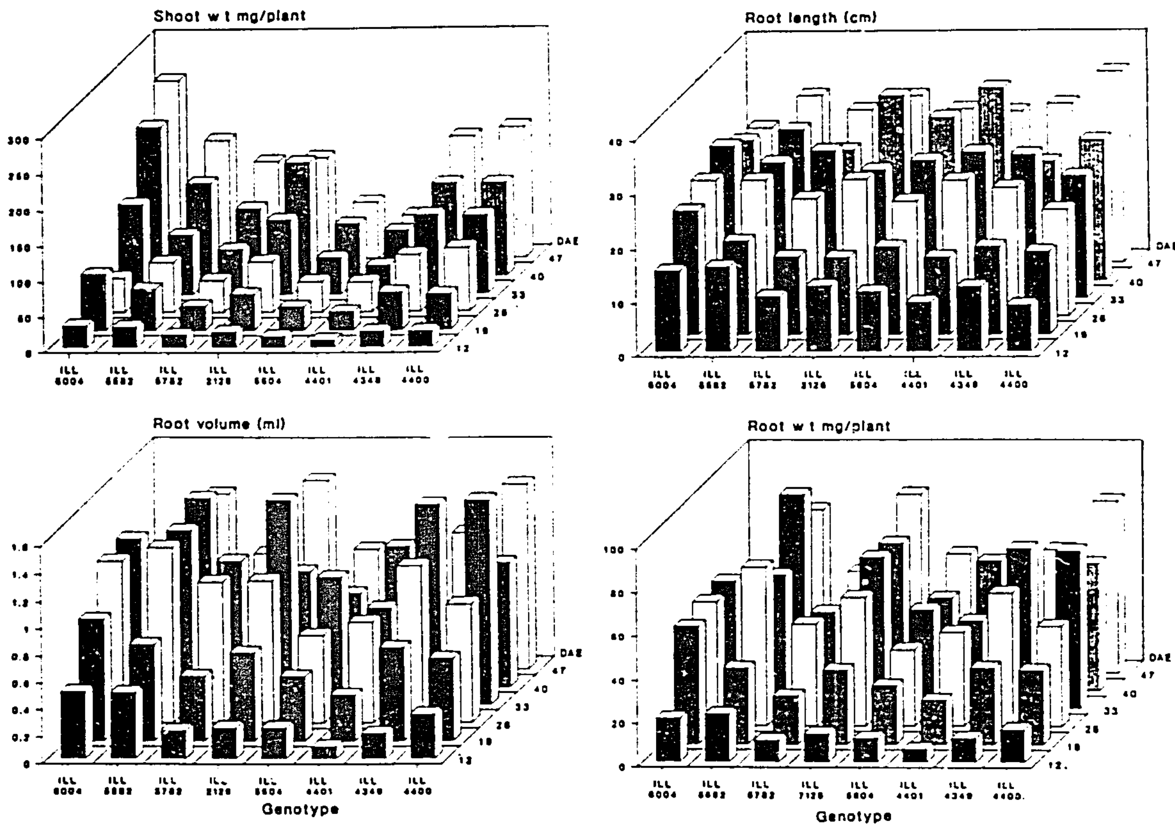

Figure 3.5.1. Shoot weight and length, volume and dry weight of roots of eight diverse genotypes of lentil at various stages of growth. Green house pot culture study, 1990.

3.6. Lentil Entomology

Studies on the extent of damage by Sitona crinitus to lentil yield and nitrogen fixation were continued. For storage pests experiments were conducted on methods of protection in the store.

3.6.1. Effect of S. crinitus on Lentil Yield and Nitrogen Fixation

In the previous year (1988/89) 15 N technique was used to determine the effect of the Sitona larvae feeding in the nodules on the nitrogen fixation of the lentil plants. Microplots in the check and 20 kg/ha carbofuran (5 % G) treatments received 10 kg N/ha of 10 % 15 N atom excess as ammonium sulphate; microplots of the reference crop (non-nodulating chickpea) received 100 kg N/ha of 1 % 15 N atom excess fertilizer. The experiment was carried out at Breda, Tel Hadya and Jinderess using 2 sowing dates (late November and early January).
The rainfall during 1988/89 season was low, resulting in low yields, especially in the late sowing dates.

The application of carbofuran increased lentil seed and total biological yield at all locations in the early sowing date, but significantly only at Jinderess with the higher rainfall of 354 mm (Table 3.6.1). At Jinderess the percent nitrogen derived from fixation was significantly higher in the early (71 %) than in the late sowing (43 %). Although about 50 percent nodule damage without Sitona control was observed in both early and late sowing, the percent nitrogen derived from fixation was the same. Nitrogen yields from

Table 3.6.1. Effect of sowing date and carbofuran application (20 kg/ha 5% G) on lentil seed and total biological yield, nodule damage by Sitona and nitrogen fixation at 3 locations in Syria, 1988/89.

Location (rainfall)	Treatment	Lentil yield kg/ha Seed	Total	N yield kg/ha	% N from fixation	N yield from fixation (kg/ha)	%damaged nodules
Jinderess (354 mm)	Early C 0	738	1781	56.7	71.0	40.4	51.8
	Early C 20	1138	2468	68.0	71.0	48.4	13.5
	Late C 0	370	1083	27.4	43.3	11.9	49.9
	Late C 20	415	1288	34.5	43.1	14.9	25.0
	S.E.M.	66.4	117.8	6.9		4.5	
	LSD P<0.05	212.3	377.0	22.0		14.6	
	CV %	20.0	14.2	29.5		31.5	
Tel Hadya (235 mm)	Early C 0	345	1445	34.0	16.1	6.3	51.5
	Early C 20	429	1690	46.0	34.2	14.8	19.8
	Late C 0	226	991	26.6	34.1	9.0	34.9
	Late C 20	245	933	29.1	31.2	9.0	11.5
	S.E.M.	46.2	120.4	6.4		2.0	
	LSD P<0.05	147.8	385.0	ns		6.7	
	CV %	29.7	19.0	37.8		42.6	
Breda (190 mm)	Early C 0	221	766	17.9	36.8	6.6	42.6
	Early C 20	228	803	19.5	38.1	7.4	19.3
	Late C 0	42	202	5.8	35.0	2.0	53.7
	Late C 20	46	220	5.6	34.5	1.9	48.9
	S.E.M.	7.4	31.0	1.7		0.6	
	LSD P<0.05	23.6	99.2	5.6		2.0	
	CV %	10.9	12.4	28.9		28.6	

fixation were higher with carbofuran application, but not significantly. At Tel Hadya (235 mm rainfall) lentil yields and nitrogen fixation were lower. In early sowing the percent nitrogen and nitrogen yields from fixation were significantly higher with carbofuran application, whereas in late sowing no effect of <u>Sitona</u> control on nitrogen fixation was found. At Breda, the dry site with only 190 mm rainfall, yields were very low, but the percent of nitrogen deived from fixation was about the same as at Tel Hadya. In early sowing the percent nitrogen and nitrogen yields from fixation were slightly, but not significantly, higher with carbofuran application. In late sowing carbofuran did not reduce nodule damage and no effect on nitrogen fixation was found.

This season, 1989/90, the experiment was again conducted at the 3 locations, but the treatments were changed. The results of the previous years had consistantly shown that in spite of higher <u>Sitona</u> infestations in early sowing, yields were higher because of the longer growing period for the plants, especially in dry seasons. Therefore only the early sowing date, end of November, was included. As the seed treatment with Promet proved to be effective at Tel Hadya last season, 2 dosages of Promet (12 and 25 ml/kg seed) and 2 dosages of carbofuran (10 and 20 kg/ha 5 % G) were used as treatments this season. 15 N technique was used to quantify the nitrogen fixation, whereby microplots in the check and all treatments received 10 kg/ha N of 10 % 15 N atom excess as ammonium sulphate, and the microplots of the reference crop(non- nodulating chickpea) received 100 kg/ha N of 1 % 15

N atom excess fertilizer. Because of the low rainfall again this season and severe frost in mid March at Tel Hadya and Breda yields in general were low.

At Jinderess with 333 mm rainfall the lower and higher treatment levels of both carbofuran and Promet significantly increased lentil seed and total biological yield (Table 3.6.2). No difference was found between the two levels of both insecticides indicating that the lower dosages are effective. Promet treatment tended to give higher yields than carbofuran, although the difference were not significant. The nitrogen yields were significantly higher in both Promet and the carbofuran 20 kg/ha treatments. Although the mean nodule damage of 5 sampling dates was 64 percent in check plots and was significantly reduced by all treatments, the percent nitrogen derived from fixation did not differ and was between 41 and 43 percent in various treatments. The nitrogen yield from fixation, however, was significantly higher in both Promet treatments and the 20 kg/ha carbofuran treatment than in the check.

At Tel Hadya, yields were low and yield increases due to Sitona control were non-significant. All treatments significantly reduced the nodule damage from 76.5 to 20-26%. The percent nitrogen and nitrogen yields derived from fixation were higher with Sitona control, but not significantly.

Table 3.6.2. Effect of 2 levels of carbofuran (10 and 20 kg/ha 5% G) and Promet (12 and 25 ml/kg seed) on lentil seed and total yield, nodule damage by Sitona, and nitrogen fixation at 3 locations in Syria, 1989/90.

Location (rainfall)	Treatment	Lentil yield kg/ha Seed	Lentil yield kg/ha Total	N yield kg/ha	% N from fixation	N yield from fixation (kg/ha)	%damaged nodules
Jinderess (333 mm)	Check	1634	4598	98.2	42.3	41.5	63.8
	C 10	1890	5411	134.1	41.7	56.1	23.7
	C 20	1913	5461	145.9	43.7	63.7	15.8
	P 12	1959	5701	160.2	41.2	65.9	24.0
	P 25	1928	5724	149.6	43.4	64.6	23.2
	S.E.M.	63.4	177.8	12.6		5.5	1.6
	LSD P<0.05	195.4	547.9	38.8		17.0	4.9
	C.V. %	6.8	6.6	18.3		18.9	21.5
Tel Hadya (233 mm)	Check	320	2812	70.8	44.3	31.4	76.5
	C 10	332	2957	77.1	47.1	36.3	21.9
	C 20	338	2866	78.7	45.8	36.0	26.3
	P 12	348	2977	78.2	46.0	35.9	19.5
	P 25	331	2975	80.9	45.5	36.7	20.5
	S.E.M.	51.8	146.9	4.1		2.0	3.2
	LSD P<0.05	ns	ns	ns		ns	9.8
	CV %	31.0	10.1	10.8		11.3	19.4
Breda (183 mm)	Check	39	558	17.7	38.0	6.8	47.5
	C 10	15	528	17.3	37.8	6.5	9.9
	C 20	44	604	20.3	38.0	7.7	6.3
	P 12	34	592	18.9	38.4	7.2	6.3
	P 25	36	598	21.3	36.8	7.9	4.2
	S.E.M.	13.7	16.1	0.6		0.4	1.6
	LSD P<0.05	ns	49.5	1.9		1.1	4.9
	CV %	81.7	5.6	6.3		10.4	21.5

At Breda with only 183 mm rainfall plant growth and yields were extremely low. Promet treatments and carbofuran 20 kg/ha slightly increased lentil total biological yield and nitrogen yield. Nodule damage was significantly reduced by both the insecticide but no difference existed in the percent nitrogen derived from fixation. The nitrogen yield from fixation was significantly higher in the Promet 25ml/kg seed treatment than in the check.

The 2 seasons results revealed that the nodule damage caused by Sitona larvae did not significantly decrease the percentage of plant nitrogen derived from fixation. However, Sitona control increased nitrogen yields from fixation at all locations in both years. As in both seasons rainfall was low the experiment will be repeated at Tel Hadya and Jinderess in the coming season.

3.6.2. On-farm Evaluation of Promet Seed Treatment for Sitona Control

The effectiveness of Promet seed treatment (12 ml/kg seed) in comparison to carbofuran (10 kg/ha 5% G) was studied in on-farm trials at 2 locations near Breda station with low rainfall (Azzan and Abtin) and at 2 locations near Jinderess with higher rainfall (Alkamiye and Afrin). Both treatments increased lentil seed and biological yields at all locations, but only the increase in biological yield in Promet treatment at Alkamiye was significant (Fig. 3.6.1). At Afrin no yield data could be obtained because of accidental harvest of the crop by the farmer.

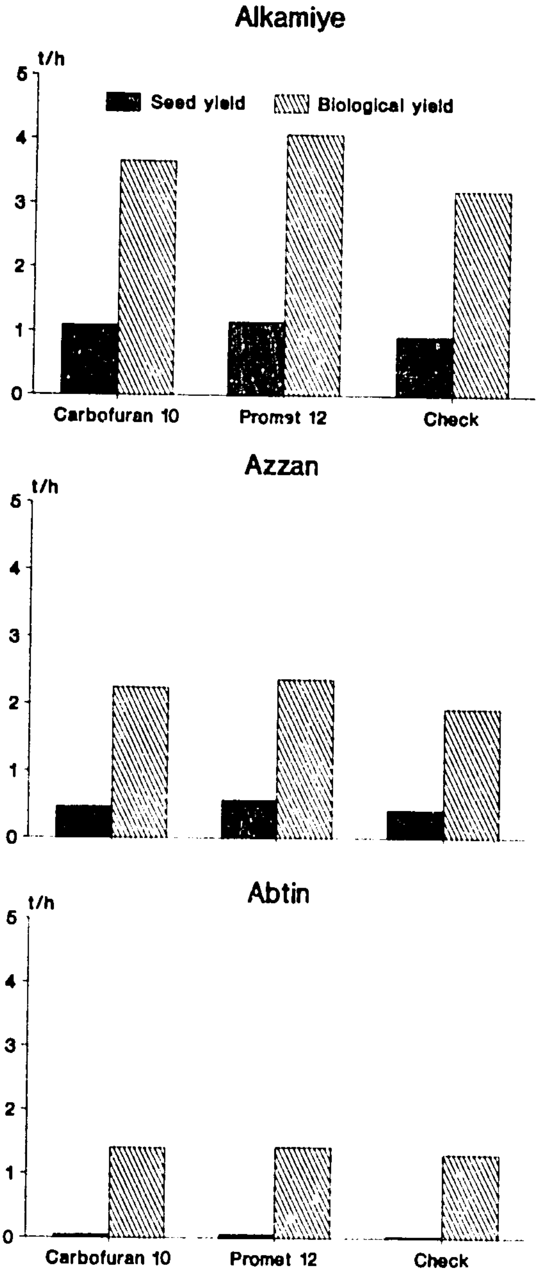

Figure 3.6.1. Effect of application of carbofuran (10kg/ha, 5% G) and Promet (12 ml/kg seed) on lentil seed and biological yield at 3 on-farm locations in northern Syria, 1989/90. Standard errors of mean for seed and biological yields, respectively: Alkamiye 0.079 and 0.148, Azzan 0.084 and 0.166, Abtin 0.006 and 0.052 t/ha.

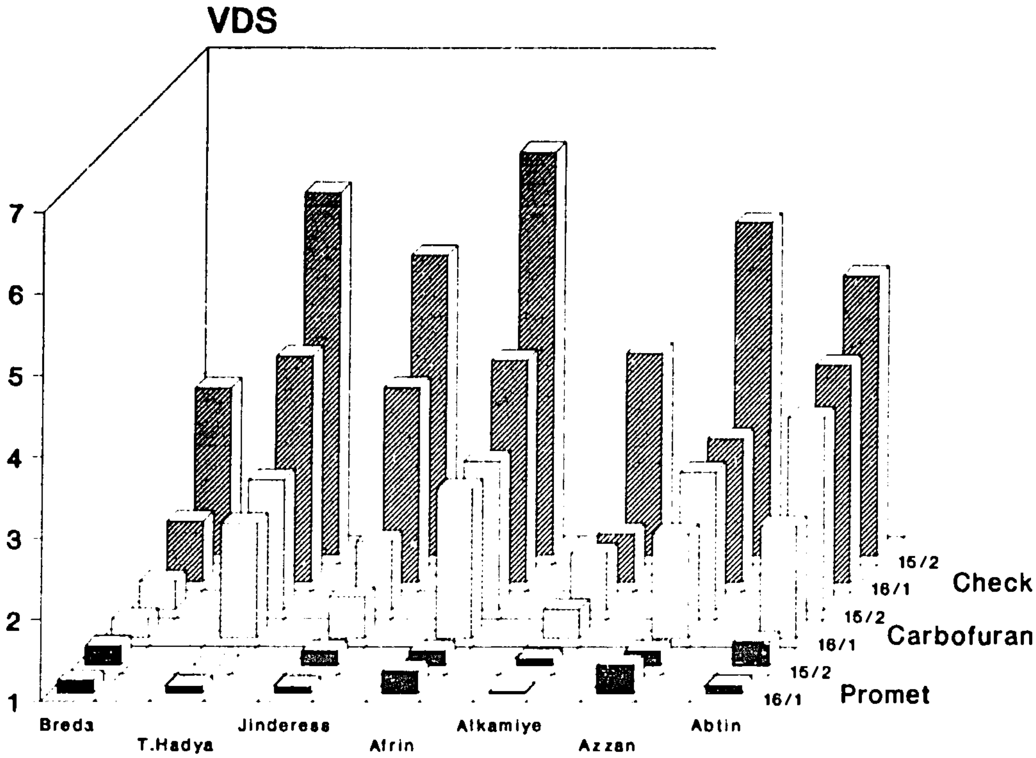

Figure 3.6.2. Effect of carbofuran (10kg/ha 5% G) and Promet (12 ml/kg seed) treatment on <u>Sitona</u> feeding damage in lentil measured by visual damage score on 16 January and 15 February at 7 locations in northern Syria, 1989/90.

The feeding damage of the Sitona adults was assessed at seven sites twice (mid-January and mid-February) using a visual damage score (VDS, 1 to 9). Promet effectively suppressed feeding, whereas in the carbofuran treatments some feeding damage occurred (Fig. 3.6.2). The extent of damage also differed between locations, being higher at Tel Hadya, Jinderess, Afrin and Azzan, as compared to that at Breda, and Alkamiye.

Oviposition of S. crinitus was monitored by counting the number of eggs extracted from 100 cc soil samples taken at 2 week intervals. At all locations oviposition started in the beginning of January, reached a peak in mid-February and ceased in early April (Fig. 3.6.3 and 3.6.4). At the dry locations, Breda, Azzan and Abtin, the number of eggs in general was lower and oviposition more uniform over the 3 months period as compared to the other locations with higher rainfall where a pronounced peak of oviposition was observed. Both Promet and carbofuran treatments greatly reduced the number of eggs with Promet being more effective.

The mean nodule damage at 5 sampling dates over a 2 months period at the 3 stations and 4 on-farm sites is presented in Figures 3.6.5. and 3.6.6, respectively. At Breda and the other dry locations nodule damage was low at the end of February and only increased in March, whereas at Tel Hadya, Jinderess and Afrin nearly 80 percent nodule damage was observed at the first sampling date. At all locations Promet and carbofuran significantly reduced the nodule damage at all

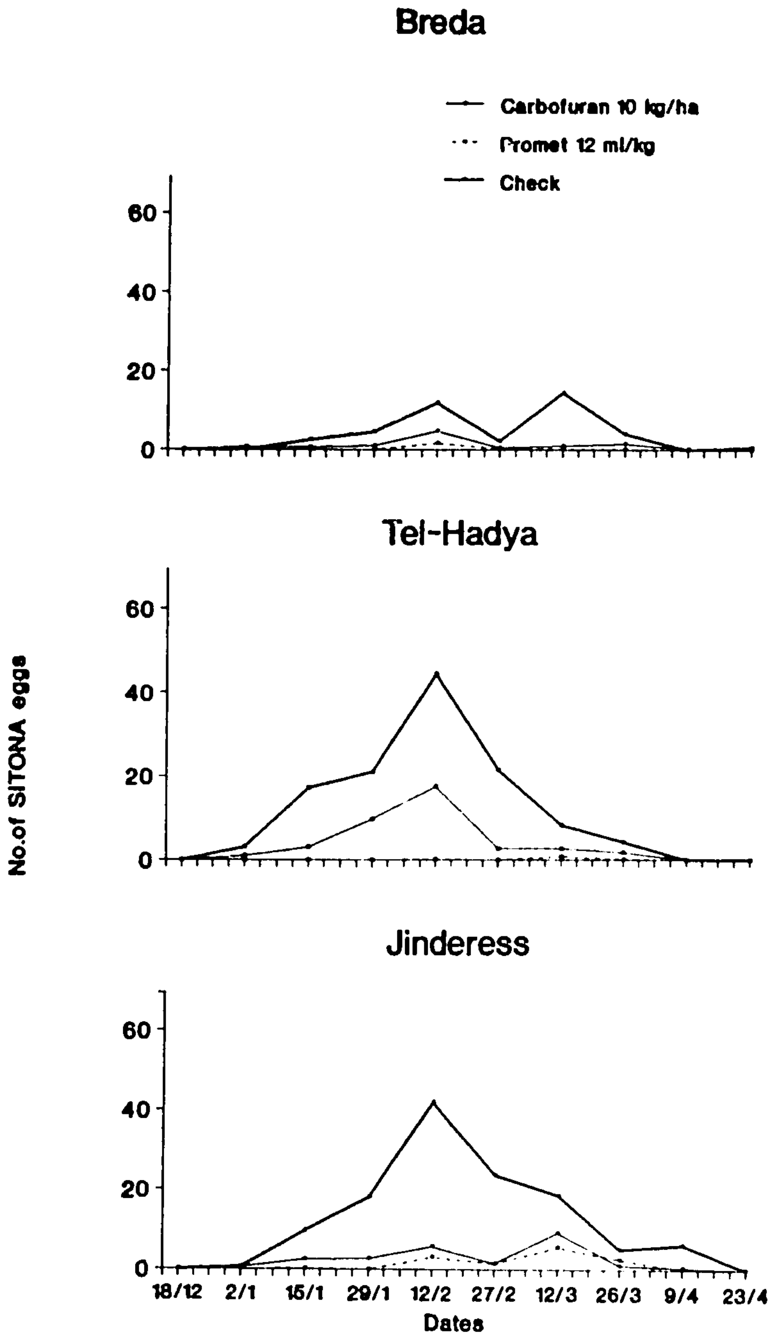

Figure 3.6.3. Mean number of Sitona crinitus eggs extracted from 100 ccm soil samples with and without carbofuran (10kg/ha, 5% G) or Promet (12 ml/kg seed) treatment at Breda, Tel Hadya and Jinderess, Syria, 1989/90.

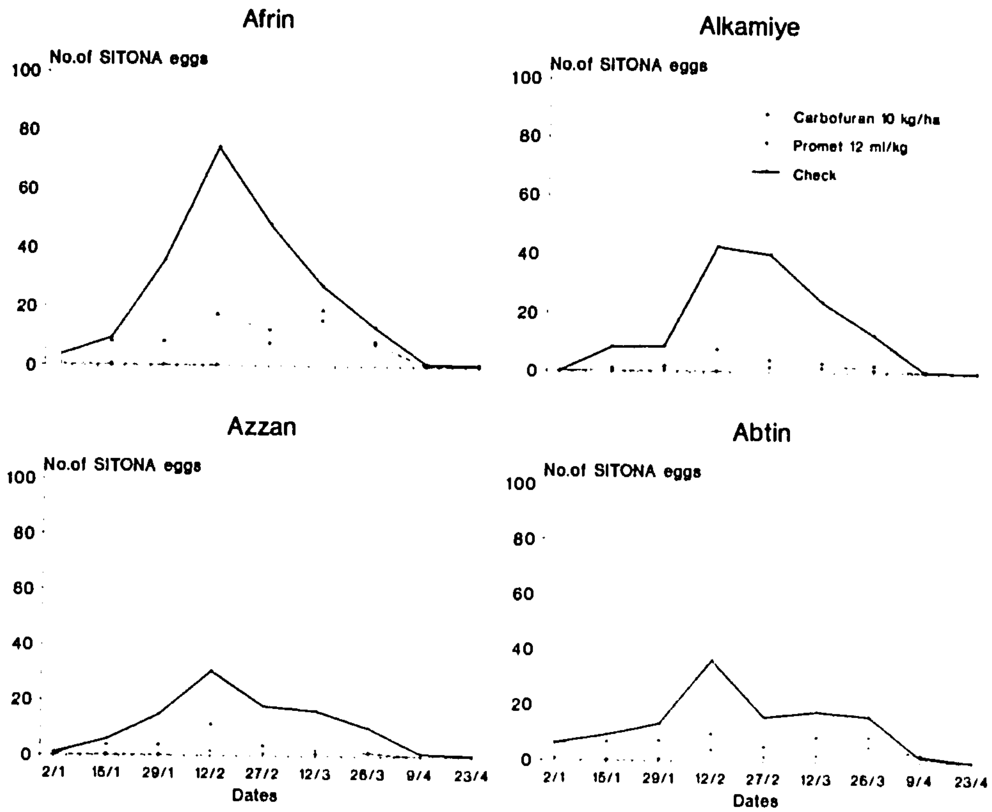

Figure 3.6.4. Mean number of *Sitona crinitus* eggs extracted from 100 ccm soil samples with and without carbofuran (10kg/ha, 5% G) or Promet (12ml/kg seed) treatment at 4 on-farm locations in northern Syria, 1989/90.

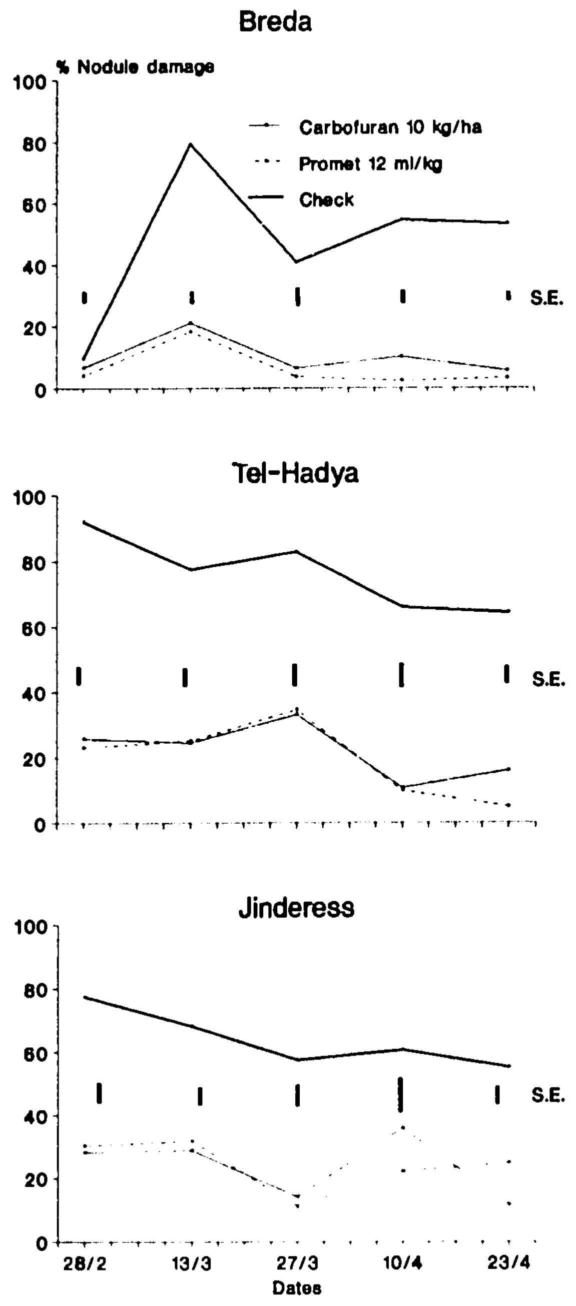

Figure 3.6.5. Effect of carbofuran (10kg/ha, 5% G) and Promet (12ml/kg seed) application on Sitona damage to nodules in lentil at Breda, Tel Hadya and Jinderess Syria, 1989/90.

dates. The curves for the 2 insecticide treatments closely followed the curve for the check, with clear treatment effects indicating that the sampling method is capable of determining the development of nodule damage.

Comparing the results of visual damage score, number of eggs and nodule damage reveals that low feeding damage results one associated with lower oviposition which in turn results in lower nodule damage; this has been confirmed by the regression studies. The number of eggs laid/100 cc soil (y_1) at the peak in mid-February was related to the visual damage score in mid January (x_1) in a quadratic fashion described by the equation $y_1=4.10-5.08x_1+4.68x_1{}^2$ with a multiple correlation coefficient of 0.8449 ($P<0.01$). The percentage of damaged nodules (y_2) in mid March was related to the number of eggs (x_2) at the peak in mid February again in a quadratic pattern described by the equation $y_2=18.75-0.0190x_2+2.1668x2^2$ with a multiple correlation coefficeint of 0.8408 ($P<0.01$). The direct relationship between the visual damage score (x_1) and the nodule damage (y_2) was slightly weaker but exponential and could be described by the equation $y_2=21.47+1.1960x_1+3.8689x1^2$ with a multiple correlation coefficient of 0.7387 ($P<0.01$).

3.6.3. Protection of Lentil Seeds in Storage

The previous surveys of storage pests in Jordan and Syria revealed that the univoltine Bruchus spp. are more common in lentil. However, the multivoltine species, Callosobruchus chinensis also causes considerable

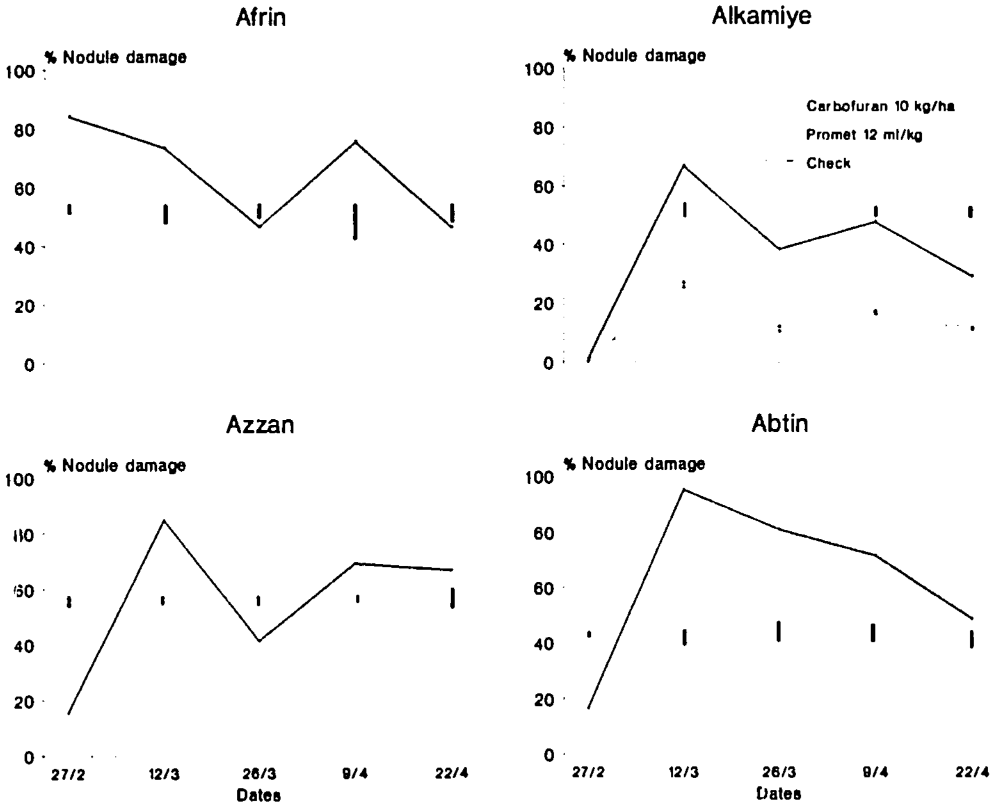

Figure 3.6.6. Effect of carbofuran (10 kg/ha, 5% G) and Promet (12ml/kg seed) application on Sitona damage to nodules in lentil at 4 on-farm locations in northern Syria, 1989/90.

losses necessitating control methods. A number of traditional methods of seed protection were tested for their effectiveness in comparison with 2 insecticides, Actellic (1 g and 0.5 g/kg seed) and K-othrin (0.5 g/kg seed). Treatments were same as those for chickpea (Section 2.4.4).

Every 3 months 500 lentil seeds were infested with 4 female and 4 male C. chinensis and the number of progeny per female and percent infestation counted after 1 month. Except for the insecticide treatments and olive oil + salt, all other treatments were not effective for even a period of one month giving 35 to 54 progeny per female and 26 to 44 percent infestation which did not differ from the check (55 progeny and 41 percent infestation). Therefore these treatment were dropped from further evaluation. The insecticides and olive oil + salt treatment continued to be effective, even after a period of 10 months. The lower dosage (0.5 g/kg seed) of Actellic was as effective as the higher dose.

Drs. O. Tahhan and S. Weigand.

4. FABA BEAN IMPROVEMENT

The 1989/90 season was the first for the ICARDA faba bean improvement team based at Douyet, Morocco. For the past season there was a full set of ICARDA trials and nurseries at Douyet Research Station, and at ICARDA headquarters only work on the germplasm collection of faba bean continued. Core activities on faba bean will be completely phased out by the end of 1991, except that collection, conservation, evaluation, documentation and distribution of germplasm will be continued in the Genetic Resources Unit, and dissemination of information through the Communication, Documentation and Information Unit. Remaining core activity in the interim period will aim to continue the smooth transfer of research to INRA, Morocco, which will assume responsibility for faba bean improvement.

Faba bean is predominately grown in wheat-based farming systems in the WANA region, mainly in medium rainfall environments (above 450mm). For this reason, Douyet Research Station near Fes, Morocco, was chosen as the site for the transfer of faba bean improvement research from ICARDA to INRA, Morocco. The goal of faba bean improvement research has been to make the crop more competitive with other crops, thereby, halting the decline in faba bean area over the past twenty years. With faba bean as a more appealing alternative to continuous cereals, a more sustainable farming system could be developed in the medium rainfall areas of WANA.

The shift of faba bean research to North Africa brought a major shift in emphasis to Orobanche resistance. Increased research in this area has achieved promising results. Research on other major pests of faba bean (chocolate spot, rust, nematodes, and ascochyta blight) and to improve plant response to productive environments through altering the plant type has been given major emphasis in the transfer of ICARDA work from Headquarters to Morocco.

4.1. Transfer of Faba Bean Improvement Research to North Africa

In accordance with the decision of the Consultative Group on International Agricultural Research (CGIAR) to phase-out crop improvement on faba bean at ICARDA headquarters and to transfer this to a North African national research program, the ICARDA faba bean improvement team was transferred to Douyet Research Station (near Fes) of INRA, Morocco as of September 1, 1989. The objective of this move has been to develop an INRA, Morocco faba bean team to assume the responsibility of ICARDA's faba bean crop improvement research. Special efforts were made during the first season to establish strong foundations to complete the transfer by the end of 1991 to set the stage for special funding which guarantees the smooth continuity of research beyond 1991, when ICARDA's core funding on faba bean will terminate. Breeder and agronomist counterparts have been identified and stationed at Douyet with the ICARDA faba bean team. Day to day interaction has helped in training these counterparts to assume their future roles. Efforts are continuing to identify a counterpart pathologist who will be in place by January, 1991.

Specific accomplishments in establishing a faba bean project in Douyet are as follows:

(a) Two offices with two computers and a pathology laboratory with basic equipments were established.

(b) Screenhouse facilities for pure line breeding (21) were transferred and field facilities for disease screening research were established.

(c) Faba bean improved germplasm, including inbred and advanced lines with disease resistance, closed flowers, determinate growth habit and IVS were transferred from ICARDA to Douyet.

(d) North African Regional Large and Small Yield Trials and Orobanche nurseries were initiated and distributed.

(e) Screening for resistance to Orobanche at Douyet, chocolate spot and Ascochyta blight at Meknes, and stem nematodes at Guich began in 1989 under artificial inoculations.

(f) Verification trials to transfer Orobanche resistant lines to farmers were initiated in close collaboration with extension personnel in Morocco.

(g) A two week faba bean improvement course (breeding/pathology) was conducted in collaboration with INRA and ENA-Meknes. The course hosted 14 participants from six different countries.

While all efforts have been made to transfer ICARDA's faba bean research to INRA, Morocco, to accomplish this transfer by December, 1991, in a way that will have a sustainable impact, is not possible. The INRA faba bean breeder and agronomist were only in place in February, 1990 and there is still need for a pathologist to be identified. Since none of those personnel have previous faba bean experience, the minimum on-the-job training these national staff will need would be three to four years. Furthermore, INRA, Morocco, quite correctly desires to send these staff abroad for Ph.D. training to have a well-trained faba bean improvement program.

For the above reasons, major efforts were made in developing a bilateral grant proposal to support a faba bean project in Morocco. This proposal has made provision to provide necessary facilities for the INRA faba bean program and an operating budget. Also, there is provision for a faba bean breeder/pathologist to be recruited by ICARDA internationally to backup the INRA faba bean team in this transition period. A BMZ team met with INRA and ICARDA in September, 1990 and discussed the proposal with a favorable reaction. Suggestions have been incorporated and the proposal has been formally submitted to BMZ by the Government of Morocco. 'Bridge-funding' to meet any gap between the end of 1991 when ICARDA core funding stops and the time when the bilateral project with INRA, Morocco assumes financing for the faba bean project, is also being sought. Funding for Tunisia and Algeria national programs for faba bean research has also been requested.

4.2. Faba Bean Breeding

Faba bean breeding has concentrated on providing high yielding lines with acceptable consumer traits such as large-seeded, long-podded lines for vegetable use, large and intermediate seeded lines as pulse and small seeded lines for use as animal feed. The major activities of faba bean improvement research were on resistance to biotic stresses, particulary Orobanche, and in altering the plant type to control vegetative growth, flower and pod drop, and converting faba bean into a self-pollinated crop.

4.2.1. The Season in Morocco

In general, the weather conditions at Douyet in 1989/90 were characterized by uneven rainfall distribution (Fig.4.2.1). Of the total 578 mm of rainfall during the season, 71% was received between October and January. The remaining 29% was received in March, April and May. These conditions delayed planting and affected crop growth and development.

4.2.2. Use of Enhanced Germplasm by National Programs

Iran released 'Barakat' for green pod production in 1987 because of higher green pod and dry seed yield, and because of partial resistance to chocolate spot and Ascochyta blight. Line 80S43977 has been released as 'Favel' in Portugal in 1989 because of high yield and large seed size. In Ethiopia a cross bulk has been purified and is now in pre-release multiplication.

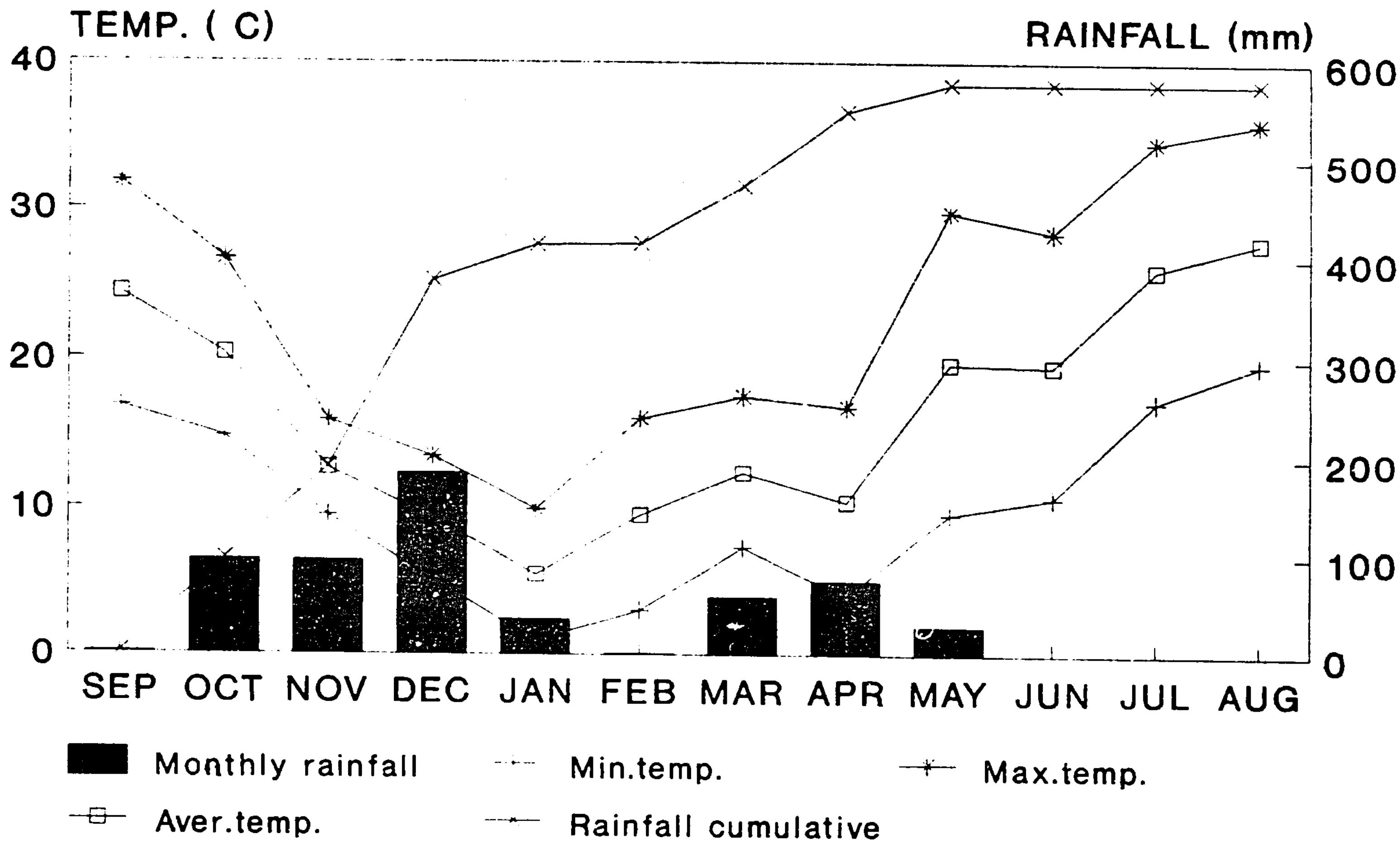

Figure 4.2.1. Climatological data at Douyet Agricultural Research Station in 1989/90.

Determinate lines are in on-farm trials in China and Syria. In Syria 80S44027 is in the third year of on-farm testing. FLIP 86-146FB was chosen for on-farm trials in southern China because this determinate line fits in well with the predominate cotton-faba bean relay cropping system. In Tunisia, the lines 80S80028, S82113-8 and S82033-3 have been selected for pre-release multiplication because of their yield potential in drought conditions (Fig. 4.2.2). A line in Tunisia, FLIP 83-106 FB (small-seeded), has been identified for multiplication. In Algeria 14 lines were provided for multilocation testing. A summary of the use of ICARDA lines for multilocation, on-farm, and verification trials is given in Table 4.2.1.

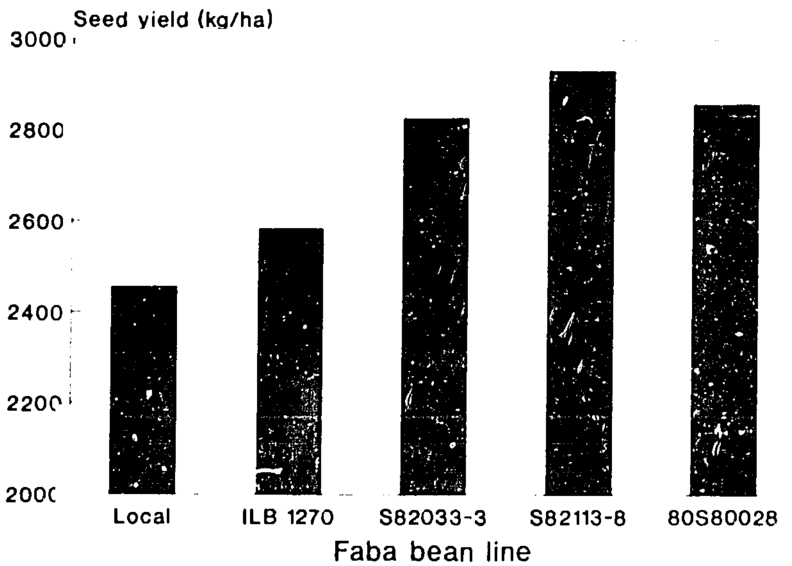

Figure 4.2.2. Average performance of ICARDA faba bean lines under drought conditions in Tunisia for the years 1988, 1989, and 1990. (Data courtesy of Mr. H. Halila and Mr. M. Kharrat).

Table 4.2.1. Use of ICARDA lines by National Programs.

Country	Line	Use
Algeria	14 lines	Multilocation testing
Chile	ILB 1814	Pre-release multiplication
China	FLIP 86-146FB[1]	On-farm trials
	3 lines	Large scale increase, 1 ha each
Egypt	ILB 1270	Pre-release multiplication
Ethiopia	74TA12050x74TA236	Pre-release multiplication
Iran	ILB 1269	Released as 'Barakat'
Iraq	ILB 1814	Pre-release multiplication
Portugal	80S43977	Released as 'Favel'
Syria	80S44027	On-farm trials
	Flip 84-239FB1	
Tunisia	80S80028, S82033-3, S82113-8	Pre-release multiplication
	ILB 1270	Large scale increase

1 Determinate line.

With the transfer of ICARDA faba bean improvement activities to Douyet, Morocco and the planned assumption of responsibility for this by INRA, Morocco after 1991, efforts on production of finished cultivars have been reduced and increasing emphasis has been given to the production of enhanced germplasm pools and stocks for the use of national programs.

Resistance to pests constitutes the bulk of specific requests of national programs, namely, resistance to Orobanche, chocolate spot, stem nematodes, Ascochyta blight, and rust. Egypt has used ILB 938, a disease resistance source, for production of four lines which are to be released with resistance to chocolate spot and rust (Table 4.2.2).

Table 4.2.2. Use of ICARDA germplasm, resistance sources, populations, and early generations lines by National Programs during 1987-1990.

Year	Country	No.of lines or crosses	Type of material
1989	Algeria	339	Disease resistant lines for yield testing in screening nursery
1989	Algeria	96	Determinate lines in screening nursery
1987	Egypt	1250	BPL's aphid screening
1982-88	Egypt	1	ILB 938 used for crosses to develop disease resistant varieties
1988	Egypt	600	BPL's aphid screening
1988	Egypt	200	Early generation lines for screening
1988	Egypt	19	F2 populations-IVS
1989	Egypt	600	BPL's aphid screening
1980-89	Ethiopia	1	Cross bulk purified for variety release
1984-89	Ethiopia	27	Lines in advanced national yield trials
1984-89	Ethiopia	532	Early generation lines in screening nurseries
1988	China	617,33	F3 progenies; F3 Bulks Chinese Disease resistant; IVS, deter. populations and progenies
1987	Morocco	200	F2 populations and F3 derived progenies
1988	Morocco	96	Crosses made for disease resistance, IVS, and determinate
1989	Morocco	339	Disease resistant lines for yield testing in screening nurseries
1989	Morocco	96	Determinate lines in screening nursery
1988	Sudan	19	F2 populations IVS
1988	Sudan	10	F2 populations - earliness (Sudan, Chinese)
1988	Tunisia	190	Lines for disease screening nursery
1989	Tunisia	339	Disease resistant lines for yield testing in nursery
1989	Tunisia	96	Determinate lines in screening nursery
1990	China	3	Crosses for large seeded N87033, N87043, and N87035
		229	F3 progeny rows
1990	Egypt	600	BPL's for aphid resistance screening
1990	Tunisia	500	BPL's for _Orobanche_ resistance screening
		500	BPL's for stem nematode resistance screening
1990	Morocco	500	BPL's for stem nematode resistance screening

Crosses have also been made between large-seeded types such as Aquadulce and New Mammoth with local landraces at the request of national programs, and F_2/F_3 populations provided (Table 4.2.2). In 1988, F_3 populations with the IVS (independent vascular supply) trait have been supplied to China, Egypt, Sudan, and Morocco at their request. In 1990, crosses were made at Douyet and at Cordoba, Spain to combine Orobanche resistance with large seed and long pods of Aquadulce. Also, crosses were made at Douyet to combine Orobanche and chocolate spot resistance. Backcrosses to the Orobanche resistance sources will be made in 1991.

The main emphasis in faba bean breeding will be to ensure a smooth transfer of ICARDA improvement research to INRA-Morocco, and to the other national programs of North Africa. This will be effected through transferring enhanced germplasm, visits to NARSs in North Africa and close collaborative work with colleagues in the national programs in exploiting the full potential of the enhanced germplasm.
Dr. L.D. Robertson.

4.2.3. Development of Trait Specific Genetic Stocks

Disease resistance research included maintaining the uniformity of the disease resistant inbreds for distribution to national programs in international disease screening nurseries and for use in producing segregating populations with disease resistance for selection by national breeders and pathologists. Most work on disease resistance involved selection from F_3 to F_6 progenies with disease resistance and yield for use in the national programs of North Africa.

4.2.3.1. Germplasm for disease resistance

Broomrape (Orobanche crenata Forsk.): This is the most important plant parasitic weed which attacks faba bean in the dry and hot areas of the Mediterranean region. O. crenata is difficult to manage and all commercial faba bean cultivars grown by farmers today are susceptible. The wide prevalence and severity of O.crenata in certain areas in North Africa has forced farmers to drop faba bean cultivation. The use of chemicals to control O. crenata is expensive and breeding for resistance to this plant parasitic weed has long been hampered by the lack of useful sources of resistance. With the transfer of faba bean improvement research to Douyet, Morocco, emphasis on screening for resistance to Orobanche has increased. Success from screening the BPL collection has been limited; from two years of screening 900 BPL's, only one (BPL 2830) was rated as resistant.

However, considerable progress has been made with material received from Spain that used Orobanche tolerant line from Egypt-F 402. Fifty progenies from the cross (F402xINIA06)xF402 were tested in artificially heavily infested fields in 1988 and 1989 in Syria and 1989 in Morocco. A total of 85 single-plant selections were rated as highly resistant, compared to the local susceptible check.

Three selections; 18009, 18035, and 18105 were consistently rated as resistant at both locations compared to local check plants in adjacent rows which were almost completely destroyed by the parasite. The differentiation between resistant and susceptible faba bean lines was based on the number and weight of Orobanche shoots, and also on the performance of the parasite. The yield potential of these selections was compared with that of the widely grown commercial cultivar "Aquadulce" at Douyet Agricultural Research Station in Morocco in 1989. Plants were grown in plots 5x6m, employing a complete randomized block design with three replications. The significantly lower number and weight of Orobanche shoots per plant of the resistant selections 18009, 18035, and 18105 were associated with a significantly higher number of pods and seed yield compared to Aquadulce (Table 4.2.3, Fig. 4.2.3).

When the 85 selections from 1989 and new material from Spain (184 lines) were tested in 1989/90, many resistant selections from the crosses were found (47 from previous years and 144 of the new lines). These had a lower number of Orobanche shoots/faba bean plant compared to the local susceptible check, Aquadulce (Figs. 4.2.4 and 4.2.5). This resulted in much higher yield levels of the resistant lines (2 to 4.9 t/ha vs. 0.9 t/ha for Aquadulce).

Table 4.2.3. The effects of Orobanche crenata on yield in faba bean lines grown at Douyet/Morocco in 1989/90.

Selection 88. Lat	Orobanche shoot/host plant Number	Weight (g)	Number of faba bean pods/plant	Yield faba bean seed (kg/ha)
18009	0.40**	0.60**	10.5**	1230**
18035	0.65**	0.95**	11.1**	1220**
18105	0.80**	0.90**	9.5**	1120**
Aquadulce	5.00	6.75	2.8	440

* Plot size 30 m^2 with a range of 7-12 seeds of Orobanche/ cm3 soil.
CVs for number of Orobanche shoots = 17.8%, weight of Orobanche shoots = 27.4%, number of faba bean pods = 16.3%, and faba bean yield = 13.9%.
** Significant at P<0.05.

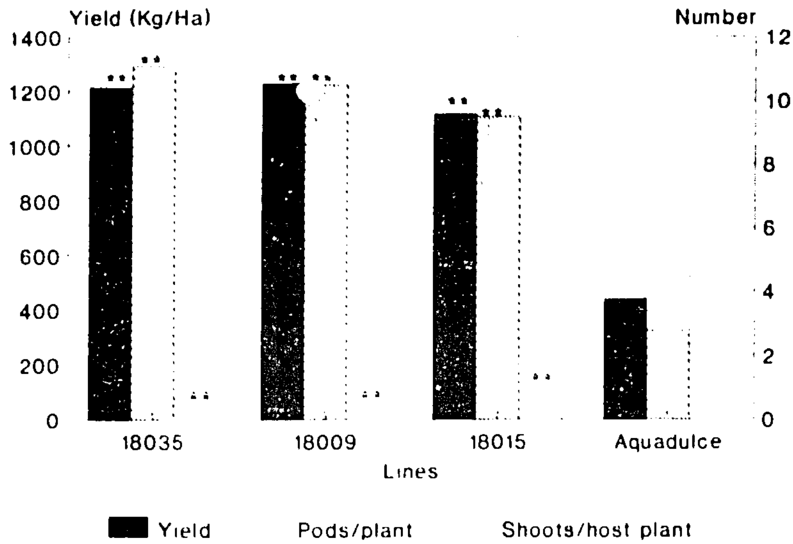

Figure 4.2.3. The effect of *Orobanche crenata* on faba bean yield.

** Significant at 1% level.
CV for faba bean yield = 13.9%; cv for number of faba bean pods = 16.3%; cv for number of *Orobanche* shoots per faba bean plant = 17.8%.

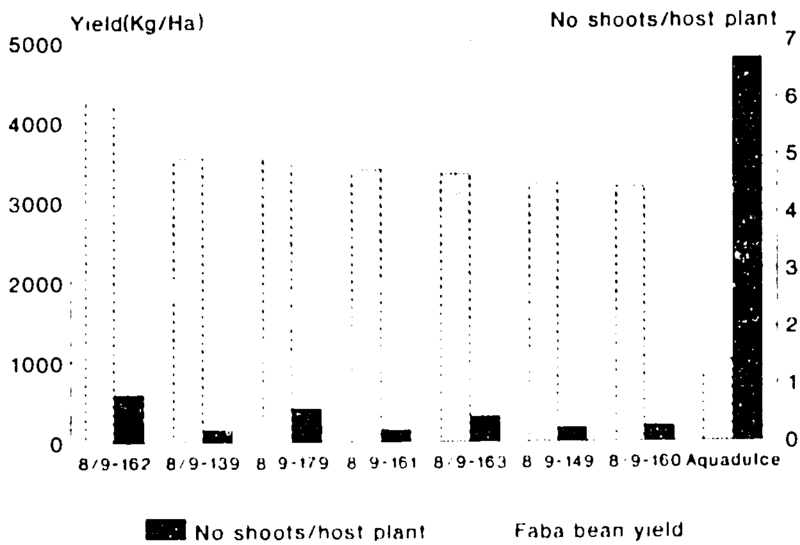

Figure 4.2.4. Performance of seven new *Orobanche*-resistant progenies compared to the local check Aquadulce in an artificially infested field at Douyet in 1989.

The original progenies were selected by Drs. J.I. Cubero and J. Hernandez at Cordoba, Spain. Crosses are being made in Spain to combine this Orobanche resistance with the Aquadulce landrace type and at Douyet to combine with chocolate spot resistance sources.

Mr. Z. Fatemi, Drs. S.B. Hanounik and L.D. Robertson.

Ditylenchus dipsaci: Screening for resistance to stem nematodes (D. dipsaci) was carried out in collaboration with INRA and IAV-Hassan II at Guich Agricultural Experimental Station in Rabat. Infested faba bean stems collected from the previous season were used to inoculate 200 faba bean germplasm accessions (BPL 3006 to BPL 3263) from ICARDA using procedures mentioned in ICARDA's 1989 Manual of Screening Techniques for Disease Resistance in Faba Bean.

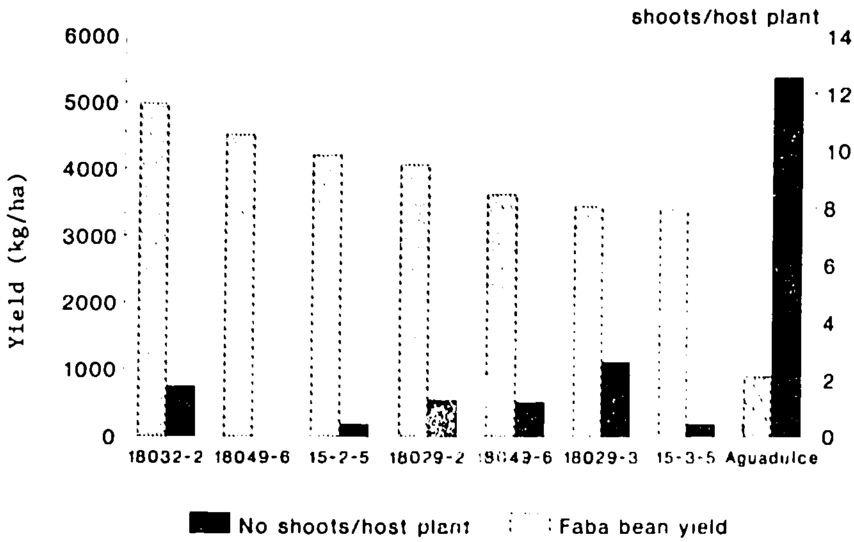

Figure 4.2.5. Performance of seven advanced Orobanche-resistant faba bean lines compared to the local check Aquadulce in a naturally infected field at Douyet in 1989.

Of the 200 test entries included in this nursery, 147 were rated 3 on ICARDA's 1-9 scoring scale with the remaining 53 entries rated 5, including local check plants. One line INRA 29H from France was rated 1.

This is the first time the site at Guich was used in screening for stem nematodes and, therefore, disease reaction was generally low. The same site will be used in 1990/91 and a higher disease reaction should occur due to the build-up of nematode population in the soil from the addition of infested stems this season.
Drs. A. Ammati, S. Hanounik and L.D. Robertson and Messrs F. Abbad and Z. Fatemi.

Resistance to viruses: The results are reported in the 1990 Annual Report of the Genetic Resources Unit. Of the 200 faba bean lines evaluated for their reaction to bean yellow mosaic virus by aphid inoculation, eight BPL's (1584, 1567, 2875, 1592, 1530, 1541, 1581, and 1597) were found resistant.
Drs. K. Makkouk and L.D. Robertson.

4.2.3.2. Development of disease resistant inbred lines

There were 287 selections for chocolate spot, 308 for ascochyta blight, 64 for rust, and 13 for stem nematodes (Table 4.2.4). These are now being distributed through the International Legumes Nursery Network and are being maintained in insect-proofed screenhouses for seed multiplication for future use.

4.2.3.3. Recombination of disease resistance with local adaptation

This activity was shifted to Douyet in 1989. Several technicians were trained at Douyet in crossing and 58 crosses were made with North African lines for disease resistance. Crossing in 1990 emphasized combining Orobanche resistance and large seed, long pods, and combining resistances to Orobanche and chocolate spot.

Table 4.2.4. Some of the most important inbred sources of resistance for chocolate spot, Ascochyta blight, and rust.

Disease	Sources[1]
Chocolate spot	BPL 110, 112, 261, 266, 710, 1179, 1196, 1278, 1821, ILF 3025, 3026, 2282, 3033, 3034, 3036, 3056, 3106, 3107, 2302, 2320, L82003, L82009
Ascochyta blight	BPL 74, 230, 365, 460, 465, 471, 472, 646, 818, 2485, ILB 752, L83118, L83120, L83124, L83125, L83127, L83129, L83136, L83142, L83149, L83151, L83155, L83156, L832001
Rust	BPL 7, 8, 260, 261, 263, 309, 406, 417, 427, 484, 490, 524, 533, 539; Sel. 82 Lat. 15563-1, 2, 3, 4
Stem nematodes	BPL 1, 10, 11, 12, 21, 23, 26, 27, 40, 63, 88, 183

1. There are several sublines of most sources listed.

4.2.4. Development of Improved Cultivars and Genetic Stocks for Wheat-based Systems.

Faba bean in most of the ICARDA region is grown in wheat-based farming systems where there is adequate rainfall/supplementary irrigation.

Faba bean is used to a large extent as a green vegetable with the requirement of large seeds and long pods. Small seeded faba bean is used as forage. To be competitive with other crops in this farming system faba bean has to have high and stable yield. This necessitates genotypes with resistance to Orobanche crenata, Botrytis fabae, Ditylenchus dipsaci, Ascochyta fabae and Uromyces fabae.

Emphasis was therefore placed on developing such germplasm, and for 1989/90 most crosses involved at least one pest resistant parent. All advanced and preliminary yield trials were conducted not only at Tel Hadya and Terbol but also at Douyet.

4.2.4.1. Yield potential of indeterminate faba bean

For the 1989/90 season, yield trials were conducted at Tel Hadya, Syria and Terbol, Lebanon. All this research has now been fully transferred to Douyet, Morocco.

The season at Douyet was marked by early and large amounts of rain. Because of this, planting was much delayed, which caused a significant reduction in yields; C.V.s were very high and ranged from 16 to 48% and trial mean seed yields ranged from 884 to 2138 kg/ha. Because of the high C.V.s, no trial had significant differences among lines at the 5% probability level.

The highest yield in replicated trials was 2651 kg/ha. A total of 128 lines outyielded the best check, but none significantly (Table 4.2.5).

4.2.4.2. On-farm verification trials to control O. crenata by the use of resistant faba bean lines

Two On-farm verification trials were conducted in close collaboration with the Extension Department of Meknes, to manage O. crenata by the use of three resistant lines (Sel.88.Lat. 18009, 18035 and 18105) in naturally infested farmers fields. These lines showed a very high level of resistance to O. crenata and produced greater yields compared to the local susceptible cultivar Aquadulce, which was almost completely destroyed in adjacent rows. Farmers requested these lines despite their small seed size (50-70 g/100 seeds). Verification trials will continue on a larger scale in 1990/91.

Mr. Z. Fatemi, Drs. S.B. Hanounik and L.D. Robertson.

4.2.4.3. Segregating populations

This year 651 single plant selections were made in segregating populations and progeny rows grown at Douyet, Morocco for determinate and IVS plant type. These will be planted as progeny rows at Douyet, and at Meknes (for disease resistance screening) in Morocco. Forty three single plant selections were made for closed flower at Douyet; 743 single plant selections were made at Meknes for disease resistance (chocolate spot and Ascochyta blight). All nurseries were inoculated artificially and scored for disease reaction using ICARDA's 1-9 rating scales.

Mr. Z. Fatemi, Drs. S.B. Hanounik and L.D. Robertson.

Table 4.2.5. Results of faba bean yield trials Douyet and Jemaa shim 1989-90.

Trial	No.of test entries	No.of lines>check	Seed yield (kg/ha)			
			Trial mean	Best line mean	Check mean	CV (%)
Advanced Trials						
FBMAYT-L	36	12	1869	2279	2010	24
FBAYT-L-1	36	6	2083	2651	2390	20
FBAYT-S-1	25	18	2138	2531	1920	16
FBAYT-D-1	36	0	1305	1960	1960	45
FBAYT-D-1	36	6	1006	1674	1110	28
Preliminary Trials						
FBMPYT-L	25	0	1445	2209	2260	30
FBMPYT-L-1	36	28	1638	2228	1350	21
FBMPYT-S-1	36	24	2009	2503	1890	17
FBMPYT-D-1	49	0	884	1422	1620	26
Regional Trials						
FBNARYT-L	24 D	2	1678	2126	2030	26
FBNARYT-L	24 J.S	9	604	648	978	56
FBNARYT-S	24 D	6	1750	2147	2030	16
FBNARYT-S	24 J.S	14	1153	1588	1100	40
FBMNYT-L	12 D	3	1010	2145	1950	24
FBMNYT-L	12 J.S	0	918	1183	1320	48

Check was Aquadulce for all trials.
D = Douyet, J.S = Jemaa shim.

4.2.5. Development of Alternative Plant-type

4.2.5.1. Determinate and IVS 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 curtail excessive vegetative growth and subsequent lodging, and will give a corresponding increase in harvest index.

The determinate mutant from N. Europe is poorly adapted to the

Mediterranean environment, and efforts are being made to transfer the character into an adapted background. In the 1988/89 season 26 crosses were made at Douyet with Aquadulce and other types adapted to North Africa. Emphasis was given to disease resistance and seed size and pod length which are important for North Africa. Work has been reduced on determinates with the shift to North Africa. Efforts will be made to consolidate gains and maintain the improved genetic stocks derived from the crossing program.

Because of independent vascular supply (IVS) to each flower, the IVS lines produce more pods in each raceme because flower shedding is greatly reduced. Work was carried out using the new, earlier flowering IVS source based on Sudanese Triple White. A total of 410 selections were made in 40 F_2 populations at Douyet in 1989; half of these involved a disease-resistant parent. In the 1989/90 season 491 selections were made for IVS in segregating populations at Douyet and 177 disease-resistant IVS selections were made at Meknes. Work will continue with emphasis on large seed size and disease resistance.
Mr. Z. Fatemi and Dr. L.D. Robertson.

4.2.5.2. Closed flower genetic stocks

With tightly closed flowers, outcrossing can be as low as 5%. Until this season, populations and progenies from crosses with the available sources of closed flower character have been very late. At Tel Hadya 49 single plant selections could be made for closed flower and earliness in F3 and F4 progeny rows. These were used in Morocco in

1989/90 for making additional crosses to continue adaptation to the Mediterranean environment and 47 additional single plant selections were made.

Mr. Z. Fatemi and Dr. L.D. Robertson.

4.2.6. North African Regional Nurseries

North African regional yield trials, large and small, were distributed in the 1989/90 season to Morocco and Algeria. Tunisia and Libya will be added in 1990/91. Most lines in Algeria and Morocco exceeded the local check (Aquadulce) but there were high C.V.s for the trials (Tables 4.2.6 and 4.2.7).

An Orobanche resistance nursery was also initiated in 1989/90 and distributed to Morocco, Algeria and Tunisia. In this nursery the faba bean lines 18009, 18035 and 18015 were tested further at three locations in Morocco, and one location in each of Algeria and Tunisia in naturally infested fields to study their resistance to different populations of O. crenata in the region. These lines were rated as resistant to the parasite across all locations, except to the reddish population of Orobanche which occurs in the area of the testing site near Beja in Tunisia. The susceptible reaction induced on these lines in Tunisia further supported the presence of pathogenic variabilities in the parasiste. These variabilities could occur through hybridization. There is an urgent need to identify new sources of resistance to the reddish population of the parasite.

Mr. Z. Fatemi, Drs. S.B. Hanounik and L.D. Robertson.

Table 4.2.6. Seed yield for the North African Regional Yield Trial-Large in 1989/90 at two locations in Morocco and one location in Algeria.

Pedigree/Accession	Seed yield (kg/ha)		
	Morocco		Algeria
	Douyet	Jemaa Shim	
FLIP 82-30FB	1932	740	1870
FLIP 82-45FB	2170	365	1520
FLIP 84-107FB	2286	183	1460
FLIP 84-128FB	1619	583	2030
FLIP 84-147FB	2610	953	1840
FLIP 85-89FB	1946	978	1290
FLIP 86-35FB	1495	353	2060
FLIP 86-36FB	1911	403	1130
FLIP 87-26FB	1592	965	1810
FLIP 87-70FB	1805	438	1220
FLIP 87-137FB	2005	535	1970
FLIP 87-140FB	1974	835	1350
FLIP 87-147FB	1474	945	1570
FLIP 88-1FB	1843	553	1450
FLIP 88-2FB	1956	745	1610
FLIP S82-113-8	2411	505	1420
FLIP 79S4	2652	353	1480
FLIP 80S44027	1083	553	1190
FLIP 80S80028	2215	400	1180
FLIP 80S80135	2093	827	1090
Reina Blanca	1983	680	1170
Turkish Local	1982	432	1180
AQUADULCE	2011	520	990
Local Check	1931	648	990
C.V. (%)	26	56	46

Table 4.2.7. Seed yield for the North African Regional yield Trial-Small 1989/90 at two locations in Morocco and one location in Algeria.

Pedigree/Accession	Seed yield (kg/ha) Morocco Douyet	Jemaa Shim	Algeria
FLIP 82-9FB	2074	1183	1040
FLIP 82-35FB	1989	1345	1280
FLIP 83-106FB	2051	1495	2090
FLIP 84-46FB	1923	1010	1830
FLIP 84-48FB	1695	990	1470
FLIP 84-59	1961	1070	1550
FLIP 85-13FB	2006	1588	1680
FLIP 85-28FB	2319	755	1630
FLIP 85-48FB	1984	1200	1600
FLIP 86-80FB	2140	723	1590
FLIP 86-85FB	2220	1188	1570
FLIP 86-86FB	2533	1170	2100
FLIP 87-77FB	2375	1285	1680
FLIP 88-3FB	2055	1303	880
FLIP 88-4FB	2375	985	1790
FLIP 88-6FB	2105	793	1160
76 TA56267	1846	1410	1890
B87148	2067	1040	640
B84149	2123	1263	830
B87249	1865	1590	1210
B87258	1992	1180	970
B87259	1632	1250	730
B87263	1714	753	640
Local Check	1897	1108	840
C.V. (%)	16	40	39

4.3. Faba Bean Diseases

Low and unstable faba bean yield in North Africa is due mainly to a number of important diseases. The wide prevalance and severity of these diseases has introduced some significant changes in faba bean cultivation in the region. Some devastating pathogens such as Orobanche crenata and Botrytis fabae have forced farmers to give up growing faba bean, whereas, other seed-borne pathogens, like Ascochyta fabae and Ditylenchus dipsaci have caused the enforcement of new quarantine regulations which have halted faba bean exports from infested areas.

Research in faba bean pathology concentrated on finding new sources of resistance to the pathogens and incorporating them into high yielding backgrounds in a joint effort with the breeding program. Research has also been done to understand the pathogenic variability of the most important pathogens and the mechanisms of resistance of the sources of resistance.

4.3.1. Relations between the Initial Density (Ii) of O. crenata and Faba bean Yield

The potential of O.crenata to cause damage to faba bean depends mainly on its inoculum density in the soil. In general, the initial inoculum density available at planting and the rate of reproduction of the parasite during the season determine the amount of damage at the end of the season.

The effect of the initial inoculum density (Ii) of O. crenata in the field on faba bean yield was investigated. Different quantities of Orobanche seeds (based on an average count of 250 seeds of Orobanche/1mg) were mixed throughly with 5 soil lots from Douyet

Station to obtain a series of 3, 5, 9, 14 and 22 seeds per cc soil. These densities were determined by a centrifugational extraction method employing a flocculation solution of $MgSO_4$ with 1.16 g/ml of water. Soil with different inoculum densities was placed in 0.3 m wide x 0.3 m deep x 2.0 m long microplots prepared earlier in the field. The susceptible faba bean cultivar Aquadulce and the resistant line Sel.88.Lat. 18009 were used in the test. A split plot design with initial densities in the main plot and faba bean lines in the sub-plots was used with five replications.

In general, yields of the resistant line 18009 were significantly greater than those of the susceptible cultivar Aquadulce at all Orobanche densities (Fig. 4.3.1). There were no significant decreases in yield of the susceptible cultivar Aquadulce as Ii was increased from 3 to 5 seeds per cc soil. The yield, however, decreased significantly as Ii was increased from 5-22 seeds per cc soil. With the resistant line 18009, there was no significant decrease in yield as Ii was increased from 3 to 22 seeds/cc soil. With every successive increase in Ii, there was a significant increase in the number of Orobanche shoots per host plant in the susceptible cultivar whereas in the resistant line 18009, no such increase was observed (Fig. 4.3.2). These results demonstrated the stability of yield of the resistant line 18009 compared to Aquadulce over the range of 3-22 Orobanche seeds per cc soil. Under the conditions of this study, the tolerance limit of Aquadulce was at 5 Orobanche seeds per cc soil (Fig. 4.3.1).

The significant increase in the number of Orobanche shoots/host plant in Aquadulce with increasing Ii was associated with a significant decrease in the weight of single broomrapes (Fig. 4.3.3). This was apparently due to a strong intra-specific competition for assimilates and severe host damage as shown by the significant decrease in yield of the susceptible cultivar Aquadulce beyond its tolerance limit (Fig. 4.3.1).

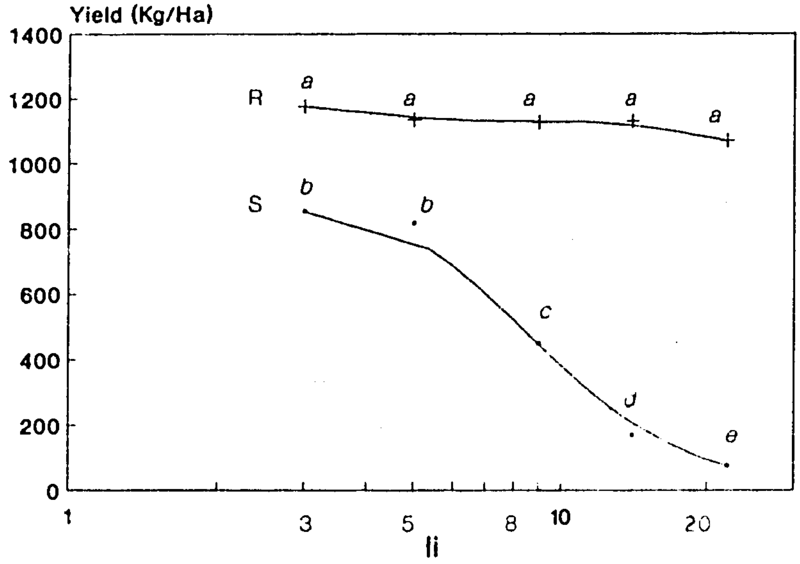

Figure 4.3.1. Relations between initial density (Ii) of Orobanche crenata (seeds per cc soil) and yield of the susceptible (S) faba bean cultivar Aquadulce and the resistant (R) lines Sel.88Lat. 18009 in the field. Means with different letters are significantly different at 1% level (cv for Ii = 9.8%; cv for cultivars = 7.3%).

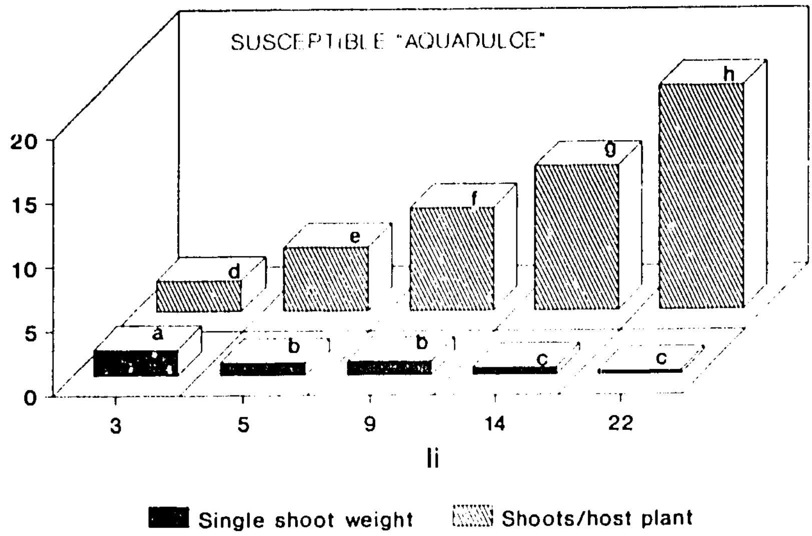

Figure 4.3.2. Relations between initial density (Ii) of Orobanche crenata (seeds per cc soil) and number of Orobanche shoots per host plant on the susceptible faba bean cultivar Aquadulce and the resistant line Sel.88. Lat.18009 in the field. Bars with different letters are significantly different at the 5% level on the resistant line and at the 1% level on the susceptible cultivar Aquadulce (cv for Ii = 10.9%; cv for cultivars = 11%).

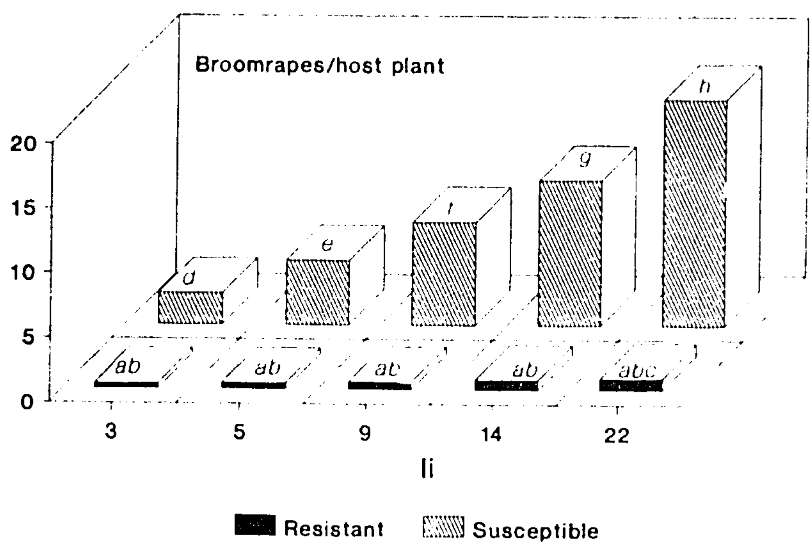

Figure 4.3.3. Effect of the initial density (Ii) of Orobanche crenata (seeds/cc soil) on the number of Orobanche shoots per host plant and the weight of single Orobanche shoots (g) supported by the susceptible faba bean cultivar "Aquadulce" in the field. Bars with different letters are significantly different at 1% level (cv for number of Orobanche shoots per host plants = 10.9%; cv for weight of single Orobanche shoots = 39.9%).

Additional work is needed under different ecological conditions to develop mathematical models regarding these quantitative relationships. This information is important for planning control programs and also for predicting yield losses. If Ii before planting is lower than the tolerance limit of Aquadulce, appreciable damage should not occur and chemical treatment would not be necessary.

Mr. Z. Fatemi and Dr. S. Hanounik.

4.3.2. Pathogenic Variability among different Populations of <u>Orobanche</u> on Faba bean in North Africa

The resistant faba bean lines Sel.88.Lat. 18009, 18035 and 18105 were tested further at three locations in Morocco and one location in each of Algeria and Tunisia in naturally infested fields to study their resistance to different populations of <u>Orobanche</u> in the region. These lines were rated as resistant to the parasite across all locations, except to the reddish population which occurs in the area of the testing site near Beja in Tunisia (Table 4.3.1). The susceptible reaction induced on these lines in Tunisia demonstrated the presence of pathogenic variabilities in the parasite. There is an urgent need to determine if the reddish population in Tunisia is a new species or a new virulent pathotype. Screening of ICARDA's germplasm will continue in 1990/91 in collaboration with the national program in Tunisia to identify sources of resistance to this new population of <u>Orobanche</u> in the Beja area.

Messrs H. Halila, M. Kharrat, Z. Fatemi and Dr. S. Hanounik.

Table 4.3.1. Reaction of certain faba bean lines to different populations of broomrape in Syria and North Africa.

Sel.88 Lattakia	Pedigree Cordoba	Reaction[1]				
		Syria		Morocco	Algeria	Tunisia
		87	88	89	89	89
18105	280264	R	R	R	R	S
18009	329K	R	R	R	R	S
18035	437K	R	R	R	R	S
Local	-	S	S	S	S	S

1) R = resistant; no Orobanche shoots or very small shoots with very little seed formation, less than 0.5 shoots per plant, and S = susceptible; shoots very common, more than four per plant, shoots large with normal seed formation, yield of host reduced greatly or lost completely.

4.3.3. Races of Botrytis fabae and Ascochyta fabae in the Mediterranean Region

A total of four races have been reported from Syria in each of B. fabae and A. fabae. Because of different cultural practices, climatic conditions and faba bean cultivars grown, the structure of the population of B. fabae and A. fabae and their race complexes may very from one geographical region to another. These variations need to be monitored and documented in each production region to plan effective breeding strategies.

Inbred lines with known differential disease reaction to races of B. fabae and A. fabae have been tested since 1986 through the faba bean international chocolate spot and Ascochyta blight nurseries, respectively. These evaluations were made with the help of ICARDA's collaborators in Morocco, Algeria, Tunisia, Egypt, Syria, Italy, France, and other countries. Based on the reaction of these differentials (Table 4.3.2), the following conclusions were made:

Botrytis fabae: Race 4 is prevalent in Egypt, Races 2 and 3 in Morocco and Races 1 and 4 in Morocco, Tunisia, Egypt, Syria, and Italy. Line BPL 710 has been rated as resistant at all locations and, therefore, its resistance is still effective against all of these races.

Ascochyta fabae: Races 3 and 4 are prevalent in Italy and France, and Races 2 and 4 in Tunisia, Syria and Italy. Line 471 has always been rated as resistant and therefore, its recent susceptible reaction in Italy suggests new virulence.

Messrs H. Halila, M. Kharrat and Dr. S.B. Hanounik.

Table 4.3.2. Reaction of differential faba bean lines to *Botrytis fabae* and *Ascochyta fabae* in the Mediterranean region.

Line	Susceptible to	Disease reaction[1]						
		Mor.	Alg.	Tun.	Egt.	Syr.	Itly.	Fran.
					B. fabae			
BPL 1763	Race 4	NT	NT	NT	S	R	NT	NT
BPL 1821	Races 2,3	S	R	R	R	R	NT	R
ILB 1814	Races 1,4	S	R	S	S	S	S	R
BPL 710	None	R	R	R	R	R	R	R
Reb-40	Races 1,2,3,4	S	S	S	S	S	S	S
					A. fabae			
BPL 818	Races 3,4	R	NT	R	NT	R	S	S
ILB 1814	Races 2,4	R	R	S	NT	S	S	R
BPL 471	None	R	R	R	NT	R	S	R
Giza-4	Races 1,2,3,4	S	R	R	NT	S	NT	R

[1] = Disease reactions were recorded on ICARDA's 1-9 rating scale.
NT = Not tested.

4.3.4. Viruses

A new virus affecting faba bean was identified. It is a small isometric virus, 18-19 nm in diameter, has a ssDNA genome, is persistently transmitted by aphids and affects mainly members of leguminosae. The virus was provisionally named faba bean necrotic yellow virus.

Dr. Khaled Makkouk.

4.4. Faba Bean Entomology

4.4.1. Control of Bruchus dentipes

Different insecticides were tested in farmers' fields for their effectiveness to control B. dentipes, the dominant storage pest of faba bean (Fig. 4.4.1). As a single application of any insecticide did not

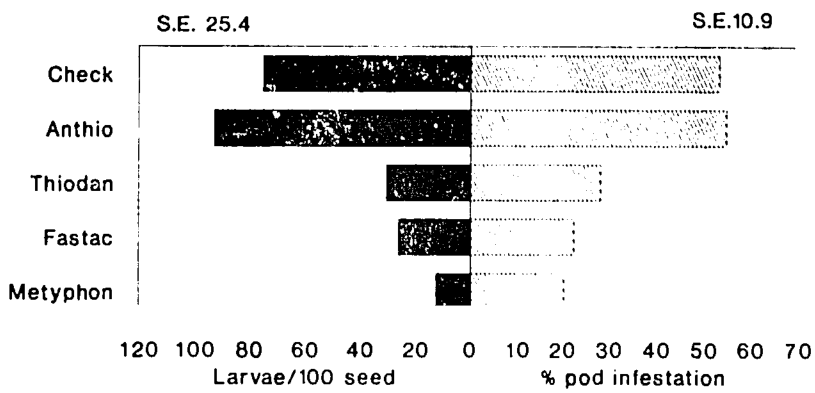

Figure 4.4.1. Effect of two applications of different insecticides on larval infestation of Bruchus dentipes in faba bean at farmers' fields, Aleppo, 1989/90.

give adequate control last season, two applications (at early podsetting and 10 days later) were used this year. The application of Metyphon (Methyl Parathion) EC50, 1 cc/l, was most effective and significantly reduced the seed infestation by bruchid larvae (Fig. 4.4.1). Fastac and Thiodan 35, 4 cc/l, decreased the infestation less effectively, whereas Anthio did not show any effect and infestation was as high as in the check. The high infestation of 50 percent in the check indicates that control methods for this insect pest are required. Drs. O. Tahhan, S. Weigand and M. El-Ahmed (ARC, Syria).

5. DRY PEA IMPROVEMENT

The pea improvement work at ICARDA was initiated in 1986/87 when the Center received a special grant from The Federal Republic of Germany (BMZ). Since extensive research is being done on the improvement of peas at a number of institutions in the developing and developed countries we are capitalising on this research, instead of running our own breeding program, to identify dry pea cultivars adapted to the farming systems of WANA. Our work is concentrated in the following areas:

I. Collecting enhanced germplasm/cultivars from the institutes working on dry peas in developed and developing countries and testing them at ICARDA to identify superior lines for evaluation by the national programs in WANA.

II. Developing suitable production technology and its transfer to the national programs for testing and adaptation.

III. Testing the value of dry pea straw as animal feed in collaboration with PFLP.

5.1. Germplasm Collection and Evaluation

The germplasm accessions including improved genetic stocks obtained from various institutions were evaluated at Tel Hadya in an augmented block design. Three hundred and forty eight accessions (hereafter referred as Acc No.) along with 3 repeated checks (Acc No. 223, - 224 and - 225) were sown on 14 November, 1989. The data were recorded on the phenology and morphological characters. The days taken to first flower ranged from 112 for Acc No. 221 to 157 days for Acc No. 202; days from sowing to maturity ranged from 141 for Acc No. 285 to 175 days for Acc No. 333; plant height ranged from 11 cm for Acc No. 228 to 64 cm for Acc No. -187; and seed yield from 0 to 1946 kg/ha. Fifty highest yielding entries are given in Table 5.1.1.

5.2. Preliminary Yield Trial

Forty-eight superior entries selected from the germplasm as well as the Preliminary Yield Trial (PYT) of 1988/89, were tested during the 1989/90 season in PYT at two locations, Tel Hadya and Terbol. Seed yield, time taken to 50% flowering, and cold damage are presented in Table 5.2.1. Seed yield varied from 0 to 866 kg/ha at Tel Hadya and from 459 to 2964 kg/ha at Terbol. The top five highest yielding entries, based on the mean over locations, included Acc Nos. 8, -21,-125, -217, and -222. Some of the semi-leafless types namely, Acc Nos. 30, -215, and -275 were among the high yielding lines. This was the first year when the lines suffered due to cold. The cold damage, measured in terms of percent killed plants, was highest in Acc No. 229 (34.8 % killing) and was followed by Acc No. 272 (14.6 % killing), Acc No. 25 (10.3 % killing), Acc No. 154 (7.5 % killing) and Acc No. 281 (6.0 % killing). All other entries showed less than 5% kill. The best entries from this trial were promoted to Peas International Adaptation Trial (PIAT) for 1990/91.

Table 5.1.1. Seed yield, days to flowering, cold damage and leaf type of 50 highest yielding lines in pea germplasm evaluated during 1989/90 at Tel Hadya.

Acc No.	Seed yield (kg/ha)	Days to flowering	Cold damage*	Leaf type[1]
8	1206	123	0.0	C
182	1131	126	0.0	C
98	993	134	0.0	C
320	931	117	0.0	C
315	899	118	0.0	C
2	889	116	0.0	C
22	889	117	0.0	C
321	875	119	0.0	C
301	840	120	1.1	C
217	840	113	0.0	C
247	835	117	0.0	C
167	758	118	0.0	C
117	724	118	0.0	C
319	711	118	0.0	C
316	687	116	0.0	C
240	687	118	0.0	C
24	661	121	0.0	SL
77	646	129	0.0	C
220	626	119	0.0	C
331	612	123	2.0	C
67	607	123	0.0	C
216	604	120	0.0	C
317	589	115	0.0	C
254	583	120	0.0	C
196	571	120	0.0	SL
153	569	121	0.0	C
6	569	119	0.0	SL
152	562	123	0.0	C
106	557	118	1.0	C
291	557	119	0.0	C
155	556	121	0.0	C
7	542	122	0.0	C
28	535	120	0.0	C
249	532	119	0.0	SL
284	521	117	0.0	C
70	521	121	0.0	C
251	521	121	0.0	C
255	515	119	3.0	C
109	511	124	6.2	C
1	510	127	12.3	C
42	507	120	5.1	C
178	507	120	0.0	C
256	500	121	0.0	C
107	500	119	0.0	C
252	500	120	0.0	C
129	494	152	0.0	C
55	493	122	12.8	C
172	486	119	0.0	C
273	486	118	0.0	C
53	482	114	0.0	C

* % Killed plants   1 C = conventional, SL = semi-leafless

Table 5.2.1. Seed yield, days to flowering, leaf type and cold damage of some of the high yielding entries in Preliminary Yield Trial.

Acc No.	Seed yield (kg/ha)			Days to flowering	Leaf type	Cold damage*
	Tel Hadya	Terbol	Mean			
8	732	2964	1848	136	C	0.0
21	744	2750	1747	136	C	0.2
30	671	1937	1304	133	SL	0.0
75	517	1880	1198	141	C	3.6
101	586	1980	1283	134	C	0.3
107	624	2249	1436	128	C	0.0
122	662	1615	1139	133	C	1.2
125	718	2760	1739	136	C	0.3
135	388	1690	1039	129	C	0.3
154	645	2361	1503	129	C	7.5
169	579	1914	1247	134	C	0.0
173	515	2517	1516	138	C	0.2
215	638	2278	1458	141	SL	0.0
216	719	2270	1494	131	C	0.0
217	866	2279	1573	125	C	0.2
221	630	2351	1491	131	C	1.0
222	670	2493	1581	138	C	0.0
226	650	1457	1054	129	SL	0.0
240	853	1364	1108	130	C	0.0
248	645	1980	1313	132	C	0.9
252	711	1648	1179	132	C	0.0
267	812	1691	1251	132	C	0.3
271	499	2187	1343	127	C	0.5
273	627	1620	1123	128	C	0.5
275	761	2200	1480	127	SL	0.3
278	607	2227	1417	127	C	0.5
282	423	1865	1144	136	C	3.1
286	618	1667	1142	127	SL	0.0
287	613	1893	1253	127	SL	0.9
290	636	1908	1272	126	C	0.7
291	362	1971	1167	126	C	0.5
295	752	2095	1423	134	C	0.2
296	325	2127	1226	139	C	0.0
Mean	534.4	1721.9				
S.E.	60.0	217.7				
C.V. (%)	19.4	21.9				
L.S.D. (P<0.05)	168.5	610.6				
Efficiency	115.52	113.13				

SL = Semi-leafless, C = Conventional, * = % Killed plants.

Table 5.3.1. Seed yield, days to flowering and cold damage of entries in Pea International Yield Trial during 1989/90.

Acc No.	Seed yield (kg/ha) Tel Hadya	Jinderess	Terbol	Mean	Days to flowering	Cold damage*
8	417	1296	2196	1303	134	0.8
21	635	1435	2452	1508	133	0.0
22	528	722	1535	928	125	0.4
24	324	824	825	658	127	0.2
30	398	722	1352	824	128	0.2
38	0	463	792	418	132	30.3
62	213	778	823	60	127	3.2
70	204	935	1545	895	126	17.2
72	302	1065	1562	976	135	2.6
75	130	574	1324	676	136	10.9
109	93	963	1450	835	127	0.9
167	630	861	1109	867	126	0.0
216	472	889	1668	1010	127	0.0
217	689	583	1975	1082	120	2.6
221	463	935	1749	1049	128	3.2
226	404	731	1102	746	125	0.2
227	228	565	802	532	128	1.0
248	444	963	1559	989	127	2.6
267	269	1028	1244	847	126	3.4
278	306	1111	1601	1006	120	4.7
286	306	704	978	662	122	1.8
290	287	472	946	568	126	9.7
291	107	806	1301	738	127	1.3
223 (Check)	130	296	815	414	138	25.6
Mean	332.33	821.77	1362.70			
S.E.	89.08	152.56	181.00			
C.V. (%)	46.43	32.16	23.01			
L.S.D. (P<0.05)	253.57	434.28	515.21			

* = Percent killing at Tel Hadya.

5.3. Pea International Adaptation Trial (PIAT)

Twenty three entries selected from PYT and PIAT conducted during 1988/89 were tested at Tel Hadya, Jinderess and Terbol (Table 5.3.1). Several test entries yielded significantly higher than the check. The five best yielding entries at Tel Hadya were Acc. Nos. 21, -22, -167,-

216 and -217; at Jinderess Acc Nos. 8, -21, -72, -267 and -278; and at Terbol Acc Nos. 8, -21, -216, -217 and -221. Accession No. 21 proved most productive at all the locations. Accession numbers 217 and -278 were earliest to flower (Table 5.3.1). At Tel Hadya, some of the lines showed high cold damage: Acc No. 38 (30.35 % killing), -223 (25.64 % killing), -70 (17.26 % killing), -75 (10.96 % killing), and -290 (9.70 % killing). Accession numbers 216 and -167 were completely free of any cold damage.

5.4. Response of Pea Cultivars of different Leaf Morphology to varying Plant Population and Moisture Supply

Response of four dry pea lines of different leaf morphology to three population levels was studied under rainfed (233.4 mm seasonal moisture supply) and supplementary irrigated (379.9mm seasonal moisture supply) conditions at Tel Hadya. Moisture supply was in the main-plots and the combination of genotypes and plant population in sub-plots. The genotypes included a semi-leafless type (Acc. No. 11), a conventional leaf type (Acc. No. 10), a small leaflets type ('Progretta') and a leaf-less type ('Filby'). Population levels were 36,50, and 80 plants/m^2, obtained by varying the inter-row distance which was 27.5, 20.0 and 12.5 cm, respectively.

The yield was significantly increased by improved moisture supply (Table 5.4.1). Variations in plant population caused no significant differences in yield in any of the genotypes under rainfed conditions, whereas with supplementary irrigation yield increased significantly for the leafless type (Filby) as population was raised from 36 to 50 plants/m^2. Because of these differential responses, the interaction between genotype and population, averaged over the two moisture supply regimes, was significant. Results suggest that it would be better to use higher population of 80 plants/m^2 for the leafless type both under rainfed and irrigated conditions, whereas for the rest of the genotypes a population of 36 plants/m^2 will be sufficient.

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Table 5.4.1. Seed yield (kg/ha) response of peas of varying leaf morphology to plant population at two moisture regimes, at Tel Hadya, 1989/90.

Moisture (M) and Genotype (G)	Population/m^2 80 (P1) (12.5 cm)	50 (P2) (20.0 cm)	36 (P3) (27.5 cm)	Mean
Rainfed				
Acc No. 11	205	208	243	218.7
Acc No. 10	359	370	250	326.3
Progretta	200	234	197	210.3
Filby	338	343	266	315.7
Mean	275.5	288.8	239.0	267.8
Irrigated				
Acc No. 11	968	771	815	851.3
Acc No. 10	1255	1214	1194	1221.0
Progretta	917	885	740	847.3
Filby	1215	984	849	1016.0
Mean	1088.8	963.5	899.5	983.9
Mean				
Acc No. 11	587	490	529	535.0
Acc No. 10	807	972	722	773.7
Progretta	559	560	468	529.0
Filby	776	634	558	656.0
Mean	682.0	619.0	569.0	
L.S.D. (at P = 0.05):				
- Moisture regime means			38.6	
- For comparing 2 G x P means			141.7	
- For comparing 2 G x P means at same level of M			200.4	

6. OROBANCHE STUDIES

Orobanche spp. are root parasitic weeds which attack various legume plants and represent a major threat to the production of some of these crops in the Mediterranean region. Faba bean, lentil, chickpea, dry pea and forage legumes are affected by the parasite. The research on this parasite is carried out in collaboration with the University of Hoherheim, F.R. of Germany, with a grant from GTZ. This fifth year of the Project was characterized by another dry season with a rather low damage from Orobanche. There was a research thrust shift with more emphasis on an integrated control management within the project (Fig. 6.1.1).

Various single methods of control have been under study in this project and some basic research has also been carried out (Table 6.1.1). Control methods are being tested singly for their suitability for integrated control and several combinations tested so far have proved effective and economic.

6.1. Chemical Control

6.1.1. Faba bean

Various herbicide treatments were tested including imazaquin (SCEPTER), imazapyr (ASSAULT, ARSENAL), imazethapyr (PURSUIT, PIVOT) and glyphosate (ROUNDUP) in pre- and post-emergence applications (Table 6.1.2). Several treatments were free of Orobanche, while 24.9 Orobanche shoots/m^2 were present in the untreated plots. Seed yield

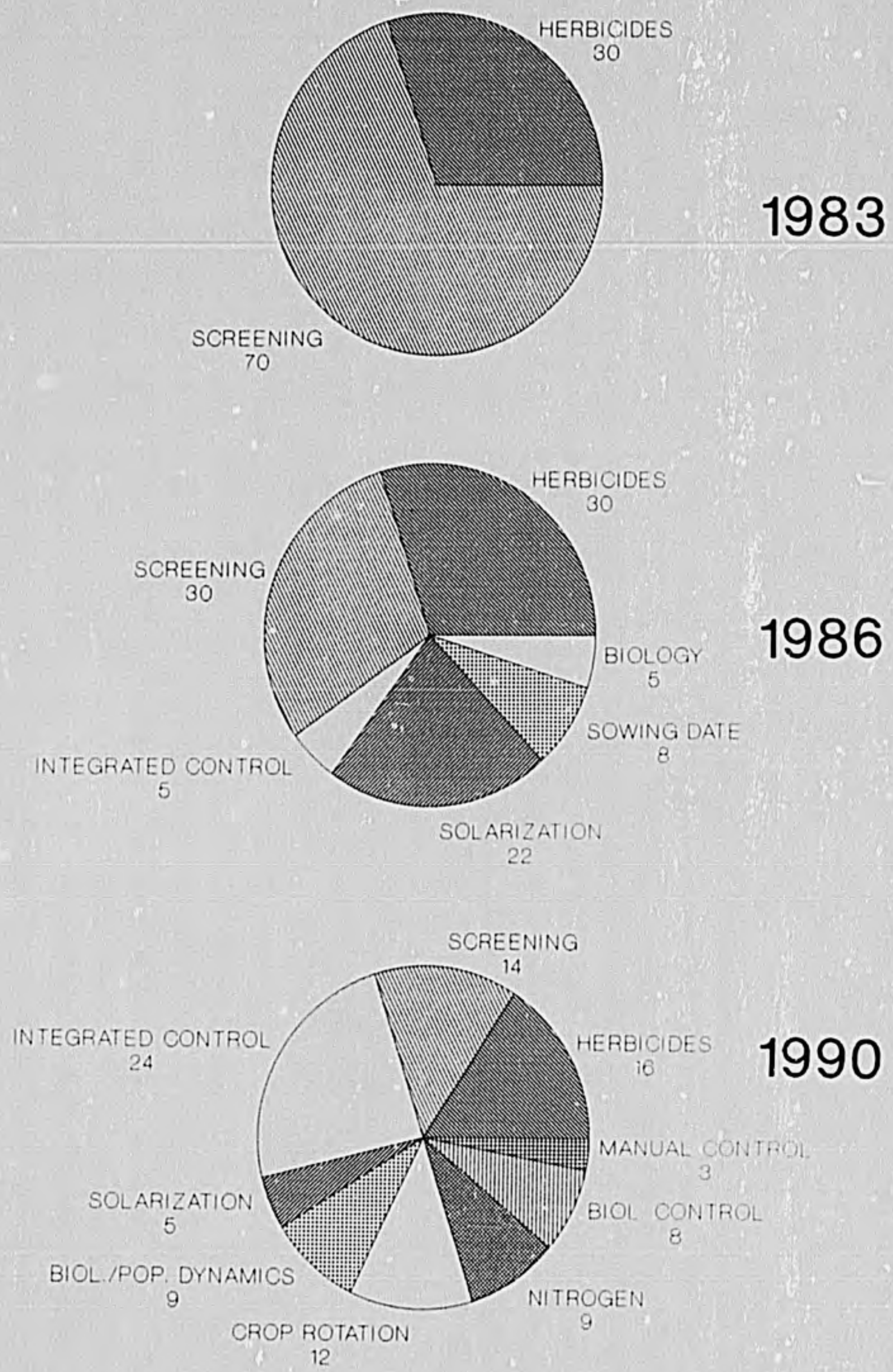

Figure 6.1.1. Changes in the program of the Orobanche work at ICARDA during the last 7 years, (% emphasis).

was obtained only in a few treatments due to severe frost damage. Results of shoot dry weight only are, therefore, presented in Table 6.1.2.

Table 6.1.1. Single Orobanche control techniques as preventive and/or curative measures.

Methods	Comments
Delayed sowing*	Crop and system dependent
Host plant resistance*	Intensive research needed
Herbicides*	Medium technical input
Soil disinfestation*	High technical input and costs
Change in crop rotation*	System dependent
Trap crops, catch crops*	System dependent
Nitrogen fertilization*	Not suitable for legumes
Manual control*	To reduce increase in seed bank
Deep ploughing*	System dependent
Biological control*	By encouraging natural control agents
GR - compounds	Still experimental
Flooding	System dependent
Avoid growing susceptible crops	If land unlimited

* Under study in the Orobanche Project.

With imazapyr (25 g a.i./ha, pre-emergence) crop phytotoxicity was observed which reduced plant vigour. This, however, increased frost hardiness and some seed yield was obtained. Phytotoxicity (scored on March 11) from herbicide treatments and frost damage (scored on March 17) on the crop were highly negatively correlated (-0.72). Frost damage and low Orobanche infestation reduced the correlation between Orobanche shoots/m^2 and crop yield to almost zero.

In order to investigate the efficacy of herbicides having a similar mode of action like imazaquin, fosamine (Krenite), a growth regulating product of the sulfonylureas, was tested post-emergence at 4 rates in an unreplicated trial. The rate of 2 x 120 g a.i./ha resulted in a complete control of <u>Orobanche</u> (Table 6.1.3).

Table 6.1.2. Effect of various herbicide treatments on <u>Orobanche</u> infestation and crop dry weight in faba bean.

Treatment			Orobanche shoot		Crop	Phyto-	Frost
Herbicide	Rate (g a.i./ha)	No. & time of application	No./m^2	Dry weight (kg/ha)	dry weight (t/ha)	toxicity (1-9)*	damage (1-5)*
Imazaquin	20						
+ Imazethapyr	20	2 (PO)**	0.0	0.0	1.37	2.4	1.0
Imazaquin	30	2 (PO)	0.0	0.0	1.33	2.3	1.0
Imazaquin	40	2 (PO)	0.0	0.0	1.57	1.9	1.0
Glyphosate	80						
+ Imazaquin	20	2 (PO)	0.0	0.0	1.72	2.5	1.0
Glyphosate	80	2 (PO)	0.1	0.1	2.10	1.5	3.0
Imazethapyr	30	2 (PO)	0.6	6.1	1.71	2.4	3.5
Imazethapyr	20	2 (PO)	2.8	24.2	2.07	1.6	4.5
Imazapyr	25	1 (PR)	3.0	43.8	2.25	1.0	4.2
Imazethapyr	75	1 (PR)					
+ Glyphosate	60	1 (PO)	3.1	39.7	2.20	1.1	3.8
Imazethapyr	75	1 (PR)	13.0	119.3	1.31	1.0	4.7
Imazethapyr	100	1 (PR)	14.1	125.2	1.24	1.0	4.5
Imazapyr	15	1 (PR)	16.3	161.1	2.11	1.0	4.5
Imazethapyr	50	1 (PR)	16.6	127.2	1.41	1.0	4.5
Control (no herbicide)			24.9	215.7	1.57	1.0	4.5
L.S.D. (P=0.05)		8.5	71.3	0.56	0.38	0.91	

* 1 = no effect, 9 or 5 = total damage
** PO = post emergence, PR = pre-emergence

Visual observation revealed that pod development in the untreated plot was low and substantially more pods developed in the treatment with fosamine 2 x 120 g a.i./ha. There is a need to have more studies on this promising herbicide in the future.

Table 6.1.3. Effect of post-emergence application fosamine herbicide (Krenite) on Orobanche in faba bean.

No.	Treatment g a.i./ha	Orobanche shoots/m^2
1	Control	7.75
2	Fosamine 2 x 40	4.25
3	Fosamine 2 x 80	1.50
4	Fosamine 2 x 120	0.00

6.1.2. Lentil

Lentil has shown high susceptibility to herbicides in our earlier studies. Therefore, only the relatively safer herbicides imazaquin (2 x 7.5 g a.i./ha, post-emergence) and imazethapyr (1 x 60 g a.i./ha, pre-emergence) were tested. Due to drought, the emergence of Orobanche was low and some emerged shoots were found only in the untreated plots. No phytotoxicity from the treatments was noticed. Also no significant differences between treatments could be found with regard to straw or seed yield of lentil, although there was a tendency for the straw yields to be higher in the plots treated with the herbicides.

6.1.3. Chickpea

Chickpea is also very susceptible to herbicides. Glyphosate had shown some efficacy earlier and was tested again at a low rate as was imazethapyr. The latter was applied pre-emergence. The study was done using ILC 482 and ILC 3279 chickpea cultivars.

Table 6.1.4. Effect of herbicides on Orobanche and crop yield in chickpea.

Treatment			Orobanche shoot		Yield of chickpea	
Herbicide	Rate (g a.i./ha)	No. & time of application	No./m^2	Dry weight (kg/ha)	Seed (kg/ha)	Straw (kg/ha)
Control			0.22	1.41	342	1.15
Glyphosate	20	2 (PO)*	0.09	0.47	368	1.12
Imazethapyr	60	1 (PR)	0.09	0.47	300	1.04
L.S.D.(P=0.05)			0.22	1.57	129	0.33

* PO = post-emergence, PR = pre-emergence.

Imazethapyr treatment caused phytotoxicity and reduced yield (Table 6.1.4). With the low amount of Orobanche infestation the treatment effects were not too meaningful but the results indicated that glyphosate had some promise. ILC 3279 tolerated herbicides better than ILC 482.

6.1.4. Dry Pea

Four herbicide treatments were tested (Table 6.1.5). Both imidazolinones gave better control of Orobanche and higher crop yield than glyphosate. The best treatment was imazethapyr 1x60 g a.i./ha pre-emergence. There was no crop phytotoxicity, but due to heavy frost damage treatment effects were low and crop seed yield almost zero. In the pre-emergence treatment with imazethapyr the lowest frost damage was noticed, indicating that the plants were probably suffering slightly from the herbicide and were therefore not as vigorous as the others. The treatment of 2x20 g a.i./ha of imazaquin which was best last season was tested only in the integrated control experiment and proved again effective (see Table 6.8.3).

Table 6.1.5. Effect of various herbicides on Orobanche control and crop yield in pea.

Treatment			Orobanche shoot		Pea	
Herbicide	Rate (g a.i./ha)	No. & time of application	$No./m^2$	Dry weight (kg/ha)	straw yield (t/ha)	Frost damage (1-5)*
Control			3.8	23	1.03	2.75
Glyphosate	60	2 (PO)**	4.9	20	0.84	2.39
Imazethapyr	20	2 (PO)	0	0	1.12	2.13
Imazaquin	20	2 (PO)	0.2	1	-	-
Imazaquin	30	2 (PO)	0	0	1.26	2.38
Imazethapyr	60	1 (PR)	0.1	1	1.56	1.75
L.S.D. (P=0.05)			3.4	20	0.30	0.82

* 1 = no damage, 5 = total damage (scored on 22 March)
** PO = post-emergence, PR = pre-emergence

New herbicides tested for Orobanche control in dry pea included chlorsulfuron (Glean) and imazapyr (Arsenal), which were used as pre-emergence herbicides. The rates used with chlorsulfuron were perhaps too high, as there was severe crop damage; however, no Orobanche shoots could be found in these treatments. Lower rates should be tested in future. Imazapyr proved safe for the crop, and no Orobanche shoots emerged in this treatment although some underground attachments were found on the roots (Table 6.1.6).

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Table 6.1.6. Effect of two new preemergence herbicides on Orobanche dry infestation in dry pea.

Treatment Herbicide	Rate g a.i./ha	Orobanche shoots/m^2	Remarks
Control		1.50	92 underground attachments/m^2
Chlorsulfuron	5	0.00	Phytotoxicity on crop, partial recovery
Chlorsulfuron	10	0.00	Severe phytotoxicity on crop, no recovery
Imazapyr	25	0.00	No crop damage, 28 underground attachments/m^2

6.2. Selection of Resistant Genotypes

6.2.1. Forage Legumes

A field experiment conducted over two years, complemented by laboratory studies, to investigate interspecific and intraspecific differences in susceptibility to Orobanche was completed. Five accessions of six different forage legume species were evaluated. High interspecific variation occurred, with all tested Lathyrus ochrus accessions being free of any emerged Orobanche shoot, while L. sativus and L. cicera were highly susceptible to the parasite producing 44.8 and 40.5 Orobanche shoots/m^2 (mean of two years). A high intraspecific variation was observed in Vicia narbonensis. Accession "67" had 8.2 times more Orobanche shoots than the other accessions of this species. Also V. sativa accession "1416" was considerably more susceptible than the other accessions of this species (Figure 6.2.1). The less susceptible species/accessions can be of value in an integrated Orobanche control program.

6.2.2. Faba bean

Selections were made during the last 3 years from the Orobanche tolerant cultivar "Giza 402" originating from Egypt and a total of 63 entries were grown during 1988/89 at a coastal site in Syria to avoid frost damage. Eight lines with very low infestation were selected and are now being used at Douyet, Morocco. Progress with this material had been reported in the section on faba bean improvement.

6.2.3. Lentil

The progress made is reported in lentil improvement section.

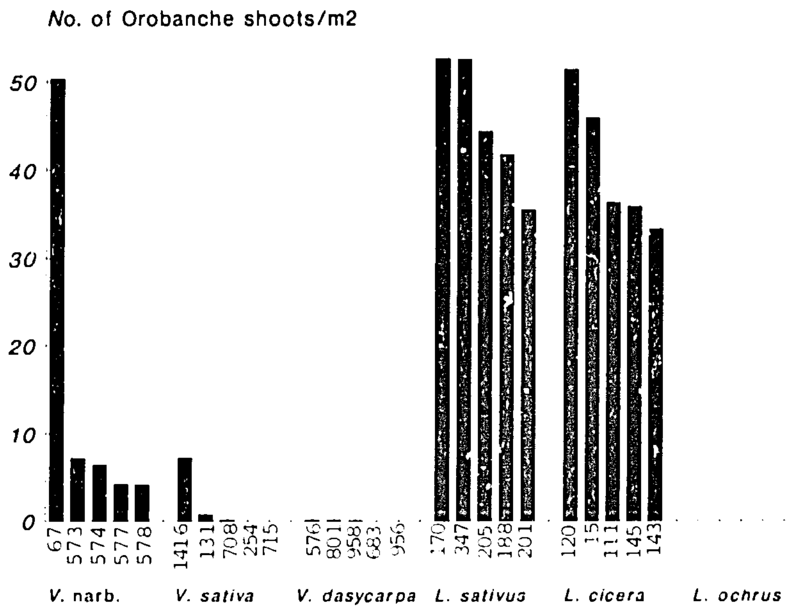

Figure 6.2.1. Variation in the susceptibility to Orobanche attack in 6 forage legume species each with 5 accessions (mean of two seasons).

6.2.4. Chickpea

Reaction of chickpea lines to various Orobanche seed densities in the soil was studied two times in the greenhouse. The experiment included 4 chickpea lines, 8 Orobanche seed densities and 6 replications per treatment. The optimal Orobanche seed density for screening chickpea was 33 to 100 seeds/kg soil. With 333 seeds/kg soil no crop seed yield was obtained and the dry weight of Orobanche was maximum (Table 6.2.1). These results will be a sound basis for further intensified screening. Differences in the susceptibility of the 4 test entries were low, but ILC 5193 had the lowest number of Orobanche shoots/plot.

Table 6.2.1. Effect of various Orobanche seed densities on the Orobanche infestation in chickpea (mean over 4 entries) in the greenhouse.

Orobanche seeds/kg soil	Orobanche shoots emerged/pot		Underground Orobanche attachments/pot		Dry weight of chickpea (g/pot)	
	I*	II	I	II	I	II
0	0.00	0.00	0.00	0.00	2.98	2.22
3	0.00	0.20	0.15	0.29	4.02	2.51
10	0.25	0.45	0.55	0.83	2.48	2.54
33	1.16	0.75	3.10	1.08	3.57	2.49
100	1.83	3.29	6.95	11.00	2.18	1.99
333	3.37	4.00	7.85	13.79	1.74	1.68
1000	1.91	2.87	4.90	19.95	1.40	1.35
3333	2.08	2.37	3.65	20.04	1.31	1.22
L.S.D. (P=0.05)	0.84	0.92	2.43	3.61	0.32	0.25

*I = 1st screening, II = 2nd screening.

6.2.5. Dry Pea

Screening was carried out in the greenhouse using the polybag technique (49 entries) and in a field experiment (24 entries). The greenhouse experiment was a repeat of an earlier study and it confirmed the variability in the susceptibility of pea genotypes to *Orobanche*, but some variation in the reaction was observed between the two screenings. The 10 entries showing extremes in the reaction are listed below (Table 6.2.2). There was a good correspondence between the field and the greenhouse observation for accession Nos. 290 and 291 while accession 21 exhibited considerably more resistance in the greenhouse than in the field.

Table 6.2.2. Reaction of some dry pea accessions to *Orobanche* in greenhouse and field.

Screening in	Accession No.	*Orobanche* attachments
Greenhouse		Per pot
	290	2.4
	21	3.8
	271	4.0
	65	4.1
	291	5.1
	227	12.0
	216	13.8
	267	17.1
	4	18.0
	L.S.D. (P=0.05)	4.7
Field		Per m^2
	38	4.6
	Local check	7.3
	291	11.3
	167	14.6
	22	15.6
	290	16.3
	21	26.3
	267	42.3
	75	44.3
	8	45.0
	L.S.D. (P=0.05)	26.4

The visual evaluation of accessions in a pea experiment conducted for agronomic studies revealed 34 accessions having low Orobanche infestation: Accession Nos. 10, 20, 77, 86, 87, 110, 126, 144, 164, 183, 189, 190, 191, 198, 200, 201, 202, 208, 228, 289, 299, 304, 307, 313, 314, 315, 317, 320, 321, 329, 330, 333, 350, 351.

Drs. Ali Abd El Moneim, W. Erskine, K.B. Singh, K.-H. Linke and M.C. Saxena.

6.3. Soil Solarization

The persistance of the effect of solarization was studied in an experiment in which solarization was done in July 1987 and the plots of which were not cultivated since then. Lentil was sown in December 1989 and seed and straw yield was evaluated in spring 1990, i.e. 3.5 years after solarizing the soil. No Orobanche emerged due to dry weather conditions. There were some differences in seed and straw yield of the crop in the different solarization treatments, with highest yields in the 50 day solarization treatment and lowest in the untreated control (Table 6.3.1); differences however were significant at the 5% level of probability. Weed cover was significantly less in the 50 days treatment than the control.

Drs. K.-H. Linke and M.C. Saxena.

Table 6.3.1. Residual effect of solarization (3.5 years after solarization) on lentil yield.

Treatment in 1987	Lentil straw (kg/ha)	Lentil seed (kg/ha)	Weed cover (%)
Control	1025	103	20.0
20 day solarization	1255	194	15.0
30 day solarization	1342	159	14.3
40 day solarization	1329	234	9.0
50 day solarization	1386	278	8.5
S.E.M.	100	57	2.4
LSD (P=0.05)	N.S.	N.S.	7.8

6.4. Biological Control

6.4.1. Insect: *Phytomyza orobanchia*, an agromyzid fly, is the only insect which appears to have a potential for biological control of *Orobanche*. *Orobanche* shoots naturally infested by *P. orobanchia* were collected at the end of last season in order to study the survival of pupae in the off-season. The pupae left in the field (inside the *Orobanche* shoots) had a high survival rate (Table 6.4.1). Storing the *Orobanche* stalks in the cold room (+ $5^{o}C$) for the whole summer period damaged the pupae. The maximum summer temperature was 40°C in the field. Since the number of pupae tested was low, it will be worthwhile to repeat this study.

Table 6.4.1. Survival of Phytomyza orobanchia under different storage conditions.

Storage treatment (9 months)	No. of pupae	No. of adults emerging
Field	13	6
Cold room (+5 °C)	14	0

Another experiment studied the effectivity of P. orobanchia in reducing the Orobanche infestation in the field. Plots were covered with insect-proof cages and half of the total number of cages were treated with insecticide (every 5 days) while in the other cages 200 g of insect infested Orobanche shoots from the previous season were added in order to increase the insect population. No difference was observed for the number of Orobanche shoots/m^2 because of low population of the insect due to the dry weather (Table 6.4.2).

Table 6.4.2. Effect of Phytomyza orobanchia on Orobanche and crop yield in lentil.

Treatments	Orobanche shoots/m^2	Orobanche shoots with damage (%)	Lentil straw g/m^2	Lentil seed g/m^2
Infested Orobanche shoots added (no insecticide)	8.2	56.7	69.4	0.6
No Orobanche shoots added, and crop sprayed with insecticide	8.2	48.2	75.3	5.9

6.4.2. Fungi: Ulocladium atrum

This fungal pathogen was found promising for the control of Orobanche in the previous season, provided the environmental conditions (rel. humidity 50 to 80%, temperature ca 20°C) were suitable. Suspensions with 200,000 spores/ml were applied on emerging Orobanche shoots in faba bean, 0, 1, 2, 3, or 4 times. First spraying was on 4 April. From that time the rel. humidity of the air decreased and the day temperatures exceeded 30°C. Hence there was no effect of the treatments on the Orobanche or yield.

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6.5. Crop Rotation

Ten different crops were planted in 1987/88 and rotated with lentil in 1988/89 on the same plots. A second similar experiment was started in 1989/90 with 14 different crops, also in rotation with lentil. These are to investigate changes in the Orobanche seed bank in soil. A total of 160 soil samples (each from 10 subsamples) were evaluated before sowing and the same number again after harvest. The average decay of Orobanche seeds was 11.8%, with the highest decay of 42.6 % in plots planted with Phaseolus beans.

Faba bean produced the highest number of shoots and seeds of Orobanche per unit area (Table 6.5.1). Compared to more humid years seed production of Orobanche was low in this season. Underground attachments of Orobanche were higher in narbon vetch and lentil, and lower in chickpea, wooly-pod vetch and cumin than in faba bean. The production of Orobanche shoots in chickpea, wooly pod vetch and cumin was zero.

Table 6.5.1. Orobanche production under different crops.

Crop	Soil seed bank (Orobanche seeds/m^2)	Root infestation (No. of Orobanche/m^2)	Orobanche shoots/m^2	Orobanche seed production/m^2
Faba bean	102 400	294	12	111 850
Narbon vetch	76 000	502	3	7 334
Lentil	83 200	563	1	2 111
Field pea	84 600	263	<1	937
Chickpea	144 000	66	0	0
Wooly-pod vetch	32 800	100	0	0
Cumin	55 200	66	0	0

In a parallel pot experiment investigating the decay rate of Orobanche seed in soil under 14 different crops, the mean decline of Orobanche seed was 36.8 % after one cropping with the highest reduction of 54.3 % occuring when faba bean was grown.

Mr. H. Schnell, Drs. K.-H. Linke and M.C. Saxena.

6.6. Transpiration and Photosynthesis in some Hosts as Affected by Orobanche Parasitism

The objective of this study was to quantify the effect of parasitism on transpiration and photosynthesis of the host plants. Aim was also to evaluate the effectivity of an antitranspirant ("Wiltpruf 5600") for

Orobanche control based on the hypothesis that *Orobanche* has a high transpiration rate for the acquisition of nutrients from the host and a suppression of transpiration may raise *Orobanche* shoot temperature and thus kill the parasite. Study was carried out in lentil, faba bean and dry pea and measurements were made at several stages of growth as the parasitism developed.

Transpiration and photosynthesis were higher in the uninfected host plant than the one infected by *Orobanche* (Table 6.6.1). Interspecific differences observed in the hosts can be attributed to the differences in the water supply available to them. *Orobanche* surprisingly had a very low transpiration rate (1.9 mmol water vapor/m^2/s). As expected, the parasite showed no photosynthesis and it released CO_2 by respiration.

Table 6.6.1. Transpiration and photosynthesis of hosts and parasite.

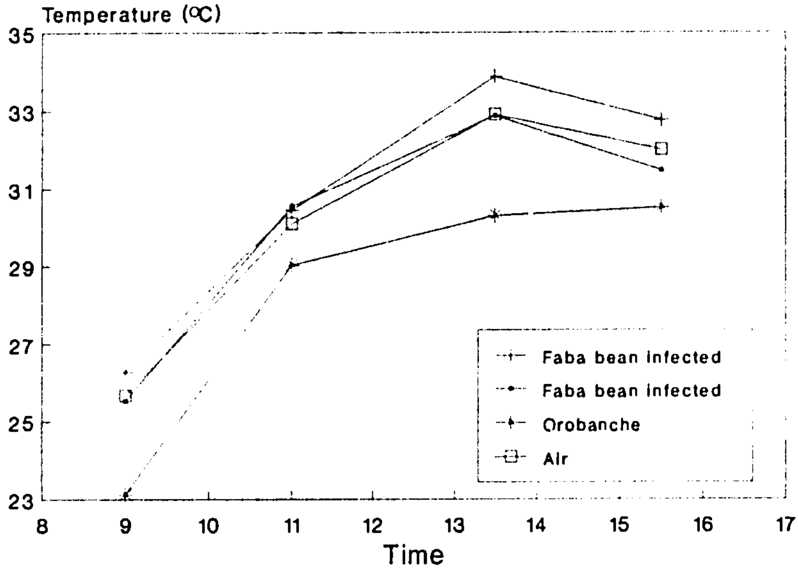
Crop	*Orobanche* infection	Transpiration (mmol $H_2O/m^2/s$)	Photosynthesis (mol $CO_2/m^2/s$)
Lentil	-	2.9	7.7
	+	1.2	2.6
Faba bean	-	7.3	16.8
	+	4.9	8.5
Pea	-	1.1	3.5
	+	0.9	2.0
Orobanche		1.9	-6.1

The transpiration rate should be related to the tissue temperature. It was, however, seen that inspite of low rate of transpiration the tissue temperature in Orobanche was lower when compared to the air temperature (Figure 6.6.1). A large number of hydathodes (leaf glands) occurring on the surface of the parasite might have a role in reducing the heat load on the parasite. The tissue temperature of the infected host plant during mid day (Figure 6.6.1) was higher than of the uninfected host plant because of increased water stress.

The antitranspirant had no effect on the stomatal conductance, transpiration and tissue temperature in the parasite. The only effect was a slightly faster browning of the corolla tubes in Orobanche. Thus, unlike in case of Striga, use of antitranspirant was not effective in controlling Orobanche in the cool season food legumes.
Mr. M. Knapp, Drs. K.-H. Linke, M.C. Saxena and J. Sauerborn.

6.7. Use of Nitrogen for Orobanche Control

In-vitro experiments have shown that ammonium nitrogen in contrast to nitrate can inhibit the germination of Orobanche seeds. A field experiment was therefore conducted to test this in the field, using faba bean. The treatments included 32 combinations of various rates of nitrogen (0, 14, 28 kg N/ha) as ammonium sulphate and 3 rates of two nitrification inhibitors, Didin (dicyandiamide) and N-serve (nitrapyrin).



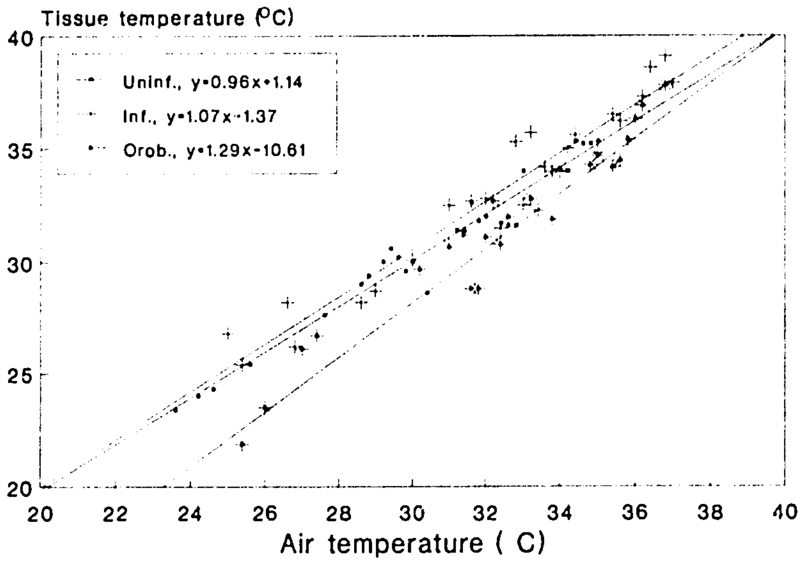


Figure 6.6.1. Top: Temperature of infected/uninfected faba bean, Orobanche and surrounding air during the day. Bottom: Regression lines for the relation between tissue and air temperature in host and parasite.

The faba bean crop was damaged by a severe frost in mid March, therefore no yield data could be obtained. The number of emerged _Orobanche_ shoots decreased by 20 % and 35 % at 14 and 28 kg N/ha, respectively as compared to control. The nitrification inhibitors had no effect in this respect. Soil analysis revealed that the ammonium did not penetrate beyond a depth of 5 cm for at least the first 11 days. This might explain the relatively small effect of ammonium and the lack of effect of the inhibitors. Both inhibitors were effective in maintaining a higher ammonium concentration in the soil (Figure 6.7.1).

Didin was more effective as nitrification inhibitor and N-serve showed an adverse effect on the root growth of faba bean. In future studies it is advisable to apply these compounds earlier (e.g. just before sowing) with a larger amount of irrigation water (e.g. 10 mm) or they should be incorporated into the soil mechanically.

Ms. M.v. Hezewijk, Drs. K.-H. Like, M.C. Saxena and A. Pieterse.

6.8. Integrated Control

An integrated management system is the most promising way to tackle the _Orobanche_ problem. Emphasis on this aspect is therefore steadily increasing and the single control methods are being evaluated with the aim of using them in a scheme of integrated control.

6.8.1. Faba bean

The most striking _Orobanche_ control in faba bean in the previous years

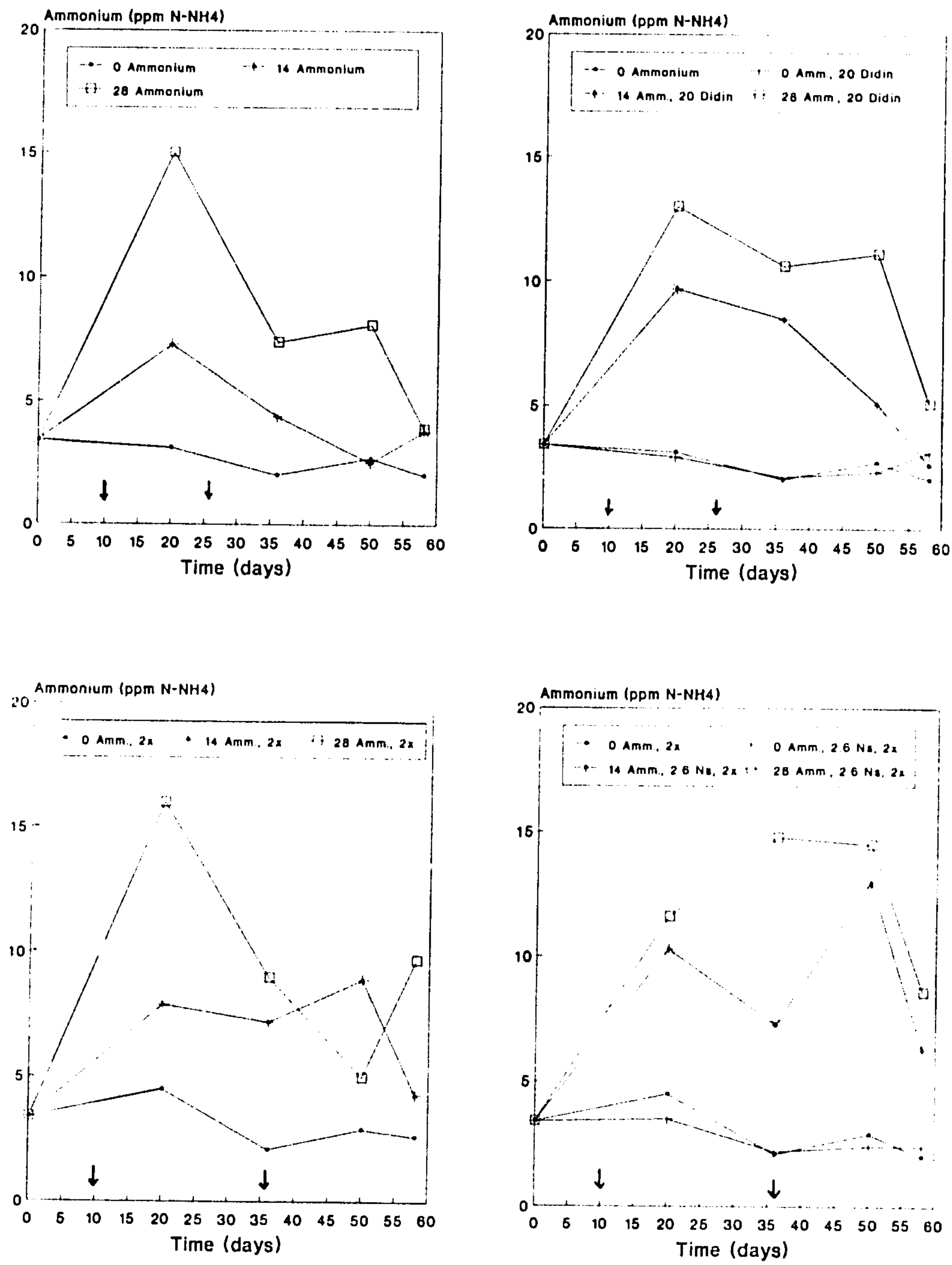


Figure 6.7.1. Ammonium nitrogen content of soil samples after 2 applications of either N-serve or DCD at 8 levels of nitrogen supply (0, 14 and 28 kg nitrogen applied as ammonium sulfate per ha). Arrows show the times of application of nitrification inhibitors.

was obtained by a combination of slightly delayed sowing and the application of a herbicide. This was confirmed again this year (Table 6.8.1). Due to the frost damage on early planted faba beans, however, the positive effect on the crop could not be well demonstrated, but Orobanche control was complete with most treatments.

Table 6.8.1. Integrated control in faba bean; combination of herbicide and sowing date.

Herbicide	Sowing date*	Orobanche shoots/m^2	Orobanche dry weight (kg/ha)	Crop straw dry weight (kg/ha)	Crop seed yield (kg/ha)
No herbicide	N	24.9	215.7	1571	60
No herbicide	D	12.2	126.8	1103	52
Glyphosate 2x80	N	0.3	0.1	2103	73
Glyphosate 2x80	D	0.0	0.0	1421	440
Imazethapyr 1x75	N	13.0	119.3	1311	10
Imazethapyr 1x75	D	1.5	18.0	1362	408
Imazaquin 2x40	N	0.0	0.0	1565	0
Imazaquin 2x40	D	0.0	0.0	987	365
S.E.M.		2.2	23.8	222	51
L.S.D. (P=0.05)		8.2	67.4	630	145

* N = 23/10/89, D = 13/11/89

6.8.2. Lentil

The best way to avoid damage from Orobanche in lentils was to use a genotype which is adapted for late sowing. ILL 8 can be sown nearly 25 days later than ILL 4400 without any yield reduction if there is no Orobanche infestation. Because of this adaptation to late sowing it is suitable for managing Orobanche by delayed sowing. To improve further on the control measure, this treatment was tested in combination with a low rate of two different preemergence herbicides. As in other experiments, emergence of Orobanche was rather low. Only in the 'no herbicide' plots a few shoots were found. Underground infestation was present but due to lack of water for the crop many of the Orobanche attachments did not develop into an emerged shoot. No emerged Orobanche shoot was found with ILL 8 (sown late), but ILL 4400 sown at normal time had some infestation. No differences were observed between the herbicide treatments (Table 6.8.2). The low amount of rainfall favoured the early-sown lentil (ILL 4400) and therefore the late-sown crop (ILL 8) was of no advantage under this condition.

Table 6.8.2. Effect of integrated control in lentil: combination of genotypes (along with their optimum sowing date) and herbicides on Orobanche infestation and crop yield in lentil.

Herbicide	Rate (g a.i./ha) and times of application	Genotype	Orobanche shoots/m^2	Lentil straw (kg/ha)	Lentil seed (kg/ha)
No herbicide		ILL 4400	0.89	1531	311
No herbicide		ILL 8	0.00	935	236
Imazaquin	7.5x2	ILL 4400	0.00	1575	240
Imazaquin	7.5x2	ILL 8	0.00	1120	326
Imazethapyr	60.0x1	ILL 4400	0.00	1452	204
Imazethapyr	60.0x1	ILL 8	0.00	1110	281
S.E.M.			0.50	242	117
L.S.D.(P=0.05)			N.S.	548	N.S.

6.8.3. Chickpea

The effect of 2 genotypes and 2 preemergence herbicide treatments was tested in a split-plot design. The genotype ILC 3279, which earlier was found to have a low susceptibility to Orobanche, had only half as much Orobanche infestation as ILC 482, and the glyphosate as well as the imazethapyr treatment reduced the Orobanche infestation by a factor of 3. Nevertheless, these effects were not statistically significant. The imazethapyr (1x60 g a.i.lha pre-emergence) produced phytotoxicity on the crop and resulted in a reduced production of biomass with ILC 3279, while the other genotype was not affected.

6.8.4. Dry Pea

Three methods were tested in combination comprising sowing date, preemergence herbicide and genotype. Use of imazaquin (2x20 g.a.i./ha) caused most significant reduction in Orobanche which confirms results of the previous season (Table 6.8.3). Delaying the sowing date from 20 Nov. to 10 Dec. resulted only in a 50% reduction of the infestation, but crop biomass production also decreased by 20%. Genotype effect was not present. Accession no. 290, which earlier was found to have some degree of resistance to Orobanche, was not different from the 'Local Pea' in this study.

Table 6.8.3. Integrated control in pea: combination of genotype, sowing date and herbicide.

Herbicide (g a.i./ha)	Genotype	Sowing date	Orobanche shoots/m^2	Orobanche dry weight (kg/ha)	Pea straw dry weight (kg/ha)
No herbicide	Local Pea	Nov. 20	4.6	14	559
No herbicide	Local Pea	Dec. 10	1.8	11	529
No herbicide	Acc. 290	Nov. 20	3.8	18	433
No herbicide	Acc. 290	Dec. 10	2.6	14	370
Imazaquin 2x20	Local Pea	Nov. 20	0.1	1	714
Imazaquin 2x20	Local Pea	Dec. 10	0.5	4	555
Imazaquin 2x20	Acc. 290	Nov. 20	0.0	0	463
Imazaquin 2x20	Acc. 290	Dec. 10	0.2	2	315
S.E.M.			0.9	4	16
L.S.D. (P=0.05)			2.9	15	51

6.8.5. Forage Legumes

Narbon vetch (Vicia narbonensis), which has high productivity, is susceptible to Orobanche. Hence a package of Orobanche control methods was tested against no Orobanche control. The two treatments compared are listed in Table 6.8.4. The number of Orobanche shoots/m^2 was significantly reduced by the test package. The low rainfall reduced the potential for biomass production under the delayed sowing treatment which was a component of the package for Orobanche control. Hence straw yield differences between the two treatments were not significant.

Table 6.8.4. Integrated control of Orobanche in Vicia narbonensis.

Package	Orobanche shoots/m^2	Orobanche dry weight (kg/ha)	Crop straw dry weight (kg/ha)	Crop seed yield (kg/ha)
Vicia narbonensis acc. 67	12.7	90	946	0
Vicia narb. acc. 578 + delayed sowing (14 days) + herbicide (2x20 g a.i./ha imazaquin)	0.4	6	737	174
S.E.M.	2.7	11	109	38
L.S.D. (P=0.05)	12.2	49	NS	173

Based on the work done so far a package for the control of Orobanche for every legume crop threatened by the parasite can be suggested (Table 6.8.5). As more information becomes available, the package for integrated control can be further refined. Hand pulling of Orobanche and use of right rotations might further help in reducing the seed bank of the parasite.

Table 6.8.5. The most promising combinations for integrated Orobanche control.

Lentil	Delayed sowing + adapted genotype
Chickpea	Less infected genotype + herbicide
Faba bean	Delayed sowing + herbicide; less infected genotype + herbicide
Feed legumes	Less/not infected species; delayed sowing, use of herbicide, less infected genotype, mowing + soil tillage
Field pea	Delayed sowing + herbicide

Integrating the sowing date into an Orobanche control strategy has proved to be a useful tool. A compilation of data on the effect of sowing date from various experiments at Tel Hadya demonstrates the decline of Orobanche attack with delay in sowing. There is of course also a decrease in crop biomass by delaying the sowing date, but the control of parasite is better and the overall result therefore is positive (Figure 6.8.1).

Drs. K.-H. Linke and M.C. Saxena.

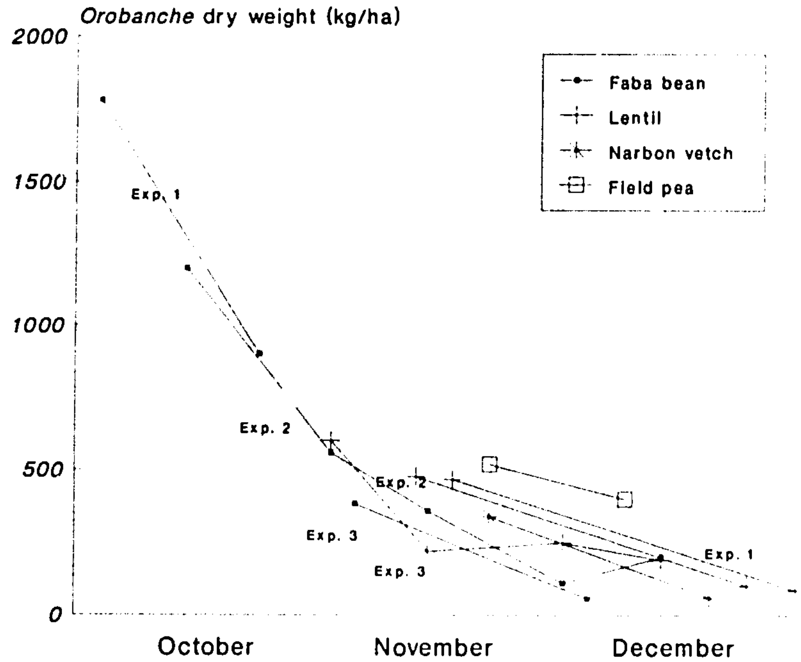


Figure 6.8.1. Summary of the effect of sowing date at Tel Hadya on the Orobanche dry weight in 4 crops at harvest time.

7. INTERNATIONAL TESTING PROGRAM

The international testing program on faba bean, lentil, kabuli chickpea, lathyrus, vetches and dry pea is the vehicle for the dissemination of genetic materials and improved production practices, in the form of international nurseries and trials, to the national program scientists in and outside the WANA region. The genetic materials comprise early segregating populations in F_3 and F_4 generations, and elite lines with wide and specific adaptation, special morphological or quality traits, and resistance to common biotic and abiotic stresses. The trials on improved production practices deal with the manipulation of the Rhizobium-legume symbiosis and weed control. Nurseries are only sent on request and often include specific germplasm developed for a particular region or a national program.

The testing program helps in identification of genotypes with specific and wide adaptation. The performance data permit assessment of genotype x environment interaction and help in targeting breeding efforts for specific agroecological conditions. Through the agronomic trials, research is encouraged in the national programs on optimum agronomic practices for different agro-ecological conditions to fully realize the yield potential of their cultivars.

Implementing the recommendations of the second External Program Review of ICARDA we have stopped the distribution of all the yield trials and screening nurseries of faba bean to the national programs from ICARDA headquarters. Only nurseries with genetic material having special characteristics including determinate types and stress resistance sources were, therefore, distributed for the 1990/91 season. In collaboration with the PFLP, nurseries on Lathyrus spp. and Vicia spp. were included in the international testing program for the first time.

The chickpea and lentil nurseries were further diversified during 1990/91 and a new nursery of disease resistant sources in chickpea (Chickpea International Fusarium Wilt Nursery), and one in lentil (Lentil International Rust Nursery) were added. Thus 1030 sets of 43 different types of nurseries (Table 7.1.1) were despatched to various cooperators during the 1990/91 season. Several cooperators requested large quantities of seed of some elite lines identified by them from the international nurseries/trials for multilocation yield testing and on-farm trials. Dry season during 1988/89 limited the seed multiplication and hence we could not meet all these requests.

The salient features of 1988/89 international nursery results received from cooperators until 21 October, 1990, are presented here.

7.1. Faba bean

Results of 14 sets of Faba Bean International Yield Trial-Large Seed (FBIYT-L) indicated that only at two locations (Deir-ezzor and Tel Hadya in Syria) some of the lines outyielded the local check by a significant ($P \leq 0.05$) margin. The five best yielding entries across

Table 7.1.1. Food legume international nurseries supplied for the 1990/91 season.

International Trial/Nursery	No. of sets
Faba bean	
Ascochyta Blight Nursery (FBIABN-91)	25
Chocolate Spot Nursery (FBICSN-91)	25
Rust Nursery (FBIRN-91)	20
Determinate Nursery (FBISND-91)	35
Weed Control Trial (FBWCT-91)	7
Inoculation Response Trial (FBIRT-91)	6
Orobanche Chemical Control Trial (FBOCCT-91)	4
Lentil	
Yield Trial, Large-Seed (LIYT-L-91)	50
Yield Trial, Small-Seed (LIYT-S-91)	35
Yield Trial, Early (LIYT-E-91)	40
Screening Nursery, Large-Seed (LISN-L-91)	32
Screening Nursery, Small-Seed (LISN-S-91)	23
Screening Nursery, Early (LISN-E-91)	36
Screening Nursery, Tall (LISN-T-91)	35
F_4 Nursery, Large Seed (LIF_4N-L-91)	10
F_4 Nursery, Small Seed (LIF_4N-S-91)	13
F_4 Nursery, Early (LIF_4N-E-91)	14
Cold Tolerance Nursery (LICTN-91)	15
Ascochyta Blight Nursery (LIABN-91)	10
Fusarium Wilt Nursery (LIFWN-91)	20
Rust Nursery (LIRN-91)	12
Inoculation Response Trial (LIRT-91)	13
Weed Control Trial (LWCT-91)	8
Chickpea	
Yield Trial Spring (CIYT-Sp-91)	35
Yield Trial Winter, Mediterranean Region (CIYT-W-MR-91)	40
Yield Trial Southernly Latitudes-1 (CIYT-SL1-91)	15
Yield Trial Southernly Latitudes-2 (CIYT-SL2-91)	15
Yield Trial Latin American (CIYT-LA-91)	15
Screening Nursery Winter (CISN-W-91)	60
Screening Nursery Spring (CISN-Sp-91)	45
Screening Nursery, Southernly Latitudes-1 (CISN-SL1-91)	10
Screening Nursery, Southernly Latitudes-2 (CISN-SL2-91)	8

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Cont'd 2/..

International Trial/Nursery	No. of sets
Screening Nursery, Latin American (CISN-LA-91)	9
F_4 Nursery, Mediterranean Region (CIF_4N-MR-91)	35
F_4 Nursery, Southernly Latitudes (LIF_4N-SL-91)	10
Ascochyta Blight Nursery: Kabuli (CIABN-A-91)	25
Ascochyta Blight Nursery: Kabuli & Desi (CIABN-B-91)	28
Fusarium Wilt Nursery (CIFWN-91)	39
Leaf-Miner Nursery (CILMN-91)	20
Cold Tolerance Nursery (CICTN-91)	38
Inoculation Response Trial (CIRT-91)	26
Weed Control Trial (CWCT-91)	16
Forage Legumes	
Lathyrus spp. Adaptation Trial	13
Vicia spp. Adaptation Trial	13
Peas	
Adaptation Trial (PIAT-91)	27
TOTAL	1030

locations included FLIP84-107FB, FLIP 84-127FB, FLIP 84-138FB, FLIP84 114FB, and 74 TA22 (ILB 9). The ANOVA for stability for seed yield revealed that only the mean squares due to pooled deviations, the non-linear portion of genotype x environment interaction, was significant (Table 7.1.2). The perusal of stability parameters for individual entries revealed that the performance of 15 entries out of 23 was predictable. The entries namely, FLIP 88-2FB, FLIP 87-141FB, 80S 44027, FLIP 84-114FB, FLIP 84-104FB, ILB 1270, ILB 1821, FLIP88-1FB, FLIP 84-138FB, and 80S 80135 in descending order of superiority displayed average stability and predictable behaviour. Another entry, FLIP 84-127FB, with above average performance, regression coefficient more than unity and the deviations approaching to zero, was responsive to high yielding environments.

Table 7.1.2. ANOVA for stability for seed yield for the entries in FBIYT-L, FBIYT-S, and FBIYT-D conducted during 1988/89.

Source of variation	FBIYT-L		FBIYT-S		FBIYT-D	
	DF	MS($x10^4$)	DF	MS($x10^4$)	DF	MS($x10^4$)
Entry	22	28.55*	22	63.23*	18	44.66*
Entry x location + location	299	111.45*	322	124.38*	285	109.53*
Location (linear)	1	28265.30*	1	3555.45*	1	28483.80*
Entry x location (linear)	22	15.80	22	27.01*	18	19.15*
Pooled deviation	276	17.07*	299	13.05	266	8.97
Pooled error	616	10.15	660	15.84	576	6.91

* Significant at P = 0.05.

The Faba Bean International Yield Trial-Small Seed (FBIYT-S) analysed for 15 locations revealed that only at one location, Atshana in Iraq, 4 entries exceeded the respective local check in seed yield by significant margins. Across locations, the five highest yielding lines were: FLIP 83-88FB, FLIP 83-89FB, FLIP 87-169FB, FLIP 83-106FB and ILB 1819. The stability analysis for seed yield (Table 7.1.2) revealed that only the linear portion of genotype x environment interaction was significant and important. Except ILB 1812, all entries exhibited predictable behaviour. Four entries, FLIP 83-89FB, FLIP 83-3FB, FLIP 83-1FB, and FLIP 83-105FB, having regression coefficients more than unity, above average mean performance and deviations approaching zero, were adaptable to high yielding environments. The entries FLIP 83-88FB, FLIP 87-169FB, FLIP 83-106FB, Giza 3, FLIP 87-170FB, 80S 50088, FLIP88-5FB, and FLIP87-167FB, having above average yield, regression coefficients equal to one and deviations approaching zero had general adaptation.

The Faba Bean International Yield Trial-Determinate (FBIYT-D) was reported from 14 locations and at no location the test entries exceeded the respective local check by a significant margin. Across locations, the five heaviest yielding entries included ILB 1814, FLIP 86-107FB, FLIP 86-122FB, FLIP 86-118FB, and FLIP 86-125FB. The heaviest yielding determinate line yielded 12.46 per cent less than the high yielding indeterminate check, ILB 1814. The ANOVA for stability for seed yield (Table 7.1.2) revealed that mean square due to entry x location-(linear) interaction was significant. The three entries, FLIP 86-122FB, FLIP 86-118FB and FLIP 86-109FB, had above average performance, regression coefficients equal to unity, and deviations from regression approaching zero, and were thus having general adaptation. Four of the 18 determinate entries, namely, FLIP 86-107FB, FLIP 86-125FB, FLIP 84-246FB, and FLIP 84-243FB showed unpredictable behaviour.

Of the 16 locations where Faba Bean International Screening Nursery-Large Seed (FBISN-L) was tested, it was only at Gorgon (Iran), Terbol (Lebanon), Allal Tazi (Morocco), and Hama (Syria) where the seed yield of 1, 3, 1, and 1 test entries respectively exceeded that of the local checks by a significant margin (at $P \leq 0.05$). The five best entries across locations included FLIP 84-70FB, FLIP 86-36FB, 85/340, Aquadulce and FLIP 84-94FB.

In the Faba Bean International Screening Nursery-Small Seed (FBISN-S) conducted at 15 locations, seed yields of one entry at Gorgon (Iran), five at Terbol (Lebanon), 26 at Elvas (Portugal), one at Cordoba (Spain) and four at Oud Meliz (Tunisia) exceeded the seed yield of the respective local check by a significant margin ($P \leq 0.05$). The five best yielders across locations included FLIP 86-82FB, FLIP 86-80FB, 80S 43977, FLIP 85-28FB and FLIP 85-13FB.

In the Faba Bean International Screening Nursery-Determinate Type (FBISN-D) conducted at 16 locations, the seed yield of 5 entries at Elvas and one at Oud Meliz exceeded the yield of respective local check by a significant margin ($P \leq 0.05$). The top five yielders across locations included, ILB 1814, FLIP 86-115FB, FLIP 86-123FB, FLIP 86-117FB and FLIP 87-101FB. The top determinate yielder in this nursery gave 31.8 per cent less yield than the indeterminate high yielding check, ILB 1814.

Three F_4 nurseries, one each for determinate, ascochyta blight resistant, and botrytis resistant crosses, were distributed during the 1988/89 season. At most locations some individual plants with desirable attributes were selected.

The results on Faba Bean International Ascochyta Blight Nursery (FBIABN) were reported from 3 locations. At Radzikow in Poland two entries, A87304(31818-1) and A87245 (BPL 2148) were rated at 4 on 1-9 scale (1=free, 9=highly susceptible), and the entries A87175(L83106), A8721(L83106), A8729(L83106), A8759(L83106), A87218(L83106), and A87273(L83106) were rated at 5. All other entries were rated more than 6. In U.K., 13 of the 22 test entries were rated between 1 and 4 and included A8721(L83120), A87304(31818-1), A87175(S83135), A8715(BPL818), A8717(A2), A8735(L83129), A87212(BPL 2138), A87245(BPL 2148), A8712(BPL 472), A8719(L83118), A8759(L82001), A87218(BPL 2144), and A87233(BPL 2148). At Hama in Syria, there was no disease development during the season.

The results of Faba Bean International Chocolate Spot Nursery (FBICSN) were reported from two locations, Holetta in Ethiopia and Cambridgeshire in U.K. Five entries at Holetta namely, B8722 (L83106), B87140(ILB 3025), B87187(ILB3033), B87195(ILB 3034), and B87201(ILB 3036); and nine entries including B8715(BPL1179), B8727(L83114), B87103(S83061), B87140(ILB 3025), B87142(ILB 3026), B87143(ILB 3026), B87187(ILB 3033), B87195(ILB 3034), and B87201(ILB 3036) at Cambridgeshire were rated between 1 and 4 on 1 to 9 scale (1 = free, 9 = highly susceptible).

The results of Faba Bean International Rust Nursery (FBIRN) were reported from three locations. At Holetta two entries namely R878 (BPL 263) and Rebaya-40 were rated at 3 and all other entries including the susceptible check were rated 5 with the exception of R8710 (BPL406) which was rated at 7 on 1 to 9 scale. At Tarquinia in Italy four entries namely, R8735(BPL 552), R8747(BPL588), R8759(BPL663) and R8761(BPL665) were rated at 3. At Cambridgeshire four entries, namely, R878(BPL 263), R8724(15563-2), R8759(BPL663) and R8761(BPL 665) were rated at 3 or 4.

The results of Faba Bean Weed Control Trial were reported from four locations. At Douyet in Morocco none of the weedicide treatments yielded significantly higher than weedy check. The treatment involving pre-emergence application of terbutryne (Igran) at 2.5 kg a.i./ha + pronamide (Kerb) at 0.5 kg a.i./ha was significantly superior to weedy check at all other locations (Chillan in Chile, Terbol and Elvas). Pre-emergence application of terbutryne (Igran) at 2.5 kg a.i./ha, and pre-emergence application of methabenzthiazuron (Tribunil) at 3.0 kg a.i./ha plus pronamide (Kerb) at 0.5 a.i./ha were significantly better than weedy check at Terbol and Elvas.

In Faba bean International Fertility-Rhizobium Evaluation and Rhizobium Inoculation Response Trial, reported from Holetta, Ethiopia none of the treatments was significantly superior to respective control.

Results of Faba Bean International Orobanche Chemical Control Trial was reported from three locations but the ANOVA for seed yield was significant only at one (Douyet). Glyphosate at 0.08 kg a.i./ha applied three times at 15 day intervals starting at flowering was most effective in controlling Orobanche.

7.2. Lentil

Data from 23 locations were analysed for seed yield for Lentil International Yield Trial-Large Seed (LIYT-L). At 12 locations, namely, Mahit (Iraq), Pulawy (Poland), Beja and El-kef (Tunisia), Lincoln (New Zealand), Mintaro (Australia), Terbol (Lebanon), Al Aziziah (Saudi Arabia), Madrid (Spain), Tel Hadya, Breda (Syria), and Sidi Laidi (Morocco), some of the test entries exceeded the respective local check in seed yield by a significant (P = 0.05) margin. The five heaviest yielding lines across locations were FLIP 87-16L, FLIP 87-12L, FLIP 87-17L, 81S 38326, and 78S 26002. Stability analysis based on the Eberhart and Russell (1966) model for seed yield of LIYT-L entries revealed that mean squares due to pooled deviations (non-linear portion of genotype x environment interaction) and entry x location interaction (linear) were significant (Table 7.2.1). This exhibited the presence of differences among entries for their linear and non-linear responses. The entries FLIP87-12L, FLIP 87-17L, 81S 38326, ILL 4606, and FLIP 86-2L had above average mean yield, unit regression coefficients and non-significant deviations from regression indicating general adaptation.

The results of Lentil International Yield Trial-Small Seed (LIYT-S) revealed that at 9 (Beni Slimane in Algeria; Turret Field in Austria; Terbol in Lebanon; Madrid in Spain; Idleb, and Breda in Syria; El-kef, and Beja in Tunisia; and Lincoln in New Zealand) out of 14

Table 7.2.1. ANOVA for stability for seed yield for the entries in LIYT-L, LIYT-S, and LIYT-E conducted during 1988/89.

Source of variation	LIYT-L		LIYT-S		LIYT-E	
	DF	MS($\times 10^4$)	DF	MS($\times 10^4$)	DF	MS($\times 10^4$)
Entry	22	19.40*	22	16.06*	22	18.55*
Entry x location + location	506	64.62*	299	60.05*	161	39.62*
Location (linear)	1	29453.10*	1	15707.90*	1	4763.46*
Entry x location (linear)	22	33.25*	22	9.51	22	6.44
Pooled deviation	483	5.21*	276	7.38*	138	10.68*
Pooled error	1012	2.48	616	2.95	352	1.45

* Significant at P = 0.05.

locations some of the test entries exceeded the respective local check in seed yield by a significant (P = 0.05) margin. The five heaviest yielders in this trial were FLIP 84-51L, FLIP 87-57L, FLIP 87-53L, FLIP 87-56L and FLIP 84-59L. Stability analysis for seed yield of the entries revealed that only mean square due to pooled deviations was significant (Table 7.2.1). Three entries namely FLIP 87-48L, FLIP 84-29L and 78S 26013 had above average mean, non-significant deviations from regression, and regression coefficients equal to unity, and thus had general adaptation.

The results of Lentil International Yield Trial-Early (LIYT-E) revealed that at four locations namely, Khulamtar (Nepal), Rabiah (Iraq), Pesso Fundo (Brazil) and Buvmbwe (Malawi), 3, 1, 17, and 1 test entries, respectively, exceeded the respective local check in seed yield by significant ($P \leq 0.05$) margin. The five heaviest yielders across locations included ILL 2573, ILL 2501, 1LL 3614, FLIP 84-112L and ILL 2582. The ANOVA for stability analysis for seed yield revealed the significance of mean square due to pooled deviations (Table 7.2.1). None of the entries having above average yield and regressicn equal to unity were predictable across environments for seed yield.

For Lentil International Screening Nursery Large (LISN-L), Small (LISN-S), Tall (LISN-T), and Early (LISN-E) the data for seed yield were reported from 20, 19, 26, and 16 locations, respectively. The analyses revealed that at 9 locations in LISN-L (Sidi Bel Abbes, Algeria; Ramtha and Jubeiha, Jordan; Faisalabad, Pakistan; Elvas, Portugal; Rawdat Harma, Qatar; Madrid, Spain; Gelline, Syria; Elkef, Tunisia), 8 locations in LISN-S (Gazvin and Maragheh, Iran; Jubeiha and Ramtha, Jordan; Rawdat Harma, Qatar; Madrid, Spain; Aleppo and Idleb, Syria), 14 locations in LIYT-T (Beni Slimane, Setif, and Sidi Bel Abbes, Algeria; Clare, Australia; Karaj and Maragheh, Iran; Arbil, Iraq; Catagirone, Italy; Jubeiha and Ramtha, Jordan; Elvas and El Encia, Portugal; Idleb, Syria; Kef, Tunisia), 10 locations in LISN-E (Turret Field, Australia; Ramtha, Jordan; Sidi Laidi, Morocco; Faisalabad, Pakistan; Elvas, Portugal; Beja and El Kef, Tunisia; Karaj, Iran; Maracaju, Brazil; Debre Zeit, Ethiopia) some of the test entries exceeded the respective local check by a significant margin (P=0.05). The five heaviest yielders across the locations for these nurseries are given in Table 7.2.2.

Table 7.2.2. The five heaviest yielding lines across locations in different lentil screening nurseries, 1988/89.

	Name of Nursery			
Rank	LISN-L	LISN-S	LISN-T	LISN-E
1	FLIP 88- 8L	FLIP 87-51L	FLIP 88-50L	FLIP 88-47L
2	FLIP 88- 1L	FLIP 89-24L	FLIP 88-8L	FLIP 88-45L
3	FLIP 88- 7L	FLIP 89-20L	Idlib - 1	FLIP 89-45L
4	FLIP 87-15L	FLIP 89-25L	FLIP 84-51L	FLIP 89-48L
5	FLIP 87-20L	FLIP 88-30L	FLIP 84-59L	FLIP 88-35L

The results of Lentil International F_3-Trial (LIF_3T) and F_3-Trial-Early (LIF_3T-E) were reported from 6 locations each. At most of these sites the individual plant selections were made by the national programs.

The results of Lentil International Cold Tolerance Nursery were received only from Erzurum in Turkey. The susceptible check took the rating of 5 on 1-5 scale (1=free; 5=killed because of frost). Some entries namely, ILL 857, ILL 465, ILL 780, ILL983 and local check took rating between 2 and 3 and were relatively tolerant to cold as compared to others.

The results of Lentil International Ascochyta Blight Nursery were received only from Erzurum in Turkey and Lincolin in New Zealand. At both locations the local susceptible check took the rating of 3 indicating that the disease development was not sufficient to permit good screening.

The results for Lentil Weed Control Trial received from five locations showed that effect of treatments on seed yield was significant at two locations only. All the weedicide treatments at Setif (Algeria) were significantly superior to weedy check whereas at Douyet (Morocco) only three treatments T9 (methabenzthiazuron (Tribunil) at 2.0 kg a.i./ha plus pronamide (Kerb) at 0.5 kg a.i./ha), T6 (Cyanazine (Bladex) at 0.5 kg a.i./ha), and T7 (prometryne (Gesagard) at 1.5 kg a.i./ha) were significantly superior.

The Lentil International Fertility-Rhizobium Evaluation Trial was conducted at three locations and the ANOVA for treatments for seed yield at all the locations was not significant.

The Lentil International Rhizobium Inoculation Response Trial (LIRT) was reported from 4 locations. The results, however, revealed that only at Pant Nagar (India), the inoculation with strain no. 735 excelled the control in seed yield by a significant margin.

7.3. Chickpea

The seed yield data were analysed for 16 locations for Chickpea International Yield Trial-Spring (CIYT-SP). A large number of test entries exceeded the respective local check by a significant margin (P=0.05) at six locations (Montboucher, France; Karaj, Iran; Padilla Tam, Mexico; Al Aziziah, Saudi Arabia; Badajoz, Spain; Adana, Turkey). The five best entries across the locations were FLIP 86-53C, FLIP 84-164C, ILC 482, FLIP 84-182C and FLIP 84-7C.

The ANOVA for stability revealed that mean squares due to both linear and non-linear portions of g x e interaction were significant with preponderance of linear portion. Nine entries, namely FLIP 84-7C, FLIP84-182C, FLIP 81-293C, FLIP 86-71C, FLIP 86-19C, FLIP 85-86C, FLIP 85-11C, FLIP 84-78C, and FLIP 86-41C exhibited non-significant deviations from regression, had above average mean, and regression co-efficients equal to unity and thus exhibited general adaptability.

The seed yield data for Chickpea International Yield Trial-Winter-Mediterranean Region (CIYT-W-MR) revealed that at 15 locations (Dahmoni, Khroub, Oued Smar, Setif and Sidi Bel Abbes, Algeria; Caltagirone and Tarquinia, Italy; Sevilla, Spain; Idleb, Gelline, Tel Hadya, and Jinderess, Syria; Beja, Tunisia; Adana and Izmir, Turkey) out of 32, some entries exceeded the respective local check by a significant margin (P=0.05). The five best entries across locations included FLIP 84-92C, FLIP 84-79C, FLIP 85-42C, FLIP 84-102C and FLIP 81-293C. The ANOVA for stability for seed yield indicated that mean squares due to pooled deviations were significant (Table 7.3.1). Three entries namely, FLIP 85-42C, FLIP 84-102C, and FLIP 85-48C had regression coefficient equal to one, deviations from regression approaching to zero and the seed yield more than the general mean, and were thus widely adaptable.

The ANOVA for seed yield for entries in Chickpea International Yield Trial-Large-Seed (CIYT-L) for 37 locations revealed that at 18 locations (Dahmoni, Khroub, Oued Meliz, Setif and Sidi Bel Abbes, Algeria; Saskatoon, Canada; Chillan, Chile; Montpelier, France;

Tarquinia, Italy; Cordoba and Sevilla, Spain; Al Ghab, Jinderess, Syria; Beja, Tunisia; Amasya, Adana, Izmir and Erzurum, Turkey) some of the test entries exceeded the respective local check by a significant margin. The five heaviest yielders across the locations were FLIP 85-15C, FLIP 86-5C, FLIP 85-75C, FLIP 83-77C, and FLIP 84-19C.The ANOVA for stability (Table 7.3.1) revealed that mean squares due to both linear and non-linear portions of g x e interaction were significant with preponderance of linear portion. Eight entries namely FLIP 83-77C, FLIP 85-5C, FLIP 85-56C, FLIP 85-75C, FLIP 85-60C, FLIP 85-54C, FLIP 86-13C and FLIP 85-55C exhibited non-significant deviations from regression, had above average mean and regression coefficient equal to unity and thus exhibited general adaptability.

In the Chickpea International Yield Trial-Sub-Tropical Region (CIYT-STR), out of 4 locations analysed a few test entries exceeded the respective local check in seed yield by a significant margin at two locations (Atshana, Iraq; and Breda, Syria). The five heaviest yielders across locations were ILC 482, FLIP 86-47C, FLIP 86-52C, FLIP 84-62C, and FLIP 86-29C. The ANOVA for stability for seed yield for the entries in CIYT-STR exhibited that both linear and non-linear portion of g x e interaction were significant. Seven entries, namely, ILC 482, FLIP 86-47C, FLIP 86-52C, FLIP 84-62C, FLIP 86-18C, FLIP 86-49C, and FLIP 86-44C had above average yield, regression equal to one, and deviations approaching to zero and were thus with general adaptation. Two more entries, FLIP 86-29C, and FLIP 85-94C had above average mean, deviations approaching to zero and regression above one, and were adaptable to high yielding environments.

Table 7.3.1. ANOVA for stability of seed yield for the entries in CIYT-SP, CIYT-MR, CIYT-STR, CIYT-L and CIYT-T conducted during 1988/89.

Source of variation	CIYT-SP		CIYT-MR		CIYT-STR		CIYT-L		CIYT-T	
	DF	MS($x10^4$)	DF	MS($X10^4$)	DF	MS($x10^4$)	DF	MS($X10^4$)	DF	MS($x10^4$)
Entry	22	27.70*	14	42.41*	22	4.84*	22	29.14*	22	15.70*
Entry x location + location	345	101.27*	690	64.66*	69	19.10*	759	86.95*	552	56.19*
Location (linear)	1	33092.20*	1	40082.30*	1	1224.09*	1	60458.20*	1	26584.10*
Entry x location (linear)	22	27.22*	22	5.94	22	1.99*	22	22.64*	22	17.82*
Pooled deviation	322	3.87*	667	6.60*	46	1.08*	736	6.85*	529	7.64*
Pooled error	704	2.92	1364	3.66	176	0.71	1496	4.69	1100	5.15

* Significant at P = 0.05.

The Chickpea International Yield Trial-Tall (CIYT-T) was reported from 28 locations. ANOVA for seed yield revealed that at 8 locations (Tessala, Algeria; Athalassa, Cyprus; Bakrajo, Iraq; Marchouch, Morocco; Al-Ghab, and Jinderess, Syria; Izmir and Erzurum, Turkey), some of the test entries exceeded the respective local check in seed yield by a significant margin (P=0.05). The five heaviest yielders across locations included FLIP 85-45C, ILC 195, FLIP 85-19C, ILC 3279, and FLIP 85-13C. The ANOVA for stability (Table 7.3.1.) revealed that mean squares due to both linear and non-linear portions of g x e interaction were significant with preponderance of linear portion. Eight entries, namely, FLIP 85-19C, ILC 3279, FLIP 85-13C, FLIP 86-61C, FLIP85-44C, FLIP 85-57C, FLIP 85-49C and FLIP 85-62C exhibited non-significant deviation from regression, had above average mean and regression coefficient equal to unity and thus exhibited general adaptability.

The results of Chickpea International Yield Trial - Early were received from 3 locations and at one location the test entries exceeded the local check by a significant margin. The overall mean of entries across locations revealed that ILC 2694, ILC 2440, ILC 2910, ILC 2904 and ILC 1687 were the top yielders.

The results of Chickpea International Yield Trial-Dual Season was reported from 6 locations. The correlation between spring and winter for seed yield of entries was significant at Sidi Bel Abbes in Algeria and Marchouch and Jema'a Shain in Morocco. This showed that the cultivars at these locations could be used for dual season. At Terbol, Douyet, and Tel Hadya there was no association between spring and winter yields. These results indicated the need to develop cultivars separately for winter and spring seasons for these locations.

The analysis of seed yield in Chickpea International Screening Nursery-Winter (CISN-W) revealed that at 15 out of 29 locations, some of the test entries exceeded the respective local check by a significant margin (P = 0.05). The five heaviest yielders across the locations included FLIP 87-45C, FLIP 87-60C, FLIP 86-95C, FLIP 87-52C and FLIP 86-87C.

The results of Chickpea International Screening Nursery-Spring (CISN-S) were reported from 24 locations. At Santa Maria, Portugal; Jubeiha, Jordan; Padilla Tam, Mexico; Marchouch, Morocco; Cordoba, Spain; Beja, Tunisia; and Amasya, Turkey, some of the test entries exceeded the respective local check in seed yield by a significant (P=0.05) margin. The five best yielding lines across locations included FLIP 87-47C, FLIP 87-44C, FLIP 87-56C, FLIP 87-1C and FLIP 87-59C.

The Chickpea International F_4 Nursery was sent to 20 cooperators and the results were received from 9. Most of the cooperators found these crosses useful for effecting individual plant selection for their breeding program.

The Chickpea International Screening Nursery - Early was reported from two locations, Tel Hadya and Rampur (Nepal). The yields in Nepal were very low due to infestation of Botrytis grey mould. At the other location none of the entries exceeded the local check by a significant margin.

The Chickpea International Ascochyta Blight Nursery (CIABN) results from 12 locations revealed that at four locations the disease infestation was inadequate to permit good screening. For other locations, considering the frequency of occurrence of an entry among the tolerant group (with rating up 4 on 1-9 scale), it was clear that among kabuli lines ILC 72, ILC 4421, FLIP 82-150C, FLIP 83-47C, FLIP 83-97C, FLIP 84-78C, FLIP 84-79C, FLIP 84-92C, FLIP 84-93C, and FLIP 85-94C were tolerant and had broad-based resistance to Ascochyta blight. Similarly, among desi types, ICC 13301, FLIP 87-502C, FLIP 87-506C, FLIP87-507C, ICC 13266, ICC 13497, ICC 13508, ICC 13528 and ICC 13555 were found to fall most frequently in the tolerant group.

The Chickpea International Leaf Miner Nursery (CILMN) was reported from Sidi Bel Abbes (Algeria) and Amasya (Turkey). At Sidi Bel Abbes the damage due to leaf miner was minimum for ILC 394 (15%) and ILC 5614, ILC 5616, ILC 5648 and ILC 5901 had 20% damage showing tolerant reaction. At Amasya ILC 655, ILC 992, ILC 1334, and ILC 3828 proved tolerant.

For Chickpea International Cold Tolerance Nursery (CICTN) the reaction was reported from eight locations. ILC 3465, ILC 3468, ILC 3470, FLIP 82-115C, FLIP 83-66C, FLIP 84-176C, FLIP 84-188C, FLIP 85-84C, FLIP 85-93C, FLIP 86-85C, and FLIP 86-86C took rating of 5 or less on 1-9 scale (1=free; 9=killed) and were tolerant.

The data on Chickpea Weed Control Trial (CWCT) reported from 5 locations revealed that weeds in chickpea caused an overall loss of 46.1% across locations. The pre-emergence application of terbutryne (Igran) @3.0 kg a.i./ha alone or with pronamide (Kerb) @0.5 kg a.i./ha was the best treatment at most of the locations. Maloran or Bladex in combination with Kerb, were also effective weedicide treatments giving significantly higher yield as compared to the weedy check.

The results of Chickpea International Fertility-Rhizobium Evaluation Trial were reported from three locations but the treatment effects were significant only at Setif (Algeria). The treatments with application of nitrogen exhibited significant increase in seed yield over unfertilized control. This indicated that natural Rhizobium was not sufficient to meet the nitrogen requirement of the crop at this location.

The results of Chickpea International Rhizobium Inoculation Response Trial were received from four locations. There were significant treatment differences for two locations, Sevilla (Spain) and Setif (Algeria). Only at Setif inoculation with strains No. 39 and No. 44 gave significantly higher yield than uninoculated treatment.

7.4. Dry Pea

The Peas International Adaptation Trial was conducted for the second time during the 1988/89 season. The results were received for seed yield from 10 locations and revealed that one of the entries (Ballet) yielded as high as 6423 kg/ha at Douyet (Morocco) and the yields of a few more entries (SV51741, Century, ILP 845, and ILP 974) exceeded 5 t/ha. On the basis of average yield of entries across locations, SV51741, ILP 845, Ballet, Frisson, and Acc No. 21 (Local Sel 1690) were among the top yielders.

7.5. Identification of Superior Genotypes by the NARS

From the genetic materials supplied in the International Testing Program the national programs identified and released 5 varieties of chickpea [Jubeiha 1, and Jubeiha 2 in Jordan; Janta 2 (ILC 482) in Lebanon; Dalma 89 (FLIP 85-7C) and Tabavo 89 (FLIP 85-135C) in Turkey] and five varieties of lentil [Jordan 3 (78S 26002) in Jordan; Precoz (ILL 4605) in Morocco; Mansehra 89 (ILL 4605) in Pakistan; Erzurum 89 (ILL 942), and Malazgirt 89 (ILL 1384) in Turkey] for general cultivation during 1989/90. In addition a large number of lines were identified for multilocation testing, on-farm trials or pre-release multiplication. Also a large number of lines resistant to various stresses were identified and are being used for direct or indirect exploitation.

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8. COLLABORATIVE PROJECTS

8.1. Nile Valley Regional Program

The Nile Valley Regional program (NVRP), started in 1988/89, deals with research, transfer of technology and training to improve production of cool season food legumes in Egypt, Ethiopia and Sudan. Adopting a multi-institutional and multidisciplinary approach it undertakes problem oriented research making full use of the expertise and infrastructure available in the participating countries. The Food Legume Improvement Program collaborates with the national scientists of the three countries in developing the annual workplan, providing germplasm, technical evaluation of experiments and preparation of reports and in conducting training. The project in Egypt is funded by The European Economic Community, in Ethiopia by the Government of Sweden (SAREC), and in Sudan by the Government of The Netherlands. Significant progress in research was achieved in each country during the 1989/90 crop season. Highlights of research are presented here.

8.1.1. Egypt

8.1.1.1. Faba bean

Faba bean area in Egypt has shown a steady increase in last five years, rising from 119,627 ha in 1985 to 157,776 ha in 1989. Average productivity has also increased from 2.52 t/ha to 2.74 t/ha. Thus the production has increased by nearly 32%. Some of these increases in the productivity can be ascribed to the transfer of results of the Nile Valley Project to the Egyptian farmers. During the 1989/90 season, work was continued on farmers fields as well as at various research stations in major production areas.

In cooperation with the staff of the Agricultural Development Project in El-Minia, 90 demonstrations (271 ha, involving 110 farmers across nine districts) were conducted to compare the farmer's practice with an improved production package involving Orobanche tolerant faba bean cultivar Giza 402 sown in early November at a seed rate of 184.5 kg ha, with a fertilizer application of 35.7 kg N and 71.4 kg P_2O_5/ha, weed control either by hand or with herbicide, aphid control with Pirimor and adequate water supply. Demonstration seed yields were 0.48 t/ha (17.5%) and straw yields 1.08 t/ha (14.8%) higher than the yields of the neighbouring farmers. Similarly in Fayoum, on 48 demonstrations (161 ha, involving 48 farmers) the seed and straw yield increases were, respectively, 0.63 t/ha (29.8%) and 0.51 t/ha (18.2%), over the neighbouring farmers. In Behaira, where Giza 3 cultivar was used and the crop was sprayed with Dithae M 45 (250 g/100l) four times as a part of the package, the seed yield increase, averaged over 16 demonstration plots, was 1.9 t/ha.

Pilot-production plots on Orobanche control through the use of Orobanche tolerant cultivar Giza 402 and spraying 179 cc of glyphosate (Lancer) in 500 l water/ha at flowering and 15 days thereafter, were laid out in Minia, Fayoum and Behaira governments. Farmers were provided seeds of Giza 402 and fertilizer through the village cooperatives and glyphosate and knap-sack sprayers by the NVRP staff.

The results are shown in Table 8.1.1. The demonstration package reduced *Orobanche* infestation and caused significant increase in seed yield of faba bean. These increases were highly economical.

Table 8.1.1. Effect of *Orobanche* control package on the *Orobanche* infestation and seed yield in faba bean in three governorates in Egypt.

Governorate	Attributes	Demonstration farm	Neighbouring farm
Behaira	Seed yield (t/ha)	2.38	1.33
	Orobanche shoots/m^2	1.3	30.1
Minia	Seed yield (t/ha)	2.52	1.47
	Orobanche shoots/m^2	25.10	36.90
	Orobanche dry wt, g/m^2	38.90	65.60
Fayoum	Seed yield (t/ha)	2.42	1.43
	Orobanche shoots/m^2	9.80	31.60
	Orobanche dry shoots, g/m^2	19.60	68.20

Follow-up with farmers in Behaira showed that 70% of the surveyed farmers thought adoption of the improved package would increase faba bean production.

Researcher managed on-farm trials in Behaira and Minia focused on land preparation, planting methods and sowing date. Plant population and seed yields were higher and production costs lower in the 'no tillage' and 'reduced tillage' (involving rototilling of previous seasons ridges, seed broadcast, and again rototilling to cover seed) as compared to conventional tillage system. Researcher-managed trials also identified faba bean genotypes adapted for no-tillage sowing system.

Highlights of backup research are as follows:

(a) Evaluation of eight hybrid bulk populations and two breeding lines with two standard checks (Giza 3 and Giza 402), under natural but good field infestation with chocolate spot and rust at Sakha and Nubaria research stations, indicated that two hybrid bulk populations, 714 and 717, were most promising and exceeded the check cultivar Giza 3 seed yield by 27.3 and 20.5%, respectively.

(b) Of 27 F_5 families derived from seven crosses for chocolate spot resistance, evaluated under natural field infection at Sakha and Nubaria, as well as under controlled conditions, two lines were highly resistant and exeeded Giza 3 significantly in yield.

(c) Of the chocolate spot resistant sources supplied by ICARDA as FBCSIN, two lines (S83081 and ILB 3035) were identified as promising.

(d) In a nursery of 382 F_3 families derived from 33 crosses evaluated for Orobanche resistance at Giza research station in a heavily infested field, 56 families were very promising. Also 18 breeding lines were found to posses high level of resistance to Orobanche.

(c) Ten F_3 crosses, along with several F_5 families derived from six crosses, were evaluated for aphid (Aphis craccivora) resistance at Sids research station under heavy natural infestation. Twenty-four individual F_3 plants along with 11 F_5 families were selected.

(f) The method for laboratory screening of faba bean for aphid resistance was standardised. Using this method, 600 BPL's and 192 breeding lines from Giza 402 were screened. Of these, seven lines (BPL 3345, -3416, 3129, -3351, -3474, -3116, -3347) were found highly resistant and 25 resistant. These will be re-screened.

Pre-release multiplication of seed of four lines selected earlier from crosses involving chocolate spot resistance, as well as that of Reina Blanca, was done. These will soon be released for cultivation, because their performance has been consistently good over last several years.

8.1.1.2. Lentil

The area under lentil had gone down after construction of Aswan high-dam, but there is again an increase because of increasing demand and high price of lentil in the market. Last year the area in Egypt under lentil was 8000 ha with an average yield of 1.9 t/ha. Recent efforts with lentil demonstration plots have encouraged farmers in the Delta region to produce the crop and the governorates of Sharkia and Kafr-El-Sheikh now contribute to nearly 50% of total area under lentil in Egypt.

On-farm demonstration of improved production package (one irrigation 3-4 weeks after sowing, weed control using Gesagard @2.5 kg/ha as preemergence herbicide, and control of downy mildew using Ridomil-Mancozeb 58 WP@ 250 g/100 l, three times at 10 day intervals) using Giza 9 cultivar sown in the first fortnight of November and fertilized with 35.7 kg N + 71.4 kg P_2O_5/ha, was done on 7 sites in Sharkia and 5 sites in Kafr El-Sheikh. Aphids were controlled by spraying Pirimor when necessary. The seed and straw yields in demonstration plots in Sharkia increased by 23.8% and 10.2%, respectively over the neighbouring farmers yields. The increases in Kafr El-Sheikh were relatively smaller, being 20% and 6%, respectively. These increases were, however, economical.

Researcher managed on-farm trials showed that using rotovator to cover seed broadcast on untilled soil after rice harvest resulted in better stand, increased yield and reduced cost of production as compared to conventional tillage and seeding method. Studies on irrigation and sowing method showed that broad-bed sowing with two irrigations was better than ridge sowing with one or two irrigations.

The highlights of backup research were as follows:

(a) Breeding research helped in identifying 70 lines that out-yield the best check Giza 9. Of these 10 lines showed field resistance to aphids, 5 tolerance to water-logging and 47 showed good response to irrigation.

(b) In the wilt-sick plot at Giza, 5 entries (H4/9/83, ILL 2490, ILL 5748, FLIP 86-38L, and FLIP 87-16L) were rated resistant to wilt with a seedling mortality of less than 20%, out of a total of 110 genotypes.

(c) Aphid resistance screening in the laboratory revealed high level of resistance in three lentil genotypes (ILL 1573, FLIP 84-26, FLIP 86-64L).

(d) Evaluation of several herbicides for the control of Orobanche in Giza 370 applied as post-emergence 7 and 11 weeks after sowing revealed that Scepter and Pursuit were very effective. (Table 8.1.2). Scepter delayed the maturity of the crop by 18 days.

(e) Screening of 60 accessions of lentil for Orobanche resistance at Giza revealed that H4/9/81, H10/8/81, line 6908, ILL 112 and H5/8/81 had low Orobanche infestation. Line 107, H4/8/81 and line 318 also proved promising.

Seed multiplication was done of Precoz and H5/6/81 lentil and 433 and 35 kg seed, respectively was produced. Single plant selections were made in the two varieties for growing as progeny rows to produce breeders seed.

Table 8.1.2. Effect of different herbicides on the control of Orobanche and seed yield of lentil at Giza, Egypt.

Treatment Herbicide	Rate a.i./ha	Time of appln.	Orobanche/8m^2 No.	Orobanche/8m^2 Dry wt (g)	Seed yield (t/ha)
Scepter	10	2	1.75	0.98	1.333
Pursuit	10	2	12.2	9.24	1.642
Glyphosate	40	2	165.0	180.18	1.420
Check	-	-	452.7	555.64	0.827

8.1.1.3. Chickpea

Chickpea is produced on nearly 13,000 ha in Egypt with an average yield of about 1.5 t/ha. There is scope for the expansion of its cultivation in the newly reclaimed areas.

Researcher-managed verification trials in Egypt indicated that three promising lines (L70, ILC 249, and FLIP 14-80C) out-yielded farmers' cultivar by 12 to 24% over three locations with maximum yield advantage of 56% in Quina governorate. In Nubaria, FLIP 14-80C, ILC 249 and L 70 out yielded farmer's variety by 50%, 25% and 25%, respectively.

The need for Rhizobium inoculation in chickpea was apparent at Quina where inoculation with ICARDA strain No. 39 increased seed yield by 68%. At Assuit, ICARDA strain No. 31 increased seed yield by 37%.

Back-up research concentrated on identifying superior yielding, large seeded kabuli lines with resistance to root-rot and wilt. A crossing program will be started in the 1990/91 season.

8.1.2. Ethiopia

Faba bean, lentil, chickpea and dry pea are the important highland pulses in Ethiopia. They are valued as protein-rich food crop, and a source of valuable forage for animal. They also provide fuel and are used by farmers in their cropping systems to restore soil fertility. Research was carried out on all these four food legumes in the NVRP.

8.1.2.1. Faba bean

Pilot demonstration plots, using improved cultivar (CS 20 DK), a seed rate of 200 kg/ha, 100 kg DAP/ha and two hand weedings, had a seed yield ranging from 1.2 t/ha in Burksami to 2.9 t/ha at Sode giving a yield advantage ranging from 0.6 to 1.8 t/ha with an overall mean advantage of 1.1 t/ha across locations. The partial budget analysis revealed that improved package gave 40% more net benefit than the farmers' practice and on the local market price basis the marginal rate of return on investment in the improved package was 284%.

In the popularization sites, where earlier demonstrations had been carried out and only seeds of improved genotype were given through the cooperatives, the yield of improved production method ranged from 1.6 to 2.4 t/ha with a yield advantage ranging from 0.3 to 1.4 t/ha (0.7 t/ha across all locations) over farmers' practice.

Researcher-managed variety verification trial in West Gojam at 5 sites using CS 20 DK, Ingida, Kasa, NC 58 and local check cultivars showed that improved cultivars out-yielded the local by a margin of 1.1 t/ha. The net benefit for improved cultivars was almost double that of the local cultivar.

Evaluation of faba bean production package on farmers fields in Arsi was done at five sites and included three factors of production (improved cultivar CS20DK, 100 kg DAP/ha, and 2 hand weedings). The improved package gave an average yield advantage of 1.3 t/ha over the traditional practice and was economically highly advantageous.

Verification trials on aphid control have been conducted over two years. Aphid control through Pirimor and Actellic gave a seed yield increase of 32% and 16% respectively. A partial budget analysis revealed that Pirimor treatment gave the highest net benefit of 1165 Ethiopian Birr/ha followed by Actellic which gave 1121 E Birr/ha net benefit.

Verification trials on weed control (hand weeding, use of preemergence herbicide Terbutryne @2 kg a.i./ha, and combination of the two) showed significant increases in yield with hand weeding at Wolmera and with terbutryne + hand weeding at Debre Zeit over the no-weeding treatment common with farmers. The yield increases were 24.7% in Wolmera and 27.7% in Debre Zeit. Terbutryne alone at Debre Zeit gave 14% increase in yield. Economic analysis indicated that the above weed control practices were nighly economical.

A survey of the adoption of the recommended practices showed that the adoption of improved variety, hand weeding and fertilizer application by the 'host' farmers 2 years after the demonstration was quite high. Seventy-seven percent of the host farmers planted improved variety CS 20 DK in 1988 and 1989 crop season. More than 75% weeded their crop at least once and more than 46% applied DAP fertilizer.

Highlights of the backup research are given below:

(a) In the National Variety Trial 75TA 26026-1-2-1 out yielded local best checks by significant margin giving a yield of 3.3 t/ha.

(b) From the 109 entries received from ICARDA in five international nurseries and four international yield trials and 162 local collections received from PGRC/E, 243 single plants and 13 bulks were selected based on podding character, earliness and disease reaction.

(c) Eighteen determinate and 3 segregating non-determinate plants and 15 bulks were selected from the determinate faba bean lines. From the IVS source, one single line and 8 bulks were selected.

(d) Ethiopia, being a secondary center for faba bean domestication, has a large genetic variation in the landraces. Their purification and development of pure lines was started in 1987. A total of 525 lines have been advanced for the 4th cycle of selfing in 1990 season.

(e) An off-season generation advance was attempted at Holetta and Nazret, but the attempts were not very successful because off-season at Holetta was cool and rainy delaying the crop maturity whereas Nazret was hot and dry and had high pest and disease incidence and flower abortion. Debre Zeit or Denbi stations will be tested next season.

(f) Breeder seed was produced on 14.3 and 2.5 ha respectively for CS 20 DK and NC 58.

(g) Survey on 33 fields in Shawa adminstration region showed that chocolate spot, black root-rot and rust were the most frequently occurring diseases. Chocolate spot was more important on higher elevations and on Nitosols, and appeared at any stage of crop growth. Rust was important on lower altitudes and appeared in the later part of crop growth. Black root-rot was common at high altitudes on black clay soils.

(h) Among 190 accessions tested for chocolate spot resistance, 3 were moderately resistant (rating 4 on 1-9 scale) and 24 tolerant. From this 1st stage testing, 173 lines were selected and promoted for second stage testing in the 1990 season. In the stage II testing 24 lines were moderately resistant, 68 tolerant. About 5 lines and 5 single plant selections were made and promoted to stage III for testing in the 1990 season. In stage III, 256 lines/single plants were tested. Of these 22 were resistant/moderately resistant and were promoted for yield trial after seed multiplication in the off-season.

(i) Survey of field and storage pests of faba bean revealed that Helicoverpa armigera (H.n.) was present in 13 out of 15 fields, three species of aphids (Aphis craccivora, A fabae Scop. and Acyrthosiphon pisum Harsis. occurred in small numbers, and Callosobruchus chinensis (L.) was present in most stores with highest infestation level of 14% in Hamsa Gosha. Primiphos methyl 2% a.i. dust was effective in providing long protection to seeds from bruchids in storage and better than hydrogen phosphide and noug (niger seed) oil.

(j) A collection of 119 Rhizobium isolates has now been developed and of 77 of these tested for their infectivity and symbiotic efficiency, 23 were found to be superior. Field tests gave significant increases in yield by inoculation with superior strains including those provided by ICARDA. Studies in symbiotic N_2-fixation, carried out in collaboration with IAEA using wheat as reference crops adopting N^{15} technique, revealed that faba bean fixed 110.5 kg N/ha without P fertilizer and 115.2 kg/ha with 60 kg P_2O_5/ha at Holetta research station.

(k) The protein content of faba bean genotypes included in the National Variety Trial ranged from 26.0-28.8%. The cooking time varied depending on the location: 13.4 to 25.7 min for CS 20 DK and 11.2 to 15.1 min for NC 58. Level of K in the soil showed a negative correlation with the cooking time.

8.1.2.2. Lentil

Work on lentil was mainly done at Debre Zeit. In the preliminary yield trial of 17 test entries the yield was very low because of frost damage. Despite that NEL 358 gave good yield (700 kg/ha) and significantly out-yielded the check (500 kg/ha). NEL 358 has been named as 'Chalo' by the farmers because of its good tolerance to most of the biotic and abiotic stresses.

Need for inoculation studies at Ginchi and Denbi showed that the local Rhizobium were quite effective. Laboratory test of 13 isolates of rhizobia revealed 6 to have superior infectivity on NEL 358 lentil. Of these, 3 were found to have better N_2-fixation in the sterile hydroponic system. These will be tested in soil cores next season.

8.1.2.3. Chickpea

Most of the chickpea grown in Ethiopia is of desi type and there is a good collaboration of the national scientists with ICRISAT. In the NVRP, only limited work was carried out during the 1989/90 season. At

Adet research station, 260 chickpea accessions earlier collected from Gojam and Gonder were evaluated in 1988/89 and 17 accessions selected. These were again evaluated in a screening nursery in the 1989/90 season. Eight accessions were selected based on earliness, dry root-rot resistance and yield.

Fifty-two chickpea genotypes were tested in a preliminary yield trial at Adet. Fifteen accessions proved high yielding. Of these ICCL 820049/85-DZ/5.2 gave the highest yield (3.1 t/ha) followed by ICC 14160 (2.9 t/ha).

Of 128 Rhizobium isolates collected from different chickpea growing areas, 33 were tested and 23 found infective and effective. Evaluation of N_2-fixation efficiency in sterile hydroponic system revealed that 11 of these were superior. Need for inoculation studies in Ginchi revealed that local population of Rhizobium there was quite effective.

8.1.2.4. Dry pea

Dry pea is grown extensively in Ethiopia and the crop is used for both green pods and dry seeds. The green stalks are used as feed for cattle.

Evaluation of promising field pea lines in the national varietal trials (13 entries in Set 'A' for areas of >2400 m elevation; 12 entries in Set 'B' for areas of 1800-2400 m elevation) revealed that several test entries exeeded the check by a significant margin. The highest yielding genotype in Set A was 061 K 2P-2/92 giving 4.1 t/ha seed yield which was followed by Parvuss x Upton giving 3.9 t/ha and Kyondo giving 3.8 t/ha. The checks G 22763-2 C, NC 95 Haik, and local variety yielded 3.5, 3.6 and 3.0 t/ha respectively. The highest location yields were from Bekoji (5.7 t/ha) followed by Lole (4.9 t/ha) and Sinana (3.9 t/ha). In Set 'B', the highest yielding variety was 305 PS 210572 (3.5 t/ha) and the highest location mean was from Asassa (5.0 t/ha).

A total of 187 landraces and 23 genotypes from ICARDA were evaluated. A total of 147 single plant selections from land races and 18 single plants and 9 bulks from ICARDA introductions were selected.

Breeders seed of G22763-2C and FPexXDZ were multiplied at Denbi and Holetta.

A total of 140 accessions were screened for resistance to pea aphid (Acyrthosiphon pisum) at Kulumsa under natural infestation. Only 4 genotypes had low counts of aphid and tested resistant, three were highly susceptible (>30 aphids/plant), and remaining were intermediate in their reaction.

Biological nitrogen fixation studies, in collaboration with the IAEA using N^{15} marked nitrogen fertilizer and barley as reference crop, revealed that dry pea crop fixed 115.8 kg N/ha without P fertilizer application and 204.7 Kg N/ha when 60 kg P_2O_5 was applied at Holetta research station.

8.1.3. Sudan

This was the second season of the NVRP in Sudan covering faba bean, lentil and chickpea. Work on faba bean was done both in the traditional as well as non-traditional (south of Khartoum) areas whereas work on lentil and chickpea was mainly done in the Nile and Northern provinces.

8.1.3.1. Faba bean

On-farm demonstration plots were laid out in private schemes in Dongla area in the Northern Province and in the Kali scheme in the Nile province. The package in Dongla included newly released cultivar (SML), one hand weeding and control of insect pests by the use of Folimat, when necessary. The package in the Nile Province consisted of early sowing, optimum irrigation and control of insect pests. The demonstrations were highly successful as shown by the data in Table 8.1.3.

Highlights of back-up research are as follows:

(a) Bulk 1/3 and BB7 gave an increase of 23% and 19% over the standard check (Hudeiba 72), respectively, in the Nile Province. They also have better seed quality.

(b) In the Northern province, where medium-seeded types are grown, line SML/4 gave seed yield increase of 12% and 37% over the standard and local checks, respectively.

(c) A genotype tolerant to powdery mildew was identified. Seven out of 112 genotypes tested at Shambat showed no virus or phyllody symptom.

(d) For the non-traditional areas being newly brought under faba bean production, line 00104 showed consistently good performance and will soon be released.

(e) Leaf-miner infestation in 1989/90 season started early and in a heavy form; hence good screening of the genotypes of faba bean was possible. Results showed that 24 of the 34 entries found resistant in the previous four seasons maintained acceptable resistance. Thirty one new lines also had less than 20% infestation and will, therefore, be tested further.

(f) The economic threshold studies on leaf-miner in the new areas confirmed that insecticide spray should be done when 25% of the leaflets were infested. Danitol S was the most effective insecticide. In the traditional growing areas of faba bean Spodoptera exigera was the most important pest and it could effectively be controlled by one or two sprays of Folimit 80 (2.25 l/ha) during last November early December. Pod-borer (Helicoverpa armigera) damage was not high this season but its control could be effectively obtained by a single spray of Bolstar (1.8 l/ha) in the 3rd week of February when egg hatching is at the peak.

(g) At Aliab and Wad Hamid in the Nile Province, weeds reduced the seed yield of faba bean by 55% and 20%, respectively. The relationship between seed yield (y, t/ha) and weed dry weight (x, t/ha) was linear and negative at Aliab: y=3.098 - 1.385 x (R^2=0.9). Pursuit (0.05 kg a.i./ha) alone or in mixture with Goal (0.24 kg a.i./ha) applied as pre-emergence application increased faba bean yield by 130 and 170% over unweeded check yield of 1.16 t/ha at Aliab. These herbicides were also very effective at Wad Hamid.

Table 8.1.3. Yield and economics of faba bean production in demonstration plots in Dongla (Northern Province) and Kali Scheme (Nile Province) in 1989/90.

Location	Particulars	Demonstration farmers	Neighbouring farmers	Difference
Dongla	Yield (kg/ha)	2894	2127	767
	Price (LS/kg)	7.81	7.81	-
	Gross benefit (LS/ha)	22602	16612	5990
	Net benefit (LS/ha)	12903	7482	5420
Kali	Yield (kg/ha)	2259	1600	659
	Price (LS/kg)	6.85	6.85	-
	Gross benefit (LS/ha)	15472	10929	4513
	Net benefit (LS/ha)q	11134	7018	4116

LS = Sudanese Lira; 12 LS= 1 US$.

8.1.3.2. Lentil

The Government of Sudan is aiming to reduce the import of lentils (currently 0.15 million tonnes) and eventually to become self sufficient in lentil production. In line with this policy an improved production package of lentil was demonstrated in Wad Hamid and Rubatab areas of the Nile Province, as these are the potential areas for future lentil production. In Wad Hamid no lentil is currently grown by farmers; hence comparison was made with chickpea. The net benefit from lentil was LS 5488/ha against LS 3367/ha for chickpea grown with improved production package and LS 2565/ha for chickpea grown with traditional method. At Rubatab, where farmers grow lentil, the demonstration plots had an average seed yield increase of 33% over four sites as compared to the yields obtained by neighbouring farmers.

Backup research results are summarized below:

(a) Lentil verification trial at Rubatab showed that NEL 705 and Selaim were the highest yielders. Precoz (ILL 4605) did not perform well.

(b) Studies on seed rate showed that 80-100 kg/ha was optimum for NEL 795 lentil, and lower seed rates resulted in a significant reduction in yield. The crop did not respond to application of N and P fertilizer, or to inoculation with Rhizobium.

(c) Fusarium wilt (Fusarium oxysporum) was the most common disease on lentil, although at some locations powdery mildew (Erysiphe polygoni) was also noticed. NEL 795 showed good tolerance to wilt.

(d) Survey of insect-pests in Wad Hamid and Rubatab showed that Spodoptera exigua was more important in Wad Hamid and Helicoverpa armigera in Rubatab. Single spray of Folimet in November significantly reduced the infestation of S. exigua and a spray in February controlled the pod borer effectively.

(e) Weeds reduced lentil seed yield by 48% at Rubatab. Preemergence application of Gesagard (1.5 kg a.i./ha) without or with Kerb (0.5 kg a.i./ha) resulted in very good weed control and significant increase in yield over weedy check. These treatments were as effective as the weed-free check.

8.1.3.3. Chickpea

Both kabuli- and desi-type chickpea are grown in Sudan. Wad Hamid is an important chickpea production area and there is also scope for expanding the production in Rubatab. Demonstration plots were laid out at 12 sites in Wad Hamid and six sites in Kurgus area in Rubatab using the improved cultivar (Shendi), a seed rate of 60 kg/ha sown broadcast followed by ridging in mid November. The demonstration crop was protected from insect-pests by spraying once and in some cases two times. Yields were compared with neighbouring farmers. The results, presented in Table 8.1.4., showed that yield increased by 23.8% in Wad Hamid and 42% in Rubatab with the package used in demonstration. The application of the package was highly profitable. The sensitivity analysis, using lower product price or higher package costs, showed high stability.

Table 8.1.4. Yield and economics of chickpea production in demonstration plots in Wad Hamid and Rubatab area (Nile Province) in 1989/90.

Location	Particulars	Demonstration farmers	Neighbouring farmers	Difference
Wad Hamid	Yield (kg/ha)	1579	1275	304
	Price (LS/kg)	6.67	6.67	-
	Gross benefit (LS/ha)	10533	8504	2028
	Net benefit (LS/ha)	3367	2565	802
Rubatab	Seed yield (kg/ha)	1940	1369	571
	Price (LS/kg)	6.34	6.34	
	Gross benefit (LS/ha)	12300	8679	3621
	Net benefit (LS/ha)	3260	2168	1092

Highlights of the backup research are as follows:

(a) In the Chickpea Advanced Yield Trial at Hudeiba, ILC 1327, ILC 1631, ILC 1353 and Shendi were higher yielding than the local, although they had nearly the same phenology. In the Chickpea Preliminary Yield Trial, also at Hudeiba, ILC 1687, -2694, -2824,-2825, -2875, -2877, -2904 and Shendi performed well. These lines will be evaluated in the advanced yield trial next season.

(b) Seed rate studies showed that 60 kg/ha was optimum for Shendi. Ridge vs. flat planting had no effect on yield at both Hudeiba and Rubatab. More frequent irrigation during the reproductive period (10 day interval) and longer irrigation interval in the vegetative phase (20 days interval) was a better water management schedule than 10 day or 20 day schedule throughout the season at Rubatab, whereas at Hudeiba the 10 day schedule throughout was the best (Table 8.1.5).

Table 8.1.5. Effect of different irrigation schedules on the seed yield of chickpea at Hudeiba and Rubatab.

Irrigation interval (days)		Seed yield (kg/ha)	
Vegetative phase	Reproductive phase	Hudeiba	Rubatab
10	10	2310	1751
20	10	2096	1985
10	20	1376	1633
20	20	1153	1645
S.E.		± 116.5	

(c) *Fusarium* wilt, dry root-rot and stunt virus diseases were observed on chickpea at Hudeiba and Rubatab. The incidence of wilt was higher in flat sowing than ridge sowing at Rubatab. A wilt-sick plot is being developed. October-sown crop had higher disease incidence than late November sown crop.

(d) Need for inoculation with *Rhizobium* was apparent at Wad Hamid where application of nitrogen fertilizer and inoculation resulted in a significant and similar increase in the seed yield. At Rubatab and Hudeiba, there was no need for inoculation.

(e) *Spodoptera exigua* was a severe insect pest at Wad Hamid and *Helicoverpa armigera* at Rubatab, with respective infestation levels reaching 82% and 42% on farmers fields. These could be effectively controlled by spraying Folimat.

(f) *Bruchidus incarnatus* was main store pest in Shendi area and at Hudeiba research station *Tragoderma granarum* was also found to affect the chickpea in storage.

(g) Weeds reduced seed yield by 18% at Hudeiba and 30% at Rubatab. Hand weeding was better than chemical weed control.

8.2. North African Regional Program

The North African Regional Program has received special attention since 1981 when a food legume scientist was placed in the region. This was done because of the need for decentralization of crop improvement efforts to meet the specific adaptation requirements of this region. Also, the national programs needed stronger technical support for expanding their own research which had received little attention in the past. Up to the middle of 1986 the ICARDA Legume scientist was located in Tunisia and since then he has been operating from Morocco. His major function has been to strengthen crop improv ent research efforts at national and regional levels, encourage networking, upgrade the capacity in the national programs for research through training and participation in various professional activities, and assist the base program by coordinating regional efforts and providing necessary feed back. Detailed reports of the research work done during 1989/90 will be presented in the individual country reports. Only major highlights are reported here.

8.2.1. Provision of Trials and Nurseries to the National Programs in North Africa

Relevant germplasm of faba bean, chickpea, lentil and pea was provided to the national programs in the form of international trials and nurseries, details of which are summarised in Table 8.2.1. These trials complemented the national and regional trials that were developed in collaboration with the national programs.

8.2.2. Achievements in Algeria

Cooperative research on food legumes in Algeria covered faba bean, chickpea, lentil, and pea, and was conducted at several stations of ITGC with major coordination efforts at Sidi Bel Abbes.

Table 8.2.1. Number of yield trials, screening nurseries, segregating population nurseries and agronomic trials provided to the national programs in North Africa, F= faba bean, C= chickpea, and L= lentil.

Country	Number of trials/nurseries											
	Yield trials			Nurseries			Segregating populations			Agronomy		
	F	C	L	F	C	L	F	C	L	F	C	L
Algeria	2	19	17	2	5	11	2	13	8	1	6	3
Libya	-	3	3	-	3	1	2	2	-	1	5	-
Morocco	2	6	4	2	4	2	9	11	2	-	1	4
Tunisia	2	14	7	2	12	14	9	9	3	-	-	-
Total	6	42	31	6	24	28	22	35	13	2	12	7

8.2.2.1. Faba bean

Work on faba bean was mainly done at Tessala. In the faba bean preliminary screening nursery - determinate (FBPSN-Det-1990) a total of 111 accessions were evaluated and from these 13 were selected. Several of these accessions gave 2-3 times as much yield as the standard checks Aquadulce, New Mammoth and Quarantine. The selections that particularly performed well were D82243-39-2, D85172-23-1-2, D85025-13-1-1. There was a severe epiphytotic of rust in this nursery and these selections showed excellent resistance.

In the preliminary screening nurseries for chocolate spot and Ascochyta blight large number of lines gave significantly better performance than the standard checks. Selection nos. S84155.18.1.1.1. and S84176.91.2.1.1. in FBPSN-AB and selection nos. S84085.12.2.2.1. and S84122.4.1.1.1. in FBPSN-BOT gave almost 2 times as much yield as the standard checks. A total of 13 and 17 lines were selected from each of these nurseries, respectively.

In the preliminary yield trial FLIP-82-28FB, ILB 1812 and FLIP 82-30FB were promising. In the North African Regional Yield Trial-Large Seed (FBNAEYT-L) FLIP 86-35FB, FLIP 84-128 FB and FLIP-87-137 FB showed very good performance. In the North African Regional Yield Trial-Small Seed (FBNAEYT-S) FLIP-86-86 FB, FLIP-83-106 FB and 76TA 56267 showed excellent performance.

8.2.2.2. Dry Pea

In the Pea Adaptation Trial (PIAT-1990) conducted at Tasella, Ballet, P.S. 210713, and S.V. 51741 were significantly better yielding than the local check SBA 184.

8.2.2.3. Chickpea

Work on chickpea was carried out at Tessala (Zone 1), Station (Zone2) and Zidene (Zone 3) with the long term rainfall average of 450, 395, and 390 mm, respectively. The rainfall during 1989/90 was 282.2, 326.9 and 277 mm respectively.

In the evaluation of 43 germplasm lines from north Africa at Station, 14 lines were selected based on disease reaction and yield, in which ILC 482 was the highest yielder.

In the CIABN consisting of 40 entries, 9 lines had a disease reaction rating of 4 (on 1-9 scale), whereas the susceptible check had a score of 9. In the national program nursery on Ascochyta blight 7 lines were identified to have a rating of 4. These selections will be tested further in the laboratory. In the F_3-nursery of Ascochyta blight resistant crosses, 14 selections were made to produce F_4 generation.

In the CIYT-W-MR at Tessala several lines yielded significantly higher than ILC 3279 (2.99 t/ha) which served as the best check. These included FLIP 84-15C, FLIP 86-2C, ILC 482, FLIP 86-42C and FLIP 85-5C. In the CIYT-SP at the same station the mean seed yield was 486 kg/ha only and ILC 482 with yield of 830 kg/ha was the best yielder. In other trials FLIP 84-72C, 84-8C and 84-181C proved superior in winter. FLIP 84-72C showed resistance to Ascochyta blight. In the multilocation test for the 1st year FLIP 84-60C proved promising. FLIP 83-98C was resistant to Ascochyta blight and showed good performance in the multi-location testing for the second year.

In the national yield trial for winter at Tessala, ILC 482 was highest yielder followed by line from cross FLIP 84-158C x 81TH 484/ILC 2959 both of which yielded more than 4t/ha as against 3.6t/ha given by ILC 3279 (best check).

In the North African Winter Chickpea Yield Trial at Tessala FLIP 83-71C was best (3.3 t/ha seed yield) and significantly better than improved check ILC 3279 (seed yield 2.49 t/ha).

Seed of FLIP 81-57W and FLIP 81-293 C were multiplied for release in Western Algeria.

Collaboration was initiated among ITGC, INA and ICARDA to develop chickpea disease work on Ascochyta blight and Fusarium wilt. Screening facilities were developed at Sidi-Bel-Abbes for Ascochyta blight in the field and laboratory facilities were developed at Guelma for wilt screening.

Demonstration of winter sowing of chickpea continued and seed of ILC 3279 have been multiplied on more than 300 ha to satisfy the seed demand of farmers.

8.?.2.4. Lentil

In the evaluation of North African Germplasm L.V. 153A and L.V. 151 proved superior entries; both originated from Morocco. 78S26002 also gave high yield. Of 45 accessions tested in this nursery 14 selections were made for further evaluation.

In the LIYT-E at Station, FLIP 87-75L, FLIP 88-39L and line 162 and Fam 370 proved superior, and had same maturity as Syrie 229 (best local check). In the LIYT-L which was conducted at Tessala, Station and Zidene locations, FLIP 88-11L and 81 S382326 were significantly superior to improved checks (ILL 4400 and Syrie 229) across the locations. FLIP 88-8L, FLIP 85-35L, FLIP 87-16L and Idleb 1 did well at Tessala.

In the preliminary yield trials A & B at Zidene and Tessala respectively, 40 entries were tested, of which 20 were high yielding and 12 yielded significantly higher than the best check. These included: FLIP-84-144L, 87-49L, 89-1L, 84-51L and 85-33L besides ILL 4400 in 'A' trial. These will go for multi-location testing in the 1990/91 season.

In the multilocation yield trial for 2nd year, Balkan 755, Nel 468 and L56 were higher yielding besides ILL 5582 and ILL 5700. These will be promoted for verification trial.

In the verification trial conducted at Tessala Station and Zidene, line 310C X Eston SBA 1 consistently yielded highest and will be used for pre-release multiplication and demonstration in 1990/91.

In the North Africa Elite Yield trial (LNAEYT), in which 13 entries contributed by the North African national programs were evaluated, Ouslatia, ILL 4606, FLIP 84-103L entered by Tunisia and FLIP 87-192L, FLIP 86-162L, NYLON, and FLIP 87-22L entered by Morocco were significantly better than the Algerian entries. The responsibility of coordinating this trial was with Algerian national program.

Seeds of FLIP 86-20L were multiplied for release in Eastern Algeria.

8.2.3. Achievements in Libya

Food legume program in Libya is comparatively new and, therefore, small. During this season, which received suboptimal rainfall, trials were conducted at four locations, Tajura, and Zahra (western region), Misurata (central region), and El-Safsaf (eastern region) stations. The dry season encouraged root-rot/wilt diseases in chickpea and a high prevalence of virus diseases (bean yellow mosaic and bean leaf roll) in faba bean in western part and Ascochyta blight in chickpea in eastern part. Rust on faba bean and powdery mildew on pea was common. Nodulation of the crop as generally poor.

8.2.3.1. Faba bean

Five trials were conducted. In the FBICSN-90 17 entries were tested at Tajura under natural chocolate spot infestation and ILB 3026 and Rebaya 40 were selected for further evaluation. The disease infestation was not very high. In the FBISN-DT-90 36 determinate faba bean lines were evaluated at Tajura and Zabra. Bean yellow mosaic and rust were present at Tajura where FLIP 86-119FB performed best, yielding 2.6 t/ha. Bean yellow mosaic, chocolate spot and alternaria leaf spot were wide spread in Zahra reducing the yield. One of the two check lines (ILB 1814) yielded highest (1.8 t/ha). In the FBAYT-90 at El-Safsaf ILB 1814,-7954, FLIP 82-54, Gemini, Reina Blanca and Turkish local performed well.

Weeds are a serious problem in faba bean in Libya. Therefore FBWCT-90 was conducted at Zahra and Misurata. Pre-emergence application of cyanazine (Fortrol) + pronamide (Kerb) @0.5 kg a.i./ha or post-emergence application of dinoseb acetate + fluazifob butyl (Fusilade) @1.0 and 0.5 kg a.i./ha, gave excellent weed control and were at par with weed-free check. Cyanazine + pronamide combination also proved its efficiency at Musurata.

Study on sowing dates (15 Oct, 1 Nov, 15 Nov and 1 Dec) and row spacing to vary plant population (30, 60 and 90 cm) at Zahra showed that 15 Oct and 1 Nov were the best dates and a plant population of 22.2 plants/m^2 (30 cm row spacing) was optimum.

8.2.3.2. Chickpea

Seven trials were conducted. In the CIABN-A-90 at Tajura, no Ascochyta blight developed, but root-rot and wilt, stunt virus and root lesion nematode (Pratylenchus spp.) were observed. Nodulation was poor.

Chickpea international screening nursery (CISN-W-90) was grown at Zahra having 30 entries. FLIP 88-26C and FLIP 88-11C, which yielded 1.2 and 0.91 t/ha against 0.68 t/ha yield of local check were selected. In the chickpea international yield trial for southernly latitudes (CIYT-SL-90) grown at El-Safsaf, Ascochyta blight developed, and six entries with a disease rating of 5 or less on 1-9 scale were selected. These included ILC 482-147, FLIP 87-43C, FLIP 87-45C, FLIP 87-48C, FLIP 87-55C, FLIP 87-89C. In an advanced yield trial of entries from North

Africa grown at El-Safsaf all showed high susceptibility to Ascochyta blight.

In the CWCT-90 conducted at El-Safsaf, Igran as a pre-emergence herbicide proved effective. It, however, could not control Galium sp. effectively. The trial was damaged by Ascochyta blight.

Experiment at Zahra on need for inoculation revealed that inoculation with an effective strain of Rhizobium was necessary. At Tajura also the same was the case.

8.2.3.3. Lentil

Only two experiments were conducted at El-Safsaf station. In the LIYT-E-90 all the entries were free from any disease and several selections were made. In LAYT-90, comprising lines found promising in North Africa, four entries (78S 260002, FLIP 84-76L, FLIP 84-81L and FLIP 84-148L) were found promising.

8.2.3.4. Dry Pea

Twenty-four entries were evaluated in the PIAT-90 at Tajura. The experiment was damaged because of birds and powdery mildew and therefore no yields were obtained.

8.2.4. Achievements in Morocco

8.2.4.1. Faba bean

Some of the results have already been presented in the faba bean section (Section 4) earlier. Fifty faba bean advanced lines were identified as Orobanche resistant and higher yielding as compared to the best local check Aquadulce. The yield of some of these lines ranged from 2.8-5.0 t/ha compared to only 0.9-1.1 t/ha for Aquadulce. The results of testing three of these lines at Douyet and two farmers' fields demonstrated that the use of genetic resistance to control Orobanche could at least triple faba bean yield as compared to the yield of local land races. Seeds of these lines is being multiplied in insect-proof cages to run more extensive on-farm trials in the coming season.

More than 1000 single plant selections were made in faba bean segregating progenies under artificially induced epiphytotics in Meknes, for resistance to chocolate spot, Ascochyta blight and rust.

A total of 200 bulks for yield testing and about 1000 single plant selections were made at Douyet in faba bean segregating populations previously selected for disease resistance. Selections were made for yield and seed size combined with closed flower, determinate and IVS characters.

Moroccan national program coordinated the Regional North African Elite Yield Trial on faba bean. Screening for resistance to stem nematodes in collaboration with Univ. Hassan II resulted in identification of promising lines.

Disease survey of faba bean revealed that chocolate spot, Orobanche, stem nematode and BLR virus were the most important yield constraints in that order.

Studies on Sitona control in faba bean confirmed that seed treatment of faba bean with Promet @25 ml/kg seed was very effective in controlling the nodule damage.

8.2.4.2. Chickpea

There was a severe epiphytotic of Ascochyta blight in major chickpea growing areas in Morocco in 1988/89 and ILC 482 was severely damaged because of this epiphytotic. ILC 195 could, however, withstand the disease better. These two cultivars were released for winter sowing in the central-southern dry areas in 1987. Hence new genotypes were introduced in the catalogue trials and they included FLIP 83-47C, 83-48C and 84-92C because of high and broad-based resistance to Ascochyta blight. Line FLIP 83-47C had very high resistance to Ascochyta blight in 1989/90 at 5 different locations including the Merchouch site which had the most virulent isolate of the pathogen.

New recommendations for catalogue trials based on disease reaction in 1989/90 season include FLIP 84-79C and FLIP 84-93C. Seed multiplication of these lines has been started. The first cycle started in the summer season at Annaceur.

Disease survey revealed that Ascochyta blight, root-rot and wilt, and root-lesion nematodes are the most important pathogens, in that order. Work on pathogenic variability in Ascochyta blight in collaboration with INRA, ENA, Meknes and Faculty of Science of Marrakech was strengthened and results confirmed that Merchouch isolate was most virulent.

In screening chickpea germplasm for tolerance to leaf miner, lines ILC 5594, 5600, 5655 and 5901 and FLIP 84-92C proved their resistance/tolerance, with the last two lines having high level of resistance.

Studies on need for inoculation revealed that inoculation with effective strains of Rhizobium was necessary in the non-traditional production areas. Soil core studies have been started to map the presence of effective Rhizobium strains for non-traditional areas. Studies on symbiotic nitrogen fixation using 15N technique to quantify the effect of season of sowing and inoculation and the residual effect of these treatments on the nitrogen nutrition of subsequent wheat crop were started.

On-farm demonstration of winter chickpea was continued with DVP/DVRA on 50 farms using ILC 195. Winter sowing was impressive again giving yields of up to 3.5 t/ha.

The winter chickpea adoption study in Morocco, initiated in 1988/89 season with DPV, INRA and ICARDA (FLIP & FRMP), was continued during the 1989/90 season. The feed-back obtained in 1988/89 helped in planning the research strategy for the 1989/90 season. Thus the lines of chickpea included in the catalogue trial had better seed size than ILC 195 and ILC 482 and had better Ascochyta blight resistance as desired by the farmers. Seed multiplication was strengthened to remove the bottleneck of seed shortage. Work on weed management was increased. A training course was organised for the extension workers with DVP to make them better familiar with the winter sowing technology.

8.2.4.3. Lentil

Because of its resistance to rust, ILL 4605 was released in Morocco in 1989. It had high yield, early maturity and good seed size and cooking quality. Also two Moroccan lines, L24 and L56 were released because of good seed quality and specific adaptation to the lentil growing areas in Morocco. Three lines, ILL 6002, 6209 and 6212, which were in pre-release catalogue trial, were found to maintain their rust resistance for the third consecutive year of rust epidemic. Their yield ranged from 2.5 to 3.0 t/ha as compared to a yield of 0.3 t/ha for the best local entry Nylon under the rust epidemic of 1989/90. A new rust resistant line ILL 6001 is being recommended for the catalogue trial in 1990/91. Line 78S 26002 is being considered for release because of its good general performance and canopy architecture.

Weed control studies have shown that Tribunil @2 kg a.i./ha with Kerb @0.5 kg a.i./ha as pre-emergence application is an effective herbicide treatment of weeds in lentil. Cyanazin @0.5 kg a.i./ha as a pre-emergence application is also effective.

Disease survey confirmed that wilt and rust were the two most important diseases, with rust being particularly more important in the last 3 seasons.

Verification trials were started this year on lentil with 5 promising lines. Mechanization of sowing and harvesting was demonstration to the farmers. It is proposed to start a socioeconomic study in collaboration with DVP to monitor adoption of new cultivars and production technology and to get the feed-back from farmers on the problems that they are facing.

8.2.5. Achievements in Tunisia

The development of research on food legumes in Tunisia is exemplary. INRAT has taken lead in establishing a multi-disciplinary, multi-institutional network of legume scientists at the national level. It has also contributed substantially to the North African Regional Program on food legumes and taken up regional leadership in the Ascochyta blight and root-rot/wilt deceases of chickpea. During 1989/90, research was carried out at Beja, Oued Meliz and Le Kef. The season was exceptionally dry and only 60% of the long term average rainfall was received. This adversely affected the yields of all the food legumes. Wilt was observed as a major problem in chickpea at several areas and rust infestation was severe in faba bean and lentil.

Also downy mildew was recorded at Beja and a new type of _Orobanche_ with red flowers was observed at research station and farmers' fields in Beja and Bou Salem. Stem nematode in faba bean and root-lesion nematode in chickpea were observed. In Beja and Cap Bon areas faba bean was affected by stem-borer (_Lixus algirus_).

8.2.5.1. Faba bean

Results over last six years confirmed the superiority of Reina Blanca (ILB 1270) over the local check, with an average yield advantage of 9%. In the last three dry seasons, three large seeded selections S 82113-8, S 82033-3, and 80S 80028 gave a 18-20% yield increase over checks. Amongst the small seeded entries, FLIP 83-106B was superior to check by a margin of 8% over last three years.

Fifty single plant selections were made for agronomic traits from F_5 and F_6 segregating populations for further evaluation in the 1990/91 season. For chocolate spot resistance, lines B8811, B8822 and B88140 from FBIACSN-90 and M82009-36-1, M82009-36-3, M82009-37 and S83075-7 from F_5 and F_6 segregating populations were identified. For Ascochyta blight resistance lines A8817, A88304, A8835 from FBIABN-90 and M82009-46, S38108-28, S86107 and S86111 from F_5 and F_6 segregating populations were identified. Entries in FBICSN-90 and FBIABN-90 were tested both in field as well as in laboratory (detached leaf technique).

8.2.5.2. Chickpea

A number of chickpea lines out yielded the local check at the three locations - Beja, Oued Meliz and Le Kef. In general, the newly released varieties performed well. However, Chetoui (ILC 3279) suffered from drought. Two chickpea lines FLIP 84-92C and FLIP 84-79C continued to perform better than the checks.

Materials with large seed, good resistance to Ascochyta blight, better yield and tall stature suitable for mechanical harvest have been identified. Also a number of progenies (F_6/F_7) have been selected for dual resistance to wilt and Ascochyta blight, better yield and erect growth habit. However, their seed size and earliness need to be improved.

A new rating scale for Ascochyta blight using linear infection index proved more appropriate than 1-9 scale for genetic studies on Ascochyta blight. Work was initiated to explore the possibility of using the pathogen toxins for screening chickpea for wilt disease. Results on sowing date and chickpea genotypes with different wilt reactions showed that good resistance to wilt late in the season was necessary to get full advantage of early sowing.

Four tons of seed of Amdoun-1 chickpea were produced for farmers who continue to grow chickpea in the wilt-infested fields. Lines FLIP 83-47C and FLIP 84-92C were in pre-release multiplication as dual season (winter and spring) cultivars.

8.2.5.3. Lentil

Lentil showed its adaptation to droughty condition by showing good performance in this dry season at Le Kef with yield level of 2.45 t/ha with FLIP 88-51L. Results of 1989/90 confirmed those of previous years' that lentil should be popularized in the drier areas of the northern part of the country. Lentil line 78S 26002 confirmed its superiority across locations and is being considered for release to farmers.

Results of limited surveys indicated that seed size was not a major factor in consumer preference. Small seeded lentils were consumed in the central and southern parts of the country.

8.2.5.4. Agronomy and on-farm trials

Weeds in all the food legumes caused considerable seed yield losses (upto 90%). Two hand weedings provided good weed control. Results of on-farm trials showed the superiority of this treatment over the farmer's practice of using an animal drawn cultivator.

Early sowing of chickpea, faba bean and lentil combined with higher plant density and weed control almost doubled the seed yield of these crops over the farmer's practice in the on-farm trials, Among the new lentil varieties, ILL 4606 performed best providing 30% yield advantage over the farmer's check variety. In chickpea, Kessab (FLIP 83-46C) and FLIP 84-92C performed exceptionally well in both winter and spring sowing in the on-farm trials.

9. TRAINING AND NETWORKING

The purpose of training is to develop or enhance the technical capabilities of NARS scientists and their support staff. It also aims at strengthening networking and to assist in transfer of technologies. Table 1 summarizes the activities undertaken by FLIP during 1990 to meet the above objectives. This was done in some cases in collaboration with NARSs and other ICARDA programs. A total of 242 participants received training in the improvement of lentil, kabuli chickpea and faba bean (Table 9.1.1).

9.1. Group Training at ICARDA

Details of group training are summarized in Table 9.1.2.

9.1.1. Food Legume Residential Course

The annual long term residential course, 1 March-30 June, 1990, was attended by 15 participants from 12 countries. The course covered general aspects of improvement of food legumes with emphasis on developing practical skills. Instruction in the field, laboratory or plastic house was given by a multidisciplinary team of legume scientists. The trainees were also exposed to systems approaches in crop improvement research. Individualized attention was given to cover complementary topics such as planning of experiments, computerized and manual analysis of data, data interpretation, and report writing.

Table 9.1.1. Summary of training activities in 1990.

Type of Training	Participants	Represented countries
I. Training at Aleppo		
1. Group Courses		
1.1. Residential	15	12
1.2. Insect Control	12	10
1.3. Biology & Control of *Orobanche*	10	7
1.4. Breeding Methodologies	14	12
1.5. Virology	9	8
1.6. Biotechnology	11	9
2. Individual Non-Degree	27	9
3. Graduate Research	16	7
II. In-country Training Course		
1. Faba Bean Improvement, Morocco	14	7
2. Field Inspection of Diseases in Seed Multiplication, Algeria	15	5
3. Lentil Harvest Mechanization, Jordan	16	7
4. Agronomy of winter chickpea, Morocco	35	5
5. Breeding Methodology, Turkey	14	1
6. Food Legume Improvement, Iran	34	1

Table 9.1.2. Participation in group training.

Type of training	Countries	Participants
Residential		
Food Legume Improvement	Algeria, Bangladesh, China Ecuador, Ethiopia, Lebanon, Libya, Morocco, Oman Pakistan, Sudan, Syria, Turkey	15
Short Courses at Aleppo		
Insect Control	Egypt, Ethiopia, Libya, Morocco Sudan, Syria, Tunisia, Turkey, U.A.E., Yemen	12
Biology & Control of Orobanche	Algeria, Egypt, Ethiopia, Morocco Spain, Syria, Tunisia, Turkey	10
Breeding Methodologies of Food & Feed Legumes	Algeria, Bangladesh, Egypt, Ethiopia, Jordan, Libya, Mexico, Morocco, Pakistan, Sudan, Syria, Yemen.	14
Virus Diseases of Food Legumes	Algeria, Ecuador, Ethiopia Lebanon, Morocco, Sudan, Syria, Tunisia	9
Application of Biotech-nology in Food Legumes	China, Egypt, Jordan, Kuwait, Lebanon, Syria, Tunisia, Turkey, Yemen	11
Short Courses-In-country		
Faba Bean Improvement, Morocco	Algeria, Colombia, Egypt, Libya, Morocco, Peru, Tunisia	14
Field Inspection of Food Legume Diseases in Seed Multiplication, Algeria	Algeria, Libya, Morocco Tunisia	15
Lentil Harvest Mechanization, Jordan	Iraq, Jordan, Lebanon, Morocco Syria, Tunisia, Turkey	16
Agronomy of Winter Chickpea, Morocco	Algeria, France, Morocco, Tunisia	34
Breeding Methodologies of Food Legumes, Turkey	Turkey	14
Food Legume Improvement, Iran	Iran	34

9.1.2. Insect Control Course

Food legume crops are attacked by many insect pests which result in sizable yield reduction and post harvest losses. The same applies for cereal crops as well. Realising the need of NARSs for strengthening the research skills in this field, the Cereals and Food Legume Improvement Programs conducted a joint training course on "Insect Control in Food Legumes and Cereals", 19-8 April, 1990 at Aleppo. The course covered topics such as sampling and identification of insects and monitoring of insect populations, collection of insects, screening for host plant resistance, use of pesticides, and application of biological control. The course will continue to be offered in the future with increased time allocated for practical skills such as planning of experiments.

9.1.3. Biology and Control of Orobanche

The parasitic weed Orobanche represents a major constraint to the production of faba bean, lentil, chickpea, peas and forage legumes in the Mediterranean region with yield losses ranging from 5 and 100%. The difficulty to control this pest is related to the biology of the parasite. To strengthen the research skills of NARSs in this field the course on "Biology and Control of Orobanche" was conducted 10-19 April 1990, at Aleppo. The course was attended by 10 participants from 7 countries and covered general and specific biology of parasitic weeds, crop damage and economic importance, control measures (cultural, chemical, biological and physical), assessment of control effects in various crops, application of herbicides, germinability and viability tests on Orobanche seeds.

9.1.4. Breeding Methodologies of Food and Feed Legumes

To promote sound strategies and strengthen the network of collaborators in the improvement of legume germplasm, a training course on "Breeding Methodologies of Food and Feed Legumes" was conducted 6-17 May, 1990 at Aleppo jointly with PFLP. The course was attended by 14 participants from 12 countries and covered topics such as quantitative genetics as applied to plant breeding, plant genetic resources, breeding methods, mutation breeding, cytogenetic methods, breeding for resistance to environmental stresses, diseases and insects, variety maintenance and experimental design.

9.1.5. Virus Diseases of Food and Forage Legume

To provide an understanding of the effect of virus diseases on food and forage legumes and methods to minimize yield losses induced by them, a training course on "Virus Diseases of Food and Forage Legumes" was conducted, 13-27 May, 1990 at Aleppo. The course included virus identification, means of spread, purification and serology, seed transmission and detection of seed-borne infections, ecology, evaluation of yield loss and screening for resistance. Practical aspects covered included host range studies, symptomatology, preparing and preserving virus cultures, virus purification, antiserum production, serological techniques including enzyme-linked immunosorbent assay and molecular hybridization, and screening for virus disease resistance.

The level of the nine participants from eight countries was high enough to permit treatment of advanced technology in dealing with virus diseases.

9.1.6. Application of Biotechnology in Food Legume Improvement

Plant biotechnology tools offer innovative approaches in plant improvement research. To increase the awareness of the food legume scientists about the potential of biotechnological tools in facilitating the crop improvement research, ICARDA for the first time conducted a training workshop on "Application of Biotechnology in Food Legumes", 22 July - 2 August, 1990 at Aleppo. The course was attended by 11 participants from 8 countries. The workshop introduced participants to theoretical and practical aspects of DNA work and covered current and future uses of DNA technology in plant breeding. Two lecture series included gene structure, regulation and transfer, gene identification and marking, genome mapping, application of genetic engineering as well as the use of wide crossing and somaclonal variation. During the practical sessions, each participant successfully extracted DNA from chickpea and its wild relatives, purified it, digested it by a restriction endonuclease Taq I, electrophoresed the fragments and probed them with a non-radioactive probe.

9.2. In-country Courses

9.2.1. Lentil Harvest Mechanization

The fifth "Lentil Harvest Mechanization Course" was held 12-21 May, 1990, in Amman, Jordan. Sixteen trainees from seven countries participated. The syllabus covered both the theory and practice of lentil harvest mechanization. This was done in an integrated approach to cover breeding, agronomy, economics and farm machinery. Discussion focussed on guiding the trainees to tackle lentil harvest mechanization problems in an integrated manner and on ways to transfer the available technologies to farmers.

9.2.2. Faba Bean Improvement

The course was held 9-20 April, 1990 at the facilities of ENA-Meknes in Morocco. There were 14 trainees from 7 countries. The course presented faba bean breeding and pathology in an integrated manner, and aimed at providing an introduction to faba bean improvement with an emphasis on selection for disease resistance. The course brought together breeders and pathologists working on faba bean and provided them opportunity to learn more on creation of variability, selection techniques, and seed production of the released cultivars.

9.2.3. Field Inspection of Food Legume Diseases in Seed Multiplication

Over the past years several cultivars of faba bean, chickpea and lentil have been released in many countries of the region. Since the impact of these improved cultivars on the national production will depend on the seed availability to farmers, efficient seed production programs need to be developed. Responding to the need expressed by national programs in the last coordination meeting in the countries of North Africa, the Food Legume Improvement Program in corporation with the Seed Production Unit of ICARDA conducted a training course on "Field Inspection of Food Legume Diseases in Seed Multiplication", 30 April - 3 May, 1990 in Algeria. Fifteen trainees from five countries participated in this course, which covered the symptomology of fungal, virus and nematode diseases; field infestation limits of diseases tolerance; methodology of field inspection of food legume diseases; seed health testing; and control methods.

9.2.4. Agronomy of Winter Chickpea

The winter chickpea adoption study done last season indicated that lack of information on the winter-sown chickpea was one of the constraints limiting expansion of that technology in Morocco. A course was therefore organized in Morocco at the National Agricultural School (ENA), Meknes, 21-24 May 1990, in collaboration with INRA, DPV and ENA - Meknes to provide extension agents with better understanding of the winter chickpea technology.

A total of 35 trainees participated in the course:

Morocco : 17 extension agents from DPV
8 Researchers/Technicians from INRA
3 graduate students from ENA

Algeria : 2 Researchers from ITGC

Tunisia : 2 Researchers from INRAT
1 from office des cereals

France : 1 graduate student from ENSA/Monpleier

Belgium : 1 graduate student

The course covered all aspects of importance in the production of a successful winter chickpea crop and discussed the potential advantages and possible disadvantages of this technology.

9.2.5. Breeding Methodologies

As per the agreed work plan for ICARDA/Turkey collaboration, the Food Legume Improvement Program conducted an in-country training course on "Breeding Methodologies of Food Legumes", at Diyarbakir, Turkey, 28 May -1 June, 1990. Fourteen trainees from Eskisehir, Izmir, Samsun, Diyarbakir, Erzurum, Adana and Antalya participated in this course. Topics covered included: mutation as a tool in plant breeding; breeding for disease resistance; breeding of self-pollinated crops; applications of statistics in plant breeding; and non-convential breeding.

9.2.6. Food Legume Improvement

An in-country training on food legume improvement was jointly organized by the Agricultural and Natural Resource Research Organization (ANRRO) of Iran and ICARDA at Karadj, Iran, 18-24 June 1990. Thirty-four participants, including 9 women, from the Soil and Water Institute, Plant Protection Institute, and Seed and Plant Improvement Institute, attended the course. The course covered both theoretical and practical aspects of breeding, agronomy, physiology, plant protection, mechanization, genetic resources and experimental design. The practicals included crossing techniques, identification of insect pests, data recording and management, and visits to various laboratories.

9.3. Individual Non-degree Training

As per the request of NARSs, training on individual basis was offered for 27 participants from nine countries. Skills covered and countries represented are given in Table 9.1.3. The syllabi were tailored to meet the specific needs of NARSs and the academic background and performance objectives of the participants.

Table 9.1.3. Participation in the individual non-degree training, 1990.

Topic	No. of participants	Countries
1. Agronomy & crop physiology	6	Syria, Turkey, Sudan,
2. Trial Management	1	Tunisia
3. Breeding	3	Turkey, Pakistan, Syria
4. Pathology	5	Algeria, Ethiopia, Morocco
5. Virology	3	Sudan, Ethiopia, Tunisia
6. Entomology	2	Ethiopia, Sudan
7. Biological Nitrogen Fixation	5	Bulgaria, Syria, Turkey
8. Quality	2	Syria, Tunisia

9.4. Graduate Research Training

As part of the degree oriented training two M.Sc. and Ph.D. students joined the program during 1990. The total number of graduate students during 1990 was sixteen (Table 9.1.4). Two students received their M.Sc., one Ph.D. degree and some were writing their thesis at their universities.

Table 9 1.4. Participation in Graduate research training in 1990.

Name	Degree	University	Country
Registered in 1990			
1. Aziza Dibo Ajouri	Ph.D.	Aleppo	Syria
2. Heicho Schnell	Ph.D.	Hohenheim	FR Germany
3. Markus Knapp	M.Sc.	Hohenheim	FR Germany
4. Jehad Zaki Abd Al-Raheem Yasin	M.Sc.	Jordan	Jordan
5. Hossam El Din M. El-Sayed Ibrahim	Ph.D.	Alexandria	Egypt
6. Christiane Weigner	Ph.D.	Tübingen	W. Germany
Registration continuing from previous years			
1. Ghada Hinti	M.Sc.	Aleppo	Syria
2. Fatima Ahmed Mustafa	M.Sc.	Gezira	Sudan
3. Christiane Schieble	M.Sc.	Hohenheim	Germany
4. Ahmed Saoud	Ph.D.	Damascus	Syria
5. Andreas Gross	Ph.D.	Hohenheim	FR Germany
6. Marja van Hezewijk	Ph.D.	Amsterdam	The Netherland
7. Bashir Ahmed Malik	Ph.D.	Quaid Azam	Pakistan
8. Ahsanul Haq	Ph.D.	Punjab	Pakistan
9. Edwin Weber	Ph.D.	Hohenheim	FR Germany
10. Stefan Schlingloff	Ph.D.	Giessen	FR Germany

9.5. Networks

The Program has assisted in development of research networks at various levels to encourage research on food legumes. They are summarized below:

9.5.1. Inernational

9.5.1.1. International Nurseries and Trials Network: Some 52 countries participate in this.

9.5.2. Regional

9.5.2.1. North African Regional Network: It involves participation of Algeria, Libya, Morocco and Tunisia. Linkages of this network with the programs in southern Europe and CIHEAM have been developed.

9.5.2.2. Nile Valley Regional Network: It involves the participation of Egypt, Ethiopia and Sudan. Linkages with NAR networks have been developed.

9.5.2.3. West Asian Regional Network: It involves the participation of Turkey, Syria, Jordan, Iraq and Cyprus. Major activity in this has been the joint travelling workshops.

9.5.3. National

FLIP has encouraged development of research networks on food legumes in several countries to ensure coordination and complementarity of efforts of the national programs. The national research networks are in place in the following countries.

- 9.5.3.1. Algeria
- 9.5.3.2. Libya
- 9.5.3.3. Morocco
- 9.5.3.4. Tunisia

9.5.3.5. Egypt

9.5.3.6. Ethiopia

9.5.3.7. Jordan

9.5.3.8. Pakistan

9.5.3.9. Sudan

9.5.3.10. Syria

9.5.3.11. Turkey

In all these countries except Pakistan, regular coordination meetings are held in which FLIP representatives also participate. Research and training activities are reviewed and plans developed. In 1989/90 season, FLIP participated in all these coordination meetings and assisted these networks in meeting their objectives.

9.5.4. Disciplinary Networks

During 1989/90 season the foll-wing two disciplinary networks operated:

9.5.4.1. Research network on aphid control: This included the three Nile Valley countries and was coordinated by ICARDA.

9.5.4.2. Biological nitrogen fixation network: This includes several countries in WANA and is coordinated by ICARDA.

9.6. Conference

An International Conference on Breeding Cool Season Food Legumes for Stress Resistance was organized in Ravello, Italy, 10-12 Sept. 1990. Seventy six participants from 14 countries attended the conference. The proceedings of the conference are being printed.

10. PUBLICATIONS

10.1. Conference Papers

Bouznad, Z., Solh, M.B. and Tabab, R. 1990. Causes of wilt and root-rot of chickpea in Algeria. Proceedings of the International Conference of Plant Protection, December 1990, Agadir, Morocco.

Cleyet-Marel, J.C., di Bonito, R. and Beck, D.P. 1990. Chickpea and its root-nodule bacteria: Implications of their relationships for legume inoculation and biological nitrogen fixation. Pages 101-106. In Proceedings of the Zaragoza/Spain Seminar, 11-13 July 1988: Present status and future prospects of chickpea crop production and improvement in the Mediterranean countries. M.C. Saxena, J.I. Cubero, and J. Wery (eds.). Options Mediterraneennes-Serie Seminaires-No. 9 CIHEAM, Zaragoza, Spain.

Diekmann, J., Tarsha, A.F. and Singh, K.B. 1990. Mist system for plant disease nursery. Paper presented in the American Society of Agronomy 82nd Annual Meetings, San Antonio, USA, 21-26 October 1990.

Erskine, W., Nordblom, T.L., Cocks, P.S., Pala, M. and Thomson, E.F. 1990. The use of on-farm research as a method of extending legume production in Mediterranean farming systems. Page 273-282. In The role of legumes in the farming systems of the Mediterranean areas. Osman, A.E. et al. (eds.), Kluwer Academic Publishers, Dordrecht.

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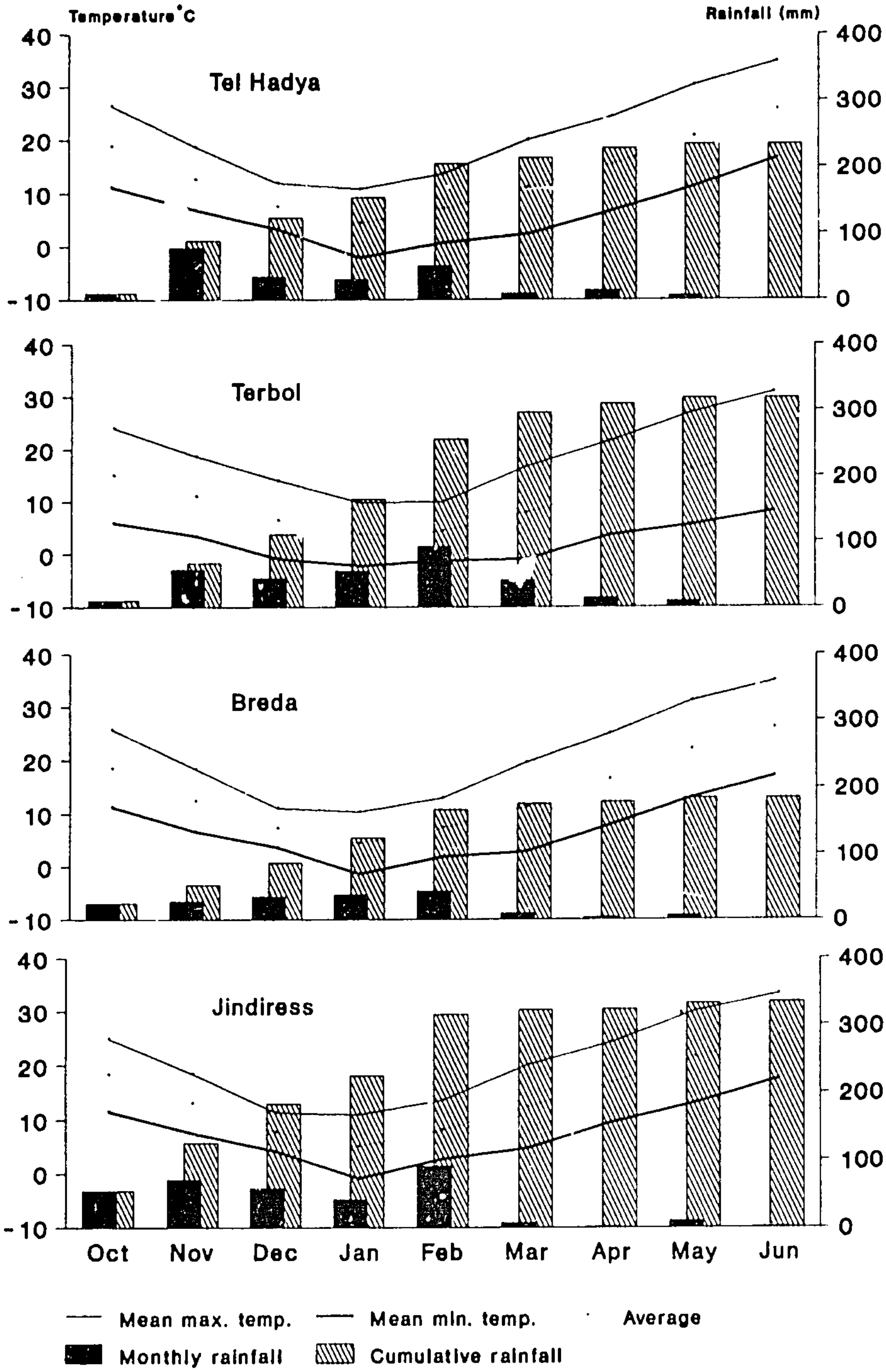
11. WEATHER DATA 1989/90



12. STAFF LIST

M.C. Saxena	Program Leader
D. Beck	Microbiologist
S.P.S. Beniwal	Legume Scientist (Ethiopia)*/(Morocco)
W. Erskine	Lentil Breeder
S.B. Hanounik	Faba Bean Pathologist (Morocco)
M. Habib Ibrahim	Senior Training Scientist
L.D. Robertson	Faba Bean Breeder (Morocco)
K.B. Singh	Chickpea Breeder (ICRISAT)
M. Solh**	Legume Scientist (Morocco)*
S. Weigand	Entomologist
R.S. Malhotra	International Trial Scientist
F. Weigand	Consultant Molecular Biologist
Geletu Bejiga**	Post. Doc. Fellow Chickpea Breeding
K.-H. Linke	Post. Doc. Fellow Orobanche (GTZ)
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M.A. Haq**	Assistant Training Scientist
Bruno Ocampo	Research Associate
Stefan Schlingloff**	Research Associate
Edwin Weber**	Research Associate
Andreas Gross**	Visiting Research Associate
Hassan Mashlab	Research Associate
Fadel Afandi	Research Associate
N. Nabil Ansari	Training Assistant
M.Y.N. Agha	Research Assistant
Ibrahim Ammouri	Research Assistant
Suhaila Arslan	Research Assistant
Bashar Baker	Research Assistant
Talal Fadel**	Research Assistant
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Mahmoud Hamzeh**	Research Assistant
Hasan Al Hasan	Research Assistant
Abdullah Joubi	Research Assistant
Munzer Kabakebji	Research Assistant
Siham Kabbabe	Research Assistant
Gaby Khalaf	Research Assistant
Hasan Masri	Research Assistant
Hani Nakkoul	Research Assistant
Nabil Tarabulsi	Research Assistant
Riad Ammaneh	Senior Research Technician
Amir Farra	Senior Research Technician
Fadwa Khanji	Senior Research Technician
Murhaf Kharboutly	Senior Research Technician
Pierre Kiwan	Senior Research Technician (Terbol)
Moaiad Lababidi	Senior Research Technician
Raafat Azzo	Research Technician
Aida Djanji	Research Technician
Abdel K. Bunian	Research Technician

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Mariette Franjieh**	Research Technician
Mohamed Issa	Research Technician
Bernadette Jallouf**	Research Technician
M.I. El-Jassem	Research Technician
Siham Kabalan	Research Technician
Nidal Kadah	Research Technician
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Omar Labban	Research Technician
Mohamed I. Maarawi	Research Technician
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A. Rahim Osman	Research Technician
Diab Ali Raya	Research Technician
George Rizk**	Research Technician (Terbol)
Ahmed Samara**	Research Technician (Terbol)
Ziad Sayadi	Research Technician
Rania Barrimo**	Senior Secretary
Hasna Boustani	Secretary
Mary Bogharian	Secretary
Nuha Sadek	Secretary
Naaman Ajanji	Driver
Ibrahim Mustafa**	Driver
Asaad Omar Al Darwish	Fieldman
Hussein El-Humeidi	Fieldman
Ahmed Halabi**	Fieldman
Abdullah El Khaled	Store Attendant

* Till July 1990.
** Left during the year