FOOD LEGUME IMPROVEMENT PROGRAM

Annual Report for 1989

ICARDA

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International Center for Agricultural Research in the Dry Areas

ICARDA

Box 5466, Aleppo, Syria

FLIP Annual Report

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1. INTRODUCTION

1.1. GENERAL

The Food Legume Improvement Program (FLIP) continued its efforts during 1989 on the improvement of kabuli chickpea, lentil and faba bean within the framework of the Medium-term Plan of the Center. Crop improvement research, training and information dissemination activities were undertaken with a view to enhance the capability of the national programs in the West Asia and North Africa (WANA) region and to encourage and assist them in their efforts to improve the productivity and yield stability of the cool season food legumes and in the transfer of technology to their farmers. In line with the increasing thrust at the Center in the Medium-term Plan on improving productivity of the farming systems in relatively drier areas, efforts on improvement of kabuli chickpea and lentil were increased with a corresponding reduction in the efforts on faba bean, which is usually grown under more assured moisture supply conditions. Research on adaptation of dry peas to the dry rainfed farming systems of WANA was continued, under a restricted core grant from the BMZ, Federal Republic of Germany.

As in the past, multidisciplinary teams of researchers from FLIP and other research programs at ICARDA worked on specific research projects in each of the crops with full involvement of the scientists from the national programs wherever possible. Kabuli chickpea improvement work was carried out jointly with the International Crops Research Institute for Semi-Arid Tropics (ICRISAT). In pursuance of the policy of decentralization of breeding efforts, activities continued to expand in the North African Regional Project and the FLIP scientist located at Morocco worked closely with the national programs in Algeria, Libya, Morocco and Tunisia and coordinated activities of the regional network. Networking of research efforts on all the three cool season food legumes in the Nile Valley of Egypt and Sudan and the highlands of Ethiopia received boost with the start of the Nile Valley Regional Program (NVRP) as the IFAD/Italian Government supported Nile Valley Project on faba bean terminated. FLIP worked very closely with the national programs in Iraq, Jordan, Pakistan, Syria and Turkey in developing strong local crop improvement efforts and ensuring complementarity. Linkages with legume researchers in China and the USSR were expanded.

Collaboration with several institutions in the industrialised countries of Europe and North America continued for basic research to improve the efficiency of our crop improvement efforts and develop better understanding of the mechanisms of host-plant resistance to various biotic and abiotic stresses. Application of biotechnology in crop improvement was one of the important activities in this collaboration.

The principal research station of ICARDA at Tel Hadya as well as the subsites in northern Syria (Breda, Jindiress, and Lattakia) and the Bekka valley of Lebanon (Terbol) were used for the major crop improvement research work. The weather conditions prevailing at each of these sites is depicted in the Figures in Section 11. In general, the season was drier than the long-term average at all test sites affecting crop growth and yield adversely. However, it did provide a good opportunity for the evaluation of the breeding material of lentil and kabuli chickpea for drought tolerance. Research sites of different national programs were also used for strategic joint research on the development of breeding material with specific resistance to some biotic stresses. For the advancement of breeding material by an additional generation during summer, the high elevation research site of the Jordan Ministry of Agriculture in Shawback (for lentil and faba bean) and the Terbol research station (for kabuli-chickpea) were used.

1.2. ACHIEVEMENTS

A summary of the major achievements of the program in research, training and networking activities during the 1988/89 season is given below:

1.2.1. Kabuli Chickpea

Program continued to place emphasis on both winter- and spring-sown chickpeas. The importance of winter sowing became particularly evident in this relatively drier season when spring-sown chickpea failed to give any seed yield in several areas. The area under winter sowing is increasing throughout WANA. Winter sowing of new breeding lines at three locations (Tel Hadya, Jindiress and Terbol) over six years (1983/84 to 1988/89) gave a yield increase of 62% (625 kg seed/ha) over the spring-sown crop. Adoption and impact studies on winter sowing have shown interesting results in Syria and Morocco.

The national programs continued to make good use of the genetically enhanced material supplied by ICARDA. Six cultivars, namely TS 1009 and TS 1502 in France, Janta 2 in Lebanon, ILC 237 in Omman, and Elmo and Elvar in Portugal, were released as cultivars. With these, the total number of releases reached 27 in 13 countries including Algeria, Cyprus, France, Italy, Lebanon, Morocco, Omman, Portugal, Spain, Sudan, Syria, Tunisia, and Turkey. In addition, scientists in 12 countries have selected 42 entries for pre-release multiplication and/or on-farm testing. We furnished 15,595 entries to NARSs in 42 countries for use in their breeding programs.

Screening for biotic and abiotic stresses was given high priority. Resistant sources have been identified for two diseases (Ascochyta blight and Fusarium wilt), two insect-pests (leafminer and seed beetle), cyst nematode and cold either in cultivated species or in the wild _Cicer_ spp. or both. Efforts are underway to transfer genes for resistance from wild to cultivated species using conventional interspecific hybridization and also embryo rescue technique. A major achievement in interspecific hybridization was the production of F_2 seeds from crosses _C. arietinum_ X _C. echinospermum_ and _C. reticulatum_ X _C. echinospermum_ for the first time, providing the opportunity of transferring genes from _C. echinospermum_ to the cultivated species.

The low rainfall that characterized the 1988/89 season provided an excellent opportunity to select drought-resistant lines. From the drought-tolerance project on chickpea initiated four years ago, the early maturing selections made performed well this year. There is a gradual shift toward earliness in the material being generated. For example, only 10% of the lines were found to be early and productive in the international trials, which included entries developed four years ago. In contrast, in the preliminary trials, which included entries developed last year, nearly 50% proved early and gave reasonable yield this year. A line-source sprinkler system proved very effective in the study of the response of diverse genotypes to varied moisture supply and to identify true response to drought. Multi-location testing of several early maturing lines in the southernly latitudes showed good adaptation in areas where in the past ICARDA enhanced germplasm showed poor adaptation.

Studies on breeding methods included: investigation of the associations of various characters with seed and total biological yield on 6170 accessions of kabuli chickpea; analysis of stability of different characters across environments; inheritance of cold tolerance; genetics of resistance to Ascochyta blight; and development of modified bulk-pedigree method for breeding cold and Ascochyta blight resistant chickpeas.

Studies on the pathogenic variability in _Ascochyta_ _rabiei_ were continued using single-spored isolates on the currently available host differential set of 9 genotypes under controlled environmental conditions. The six isolates differed in aggressiveness with isolate 3 being the weakest and isolate 6 most aggressive. Using these 9 genotypes and 6 isolates almost all levels of disease severity were recorded. Present study indicated that there was no reversal of ranking in the genotypes with different strains and therefore screening of breeding material against most aggressive isolate 6 should be sufficient to identify resistant genotypes.

Work on the application of restriction fragment length polymorphism (RFLP) to identify economically important genes in chickpea genotypes and the isolates of Ascochyta rabiei has been started in cooperation with the University of Frankfurt, FRG. The analysis of 15 chickpea genotypes performed to date revealed that chickpea has a high degree of polymorphism making it specifically suitable for RFLP analysis.

One spray of Endosulfan reduced the percent mining of leaves by leafminer and increased seed yield of spring chickpea in the studies carried out at 3 locations in farmers' fields in northern Syria. Studies at Tel Hadya showed that neem seed extract might be an effective alternative to conventional insecticides for the control of leaf miner. Studies on the integrated control of pod borer were continued at Izraa Research Station, as a part of a graduate student thesis, in collaboration with the University of Damascus. Variations on the susceptibility of chickpea genotypes to aphid infestation appeared to be related to the pH of leaf washings - higher pH indicated higher susceptibility.

Studies on dinitrogen fixation in chickpea involved investigations on identification of an alternate inoculant carrier to peat and the chickpea host plant genotype and Rhizobium strain interactions. A soil containing >10% organic matter from the Ghab valley of Syria, when amended with charcoal, proved equally effective to peat in maintaining high (>10^9 g^{-1}) populations of rhizobia nodulating chickpea over periods of 126 days, indicating the suitability of this material as an inoculant carrier. Studies on inoculation of a range of chickpea cultivars with different strains of Rhizobium showed significant interactions for seed and nitrogen yield responses as well as for the fraction of total nitrogen derived from fixation, suggesting that through appropriate combinations biological nitrogen fixation could be considerably improved.

1.2.2. Lentil

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 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 biologicaly-fixed nitrogen in the wheat-based cropping system is the aim of the activities in Rhizobium research and Sitona weevil control.

During 1989 the National Programs of Australia, Canada, Chile and

Morocco released lentil cultivars received through the Food Legume International Testing Network, bringing the total to eleven of such countries. 'Centinela' (Chile) and 'ILL 4605' (Morocco) were both released on the basis of their resistance to lentil rust, reflecting an increased emphasis within lentil improvement given to breeding for resistance to key diseases. Screening for resistance to Fusarium wilt is now undertaken at Tel Hadya in cooperation with the University of Aleppo. Screening for resistance to Ascochyta blight is done at Tel Hadya and by the joint breeding program in Pakistan. Rust screening is conducted in cooperation with the Moroccan program. As a result, sources of resistance to these diseases are now available and being shared with national programs through the International Testing Network.

The breeding program, divided into three streams directed towards the three agroecological zones (low-med. elevation Mediterranean region, lower latitudes and high elevation), continued making nearly 300 crosses to develop segregating populations targeted for different regions with emphasis placed on relevant constraints, providing breeding material for national programs for selection and cultivar development in situ. In support of these activities the program developed four new nurseries this year. The subnormal rainfall at Breda and Tel Hadya locations this year facilitated selection of breeding lines for drought tolerance and, in addition, the use of line-source sprinkler system proved very effective for this purpose. Special traits associated with better crop performance under drought were identified.

To support the genetic improvement work, studies were carried out on variability in lentil growth habit, genotype x environment interaction for the potential feeding value of lentil straw, methods of plant selection, and heterosis. The program also developed a uniform system for the description of the developmental stages of lentil, adoption of which will help communication amongst the lentil scientists.

The genetic improvement in lentil in future might require transfer of alien genes to the cultigen. Studies showed that <u>Agrobacterium tumefaciens</u> can be used as a gene vector for application of genetic engineering in lentil.

Nearly 0.6 million MT of red cotyledon lentil is consumed annually in the world after post-harvest processing into split dehulled seed. The process involves cleaning of seed, brief immersion of seed in water, spin-drying, standing to temper, separation into seed size fractions, dehulling/splitting, and final separation. The effects of seed size fraction, immersion times, temperature and duration of air-drying, and standing time on the efficiency of dehulling/splitting lentil were examined. High dehulling yield resulted from the small seed fraction (4mm), an immersion time of one minute, no air-drying, and a standing time of 24 hours. A genotype x environment interaction study revealed that it would be feasible to consider selecting genotypes for improved dehulling properties, but at present we will monitor the quality traits and maintain them at a comparable level to the local cultivar while focusing on improving the yield of seed and straw and other agronomic characters.

Studies on biology and control of Sitona crinitus, being a major insect pest of lentil in the region, were continued. Nodule damage from the larvae of this insect could be controlled effectively by application of Carbofuran. Seed dressing with Promet also proved very promising and this may serve as a safer and cheaper method of control than the use of Carbofuran. Effect of nodule damage control on the biological nitrogen fixation is being investigated.

The ICARDA lentil growing region includes a wide diversity of soils, climates, crop management and history of lentil production. Indigenous populations of Rhizobium leguminosarum should, therefore, be very diverse. Hence, sampling of this population from nodules of lentils growing in seven countries from ICARDA region was done. Symbiotic effectiveness studies under aseptic hydroponic culture showed that 50% of total isolates (mostly from Turkey and Jordan) were highly effective whereas the rest (mostly coming from Syria, Egypt and north west Africa) were moderate to low in symbiotic efficiency. Isolates that could tolerance high temperature (>40^{o}c) and high salinity levels (0.5% NaCl) were also identified. Efficient strains are being further studied for their performance under field conditions. Studies on host plant genotype and rhizobial strain combinations in the field showed significant interactions for yield response thereby indicating the possibility of improving biological nitrogen fixation in lentil by selecting appropriate combinations of the symbionts.

Lentil harvest is the major production problem in the Mediterranean region because of the high cost of hand harvest. Systems of mechanization developed earlier were tested again in 1988/89 but because of cold and dry winter, the crop growth was restricted which precluded machine harvest and demonstrated the ecological limits of lentil harvest mechanization.

1.2.3. Faba bean

In accordance with the decision of the Consultative Group on International Agricultural Research (CGIAR) to phase-out crop improvement research at ICARDA by transferring it to the national programs, the ICARDA faba bean breeder and pathologist moved to Douyet Research Station (near Fes in Morocco) as of 1 September 1989, with simultaneous reduction in the research work at Tel Hadya and Lattakia and increase at various research stations in Morocco. Also, work in other north African countries and in the Nile Valley of Egypt and Sudan and the high-lands of Ethiopia was expanded.

The national programs continued to use ICARDA enhanced germplasm. The line 80S 43977 has been released as 'Favel' in Portugal. In Ethiopia 27 lines are in advanced national multi-location trials and 532 lines are in preliminary screening nurseries. One determinate line (FLIP 84-146 FB) is in on-farm trials in southern China for relay cropping with cotton. In Syria, determinate line 80S 44027 is in the second year of on-farm testing. In Algeria 14 lines were included in multilocation testing and some of the large seeded selections (Seville Giant, New Mammoth) are candidates for release.

The work at Lattakia had led to identification of a large number of lines with resistance to one or more of the common faba bean diseases (chocolate spot, Ascochyta blight, rust, stem nematode) in the past. One hundred and thirty six disease-resistant sources were evaluated for IBPGR/ICARDA faba bean descriptors. Publication of this data in catalog form will increase the use of this material by the national breeding programs for disease resistance.

Work on common viruses showed that two pure lines (BPL 756 and 758) were resistant to BLRV and tolerant to BYMV. Four BPL's had high level of resistance to BYMV. Results of a preliminary study suggested that Phomopsis spp. could be a potential biological control agent against Orobanche crenata in faba bean.

As a part of the Nile Valley Regional Program a total of 1100 faba bean lines from Egypt, Sudan, Ethiopia and ICARDA were screened for resistance to Aphis craccivora in the Giza laboratory, of which 40 lines showed some degree of resistance. The field screening of a total of 344 lines revealed 36 lines with resistance. In two field experiments with 15 previously selected genotypes each, 5 to 6 genotypes with low aphid infestation and yield reduction were identified. Of the most promising lines identified to date a "Regional Aphid Screening Nursery" will be established and tested in the three countries. In the screening of 114 BPLs at Tel Hadya in the plastichouse for resistance to Aphis fabae, five BPLs were found to be resistant, of which one was also resistant and two tolerant against A. crassivora.

Field experiments on response of some promising and diverse faba bean genotypes to different strains of Rhizobium again showed significant interactions for seed and nitrogen yield highlighting the potential for exploiting cultivar-strain interactions for improved biological nitrogen fixation even in an area where the naturalized population of Rhizobium is adequate.

1.2.3. Dry Peas

Work continued on the evaluation of dry pea cultivars developed elsewhere for their adaptation to the farming systems of WANA and providing the adapted materials to the NARSs in the region. Of the 308 lines evaluated during the season, 14 were selected because of their superior performance, for multilocation testing at ICARDA. From the preliminary yield trials at Tel Hadya and Terbol, 23 accessions were selected for the Pea Adaptation Trial in WANA for the 1989/90 season. National programs have found the material supplied useful. Sudanese program released "Karima-1" as a cultivar for the Northern Province of Sudan.

1.2.4. Orobanche Control

This research, conducted jointly with the University of Hohenheim, FRG, emphasised development of integrated control of the parasite in the cool season food and forage legumes. The most promising combinations of control measures were: slightly delayed sowing (than the date optimum for non-infested crop) + glyphosate herbicide for faba bean; delayed sowing of the adapted cultivar (ILL 8) + imazaquine herbicide in lentil; less infested genotype + hand pulling in Chickpea; less infested genotype + imazaquine herbicide in field pea.

1.2.5. International Testing Program

This program is a vehicle for dissemination of genetic materials and improved production practices in the form of international nurseries and trials, to national program scientists in and outside WANA region. A total of 1022 sets of nurseries and trials (447 sets for 19 types for chickpea, 410 sets of 17 types for lentil, 127 sets of 8 types for faba bean and 38 sets of one type for dry pea) were distributed for the 1989/90 season to 105 cooperators in 47 different countries.

1.2.6. Nile Valley Regional Program

The Nile Valley Project (NVP) on faba bean which was successfully operated in Egypt and Sudan from 1977 to 1988, and in Ethiopia from 1985 to 1988, was raised to a regional program in 1989. The research, training and development activities were expanded to include chickpea and lentil in addition to faba bean. On-farm trials with improved production practices gave economic increases in yield in all three crops. Back-up research helped in developing breeding material with improved resistance to diseases and insect pests and in developing economic and more efficient production techniques for evaluation in the on-farm trials. Adoption studies on the improved production techniques have been initiated in the program.

1.2.7. North African Regional Program

Cooperation with the national programs in Algeria, Morocco, Tunisia and Libya expanded during 1988/89. Several selections of ICARDA advanced 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 released or recommended for pre-release multiplication. For chickpea, FLIP 83-47C and 84-92C will be released to farmers in Tunisia as dual season (winter and spring-sown) cultivars. In Algeria, FLIP 81-57W and FLIP 81-293C and in Morocco FLIP 83-47C, FLIP 83-48C, and FLIP 84-92C were recommended for pre-release multiplication because of wide adaptation and resistance to Ascochyta blight. For lentil, Precoz (ILL 4605), L24 and L56 were released and ILL 6002, ILL 6209 and ILL 6212 were recommended for pre-release multiplication in Morocco. Precoz particularly with stood well the epidemic of rust in Morocco this season. In Tunisia, FLIP 84-103L, and 78S 26002 and in Algeria FLIP 86-20L are in pre-release multiplication. For faba bean, Aquadulce and New Mammoth in Algeria and FLIP 83-106 FB and two selections from local populations in Tunisia are candidates for release.

Disease surveys in the three countries provided a good assessment of the disease situation. Based on field and laboratory screening six chickpea lines showed broad-based resistance to Ascochyta blight across Algeria, Morocco and Tunisia: FLIP 82-150C, 83-47C, 83-48C, 84-92C, 84-93C and 84-182C. In Tunisia, 183 accessions of chickpea were confirmed as having resistance to Fusarium wilt after two cycles of screening. In Morocco, nearly 100% control of nodule damage by Sitona larvae was obtained with Promet seed treatment in faba bean.

Agronomic studies were conducted on all the three food legumes and on-farm evaluation was carried out. Demonstrations of winter-sowing of chickpea were increased and socio-economic appraisal of the technology was started in Morocco.

1.2.8. Training and networking

In order to strengthen the research skills in the national programs, group-training and individual non-degree as well as degree training programs were continued. A total of 154 participants used these training opportunities. Group training included 'Residential Training Course' as well as specialised short courses on 'Insect Control', 'Disease Methodologies', 'Lentil Harvest Mechanization' and 'Legume Inoculant Production'. We also conducted 'in-country' courses on 'Breeding Methodologies and Hybridization Techniques' in Pakistan, 'Hybridization Techniques' in Morocco and Egypt and 'Seed Technology' in Morocco.

To enhance the interaction between the food legume scientists within and outside WANA we organized or co-sponsored a series of workshops and meetings. These included: 1.'International Workshop on Present Status and Future Prospects of Faba Bean Crop Improvement in the Mediterranean Countries', Zaragossa, Spain; 2. 'International Symposium in China', Hangzhou, Zhiejiang Province, PRC; 3. 'Consultancy Meeting on Breeding for Disease Resistance in Kabuli Chickpea', Aleppo; 4. 'Chickpeas in the Nineties', ICRISAT, India. Also a 'West Asian Seminar on Food Legumes' was held in Turkey and a 'Meeting for North African Regional Program on Food Legumes' was held in Morocco. In addition, several travelling workshops were organized in the region to expand information exchange on research methods and evaluation procedures.

2. KABULI CHICKPEA IMPROVEMENT

The kabuli chickpea improvement is a joint project with ICRISAT Center, India. The aim of the project 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 area under chickpea in other two main regions (Indian subcontinent and East Africa) is also devoted to kabuli type. Kabuli chickpea is also grown in high elevation areas (>1000 m above sea level) in West Asia, especially Turkey, Iraq, Iran, and Afghanistan. Ascochyta blight and Fusarium wilt are two major diseases of chickpea. Leaf miner in the Mediterranean region and pod porer 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 more than 350 mm 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. Winter sowing allows chickpea crop to be harvested by machine. Major efforts are underway to stabilize chickpea productivity by breeding cultivars resistance to various stresses, such as diseases (blight and wilt), insect-pests (leaf miner and pod borer), cold, and cyst nematode. Efforts are underway to collect basic information for generating input responsive cultivars, especially those which respond to application of phosphate and water. Research input on drought tolerance has also been increased as the spring sown crop is often exposed to drought stress.

During 1989, 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 and ICARDA collaborated. The screening on 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 Sasketchwan, Canada is collaborating with ICARDA in the study of land races of the kabuli type of chickpea. Studies on mechanism of drought and cold resistance and some aspects of biological nitrogen fixation are being studied in collaboration with INRA, Montpellier, France. Studies on leaf miner resistance and application of restriction fragment length polymorphism (RFLP) in characterizing chickpea genotypes are carried out in collaboration with the Max Planck Inst., FRG.

2.1. Chickpea Breeding

The main objective of the breeding project is to produce cultivars and genetic stocks with high and stable yield. 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: resistance to Ascochyta blight and Fusarium wilt, tolerance of drought and heat, early maturity, medium to large seed size (30% of resources);
2. Indian subcontinent and East Africa: Resistance to Ascochyta blight and/or Fusarium wilt, heat tolerance, early maturity, small to medium seed size, responsive to supplemental irrigation (15% of resources);
3. Latin America: Resistance to Fusarium wilt, large seed size (5% of resources); and
4. High elevation areas: Spring sowing, cold tolerance at seedling stage and heat tolerance at maturity, resistance to Ascochyta blight, early maturity, and medium seed size (10% of resources).

2.1.1. Use of improved germplasm by national programs

2.1.1.1. International nurseries and trials

During 1989, more than 15000 breeding lines were furnished to 42 countries (Table 2.1.1.). Sixty-five percent of the material was provided to NARSs in the WANA region, 7% to other developing countries and remaining 28% to developed countries. Fifty-two percent material

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

Country	Trials and nurseries		Breeding lines	Total entries
	No. of sets of trials/nurseries	No. of entries		
Algeria	41	1268	13	1281
Argentina	2	46		46
Bangladesh	2	58		58
Bulgaria	2	122		122
Canada	-	-	703	703
Chile	-	-	200	200
Costa Rica	1	23	4	27
Cyprus	3	113		113
Egypt	5	125	24	149
Ethiopia	9	235		235
Federal Republic of Germany	-	-	116	116
France	11	493		493
Greece	2	84		84
India	6	288		288
Iran	10	400		400
Iraq	3	119	3	122
Italy	19	825	419	1244
Jordan	12	435		435
Kuwait	-	-	4	4
Lebanon	7	302		302
Libya	8	308		308
Morocco	21	715		715
Mexico	11	277	59	336
Nepal	1	29		29
New Zealand	-	-	40	40
Oman	2	46		46
Pakistan	24	1204	14	1218
Portugal	9	307		307
Qatar	1	29		29
Saudi Arabia	7	283		283
Spain	25	763	28	791
Sri Lanka	5	119		119
Sudan	2	52		52
Swaziland	2	52		52
Syria	56	1581		1581
The Netherlands	-	-	8	8
Tunisia	35	1168		1168
Turkey	44	1653	7	1660
U.K.	-	-	9	9
U.S.A.	5	133	70	203
U.S.S.R.	5	167		167
Yemen P.D.R.	2	52		52
Total	400	13874	1721	15595

furnished to developed countries was for the joint research projects with ICARDA. These countries were Canada, Federal Republic of Germany, Italy, The Netherlands, and U.S.S.R. NARSs are making good use of the material furnished to them.

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

2.1.1.2. On-farm trials

During 1988/89, five newly bred lines, namely FLIP 83-47C, FLIP 83-48C, FLIP 83-71C, FLIP 83-98C, and FLIP 84-15C, were evaluated against the two standard checks, Ghab 1 and Ghab 2, at 16 locations in collaboration with the Directorate of Scientific Agric. Research, Syria. Four trials failed due to extremely low rainfall, below 200 mm. Two lines, FLIP 84-15C and FLIP 83-47C yielding 1456 kg and 1459 kg ha^{-1}, were marginally superior to the best check Ghab 1 (1422 kg ha^{-1}). But the 100-seed weight of FLIP 84-15C is 45 g against 28 g of Ghab 1 and FLIP 83-47C has higher level of resistance to Ascochyta blight and cold than Ghab 1. In view of the poor performance of Ghab 2, it was decided to drop it from the future tests as a check.

The program has been involved in the on-farm trial activities with many NARSs in West Asia and North Africa through the supply of seed of the entries and advice to conduct trials.

NARS scientists and Dr. K.B. Singh.

2.1.1.3. Pre-release multiplication of cultivars by national programs

Forty-two lines have been identified from the international nurseries by scientists in 12 countries for pre-release multiplication and/or on-farm testing (Table 2.1.2). These lines meet the requirements of the national programs for seed size, plant height and days to maturity. Further, all new genotypes are tolerant to cold and Ascochyta blight.

Table 2.1.2. Chickpea cultivars identified for pre-release multiplication and on-farm testing.

Country	Cultivar
Afghanistan	FLIP 84-145C, FLIP 81-293C, FLIP 81-57W
Algeria	FLIP 81-293C, FLIP 81-57W, ILC 190
Cyprus	FLIP 85-10C.
Egypt	ILC 2022, FLIP 80-36C.
Jordan	ILC 482, ILC 3279.
Iraq	FLIP 81-269C, FLIP 82-142C, FLIP 82-169C, ILC 482, ILC 3279.
Lebanon	FLIP 85-5, FLIP 84-15C.
Libya	ILC 484, FLIP 84-92C.
Morocco	FLIP 82-150C, FLIP 83-47C, FLIP 84-92C, FLIP 84-144C.
Syria	FLIP 82-150C, FLIP 83-47C, FLIP 83-48C, FLIP 83-71C, FLIP 83-98C, FLIP 84-15C
Tunisia	FLIP 84-92C, FLIP 83-47C.
Turkey	FLIP 85-13C, FLIP 85-14C, FLIP 85-15C, FLIP 85-60C, FLIP 83-31C, FLIP 83-77C. 87AK 71112, 87 AK 71113, 87 AK 71114, 87 AK 71115.

2.1.1.4. Release of cultivars by national programs

Researchers in 13 countries have selected 27 lines and have released them as cultivars (Table 2.1.3): 23 for winter sowing in the Mediterranean region, and 2 for winter sowing in more southernly latitudes. Two varieties were released for spring sowing. There is a need to generate more early maturing lines for spring sowing in the Mediterranean region and for winter sowing in the southernly latitudes. NARS scientists and Dr. K.B. Singh.

Table 2.1.3. Chickpea cultivars released by different national programs.

Country	Cultivar 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, high yield
	Kyrenia (ILC 464)	1987	Large seed
France	TS1009 (ILC 492)	1988	Released by TOP SEMENCE
	TS1502 (FLIP-81-293C)	1988	Released by TOP SEMENCE
Italy	Califfo (ILC 72)	1987	Tall, high yield
	Sultano (ILC 3279)	1987	Tall, high yield
Lebanon	Janta 2 (ILC 482)	1989	High yielding, wide adapatation
Morocco	ILC 195	1987	Tall, high yield
	ILC 482	1987	High yield, wide adaptation
Oman	ILC 237	1988	High yield, irrigation responsive
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 (NEC 2491/ILC 1335)	1987	High yield, irrigation responsive
Syria	Ghab 1 (ILC 482)	1986	High yield, wide adapatation
	Ghab 2 (ILC 3279)	1986	Tall, cold-tolerant
Tunisia	Chetoui (ILC 3279)	1986	Tall, high yield
	Kassab (FLIP 83-46C)	1986	Large seed, high yield
	Amdoun 1 (Be-Sel-81-48)	1986	Large seed, Fusarium wilt resistant
Turkey	ILC 195	1986	Tall, cold tolerant
	Guney sarisi 482 (ILC 482)	1986	High yield, wide adapatation

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

2.1.2. Screening for multiple stresses

2.1.2.1. Cultivated species

Screening of germplasm lines was initiated in 1978 for Ascochyta blight (Ascochyta rabiei), in 1979 for cold, in 1981 for leaf miner (Liriomyza cicerina), in 1982 for seed beetle (Callasobruchus chinesis), in 1986 for cyst nematode (Heterodera ciceri), and in 1987 for Fusarium wilt (Fusarium oxysporum). Lines evaluated between 1978 and 1989 to different stresses have been 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.

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Table 2.1.4. Screening of chickpea germplasm accessions to biotic and abiotic stresses at Tel Hadya between 1978 and 1989.

Scale	Ascochyta blight	Fusarium wilt	Leaf miner	Seed beetle	Cyst nematode	Cold
1	0	5	0	0	0	0
2	0	1	0	0	0	0
3	16	2	0	0	0	15
4	16	9	8	0	0	114
5	1048	17	201	0	0	656
6	345	45	509	164	604	491
7	1814	40	1167	185	808	704
8	1168	380	8	1551	0	1724
9	11284	1143	3585	3253	3856	1811
Total	15691	1642	5478	5153	5268	5515

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

2.1.2.2. Wild species

Evaluation of eight annual wild Cicer species continued for the second year to identify sources of resistance to different stresses. Results of two years evaluation are summarized in Table 2.1.5. Higher susceptibility rating from the two years evaluation has been taken as the actual rating. Sources of resistance were found for all the five stress factors, Ascochyta blight, leaf miner, seed beetle, cyst

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

Scale	Blight		Leaf miner		Seed beetle		Cyst nematode		Cold	
	No.	Species[b]	No.	Species	No.	Species	No.	Species	No.	Species
1	0		0		20	1,3,4,5,7	0		1	1
2	5	5,6	15	2,5,8	12	1,5,6,7	0		20	1
3	63	1,3,5,6	36	1,4,5,6	4	1,7	12	1	24	1,4,5,6
4	2	4,6	25	1,4,5,6,7	3	1,6,7	0		15	4,5,6
5	25	1,4,5,6,7	28	1,5,6,7	2	3,5	11	1,7	8	6
6	14	1,5,6,7	9	6,7	8	1,5,7	0		7	5,6,8
7	12	1,2,4,5,7	6	1,5,7	18	2,4,5,7	5	7,8	11	2,5,6,8
8	2	1,3	0		53	2,5,6,7,8	30	1,5,6,7,8	13	5,6
9	8	5,7,8	2	1	10	5,6,8	79	2,3,4,5,6,7	38	2,3,5
Total	131		121		130		137		137	

(a) Scale: 1 = free; 5 = intermediate; 9 = killed.

(b) Species code: 1 = *C. bijugum*; 2 = *C. chorassnicum*; 3 = *C. cuneatum*;
4 = *C. echinospermum*; 5 = *C. judaicum*; 6 = *C. pinnatifidum*;
7 = *C. reticulatum*; 8 = *C. yamashitae*.

nematode, and cold. Wild species were the only source of resistance so far to seed beetle and cyst nematode and they had higher level of resistance than the cultivated species for Ascochyta blight, leaf miner, and cold. Whereas no source of resistance was found in cultivated species for seed beetle, as many as 20 lines of five different species were free from any beetle attack. These lines should be used (1) to study the mechanism of resistance, (2) to study the food value as compared to cultivated species, and (3) to transfer genes for resistance from the crossable species such as _C. reticulatum_ to cultivated species. The most important species for resistance to different stress factors was _C. bijugum_ while _C. yamashitae_ was least important. There is a need to evaluate the existing collections to other important stresses and to collect additional accessions for evaluation.

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2.1.2.3. Combined resistance to cold and Ascochyta blight

Winter chickpea must possess resistant/tolerance to both cold and Ascochyta blight. Land races found resistant to one were susceptible to the other stress. We, therefore, initiated a germplasm enhancement program for combining higher level of resistance to both cold and Ascochyta blight. Screening is done in the field for cold between October and February and for Ascochyta blight between March and June by inoculating the cold tolerant plants with plant diseased debris backed up by spray of spore suspension.

Out of 8891 F_2 plants, only 1238 plants or 13.9% were tolerant to cold. Whereas, percentage of blight resistant plants was higher (35.9%). Finally, 281 plants were selected as resistant to both stresses.

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2.1.2.4. Identification of lines resistance to multiple races of A. rabiei.

To identify sources of resistance to the six races of Ascochyta rabiei reported from Lebanon and Syria, 1,069 germplasm accessions and breeding lines were screened against the races in the greenhouse at Tel Hadya, Syria during 1985/1986. Preliminary screening of the germplasm was done by inoculating 10-day-old seedlings. Lines with little infection were retested in the seedling and podding stages. Of the total lines, 47, 27, 29, 8, and 13, and 4 were resistant to races 1, 2, 3, 4, 5, and 6, respectively. Although different lines appeared to carry genes for resistance to several races, none was resistant to all. Three lines (ILC-202, ILC-3856, and ILC-5029) were resistant to five races and are being used in breeding programs at ICARDA, ICRISAT, and national programs of North Africa, western Asia, southern and eastern Europe and the Indian subcontinent.

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2.1.2.5. Evaluation of germplasm for tolerance to herbicide

Herbicides are being adopted by many NARSs to control weeds, especially during winter sowing because of better cost-benefit ratio than hand weeding. It was, therefore, decided to develop a screening technique to evaluate breeding lines routinely to enable the program to furnish only herbicide tolerant lines to NARS. A set of 1403 lines were sown on 30 September 1988 in single row plots of 2 m length with 45cm between rows. A check line ILC 533, previously observed as highly susceptible to herbicides, was sown after every 10 test entries. From 1403 lines, more than 500 lines having a range of reactions from free to killed were selected and sown during winter and spring. Accessions were evaluated on a 1-9 scale, where 1 = no damage, 9 = complete kill.

Results of autumn screening showed that 124 lines were free from damage and 246 lines were highly tolerant (Fig. 2.1.1). Whereas all lines including resistant and susceptible were free of any herbicide damage during winter sowing. During spring, out of 124 accessions with rating 1 in autumn, only 23 lines were rated 1 (Fig. 2.1.1). Lines

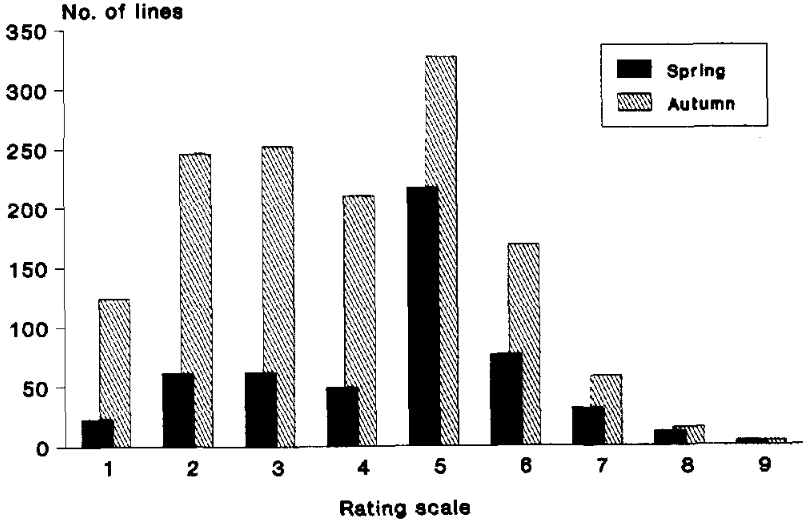

Figure 2.1.1. Frequency distribution of germplasm accessions tested for tolerance to herbicide during autumn and spring, 1988/89.

with rating 9 during autumn rated 9 during spring too. Although these results need confirmation, it is obvious that herbicide application is safe during winter.

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2.1.2.6. Effect of season on expression of iron deficiency chlorosis

A total of 6330 germplasm accessions were grown at Tel Hadya during winter of 1987/88 and were evaluated for iron deficiency chlorosis using a 1-9 scale. Majority of the lines were found resistant to iron deficiency chlorosis, but 18 lines showed susceptibility (8 to 9 ratings). These highly susceptible lines were grown at Tel Hadya during autumn, winter, and spring of 1988/1989 for confirmation of their susceptibility to iron deficiency chlororsis. Results showed that there were significant differences between seasons. Mean ratings of 18 lines were 5.7, 7.0 and 5.1 during autumn, winter and spring sowing, respectively. The symptom of iron deficiency chlorosis was more pronounced in winter than the other two seasons. The highly susceptible lines (ILC 2405, ILC 5725 and ILC 5736) were completely yellow and stunted and failed to produce any seed. These can be used as indicators of iron deficiency and for physiological studies.

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2.1.3. Screening genotypes for response to supplemental irrigation

During 1985/86, 1986/87 and 1987/88, the same set of 50 genotypes and during 1988/89 a new set of 72 genotypes were evaluated for response to supplemental irrigation. The rainfall during 1985/86, 1986/87, 1987/88 and 1988/89 were 316, 358, 504, 496, and 234mm, respectively.

Irrigation was scheduled based on daily water balance computations of rainfall and pan evaporation and validated by soil moisture measurements with the neutron probe. Mean yields of genotypes tested with and without supplemental irrigation are shown in Figure 2.1.2. Supplemental irrigation gave an average of 80% or 1.34 t ha^{-1} more yield than no irrigation. Response to irrigation showed high genetic variability. Some genotypes, such as IL 142, ILC 295, FLIP 82-150C gave highest response and other lines, such as ILC 652, ILC 1099, ILC

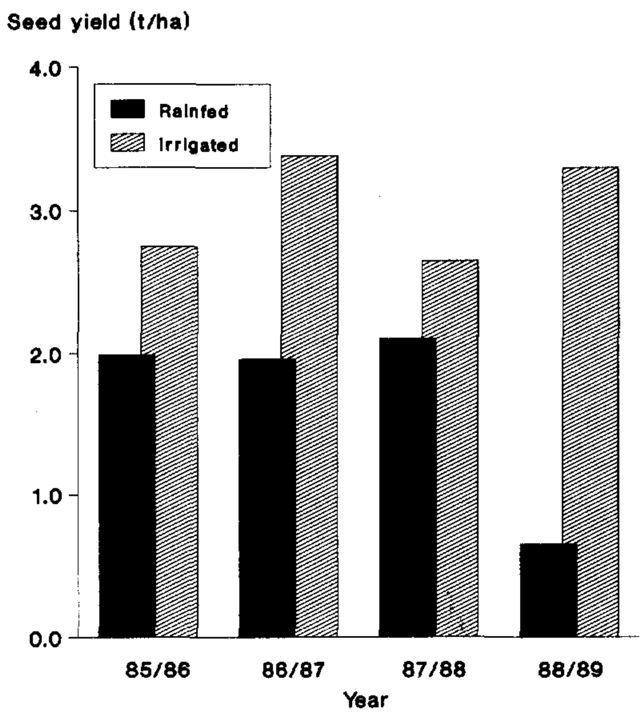

Figure 2.1.2. Mean yield of 50 chickpea genotypes during the first three years and 72 genotypes during the fourth year as affected by supplemental irrigations.

955, responded least. Although total biomass was two times more with supplemental irrigation (SI) over rainfed (R), the harvest index was lower (38%) with SI than with R (46%). Average plant height with SI was higher (58cm) than with R (47cm). But the 100-seed weight was lower with SI (34g) than with R (37g). Full irrigation produced slightly lower yield than the supplemental irrigation suggesting that the presently available cultivars do not respond to full irrigation.
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2.1.4. Development of improved germplasm for wheat-based farming systems.

2.1.4.1. Bulk-pedigree method for breeding cold and Ascochyta blight resistant chickpeas

Bulk-pedigree method for chickpea has been developed and is being practiced at ICARDA for last ten years to breed cold and Ascochyta blight resistance lines. This method makes use of facilities for the off-season advancement at Terbol (980 m elevation). In brief, it is shown in Figure 2.1.3. and described below.

Making cross. Resistant sources to cold and Ascochyta blight identified at ICARDA and confirmed in other countries through international nurseries are used in the crossing program. Each year 200 crosses, including 100 two-way and 100 three-way, are made during the main season at Tel Hadya.

F_1 generation. Each of the 200 crosses are grown flanked by their parents on either side under continuous light in the off-season (late June to early October) at Terbol, Lebanon. This pattern of planting helps in eliminating selfed plants. Continuous light helps in early

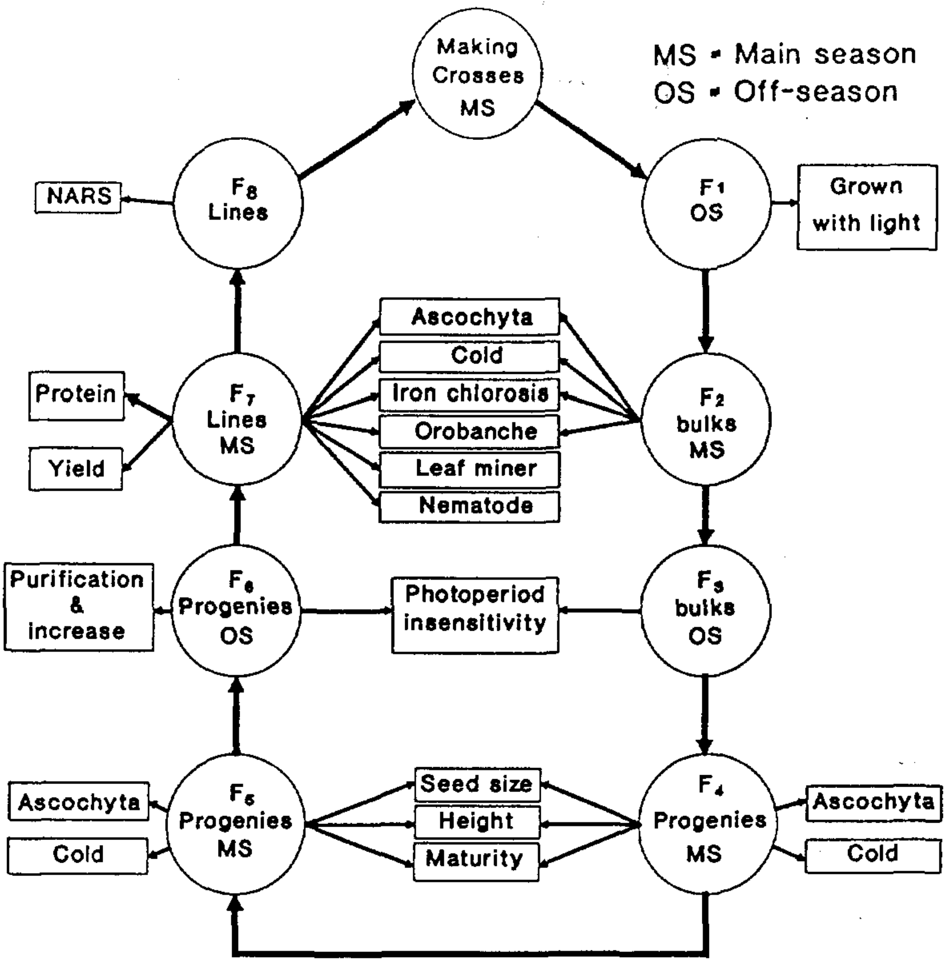

Figure 2.1.3. Bulk-pedigree method of breeding cold and Ascochyta blight resistant chickpeas.

flowering and timely maturity of all crosses. In order to be certain that F_1 plants are crossed, seed from single plants are harvested individually to be sown in plant-row in F_2 generation.

F_2 populations. About 2000 seeds are sown for each cross in early November at Tel Hadya and evaluated for cold between November and February and for Ascochyta blight between March and June. Generally, Tel Hadya experiences 30 to 40 days of freezing temperature with lowest temperature ranging between -6°C and -10°C. Plants that are susceptible to cold are uprooted and only tolerant plants remain in the nursery by the beginning of March. Depending upon the time and duration of cold, the percent of susceptible plants have varied from 0% to 55%. In early March, the nursery is inoculated with Ascochyta blight diseased debris backed up by the spray of spore suspension. Mist irrigation is used to raise the relative humidity to more than 60%. Disease development has generally been good and reaches epidemic form by middle of April. Crop matures by the beginning of June. Resistant plants are selected in each cross and harvested in bulk. In this and subsequent generations, plants showing iron deficiency chlorsis or infestion by Orobanche spp. are discarded.

F_3 generation. Upto two thousand plants from each cross is grown in the off-season at Terbol. The photoperiod sensitive plants do not mature and are thus automatically rejected. From the remaining, single plant selection is practiced for maturity, seed size, and plant height. Seed from selected plants are harvested individually.

F_4 generation. Ten thousand F_4 progenies are grown in a single row of 4 m long with plant spaced 45 cm and 10 cm apart between and within rows, respectively in the cold and Ascochyta bight nursery.

Evaluation for cold tolerance is done between November and February and for Ascochyta blight between March and June. Susceptible progenies are rejected. Three plants are selected from the promising progenies and a total of 5000 plants are harvested individually.

F_5 generation. F_5 progenies are grown in the cold and Ascochyta blight nursery at Tel Hadya. Progenies found susceptible to cold, Ascochyta blight, iron deficiency chlorosis, and Orobanche sp. are discarded, and promising and uniform progenies are bulked. While bulking, consideration is given to bulk progenies with a range of maturity, plant height, and seed size to meet all the needs of the NARSs. Generally, 500 F_5 progenies are bulked and harvested.

F_6 generation. Generally, large populations of 250 seeds per F_6 progenies are sown in a 4 rows x 10m long plot with plants spaced 15 cm and 45 cm within and between rows, respectively. Lines found photoperiod sensitive are discarded. Second, any off-type plants are rogued out and lines are purified. Anywhere between 220 and 264 lines are bulk-harvested.

F_7 generation. Each of these 220 to 264 lines are evaluated for yield at three locations, viz. Tel Hadya and Jindiress in Syria and Terbol in Lebanon during winter and spring. These lines are further evaluated for their reaction to cold, Ascochyta blight, leaf miner and cyst nematode. Lines found susceptible to cold and Ascochyta blight and highly susceptible to leaf miner and cyst nematode are discarded. Each line is also evaluated for protein content and lines with protein content less than the check are discarded. Based on yield, resistance to the biotic and abiotic stresses and protein content, between 100 to 125 lines are selected and furnished to NARSs in the form of Chickpea

International Screening Nurseries (CISN).

NARSs have made effective use of the breeding lines furnished to them. ICARDA further assists NARSs by selecting promising lines from CISNs and providing them in the form of yield trials. Success of the breeding procedure can be judged by releases of a large number of cultivars in several countries in the last six years. Though there is scope to improve this method, the modified bulk pedigree method for breeding cold and Ascochyta blight resistant chickpea has been found satisfactory.

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2.1.4.2. Bulk-pedigree method for development of drought and Ascochyta blight resistant lines

After a number of years of research, a bulk-pedigree method of breeding for drought and Ascochyta blight resistant chickpeas has been developd (Table 2.1.6). In this method effective use of off-season nursery for advancing three generations (F_1, F_4, F_6) and use of greenhouse for growing F_2 generation are made. Thus in four years, drought and Ascochyta blight resistant, high yielding chickpeas are bred and furnished to NARS for evaluation under their conditions.

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2.1.4.3. Strategy for breeding for drought tolerance

Ten trials comprising 24 entries each were grown in two replications at Tel Hadya, Jindiress and Terbol during 1988/89. Tel Hadya was affected by drought (234 mm rainfall) while the remaining two locations had below normal rainfall (350 mm rainfall) but still sufficient to grow a normal chickpea crop. Observations were collected on days to flower,

Table 2.1.6. Generation advance and bulk-pedigree method in drought and Ascochyta blight resistance breeding.

Year	Season	Generation	Breeding operations
1	MSS	F_0	Crosses made
	OS	F_1	Self F_1s to produce F_2 seeds
	GH	F_2	Harvest F_3 seeds in bulk seeds when 2/3 plants have matured.
2	MSW	F_3	Select blight resistant plants and bulk harvest F_4 seeds.
	OS	F_4	Select single early maturity plants and harvest F_5 seeds individually.
3	MSS	F_5	Select plant tolerant to drought with a range of seed size and high yield, bulk promising and uniform lines.
	OS	F_6	Large populations of each bulked lines grown and if lines found uniform and early maturity then harvest seed in bulk.
4	MSS	F_7	Evaluate new lines during spring at multilocations. Grow single row in blight nursery to check reaction of new lines. Choose high yielding, drought tolerant and blight resistant lines and furnish them to national programs for selection under local conditions and possible release as cultivars.

MSS = main season spring; MSW = main season winter, OS = off-season; GH = greenhouse.

plant height, days to maturity, biological and seed yields, and 100-seed weight. Seed yield and biological yield were measured from a plot size of 3.6 m^2. Analysis of variance was performed for each variable separately. Correlation analysis was run to determine the associations between seed yield and other characters. Selection models were set for normal environments (Jindiress, Terbol) and drought environment (Tel

Hadya). The equations set for normal environments were tested for their suitability to predict the top high yielding lines for drought environment, while the one developed for Tel Hadya was used to predict the top high yielding lines for the normal environments.

The results revealed that 100-seed weight, days to flower, plant height and days to maturity had highly significant ($P < 0.1$) associations with seed yield except at Jindiress. The equations for selection index indicated 67% variation in yield to be ascribed by days to flower (earliness), 73% by days to flower and days to maturity, and 75% by days to flower, days to maturity and 100-seed weight at Tel Hadya. However, the variations in yield accounted for by days to flower were 16% and 35% at Jindiress and Terbol, respectively (Table 2.1.7), indicating that some other characters had higher influence on seed yield under normal conditions.

The probability of success of the selection indices from drought environment to normal and vice versa (transferability of models) was measured as proportion of genotypes recovered by transferred model from top 10% based on the given model. It was clear that selections made under normal environments are more adaptable to drought environment than the adaptability of selections made under drought environment to normal environments (Table 2.1.8). Therefore, by selecting high yielding lines under favorable enviroment high yielding and adaptable lines to drought conditions can be developed.

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Table 2.1.7. Selection indices (prediction models) for seed yields at the three environments (Y = seed yields).

Location	Model	RZ%	Abbreviation
Tel Hadya			
	Y = 1470.2 - 21.05 DF	67%	TH1
	Y = 1734 - 13.67DF - 7.18 DM	73%	TH2
	Y = 1463.5 + 2.818SW - 9.1 DF -7.95DM	75%	TH3
Jindiress			
	Y = 964.4 - 7.97 DF	16%	JN1
	Y = 952.8 - 9.62 DF + 4.75 PH	17%	JN2
Terbol			
	Y = 2324 - 26.04 DF	35%	TB1
	Y = 2786 - 11.6 SW -26.66 DF	39%	TB2

Table 2.1.8. Chances of success (percentage of top 10% genotypes for seed yield in drought environment recovered under top 10% of genotypes when selections based on normal environments were used to select the material under drought conditions).

Selection models of normal environments transferred to Tel Hadya				Selection models of drought environment transferred from Tel Hadya			
From	Models	Variables	%	To	Models	Variables	%
Jindiress	JN1	DF	45.8	Jindiress	TH1	DF	8.3
	JN2	DF,H	50.0		TH2	DF,DM	8.3
Terbol	TB1	DF	45.8	Terbol	TH1	DF	29.2
	TB2	DF,SW	20.8		TH2	DF,DM	25.0
					TH3	DF,DM,SW	29.2

2.1.4.4. Segregating populations

Four hundred superior and uniform F_5 and F_6 progenies were bulked.

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2.1.4.5. Yield performance of newly bred lines

Three hundred and fifty-two newly bred lines were evaluated for yield at three locations (Tel Hadya, Jindiress and Terbol) and in two seasons (winter and spring). Although several lines were superior in yield over check, only a few were significantly better (Table 2.1.9). The 1988/89 season was the driest in recent years, yet many lines sown during winter yielded more than 2 t ha^{-1} at Jindiress and Terbol and over 1 t ha^{-1} at Tel Hadya. Though yields were low during spring sowing, especially at Tel Hadya, several lines exceeded the standard check and 33 at significant level. Because of severe drought, coefficient of variation was higher than in the previous seasons.

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2.1.4.6. Winter sowing

A comparison of spring versus winter sowing has been made over six years (1983/84 to 1988/89) at three sites (Tel Hadya, Jindiress and Terbol), using common breeding lines (ranging between 72 and 384 lines) in all trials in each year. The winter of 1984/85 was one of the coldest in the last 50 years, and the spring of 1983/84 and 1988/89, especially at Tel Hadya, was the driest.

The seed yield data in Figure 2.1.4. showed that winter-sown trials on average produced 1634 kg ha^{-1} against 1009 kg of spring-sown

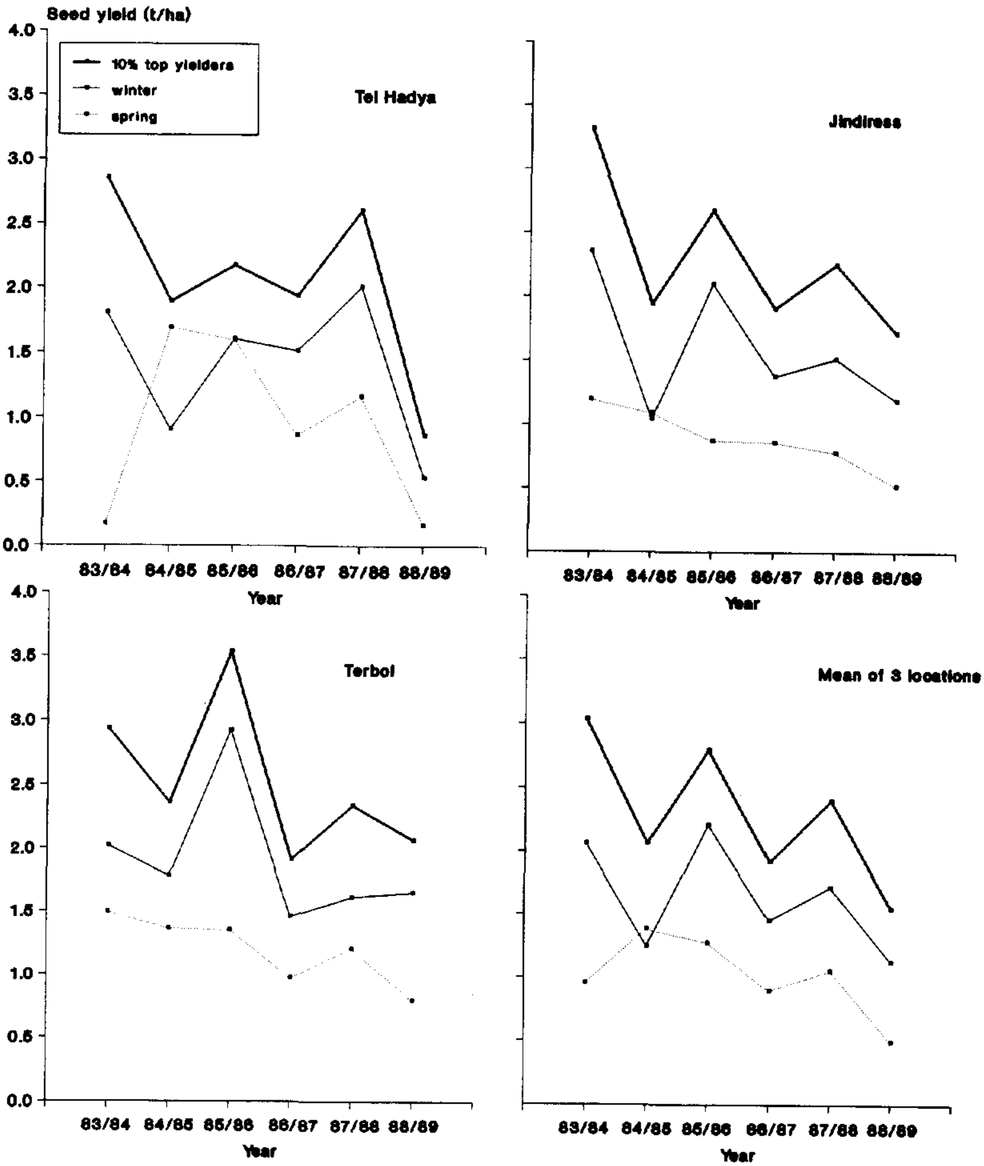

Figure 2.1.4. Mean seed yield (kg ha^{-1}) of chickpea, grown in two seasons (winter and spring) at three locations (Tel Hadya, Jindiress and Terbol) and six years.

Table 2.1.9. Performance of newly developed lines during winter and spring at Tel Hadya, Jindiress and Terbol, 1988/89.

Location and season	No. of trials	Entries			Yield (kg ha^{-1})			Range for	
		Tested	Exceeding check	Significantly exceeding check	Location mean	Check mean	Top entry	C.V. (%)	L.S.D. (kg ha^{-1})
Tel Hadya									
- Winter	16	352	65	2	535	682	1270	11-42	116-573
- Spring	16	352	73	33	164	293	740	22-167	96-259
Jindiress									
- Winter	16	352	89	3	1194	1408	2308	12-25	305-622
- Spring	16	352	17	0	520	804	1305	15-29	124-327
Terbol									
- Winter	16	352	79	3	1652	1835	2270	6-23	213-721
- Spring	16	352	36	0	793	1157	1532	15-37	223-835

Check: Winter, ILC 482; Spring = ILC 1929.

trials, giving 62% or 625 kg ha^{-1} more yield. The yield differences between winter and spring were larger during dry season than the normal season. During 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 season which was also a very cold year. The latter occurred because of deliberate selection for better cold tolerance since 1984/85.

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2.1.4.7. Development of large-seeded, tall, early maturity and spring type.

National programs need large-seeded chickpeas to satisfy consumers preference, tall type for machine harvesting and early type for spring sowing and low rainfall areas. A number of lines meeting these specific needs have been bred and a few of them are shown in Table 2.1.10. There are some lines, for example FLIP 86-81C, which combine tall stature, large-seed and high yield. Some of the new lines have the same yield potential as the local spring type, but have earlier maturity and resistance to Ascochyta blight. Such lines are expected to adapt more widely than the local land race.

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2.1.5. Genetic study

2.1.5.1. Associations of some characters with seed yield

A total of 6170 accessions of kabuli chickpea were evaluated for nine characters and biological and seed yields at Tel Hadya during the 1987/88 winter season. Accessions were grouped into seven regions,

Table 2.1.10. Performance of some promising lines of chickpea at 3 locations during 1988/89.

Line	Grain yield (kg ha^{-1})				100-seed	Days	Height
	Tel Hadya	Jindiress	Terbol	Mean	weight (g)	to flower	(cm)
Large seed							
FLIP 87-5C	986	1448	1659	1364	46	119	39
FLIP 87-7C	1003	1363	1952	1439	47	116	33
FLIP 87-8C	679	1597	1952	1409	45	118	32
ILC 482 (check)	965	1287	1881	1378	27	120	32
Trial mean	623	1293	1603	1173			
C.V. %	38.6	15.7	7.9				
S.E.	170	143.9	89.2				
Tall plant							
FLIP 86-81C	568	1628	1762	1319	39	125	42
FLIP 86-98C	749	1344	1556	1216	40	124	40
FLIP 86-103C	555	1591	1988	1378	36	125	41
FLIP 86-111C	676	1175	1595	1149	44	122	47
ILC 3279 (check)	360	1043	1659	1021	27	126	43
Trial mean	528	1178	1507	1071			
C.V. %	17.6	16.0	7.1				
S.E.	65.5	133.1	75.5				
Early maturity							
FLIP 87-56C	624	1481	1897	1334	31	110	26
FLIP 87-59C	724	1175	2107	1335	35	112	29
FLIP 87-74C	876	1634	2028	1513	37	116	30
ILC 482 (check)	833	1326	2012	1390	26	121	28
Trial mean	656	1289	1841				
C.V.	26.1	14.5	6.7				
S.E.	121	131.8	87.2				
Spring type							
S88207	310	560	1373	748	41	109	32
S88210	408	606	1175	730	34	115	30
S88233	362	671	1429	821	39	110	28
ILC 1929 (check)	160	679	1325	721	37	120	33
Trial mean	253	489	1089	610			
C.V.	26.1	17.4	37.1				
S.E.	46.6	60.2	285.4				

namely South Central Asia (Afghanistan, Iran, USSR), South Asia (India, Pakistan, Nepal), Mediterranean (Jordan, Syria, Palestine, Lebanon, Iraq, Cyprus, Turkey, Algeria, Morocco, Tunisia, Portugal, Spain, France, Italy, Greece, Egypt), Americas (Mexico, Columbia, Ecuador, Peru, Chile, USA), East Africa (Ethiopia, Sudan, Malawi), ICARDA (breeding lines developed through hybridization) and other countries (Bulgaira, Yugoslavia, Czchoslovakia, Romania). Correlation and path coefficient analyses were carried out separately for each region to determine relationships between yield and its components and to identify major direct contributors.

Correlation analysis showed that biological yield, harvest index, the number of seeds/m^2, and 100-seed weight were strongly associated with seed yield (Table 2.1.11). The biological yield had the strongest association with seed yield, except in the Americas where harvest index and the number of seeds/m^2 had close assocations with seed yield. Days to maturity had highly significant and negative relationship with seed yield in accessions from the Americas. The correlation value between plant height and seed yield was only high in accessions from South Asia.

The path coefficient analysis revealed that biological yield and harvest index were the major direct contributors to seed yield (Table 2.1.12). Contributions from other characters were mainly through biological yield and harvest index. The indirect contributions of plant height and canopy width through biological yield were high in accessions from South Asia (0.670 and 0.625) and other countries (0.603

Table 2.1.11. Correlations between seed yield and other characters in chickpea.

Character	South central Asia	South Asia	Mediterra-nean	Americas	East Africa	ICARDA	Other countries	Total germplasm
Days to flower	-0.103**	-0.110*	-0.330**	-0.365**	0.404*	-0.229**	0.128	0.320**
Flowering duration	0.111**	0.257**	0.326**	0.110*	-0.292	0.245**	-0.108	0.357**
Days to maturity	-0.097**	0.005	-0.196**	-0.803**	0.135	-0.011	-0.359**	0.351**
Plant height	0.273**	0.622**	0.160**	-0.047	0.332*	0.206**	0.434**	0.413**
Canopy width	0.275**	0.582**	0.415**	0.146**	0.237	0.455**	0.549**	0.521**
Biological yield	0.923**	0.948**	0.847**	0.641**	0.892**	0.882**	0.801**	0.856**
Harvest index	0.294**	0.132**	0.411**	0.813**	0.004	0.411**	0.359**	0.590**
Seeds/m^2	0.522**	0.514**	0.609**	0.745**	0.026	0.787**	0.492**	0.560**
100 seed weight	0.355**	0.494**	0.212**	0.158**	0.682**	0.097**	0.115	0.268**
Protein content (%)	0.231**	0.263**	0.122**	0.158**	0.111	0.057	0.270**	0.410**
No. of accessions	2176	496	1587	518	37	1155	201	6170

Table 2.1.12. The direct contribution of some characters to seed yield in chickpea.

Character	South central Asia	South Asia	Mediterra-nean	Americas	East Africa	ICARDA	Other countries	Overall total germplasm
Days to flower	-0.037	-0.057	-0.011	0.023	-0.017	-0.032	-0.072	-0.036
Flowering duration	-0.023	-0.002	-0.027	-0.013	-0.008	-0.025	-0.040	-0.312
Days to maturity	-0.339	-0.224	-0.414	-0.332	0.015	-0.301	-0.278	-0.020
Plant height	-0.006	-0.002	-0.002	0.066	-0.022	-0.003	0.004	0.005
Canopy width	-0.003	0.009	-0.006	-0.011	0.042	0.008	-0.010	-0.003
Biological yield	0.877	0.929	0.855	0.471	1.106	0.745	0.852	0.834
Harvest index	0.473	0.367	0.568	0.512	0.442	0.433	0.566	0.546
Seeds/m^2	0.103	0.071	0.101	0.251	0.049	0.223	0.145	0.101
100-seed weight	0.093	0.063	0.088	0.170	-0.012	0.161	0.133	0.079
Portein content	-0.026	-0.016	-0.011	0.006	-0.024	-0.033	-0.008	-0.015
Residual	0.099	0.103	0.127	0.162	0.147	0.101	0.199	0.147

and 0.672). The number of seeds/m^2 mainly contributed via harvest index and to some extent through biological yield. The number of seeds/m^2 was very important character in accessions from East Africa, Americas, and ICARDA's breeding lines. The 100-seed weight was one of the major indirect contributors through total biological yield and harvest index.

Analyses of the total germplasm accessions suggest that biological yield, harvest index, number of seeds/m^2, and canopy width should be considered as selection criteria in the breeding program, although the latter two characters mainly contributed via total biological yield and harvest index.

Drs. Geletu Bejiga, K.B. Singh.

2.1.5.2. Stability analysis for some characters

Chickpea experiments were conducted at three locations, (Tel Hadya and Jindiress in Syria and Terbol in Lebanon) over two seasons (winter and spring) for three years (1983/84, 1985/86, 1986/87). Analyses of variance were done to study the genotype-environment interactions and analysis of stability was done to determine the performance of lines in varying environments.

Results showed significant differences between mean of the seasons, locations and lines for days to flower, plant height, biological yield, seed yield, and 100-seed weight. Genotype x season interactions at each location were highly significant for all characters in all years, suggesting that most genotypes responded differently to each season. The pooled deviations were highly significant for all the characters except for biological yield in one of the three years confirming that the performance of these lines can not be predicted due to their differential response to different environments. Based on the mean seed yield, regression coefficient and deviation from regression, the top high yielding lines, ILC 482, FLIP 82-234C, FLIP 82-225C, S87220, S87215, FLIP 85-8C, and FLIP 84-73C, can be recommended for good environments. Lines which appeared to have relatively better adaptability to varying environments were undesirable except for poor growing conditions since they do not respond to good environments. In conclusion, this study shows that cultivars have to be bred separately for winter and spring sowing and also for favorable and unfavorable environments. Stability of seed yield was found to be independent of the stability of other characters.

Drs. K.B. Singh and Geletu Bejiga.

2.1.5.3. Inheritance of cold tolerance in chickpea

An understanding of the inheritance of cold tolerance is important to breed for cold tolerant cultivars. Therefore, an 8 x 8 diallel cross involving all parents and their 28 F_1s was studied at Tel Hadya, Syria from 1986 to 1988. Data were recorded on cold tolerance when the susceptible-cum-indicator check was killed. Results of combining ability, (Vr, Wr) graphical, and components of variance analyses revealed that cold tolerance was governed by both additive and non-additive gene effects with the preponderance of additive gene effects. The cold tolerance in this material was dominant over susceptibility and was controlled by at least five sets of genes. The heritability in the narrow sense for cold tolerance was high (87.9%). This study indicated that selection for cold tolerance in early generations should be effective.

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

2.1.5.4. Genetics of resistance to Ascochyta blight

Inheritance of resistance to race 3 of Ascochyta blight (Ascochyta rabiei (Pass.) Lab.) was studied in four resistant lines at Tel Hadya Syria from 1983 to 1986. The parents, F_1 and F_2 populations were evaluated for Ascochyta blight resistance under artificial epiphytotic conditions in the greenhouse during the 1983/84 season. The F_3 progenies from selected F_2 resistant plants for each of the four crosses involving resistant and susceptible lines were evaluated for segregation of blight resistance and susceptibility in the greenhouse during the season. Results suggested that a single dominant gene conditioned resistance to race 3 in the four parents, ILC 72, ILC 202, ILC 2956, and ILC 3279. Allelic tests indicated that the resistance gene present in these four resistant lines was the same. When these resistant parents were evaluated against six races of A. rabiei, each was resistant to races 1 and 3 and to at least two other races, but no two lines showed the same resistance pattern. Furthermore, the disease reaction of these resistant lines differed when tested in 13 countries. The variation in reaction of four resistant lines to six races and in different countries appears to be due to the presence of some other resistant genes in addition to a common gene.

Drs. K.B. Singh and Geletu Bejiga.

2.1.5.5. Genotype x environment interaction for protein content

Five trials comprising 116 breeding lines were grown at three locations (Tel Hadya, Jindiress, and Terbol) and two seasons (winter and spring). The first four trials consisted of 24 entries each, while the fifth trial consisted of only 20 entries. These trials were sown in two replications at each location using a four-row plot of 4m x 1.8m. Percent protein content was determined by Near-infrared reflectance (NIR) spectroscopy. Data were then subjected to factorial analysis separately for each trial. Results showed that there were significant differences (P = 0.001) among the lines in all the trials. The first order (location x genotype and season x genotype) and second order (location x season x genotype) interactions were only significant in trial 3 (P = 0.05) and trial 4 (P = 0.01). There was no significant interaction in trial 1 which consisted of only large-seeded lines, whereas trial 2 which consisted of all tall lines revealed significant season x genotype interactions. Early maturity lines (Trial 5) had only significant interactions of location x season x genotype. These results indicated that there are lines which do not interact with environments for protein content and thus stable lines can be identified for this character through multi-locational tests.

Drs. K.B. Singh & Geletu Bejiga.

2.1.5.6. Mutation studies

Genetic variability for such important traits as cytoplasmic-genetic male sterility, determinate growth habit, photo-period insensitivity, tall and erect plant type, long pod with 3 to 4 seeds, multiple pods per peduncle is rather limited in chickpea. A project was initiated during 1987 to increase variability for these traits using cultivars ILC 482, ILC 3279 and ILC 6104, seeds of which were exposed to 40, 50 and 60 KR of gamma irradiation or treated with 0.1% and 0.2% solution of ethylementhane sulphate (EMS) for two hours after one hour presoaking in water. The M_1 generation was grown in the off-season nursery, at Terbol between June and October and M_2 generation was grown at Tel Hadya from December 1987 to June 1988. A wide range of viable, morphological mutants affecting most plant parts, such as leaf, flower, plant height, plant type, pod, maturity, and seed, were selected from M_2 generation. All the selected mutants were grown in M_3 generation at Tel Hadya during winter 1988/89 to confirm their mutant nature. Mutants of economic importance in ILC 482 included one with 50% large seed size, another mutant with multiseeded pods, and a third with 15 days early flowering. In tall parent ILC 3279, a mutant with 20% more plant height was identified.

Mr. M.A. Haq and Dr. K.B. Singh.

2.1.6. Evaluation of germplasm

Six thousand two hundred twenty-one germplasm accessions, which were evaluated during the winter season, were classified into eight categories for six major characters, namely biological yield, seed yield, harvest index, number of seeds/m^2, percent protein content and canopy width. Their respective frequencies were estimated using the mean (x) and standard deviation (s) of the entire evaluation data (Table 2.1.13). The class limits of the eight categories were determined as follows: Class 1: > x + 3s; Class 2: x +2s to x + 3s; Class 3: x +1s to x + 2s; Class 4: x to x +1s; Class 5: x-1s to x;

Class 6: x -2s to x -1s; Class 7: x -3s to x - 2s; Class 8: < x - 3s.

Class 1 is the most desirable, while class 8 is the least desirable. There were 18, 9, 11, 26, 15 and 2 accessions in the class 1 for biological yield, seed yield, harvest index, number of seeds/m^2, protein content and canopy width, respectively. Majority of the accessions were in class 4 and 5 (Figure 2.1.5a-f). Comparatively few lines were undesirable. This type of classification has helped in selecting highly desirable lines for breeding program.

Drs. Geletu Bejiga and K.B. Singh.

Table 2.1.13. Mean of biological yield, seed yield, harvest index, number of seeds/m^2, and percent of protein in the seed for 6221 accessions evaluated during winter season of 1987/88 at Tel Hadya, Syria.

Character	Mean(x)	Standard deviation (s)
Biological yield (g)	517	133
Seed yield (g)	245	70
Harvest index (%)	48	7.8
Number of seeds/m2	999	399
Protein content (%)	22.6	1.5

2.1.7. Wild *Cicer* species

2.1.7.1. Evaluation of germplasm

One hundred and thirty-seven accessions of eight annual wild *Cicer* species, including *C. bijugum*, *C. chorassanicum*, *C. cuneatum*, *C. echinospermum*, *C. judaicum*, *C. pinnatifidum*, *C. reticulatum*, and *C. yamashitae*, were sown on 2 Dec 1988 along with a line of cultivated species as check. The check was sown frequently after every 10 test

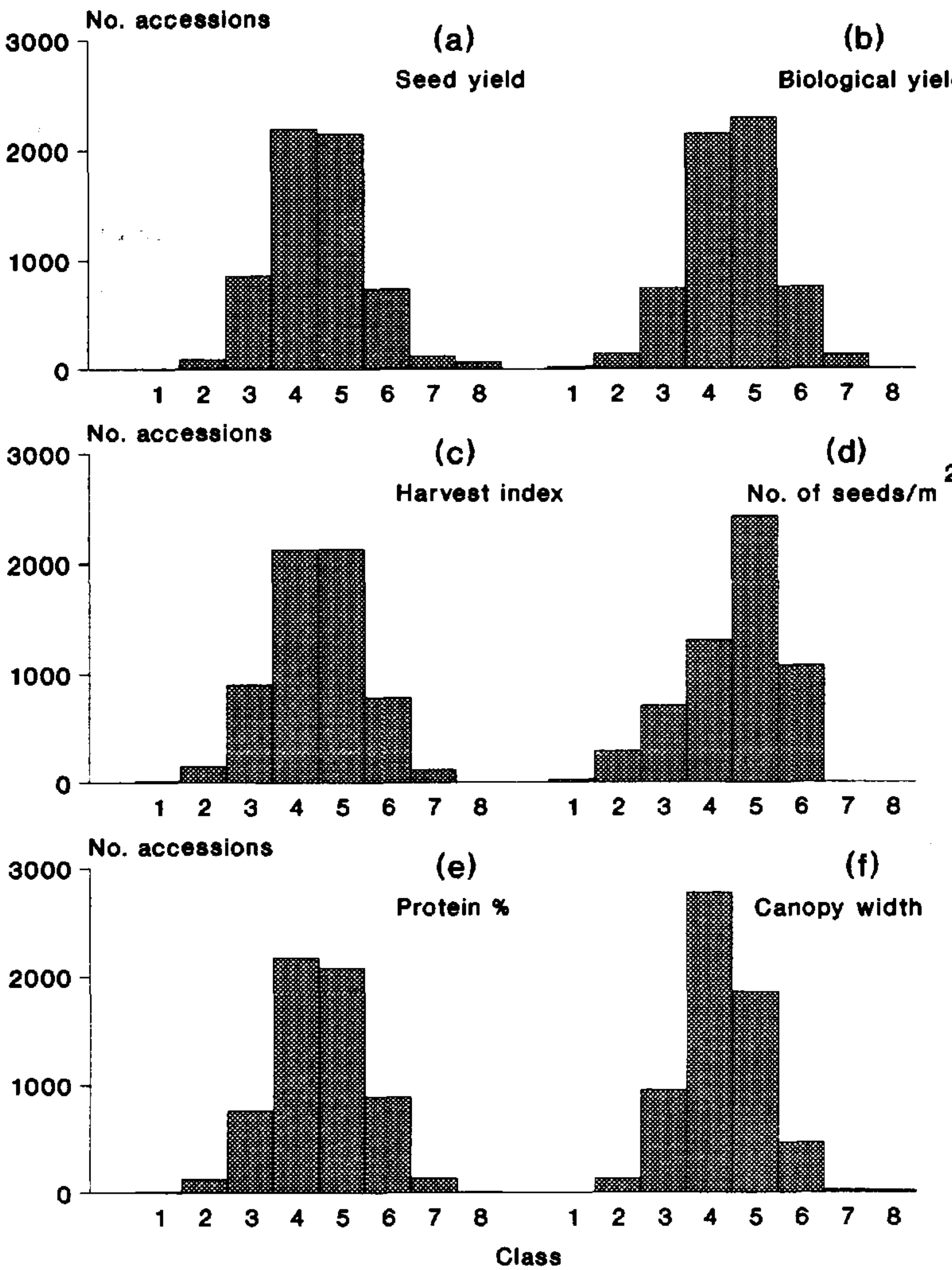

Figure 2.1.5. Frequency distribution for (a) seed yield, (b) biological yield, (c) harvest index, (d) number of seeds/m^2, (e) protein content; and (f) canopy width.

entries. The plot size was one row, 2 m long. Spacings between and within row were 0.45m and 0.1m, respectively. The experimental plot was irrigated twice during April and May 1989, each time with 50 mm water to avoid drought stress. The crop was protected from Ascochyta blight by spraying Bravo 500 fungicide five times between February and April. Observations were recorded on five plants randomly chosen in the field. Data on seed yield, 100-seed weight, protein content and leaf area were recorded.

Results of evaluation for 32 characters are presented in Tables 2.1.14. and 2.1.15. Wild species were marginally superior to cultivated species for a few characters. For example, early maturity (127 days in C. judaicum ILWC 37/S-2 in comparison with 185 days of the check ILC 482); seeds per pod (C. cuneatum pods bear several seeds and 2.5 seeds per pod was the average recorded in C. judaicum ILWC 19-2); pods per plant (223 in C. bijugum ILWC 32-2 and 182 in ILC 482); and protein content (23.6% in C. judaicum ILWC 33/S-6 and 20.4% in the check ILC 482). On the contrary, their main limitation is small seed size and poor seed appearance, which will limite their use as donors of genes for desirable traits.

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

2.1.7.2. Interspecific hybridization

During 1987/88, a 9 x 9 diallel cross comprising eight annual wild Cicer species and one cultivated species was made. Seventy-two crosses including reciprocals were attempted. The crossing block was grown during the 1987-88 season both in the field and in plastic house, but

Table 2.1.14. Mean and standard error for genetic variability of different morpho-agronomic characters in wild *Cicer* species.

Character	*C. arietinum*	*C. bijugum*	*C. chorassanium*	*C. cuneatum*	*C. echinospermum*	*C. judaicum*	*C. pinnatifidum*	*C. reticulatum*	*C. yamamshitae*
Days to emergence	42 ± 0.00	73 ± 15.15	70 ± 3.54	71 ± 6.45	58 ± 2.46	59 ± 0.76	59 ± 0.88	57 ± 0.46	59 ± 1.07
Days to flowering	103 ± 0.00	122 ± 10.08	115 ± 0.82	108 ± 0.36	119 ± 2.96	107 ± 0.97	116 ± 0.62	115 ± 0.81	115 ± 1.07
Days to maturity	185 ± 0.00	173 ± 26.97	152 ± 1.19	149 ± 0.36	171 ± 1.00	141 ± 1.68	148 ± 0.85	173 ± 1.04	144 ± 4.26
Petal size	9.5 ± 0.00	7.8 ± 2.14	4,7 ± 0.27	8,5 ± 0.36	10.2 ± 0.86	5,0 ± 0.08	6.2 ± 0.13	14,0 ± 4.33	7.0 ± 0.00
Sepal size	5.5 ± 0.00	4.6 ± 2.26	2,3 ± 0.27	5,0 ± 0.00	5.8 ± 0.86	5,0 ± 0.07	4.0 ± 0.09	5,3 ± 0.10	5.0 ± 0.00
Plant height	40 ± 1.31	12 ± 10.08	3 ± 0.27	15 ± 0.36	8 ± 1.64	12 ± 1.79	12 ± 0.64	7 ± 0.23	6 ± 0.71
Canopy width	38 ± 1.05	51 ± 69.93	11 ± 2.68	25 ± 4.61	53 ± 18.02	45 ± 2.30	30 ± 2.06	38 ± 1.49	14 ± 2.84
Leaf size cm^2	7.9 ± 0.00	2.4 ± 2.31	1,0 ± 0.00	2.0 ± 2.00	2,3 ± 1.88	1,0 ± 0.00	1.0 ± 0.00	2,7 ± 0.13	2.0 ± 0.00
Leaf lets/leaf	12 ± -	5 ± 0.00	3 ± 0.00	16 ± 0.71	11 ± 0.04	9 ± 0.16	7 ± 0.06	11 ± 0.23	6 ± 0.35
Primary branches	3 ± 0.08	5 ± 3.85	2 ± 1.16	2 ± 0.71	4 ± 1.64	4 ± 0.19	4 ± 0.30	4 ± 0.26	4 ± 1.07
Secondary branches	12 ± 0.46	15 ± 27.86	1 ± 0.58	5 ± 1.07	16 ± 9.82	10 ± 0.56	11 ± 0.64	14 ± 1.10	5 ± 1.78
Tertiary branches	5 ± 0.23	5 ± 14.45	0 ± -	2 ± 2.00	5 ± 6.70	5 ± 0.64	3 ± 0.34	4 ± 0.63	1 ± 0.71
Pods/plant	140 ± 6.93	81 ± 196.11	11 ± 1.45	29 ± 10.30	113 ± 93.20	41 ± 3.82	49 ± 3.65	53 ± 4.92	67 ± 30.89
Seeds/pod	1.0 ± 0.01	1,0 ± 0.00	1,0 ± 0.00	1.5 ± 0.36	1.0 ± 0.00	1.3 ± 0.07	1.0 ± 0.00	1,0 ± 0.00	1.0 ± 0.00
Biological yield	1559 ± 783.50	444 ± 20805.46	17 ± 32.90	108 ± 368.14	458 ± 3756.10	129 ± 116.37	108 ± 77.73	342 ± 352.26	151 ± 657.10
Seed yield	920 ± 471.4	226 ± 10603.20	3 ± 8.96	33 ± 145.91	343 ± 2460.66	28 ± 31.11	36 ± 31.57	167 ± 348.67	66 ± 350.03
Harvest index	59 ± 0.66	46 ± 215.57	15 ± 3.18	28 ± 3.91	75 ± 7.88	20 ± 1.25	32 ± 1.29	49 ± 1.21	38 ± 6.75
100 seed weight	29.2 ± 0.30	10.5 ± 49.58	1,0 ± 0.00	2.0 ± 0.00	14.5 ± 3.00	1.2 ± 0.16	2.0 ± 0.06	13,0 ± 0.72	2.0 ± 0.00
Protein %	16.4 ± 0.00	19.9 ± 7.69	20,0 ± 11.56	- -	20.0 ± 1.40	20.0 ± 0.18	19.6 ± 0.15	20,4 ± 0.20	20.5 ± 0.35

Table 2.1.15. Morphological variation in wild *Cicer* species.

Character	*C. arietinum*	*C. bijugum*	*C. chorassanium*	*C. cuneatum*
Flower color	White	Lilac	Creamy	Lilac
Maturity uniformity	+	-	-	-
Growth habit	Semi-spreading	Spread	Prostrate	Climbing
Stem color	Green	Partly purple	Predominantly purple	Green
Stem pubescence	+	+	+	+
Leaf shape	Obovate	Oblong	Cuneate flagellate	Manow cuneate
Leaf edge	Dentate	Dentate	Dentate	Dentate
Stipule shape	Ovate tria.	Triangular	Minute	Minute
Pubescence	+	+	+	+
Pod dehiscence	-	+	+	+
Seed shape	Round	Oblong	Ovoid	Round
Seed color	Beige	Pale brownish	Dark brown	Brown
Seed surface	Smooth	Very fine echinate spines	Bruised	Very fine echinate spines

C. echinospermum	*C. judaicum*	*C. pinnatifidum*	*C. reticulatum*	*C. yamamshitae*
Pink Lilac	Purplish	Pink	Pink	Violet
-	-	-	-	-
Spreading	Prostrate	Semi-spread	Spread	Spreading
Partly purple	Partly purple	Green	Partly purple	Green
+	+	+	+	+
Oblong	Cuneate	Cuneate	Oblong	Eliptic
Dentate	Incised	Deeply incised	Dentate	Incised
Dentate	Ovate	Flagellate	Flagellate	Triangualr
+	+	+	+	+
+	+	+	+	+
Oblong	Triangular	Hearty bilobate	Oblong	Hearty bilobate
Dark brown	Brown greyish	Dark brown	Brown	Grey
Whitish echinate spines	Finely veined	Creamy reticuls	Creamy reticule	Creamy veins

+ = present, - = absent

the success in crossing in the plastic-house was negligible. A large number of flowers were pollinated in each cross combination (Table 2.1.16). The F_1s were grown in the field in the 1988/89 season and attempts were made to determine the true crosses.

Out of 72 cross-combinations, eight crosses were successful and these were C. arietinum (ILC 482) x C. reticulatum (ILWC 36), C. reticulatum (ILWC 36) x C. arietinum (ILC 482), C. arietinum (ILC 482) x C. echinospermum (ILWC 35), C. echinospermum (ILWC 35) x C. arietinum (ILC 482), C. echinospermum (ILWC 35) x C. reticulatum (ILWC 36), C. reticulatum (ILWC 36) x C. echinospermum (ILWC 35), C. bijugum (ILWC 34) x C. judaicum (ILWC 20) and C. pinnatifidum (ILWC 29) x C. judaicum (ILWC 20) (Table 2.1.17). All these cross-combinations were reported earlier. But we succeeded in having F_1's setting a large amount of seeds in the crosses involving C. echinospermum which were earlier reported to be sterile.

Among the successful crosses, the most interesting were those with C. echinospermum. Despite the semisterility of the pollen, F_1's involving C. echinospermum produced very large amount of seeds and were more vigorous than their parent species, C. arietinum, C. echinospermum and C. reticulatum. It will be interesting to follow these crosses and examine whether they can throw high yielding segregants.

In two cross-combinations, C. bijugum x C. judaicum and C. pinnatifidum x C. judaicum, very few seeds were produced. Here a mechanical barrier was observed. The fertilization failed because of the elongation of style out of the keel before the dehiscence of the

Table 2.1.16. Number of flowers crosses and (percent success) in annual Cicer species.

Male/Female	C. arietinum	C. bijugum	C. chorassan	C. cuneatum	C. echinospe	C. judaicum	C. pinnatifi	C. reticulat	C. yamamshit
C. arietinum	-	116 (0)	19 (0)	123 (0)	48 (75)	45 (0)	61 (0)	60 (75)	57 (0)
C. bijugum	167 (0)	-	58 (0)	118 (0)	170 (0)	64 (23)	118 (0)	153 (0)	106 (0)
C. chorosanicum	-	-	-	3 (0)	-	6 (0)	6 (0)	6 (0)	12 (0)
C. cuneatum	58 (0)	124 (0)	47 (0)	-	97 (0)	89 (0)	104 (0)	32 (0)	105 (0)
C. echinospermum	78 (18)	255 (0)	19 (0)	43 (0)	-	110 (0)	54 (0)	167 (18)	66 (0)
C. judaicum	63 (0)	71 (0)	38 (0)	39 (0)	60 (0)	-	44 (0)	70 (0)	50 (0)
C. pinnatifidum	42 (0)	174 (0)	61 (0)	57 (0)	53 (0)	22 (50)	-	54 (0)	83 (0)
C. reticulatum	55 (5)	240 (0)	41 (0)	84 (0)	131 (16)	63 (0)	-	-	76 (0)
C. yamashitae	63 (0)	14 (0)	84 (0)	42 (0)	168 (0)	69 (0)	86 (0)	119 (0)	-

() = Numbers in parenthesis are percent of successful hybrids.

Table 2.1.17. Pollen fertility (%) of the successful cross-combinations (F_1)

Female/Male	C. ari.	C. bij.	C. cho.	C. cun.	C. ech.	C. jud.	C. pin.	C. ret.	C. yam.
C. arietinum	-	-	-	-	51	-	-	100	-
C. bijuqum	-	-	-	-	-	41	-	-	-
C. chorassanicum	-	-	-	-	-	-	-	-	-
C. cuneatum	-	-	-	-	-	-	-	-	-
C. echinospermum	30	-	-	-	-	-	-	56	-
C. judaicum	-	-	-	-	-	-	-	-	-
C. pinnatifidum	-	-	-	-	-	13	-	-	-
C. reticulatum	100	-	-	-	56	-	-	-	-
C. yamashitae	-	-	-	-	-	-	-	-	-

stamen. Hand pollination was employed to produce F_2 seeds.

An 8 x 4 top cross between eight wild Cicer species and four cultigen has been made during the 1988/89 season.
Dr. K.B. Singh and Mr. Bruno Ocampo.

2.1.7.3. In vitro culture

Since crosses between many wild Cicer spp. and cultivated species were unsuccessful, embryo rescue technique was employed. An attempt was made to search for a suitable nutrient medium to enable the development of the excised parental species embryos, as well as their rhizogenesis. A mixture of Murashinge and Skoog agar solidified medium derived by a combination of mineral salts, vitamins as in B5 medium, and Benzyladenine (0.1 to 1.0 uM) and IBA (1 uM) as hormones was found to be the most suitable nutrient. Problems were encountered in embryo dissection that led to injury of small embryos so altering their response to culture conditions. However, some embryos were successfully cultured in vitro. In future, effort will be directed to find a satisfactory medium for shoot and root regeneration.
Mr. B. Ocampo and Dr. K.B. Singh.

2.1.7.4. Cytology

Cytological analysis aimed at studying the cytological causes underlying sterility observed in the interspecific hybrids, to confirm hybridization, and to determine the karyotype of the annual Cicer species.

The meiotic analysis of the F_1s from the four fertile cross-combinations involving C. echinospermum as one parent did not show apparent irregularities in homologous pairing, as well as in their disjunction. Furthermore, the microspore mother cells regularly released four microspores. The reason for only partial pollen fertility of the above F_1's might be attributed to genetical disharmonies (Table 1.1.17). But chromosomal sterility should not be excluded, since sometimes genic and chromosomal sterility are not so easily distinguishable.

By means of root tip mitotic analysis of the wild Cicer relatives the chromosome number of the accessions and lines was ascertained. Somatic chromosome number of all the annual Cicer species was found to be 2n = 16, the same as in the cultigen, but they are karyotypically different. The karyotype of C. echinospermum (ILWC 35/S-1) and C. reticulatum (ILWC 21-15) and C. arietinum (FLIP 82-150C) have been determined using the meiotic technique.

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

2.1.8. Phosphorus efficiency studies in chickpea

In a joint project between FLIP and the University of Hohenheim, 41 progenies in F_5 and their 8 parental lines were evaluated for phosphate uptake, phosphate content, and yield to assess their phosphorus use efficiency. The trial was performed at Tel Hadya and Jindiress in winter- and spring. Four fertilizer treatments used included combinations of 0 and 75 kg P_2O_5/ha (P_0 and P_1) and 0 and 100 kg N/ha (for spring sown crop 0 and 60 kg N/ha, N_0 and N_1): P_0N_0, P_1N_0, P_0N_1 and P_1N_1. The soil had 3 ppm Olsen P and 4 ppm total N in the upper 20

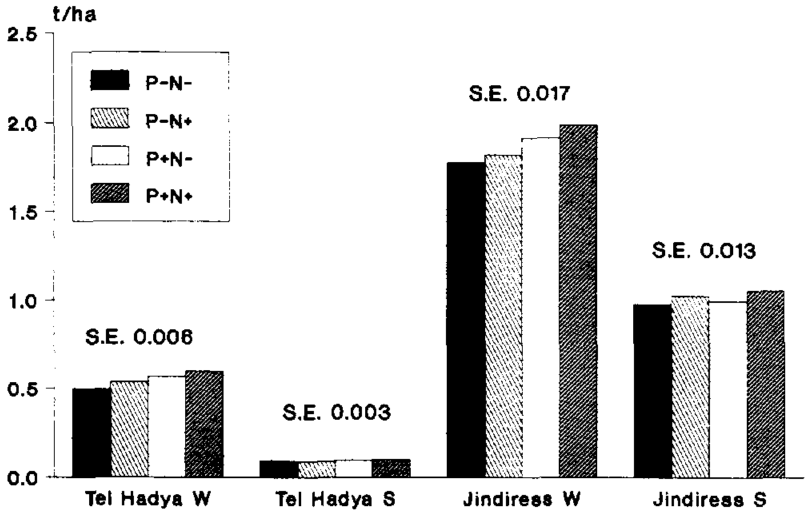

Figure 2.1.6. Effect of different fertilizer treatments on the mean yield of different chickpea lines in winter (w) and spring (s) sown trials at Tel Hadya and Jindiress, 1989.

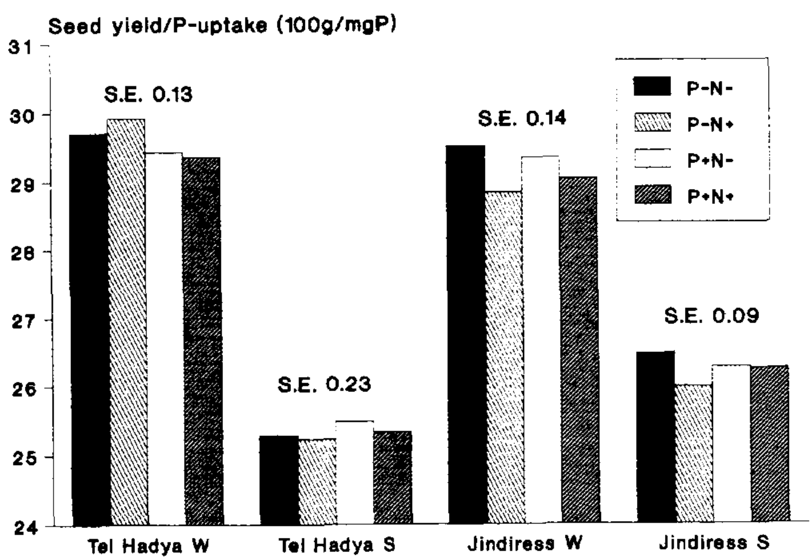

Figure 2.1.7. Effect of N and P fertilization on the mean P-use efficiency (100 g seed yield/mg P uptake) of several lines of chickpeas sown in winter and spring at Tel Hadya and Jindiress.

cm soil layer. Because of the drought, yield was severely restricted at Tel Hadya and only the winter sown trial at Jindiress gave an yield of about 2 t/ha.

Highly significant differences (at P = 0.01) were obtained for "Genotypes" as well as for "Fertilizer Treatments" for all important traits, while interactions between "Genotypes" and "Fertilizer Treatments" only appeared for P-Content of the seeds and seed yield per unit P-yield at the Jindiress in the winter trial. This is in agreement with the results of the 1987/88 season, when at Tel Hadya in only the winter sown trial with an average yield of about 2 t/ha significant interactions were obtained.

All genotypes responded well to the treatments, but under the generally restricted growth conditions genetic differences got very mich narrowed down. In the winter sown trials, response to phosphorus was higher than to nitrogen, while in spring sown trials the nitrogen response was relatively higher (Fig. 2.1.6). Although phosphorus utilization efficiency was raised by the fertilizer inputs, the most efficient use of phosphorus was made at the zero input level (Fig. 2.1.7).

Dipl. Ing. Agr. A. Gross, Prof. Dr. P. Ruckenbauer, Dr. K.B. Singh.

2.2. Application of Biotechnology in Chickpea Breeding

2.2.1. Restriction fragement length polymorphism (RFLP)

This project is conducted in cooperation with the Department of Botany, University of Frankfurt, FRG. RFLP is a molecular marker technique to improve germplasm enhancement. The use of RFLP allows to expedite the recovery of phenotypically undetectable genetic traits of desirable, recurrent parent alleles in the F-2 generation, thus reducing the length of breeding programs and increasing their efficiency. Especially in wide- and backcrossing programs, as for example in case of breeding for resistance to Ascochyta blight in chickpea, RFLP represents a valuable tool.

To initiate the use of RFLP in breeding programs plant material of 15 genotypes of chickpea and 2 each of lentil and barley were jointly analysed at the University of Frankfurt. The analysis was conducted by using a non-radioactive DNA-marker test (Boehringer kit). Thereby a r-DNA spacer length probe was used, which originated from wheat (Chinese Spring). Depending upn the enzymes used and respective enzymatic DNA digestion, varying degrees of fragment length polymorphism were obtained. All 15 chickpea genotypes as well as the 2 genotypes of lentil and barley could be distinguished according to their individual DNA electrophoresis pattern. This type of RFLP test is suitable especially for demonstrations and introducing training in the area of marker based breeding techniques. Regarding immediate practical application this technique could be used for the identification of varieties and genetic relationships.

In further experiments 15 genotypes each of chickpea and barley were analysed using an innovative probe developed by the Max Plank Institute, Munich. This probe is a synthetic oligo - nucleotid sequence. Such probes are already being frequently used in human medicine to identify genetic relationships and single gene caused diseases. It was for the first time that this type of probe has been used successfully in plants. The analysis of the 13 genotypes revealed that chickpea has a high degree of polymorphism making it especially suitable for RFLP analysis using oligo-nucleotids (Fig. 2.2.1). It has now to be clarified whether these fragments are inheritated in a mendelian fashion and the electrophoretic patterns (fingerprints) are correlated with such agronomic traits as Ascochyta blight resistance.

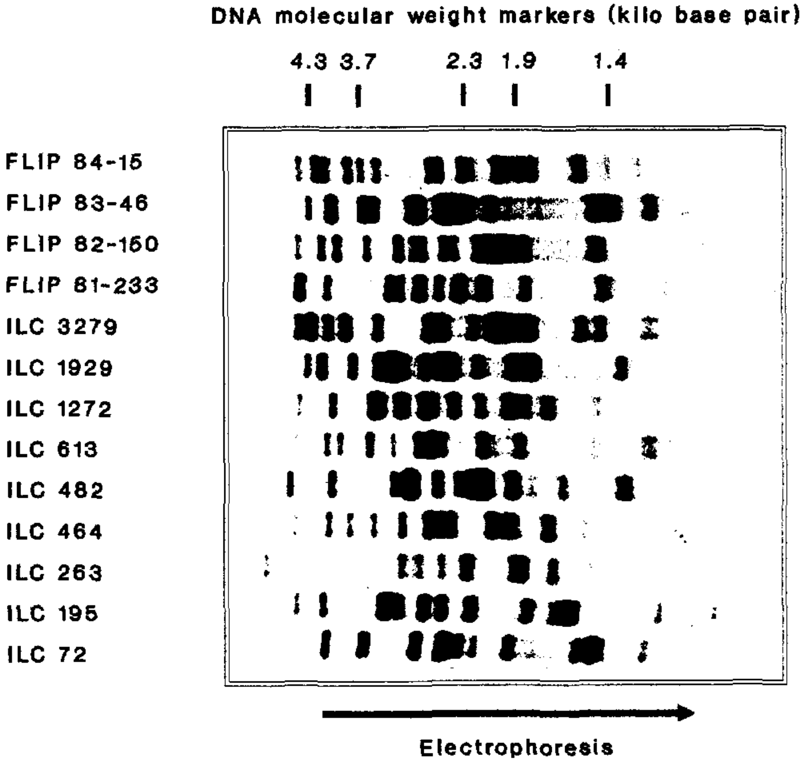

Figure 2.2.1. Genotypic differentiation of 13 chickpea accessions after hybridization to the synthetic oligonucleotide probe $(GATA)_4$. DNA of individual plants were digested with Tag I.

RFLP can also be used to distinguish between isolates of pathogens. The six existing isolates of Ascochyta rabiei were purified, freeze-dried and are being analysed at present.
(Dr. Franz Weigand, ICARDA, Prof. Gunter Kahl, University of Frankfurt, FRG, J.T. Epplem et al, Max-Planck Institute, Martinsried, FRG).

2.3. Chickpea Pathology

Chickpea suffers from several diseases. In the ICARDA region, Ascochyta blight is the most important disease, and additionally due to its role in determining the success of winter-sown chickpea it receives a high priority in chickpea pathology research at ICARDA. Major emphasis is laid on identifying durable and stable sources of resistance to Ascochyta blight in germplasm for use in the hybridization program. Fusarium wilt and other soil-borne diseases are 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 the chickpea pathology research at ICARDA are to: 1, screen chickpea germplasm to identify sources of resistance to Ascochyta blight by using field screening technique, 2, combine efforts with chickpea breeder 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, and

6, collect information on other chickpea diseases in the WANA region through field surveys and 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 race 5 and race 6, earlier screening of germplasm and breeding lines was carried out against a mixture of four races, race 1 to 4. Breeding program made use of the lines which were resistant to race 5 and race 6 in crossing programs. Also it was observed that many lines may not be resistant to race 5 and 6 individually, but they were resistant against a mixture of 1 to 6 race. Therefore, it was decided to evaluate the germplasm lines, wild species and breeding material against a mixture of 6 races (Table 2.3.1). Spore suspension prepared by mixing equal amount of

Table 2.3.1. Chickpea material screened in the Ascochyta blight nursery at Tel Hadya, 1988/89.

Material	No. of entries
F_2 populations	321
F_3 bulks	23
F4 progenies	7359
F_5 progenies	6342
F_6 progenies	1934
New germplasm lines	472
CAN entries	248
IYT, AYT, PYT lines	839
ILC 482 selections	32
Wild species accessions	132

spores of six races was sprayed in the field five times during the season. Disease started developing well, but the season being dry and warm did not permit disease development in epiphytotic form uniformly throughout the 8.5 ha field. The susceptible check sown after every ten test rows took a rating from 7 to 9 on a 1-9 scale with an average rating of 8.

Germplasm screening: Four hundred and sixty-five lines were evaluated. Only one line was found moderately resistant (rating 4) and the remaining 464 lines had ratings between 6 and 9. This moderately resistant line will be re-evaluated next season.

Breeding lines: Results of screening of breeding lines are shown in Table 2.3.2. A total of 1064 lines were screened. None of the lines

Table 2.3.2. Reaction of the chickpea breeding lines from different trials in Ascochyta blight nursery at Tel Hadya, 1988/89.

Breeding lines	No. of entries	No. of lines with a disease rating* of				
		1	2	3	4	5
CAN	219	0	0	11	136	62
CIYT	144	0	0	0	56	73
AYT	142	0	0	4	36	74
PYT	331	0	0	38	124	122
Screening nurseries	96	0	0	4	18	13
FLIP desi lines	20	0	0	7	8	5
ILC 482 selections	24	0	0	1	15	8
ILC 3279 selections	28	0	0	0	30	8
Total	1064	0	0	72	463	378

CAN = Chickpea Nursery, CIABN = Chickpea International Ascochyta Blight Nursery, CIYT = Chickpea International Yield Trial.

had 1 or 2 ratings, but 72 lines had 3, 463 lines had 4 and 378 lines had 5 rating. Lines with 3 ratings have been identified rarely in the past. Thus, breeding effort has helped in generating higher level of resistance in the material.

Screening of F_4 to F_6 progenies: Of the 14431 progenies including 6147 F_4, 6351 F_5 and 1933 F_6 none had 1 or 2 ratings, but 449 progenies were rated 3 and 4096 were rated 4 (Table 2.3.3).

Table 2.3.3. Reaction of F_4 to F_6 progenies to Ascochyta blight at Tel Hadya, 1988/89.

Generation	Reaction on 1-9 scale									Total
	1	2	3	4	5	6	7	8	9	
F_4 progenies	0	0	310	2501	2496	526	177	28	109	6147
F_5 progenies	0	0	51	1028	2828	1561	723	146	14	6351
F_6 progenies	0	0	88	567	767	434	65	12	0	1933
Total	0	0	449	4096	6091	2521	965	186	123	14431

Screening of F_2 and F_3 bulks: Reaction of 321 F_2 populations to Ascochyta blight was very variable. Some populations had many resistant plants, while a few had none. There was a clear influence of degree of resistance in parents involved in the crossing program. In 23 F_3 bulks, sown in early February and germinated in mid March due to cold, disease development was mild. As a result, majority of the plants remained resistant and need re-screening in the following season.

2.3.1.2. Greenhouse screening

Three hundred and fifteen germplasm and breeding lines found resistant against a mixture of four races during the 1987/88 screening in the field were individually screened against race 3, race 6 and a mixture of 1 to 4 races (Table 2.3.4). It is clear that screening of lines until adult plant stage is more reliable than at seedling stage alone and the greenhouse screening is harsher than the field screening. None of lines was resistant against race 6, whereas 33 lines were resistant against race 3 and eight lines against a mixture of four races. The reaction of individual lines to race 3 and mixture of four races was different. Only one selection, S87110, was resistant to race 3 and mixture of four races.

2.3.1.3. Screening of wild species

One hundred and thirty-two accessions of eight annual wild Cicer species were screened in the field against a mixture of six races, 110 accessions in the greenhouse against a mixture of four races and 99 accessions in the growth chamber against a mixture of six races. Screening in the field and greenhouse was done both at seedling and adult plant stages, but in growth chamber, it was done only at seedling stage. Results are presented in Table 2.3.5. Seventy-two, 33 and 8 lines were found resistant in field, greenhouse and growth chamber screening, respectively. Clearly growth chamber screening was more severe.

Results of the screening under three conditions were very variable. Hence, it is suggested to repeat this experiment. Further

Table 2.3.4. Reaction of promising lines in greenhouse at Tel Hadya, 1988/89.

Race	Reaction on 1-9 scale									
	1	2	3	4	5	6	7	8	9	Total
					Seedling stage					
Race - 3	0	6	41	101	105	42	17	3	0	315
Race - 6	0	0	1	12	33	139	97	24	9	315
Mixture of 1-4 races	0	1	2	21	91	52	25	8	2	202
					Adult Plant Stage					
Race - 3	0	0	0	33	56	51	60	70	45	315
Race - 6	0	0	0	0	1	5	11	35	263	315
Mixture of 1-4 races	0	0	2	6	76	28	33	31	26	202

Table 2.3.5. Result of screening wild *Cicer* species in the field, greenhouse and growth chamber at Tel Hadya, 1988/89.

Reaction on	Field		Greenhouse		Growth chamber	
on 1-9 scale	No.	species*	No.	Species	No.	Species
1-4	72	1,3,4,5,6	33	1,3,5,6,8	8	1,5,6
5-6	38	1,4,5,6,7	26	1,4,5,6	52	1,4,5,6,7
7-9	22	1,2,3,4,5,7,8	51	1,3,4,5,6,7	39	3,4,5,6,7,8
Total	132		110		99	

* Species code: 1 = *C. bijugum*, 2 = *C. chorasanicum*, 3 = *C. cuneatum*, 4 = *C. echinospermum*, 5 = *C. judaicum*, 6 = *C. pinnatifidum*, 7 = *C. reticulatum*, 8 = *C. yamashitae*.

none of the accessions was resistant under all the three screening methods. At species level, some accessions from three species, C. bijugum, C. judaicum and C. pinnatifidum, were resistant under field, greenhouse and growth chamber screenings.

Drs. K.B. Singh and Dr. M.P. Haware.

2.3.2. Pathogenic variability in Ascochyta rabiei and host plant resistance

2.3.2.1. Purification of Ascochyta rabiei isolates

The existing stock cultures of the 6 isolates of A. rabiei were single-spored. Under microscope an individual spore was identified and separated using a multi razor blade cutting device. Using this technique it can be guaranteed that the resulting cultures originated from single spores. The establishment of pure isolates is a prerequisite for any further resistance breeding work. The differentiation and identification of the different isolates will be further improved by using a host differential set and RFLP marker techniques.

2.3.2.2. Host plant differential set

A set of 9 chickpea genotypes (ILC 1929, 201, 482, 249, 190, 215, 2956, 3279 and 5964) was tested against the 6 purified, singlespored A. rabiei isolates to characterize the isolates for their agressiveness and host plant reaction. The experiment was carried out under controlled environmental conditions in a walk-in growth chamber. Readings for disease severity were taken of single plants from the 3rd to 14th day after inoculation on the following 1 to 9 scale: 1 = no symptoms, 2 = small round tissue depression or spot, 3 = elongating spot, 4 = coalescent spots, 5 = stem girdling, 6 = stem breaking, 7 = lesion growth downward from breaking point, 8 = nearly whole plant dead, 9 = plant dead. Symptoms evaluation was restricted to stem lesions, because only up to 5 unfolded leaves were present at the time of inoculation. Leaves produced during the following 12 day period obviously are not attacked by the pathogen and a scoring of these would thus give misleading results.

The experiment revealed that the 6 isolates clearly differ in their agressiveness. Isolate 3 was the weakest, followed by isolates 5 and 1. The differences between these 3 isolates were only small and non significant. Isolate 2 was moderately aggressive and exceeded by isolates 4 and 6. The most aggressive isolate 6 differed significantly (P = 0.01) from all other isolates. The host plant reaction of all 9 genotypes revealed no reversal in ranking when the isolates are arranged according to increasing aggressiveness. The genotypes could be divided into 3 groups according to their reaction to the different isolates. The first group consisting of *ILC 1929* and *201* was *highly* susceptible to all 6 isolates, even the weakest isolate 3 (Fig. 2.3.1).

The second group was formed by ILC 482, 249, 190 and 215 which had a good level of resistance to the weak isolates 3, 5 and 1, a moderate level of resistance to isolate 2, but were highly susceptible to the more aggressive isolates 4 and 6. These genotypes can be used to differentiate between isolates of lesser and higher aggressiveness. The third group, ILC 2956, 3279 and 5928 had a good level of resistance

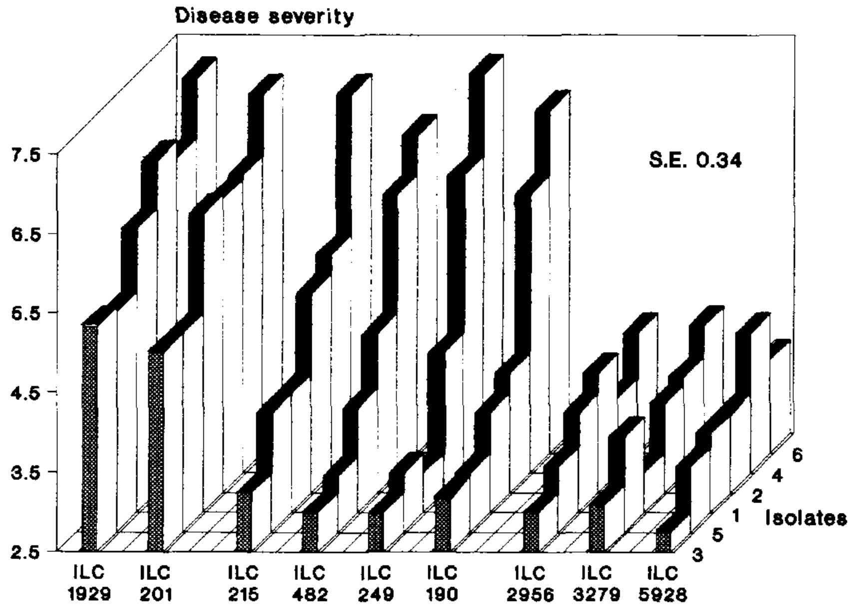

Figure 2.3.1. Host-pathogen interaction between 9 chickpea genotypes and 6 single spored isolates of Ascochyta rabiei. Disease severity was recorded on a single plant basis 9 days after inoculation on a 1-9 scale. Values are means of 4 replicates.

to all isolates. These results indicate that the host plants reaction in terms of disease development is of less qualitative but strongly quantitative nature. Using only 9 genotypes and 6 isolates almost all levels of disease severity were recorded. Taking into consideration the missing of reversal in ranking and strong quantitative nature of disease severity development it has to be concluded that the identification of different resistance genes, the number of which would be limited theoretically by the number of pathogen races, and subsequent combination of these in one genotype is not possible. For an efficient breeding strategy aiming at a high level of Ascochyta blight resistance, screening should be conducted against the most aggressive isolate 6 which was found also to be the most prevalent (40 out of 50 collected isolates) in Syria (REDDY 1985). Genotypes with resistance against this isolate will also be resistant against the other isolates.

2.3.2.3. Level of resistance in Ghab 1 and Ghab 2

Ghab 1 and Ghab 2 are two chickpea cultivars released in Syria, which were selected from ICARDAs germplasm collection and recommended for winter sowing because of their tolerance/resistance to Ascochyta blight. An experiment was conducted to check whether the level of resistance has changed in the cultivars in comparison to the original accessions in our germplasm collection. In Figure 2.3.2. the isolates are arranged according to increasing aggressiveness. ILC 482 and Ghab

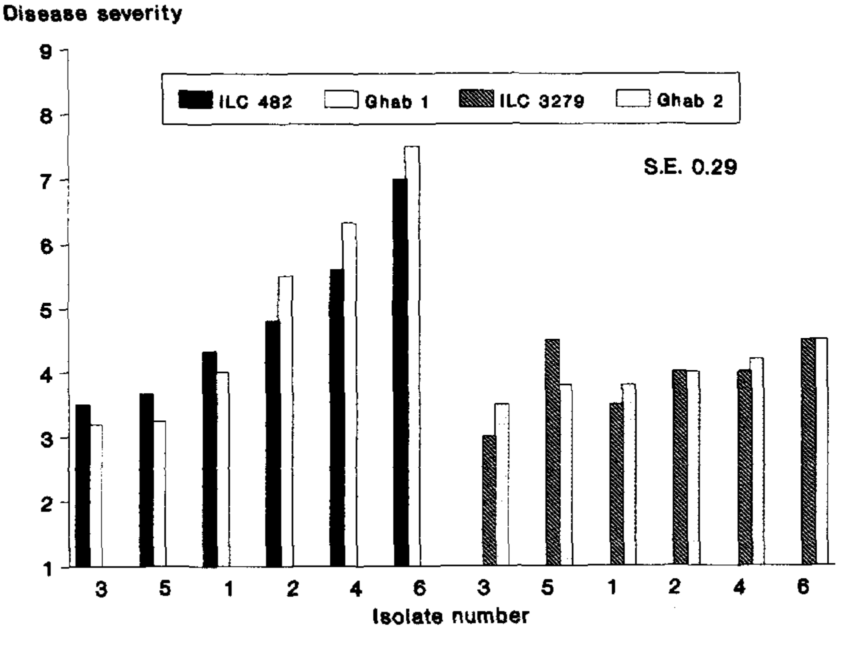

Figure 2.3.2. Comparison of Ghab 1 and Ghab 2 with ILC 482 and ILC 3279 with respect to their interaction with 6 isolates of Ascochyta rabiei. The values are means of 4 replicates.

1 showed a good level of resistance to the weaker isolates 3, 5 and 1, but were susceptible and highly susceptible to the more aggressive isolates 2, 4 and 6. In contrary ILC 3279 and Ghab 2 almost had the same degree of resistance to the weaker and the aggressive isolates. In both cases no significant differences were found between the released cultivars and the germplasm collection material.

Dr. Franz Weigand.

2.3.3. Epidemiology of Ascochyta rabiei

2.3.3.1. Effect of temperature on disease development

Temperature during the initial period of infection has a strong effect on the host- pathogen interaction and disease development. If minimum and maximum temperatures remained within the previously described limits of 6^{o} C and 30^{o}C in a walk-in growth chamber the disease developed well in both ILC 1929 and 3279 (Fig. 2.3.3). When the temperature exceeded 30^{o} C and reached up to 42^{o} C because of an accidental failure in the cooling system disease development was highly supressed in both genotypes (Fig. 2.3.3). This indicated that even when temperatures exceed the limits only for a short time, disease development is strongly affected. Thus it is necessary to continuously record the temperature in all experiments to be able to detect even short failures in the cooling/heating system which would affect the results.

2.3.3.2. Disease development modelling

Incorporating environmental factors such as duration of leaf wetness during the infection period, temperature and occurrence of rainfall

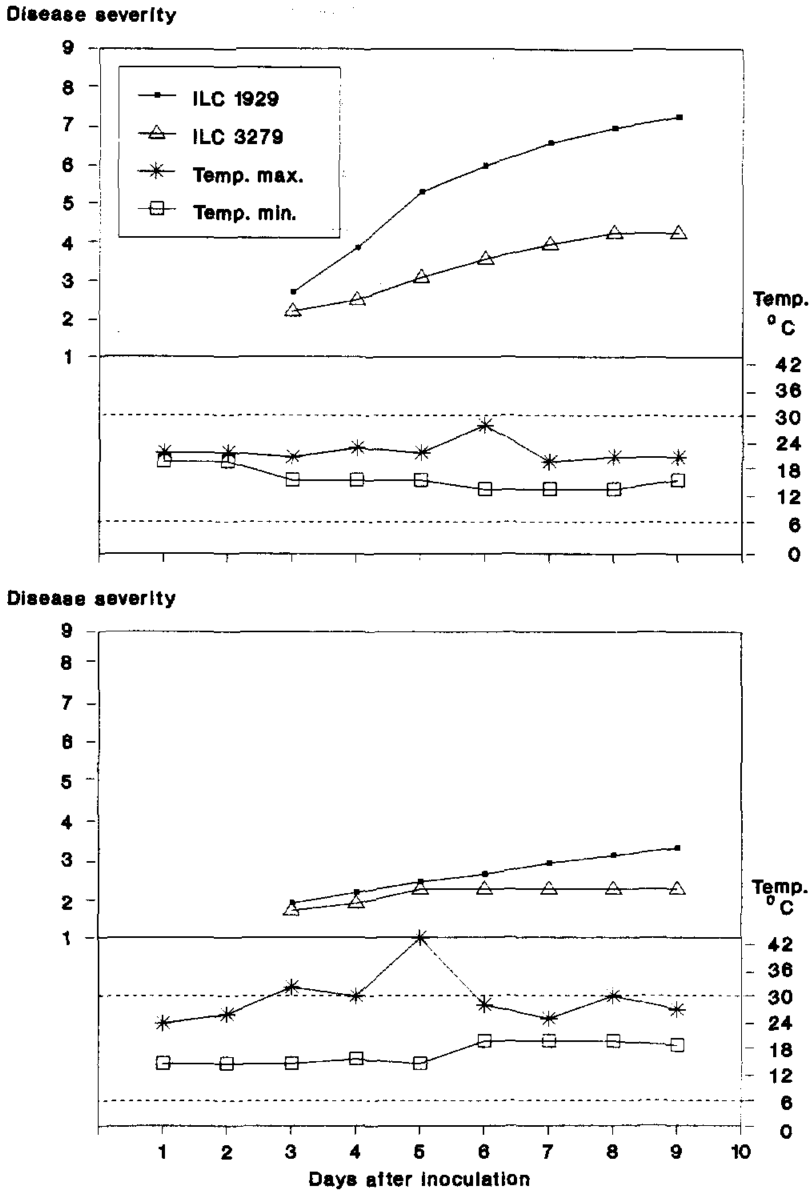

Figure 2.3.3. Effect of 2 different temperature regimes on disease development. Dotted lines in the lower parts of both graphics represent critical temperature thresholdes for disease development. Values are means of 5 replicates.

which opens the pycnidia releasing new spores for a new attack - in experiments would provide information needed for Ascochyta blight disease development modelling. Such a model would give the possibility to predict the performance of chickpea genotypes under different climatic conditions. In a first experiment conducted under controlled environmental conditions some genotypes x environment interactions were simulated. The initial infection of the 3 genotypes ILC 1929, 482 and 3279, using a weak isolate, was obtained according to the standard inoculation procedures. After a period of 19 days when the pathogen had become established in the host plant tissue, a new leaf wetness period of 48 hours was created, simulating rainfall. Both in ILC 482 and ILC 3279 chickpea disease severity did not increase following this booster infection, whereas in ILC 1929 a further increase in the disease was noticed which led to the complete killing of this line (Fig. 2.3.4). More genotypes, isolates, environmental condition combinations will be studied for longer periods in future studies.
Dr. Franz Weigand.

2.3.4. Integrated control of Ascochyta rabiei in chickpea

2.3.4.1. Phyllosphere microorganims for biological control of A. rabiei.

This study was carried out to evaluate the inhibitory effects of certain micro-organisms, that occur naturally in the phyllosphere of the chickpea lines, ILC 482, ILC 3279 and the Syrian local susceptible cultivar (ILC 1929) against A. rabiei.

Isolation of bacteria, filamentous fungi and yeasts were made from 100 leaflets, harvested from plants grown naturally in the field.

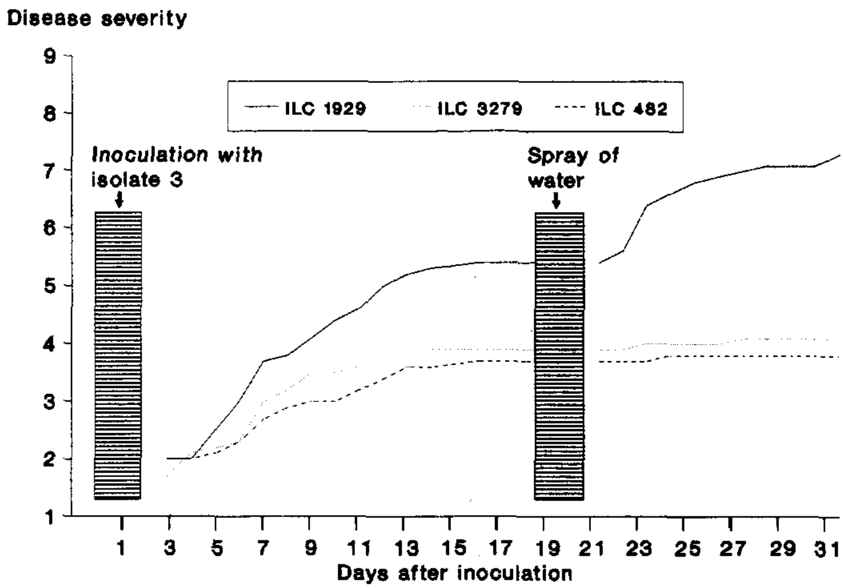

Figure 2.3.4. Influence of a second leaf wetness period (water) on disease development in three chickpea genotypes. For initial inoculation the weak isolate 3 was used. Values represent means of 10 replicates.

The surface of leaflets was rubbed while submerged in 300 ml of sterile distilled water, using a gentle brush. Isolation from leaflets washing were made on nutrient - agar (NA), acidified potato-dextrose-agar (APDA), and yeast-malt-extract-agar (YMEA), using the dilution plate technique. A total of 50 subcultures of common bacteria, fungi, and yeasts were purified and maintained to test their antagonistic effects against A. rabiei. The contents of ten petri dishes (2 wks-old) of each of the 50 micro-organisms were suspended separately in 500 ml of distilled sterilized water, and vacuum-filtered. A spore suspension containing 300,000 spors of race-6 of A. rabiei per ml of each of these vacuum filtrates was prepared. A spore suspension containing the same number of spores of A. rabiei was prepared in a chlorothalonile solution (50 mg a.i. per 100 ml of distilled sterilized water) for comparison. Another spore suspension containing the same number of spors of A. rabiei in sterilized distilled water served as a control. These spore suspensions were then plated separately on PDA, incubated at 20°C ± 2°C, then percent germination, germtube length, and pycnidial formation were measured under the microscope.

Chlorothalonil inhibited completely spore germination, germtube growth and pycnidial formation of A. rabiei. Bacterial filtrate-1, and fungal filtrates 1 and 2, were effective, but to a lesser extent (Table 2.3.6).

Table 2.3.6. The inhibitory effects of cultural filterates of certain micro-organisms from the phyllosphere of chickpea leaflets on spore germination and germtube development of Ascochyta rabiei on potato-dextrose agar.

	Spore germination[b] (%) (after 2 hrs.)	Length of germtube[c] (U) (after 12 hrs.)	Pycnidial formation[d] (after one week)
Chlorothalonil	*	*	*
Bacterial filterate-1[a]	*	*	**
Fungal filterate-1[a]	****	*	***
Fungal filterate-2[a]	*****	**	***
Water only	******	**	****

a. Bacteria-1, fungi 1 and 2 have been sent to Commonwealth Institute of Mycology, UK for identification.

b. * = 0-1%, ** = 1.1-10%, *** = 10.1-25%, **** = 25.1-50%, ***** = 50.1-75% and ****** = 75-100% germination.

c. * 0-1U, ** = 1.1-5U length of germtube.

d. * = No pycnidia, *** = Poor pyncidia formation, no spores, *** = moderate pycnidial formation, few spores, **** = abundant pycnidia and spores.

2.3.4.2. Effect of the bacterial filtrate-1 and chlorothalonil on Ascochyta blight in field

The effects of the bacterial cultural filtrate-1, chlorothalonil and their combination were tested for their ability to control Ascochyta blight on the tolerant (ILC 482) and susceptible (ILC 1929) chickpea lines in the field. The bacterial cultural filtrate-1 was prepared as described earlier. The fungicide chlorothalonil, which is recommended for the control of a wide range of Ascochyta-diseases, was used in this test at the rate of 100 mg a.i. per 100 ml of water, for comparison.

Chickpea plants were inoculated artificially at the 5% flowering stage with a spore suspension containing 250,000 spores of A. rabiei race 6 per ml of water, then immediately sprayed with different bacterial and chemical treatments. Chickpea plants were then sprayed with water three times per day (8Am, 1PM, and 5 PM) for one week, employing 25 ml of water per plant per spray. Chickpea plants received two additional bacterial and chemical treatments. The first treatment was made at the 100% flowering stage and the second at the 100% podding stage. A split plot design with chickpea lines in the main plot, and bacterial and chemical treatments in the sub plot was employed, with three replications. Disease readings were made three weeks after the second treatment using 1-9 scoring scale.

The results of this study (Fig. 2.3.5) showed a significant (P = 0.01) increase in disease severity from a low level on the tolerant line ILC 482, to a high level on the susceptible line ILC 1929 across all treatments. On ILC 482, the combination of bacterial filtrate-1

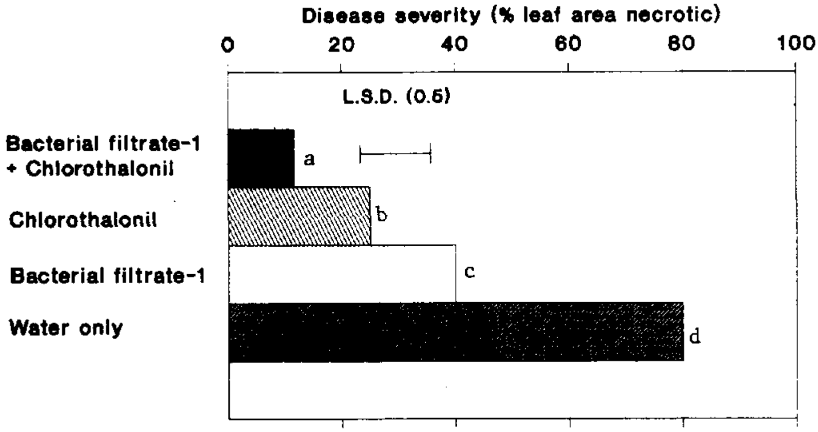

Figure 2.3.5. Effect of bacterial filterate-1 and chlorothalonil on the development of Ascochyta blight (mean of ILC 482 and ILC 1929 chickpea cultivars) in field. Columns with different letters are significantly different at P = 0.01 according to Duncan's Multiple Range Test.

and chlorothanil, suppressed significantly (P = 0.01) disease development, compared to chlorothalonil, bacterial filtrate 1 or water alone. Although disease reactions were greater on ILC 1929, similar trends were obtained with respect to treatment effects.

Additional work is needed to determine the chemical basis of inhibitory substances in bacterial filtrates-1. More work is also required to study the population dynamics of bacteria-1 in the phyllosphere of chickpea leaves.

Dr. S.B. Hanounik.

2.3.5. Survey of viruses affecting chickpea

One hundred and forty four samples showing either yellowing or yellowing in addition to stunting were collected from Syria and Lebanon. Samples were tested against beet western yellows virus (BWYV), bean leaf roll virus (BLRV) and chickpea stunt virus (CpSV) antisera. Forty-one samples gave a positive reaction with BWYV antiserum, 39 positive with CpSV antiserum and none reacted with BLRV antiserum. These preliminary results indicated the magnitude of variability that exists in what we commonly call chickpea stunt. Whether we have 2 or 3 distinct strains or different viruses requires further characterization, which is in progress.

Dr. Khaled Makkouk.

2.4. Chickpea Entomology

Studies on different control methods of the chickpea leafminer, Liriomyza cicerina were continued. Since podborers often are a major pest in southern Syria, experiments on the effect of cultural methods and different times of insecticide applications on podborer infestations were conducted at Izraa Research Station. With regard to storage pests a survey was carried out in Jordan and the screening for resistance, especially of the wild Cicer species continued.

2.4.1. Chickpea leafminer

2.4.1.1. Yield loss assessment

Leafminer damage and yield losses were measured in spring-sown chickpea at three on-farm locations (Alkamiye, Al-Ghab and Sheik Yousef) and at Tel Hadya. Because of the dry season the yields in general were low, especially at Tel Hadya and Sheikh Yousef. One spray of Thiodan 35 (1.5 ccm/l) at flowering or two sprays at pre-flowering and flowering stages significantly reduced the percent mining at Tel Hadya (Fig.2.4.1), but yield increases were not significant. Although at Alkamiye no differences were found in the mining the yield was significantly higher in the two insecticide sprays over control. In Al-Ghab and Sheikh Yousef the insecticide reduced the percent mining but yield increased significantly only at Sheikh Yousef. At all locations no differences existed in the percent mining between one or two sprays of the insecticide indicating that one spray at the right time is sufficient. The experiment also revealed that leafminer could cause significant yield losses in farmers fields in spring-sown chickpeas.

Dr. S. Weigand.

2.4.1.2. Chemical control of leafminer

As an alternative to the conventional insecticides the effectiveness of neem extract applications for leafminer control was studied. At early flowring 3 sprays (500 g neem seeds/10 l water; 500 l/ha) were made at weekly intervals. Check plots were sprayed with water. In the neem sprayed plots the percent mining was lower at both sampling dates but the yield increase was not significant (Table 2.4.1). This study will be continued to further test the efficiency of neem for leafminer control.

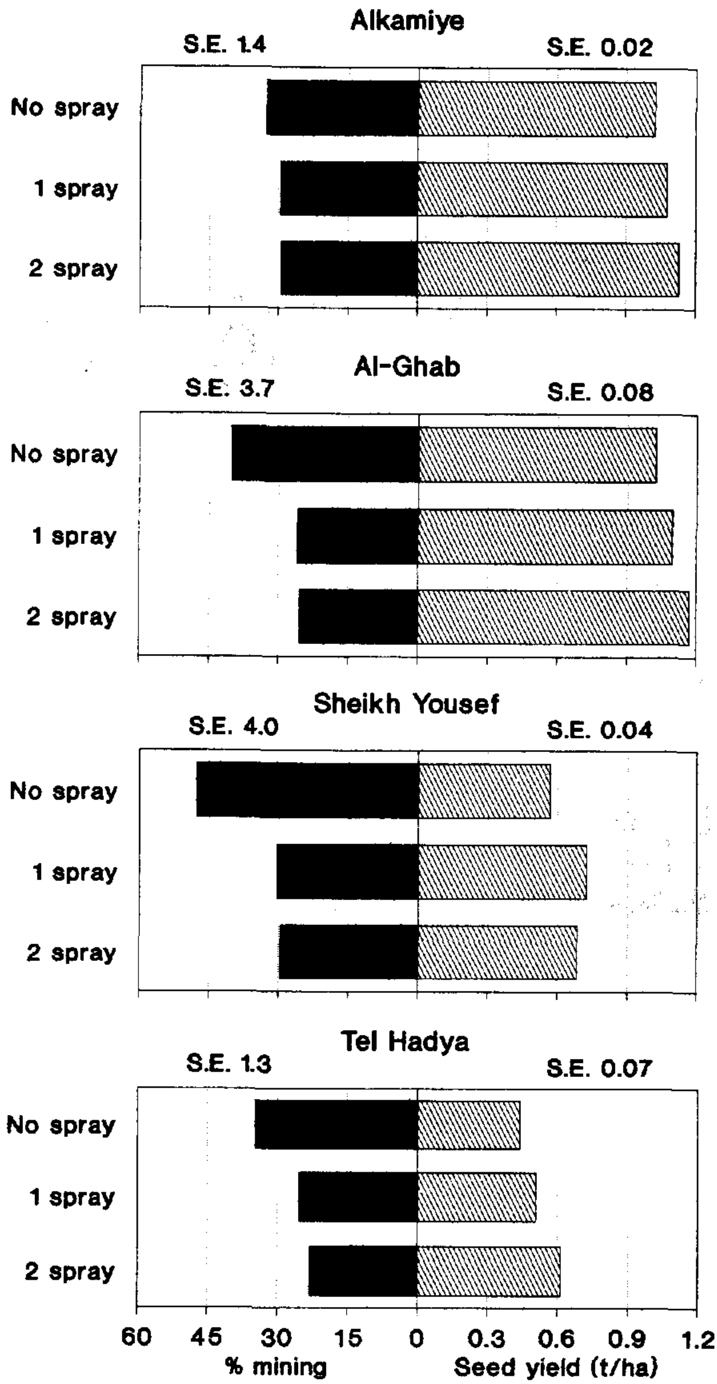

Figure 2.4.1. Effect of insecticide application (Thiodan 35 1.5ccm/l) on leafminer infestation and seed yield in chickpea at Tel Hadya and farmers fields, 1988/89.

Table 2.4.1. Effect of 3 applications of neem extract on leafminer infestation on 15 and 27 May 1989 and seed yield in chickpea, Tel Hadya.

Treatment	% mining 15/5	% mining 27/5	Seed yield kg/ha
Neem	29.7	45.8	477.2
Water	37.3	50.1	284.4
LSD (5%)	5.83	6.8	206.7
S.E.	1.83	2.1	80.4

2.4.1.3. Host plant resistance to leafminer

A number of chickpea germplasm lines were evaluated in a mass screening in the field under natural conditions, but no new resistant lines were identified. Only previously selected promising lines showed consistently low leafminer damage. To further relate the degree of resistance to the extent of damage and response to chemical control 8 resistant lines and local were grown without and with the protection of 1 and 2 insecticide applications. Because of the dry season however, yields were so low and inconsistent that no reliable data could be obtained.

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2.4.2. Chickpea podborer (Helicoverpa armigera and Heliothis spp.)

Although chickpea leafminer is the main insect pest occurring in high densities every year, podborer can also cause major damage in some years. In Syria chickpea is attacked by 3 species of podborer, Helicoverpa armigera (Huebner), Heliothis viriplaca (Hufnagel) and

Heliothis peltigera (Denis and Schiffermueller), of which the last occurrs only sporadically and is of minor importance. Observations during the last years showed that H. armigera and Heliothis spp. do not cause major damage in chickpea in northern Syria in most years; in southern Syria however, infestations often are high. During a survey in April 1989, a season with high infestations, mean pod infestations in farmers fields in northern Syria ranged between 6 and 13 percent as compared to 20 to 40 percent in the south (Table 2.4.2).

Table 2.4.2. Mean percent pod infestation of Helicoverpa armigera and Heliothis viriplaca in 2 chickpea cultivars in Syria in April 1989.

Province	Ghab 1		Ghab 2	
	No. of samples	% pod infestation	No. of samples	% pod infestation
Kamishly	3	4.3	6	2.6
Aleppo	6	6.1	4	10.0
Idleb	2	7.3	2	19.8
Hama	3	6.8	3	11.4
Homs	1	5.1	1	13.4
Tartous	1	2.3	1	2.0
Dara a	4	33.1	1	20.0
Suweida	2	21.9	1	40.9

Podborer population development and density was monitored by pheromone traps over 4 years (1986 to 1989) in southern Syria. Both H. armigera and H. viriplaca emerged in March/April. H. viriplaca had only one peak or generation and disappeared after 4 weeks, whereas H. armigera had 3 peaks and was present through harvest (Fig. 2.4.2). Temperature and rainfall had a great effect on the population. In

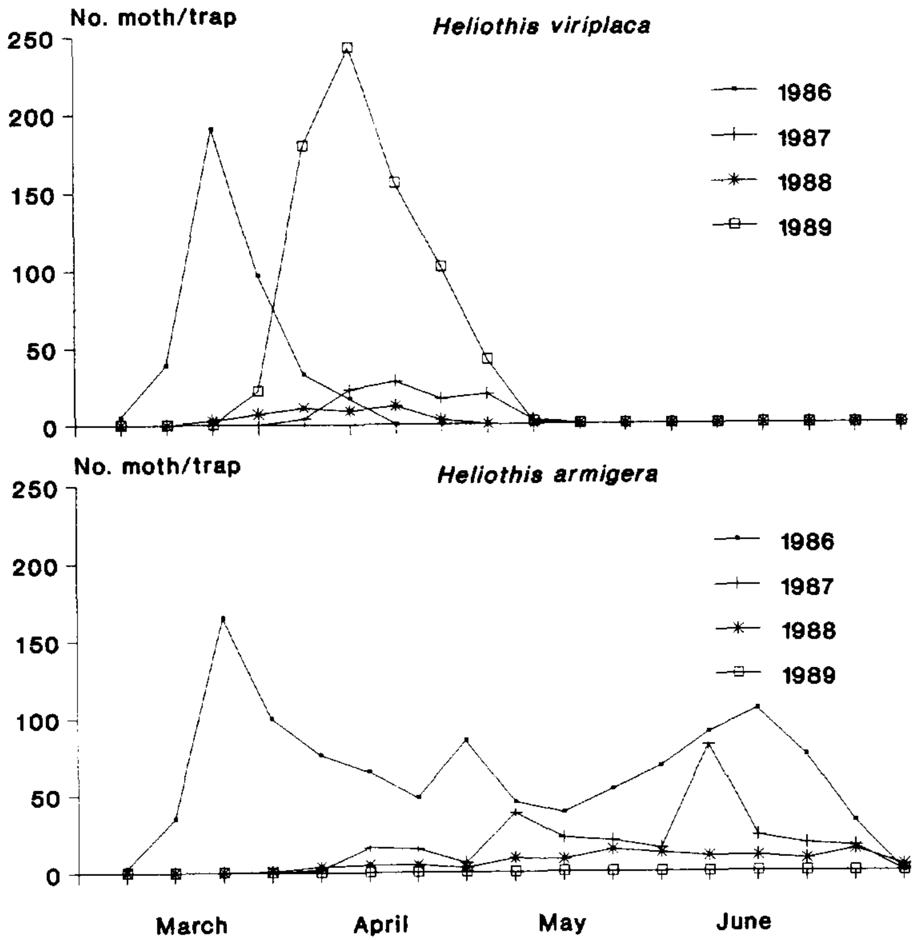

Figure 2.4.2. Pheromone trap catches of Heliothis viriplaca and Helicoverpa armigera during 4 seasons in southern Syria.

1986 and 1989 pheromone trap catches were high probably due to high temperatures and low rainfall during March/April. Low temperatures during March 1987 and high rainfall in spring 1988 resulted in low podborer population densities. Interestingly, only H. viriplaca was found in the pheromone traps as well as on the chickpea plants in 1989. The reason is not known and needs to be studied.

At Izraa Research Station in southern Syria experiments on some aspects of integrated control of podborer were conducted.

Winter sowing of chickpea might give an pportunity for an earlier build-up of populations of H. armigera and H. viriplaca resulting in higher infestations in the chickpea crop itself as well as in the following summer crops. Therefore the effect of 5 sowing dates (25 December, 18 January, 13 February, 9 March, 6 April) on podborer infestations in two chickpea cultivars- Ghab2 and Local was studied. Due to the extremely low and badly distributed rainfall this season (181 mm toal rainfall with 81 % during November to January) the chickpeas of the last 2 sowing dates did not produce any seed yield. The pod infestation was about 50 and 45 percent in the December and January sown crops, respectively, compared to significantly lower infestation of only 28 percent in the chickpeas sown in February (Table 2.4.3). No differences were found between the 2 cultivars. Inspite of the higher pod damage the yield of both varieties was highest in the first sowing date, because only the early sown chickpea could make full use of the limited rainfall. At all sowing dates yields of local cultivar were higher than those of Ghab 2 mainly due to the late maturity of the latter.

Experiment on effect of plant density in three cultivars of chickpea (Ghab 1, Ghab 2 and Local) showed that averaged overall the cultivars pod damage was lowest at the lowest plant density of 20 plants/m^2 (Table 2.4.4). The highest pod infestation was found in the highest plant density of 50 plants/m^2 in Ghab 1 and 2 and at the plant density of 25 plants/m^2 in the Local.

Table 2.4.3. Effect of 3 sowing dates on podborer infestation and grain yield of 2 chickpea cultivars, Izraa 1988/89.

Sowing date	% pod infestation Ghab 2	Local	Mean	Grain yield (kg/ha) Ghab 2	Local	Mean
25 Dec.	51.3	49.4	50.5	108.3	246.8	177.5
18 Jan.	45.7	44.5	45.1	85.5	199.0	142.3
13 Feb.	28.5	27.2	27.8	39.8	190.3	115.0
Mean	41.8	40.5		77.0	212.0	
LSD 5% for dates			5.72			15.47
cultivars			n.s.			22.0
2 dates at different cultivars			n.s.			27.8

Table 2.4.4. Effect of plant density on podborer infestation in 3 chickpea cultivars, Izraa 1988/89.

Plant density (Plants/m^2)	% pod infestation Ghab 1	Ghab 2	Local	Mean
20	34.0	42.4	36.4	37.2
25	39.0	42.9	48.1	43.3
33.3	41.1	47.6	42.8	43.9
50	43.5	51.1	43.9	46.2
Mean	39.4	46.0	48.8	
LSD 5% for plant density		3.52		
cultivars		3.31		
2 plant densities at different cultivar		6.21		

Experiment on determining the critical periods of application of Thiodan 35 (6 cm/l) to control podborer was conducted with two chickpea cultivars (Ghab 2 and Local). The number of larvae per plant, which was extremely high this season, and the respective stage of the crop at the time of insecticide application are given in Table 2.4.5. In Ghab 2 the insecticide application at flowering (13 April) resulted in the lowest pod infestation of 10.8% and highest yield of 210 kg/ha as compared to a 60% pod damage and 48 kg/ha yield in the untreated check. In the Local the lowest pod infestation (10.7%) and highest yield (356 kg/ha) were found in the earlier application date (10 April) which corresponded with flowering of the crop. Due to the high temperatures the podborer larval density increased so fast that the time intervals between the different dates of application had to be very short. Therefore no general recommendations for the economic threshold and best time of application can be concluded from this years results. All experiments will be repeated the next season.

Table 2.4.5. Podborer larval density and phenological stage of 2 chickpea cultivars at the time of insecticide application, Izraa 1988/89.

Date of application	No. of larvae/plant		Phenological stage	
	Ghab 2	Local	Ghab 2	Local
15 March	0	0	Vegetative	Vegetative
5 April	1.6	1.1	Vegetative	Early flow.
7 April	5.4	4.0	Vegetative	Flowering
10 April	9.2	7.8	Early flow.	Flow./early podsetting
13 April	10.1	10.2	Flowering	Podsetting
15 April	14.6	12.6	Flow./early podsetting	Podsetting

In the screening of 30 chickpea lines including 11 ICRISAT lines previously selected for resistance to podborer, the number of larvae per 5 plants ranged from 54 to 2, with the ICRISAT lines having the lowest infestations. The best ICARDA lines were FLIP 83-48, FLIP 83-98, and FLIP 84-15 with 17 larvae per 5 plants.

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2.4.3. Aphids

Aphis craccivora is the main aphid species feeding on chickpea and serving as an important vector of the pea leaf roll virus that causes chickpea stunt disease. Early in the season A. craccivora feed on chickpea only for a short time which is sufficient, however, for virus transmission. High aphid densities usually occur later in the season. Since this season differences in aphid infestations of different chickpea lines were observed, three chickpea lines with very low and one with high aphid infestation were selected to study a possible mechanism of resistance by measuring the pH of leaf washings. Six young and 6 middle aged leaves per plant were submersed in 40 ml de-ionized water and shaken for 10 sec to get leaf washings. The pH of leaf washings from the susceptible chickpea line ILC 1929 was higher than the values for the three resistant lines (Fig. 2.4.3). A higher pH correlated with a higher number of aphid colonies per plant. In all four chickpea lines the pH of the leaf washings of older leaves was higher than that of young leaves, indicating that the production of leaf exudates and malic acid might be decreasing with the aging of the leaves. Further studies under controlled conditions are underway to elucidate this mechanism.

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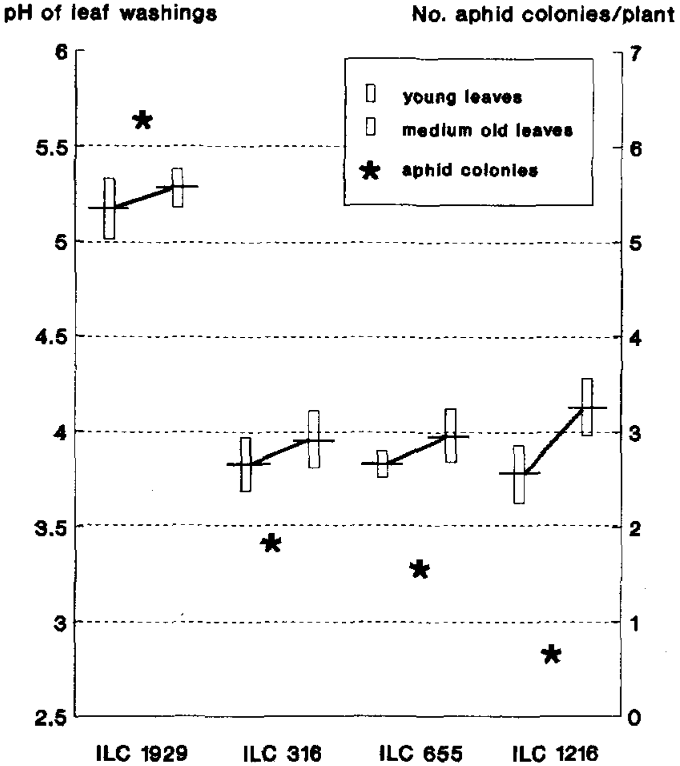

Figure 2.4.3. The pH of leaf washings and number of aphid colonies on 4 chickpea lines with different degrees of susceptibility to Aphis craccivora.

2.4.4. Storage pests

2.4.4.1. Host plant resistance

Resistance screening to Callosobruchus chinensis was continued in the laboratory with 2700 ILC accessions in 1989 and 250 lines of land races collected from Syria and Jordan. The percent infested seeds and number of progeny per female were recorded. Screening of a total of 6804 ILC accessions so far did not reveal any resistant lines, whereas 6 accessions of land races were found promising and will be re-tested. In a replicated trial for the reconfirmation of 61 accessions of 8 annual wild species of Cicer, 51 resistant accessions were identified with seed infestations ranging from 0-20% as compared to 100% for the susceptible check (Table 2.4.6).

Table 2.4.6. Evaluation of wild Cicer species for resistance to C. chinensis, 1989.

Cicer species	No. of lines tested	No. of lines Resistant	Susceptible	Mean % seed inf.* Resistant	Susceptible
C. bijugum	20	20	0	0.4	-
C. chorassanicum	1	1	0	20	-
C. cuneatum	3	3	0	3	-
C. echinospermum	3	3	0	0	-
C. judaicum	19	12	7	15	53
C. pinnatifidum	3	0	3	-	62
C. reticulatum	12	12	0	12	-

* Susceptible check as 100%

From the 51 resistant accessions 39 were selected for further studies in a replicated experiment. Based on the results obtained in the screening so far a rating scale for three main characters of C. chinensis infestation was developed (Table 2.4.7). The three characters are: eggs/female, progeny/female and % seed infestation with adults.

Table 2.4.7. Rating scale for three characters of C. chinensis infestation of chickpea.

Scale	Eggs/female & progeny/female	% seed infestation with adults
Highly resistant	<5	< 10
Resistant	5-10	10-30
Intermediate	11-30	31-60
Susceptible	31-40	61-80
Highly susceptible	>40	>80

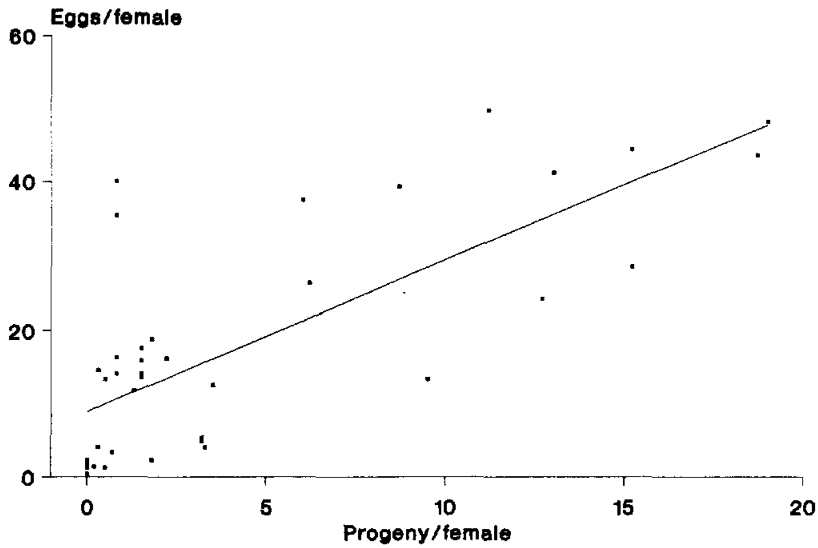

Figure 2.4.4. Reaction of 39 accessions of wild Cicer species to C. chinencis infestation in terms of eggs/female and progeny/female.

Figure 2.4.4 summarizes the results of the screening of 39 accessions of chickpea wild species, which showed that most accessions (61%) belonged to 2 groups: a) 12 accessions are highly resistant for both eggs/female and progeny/female b) 12 accessions are highly resistant for progeny/female and intermediate for eggs/female. Two accessions of C. cuneatum, ILWC 40 and ILWC 37/7 gave interesting results, as they were susceptible to eggs/female but highly resistant to progeny/female, which might be due to antibiosis. Further investigation of these two and the 24 accessions in group a and b will be conducted. Some of the highly resistant accessions have spiny seed coats, therefore, artificial seeds were prepared from flour to test their resistance when the above special morphological character has been excluded.

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2.4.4.2. Survey of chickpea storage pests in Jordan

Two weeks survey was conducted to identify the importance and distribution of actual and potential storage pests. From 53 villages in 7 provinces 66 seed samples were collected from farmers and merchants, of which 24% were infested. The highest infestation of 100% was found in Irbed. Among 1700 adults collected and identified, only 3 bruchid species (C. chinesis, C. maculatus, and Bruchus sp) were found. In addition 5 other storage pests were found which are mainly cereal pests such as Stegobium pariceum and Sitophilus granarius. The most common method of seed storage is to fill the seeds in jute sacks which are usually placed inside cement stores. Phostoxin is the most commonly used fumigant. When farmers and merchants were asked for factors affecting the selling price of chickpea according to their importance, they named first the presence of insects followed by seed size, cleanliness, color and cooking ability. The average price reduction due to insect presence was 27% when infestation was below 10% and 60% when it was more than 70%. Infested seeds are used for animal feed, sowing and poultry. None of the farmers interviewed treat their seeds before sowing while 64% of the farmers and merchants treat their stores and 40% apply foliar insecticides against Heliothis spp. and other foliar insects.

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2.4.4.3. Effect of Callosobruchus chinensis on seed germination

As the farmers in Syria and Jordan commonly use infested chickpea seeds for sowing, the effect of different levels of seed infestations by C. chinensis on seed germination was studied. Since 1 to 5 adults develop in one seed, each leaving one hole, chickpea seeds with 0, 1, 2, 3, 4 and 5 holes were tested. Germination of ILC 482 which was tested decreased from 99% for uninfested, to 97, 94, 86, 72, and 56% for seeds with 1, 2, 3, 4 and 5 holes, respectively.

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2.5. Chickpea Microbiology

2.5.1. Alternate inoculant carriers evaluation

The use of peat as a carrier for Rhizobium inoculants in many countries is hindered by its unavailability or high cost. The capability of soil to support survival of rhizobia implies that mineral soils, particularly if amended with carbon, could substitute for peat. Investigations were conducted to determine the ability of two soils containing >10% organic matter from the Ghab valley in Syria, with and without amendments of wood charcoal, to support rhizobial growth over time as compared to high quality Australian peat. In a series of three experiments, soil amended with charcoal proved equally effective to peat in maintaining high ($>10^9$ g^{-1}) populations of rhizobia nodulating chickpea over periods of 105-126 days. After a storage period of 280 days, two chickpea Rhizobium strains differing in growth rate maintained viable numbers in the soil-charcoal mixture above 10^8 g^{-1} (Table 2.5.1), indicating the suitability of this material as an inoculant carrier. The results imply that quality Rhizobium inoculants may be produced with some mineral soils and locally obtained materials where peat is not available.

Table 2.5.1. Growth of 2 rhizobia strains nodulating chickpea in two carrier materials at 27°C over a 30-week period.

Carrier	Rhizobium strain	Population CFU g^{-1} initial	15 weeks	30 weeks
Australian peat	CP 31	$2.0x10^8$	$4.0x10^9$	$2.7x10^9$
	CP 39	$1.9x10^8$	$1.3x10^9$	$3.4x10^9$
Ein Jourin soil + charcoal	CP 31	$1.6x10^8$	$2.0x10^9$	$3.0x10^8$
	CP 39	$3.0x10^8$	$5.0x10^9$	$2.5x10^8$

2.5.2. Nitrogen fixation in chickpea cultivars as influenced by Rhizobium strain

With movement of winter-sown chickpea into drier areas of the Mediterranean region, it is expected that locations previously not sown with chickpea will be utilized. Introduction of cold-tolerant, ascochyta blight resistant lines into new, drier production areas has been accompanied by nodulation deficiency in some areas. Soils in these new production areas are less likely than traditional chickpea areas to contain populations of the Cicer-specific rhizobia, and may show dramatic yield increases when plants are inoculated or nitrogen fertilized. The highly specific rhizobial requirements of chickpea has been found to extend to strain-cultivar specificity for N_2 fixation, implying the possibility that limited effectiveness of naturalized rhizobial populations with newly introduced cultivars may restrict genetic potential for dinitrogen fixation. Necessity for inoculation may therefore also exist where introduced cultivars, selected for high yields by plant breeders, cannot express their full capability for N_2

fixation in symbiosis with native rhizobial populations which have developed in coadaptation with local landraces.

In trials conducted over two seasons (1987/88 and 1988/89) in Tel Hadya, variations in N_2 fixation and yield of a range of chickpea cultivars inoculated with selected Rhizobium strains were evaluated with a view to establish base-line values for %Ndfa in recommended cultivars so improvements through rhizobial strain selection and legume breeding can be quantified. 15 N results have only been obtained from the 1987/88 trial, and are reported here.

Eight chickpea cultivars were chosen for the experiments based on their regional use and characteristics such as cold tolerance, tall-type plant architecture, ascochyta blight resistance and large seed size. Cultivars tested included ILC 195, ILC 482, ILC 3279, FLIP 83-98, FLIP 84-28, FLIP 84-46, FLIP 85-82 and FLIP 85-105.

Most probable number (MPN) measurements of indigenous chickpea rhizobia populations in the soil were low with 2.3×10^2 and 9.1×10^1 rhizobia g^{-1} soil respectively, for fields utilized in 1987/8 and 1988/89, due to absence of chickpea cultivation for several years. Due to extremely low rainfall during 1988/9 season (281 mm, poorly distributed) two supplementary sprinkler irrigations of 30 mm each were given. Rhizobia treatments comprised uninoculated and two strain treatments; the 1987/8 experiment included two single-strain inoculants (strains 31 and 39) while in the 1988/9 experiment a single-strain inoculant (strain 39) and a 3-strain mixture (strains 31, 39 and 61) were utilized. Strains were selected based on prior N_2-fixing performance on the concerned cultivars in aseptic hydroponic culture in greenhouse trials. Seeds were inoculated at sowing using liquid application method, at a rate to provide approximately 10^6 viable cells per seed. A nitrogen treatment of 120 kg N/ha applied as split dose of 60 kg/ha broadcast preplant and 60 kg/ha sidedress application at mid-anthesis was included in both experiments.

Two replicates of treatment plots (excluding N-fertilized treatments) contained a central microplot to which was applied 20 kg N/ha as 5% N^{15}-enriched ammonium sulfate spread evenly in solution over the entire microplot area 15 days after sowing. A non-nodulating Desi chickpea line as reference crop was sown in plots containing a central microplot of 1 x 1.5 m to which 100 kg N/ha as 1% N^{15}-enriched ammonium sulfate was applied evenly in solution after sowing.

Significant increases across cultivars in shoot dry mass and shoot N from inoculation treatments at mid-anthesis (Table 2.5.2) were translated into significant yield increases across cultivars both for seed and biological yield (Table 2.5.3). During 1987/88 strain 39 increased biological yield by 15% or 840 kg/ha and seed yield by 13% or 250 kg/ha over the uninoculated treatment. The strain mixture gave the largest Rhizobium response during the 1988/89 season, with a biological yield increase of 12% (250 kg/ha) and seed yield increase of 20% (100 kg/ha) over uninoculated treatment. Response to N fertilizer was observed both seasons for biological yield and for seed yield in 1987/88.

Table 2.5.2. Mid-anthesis sampling data averages of treatments for 8 cultivars, during two years.

Treatment	Shoot dry mass g/pl		Shoot N mg/pl		Nodule dry mass mg/pl	
	1987/88	1988/89	1987/88	1988/89	1987/88	1988/89
120 kg/N/ha	9.70a*	6.73a	252a	197a	116c	63c
Strain 39	9.71a	6.42a	254a	159bc	414a	345a
Strain 31/ mixture[1]	8.93a	6.39a	229a	166b	440a	411a
Uninoculated	7.21b	5.37b	188b	139c	212b	166b
CV %	19	26	25	28	38	50
S.E.	0.57	0.41	15	12	38	37
LSD .05	1.12	0.81	29	22	75	73

* Values with different letters indicate significant difference at P<0.05 using Duncans multiple range test.

1) Single strain inoculant consisting of only strain used during 1987/88; inoculant mixture of strains 31, 39, 61 during 1988/89.

Table 2.5.3. Harvest data averages for strain treatments over 8 cultivars during two years.

Treatment	Biological yield mg/ha		Seed yield kg/ha		Total N kg/ha	
	1987/88	1988/89	1987/88	1988/89	1987/88	1988/89
120 kg N/ha	6.01ab*	2.54a	2085a	496b	97a	
Strain 39	6.18a	2.16bc	2125a	432b	94ab	
Strain 31/mix[1]	5.82b	2.34ab	2086a	585a	90b	
Uninoculated	5.34c	2.09c	1857b	489b	80c	
CV %	21	17	24	26	36	
S.E.	0.136	0.10	44	33	2.2	
LSD .05	0.271	0.201	88	65	4.4	

* Values with different letters indicate significant difference at P <0.05.

Individual cultivars responded differently to different strains. When inoculated with strain 39 during 1987/88, cultivars ILC 482 and 3279 gave 909 kg/ha (47%) and 1248 kg/ha (73%) increases, respectively, in seed yield, but increased seed yield in other cultivars by only 100 to 250 kg/ha over the uninoculated treatments. During 1988/89, no significant seed yield increases due to inoculation within cultivars were observed, with low general yields (due to low available moisture). Increases from inoculation with the best strain treatment (strain mixture), however, ranged from 0 to 34% (0-180 kg/ha) for the 8 cultivars.

The measurement of crop nitrogen was an additional parameter utilized to evaluate the effects of inoculation, and significant increases across all cultivars were observed for inoculant and nitrogen treatments during 1987/88 season (results for 1988/89 not available). Increases on individual cultivars due to inoculation with strain 39 ranged from 38 kg N/ha (ILC 482) to 4 kg N/ha (ILC195), with an average increase of 14 kg N/ha over all cultivars.

Differences in total crop nitrogen were however found to be somewhat misleading when proportions of crop N derived from dinitrogen fixation were considered (15N data for 1988/89 not available). Over all cultivars, strain 39 increased N fixed by an average 15 kg/ha while strain 31 increased N fixed by 19 kg/ha over the uninoculated treatment. In Figure 2.5.1 proportions of crop N derived from fixation and from soil for inoculated (strain 39) and uninoculated treatments for six cultivars are shown. Cultivars ILC 482 and 3279 clearly showed

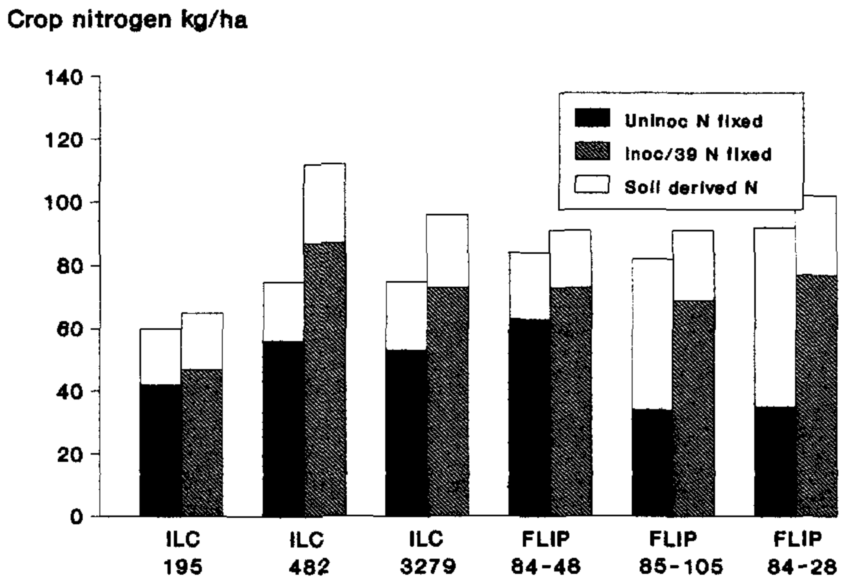

Figure 2.5.1. Proportions of crop N derived from fixation and from soil under inoculation with Rhizobium strain 39 and no inoculation in six cultivars of chickpea. Tel Hadya, 1987/88.

response to inoculation in terms of total crop N, while the other four cultivars shown did not. However, cultivars FLIP 85-105 and 84-28 both had very low levels of fixation with the native soil bacteria, and responded significantly to inoculation with strain 39 by fixing more nitrogen. Nitrogen fixation in cultivars FLIP 84-28 and 85-105 increased by 49 and 46 kg N/ha, respectively, when inoculated, more than doubling quantities of N derived from fixation. This effect of inoculation is not observable unless dinitrogen fixation is measured directly (as with 15N dilution technique).

The three cultivars shown in Figure 2.5.2 gave no total crop N response to inoculation, but demonstrate the degree of symbiotic efficiency between cultivars and the native and inoculant strains. Cultivar FLIP 83-98 was shown to be a poor N-fixer both with native strains and strain 39. This cultivar did however respond to strain 31, illustrating the large degree of cultivar-strain specificity found within the experiments. Cultivar FLIP 85-105 fixed only approximately 40% of total N with native strains, but responded significantly to inoculation, with strains 31 and 39 improving the symbiosis to approximately 80% efficiency (Figure 2.5.2). Cultivar FLIP 85-82 produced a highly efficient symbiosis with native rhizobia and strain 39, but fixation was depressed by strain 31.

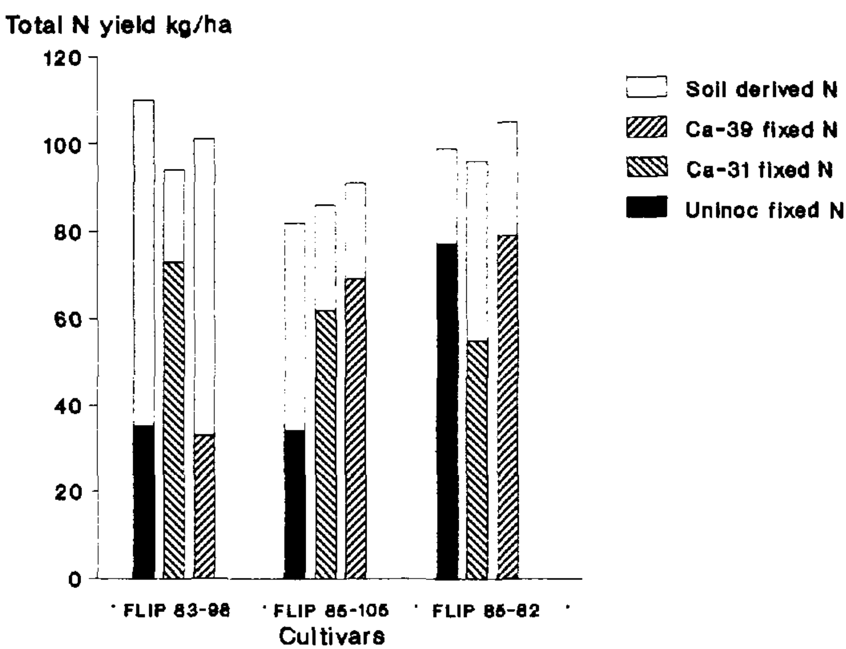

Figure 2.5.2. *Rhizobium* strain x host genotype interaction affecting total N yield and proportions of nitrogen derived from soil and from fixation in chickpea. Tel Hadya, 1987/88.

The range of symbiotic response to inoculation is best shown in Figure 2.5.3. ILC 482 produced an effective symbiosis with indigenous rhizobia (>80% N derived from fixation), but responded with increased N fixed and total N when inoculated. FLIP 83-98 produced high total crop N, but at the expense of soil nitrogen, from which approximately 60% of crop N was derived in both inoculated and uninoculated treatments. Symbiotic efficiency of FLIP 84-28 with native rhizobia was low, but increased dramatically with inoculation though without an accompanying increase in total crop N. The two latter cultivars demonstrate the ability of the plant to compensate for poor fixation by uptake of soil N, masking symbiotic efficiency.

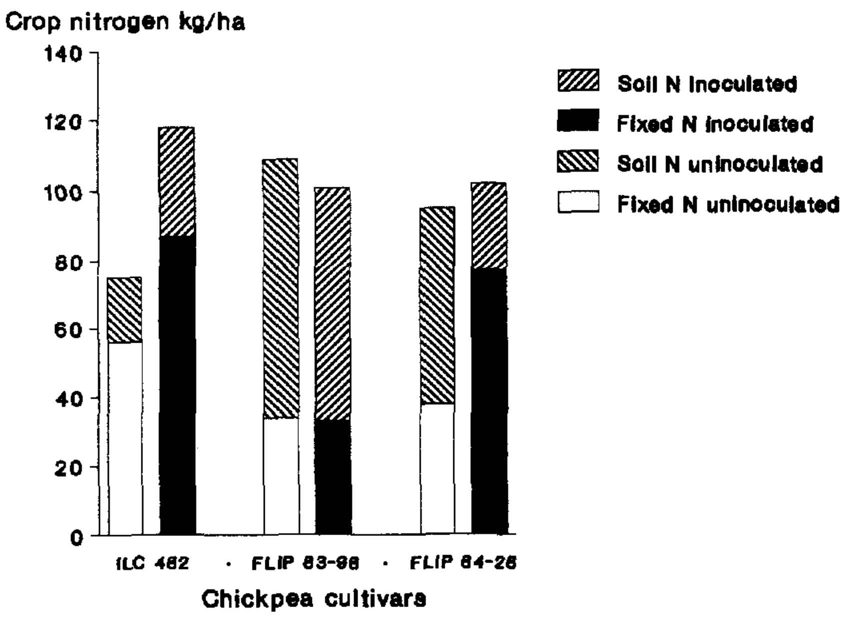

Figure 2.5.3. Response of three cultivars of chickpea to inoculation in terms of total crop nitrogen yield and the proportions derived from soil and from fixation. Tel Hadya, 1987/88.

Nitrogen fixation data from 1988/89 experiment (a dry year) and international trials will further indicate the capability of chickpea cultivars to fix N under varying agroenvironments, and quantitatively indicate the effects of inoculation with selected superior strains. The large degree of strain-cultivar interaction indicated in these experiments demonstrate that strain selection experiments, conducted in soil, are an essential prerequisite to an inoculation program.

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2.5.3. Chickpea VA-mycorrhiza studies

Research on vesicular-arbiscular mycorrhiza (VAM) in food legumes concentrated in 1988/89 season on a field trial, which was set up to investigate, if- under field conditions- a mycorrhizal crop differs in P-uptake, growth and yield from a non-mycorrhizal crop; model crop was chickpea as in previous experiments.

In general, all arable soils are populated by VA-mycorrhizal fungi. Therefore this indigenous population in the field first had to be eliminated (by soil sterilization with DAZOMET) to grow a mycorrhiza - free crop - the respective mycorrhizal crop was established by inoculating the plants grown on sterilized soil with indigenous VA-mycorrhizal fungi.

At flowering stage the spring sown chickpea crop grown on low-P soil showed a strong dependence on VAM; P-uptake and shoot biomass of plants increased as VA-mycorrhizal root length increased - unaffected by the total root length/plant (Fig. 2.5.4).

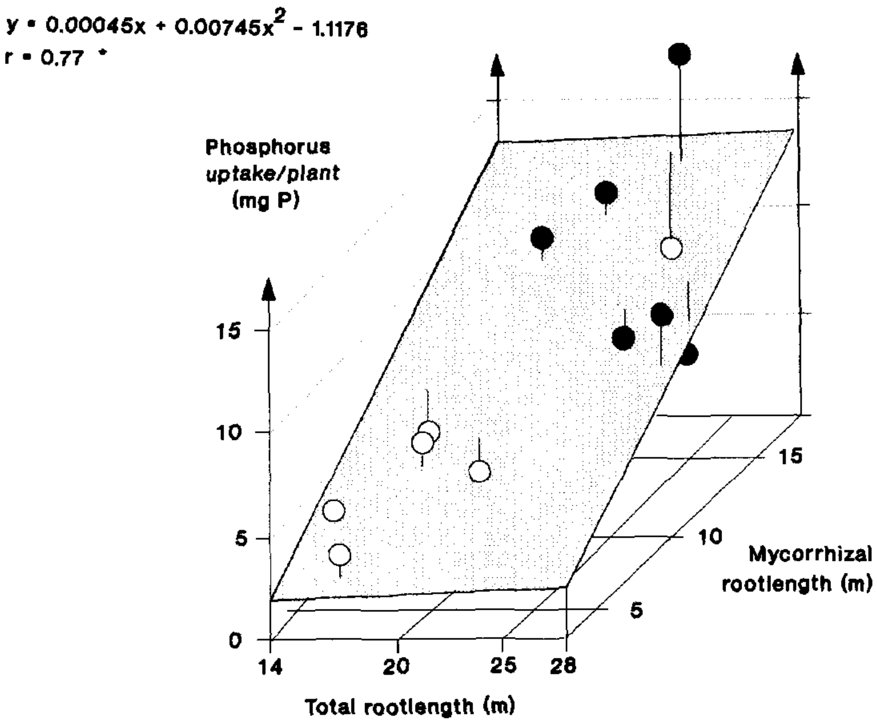

Figure 2.5.4. Phosphorus uptake as a function of total vs. VA-mycorrhizal root length.

Plants fertilized with P (60 kg P/ha) showed no significant dependence on either mycorrhizal or total root length. Unfertilized (and VAM-inoculated) plants with an extensive mycorrhizal root system had a P-uptake and shoot biomass similar to P-fertilized plants. But increased P-uptake or biomass at flowering did not reflect in higher seed yield. The spring sown crop suffered from severe drought during pod filling - it was found that variation in seed yield therefore depended mostly on the root density in the subsoil. One should expect that winter-sown crop can utilize an early advantage in growth better as it is less affected by terminal drought.

It is concluded that a chickpea crop can benefit significantly form VAM, when the P-availability in the soil is limiting crop growth. Mr. Edwin Weber, and Dr. M.C. Saxena.

2.6. Chickpea Physiology and Agronomy

2.6.1. Evaluation of spring sown chickpea for drought tolerance

In the Mediterranean basin (North Africa, West Asia and South Europe) rainfall is during the winter months; but chickpea is normally sown in spring because the traditional varieties are susceptible both to ascochyta blight and cold. The crop therefore depends mainly on the conserved moisture which is progressively depleted with crop growth. From late vegetative stage until maturity the crop experiences ever increasing evaporative demand because of development of high leaf areas and high temperatures. The spring sown chickpea crop, therefore, experiences considerable drought stress and produces low yield. A study was initiated to identify in spring sown chickpea attributes that contribute most to high and stable yield under drought. The attributes identified should permit further improvement in yield if moisture supply is improved. As in the previous seasons, a line-source sprinkler system was used to create a soil moisture gradient which permitted evaluation of genotypic response to variable moisture supply. Twenty diverse chickpea cultivars differing in origin, phenology, seed size, growth habit, height and yield were used. The cultivars included both desi and kabuli types, and landraces and crosses made at ICARDA. The season was drier than normal and the rainfed crop experienced greater drought stress than would be experienced in normal years.

Phenology: The number of days from sowing to different phenological stages varied among genotypes. ICC 82001 flowered earliest, followed by ICC 4958, Annigeri, ILC 1272, ILC 262, ILC 1929 and ICC 10991. FLIP 84-80C, FLIP 83-4C, FLIP 85-49C and FLIP 83-2C were the last to flower. This clearly indicates that among the lines tested material from India are early flowering and the land races from the Mediterranean basin intermediate and ICARDA crosses are late flowering. In the driest treatment, there were less variations in time to maturity among the genotypes from the Mediterranean basin and crosses made at ICARDA but the material from India were early (Table 2.6.1). Irrigation delayed maturity.

Table 2.6.1. Number of days from sowing to different stages of development of chickpea sown on 26 February, 1989 at Tel Hadya.

Genotype	Days from sowing to			
			Maturity	
	Emergence	Flower	Rainfed	Irrigated
ILC 100	12	57	80	96
ILC 262	12	52	77	95
ILC 464	12	56	80	96
ILC 623	12	56	83	96
ILC 624	12	56	81	96
ILC 1919	11	54	81	92
ILC 1272	11	51	77	95
ILC 1929	12	52	75	89
ILC 1930	12	56	80	92
K - 850	12	58	83	92
FLIP 82-73C	12	57	80	96
FLIP 83-2C	12	63	79	92
FLIP 84-80C	11	59	84	97
FLIP 85-4C	12	62	80	97
FLIP 85-49C	11	62	85	99
ICC 4958	12	48	76	92
ICC 10448	12	56	79	89
ICC 10991	12	53	79	92
ICCL 82011	11	44	67	84
Annigeri	12	51	76	92

Effect of water deficit on yield: The yields in the driest treatment (280 mm moisture supply) were very low but varied significantly ($P < 0.05$) among the cultivars, with seed yield ranging from 0 kg/ha in FLIP 83-2C, FLIP 84-80C and FLIP 85-4C to 635 kg/ha in ICC 4958 and 658 kg/ha in Annigeri (Table 2.6.2). For straw yield the range was from 630 kg/ha in Annigeri to 1885 kg/ha in FLIP 84-80C. Biological yield ranged from 781 kg/ha in ICC 10448 to 1885 kg/ha in FLIP 84-80C (Table 2.6.2).

All variables measured were correlated with seed yield and the important correlations are shown in Table 2.6.3. In the driest treatment, early phenology appeared to be the most important attribute for high seed yield. The results also indicate that cultivars that give high seed yield in the dry treatment are also responsive to increased moisture supply (Tables 2.6.2 and 2.6.3).

The methodology of Bidinger _et al_ (1987) for terminal stress in pearl millet was followed for further quantification of response of genotypes to drought stress. The approach takes into account the time of flowering (F) and potential yield (Y_1, non stress yield) to predict the yield under stress (Y_0) as shown by the following equation:

$$Y_0 = a + bY_1 + cF$$

From the above the drought response index can be calculated as follows:

$$\text{Drought response index (DRI) (standard residual)} = \frac{Y_0 - Y_0}{\text{Standard error of } Y_0}$$

where Y_0 = stress yield
Y_0 = regression estimate of stress yield

Table 2.6.2. Seed yield in kg/ha (SY), biological yield in kg/ha (BY), total water use (Et) and water use efficiency (WUE) of some spring chickpea genotypes grown in the driest (280 mm water) and wettest (470 mm) conditions at Tel Hadya, 1988/89.

Cultivar	Driest treatment					Wettest treatment				
	Yield		Et (mm)	Water use efficiency (kg/ha/mm Et) for		Yield		Et (mm)	Water use efficiency (kg/ha/mm Et) for	
	SY	BY		SY	BY	SY	BY		SY	BY
ILC 100	0	1180	147.9	0	7.98	1163	5593	396.2	2.94	14.12
ILC 262	395	1955	144.5	2.73	13.53	2083	5083	379.9	5.48	13.38
ILC 629	40	1283	161.4	0.25	7.95	1228	4807	357.0	3.44	13.47
ILC 1272	172	1340	158.0	1.09	8.48	2058	5135	352.2	5.84	14.58
ILC 1919	257	1337	162.1	1.59	8.25	1885	4475	356.5	5.29	12.55
ILC 1929	175	1013	158.1	1.11	6.41	1943	4747	369.6	5.26	12.85
ILC 1930	83	852	157.4	0.54	5.51	1822	4590	357.6	5.10	12.84
FLIP 82-73C	32	1583	152.4	0.21	10.39	1370	5258	373.6	3.67	14.07
FLIP 85-4C	0	1092	143.1	0	7.63	598	5687	388.9	1.54	14.62
ICC 4958	635	1310	154.3	4.12	8.49	2467	4688	333.1	7.41	14.07
ICC 10448	205	781	149.3	1.37	5.23	1688	3662	358.2	4.71	10.22
ICCL 82001	573	1218	133.2	4.30	9.14	1565	3673	295.1	5.30	12.45
ANNIGERI	658	1288	162.9	4.04	7.91	1875	3607	348.9	5.37	10.34
K-850	85	1003	161.5	0.53	6.21	1900	4555	377.7	5.03	12.06
ILC 464	27	1175				1237	5423			
ILC 623	40	1283				1200	5615			
ICC 10991	352	910				1715	3535			
FLIP 84-80C	0	1885				1040	4503			
FLIP 83-2C	0	1478				1190	4122			
FLIP 85-49C	7	1833				513	5008			
LSD (5%)	287	778				455	1022			
SE	101	275				161	360			
CV (%)	18.2	42.5				21.0	15.4			

Table 2.6.3. Correlations between seed yield in the driest treatment and some traits in spring sown chickpea, Tel Hadya, 1988/89.

Traits	
Days to flower	-0.61***
Days to mature, driest treatment	-0.58***
Straw yield (kg/ha) driest treatment	-0.14
Seed yield (kg/ha) wettest treatment	0.44***

The results showed that time to flowering and yield potential accounted for 66.5% of the variation in grain yield. The drought response index (DRI) was designed to provide an estimate of genotypic response to drought stress. For the identification of susceptible and tolerant genotypes, a threshold value (standard residual = DRI) of 1.3 was chosen, as it selects genotypes in the upper and lower 10% of the normal distribution of the stress yield. A genotype is considered to have no (zero) response to stress if the predicted yield value in the drought stress treatment is within the limits of 1.3 DRI; and has a real (non-zero) response if the value is > 1.3. A positive sign indicates that a genotype performed better than expected and a negative sign indicates that a genotype performed poorer than expected (Table 2.6.4). The results show that the measured yields in stress of 17 cultivars were adequately estimated by their time to flowering and yield potential (non stress yield) (Table 2.6.4). The remaining cultivars (ICC 4958, Annigeri and ILC 1272) had a different response to stress.

Table 2.6.4. Drought response index (DRI) for seed yield of spring sown chickpeas. Tel Hadya, 1989.

Genotype	DRI	Genotype	DRI
ILC 100	-0.97	FLIP 85-4C	0.63
ILC 262	0.67	FLIP 85-49C	0.69
ILC 464	-1.00	ICC 4958*	1.34
ILC 623	-0.88	ICC 10448*	0.40
ILC 629	-0.90	ICC 10991*	0.64
ILC 1272	-1.39	ICCL 82001	-0.38
ILC 1929	-1.06	ANNIGERI*	2.44
ILC 1930	0.56	K-850	0.07
FLIP 83-2C	0.94	ILC 1919	0.20
FLIP 84-80C	-0.29	FLIP 82-73C	-0.65

* Desi type.

Seed yield obtained from the driest treatment was regressed on seed yield potential (non-stressed yield), time to flowering and DRI for evaluating the contributions of each of the three factors in explaining grain yield under stress. Time to flowering was the major factor, explaining 67% of the variation in yield in the stress treatment and potential yield explained 35% of the variation. DRI explained 26% of the variation in stress yield, despite the fact that 17 out of 20 genotypes had DRI values less than 1.3.

Some of the components of yield measured were correlated with DRI, so as to determine whether they are advantageous under stress than others (Table 2.6.5). There were significant correlations between DRI and pods/m^2 and seeds/m^2 on the other. This indicates that the ability to produce a large number of seeds or pods/m^2 under stress was a good predictor of a low sensitivity to drought.

Table 2.6.5. Correlation of drought response index and yield components measured in the stress.

Primary branches/plant	0.15
Straw yield/m^2	-0.22
Pods/m^2	0.50*
Seeds/pod	0.01
Seeds/m^2	0.55**
100 seed weight	0.04

* $P \leq 0.05$, ** = $P \leq 0.01$

Effective rooting depth, crop water use and water use efficiency: Spring chickpea as mentioned earlier depends on stored water. The availability of the stored moisture depends on the ability of the root system to explore the soil profile and extract it. In this study changes in the maximum depth of water extraction, sometimes referred to as effective rooting depth were examined in all genotypes in the driest and wettest treatments and results of some of the genotypes are given in Figure 2.6.1. The general pattern was similar, as the season progressed, water was extracted further down the soil profile. The maximum depth of water extraction, however, varied among the genotypes. In both the driest and wettest treatments, ILC 1919, ICC 4958 and Annigeri extracted water at greatest depth than other genotypes. The latter two genotypes were shown earlier to have real response to drought other than through phenology and yield potential Table (2.6.4).

Table 2.6.2 shows total water use (E_t) and water use efficiency of 14 cultivars. In the dry treatment total water use ranged from 133.2 mm in ICCL 82001 to 162.9 mm in Annigeri. For seed yield, the following early flowering lines had high water use efficiency (WUE):

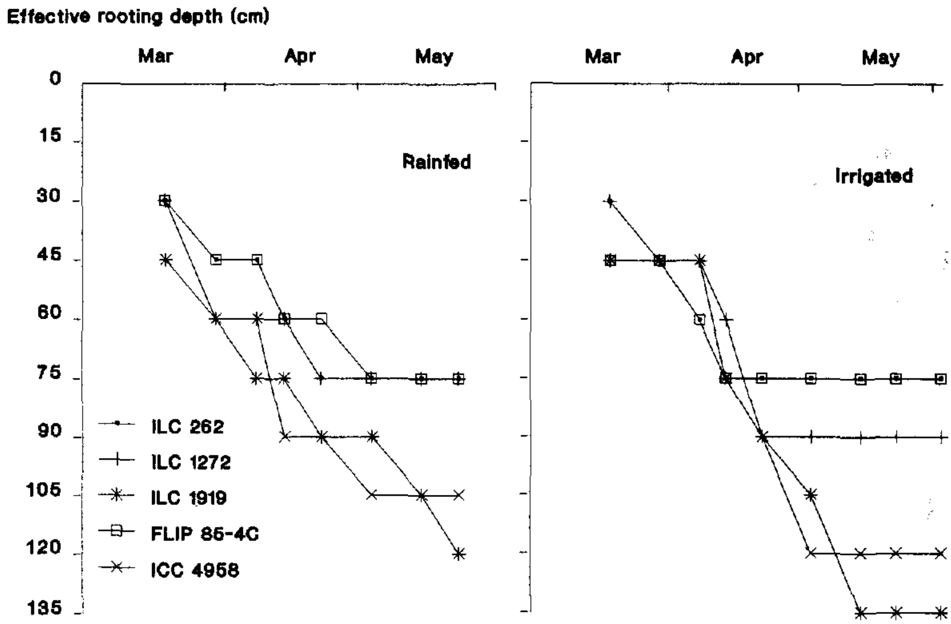

Figure 2.6.1. Effective rooting depth of five cultivars of chickpea under rainfed and irrigated conditions; Tel Hadya, 1988/89.

ICC 4958, ICCL 82001 and Annigeri (Table 2.6.2). It may be recalled that both ICC 4958 and Annigeri had high drought response index.

Conclusion: The results of the last three seasons of the study show that in rainfed spring-sown chickpea, one of the major determinants of high seed yield is early flowering, associated with phenological plasticity; the latter permits the crop to respond positively when moisture supply is increased. The results also in addition showed that other than earliness and potential yield, some cultivars e.g. ICC 4958 had different response to drought. These cultivars had deep root system, which possibly permitted the crop to continue extracting water late in the season. Genotypes that showed different response to drought will be investigated further during the 1989/90 season to determine the mechanism of their resistance to drought.

2.6.2. Yield response to increase in moisture supply

The line-source sprinkler system, by applying moisture gradient, permitted screening genotypes for their response to increase in moisture supply. Seed yield of all 20 chickpea cultivars showed a linear increase with the increase in moisture received (Figure 2.6.2). There were, however, significant differences among the genotypes in their response. The most responsive cultivars were ILC 1272 (9.57 kg/ha/mm), K 850 (9.38 kg/ha/mm), ILC 1929 (9.27 kg/ha/mm), ICC 4958 (9.24 kg/ha/mm), ILC 1930 (9.19 kg/ha/mm) and ILC 262 (9.09 kg/ha/mm); and the following were least responsive to increase in moisture supply: FLIP 85-4C (3.10 kg/ha/mm), FLIP 85-49C (3.31 kg/ha/mm) and ICCL 82001 (5.01 kg/ha/mm).

Straw yield in all the cultivars also exhibited a linear relationship with the amount of moisture received. The genotypic differences were again significant. FLIP 85-4C (a late flowering line, with very low response in seed yield to increased moisture supply) was most responsive to irrigation (19.94 kg/ha/mm) (Figure 2.6.2). The cultivars with high seed yield response to increase in moisture supply exhibited medium to low response in straw yield. These included ILC 1272 (9.24 kg/ha/mm), K 850 (6.66 kg/ha/mm), ILC 1929 (8.22 kg/ha/mm), ILC 1930 (7.93 kg/ha/mm), ICC 4958 (8.42 kg/ha/mm).

Drs. S.N. Silim, M.C. Saxena, and K.B. Singh.

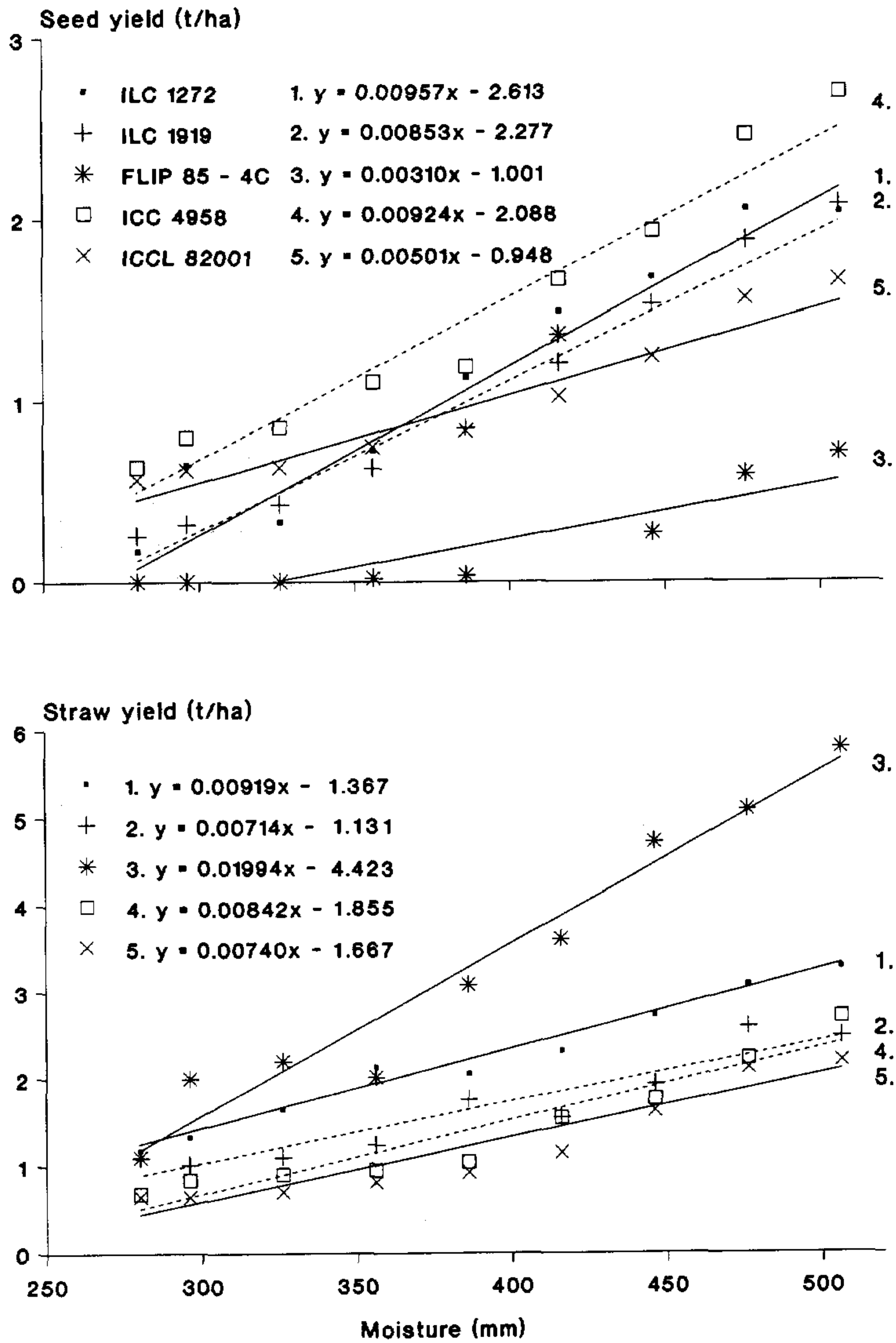

Figure 2.6.2. Relationship between moisture supply and seed and straw yields of chickpea. Tel Hadya, 1988/89.

2.7. Economic Feasibility of Winter Sowing

A survey of 31 farmers in Syria who had sown chickpea during winter and spring on more than one hectare plot was conducted. Winter-sown Ghab 1 and Ghab 2 was present on 23 and 14 sites, respectively. The economic return for 1988/89 based on the information collected during the survey is shwon in Table 2.7.1. The gross returns from winter-sown Ghab 1 and Ghab 2 exceeded the spring-sown local. The cost of production of winter-sown chickpea was higher than that of spring-sown crop because of expenditure on weed control, but the expenditure on other items was nearly the same. After deducting the cost, the net returns from Ghab 1

Table 2.7.1. 1988/89 chickpea budgets based on yield data from farmer-managed on-farm trials with large (>1 ha) plots and economic survey of farmers producing both spring and improved winter crops in Syria.

	Spring local	Winter	
		Ghab 1	Ghab 2
No. of farmers	31	23	14
Seed yield (kg/ha)	741	1028	866
Sale price (SL/kg)	13.9	13.1	
Sale value (SL/ha)	10323	13467	11345
Cost (SL/ha)			
Tillage	820	740	
Seed and seedling	1731	1292	
Fertilizer	543	588	
Weed control	417	1161	
Insecticides	488	424	
Harvest operations	1895	1932	1830
Total variable costs	5894	6137	6035
Profit	4429	7330	5310
Profit/cost ratio	0.75	1.19	0.88

and Ghab 2 were 65% and 20% higher than spring-sown local, respectively. Because of dry weather the productivity of Ghab 2 was very low.

Survey of winter chickpea has been conducted for three years. The margin of profit was much higher during the first two years. In general, it can be concluded from these surveys that winter-sown chickpea not only produces 60 to 70% more seed yield over spring-sown chickpea, but it is also 60 to 70% more profitable to grow.
Drs. K.B. Singh, T. Nordblom and M.C. Saxena.

2.8. CHICKPEA QUALITY

The objectives of the chickpea quality project are (1) to screen world germplasm for protein content and cooking time, (2) to find out various usage of chickpea through survey of the region, and (3) to provide assistance to the breeding program to develop genotypes with improved seed quality.

2.8.1. Protein content in newly developed lines

All new lines grown during winter and spring were evaluated for protein content. There was little effect of season of sowing (Table 2.8.1), Mean protein content was 22.82% during winter and 21.55% during spring. But, whereas only five lines had less than 20% protein content during winter, 70 lines had less than 20% protein content during spring. Further, there were five lines having more than 26% protein content when the matieral was grown during winter as against none during spring. Majority of the lines had protein content between 20 and 24%. Lines having less than 20% protein content are rejected.

Table 2.8.1. Frequency distribution of protein content in lines sown in winter and spring at Tel Hadya, 1988/89.

Class	Winter		Spring	
	No.	%	No.	%
16-18	0	0.00	11	3.13
18-20	5	1.14	59	16.76
20-22	146	33.33	137	38.92
22-24	212	48.40	133	37.78
24-26	70	16.00	123	3.41
26-28	5	1.14	0	0.00
Total	438	100.00	352[a]	100.00

[a]/ Difference in number of entries tested during winter and spring is because many lines did not produce any seed in spring sown crop.

2.8.2. Influence of season on protein content

Comparisons were made between protein content of the entries grown during winter and spring in two years. The 1987/88 the season was wet (504 mm of annual precipitation) and the 1988/89 season was dry (only 234 mm precipitation). The results are shown in Table (2.8.2). In general, there was no difference between the protein content in the material grown during winter or spring, but the seasonal supply of moisture had an influence on protein content. The amount of protein content was high in the dry season than in the wet season.

Dr. K.B. Singh, Mr. H. Nakkoul, and Dr. P. Williams.

Table 2.8.2. Mean protein content of the entries grown in two seasons (winter and spring) and two years (1987/88 and 1988/89) at Tel Hadya.

Year	No. of entries	Season	
		Winter	Spring
1987/88	120	20.94	19.85
1988/89	120	22.46	22.27

3. LENTIL IMPROVEMENT

Average lentil yields are low because of poor crop management and the low yield potential of landraces. In South Asia and East 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 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.

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.

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 mechanization

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 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 (3.1.1.3. and 7.2).

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 (annual average rainfall total 281 mm) and Tel Hadya (328 mm) in Syria and Terbol (545 mm) in Lebanon. During the 1988/89 season the rainfall was considerably below the long-term average at all sites with 174.6, 229, and 343.6 mm received up to harvest at Breda, Tel Hadya and Terbol, respectively. Yields followed the rainfall gradient with mean yields of biomass at Terbol, Tel Hadya and Breda of 4.4, 1.5, and 1.2 t/ha, respectively. A similar pattern was observed for seed yield with mean yields of 1236, 270 and 161 kg/ha realized at the same sites.

A summary of the results of the yield trials is given in Table 3.1.2. For seed yield the percentage of lines significantly outyielding the best check was 5, 10 and 18% at Terbol, Tel Hadya and Breda, respectively. A higher percentage of test lines merely ranked above the best check for seed yield, namely 21, 28 and 29% at Terbol, Tel Hadya and Breda, respectively. The season 1988/89 was particularly dry and cold and under these extreme conditions it is of interest that a reasonable proportion of lines at least ranked above the best check at all sites.

Drs. R.S. Malhotra and W. Erskine.

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 1988/89 season.

Location	Terbol		Tel Hadya		Breda	
	S	B	S	B	S	B
Number of trials	14	14	15	15	12	12
Number of test entries*	302	302	347	347	264	264
% of entries sig. (P<0.05) exceeding best check**	5	10.3	10	11	17.8	2.7
% of entries ranking above best check (excluding above)	21	31.8	28	28.5	28.8	23.5
Yield of top entry (kg/ha)	1666	6000	538	1933	401.5	1853
Check mean yield (kg/ha)***	1387	4422	321	1590	192.7	1277.5
Location mean (kg/ha)	1236	4442	270	1511	160.9	1211.5
Range in C.V. (%)	5-12	5-12	6-23	6-18	15-30	7-16
Mean advantage of lattice design over RBD	121	118	105	108	124	125

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

3.1.1.3. International nurseries

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

Our strategy is to encourage national breeding programs to undertake more selection locally within segregating populations. Accordingly we have launched three new targeted F3 nurseries comprising segregating populations from crosses with parents with the specific traits listed in Section 2.1. These new nurseries are - 1, small-seeded and 2, large-seeded for the Mediterranean environment and 3, winter hardy for the highland environment for a winter sowing. In addition a Fusarium wilt nursery was also initiated this season.

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	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.

A summary of the distribution of the nurseries of lentil and highlights from their results may be found in Section 7.2 of the International Testing Program.

Drs. W. Erskine, R.S. Malhotra and M.C. Saxena.

3.1.1.4. Screening for vascular wilt resistance

The major fungal disease of lentil in the Mediterranean area is vascular wilt. Screening for resistance to vascular wilt caused by *Fusarium oxysporum* f. sp. *lentis* continued in the plastic house using the method developed in the 1987/88 season (FLIP Annual Report 1988). A total of 130 lines were screened for their wilt reaction in the

1988/89 season. The lines were rated on a 1-9 scale with rating 1 = resistant and rating 9 = all plants killed. Four lines showed ratings < 3. The most resistant lines in this seedling test will be rescreened in an adult-stage screening trial next season.

The most resistant lines in the seedling test of the 1987/88 season were screened this year in pots at the adult stage to evaluate resistance at different stages of growth. Some lines were resistant at both the seedling and the adult stages. These resistant lines have been shared with national programs in the form of a newly launched Lentil International Fusarium Wilt Nursery. However, there were indications that some lines with seedling resistance were susceptible as adult plants. The differential reaction to vascular wilt at various stages of growth will be examined in more detail in the forthcoming season.

It has been possible to start relating wilt incidence to crop losses in the field using data from field trials with a high incidence of vascular wilt damage both in the research station and on farmers' fields. In one trial at Tel Hadya in the 1987/88 season the wilt incidence ranged from 0-100% over 180 plots. The maximum grain yield in the trial was over t/ha, while in heavily diseased plots the grain yield was below 100 kg/ha. There was a strong correlation (r=0.704) between wilt incidence (%) and grain yield (kg/ha). Straw yield was reduced by wilt incidence to a lower extent than grain yield (Fig. 3.1.1). The regression of grain yield onto wilt incidence indicated that every 10% increase in wilt incidence led to a loss in grain yield of 112 kg/ha. In this trial of 30 lines 49.6% of the variation in

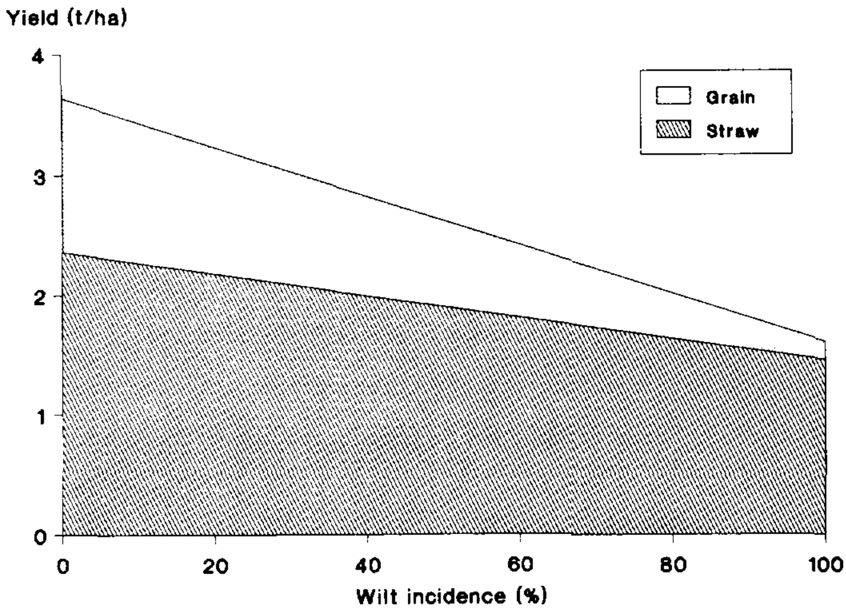

Figure 3.1.1. Relationship between wilt incidence and grain and straw yield of lentil.

grain yield was due to wilt incidence. Expressing the result in terms of crop loss every 10% increase in wilt incidence gave a crop loss of 8.77%. This served as the basis of a model of crop losses from vascular wilt which we tested with data from trials on farmers' fields.

The first test of the model was on data from an on-farm trial at Efes, Syria in the 1985/86 season, where the wilt incidence over 4 lines was from 2-70%. The model was tested by the relationship between the actual crop loss (%) and the crop loss (%) predicted by the model. The correlation between observed and predicted crop losses was r=0.983 with a slope of b = 0.78 ± 0.10.

The second test involved data from an on-farm trial in Syria sown at Taftanaz in the 1987/88 season with 5 lines showing a range in wilt incidence of 0-40%. Again the relationship between the observed and the predicted crop losses was highly significant with a correlation of $r=0.878$ and a regression slope of $b = 0.89 \pm 0.24$.

Both tests of the model showed the predicted yield losses from vascular wilt incidence to be very close to the observed losses indicating clearly the predictive value of the model. It now remains to test the model more widely on other data sets for a wider validation and to test the limits of the model. It will also be of interest to relate wilt incidence and crop losses to field inoculum density to extend the model.

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3.1.1.5. Screening for Ascochyta blight resistance

Ascochyta blight on lentil is a major problem in farmers' fields in the Indian sub-continent and in Canada. Screening for resistance to the disease was initiated at ICARDA (Tel Hadya), whereas previous screening had always been done in association with national programs, particularly in Pakistan.

The screening was conducted in the plastic house with artificial inoculation on a total of 101 lines using a score of 1 - 9 with 1 = highly resistant and 9 = complete kill. The highest score over two replications was used to indicate disease reaction.

The lowest score was 4 on a single line ILL 6824, which was also found resistant in Pakistan this year. There were an additional 20 lines rated 5, moderately resistant. The most resistant lines will be included in the International Ascochyta Blight Nursery.

Next season the number of lines to be screened will be increased considerably to embrace all breeding lines with early maturity targeted for southern latitudes.

Meanwhile the national program in Pakistan has continued to screen large numbers of entries at Islamabad in the field with artificial inoculation.
Drs. S. Hanounik, R.S. Malhotra and W. Erskine.

3.1.1.6. Variability in lentil growth habit

The growth habit of lentil is a key trait in the selection of cultivars for a mechanized harvest. Morphological analyses were made on 25 diverse lentil genotypes from 11 countries sown at normal crop density in two seasons (1985-86 and 1986-87) in N. Syria to determine the provenance of grain yield amongst branches and nodes and to assess the variation in plant architecture over seasons and genotypes.

Growth habit in lentil is strongly affected by both growing environment, including crop management and genotype, and season. The seasons produced similar vegetative frames for the crop as a result of parallel growth up to flowering time in April (Figure 3.1.2). However, there was a marked difference between the seasons in final

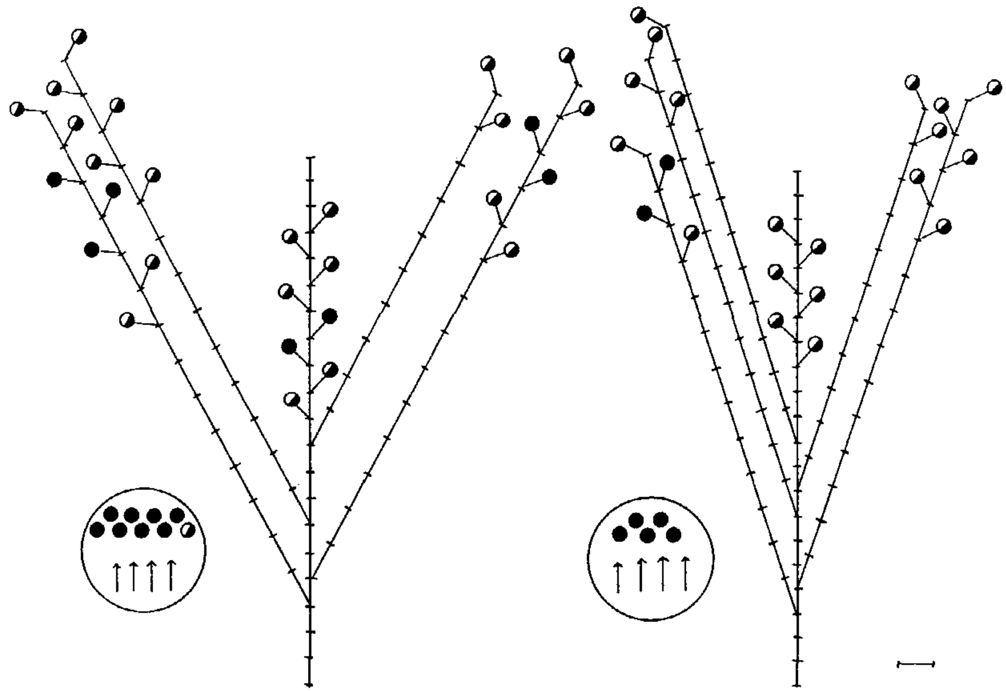

Figure 3.1.2. Diagram of average lentil plant from the 1985/86 (left) and 1986/87 (right) seasons. The grand means were used for the following characters: main stem length, node number and internode length on the main stem, angle of primary branching, numbers of primary, secondary and tertiary branches, nodal position of primary branches on the main stem, the number and nodal position of pods on the main stem and primary branches and the number of pods on secondary and tertiary branches. The average internode length on primary branches was not recorded but estimated for the diagram as 1.5x the internode length of the main stem. The insets display the number of secondary (↑) and tertiary branches (↑̸) and the pods on these branches. Pods (●) and half pods (◐) are indicated in the most commonly occupied nodal positions. The bar represents 2 cm.

yield with biological and grain yield varying from 3.7 - 2.8 t/ha and 1339 -801 kg/ha, respectively. The low yield resulted from stress during the period of reproductive growth due to the low rainfall in April and May 1987. The rainfall totals for April and May, 1987 were 13 and 3 mm, which represent only 39% and 17% of the equivalent long-term average data for the station.

Despite the seasonal variability there was considerable genetic variation in plant architecture. The variation was continuous for all characters studied with the genotypes exhibiting an indeterminate branching growth habit with a slender poorly-defined main stem and little apical dominance. The plant diagrams (Fig. 3.1.3) illustrate some extreme contrasts amongst the genotypes. They range from very short (ILL 4605) to tall (ILL 922). The branching may consist predominantly of primary branches (ILL 468) or of secondary branches (ILL 922), although usually the number of branches on primary and secondary systems is approximately equal. The early flowering and short genotypes (ILL 4605) had their pods concentrated at lower nodal positions than tall and late lines (ILL 468 and 922). The tallest lines varied with respect to both node number and internode length. Thus ILL 922 and 4349 were the tallest lines with main stem lengths of 35 and 34 cm respectively; however, ILL 4349 had developed 18 nodes on the main stem with an average internode length of 1.9 cm in contrast to 23 nodes with an average internode length of 1.5 cm on ILL 922. The study showed that there is sufficient heritable variability for plant architecture in lentil to allow the selection of types suited for harvest mechanization.

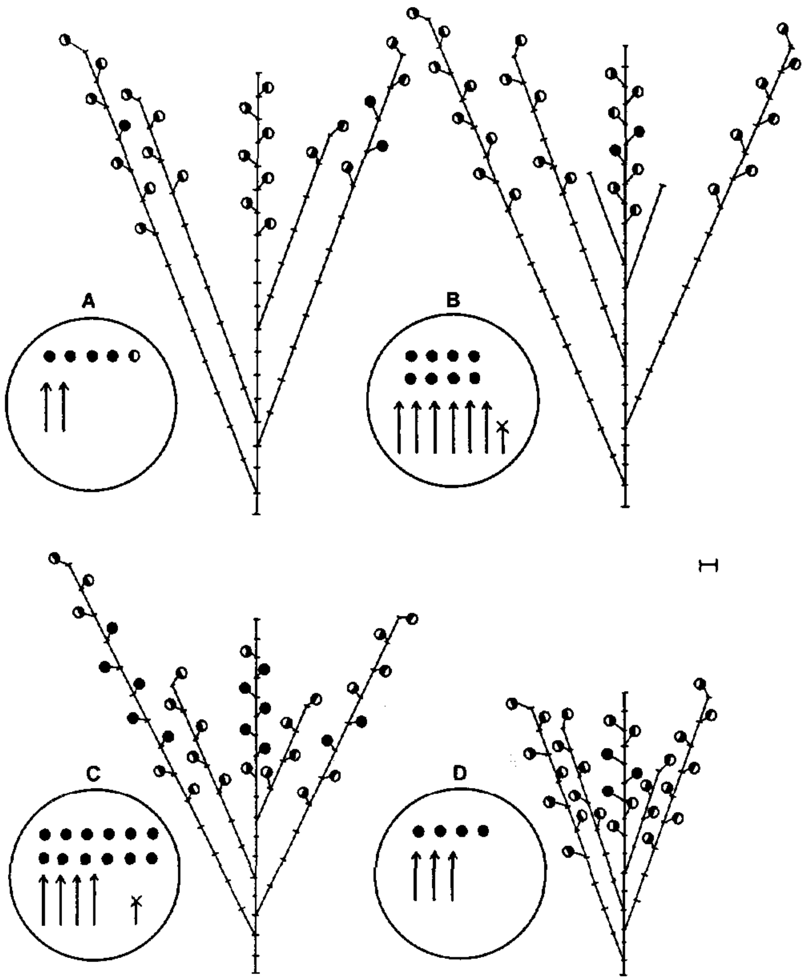

Figure 3.1.3. Diagram of average lentil plant of four lentil genotypes (A. ILL 468, B. ILL 922, C. ILL 4354, D. ILL 4605) in the 1985/86 season. Legend to the diagram is as Figure 3.1.2.

The distribution of pods between the main stem, the primary branch system, and the secondary and tertiary branches in lentil was studied for the first time and found to be unaffected by either season or genotype. This suggests that the distribution of pods - 17.5% on the main stem, 52.4% on primary branches and 30.2% on secondary and tertiary branches - may be relatively constant at crop density despite large fluctuations in the total number of pods. Half of the overall yield (49.5%) was held on the main stem and the basal two primary branches. It is clear from the lack of genetic variation for pod distribution that selection for this trait will be ineffective.

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

3.1.1.7. Variation in lentil straw quality

In the Middle East, lentil is cultivated both for grain and straw. In Syria, a farmer's revenue from straw is sometimes greater than that from the grain. Straw enters both national and international trade as a livestock feed, particularly for sheep, contributing up to 20% of the diet of ewes from November to February each year. Lentil straw comes from the traditional threshing process and includes broken branches, pod walls, leaflets and parts of the root system. We run an extensive breeding program to increase lentil seed yield. In view of the importance of lentil straw, the possible indirect effects of selection for seed yield on straw quantity and quality need clarification.

The relationship between straw and seed yields has been examined with the conclusion that continued selection for a high seed yield would not adversely affect straw yields because of the positive correlation between the two traits. It remained to quantify genetic and seasonal variation in straw quality and its variability amongst plant parts in order to formulate an approach to straw quality in the breeding program.

Seasonal and genetic variation in the potential feeding value of lentil straw was measured in two seasons on eleven diverse macrosperma lentil selections under rainfed conditions in N. Syria. Digestible dry matter (DDM) was 46% in the 1981-82 season and 43% in the 1982-83 season. The genotype-year interaction mean squares for all straw quality parameters were greater than their respective genotypic mean squares indicating low genetic variation, as judged by laboratory methods of assessing straw value, and a poor expected response to selection for improved straw quality.

In another experiment, the partition of dry matter within the straw of six selections was measured in one environment. Proportions of leaf, branch, pod and root tissue within straw were 38, 34, 23 and 5%, respectively (Fig. 3.1.4). Their mean DDM values were 62, 36, 44 and 22%, respectively. The results indicated that variation in straw quality is largely due to differences in the partition of dry matter between plant parts.

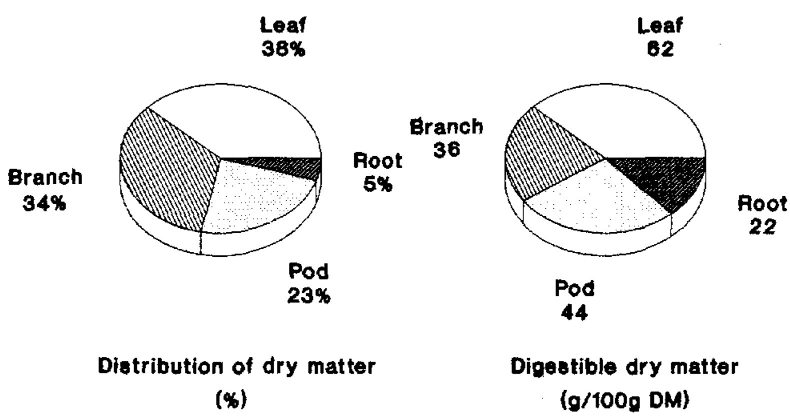

Figure 3.1.4. Distribution of dry matter (%) and digestible dry matter (g/100g DM) in six lentil lines at Tel Hadya, Syria.

The implication for lentil breeding in view of the low genetic variation for straw quality is that a positive response to selection for straw quality will be difficult to obtain using laboratory methods of measuring straw quality. There is still a need, however, to test the feeding quality of lentil straw from different genotypes _in vivo_ before entirely discounting the possibility of improving lentil straw through breeding. Emphasis may now be placed on defining environmental/ cultural factors influencing straw quality in preference to work on genetic variation.

Dr. W. Erskine, Mr S. Rihawi, Mr H. Nakkoul and Dr B.S. Capper.

3.1.1.8. Single plant selection for yield in lentil

The Mediterranean lentil has tendrils which cause inter-plant entanglement within the crop canopy at normal plant density (≥200 seeds/m^2). Plant selection for yield in this environment is problematic because the high plant density and canopy entanglement make an assessment of the yield capacity of individual plants difficult and their harvest frequently results in broken branches.

Problems associated with single plant selection for yield at crop density in lentil led us to investigate the response to plant selection undertaken at a range of plant densities and selection methods to provide guidelines for the breeding program.

Visual plant selection for yield was compared with random selection in the F_5 at three plant densities D1, D2 and D3 (66, 133 and 200 seeds/m^2 respectively) by an evaluation of F_7 progeny yields over two seasons in two populations of lentil. Random plant sampling was as effective as visual plant selection in isolating high-yielding F_7 lines (Table 3.1.4). The plant density of the selection environment did not affect the response to selection. The correlations between the seed number of selected F_5 plants and the mean yield of their F_7 progenies were r = -0.26 and -0.06 in two populations, indicating the lack of positive response to plant selection for seed number.

The results clearly show that random plant sampling for seed yield in the F_5 was as effective as visual plant selection and counting the seed after harvest in producing high-yielding F_7 progeny lines. This dismisses the 'art' in plant selection for yield in lentil. Random plant sampling is less time-consuming and more economic than the other methods of selection. Consequently, it is recommended for lentil. Additionally, as the plant density of the selection environment did not affect the efficiency of the selection, so segregating populations for plant selection should be grown at a plant density that avoids inter-plant entanglement by tendrils. In this selection environment it is then possible to focus plant selection on characters other than yield with importance to the breeding program with a higher heritability than yield such as seed and phenological traits and attributes such as plant height and lowest pod height which are important in harvest mechanization.

Dr. W. Erskine, Mr J. Isawi & the late Dr. K. Masoud (Aleppo University).

Table 3.1.4. Means and standard errors for grain yield (kg/ha) of progenies from different selection methods and densities together with parental means and the range amongst individual progeny means.

	Population 1						Population 2					
Season	1981/82			1982/83			1981/82			1982/83		
Selection method	Visual	Random	X	Visual	Random	X	Visual	Random	X	Visual	Random	X
Density D_1	891	1025	958	1273	1295	1283	1046	1050	1048	1239	1197	1218
Density D_2	928	946	937	1217	1346	1282	1004	1094	1049	1148	1340	1244
Density D_3	985	915	950	1387	1361	1374	1216	1109	1163	1178	1146	1162
Mean	935	962		1293	1334		1089	1084		1188	1228	
Parents P_1	1328			1425			1263			1016		
Parents P_2	1476			1412			1251			1352		
Range amongst progeny	360-1553			640-1807			607-1627			600-1600		
S.E. parent mean ±	75.8			81.2			85.2			82.7		
S.E. density mean ±	31.0			33.2			34.8			33.8		
S.E. method mean ±	25.3			27.1			28.4			27.6		

3.1.1.9. Heterosis in lentil

The successful use of hybrid cultivars depends upon the existence of an economically significant level of heterosis, sufficient cross-pollination to make hybrid seed production cost competitive and an efficient and reliable system of producing the female parent of the hybrid.

Heterosis in lentil was measured over two seasons at crop density on 50 hybrids involving 34 parents from 15 countries. This level of diversity maximized the possibility of heterosis through a high probability of the existence of different complementary, non-allelic loci conferring fitness. However, overall there was no significant heterosis for grain yield above the better parent.

There was, however, variation over hybrids in heterosis and 10 crosses out of 50 showed significant heterosis for grain yield over the better parent reaching a maximum of 74% in one hybrid. The ten highest yielding hybrids gave 22% heterosis over their better parents. With marked variation in heterosis it would be possible to select parents for good combining ability for yield. However, the correlation of heterosis above the better parent with better parent yield was negative and significant ($r = -0.437$). Clearly, averaged over all crosses, heterosis was greatest for hybrids with low yielding parents and least for those with high yielding parents (Fig. 3.1.5).

The exploitation of heterosis requires a suitable system for the production of the female parent. Lentil has a perfect flower that is

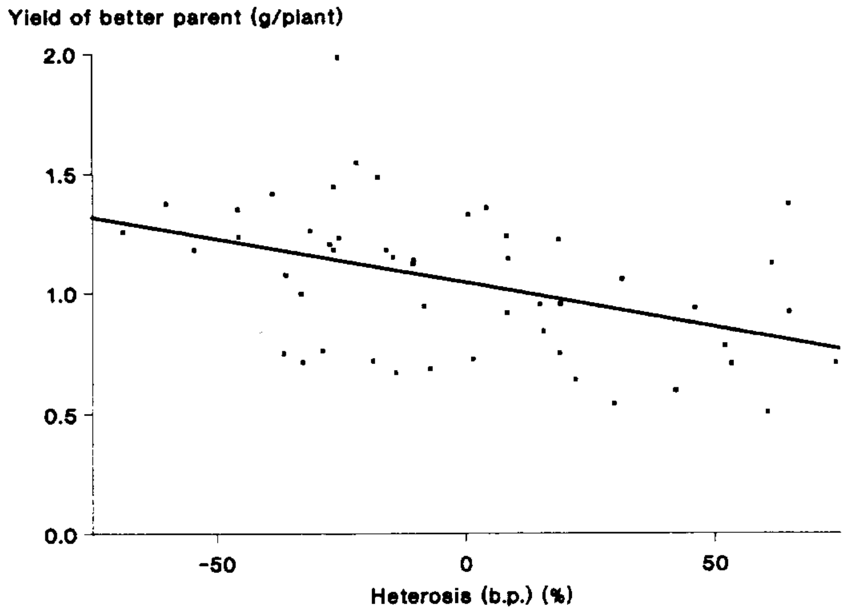

Figure 3.1.5. Heterosis (%) above the better parent (b.p.) of 50 lentil hybrids shown with the yield of their better parent averaged over two seasons at Tel Hadya, Syria.

small and fragile. Male sterility has not been reported in lentil, but is under investigation (Muehlbauer,pers. comm.). Another possibility is the use of chemical hybridizing agents (CHA). The successful use of such agents is, however, contingent upon synchronous flower development in the crop and as lentil has an indeterminate flowering habit CHA may be difficult to use effectively. The lentil flower is cleistogamous with self-pollination usually occurring prior to flower opening. The highest recorded level of cross-pollination is below 1%, but the method of transfer of this pollen between flowers is not known. This low maximum value of cross-pollination is probably insufficient to produce hybrid seed, even if the female parent were available. For these reasons, despite the demonstration of significant heterosis for yield in some crosses, it is unlikely that hybrid lentil cultivars will be economic to produce in the foreseeable future.

Dr. W. Erskine, Messrs A.S. Gill, A. Orhan and C. Pastrana.

3.1.1.10. Outcrossing estimate and variation for qualitative characters in lentil germplasm from Turkey

A major emphasis has been laid at ICARDA on studying the variation in the germplasm of the cultigen as a key to future crop improvement. A study of qualitative variability was undertaken to complement previous research on quantitative traits with the aims of 1) estimating outcrossing using a multilocus model; and 2) quantifying variation in isozymes and morphological traits to allow modelling of the effect of various ways of developing 'core collections' of germplasm. A core collection is a representative sample of a larger germplasm collection, made to facilitate the use of the collection.

Germplasm accessions from three countries - Chile, Greece and Turkey - were studied. But the results from Turkish lentils alone are described herein.

Three morphological traits were surveyed together with 18 isozyme systems making a total of 21 loci surveyed. Overall 71.4% of loci were polymorphic with a mean of 2.1 alleles per locus. Allelic frequencies and genetic diversity indices are given in Table 3.1.5 for each locus. The genetic diversity index (Gj) was calculated as 1 - R pi2 in which pi is the frequency of the ith genotype for the jth locus. Values for

Table 3.1.5. Summary of genetic variation at 13 polymorphic loci in 50 lentil germplasm accessions from Turkey.

Gene name	Gene symbol	Alleles	Allele frequency	Genetic diversity index (Gj)
<u>Morphological traits</u>				
Cotyledon colour	yc	Yc	0.626	0.468
		yc	0.374	
Seed coat pattern	scp	scp	0.794	0.337
		scp^d	0.179	
		scp^s	0.014	
		scp^m	0.014	
Stem colour	Gs	gs	0.962	0.0735
		gs	0.038	
<u>Isozymes</u>				
6-Phosphogluconate dehydrogenase	Pgd-1	a	0.466	0.498
		b	0.534	
Phosphoglucomutase-2	Pgm-2	a	0.427	0.490
		b	0.573	
Aspartate aminotransferase-2	Aat-p	a	0.376	0.478
		b	0.624	
Leucine aminopeptidase-1	Lap-1	a	0.706	0.424
		b	0.274	
		c	0.020	
Aspartate aminotransferase-3	Aat-m	a	0.228	0.352
		b	0.772	
Alchohol dehydrogenase-2	Adh-2	a	0.168	0.279
		b	0.832	
Malic enzyme-1	Me-1	a	0.149	0.253
		b	0.851	
Malic enzyme-2	Me-2	a	0.940	0.115
		b	0.028	
		c	0.032	
Diaphorase-2	Dia-2	a	0.010	0.020
		b	0.990	
Amylase	Amy	+	0.994	0.012
		-	0.006	

Gj ranged from 0.498 for 6-Phosphogluconate dehydrogenase down to zero for the monomorphic loci.

Isozymes are inherited codominantly and heterozygotes are directly identifiable allowing estimates of outcrossing. A total of 10 out of 498 plants were heterozygotes for one or more loci, giving the percentage outcrossing of 2.0%. Using a multi-locus model the probability of directly observing outcrosses (1-a) was estimated as 0.942, and a multilocus estimate of outcrossing rate in which compensation is made for non-discernible outcrosses was 2.1%.

Drs. W. Erskine and F. J. Muehlbauer, Washington State University, USA.

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

In Syria the line 78S26013 (ILL 16) will be submitted to the Variety Release Committee on the basis of its improved grain yield of 16% over the local check (Table 3.1.7), 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.

Table 3.1.6. Lentil lines released as cultivars (underlined) or in pre-release multilplication by NARSs.

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

Table 3.1.7. Mean seed yield (kg/ha) in on-farm trials conducted with ARC (Douma) from 1982/83 to 1988/89 in Syria.

Season	Entry		Advantage over check (%)	No. of sites
	Hurani 1 (Local check)	78S26013		
1982/83	823	1054	28.1	6
1983/84	855	990	15.8	7
1984/85	998	931	-6.7	13
1985/86	993	1281	29.0	9
1986/87	1687	2013	19.3	11
1987/88	1759	2023	15.0	11
1988/89	589	642	9.0	11
Mean	1101	1276	15.9	

In Lebanon the same small-seeded, red cotyledon line 78S26013 was released to farmers as 'Talya 2' during 1989.

In Jordan two lines are in pre-release multiplication - 'Jordan 2 and 3'; the latter is 78S26002, previously released in Syria.

Increasing government focus on the production of food legumes in Iraq has resulted in the identification of 78S26002 and 78S26013 for pre-release multiplication.

Progress by NARSs in North Africa is detailed in Section 7.2, but brief reference to highlights is given herein. In Tunis two lines, FLIP84-103L and 78S26002, have been identified by the national program for pre-release multiplication 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 FLIP86-20L were selected for pre-release multiplication.

Lentils in Morocco suffered a severe attack of rust for the second 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. It yielded 1380 kg/ha in contrast to 100 kg/ha with the local at Sidi Laydi, where there was a severe rust epidemic. Following the screening of breeding material under natural epiphytotic conditions, several lines (FLIP86-16L, FLIP87-19L and FLIP87-22L) were identified by the national program for pre-release multiplication with resistance to rust.
National Agriculture Research Systems.

3.1.2.2. Advances for southern latitude region

This region comprises the sub-continent of India 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.

In Pakistan AARIL-344 (ILL 2573) is being considered for release for the north of the Punjab following several years of on-farm trials run from Ayub Agricultural Research Institute (AARI) at Faisalabad. Seed of ILL 4605 is being distributed to farmers in the National Capital Territory around Islamabad. The following lines with resistance to Ascochyta blight and Botrytis over the last few years at the National Agriculture Research Centre (NARC) at Islamabad are being evaluated further for yield potential in Major and Adaptation Trials : ILL 1645, ILL 1677, ILL 1684, ILL 3614, ILL 5748, ILL 6005, ILL 6024, ILL 6025, ILL 6037, ILL 6458 and ILL 6472.

The breeders at NARC, Islamabad and AARI, Faisalabad are both undertaking hybridization in lentil and many promising progenies are in test. Additional material with a good potential comes from crosses made at ICARDA and supplied in the F3-F5 generation.

Nepal grows more than 100,000 ha of lentil spread between the Terai area adjacent to India and the Mid-Hills. The lines ILL 2578 and ILL 4404 are both in on-farm trials with ILL 4402 and also in pre-release multiplication.

In Ethiopia 'ILL 358' is under increase for distribution to farmers as part of the Nile Valley Regional Program. Several other lines have been identified by the National Program with resistance to rust and a good seed type.

National Agriculture 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. We launched a new nursery of F3 segregating populations during the last season (see 3.1.1.3).

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. The breeder at Sakatoon is using ILL 5588 and ILL 5684 in crosses 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).

National Agriculture Research Systems.

3.2. Crop Physiology

3.2.1. Adaptation of lentil to drought stress

In the low to middle elevation of West Asia and North Africa (WANA) lentil is sown between December and January in the 300-400 mm isohyets and harvested in May. The early stages of its vegetative growth is restricted by low radiation and temperature. This however, is the period of increasing rainfall, low evaporative demand and increase in soil water content. With the onset of spring, the lentil crop experiences stronger sunshine and rapid rise in maximum temperatures. The rise in temperature allows for the development of high leaf areas and consequently high evapotranspiration. This period of high evaporative demand, which in lentil occurs at flowering stage, coincides with annual termination of rainfall. Despite there being some reserve of soil moisture, it is rarely adequate to meet the crop needs, especially under high prevailing temperatures. The lentil crop, therefore, experiences considerable drought stress, particularly during reproductive phase, and produces low yield.

The objectives of the present study are to identify in the crop those attributes (traits) that contribute most to high and stable yield under the drought stress.

A field experiment was conducted at Breda (281 mm mean annual rainfall) under line-source sprinkler using 25 diverse lentil cultivars differing in origin, phenology, yield and seed size. The cultivars included both land races and crosses made at ICARDA. In the rainfed treatment, repeated observations on vigour (recorded on 1 to 5 scale; where 1 was most and 5 least vigorous, and as dry matter/m^2), leaf colour (recorded on 1 to 5 scale; with 1 dark green and 5 light green), percentage ground cover, plant height, crop water use and phenology were collected; and at maturity biological yield and seed yields were measured.

In a second experiment some lentil cultivars (ILL 2126, ILL 4349, ILL 4400, ILL 4401, ILL 5582, ILL 5604, ILL 5782 and ILL 6004), which in 1987/88 season showed differences in early vigour, phenology and yield, were evaluated for variation in rooting pattern in the plastichouse.

Total moisture supply received was 179.6 mm in the driest treatment and 376.6 mm in the wettest treatment. At maturity harvests were at 8 levels of moisture supply, in each plot, namely: 179.6 mm, 209.6 mm, 239.6 mm, 269.6 mm, 299.6 mm, 329.6 mm, 359.6 mm and 376.6 mm.

The number of days from sowing to different phenological stages varied among genotypes. ILL 6035, ILL 6024 and ILL 5586 were the earliest to flower, followed by ILL 6004, ILL 5989, ILL 5991, ILL 4403, ILL 5782, ILL 5582 and ILL 4354 (Table 3.2.1). ILL 5715 and ILL 481 were last to flower. ILL 6004, ILL 6024, ILL 6035 and ILL 4403 were the first in reaching physiological maturity and ILL 481, ILL 2126 and ILL 4349 were last. Irrigation delayed maturity. The genotypes that matured earliest in the rainfed treatment were also early in the irrigated treatment (Table 3.2.1). Similarly, the late maturing cultivars were last to mature under irrigation.

During early vegetative stage, there were variations in leaf colour from light to dark green. For example, ILL 6004, ILL 6011 and ILL 6035 were light green and ILL 4400, ILL 4401 and ILL 6049 were dark green. With the rise in temperature in March, most of the genotypes which were dark green gradually changed colour to light green, the exceptions were ILL 4400 and ILL 2126 which maintained dark green colour during most of the growth period. The cultivars that were light green during early vegetative growth exhibited early vigour ($r = -0.59$ to -0.74), had high percentage ground cover ($r = 0.24$ to 0.64) and were in general early flowering ($r = -0.38$ to -0.39) (Tables 3.2.1 and 3.2.2).

Table 3.2.1. Number of days from sowing to different stages of development in lentil sown on 28 November 1988 at Breda, Syria.

	CULTIVAR	Days from sowing to			
				Maturity	
		Emergence	Flower	Rainfed	Irrigated
V_1	ILL 5754	16	123	155	159
V_2	ILL 5989	16	114	148	156
V_3	ILL 5991	16	114	148	156
V_4	ILL 5994	18	118	152	156
V_5	ILL 6011	17	118	148	156
V_6	ILL 1939	16	123	156	159
V_7	ILL 5715	17	128	156	162
V_8	ILL 5775	18	120	152	156
V_9	ILL 5860	17	118	148	156
V_{10}	ILL 5863	18	120	148	156
V_{11}	ILL 6049	18	118	148	156
V_{12}	ILL 6004	15	114	138	148
V_{13}	ILL 6024	15	110	140	152
V_{14}	ILL 6035	15	110	138	148
V_{15}	ILL 4403	18	114	138	148
V_{16}	ILL 5782	18	114	150	159
V_{17}	ILL 2126	18	125	162	172
V_{18}	ILL 5604	17	123	152	159
V_{19}	ILL 481	17	128	162	172
V_{20}	ILL 5582	18	114	150	156
V_{21}	ILL 5586	16	110	148	156
V_{22}	ILL 4349	18	118	162	172
V_{23}	ILL 4354	16	114	150	156
V_{24}	ILL 4400	18	120	155	159
V_{25}	ILL 4401	18	120	150	156

Yields in the driest treatment (rainfed) were very low but varied significantly ($P < 0.05$) among the cultivars, with seed yield ranging from 56 kg/ha in ILL 481 to 319 kg/ha in ILL 6035; and for biological yield the range was from 494 kg/ha in ILL 6024 to 898 kg/ha in ILL 6035 (Table 3.2.3).

Table 3.2.2. Correlations between some important traits in lentil, Breda 1988/89.

Traits	7.2.1989					2.3.1989					26.2.1989				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1. Leaf colour		−0.74***	−0.06	−0.38***	0.29**		−0.59***	0.25*	−0.39***	0.09		0.12	−0.12	−0.24**	−0.54***
2. Vigour			−0.90***	0.41***	−0.22*			−0.74***	0.37***	−0.17			−0.58***	0.39***	−0.10
3. % Ground cover				−0.48***	0.10				−0.34***	−0.14				−0.33***	−0.05
4. Days to flower					0.08										
5. Reproductive period															

Table 3.2.3. Seed yield in kg/ha (SY), biological yield in kg/ha (BY), evapotranspiration in mm (E_t) and water use efficiency of lentil cultivars grown under rainfed (179.6 mm rainfall) and irrigated (376 mm) conditions at Breda, 1988/89.

Cultivars	Rainfed					Irrigated				
				Water use efficiency (kg/ha/mm E_t) for				Evapotrans	water use efficiency (kg/ha/mm E_t) for	
E_t	SY	BY	E_t	SY	BY	SY	BY	E_t	SY	BY
ILL 5756	189	687	90.0	2.100	7.633	1498	3615	285.1	5.254	12.680
ILL 5989	217	733	93.6	2.318	7.831	1524	3500	318.1	4.791	11.003
ILL 5991	224	789	89.8	2.494	8.786	1611	3796	283.9	5.675	13.371
ILL 6011	261	885	95.0	2.747	9.315	1519	3488	282.0	5.387	12.369
ILL 1939	155	607	87.4	1.773	6.945	1350	3315	294.4	4.586	11.260
ILL 5715	148	639	91.4	1.193	6.991	1304	3446	284.2	4.588	12.125
ILL 5775	194	783	96.0	2.021	8.156	1270	3285	285.1	4.455	11.522
ILL 5860	189	617	91.0	2.077	6.780	1880	4087	315.3	5.963	12.962
ILL 5863	206	674	87.6	2.352	7.694	1589	3659	282.6	5.623	12.948
ILL 6049	196	604	91.3	2.147	6.616	1506	3589	277.1	5.435	12.952
ILL 6004	283	815	92.4	3.063	8.820	1374	2981	281.6	4.879	10.586
ILL 6024	137	494	89.3	1.534	5.532	1254	2843	280.3	4.474	10.143
ILL 6035	319	898	91.3	3.494	9.836	1372	2865	277.5	4.944	10.324
ILL 4403	170	500	86.8	1.959	5.760	1320	2783	277.6	4.755	10.025
ILL 5782	165	707	91.1	1.811	7.761	1231	3139	283.3	4.345	11.080
ILL 2126	119	659	92.6	1.285	7.117	1042	2453	279.7	3.725	8.770
ILL 5604	130	587	93.3	1.393	6.292	1376	3263	285.6	4.818	11.425
ILL 481	56	602	93.0	0.602	6.473	930	2859	287.9	3.230	9.931
ILL 5582	169	674	92.0	1.837	7.326	1494	3454	282.1	5.298	12.248
ILL 5586	163	620	92.2	1.769	6.725	1643	3898	283.9	5.787	13.730
ILL 4349	94	635	92.6	1.015	6.857	683	2251	285.7	2.391	7.879
ILL 4354	198	711	90.8	2.181	7.830	1744	3824	277.4	6.287	13.785
ILL 4400	83	589	95.0	0.874	6.200	1226	3235	283.7	4.321	11.403
ILL 4401	157	511	93.6	1.677	5.459	1441	3347	282.2	5.106	11.860
LSD (5%)	58	162				293	621			
SE	20.7	57.5				104.2	220.5			
CV (%)	23.3	17.2				16.7	13.4			

All the variables measured were correlated with yield and important correlations are shown in Table 3.2.4. In the rainfed (driest) treatment, early phenology, light green leaf colour (particularly during early vegetative growth), early vigour, high percentage ground cover (starting from early growth stage) and high straw and biological yields were important attributes for high seed yield. Seed and biological yields in irrigated treatments were also associated with high seed yield in the rainfed treatment (Table 3.2.4).

Table 3.2.4. Correlations between yields in rainfed treatment and some important traits in rainfed treatment in lentil. Breda, 1988/89.

Traits	Rainfed	
	Seed yield	Biological yield
<u>Leaf colour</u>		
7.2.1989	0.27**	0.32***
2.3.1989	0.24*	-0.07
<u>Crop vigour</u>		
23.2.1989	-0.41***	-0.54***
2.3.1989	-0.34***	-0.47***
26.3.1989	-0.30**	-0.37***
<u>% Ground cover</u>		
23.2.1989	0.38***	0.39***
2.3.89	0.54***	0.59***
26.3.89	0.48***	0.46***
7.4.1989	0.47***	0.48***
Seed yield irrigated	0.51***	0.34***
Biological yield irrigated	0.37***	0.38***
Biological yield rainfed	0.80***	
Straw yield rainfed	0.54***	
Days to flower	-0.46***	-0.24*
Days to mature	-0.49***	0.12

Leaf colour score: 1-5, 1 = light green, 5 = dark green
Vigour score: 1-5, 1 = most vigorous, 5 = least vigorous.

Similarly, the attributes associated with high seed yield were also associated with high biological yield.

For further quantification of response of genotypes to drought stress, the approach of Bidinger et al. (1987) for terminal stress in pearl millet was followed as already described in section 2.6.1 for chickpea by computing drought response index (DR1).

The results showed that time to flowering and yield potential (non stress yield) accounted for 62% of the variation in seed yield and the remainder was due to internal drought response. Total dry matter was however less sensitive to time of flowering and potential yield, both accounting for only 14% of the variation in total dry matter yield. For both seed and biological yields, ILL 6035 was tolerant and for seed yield, ILL 4400 was susceptible to drought (Table 3.2.5). For biological yield ILL 6011 was tolerant and ILL 6024, ILL 4403 and ILL 44001 were susceptible to drought (Table 3.2.5).

Differences in rooting patterns change the amount and timing of water availability to the crop. The traditional view is that a large vigorous root system, through avoidance of plant water deficits, is one of the major mechanisms of drought resistance. Rooting pattern was studied at Tel Hadya in the plastichouse. ILL 4400 had high and fast build-up in root dry weight, and long and dense root system, ILL 4401 had long roots that developed fast, and the vigorous cultivar ILL 6004 invested least in the root system (Figure 3.2.1).

Table 3.2.5. Drought response index (DRI) for seed and biological yields of lentil genotypes, Breda 1988/89.

Genotype	Seed yield	Biological yield
ILL 5754	0.913	0.419
ILL 5989	-0.057	0.270
ILL 5991	-0.074	0.681
ILL 5994	0.733	0.447
ILL 6011	1.104	1.683*
ILL 1939	0.365	-0.213
ILL 5715	1.201	0.378
ILL 5775	1.021	1.223
ILL 5860	-0.877	-0.744
ILL 5863	0.601	0.077
ILL 6049	0.166	-0.683
ILL 6004	1.283	0.944
ILL 6024	-0.453	-1.980*
ILL 6035	2.228*	1.756*
ILL 4403	-0.816	-2.129*
ILL 5782	-0.742	0.160
ILL 2126	0.135	0.583
ILL 5604	-0.348	-0.379
ILL 481	-0.343	0.250
ILL 5582	-1.242	-0.260
ILL 5586	-1.012	-0.647
ILL 4349	-0.607	0.091
ILL 4354	-1.059	0.052
ILL 4400	-1.778*	-0.556
ILL 4401	-0.339	-1.320*

* = significant at -10%

The cumulative evapotranspiration (Et) of the crop were computed for the driest *(rainfed)* and the wettest *(high irrigation)* water treatment regimes for all the genotypes. The data presented in Figure 3.2.2 are for those lines that showed variation either in early vigour, phenology, response to irrigation or Et. The Et of different cultivars in the driest treatment were similar. The differences in Et in the wettest treatment for the 25 genotypes were small until towards the end

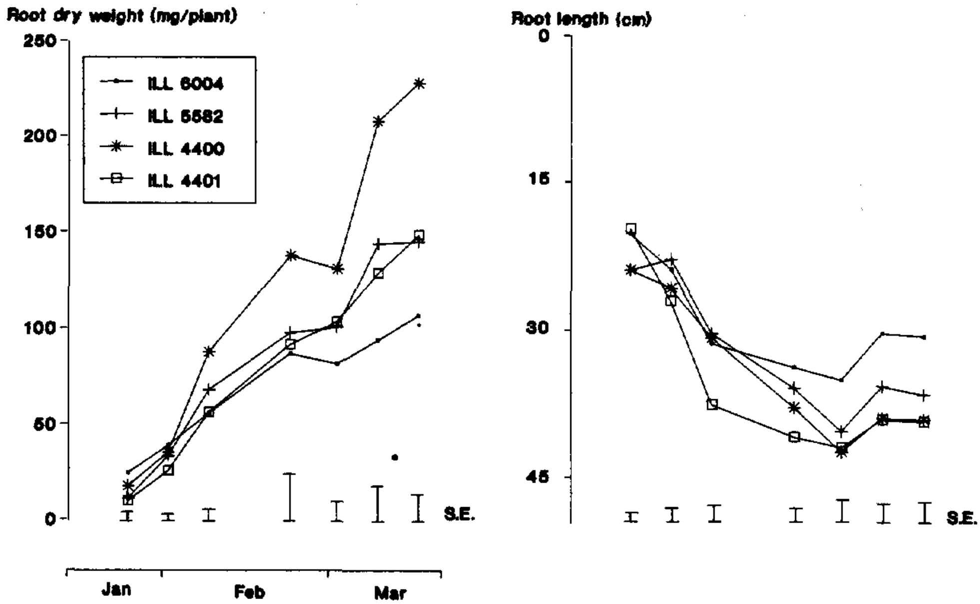

Figure 3.2.1. Root dry weight and root length of four lentil genotypes at various stages of growth.

of the season when medium to late maturing cultivars (e.g. ILL 5989 and ILL 5860) surpassed the early maturing cultivars (Figure 3.2.2 and Table 3.2.3).

A significant feature of the present study was the large difference between genotypes in seed and biological yields, and variation in water use (Table 3.2.3). In the driest (rainfed) treatment, evapotranspiration ranged from 86.7 mm to 96.0 mm; and ILL 6035, ILL 6004, ILL 6011, ILL 5994 and ILL 5991 had high water use efficiencies (Table 3.2.3).

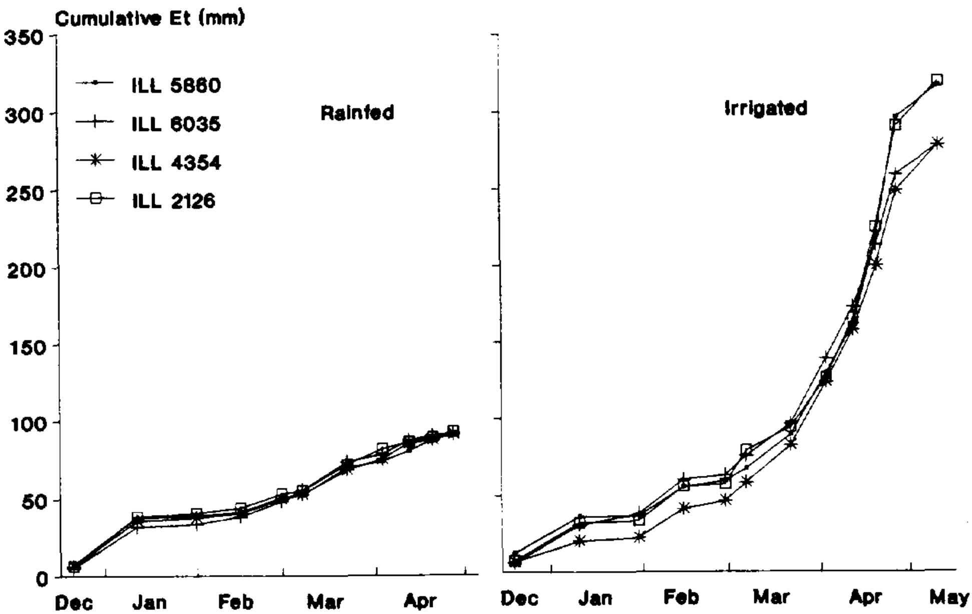

Figure 3.2.2. Cumulative evapotranspiration in four lentil genotypes as affected by moisture supply, Breda, 1988/89.

3.2.2. Yield response to increase in moisture supply

The line-source sprinkler system by applying moisture along the gradient permitted screening genotypes for response to increase in moisture supply. Seed yield of all the lentil genotypes showed a linear increase with the amount of water applied. There were significant differences among genotypes in their response to increase in moisture supply. ILL 5860 was most responsive (8.91 kg/ha/mm), followed by ILL 4354 (7.87 kg/ha/mm) ILL 5586 (7.66 kg/ha/mm) (Fig. 3.2.3). There were lines which were moderately responsive to increase in moisture supply and some lines which were not responsive e.g. ILL 2126 (4.75 kg/ha/mm) and ILL 481 (4.84 kg/ha/mm) (Fig. 3.2.3).

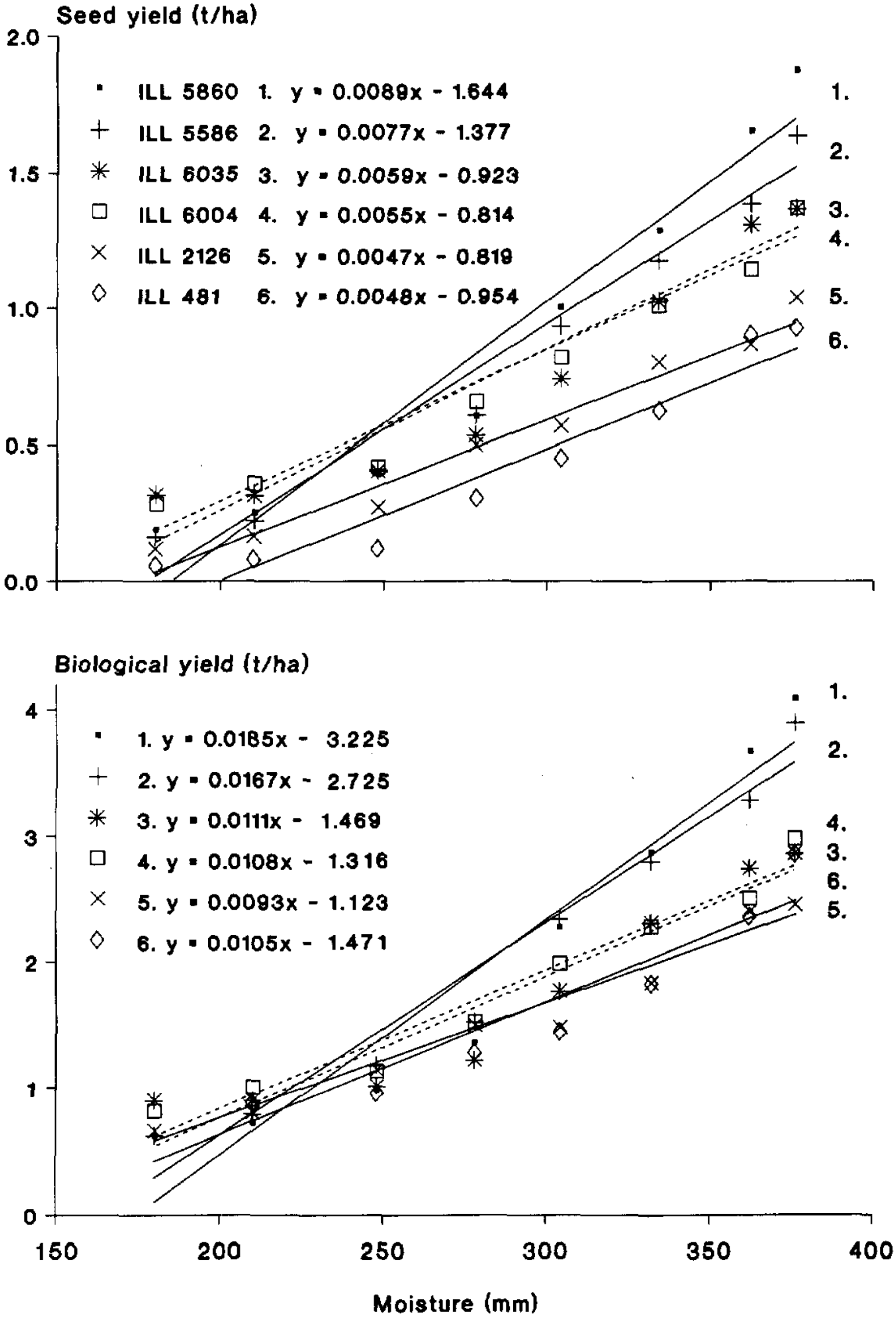

Figure 3.2.3. Relationship between moisture supply and seed and total biological yields of lentil genotypes, Breda 1988/89.

Total biological yield of all the genotypes similarly exhibited a linear relationship with increase in moisture supply. Similar to seed yield, there were significant variations in response to increase in total water received. Again ILL 5860 was the most responsive (18.48 kg/ha/mm) followed by ILL 5586 (16.67 kg/ha/mm), ILL 5991 (16.05 kg/ha/mm) and ILL 5754 (16.02 kg/ha/mm) (Fig. 3.2.3). Some lines were moderately responsive (e.g. ILL 5989, 14.30 kg/ha/mm; ILL 5782, 13.90 kg/ha/mm); and others were least responsive (e.g. ILL 481, 10.45 kg/ha/mm; ILL 2126, 9.26 kg/ha/mm; ILL 6004, 10.79 kg/ha/mm).
Drs. S.N. Silim, M.C. Saxena and W. Erskine.

3.2.3. Stages of development of the lentil plant

The life cycle of the lentil plant is continuous and starts with seed germination and ends with complete seed maturation. It is vital that a common terminology for the different stages of growth is used for unambiguous communication between growers, researchers and others. This will allow, for example, the precise timing of cultural practices such as herbicide application, and the documentation of the growth stage where damage took place as a result of vagaries of weather such as hail, wind, late frost or from attack by insects or other pests.

The lentil is grown under widely differing ecological conditions from the tropical highlands of Ethiopia to the Canadian prairies. At a single location, the growth of the crop is strongly influenced by factors such as the date of sowing, weather and cultivar. This report gives a uniform system for the description of the developmental stages of lentil.

Both temperature and photoperiod profoundly affect the timing of flower initiation in lentil. The onset of reproductive growth limits but does not halt vegetative growth. In view of the diversity of environmental conditions encountered by the crop, it is necessary to uncouple the descriptions of vegetative and reproductive growth stages and to describe them independently.

The lentil is a much-branched, softly pubescent, light green, annual herbaceous plant with a slender stem and branches. The branching habit of lentil contrasts with the better developed main stem axis of other food legumes such as pea, common bean and cowpea. Description of vegetative growth stages in lentil, therefore, necessitates the use the primary branches. Both vegetative and reproductive growth measurements in lentil focus on the basal primary branch.

Determination of vegetative and reproductive growth stages relies on node identification. The node remains as a leaf scar when the leaf drops off and hence node counts are unaffected by leaf loss. Staging of lentils for vegetative growth is accomplished by counting the number of visible nodes on the main stem up to the node subtending the basal primary branch and then continuing the node count up the basal primary branch to include the highest fully developed leaf. The cotyledonary node is designated as 0. The first two leaves are simple, scale-like and largely fused with two lateral scale-like stipules. The following two or more leaves are bifoliate and subsequent leaves multifoliate. Young leaves have leaflets resembling cylinders. As development progresses the leaflets unroll and flatten. To determine when the leaf is fully developed leaf development at the node immediately above is observed. In lentil, a leaf is considered fully developed (node is counted) when the leaf at the node above has unrolled sufficiently so that the two edges of each leaflet are not touching. When there is more than one branch from the node subtending the basal primary branch, the thickest of the branches can be used for the node count. The basal primary branch usually develops between nodes 1 to 5. Occasionally, the basal primary branch either develops late at nodes above 5 or not at all; in these cases the main stem may be used for the node count. For example, a plant with 4 nodes is in vegetative stage V4 and a plant with 16 nodes is in stage V16.

Flowering in lentil is indeterminate - occurring from axillary buds on the main stem and branches. It proceeds acropetally from lower to higher nodes. A single plant may have open flowers at high nodes and full pods in lower nodal positions at the same time. Many of the early flowers abort.

The choice of which part of the plant to be used for reproductive staging is influenced by our knowledge of the fruiting pattern. Although the main stem and basal primary branch carry the same number of pods on average, podding on the primary branches is concentrated within fewer nodes per branch than on the main stem. The nodes on the plant which are most commonly podded are nodes 11 and 12 on the basal primary branch. As a reference point spanning the most commonly podded nodes, the most advanced reproductive structure within nodes

10-13 on the basal primary branch will determine reproductive stage. Nodes on the basal primary branch are counted for the purpose of staging reproductive growth from the node on the main stem (node = 0) subtending the basal primary branch.

The developmental stages of reproductive growth are given in Table 3.2.6. The R1 stage indicates anthesis and R2 represents full bloom with the spread of flowering from the first flowering node acropetally

Table 3.2.6. Reproductive stage of development descriptions for lentil.

Stage	Stage title	Description of growth stage
R1	First bloo	One open flower at any node
R2	Full bloom	Flower open or has opened on nodes 10-13 of the basal primary branch.
R3	Early pod	Pod on nodes 10-13 of the basal primary branch is visible.
R4	Flat pod	Pod on nodes 10-13 of the basal primary branch has reached its full length and is largely flat. Seeds fill less than half of the pod area but can be felt as a bump between the fingers.
R5	Full seed	Seed in <u>any single</u> pod on nodes 10-13 of the basal primary branch are swollen and completely fill the pod cavity.
R6	Full pod cavities	<u>All</u> the normal pods on nodes 10-13 of the basal primary branche are swollen and completely fill the pod cavity.
R7	Physiological maturity	The leaves start yellowing and 50% of the pods have turned yellow.
R8	Full maturity	Ninety percent of pods on the pant are golden-brown

to nodes 10-13 on the basal primary branch. Stages R3 to R6 cover pod and seed development with stage R3 referring to first pod appearance on nodes 10-13 on the basal primary branch, with stage R4 to the completion of pod growth, and with stage R5 to the completion of seed expansion within any single pod between nodes 10-13 on the basal primary branch. Stage R6 refers to the completion of seed expansion in all normal pods at nodes 10-13 on the basal primary branch. Stages R7 and R8 designate physiological and full maturity respectively.

The stage descriptions apply to individual plants directly. To describe the stage of development of a community of plants, the stage designated should represent the average of plants studied. The average stage of a field is when 50 percent of the plants are at or beyond a particular stage of development. Consequently, the developmental stage R1 'first bloom' corresponds to that commonly used in the field to estimate time to 50% of plants in flower. Obtaining a representative sample of plants requires inspection of plants from several locations in a field. At least one 10-plant sample for every 5 ha should be used to obtain an adequate determination of average stage of development.

It is our belief that this uniform system for the description of developmental stages in lentil is universally applicable to all growing environments (field or greenhouse) and to divergent cultivars. Additionally, the descriptions may be used for single plants or communities of plants. The stage descriptions are precise and objective so that variation among persons using the system will be minimal, thereby aiding communication between those interested in the ancient lentil.

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3.2.4. Effect of sowing date on growth and yield of lentil lines

Farmers in West Asia usually sow lentil in late winter from late December to early February. Consequently the reproductive phase of growth coincides with increasing water deficit and high temperatures from April onwards, resulting in low yields. We studied the effect of an advance of sowing date from late winter (early February) to early winter (November) on the growth and yield of a range of lentil lines between 1982 and 1985 to provide information that might be useful for breeding program.

The study showed clearly the advantage of early over late winter sowing with the mean seed and straw yields from an early winter sowing of 838 and 2476 kg/ha compared to 679 and 1470 kg/ha, respectively, from a late sown crop (Table 3.2.7). The overall advantage in gross revenue from both seed and straw was between 35 and 41% depending on the relative prices of the commodities.

There were seasonal differences in the advantage in seed yield of early sowing because of the infestation by Orobanche spp. (1983/84 season) a key factor limiting the use of early sowing (Table 3.2.7). A second cause of limited advantage in seed yield from early sowing is abnormally cold winter conditions as was the case in 1982/83.

Table 3.2.7. Seed and straw yields (kg/ha) from early (November) and late (early February) winter sowing of lentil from 1982 to 1985.

	Sowing date			
	November		February	
	Seed	Straw	Seed	Straw
1982/83	995	2457	985	1962
1983/84	386	2418	529	1522
1984/85	1133	2452	523	926
Means	838	2442	679	1470

Three large-seeded and three small-seeded lines were used in the study but there was no difference in the growth pattern of the two groups. However there was clear evidence of genetic variation in growth rate. A high rate of dry matter accumulation was associated with a high final biological yield as shown by the strong correlations between the dry matter at various stages and the total biomass at maturity (Table 3.2.8). Clearly, early vigour was strongly related to biomass at harvest. The potential of the trait early vigour as a selection criterion is being investigated.

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

3.2.5. Effect of terminal heat and drought stress in lentil

In the Mediterranean basin, the reproductive phase of winter sown lentil coincides with the termination of winter rainfall and the

Table 3.2.8. Correlations between dry matter (g/m^2) at different growth stages and biomass at maturity for early winter and late winter dates of sowing in two seasons at Tel Hadya, Syria.

	1982/83		1984/85	
	Sampling date	r	Sampling date	r
Dry matter/m^2 - early sowing	16.1.1983	0.003	22.1.1985	0.177
Dry matter/m^2 - early sowing	16.2.1983	0.502*	15.4.1985	0.668**
Dry matter/m^2 - early sowing	17.2.1983	0.866**	7.5.1985	0.748**
Dry matter/m^2 - early sowing	28.2.1983	0.867**		
Dry matter/m^2 - late sowing	25.3.1983	0.463*	15.4.1985	0.549**
Dry matter/m^2 - late sowing	4.4.1983	0.495*	7.5.1985	0.570**
Dry matter/m^2 - late sowing	19.4.1983	0.595*		
Dry matter/m^2 - late sowing	10.5.1983	0.707*		

* P < 0.05
** P <0.01 > 0.05

period of rapid rise in air temperature. The reproductive phase of lentil is as a result curtailed. Earlier studies at ICARDA had shown that yield advantage from advancing date of sowing to early winter was largely due to the extended vegetative growth, and to a lesser extent to the slightly increased seed filling period. It is however, not known whether the inability to extend reproductive growth to later part of May by lentil is due to drought or heat stress. The present study conducted during 1988/89 aimed at determining whether: 1. drought or heat stress is the major factor responsible for accelerating maturity in the lentil crop, 2. the accelerated (forced) maturity is a beneficial adaptive trait *for* the Mediterranean environment, and 3. there is genetic variation among cultivars for response to terminal heat and drought stress.

Four lentil cultivars; ILL 4400, ILL 4401 (landraces), ILL 5582 and ILL 5604, were grown in the field with and without supplemental irrigation. During reproductive phase, temperature treatment was superimposed by either permitting the crop to grow under the prevailing air temperature or with increased temperature obtained by putting a plastic tunnel. The experimental design was split plot with cultivars as subplots and moisture supply and temperature treatments factorially arranged in the main plots.

In this dry year, the most important factor was moisture supply. In the irrigated treatment, number of days from flowering to maturity was increased (Table 3.2.9). Compared to the rainfed treatment, increases due to irrigation were 147% for biological yield, 353% for seed yield, 161% for pod number, 183% for seed number and 13% for 1000-seed weight, and in addition harvest index was also increased (Tables 3.2.10).

Table 3.2.9. The effect of moisture supply and temperature on some phenological stages of lentil.

		Days to maturity			
		Rainfed		Irrigated	
Cultivar	Days to flower	Normal temperature	Increased temperature	Normal temperature	Increased temperature
ILL 5582	113	148	149	168	168
ILL 4400	117	150	148	171	172
ILL 4401	118	148	150	168	168
ILL 6504	120	149	148	172	173

The plastic tunnel on the average, increased temperature by about 10°C above the normal air temperature. This increase in temperature

Table 3.2.10. Effect of variation in temperature and moisture supply on total biological yield, seed yield, harvest index, no of pods/m^2 and seeds/m^2 and 1000-seed weight of four lentil genotypes, Tel Hadya, 1988/89.

Treatments	Yield (kg/ha) Total	Yield (kg/ha) Seed	Harvest index	No. of pods/m^2	Seeds/m^2	1000-seed weight (g)
Normal temperature						
Rainfed						
ILL 5582	1750	498	0.28	1364	1420	39.8
ILL 4400	1615	291	0.18	932	1048	43.6
ILL 4401	1453	420	0.29	1938	2262	28.4
ILL 5604	1679	457	0.27	2194	2534	30.4
Mean	1624	417	0.26	1604	1816	35.6
Irrigated						
ILL 5582	3840	1647	0.42	4006	4350	52.7
ILL 4400	3900	2018	0.60	3040	3578	61.5
ILL 4401	3878	1682	0.43	4674	7202	35.1
ILL 5604	4606	2088	0.45	5218	6246	36.3
Mean	4056	1859	0.48	4235	5344	46.4
Gen. mean	2851	1138	0.37	2921	3580	41.0
High temperature						
Rainfed						
ILL 5582	2682	479	0.23	1684	1898	39.2
ILL 4400	1333	173	0.13	870	936	39.8
ILL 4401	1299	345	0.26	1632	2180	26.2
ILL 5604	1710	406	0.24	2168	2254	29.3
Mean	1756	351	0.21	1589	1817	33.6
Irrigated						
ILL 5582	4407	1862	0.43	4418	4886	502
ILL 4400	4583	1286	0.29	2622	2930	56.8
ILL 4401	3853	1693	0.44	4612	6218	32.9
ILL 5604	4310	1647	0.39	4774	5702	32.8
Mean	4288	1622	0.39	4106	4934	43.2
Gen. mean	3022	982	0.30	2848	3374	38.4
S.E. T	165.1	49.4	0.06	172.3	146.2	0.84
M	196.1	61.3	0.06	125.3	157.3	0.62
C	141.6	64.1	NS	196	262.6	0.89
C.V. (%)	19.3	24.1	32.0	27.2	30.2	9.00

did not have significant influence on phenology, biological yield, seed yield, number of pods/unit area or number of seeds/unit area; but it reduced significantly harvest index and 1000 - seed weight (Tables 3.2.9 and 3.2.10). The mean influence of increasing air temperature was 6% increase in biological yield, 13% reduction is seed yield, 19% reduction in harvest index, 2% reduction in pod number, 6% reduction in seed number and 6% reduction in 1000 - seed weight.

Seed yield response of cultivars to increase in temperature varied significantly. ILL 5582, ILL 4401 and ILL 5604 were not significantly influenced by temperature treatment, but increasing temperature reduced significantly seed yield of ILL 4400, this reduction being 37%.

The preliminary results of this study indicate that increase in temperature during reproductive growth did not influence total biomass produced, but influenced the pattern of distribution, with increased temperature favouring vegetative rather than reproductive growth. The study in addition showed that variability exists among cultivars, with ILL 4400 being more sensitive to higher temperature.
Drs. S.N. Silim and M.C. Saxena.

3.3. Lentil Harvest Mechanization

3.3.1. Comparison of various harvest systems

Lentil harvest is the major production problem in the Mediterranean region because of the high cost of harvest labour. Systems of mechanization developed to decrease the cost of production 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 3) combine harvesters on a well-prepared seed-bed sown with a tall, non-lodging cultivar.

The 1988/89 growing season was characterized by a cold and dry winter which resulted in extremely stunted plant growth. Plant height at Tel Hadya was 15-20 cm which precluded meaningful machine harvest. In Kameshly, the major area of lentil production of Syria, there was very little machine harvest on farmers' fields, in contrast to the previous season when more than 5000 ha was harvested by a combination of either swathe-mower or combine harvester. The growing conditions experienced this season provided a salutary lesson into the ecological limits of lentil harvest mechanization.

Despite the unfavourable conditions it was possible to harvest by machine at some sites in Syria. The village projects, in which promising lines are tested on farmers' fields in large plots as part of the cooperative research with the national program, provided some such opportunities. Each plot was harvested partly by hand and partly by combine harvester. The line 78S26013 yielded more than the local check 'Hurani 1' averaged over locations and harvest methods (Table 3.3.1). The combine harvested plots yielded on average 25% less than the hand harvested area.

Table 3.3.1. Seed yield (kg/ha) at two locations of two lentil lines harvested by hand and combine harvester in the village project in Syria, 1988/89.

	ILL 16		Hurani 1	
Locations	Hand	Machine	Hand	Machine
Morek	938	698	649	605
Alkamiah	635	450	687	422
Mean	788.5	574	668	513.5
Over check %	17.7	11.7		

The Syrian Libyan Company (SYLICO) grows lentil under irrigation in the Ras el Ein area of Syria. Last season they grew 300 ha of 'Idlib 1' and 78S26013 under irrigation and as a consequence the lentil was unaffected by the drought conditions. The harvest was by combine harvester with a comparison between the normal combine and a modified combine with the reel replaced by air jets and the single knife cutter-bar replaced with a double-knife bar. The normal combine performed better than the modified combine largely because the extra weight of the modifications decreased the control of cutting height increasing losses.

A lentil harvest mechanization course was conducted jointly with the General Organization of Agricultural Mechanization (GOAM) in May 1989 and a report is given in the Training Section (9.1.2).
National Agriculture Research Systems.

3.3.2. Effect of Spodnam on lentil seed yield and harvest losses

Among the different systems of mechanical harvest tested at ICARDA in the past is a combine harvest which shows great promise (ICARDA 1989). The optimum time of harvest by combine is, however, later than for hand pulling. This delay, however, accentuates pod dehiscence and pod drop. A spray of a chemical named 'Spodnam EDB' has been reported to control pod shattering and delay time of Harvest in peas, soybeans, mungbeans, dry beans and oils seed rape. Experiments were, therefore, conducted at ICARDA to test the potential of this chemical in controlling pod dehiscence and pod drop in lentil and in extending the period for mechanized harvest using Idleb 1 (ILL 5582) cultivar sown on 2 Dec.

1987 and 5 Dec. 1988 in plots 3x20 m. All plots were hand weeded.

Spodnam EDB was sprayed at pod filling stage at a rate of 1.25 l/ha in 400 l/ha of tank mix with distilled water. A check plot for comparison was sprayed with water. Crop was harvested by either hand pulling at the normal time (physiological maturity when 40-60% of pods were yellow) or at full maturity (when 100% of pods were mature) by a plot combine. In a second set of treatments the harvest was delayed by 3 weeks after 100% maturity.

The long term-average annual rainfall at Tel Hadya is 330 mm. In 1987/88, the annual rainfall was 504 mm, higher than long-term average by 53% and in 1988/89, only 229 mm was received representing 69% of the mean annual precipitation.

Seed yield loss from plot combine harvest compared to hand pulling was 26% in 1987/88 and 11% in 1988/89 (Tables 3.3.2 and 3.3.3). Averaged over two years, seed yield loss was 18.5% which is similar to the two year average of 20% reported at ICARDA in 1988 with a modified combine (ICARDA 1989).

Delaying harvest in 1987/88 had no influence on seed yield but increased seed yield loss significantly in 1988/89 by 38%. In 1988/89, harvesting by plot combine particularly accentuated the losses due to delay in harvesting, giving a total seed loss of 50% (Table 3.3.2). The difference in response to delay in harvest and methods of harvest in 1987/88 and 1988/89 was probably due to differences in moisture supply over the seasons.

Compared to control (water spray), applying Spodnam on lentil did not increase seed yield significantly. The yield advantage from applying Spodnam was 7% in 1987/88 and 3% in 1988/89. Probably in the Mediterranean basin, the rapid rise in temperature and drought which cut short the reproductive period in lentil were responsible for the ineffectiveness of this chemical.

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

Table 3.3.2. The effect of applying Spodnam and time and method of harvest of seed yield of lentil cultivar ILL 5582. Tel Hadya, 1987/88.

Chemical spray (C)	Method of harvest (H)						Mean
	Hand			Plot combine			
	Normal harvest	Delayed harvest	Mean	Normal harvest	Delayed harvest	Mean	
Water	1944	2084	2014	1450	1638	1544	1779
Spodnam	2173	2245	2208	1566	1634	1600	1904
Mean	2085	2164		1508	1636		
Mean for H	2111			1572			

	Time of harvest T	
	Normal	Delayed
Water	1697	1861
Spodnam	1869	1939
Mean	1783	1900

	LSD (5%)	SE	CV (%)
C	NS	48	
H	141	48	
T	NS	48	
C x H	NS	68	
C x T	NS	69	
H x T	NS	68	
H x T x C	NS	96	10.4

Table 3.3.3. The effect of applying Spodnam and time and method of harvest on seed yield of lentil cultivar ILL 5582. Tel Hadya, 1988/89.

Chemical spray (C)	Method of harvest (H)						Mean
	Hand			Plot combine			
	Normal harvest	Delayed harvest	Mean	Normal harvest	Delayed harvest	Mean	
Water	484	501	493	607	302	455	474
Spodnam	542	510	526	605	304	455	490
Mean	513	506		606	304		
Mean for H	509			455			

	Time of harvest T	
	Normal	Delayed
Water	545	402
Spodnam	574	407
Mean	559	405

	LSD (5%)	SE	CV (%)
C	NS	16.2	
H	48	16.2	
T	48	16.2	
C x H	NS	23.0	
C x T	NS	23.0	
H x T	68	23.0	
H x T x C	NS	32.5	13.5

3.4. Lentil Microbiology

3.4.1. Rhizobium strain-cultivar interactions for yield and N_2 fixation in lentil

With long term cultivation of the crop in areas of WANA receiving between 300 and 400 mm annual rainfall, high native populations of rhizobia nodulating lentil are expected. Though information is sparse, this appears to be true; average viable counts of rhizobia nodulating lentil in the west Asia region are in the range of 10^3-10^5 g^{-1} soil. Existence of adequate native rhizobial populations implies that improvement in dinitrogen fixation through manipulation of the symbiosis through inoculation may not be possible. Not a great deal is known regarding specificity of the crop with respect to strain-cultivar interactions, but indications by other investigators point to some degree of specificity.

It is important to establish base-line values for percent plant N derived from the atmosphere (%Ndfa) and N_2 fixed in recommended cultivars of lentil so improvements through rhizobial strain and legume cultivar breeding/selection may be quantified. The objective therefore of this study was to determine the variations in nitrogen fixation and yield in lentil cultivars inoculated by a number of Rhizobium leguminosarum strains nodulating lentil.

Experiments were conducted in N. Syria at two locations on the Tel Hadya, during 1987-88 and 1988-89 seasons, and at Breda during 1988-89 seasons. Most probable number (MPN) measurements of indigenous lentil rhizobia populations in the soil were high with 4.2 x 10^4 and 2.9 x 10^4 rhizobia g^{-1} soil respectively, for Tel Hadya fields utilized in 1987/8 and 1988/9, and 6.8 x 10^3 at Breda, due to long-term cultivation of lentil in these areas. Rhizobia treatments comprised uninoculated and two strain treatments; the 1987/8 experiment included two single-strain inoculants (strains 719 and 735) while in the 1988/9 experiments a single-strain inoculant (strain 719) and a 3-strain mixture (strains 719, 726 and 735, all of Syrian origin) were utilized. Strains were selected based on prior N_2-fixing performance on the concerned cultivars in aseptic hydroponic culture in greenhouse trials. Eight cultivars of large- and small-seeded types were used in all three trials, chosen for their realized and potential use in the region. Cultivars included ILL 8, ILL 16, ILL 1939, ILL 4354, ILL 4400, ILL 4401, ILL 5700 and ILL 6011.

In the absence of 15N data (not yet available), the parameters chosen to best evaluate treatment effect on N fixation are total crop N, and biological and seed yields. During 1987/88 season, strain 735 and application of N fertilizer significantly improved biological but not seed yield over the uninoculated treatment across all cultivars; yields were high in this trial because of favorable weather conditions (Table 3.4.1). Strain 719 did not improve the average yields in 1987/88, but increased average biological and seed yields at Tel Hadya in 1988/89 (by 15 and 30%, respectively), and biological yield at Breda

Table 3.4.1. Effect of treatments on biological yield and seed yield over 8 cultivars for two years at Tel Hadya (TH) and Breda (BR)

	Biological yield t/ha			Seed yield kg/ha		
Treatment	1987/88TH	1988/89TH	1988/89BR	1987/88TH	1988/89TH	1988/89BR
120 kg N/ha	7.21a	2.10b	0.52b	2172b	556b	72b
Strain 719	6.86ab	2.34a	0.59a	2241ab	671a	151a
Strain 735/mix	7.19a	2.38a	0.53b	2390a	684a	137a
Uninoculated	6.83b	2.03b	0.52b	2212ab	518b	138a
CV %	13	19	21	20	27	24
LSD .05	0.35	0.21	0.05	197	83	15

by 13%. Application of N fertilizer decreased seed yield by nearly 50% in Breda. The strain mixture significantly increased the average seed and biological yields in Tel Hadya but did not affect average yields in Breda.

Three cultivars of the eight tested lines (ILL 16, 5700, 6011) responded significantly to inoculation in all Tel Hadya trials, while cultivar ILL 4401 responded only during 1988/89 season (Fig. 3.4.1). Seed yield was increased in ILL 16 during 1987/88 by nearly 1 t/ha, and in ILL 6011 and 5700 by 0.3 and 0.5 t/ha, respectively. Biological yields were also increased by about 1 t/ha in cultivars ILL 5700 and 6011 (Fig. 3.4.1).

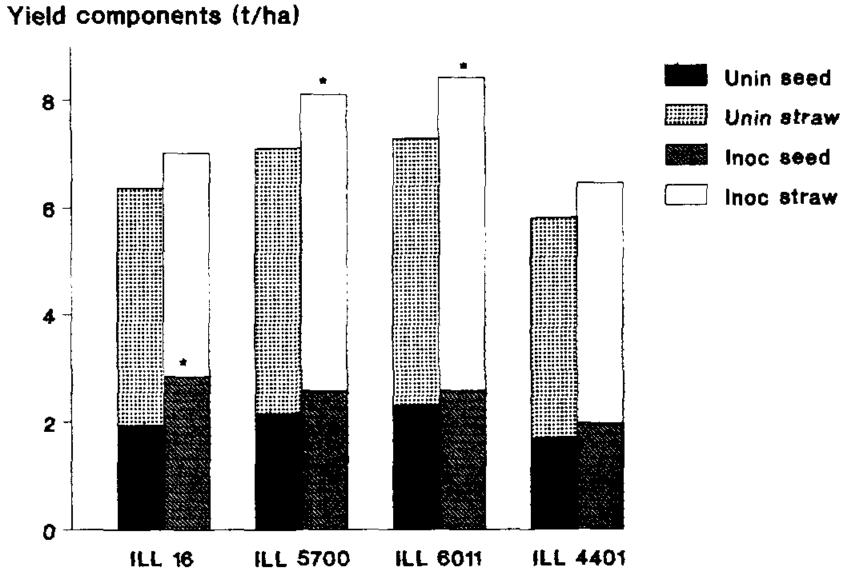

Figure 3.4.1. Response of four lentil cultivars to inoculation, Tel Hadya 1988/89.

Rainfall was low and poorly distributed in 1988/89 causing lower yields, but inoculation of these 4 cultivars in Tel Hadya produced approximately 35% biological yield increase (500 to 700 kg/ha) and from 43 to 93% seed yield increase (225 to 370 kg/ha) above the uninoculated crop with the best strain treatment (mixed strain). In Breda yields were very low, and only cultivar ILL 5700 responded significantly to inoculation with 185 kg/ha biological yield increase (37%) and 73 kg/ha seed yield increase (49%) with strain 719.

The magnitude of the symbiotic response, and typical strain-cultivar interactions for the two trials at Tel Hadya are demonstrated in Figures 3.4.2, which present data for the 1987/88 season. Cultivars ILL 8 and 1939 produced significantly less straw yield when inoculated

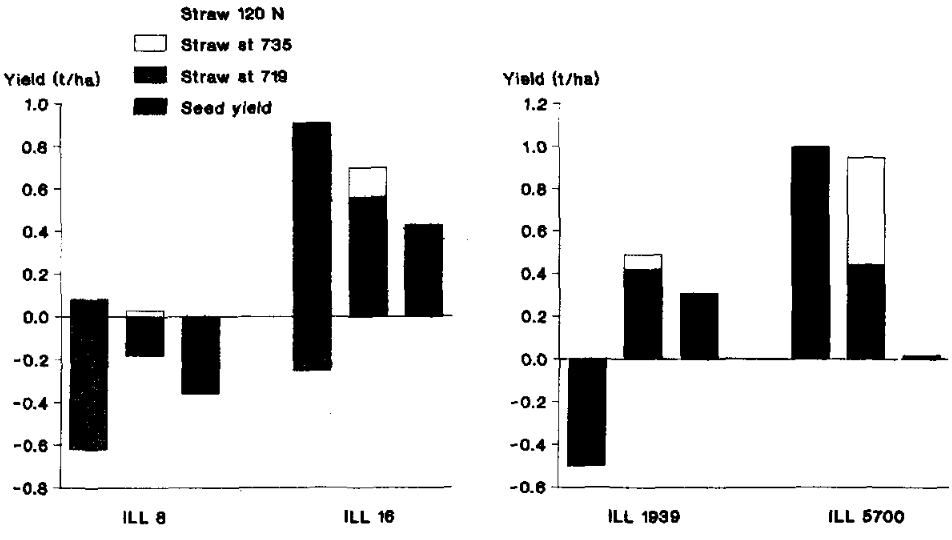

Figure 3.4.2. Contrasting yield responses of different cultivars of lentil to inoculation with two different strains of Rhizobium, Tel Hadya, 1987/88.

with strain 719, while cultivar ILL 5700 increased straw and seed yields when inoculated with this strain; seed yield was increased by nearly 1 t/ha in ILL 16. Strain 735 increased yields in all except ILL 8, where it had no effect (Fig. 3.4.2). Application of N fertilizer increased biological yields in the same three cultivars, but depressed yield in ILL 8.

The complications arising from strain specific response were ameliorated by using a strain mixture in the 1988/89 trials, where in Tel Hadya it gave the highest average yields. No yield depression effect from inoculation with strain 719 or the strain mixture was observed in the 1988/89 trials.

The magnitude of yield increases in some cultivars, and the overall yield increases due to inoculation with selected strains indicate that manipulation of the symbiosis is feasible to increase yield in lentil, even where native rhizobia populations are high. Clearly, the strain selection process outlined earlier (FLIP annual report, 1986) was effective when taken to the field. Better understanding of the effectiveness of native lentil rhizobial populations and incorporation of strain identification methodologies into field inoculation trials will lead to more consistent results from inoculation; this in turn could make development of capacity to produce inoculants in NARSs economical.

Direct measurement of N_2 fixation, using 15N, will further elaborate the effect of inoculation on symbiotic efficiency; results will be reported next season. In addition, 15N results will indicate to breeders which cultivars are able to obtain the highest proportions of crop N from fixation, and thereby minimize utilization of soil N, leading to greater eventual consideration of N fixation as it relates to systems sustainability in the breeding process.

Dr. D. Beck.

3.5. Biotechnology

3.5.1. Agrobacterium tumefaciens, a potential gene vector for lentil

The 4 wild strains of A. tumefaciens (C58, T37, B6S3, Ach 5) which were tested last year as potential gene vectors for chickpea, were tested for lentil this season. Wounded lentil cotyledons (ILL 8 and 16) were inoculated with the bacterial suspension. The strains C58, T37 and Ach 5 induced intensive tumor growth and thus represent potential gene vectors for future application of genetic engineering in lentil improvement. These identified strains would have to be used in their disarmed version, i.e. with the tumor inducing gene deleted. The transgenic nature of the regenerated plants can be proved by the nopaline synthetase test. As nopaline is only produced by the Bacterium genes, the presence of nopaline in the plants shows if the successfully integrated t-DNA is actively expressed in the host genome. To reduce the probability of undesirable somaclonal variation and to facilitate plant regeneration, germinating seeds were used instead of wounded cotyledons. Germinating lentil seeds were suspended in the bacterial suspension of the 4 wild strains for 24 hrs. The seeds were then transferred to semi-solid agar media in sterile germination boxes. All seedlings regardless of bacterial strain produced abnormal shoots and roots. Abnormalities developed to such an extent that none of the seedlings could be raised to a normal adult plant.

3.6. Lentil Entomology

Studies on the economic importance and different aspects of control of Sitona weevil were continued. The Sitona species attacking lentil in Syria was re-identified as Sitona crinitus Herbst (Dr. J.P. Aeschlimann, Montpellier) and thus only this name should be used. For storage pests, experiments on methods of protection and control in the field and store were continued and a survey was conducted in Jordan.

3.6.1. Importance of S. crinitus and effectiveness of control

As in the previous 2 seasons damage levels and yields were studied at 3 locations with different rainfall using 2 sowing dates (late November and early January) and 4 treatment levels of Carbofuran (2, 5, 10, 20 kg/ha 5% G). To determine to what extent the feeding of the Sitona larvae in the nodules affects the nitrogen fixation of the plants, 15 N technique was used. Microplots in the check and 20 kg/ha Carbofuran treatments received 10 kg N/ha of 10% 15 N atom excess as ammonium sulphate, the microplots of the reference crop (non-nodulating chickpea) received 100 kg N/ha of 1% 15 N atom excess fertilizer. Results on N^{15} atom excess of the plant samples are still awaited from the laboratory in USA.

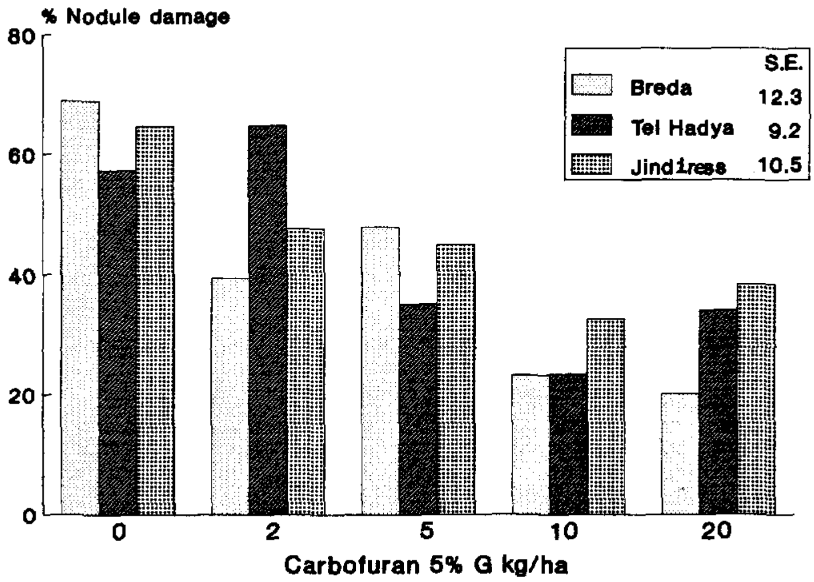

Figure 3.6.1. Effect of 4 treatment levels of Carbofuran on Sitona damage to nodules in lentil at 3 locations in Syria, 1988/89.

In the early sowing the nodule damage ranged between 60 and 70% in the untreated check plots at all 3 locations (Fig. 3.6.1). The Carbofuran treatment reduced nodule damage, but not as effectively as in previous years. Even at the higher dosages 20 to 35% of the nodules were damaged. At Breda and Tel Hadya seed and biological yields were not affected significantly by Carbofuran treatments (Figure 3.6.2). Because of the low rainfall (195 mm at Breda, 235 mm at Tel Hadya) yields in general were low. At Jindiress with 354 mm rain both the 10 and 20 kg/ha Carbofuran treatments significantly increased seed and biological yields.

At Tel Hadya Promet seed dressing was used at 2 dosages (12 and 25 ml/kg seed) in addition to Carbofuran. At both dosages the nodule

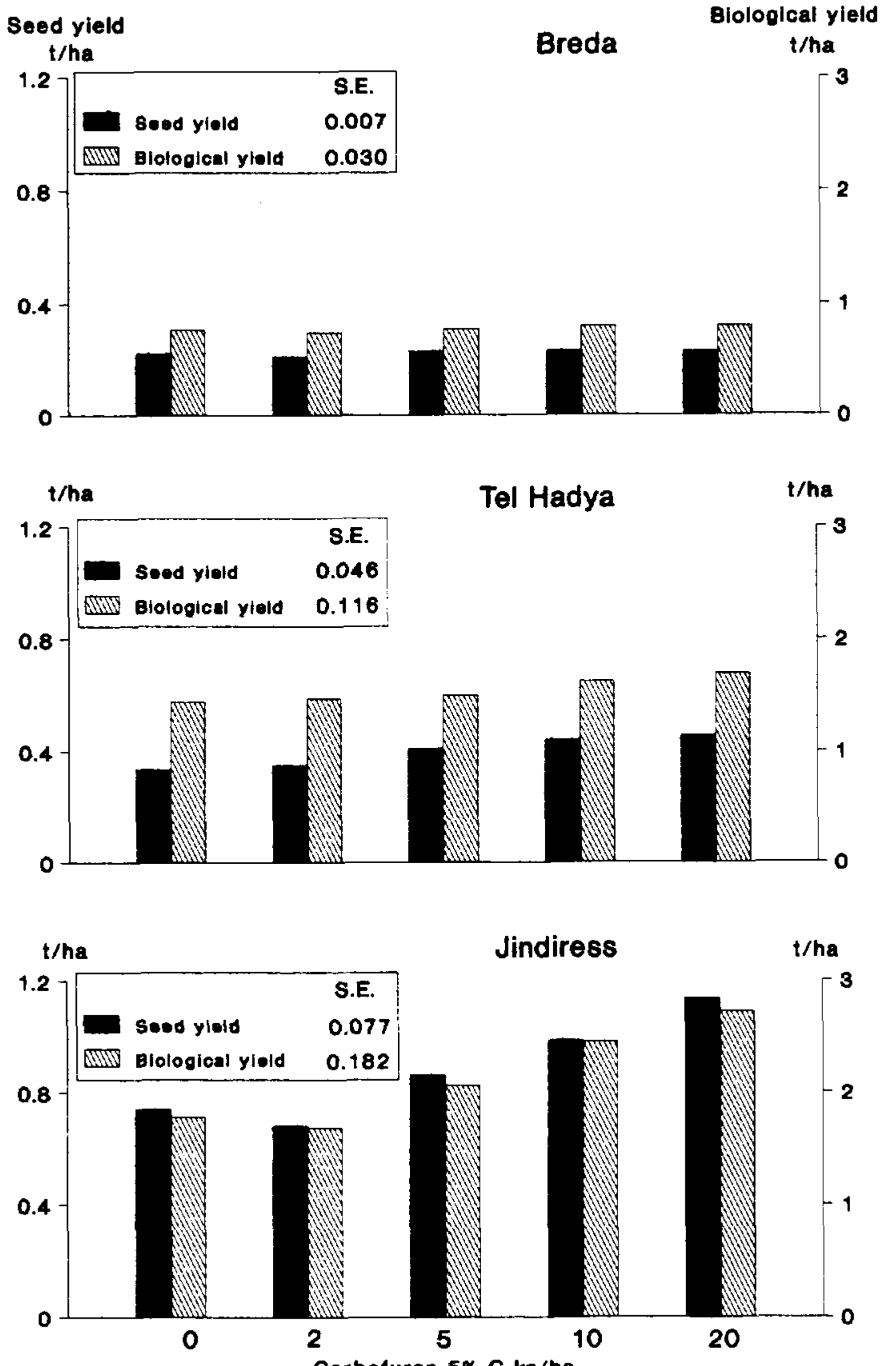

Figure 3.6.2. Effect of 4 treatments of Carbofuran on lentil yield at Breda, Tel Hadya and Jindiress, 1988/89.

damage was reduced significantly and seed and biological yield increased exceeding the yields of the Carbofuran treatments (Fig. 3.6.3). Promet therefore represents an effective alternative to Carbofuran with the additional advantage of being less toxic, easier to handle and less expensive. It will be tested at the 3 locations as well as in farmers fields during the next season.

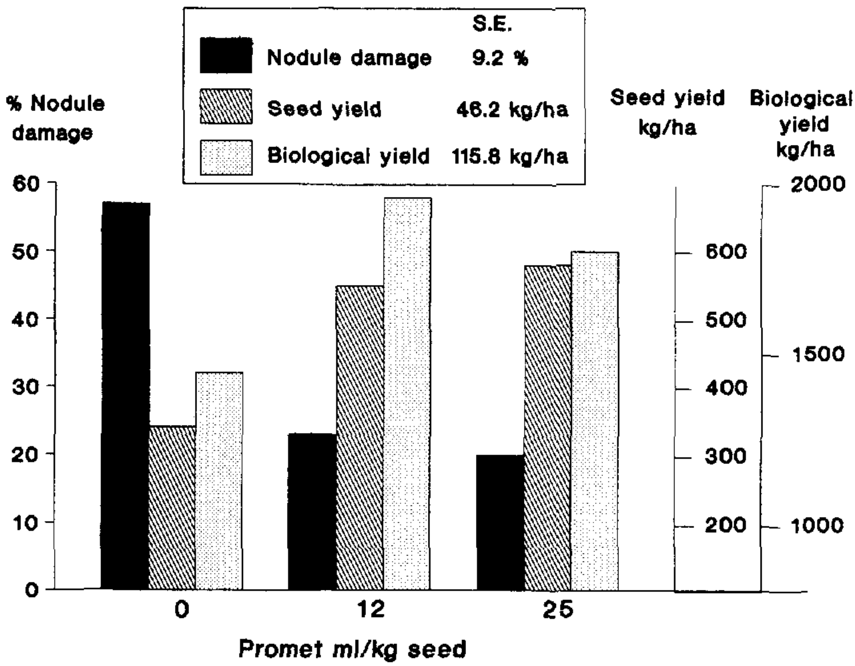

Figure 3.6.3. Effect of Promet application on Sitona damage and lentil seed and biological yield, Tel Hadya, 1988/89.

The relationship between rainfall and the biological yield response of lentil to application of 20 kg/ha Carbofuran (5%G) was further developed using data from small plots of on-farm trials at 9 locations in northern Syria, in cooperation with FRMP. The 3 seasons

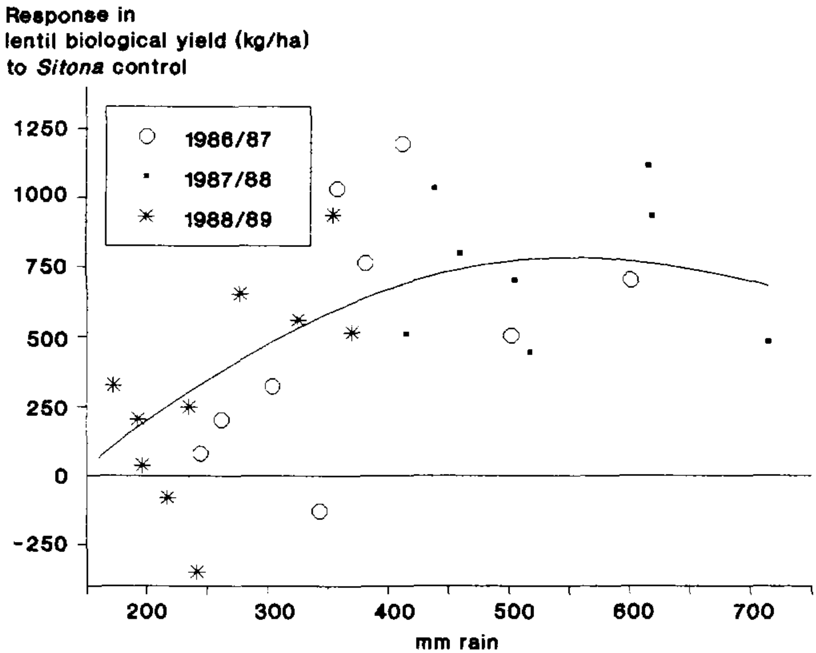

Figure 3.6.4. Response of lentil biological yield to Sitona control (20 kg/ha, 5% G Carbofuran) at locations with different rainfall during last three seasons in N. Syria.

data are shown in Figure 3.6.4. The relationship could be described by the quadratic equation $y = -644.29 + 5.182439\ x - 0.00466\ x^2$ where x = seasonal rainfall (mm), y = total biological yield increase (kg/ha). The coefficient of determination was 0.3 (P = 0.5). From this equation, maximum response to Carbofuran application was predicted at 557 mm rainfall, which is slightly higher than that predicted from the data of previous two seasons.

3.6.2. Life cycle of S. crinitus

The monitoring of the population development by adult flight traps and extraction of eggs from soil samples showed that S. crinitus after aestivation resumed activity with the emergence of lentil crop in the beginning of December (Figure 3.6.5). Peak activity occurred in December and February. Catches were highest in Jindiress. The neonate adults appeared in early May, but apparently are not very flight active and not caught in the trap. Oviposition started in mid December and decreased in April. At Breda the number of extracted eggs was very low even in the untreated plots, whereas at Tel Hadya and in particular at Jindiress high numbers of eggs were found in the check plots. The Carbofuran treatment (20 kg/ha) greatly reduced the number of eggs which results also in lower number of larvae and nodule damage. Thus the number of extracted eggs can be used as an indication for the effectiveness of control. At Jindiress the number of eggs was highly correlated with seed yield (r = -0.74).

In some lentil fields at Tel Hadya considerable damage was caused by root aphids. These were identified as Smynthurodes betae Westwood (Homoptera: Aphididae), which is a heteroecious species with a 2 year cycle, the primary host being Pistacea. Secondary hosts consist of many dicotyledonous plants, only the roots of which are attacked. Interestingly, larvae of the coccinellid predator Hyperaspis spp. were found associated with the root aphids.

3.6.3. Storage pests

3.6.3.1. Control of Bruchus ervi

B. ervi is the dominant univoltine storage pest of lentil in Syria.

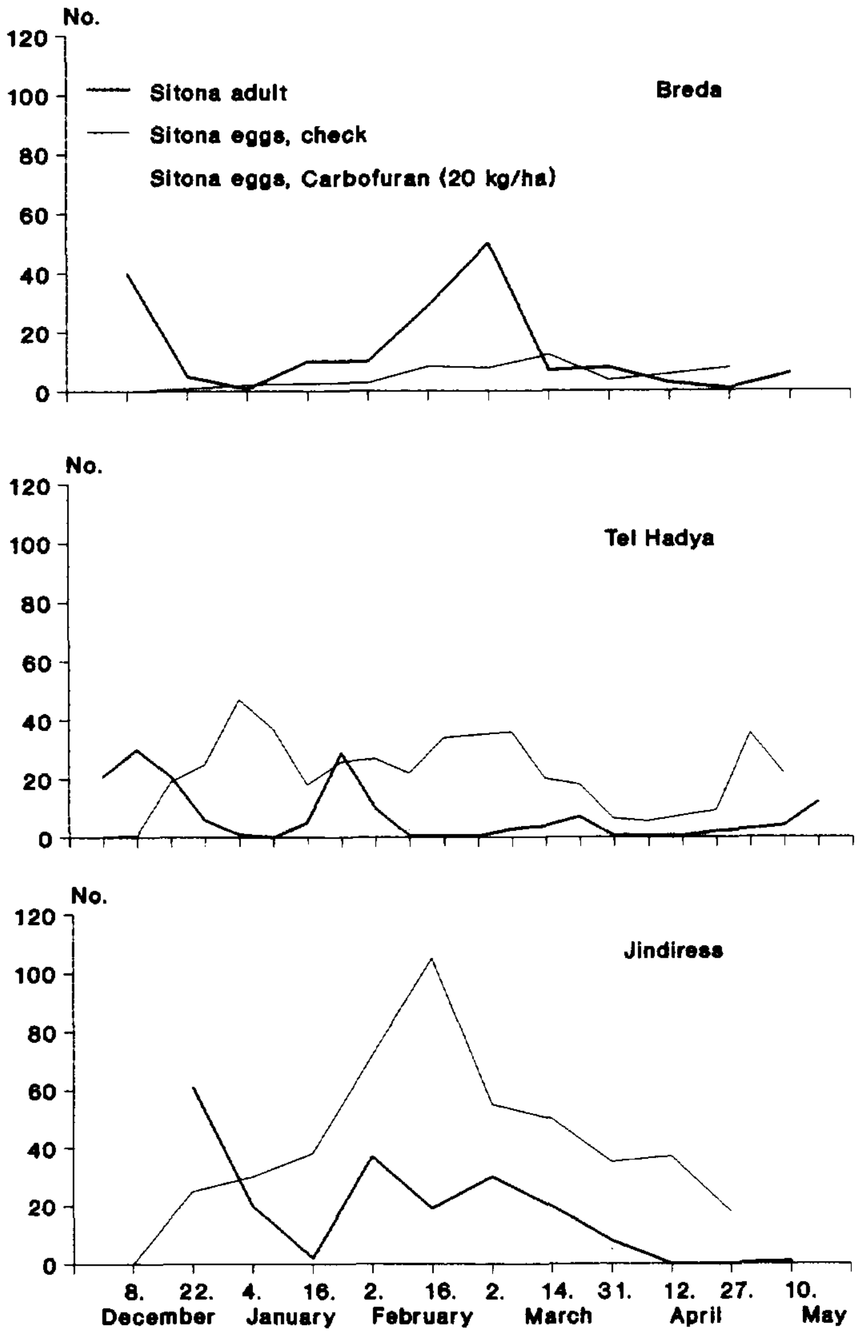

Figure 3.6.5. Number of adult <u>Sitona crinitus</u> trapped/ week and eggs extracted from 100 cc soil samples with and without Carbofuran treatment (20 kg/ha, 5% G) at Breda, Tel Hadya and Jindiress, 1988/89.

Since the infestation starts in the field, experiments on control methods in the field were continued. A lentil field was selected in Termaneen village (Western Aleppo) where previously high infestation level by B. ervi was found. The application of Endosulfan (Thiodan 35Ec at 700 g. a.i./ha) and Deltamethrin (Decis 38g. a.i./ha) at early pod setting resulted in yield increases of 10 and 7% respectively. However, the increases were mainly due to the control of black and green aphids and thrips. Since the bruchid infestation was very low this season and no clear differences between treated and untreated plots were found, the experiment will be repeated next season.

Drs. O. Tahhan, S. Weigand and M. El-Ahmed (ARC, Syria).

3.6.3.2. Survey of lentil storage pests in Jordan

Two weeks survey was conducted to identify the importance and distribution of actual and potential storage pests. From 53 villages in 7 provinces 90 seed samples were collected from farmers and merchants, of which 82% were infested. The highest infestation of 12% was found in western Irbid province. From the samples a total of 652 adult insects were collected and identified. The most frequent species was B. ervi with 89%, followed by B. lentis 7%, B. quinqueguttatus 4% and Callosobruchus chinensis <1%. The most common method of seed storage is to fill the seeds in jute sacks which are usually placed inside cement stores. Phostoxin is the most commonly used fumigant. Olive oil or salt or a mixture of both are traditionally used to protect lentil seeds stored for human consumption. When farmers and merchants were asked for factors affecting the selling price of lentil according to their importance, they named first the presence of insects, followed by seed cleanliness, size, color and cooking ability. The average price reduction due to insect presence was 24% when infestation was less than 10% and 60% when it was more than 70%. Infested seeds are used for animal feed and for sowing but not for poultry. Only 3% of the farmers interviewed treat their seeds before sowing while 56% of the farmers and merchants treat their stores. No foliar insecticide was used in lentil for control of bruchids or other insects.

Drs. O. Tahhan, S. Weigand and NCARTT (Jordan).

3.6.3.3. Effect of _Callosobruchus chinensis_ on seed germination

As the survey revealed that farmers commonly use infested lentil seeds for sowing, the effect of different levels of seed infestation by _C. chinensis_ on seed germination was studied. Since usually 1 to 3 adults develop in one seed, each leaving one hole, lentil seeds with 0, 1, 2 and 3 holes were tested. Germination of seeds of 'lentil local small' decreased drastically from 96% for uninfested seeds to 26, 3 and 0% for seeds with 1, 2 and 3 holes, respectively. This is a clear indication of the damaging effect of seed infestation on germination. In addition, not all germinating infested seeds look healthy, therefore, next season the viability of the infested seeds will be tested.

Drs. O. Tahhan and S. Weigand.

3.7. Lentil Quality - Dehulling

The world production of lentil in 1985 was 2.6 million tons, of which around 75% was small seeded (microsperma) with a red cotyledon. At least half of the microsperma lentils are consumed split and dehulled following post-harvest processing. Despite the large volume of processed lentil we were unable to find references to the process. Our study of the topic started with visits to lentil processing facilities in Pakistan, Syria and Turkey. The following summarises the elements of post-harvest processing common to the facilities visited.

Lentil seed in the above countries predominantly comes from a hand harvest, transportation to a central threshing floor and subsequent threshing. Although the details of threshing and cleaning vary considerably, the produce delivered to the lentil processor is very mixed containing up to about 20% impurities. Foreign material includes pod wall, broken branch, soil, seeds of weed species and of cereals. The first stage in lentil processing is cleaning the produce using various combinations of sieves, air elutriation, indented cylinders and sometimes a spiral separator. The cleaned seed is stored in bins before stage two - wetting. The lentils are wetted by passage through a trough in which water at ambient temperature is continually flowing. Residual water is then removed immediately in a centrifugal dryer which spins the water off through a fine grill. The seeds are then stored for some hours to temper. The tempered seed is then separated into 0.5 mm size fractions by passing through a rotary screen with round holes. Sized lentils are sent directly to the machine for dehulling and splitting, henceforth called dehuller.

Dehullers in Pakistan and Turkey consist of two horizontal round stones about 80 cm in diameter. The top stone is stationary while the lower stone rotates at around 950 rpm. The distance between the stones is adjustable by the movement of the lower stone. Factories usually have more than one dehuller, each set for a different seed size fraction. In Syria the largest dehuller is a gravity-fed rotating cylinder type. After processing in the dehuller the mixture of whole and split lentils, hulls, broken seed (smaller fragments than splits) and fine particles/dust are passed through an inclined gravity separator to remove broken seed and fine particles. Whole seeds are sieved from the splits and returned to the dehuller. The splits are fed into a horizontal-table gravity separator which rocks with a throw of about 30 cm. This separates the dehulled from hulled splits, grades the dehulled splits according to size, and removes any residual foreign matter. The dehulled splits are then bagged for distribution.

An experiment was undertaken to optimize post-harvest processing and specifically to study the effect on dehulling efficiency of different pre-treatments, namely seed size fraction, immersion time in water, drying time with forced air, temperature of air used in drying, and standing time following drying before dehulling.

This research is the first attempt to study the effects of different pre-treatments on dehulling efficiency. The process of wetting lentil seed prior to splitting and dehulling is, to phrase it in a different way, the manipulation of seed moisture content to optimize results. The key to efficient splitting and dehulling will be in understanding the relationship between seed moisture content and yield. It is clear from the results that immersion time is critical to dehulling efficiency. Yields were highest with the briefest duration of wetting - 1 minute (Fig. 3.7.1). Longer periods of immersion progressively increased soil moisture content and reduced the dehulling yield through an increase in split seed with hulls.

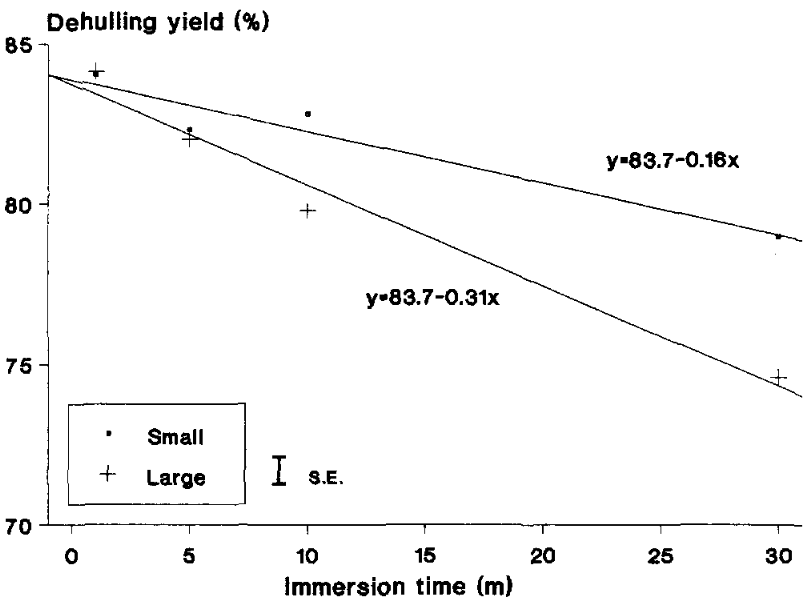

Figure 3.7.1. The effect of immersion time (m) in water on dehulling yield (%) for large-seeded (4.5mm) and small-seeded (4mm) lentil of a Syrian landrace.

The relationship between yield and drying time is interesting. The briefest duration of drying gave the highest yield (Figure 3.7.2). However, this high yield was associated with the lowest average seed moisture content amongst the drying time treatments.

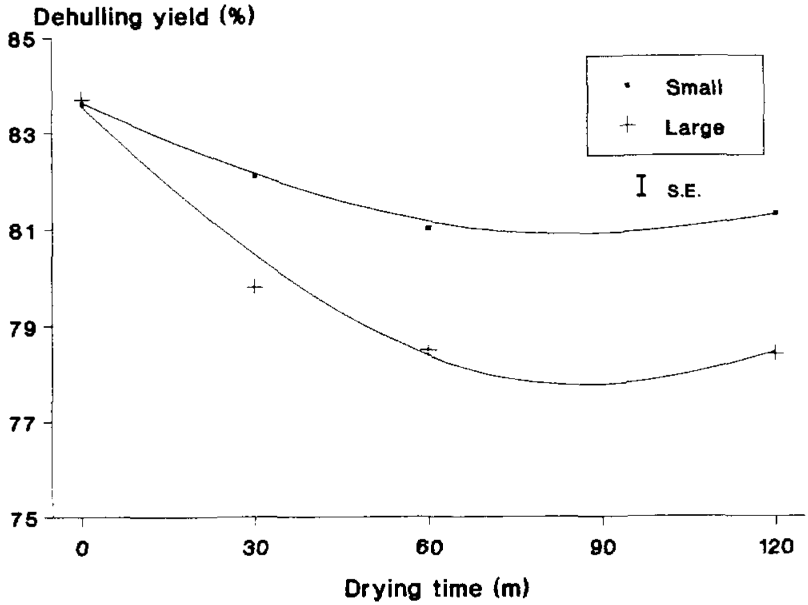

Figure 3.7.2. The effect of drying time after immersion in water on dehulling yield for large-seeded (4.5mm) and small-seeded (4.5mm) lentil of a Syrian landrace.

The standing time between drying and dehulling had a marked effect on dehulling efficiency. Allowing seed to temper for 24 hours, in contrast to immediate dehulling, increased the dehulling yield by allowing the seed moisture to fall by 1%. This gave a higher return of split and dehulled seed.

The two seed size fractions gave different yields on average. However, there were important interactions with both immersion time and drying time. Both interactions showed that given improper moisture management (i.e. a long soaking and/or drying time) large seeds give lower yields. But, with good moisture management, large seed give a good dehulling yield; they are merely more sensitive to pre-treatment than smaller seeds. This echoes the Turkish dehuller who told us, "I can dehull any red lentil."

In a second study we examined the effects on dehulling of location and genotype using three sites that ranged in total seasonal precipitation from 245-663 mm in Lebanon and Syria and 23 diverse red-cotyledon microsperma lines. Dehulling yield was measured as the sum of split dehulled seed, whole dehulled seed and whole hulled seed.

The average seed weight was 3.44 g/100 seed at a mean of 11% moisture content. The mean dehulling yield was 85.4% over locations and genotypes with the composition illustrated in Figure 3.7.3.

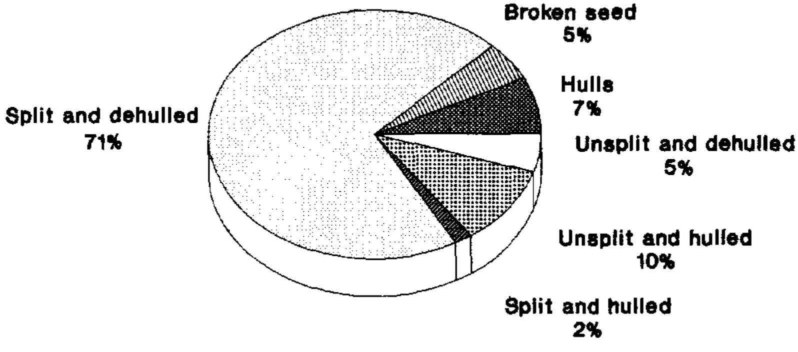

Figure 3.7.3. Distribution of seed fractions from splitting and dehulling lentil averaged over locations and genotypes.

The experiment was designed to study the effect on dehulling yield of a wide range of genotypes grown in contrasting locations. The sites covered a spectrum of soils and rainfall regimes typical of lentil production in the Middle East with grain yields varying fourfold from

464 kg/ha at Breda to 2,018 kg/ha at Terbol. The corresponding range in dehulling yield was only 1% at 84.8-85.9% from Terbol and Tel Hadya seed, respectively. The spread among locations in split dehulled seed % was also comparatively low from 67.6-73.8%. Although the effect of location, caused by differences in rainfall and soil type, on dehulling yield is statistically highly significant, it is clearly only of minor economic importance to the dehuller.

The 23 genotypes used in the experiment were a diverse sample of red cotyledon microsperma germplasm with a range in 100 seed weight of 2.79-4.31 g/100 seeds. The spread among this genetic material in dehulling yield was greater than for locations at 80.8-87.7%. The range between genotypes in % split dehulled seed was even greater at 62.1-80.2%. The broadsense heritability values for all the seed processing characters were relatively high indicating that a response to selection for the traits may be confidently expected amongst this genetic material. Although it is, thus, feasible to consider selecting for improved dehulling properties, at ICARDA we will monitor the quality traits and maintain them at a comparable level to the local cultivar while focusing on improving the yield of seed and straw and other agronomic characters. The landrace ILL 4401 from Syria had a high dehulling yield of 87.0% and an intermediate value of 71.5% for split dehulled seed, providing a bench-mark for comparison.

Seed size is of such importance to lentil processing that seed is always sieved into different size categories prior to dehulling. An illustration of the variation in seed size amongst the genotypes used in this study is given in Figure 3.7.4. In this experiment the same seed size fraction of the genotypes was compared in dehulling, although the genotypes differed greatly in average seed size. As the association of 100- seed weight with dehulling yield % was slight at r = -0.229, it is clear to the breeder that the average seed size of red cotyledon microsperma cultivars for dehulling is immaterial.

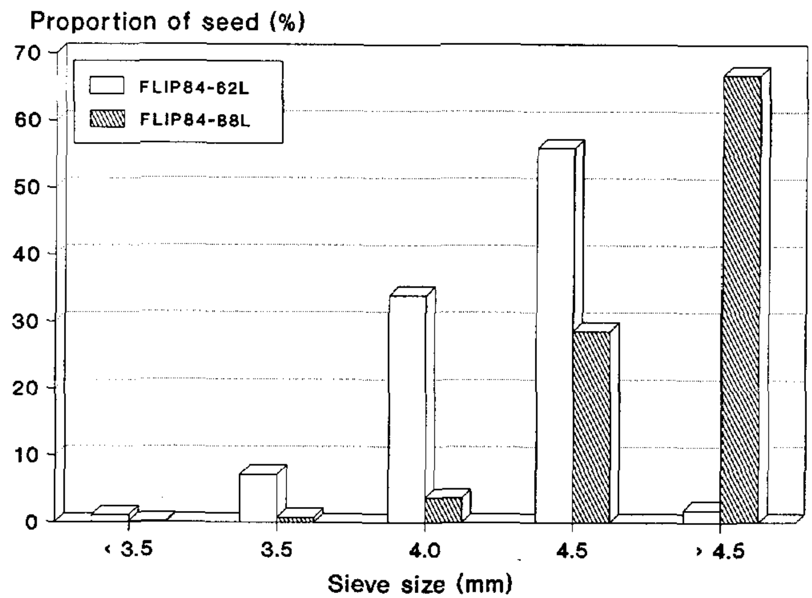

Figure 3.7.4. Seed size fractions following sieving through round holes of two contrasting red-cotyledon lentil lines.

This study has focused on the effects of location and genotype on dehulling. In an effort to increase microsperma lentil production several different management practices, such as early sowing, phosphate and Rhizobium application and mechanical harvesting, are being widely tested in West Asia. It is important that the effect of these factors on lentil dehulling is monitored to avoid losing gains in yield in the field during processing.

Drs. W. Erskine and P. Williams and Mr H. Nakkoul.

4. FABA BEAN IMPROVEMENT

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. Research activities of faba bean at ICARDA headquarters now only involve the germplasm collection. 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 ensure a smooth transfer of research to the INRA, Morocco national program, which will assume the faba bean improvement activities of ICARDA after 1991. The shift of faba bean improvement from ICARDA, Syria to INRA, Morocco is shown in Figure 4.1.1.

Faba bean is predominately grown in wheat-based farming systems in the WANA region, mainly in medium rainfall environments (above 450 mm). 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

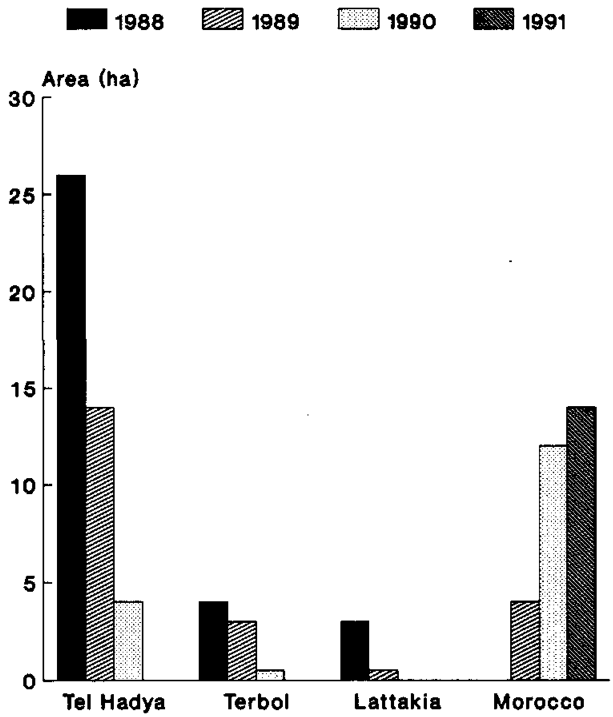

Figure 4.1.1. Shift of ICARDA faba bean improvement research to North Africa.

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. With the shift of faba bean improvement research to North Africa, major emphasis was given to transferring the work on resistance to major pests (Orobanche, chocolate spot, rust, nematodes and ascochyta blight) and to improve plant response to productive environments through altering the plant type. The relative priorities given to research, training and networking have shifted towards training and networking as the active research is phased out (Figure 4.1.2).

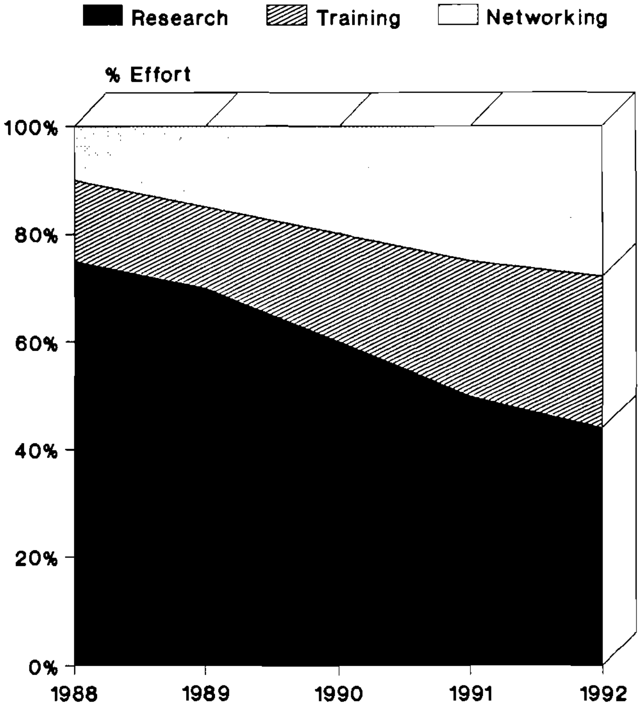

Figure 4.1.2. Trends in emphasis of activities of ICARDA faba bean improvement team.

4.1. Development of Cultivars and Genetic Stocks

Faba bean breeding 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. Protein content of all advanced lines was monitored to ensure maintenance of the high nutritional quality of faba bean. The major activities of faba bean improvement research were on resistance to biotic stresses and in altering the plant type to control vegetative growth, flower and pod drop, and converting faba bean into a self-pollinated crop.

The objective of resistance breeding was to produce lines resistant to chocolate spot, ascochyta blight, rust, and Orobanche in backgrounds useful to national programs in the WANA region. However, with the shift to North Africa, there has been a shift in relative priorities given to pests. More emphasis is being given to Orobanche and nematodes and relatively less to fungal pathogens (especially Ascochyta blight). The shift in relative priorities in resistance research is shown in Figure 4.1.3. Resistant sources were used in the breeding program, distributed to national programs as such or in enhanced germplasm, and were combined into multiple pest resistant parental sources.

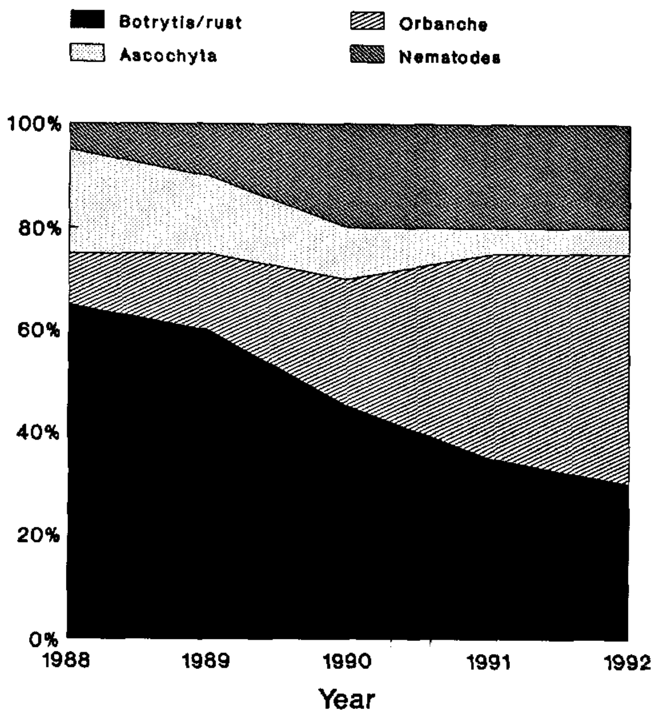

Figure 4.1.3. Shift in relative priorities for pest resistance research in faba bean at ICARDA.

Research on alternative plant types strove to increase biomass, seed size, earliness, and to incorporate disease resistance. The closed flower type was used to start production of germplasm pools adaptable to the WANA region for production of self-pollinated faba bean.

Germplasm distribution was accomplished through providing sources of resistance and alternative plant types in genetic backgrounds useful to national programs, mainly of the WANA region. Sources of resistance for crossing programs, early generation lines, and advanced lines and "pre-selected" segregating populations were distributed through the International Testing Network. With the phase-out of faba bean improvement research, this activity is being shifted to regional nursery networks such as the Nile Valley Regional Program and the North Africa Regional Program Faba Bean Nurseries. Two regional nurseries were started in North Africa, a large seeded and a small seed yield trial with half the entries contributed by the national programs of the region. INRA, Morocco will assume the responsibility for coordination of these trials.

4.1.1. 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 and in Chile and Iraq ILB 1814 is in pre-release multiplication.

Table 4.1.1. Use of ICARDA lines by National Programs.

Country	Line	Use
Algeria	14 lines	Mutilocation 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	74TA12050 X 74TA236	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 84-239FB[1]	

[1] Determinate line.

Determinate lines are in on-farm trials in China and Syria. In Syria 80S44027 is in the second 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 Algeria 14 lines were provided for multi-location testing. A summary of the use of ICARDA lines for multi-locational, on-farm, and verification trials is given in Table 4.1.1.

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 genetic stocks for the use of national programs. The Moroccan national faba bean improvement team is being developed to absorb the advanced cultivars from the ICARDA program.

Resistance to pests constitutes the bulk of specific requests of national programs, namely, resistance to <u>Orobanche</u>, 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 4.1.2). For this reason there was an evaluation of 136 disease resistance sources

Table 4.1.2. Use of ICARDA germplasm, resistance sources, populations, and early generations lines by National Programs in 1987 and 1988.

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	F_2 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	F_3 progenies; F_3 Bulks Chinese Disease resistance; IVS, deter. populations and progenies.
1987	Morocco	200	F_2 populations and F_3 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	F_2 populations IVS
1988	Sudan	10	F_2 populations-earliness (Sudan & Chinese)
1988	Tunisia	190	Lines for disease screening nursery
1989	Tunisia	339	Disease resistant lines for yield testing in screening nursery
1989	Tunisia	96	Determinate lines in screening nursery

for the IBPGR/ICARDA descriptor list with the aim to produce a catalog for the use of breeders and pathologists to improve their efficiency in selection of resistance sources for breeding programs. In the past two years 1200 BPL's (pure line germplasm accessions) have been provided to Egypt for aphid resistance screening. In 1989 lines selected for disease resistance and yield and other agronomic traits were distributed to the national programs of North Africa for selection for yield testing.

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 4.1.2). 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 1989, 96 crosses were made at Douyet, Morocco with Aquadulce and other large seeded types and sources of resistance, IVS and determinacy. The F_1's are being grown the coming 1989/90 season to produce F_2 populations for selection. Determinate lines have been provided to Algeria, Morocco and Tunisia for selection in the 1989/90 season. In Ethiopia 27 ICARDA lines are in advanced national multi-location trials and one purified bulk has been further purified for use in verification trials and submission to the variety release committee.

The main emphasis in faba bean breeding will be to ensure a smooth transfer of ICARDA improvement research to INRA-Morocco, and the other national programs of North Africa. This will be through transferring enhanced germplasm, visits to NARS's 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.

4.1.2. 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.

4.1.2.1. Germplasm for disease resistance

Orobanche crenata: Broomrape (Orobanche crenata) is considered to be the most important limiting factor in faba bean production throughout North Africa. 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 600 BPL's, nine single plant selections have been made from four BPL's.

In 1987/88, 50 progenies from the cross (F402 X INIA 06) X F402 were screened at Lattakia. In general, these progenies expressed more resistance to Orobanche than previously seen. Twelve of these showed uniform resistance to Orobanche at a much higher level than seen previously. These were retested in 1988/89 and were again found to be

Table 4.1.3. Reaction of faba bean entries to Orobanche crenata in the F6 Orobanche Nursery-I-89.

No. of Sel.	Cross No.	No. of Orobanche shoots/host plant	Reaction
1	F402xINIA06	0.025	R
2	F402xINIA06	0.03	R
3	F402xINIA06	-	R
4	F402xINIA06	0.19	R
5	F402xINIA06	0.05	R
6	F402xINIA06	0.03	R
7	F402xINIA06	0.109	R
8	F402xINIA06	0.06	R
9	F402xINIA06	0.1	R
10	F402xINIA06	0.1	R
11	F402xINIA06	0.07	R
12	F402xINIA06	0.16	R
13	ILB 1814	2.10	S

very resistant (Table 4.1.3). Eighty-single plant selections from these progenies were also found to be resistant to Orobanche in 1988/89 at Lattakia. These are now being tested along with over 150 new introductions from Spain at Douyet, Morocco. 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.

Drs. S.B. Hanounik, L.D. Robertson and K.H. Linke.

Resistance to viruses: Screening for resistance to BLRV and BYMV started in 1986 using the BPL collection. Accessions are artificially inoculated using aphid vectors in the plastichouse and in the field using screenhouses for self-pollination. To-date, 650 BPL accessions

have been screened for BLRV resistance and 350 BPL accessions for BYMV resistance. Four accessions have been found resistant to BLRV in 1988. These four accessions (BPL 756, 757, 758 and 769) are from Afghanistan; they had a delayed expression of first virus symptoms (long latent period), around fourty days, compared to 10-12 days for the susceptible lines. When tested in 1989, BPL 756 and BPL 758 were also found to have good tolerance to BLRV. In 1989 four BPL's (BPL 1351, 1363, 1366 and 1371) were found to have a high level of resistance to BYMV.
Drs. K. Makkouk and L.D. Robertson.

4.1.2.2. Development of disease-resistant inbred lines.
In the 1988/89 season the inbred collections for chocolate spot, ascochyta blight, rust, and stem nematode were increased under mesh-covered screenhouse to maintain purity and homogeneity of disease reaction. These sources were distributed to national programs in the form of disease screening nurseries and in bulked segregating populations "pre-selected" for disease resistance.

There are 287 selections for chocolate spot, 308 for ascochyta blight, 64 for rust, and 13 for stem nematodes (Table 4.1.4). In 1988/89 54 selections for ascochyta blight resistance, 58 for chocolate spot resistance, and 24 for rust resistance were evaluated for the IBPGR/ICARDA descriptor list in a simple lattice experiment.

The frequency distribution of the disease inbreds for seed yield is shown in Figure 4.1.4. There were 15 of the resistant sources with yields equal to the mean of the checks, four ascochyta sources, seven

Table 4.1.4. 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; ILB 3025, 3026, 2282, 3033, 3034, 3036, 3056, 3106, 3107, 2302, 2320; L83114, 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, L82001.
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 nematode	BPL 1, 10, 11, 12, 21, 23, 26, 27, 40, 63, 88, 183

1. There are several sublines of most sources listed. The accessions are listed in the decreasing order of their efficacy.

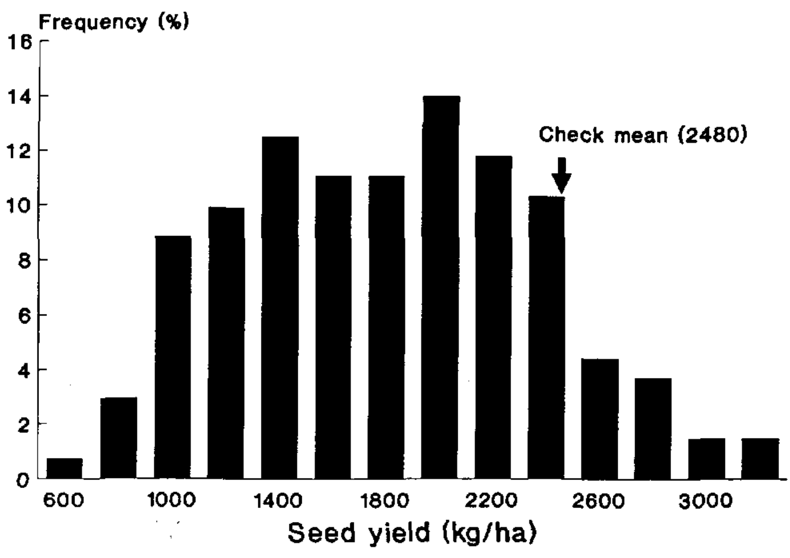

Figure 4.1.4. Frequency distribution of seed yield (kg/ha) for 136 disease resistant sources.

chocolate spot sources and four rust sources. There was considerable variability for seed weight with the disease sources, one hundred seed weight varied from 29 to 107 g/seed (Figure 4.1.5) compared to 48 g for the small seeded check (ILB 1816) and 144, for the large seeded check (ILB 1814). The majority of the disease resistant inbreds though, were of small seed size, in the range of 50-70 g per one-hundred seed. They were, on the average two days later flowering than the checks and the distribution of flowering date was skewed towards later flowering (Figure 4.1.6, skewness=1.28). The disease resistant inbreds had more pods per plant than the three large seeded checks (ILB 1814, ILB 1817, ILB 1270) (Figure 4.1.7) and were nearer the smaller seeded check (ILB 1816), which matches the results for seed weight. A similar situation was found for pod length (Figure 4.1.8).

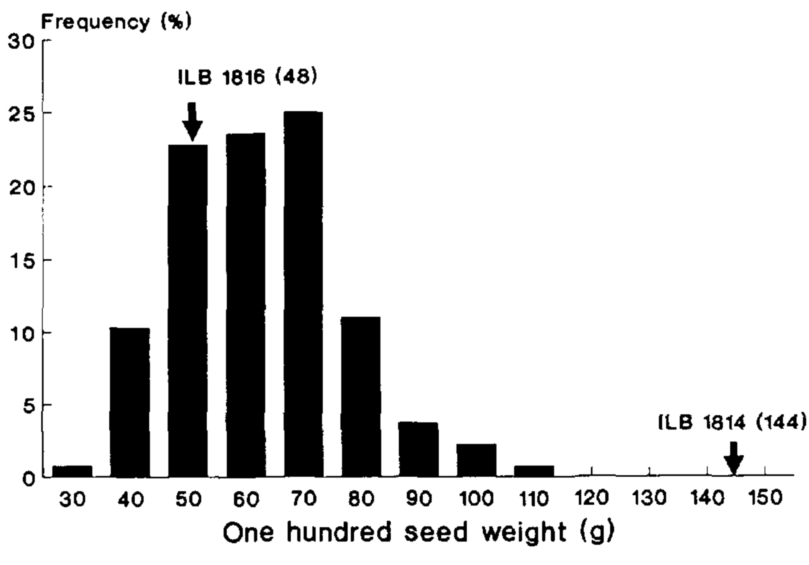

Figure 4.1.5. Frequency distribtuion of one hundred seed weight (g) for 136 disease resistant sources.

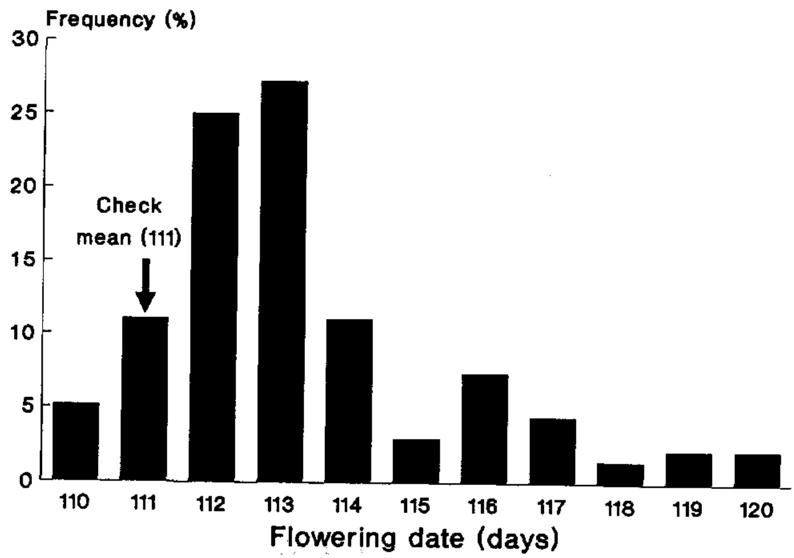

Figure 4.1.6. Frequency distribution for flowering date (days) for 136 disease resistant sources.

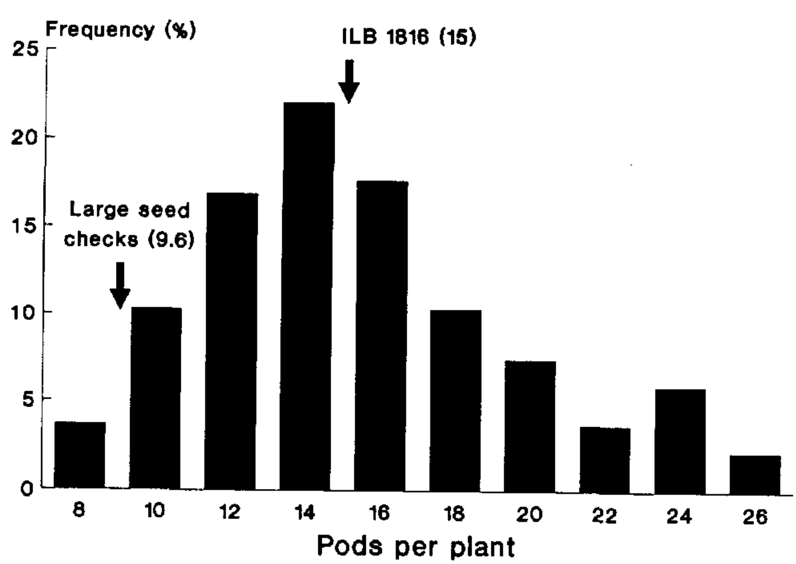

Figure 4.1.7. Frequency distribution for pods per plant for 136 disease resistant sources.

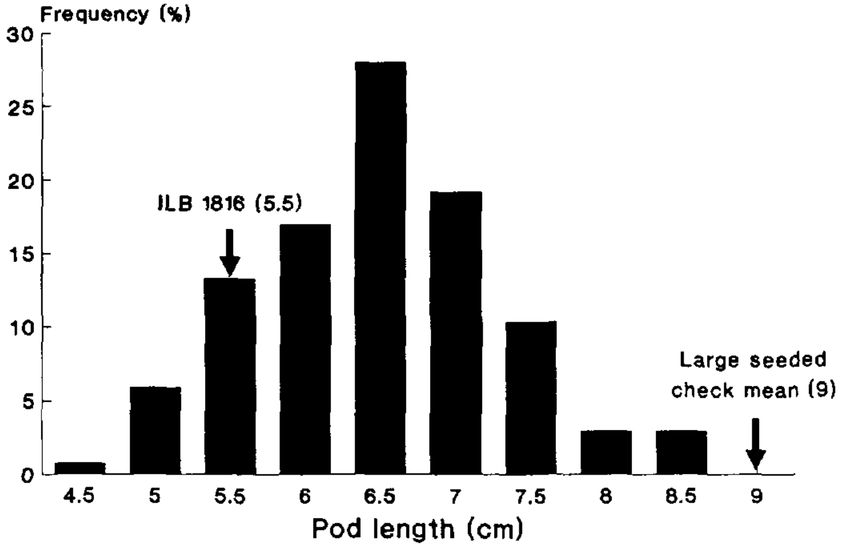

Figure 4.1.8. Frequency distribution for pod length for 136 disease resistant sources.

A study of correlations among these traits reveals the same pattern as found when 840 BPL's were evaluated in 1985/86 (Table 4.1.5). There are highly significant correlations among seed yield, one hundred seed weight and pod length. Flowering date was negatively correlated with seed yield (r=-0.50**). This data is being compiled in database form and a catalog will be published.

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

Table 4.1.5. Correlations among the 136 disease resistance sources grown at Tel Hadya in 1988/89 (upper diagonal) and for 822 BPL accessions grown at Tel Hadya in 1985/86 (lower diagonal), df=134, and df=820 respectively.

	Seed yield	Date of flowering	One-Hundred seed weight	Pods per plant	Pod length
Seed yield	-	-0.50**	0.52**	-0.21*	0.60**
Date of flowering	-0.48**	-	-0.01	-0.03	-0.20*
One hundred seed weight	0.68**	-0.43**	-	-0.57**	0.67**
Pod number	-0.04	0.04	-0.45**	-	-0.51**
Pod length	0.55**	-0.39**	0.73**	-0.50**	-

*, ** Significant at the 5% and 1% levels, respectively.

4.1.2.3. 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 Africa lines for disease resistance.

4.1.3. 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 an animal feed supplement in the region and straw is chopped and 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_

Table 4.1.6. Results of faba bean yields trials grown at Tel Hadya, 1988/89.

Trial	No. of test entries	No. of lines exceeding best check: Total	No. of lines exceeding best check: Significantly (P=0.05)	Seed yield: Trial mean	Seed yield: Best line mean	Seed yield: Best check mean	Seed yield: L.S.D. check vs. line (P=0.05)	Seed yield: C.V. (%)	Checks
FBIYT-L	22	21	4	1.12	1.35	1.04	0.183	11.9	ILB 1814
FBIYT-S	21	7(14)[a]	0(1)[a]	1.05	1.29	1.15(1.05)[b]	0.188	13.1	ILB 1814
									ILB 1812
									ILB 1819
FBISN-L[1]	30	10	0	1.00	1.17	1.09	0.214	15.7	ILB 1819
									ILB 1270
									ILB 1817
FBISN-S[1]	36	3(27)[a]	0(3)[a]	1.08	1.44	1.36(1.00)[b]	0.315	21.4	ILB 1270
									ILB 1814
									ILB 1816
AYT-L	45	4	0	1.08	1.24	1.12	0.195	13.2	ILB 1270
									ILB 1814
									ILB 1817
AYT-S	45	8(22)[a]	1(5)[a]	1.12	1.41	1.19(1.05)[b]	0.217	14.2	ILB 1814
									ILB 1816
PYT-L	45	17	2	0.97	1.39	1.02	0.251	19.0	ILB 1814
									ILB 1817
PYT-S	45	0(45)[a]	0(39)[a]	1.44	1.92	2.02(0.78)[b]	0.370	18.8	ILB 1814
									ILB 1816

[1] Results of replicated trial.

[a]. Number of lines exceeding the best small seeded check, or significntly greater than the best small seeded check.

[b]. Best small seeded check mean.

fabae, _Ditylenchus_ _dipsaci_, _Ascochyta_ _fabae_, and _Uromyces_ _fabae_. Emphasis was therefore placed on developing such germplasm, and for 1988/89 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.

4.1.3.1. Yield potential of indeterminate faba bean

The 1988/89 season at Tel Hadya was very cold and dry. Replicated trials of 295 lines were conducted at Tel Hadya (Table 4.1.6). Because of the dry and cold season yields were severely depressed with the highest yield only 2.0 t/ha as against 5.1. t/ha in 1987/88. The C.V.'s were also high compared to 1987/88. A total of 156 entries exceeded the best check (or best small seeded check in small seeded trials) but only 54 of these were significantly better than the check at the 5% probability level.

At Terbol, Lebanon the season was much better and in replicated trials of 295 lines the highest yielded was 4.7 t/ha as against 4.2 t/ha in 1987/88 (Table 4.1.7). A total of 80 lines outyielded the best check (or best small seeded check in small seeded trials) with 4 lines significantly better at the 5% probability level.

The season at Douyet was marked by low rainfall and poor distribution. Also, at flowering time there was a hot wind which severely affected seed set. C.V.'s were very high and ranged from 30.9 to 55.4 %. The highest yield in replicated trials of 295 lines was 3.63 t/ha. A total of 96 lines outyielded the best check (or best

Table 4.1.7. Results of faba bean yield trials grown at Terbol, 1988/89.

Trial	No. of test entries	No. of lines excessing best check: Total	No. of lines excessing best check: Significantly (P=0.05)	Seed Yield (t/ha): Trial mean	Seed Yield (t/ha): Best line mean	Seed Yield (t/ha): Best check mean	Seed Yield (t/ha): L.S.D. check vs. line (P=0.05)	C.V. (%)	Checks
FBIYT-L	22	0	0	3.29	3.70	3.73	0.504	11.2	ILB 1814 ILB 1817
FBIYT-S	21	1	0	3.84	4.57	4.50	1.032	19.6	ILB 1814 ILB 1817 ILB 1819
FBISN-L[1]	36	5	0	3.78	4.51	4.16	0.525	10.2	ILB 1270 ILB 1814 ILB 1817
FBISN-S[1]	36	23(24)[a]	3(3)[a]	3.46	4.20	3.46(3.44)[b]	0.606	12.9	ILB 1270 ILB 1814 ILB 1816 ILB 1817
AYT-L	45	5	0	3.24	3.65	3.55	0.587	13.3	ILB 1814 ILB 1817
AYT-S	45	6	0	3.88	4.49	4.15	0.510	9.6	ILB 1816 ILB 1817
PYT-L	45	18	1	3.68	4.57	3.76	0.612	12.2	ILB 1814 ILB 1817
PYT-S	45	21	0	3.97	4.70	4.05(4.05)[b]	0.525	9.7	ILB 1816 ILB 1817 ILB 1814

1 Results of replicated trial.

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

b. Best small seeded check mean.

small seeded check in small seeded trials) with 6 lines significantly better at the 5% probability (Table 4.1.8).

Dr. L.D. Robertson.

4.1.3.2. Segregating populations

This year 800 single plant selections were made in 210 F_2 populations grown at Douyet, Morocco for determinate and IVS plant type. These will be planted as F_3 progeny rows at Douyet, and at Meknes (for disease resistance screening) in Morocco. Single plant selections totalling 200 were made at Douyet in F_2 populations produced for North Africa and are being screened for disease resistance this year at Meknes. At Al-Menzah, Morocco 270 selections were made in 226 F_5 and F_6 progenies for chocolate spot resistance.

At Tel Hadya 207 single plant selections were made in 450 F_5 progenies previously selected for disease resistance at Lattakia. These will be tested for disease resistance at Meknes, Morocco in the 1989/90 season. At Lattakia 244 determinate slections were made in 100 F_3 progeny rows. Selections totalling 395 and 176 were made for chocolate spot and ascochyta blight, respectively, in 209 and 100 F_4 progeny rows. This material will be tested for disease resistance at Meknes in the 1989/90 season.

4.1.4. Development of alternative plant-type

4.1.4.1. Determinate faba bean genetic stocks

The determinate habit is of potential importance in faba bean

Table 4.1.8. Results of faba bean yield trials grown at Douyet, 1988/89.

Trial	No. of test entries	No. of lines excessing best check: Total	No. of lines excessing best check: Significantly (P=0.05)	Seed yield: Trial mean	Seed yield: Best line mean	Seed yield: Best check mean	Seed yield: L.S.D. check vs. line (P=0.05)	C.V. (%)	Checks
FBIYT-L	22	9	0	1.00	1.73	1.00	0.744	55.4	ILB 1814 ILB 1266
FBIYT-S	21	5	0	1.46	2.04	1.74	0.762	38.0	ILB 1814 ILB 1819 ILB 1266
FBISN-L[1]	36	8	0	2.57	3.63	3.21	1.223	34.9	ILB 1270 ILB 1266 ILB 1814
FBISN-S[1]	36	9	0	2.16	3.27	2.54	0.805	45.6	ILB 1270 ILB 1814 ILB 1266
AYT-L	45	5	0	2.57	3.42	3.12	1.233	35.2	ILB 1814 ILB 1266
AYT-S	45	6(23)[a]	0(1)[a]	2.55	3.49	3.03(2.25)[b]	1.077	30.9	ILB 1816 ILB 1266
PYT-L	45	24	4	1.26	2.36	1.22	0.565	32.9	ILB 1814 ILB 1266
PYT-S	45	13	1	1.69	3.32	1.87	0.811	35.2	ILB 1266 ILB 1814

1 Results of replicated trial.

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

b. Best small seeded check mean.

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. This work was shifted to Douyet, Morocco in the 1988/89 season where 26 crosses were made 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.

Replicated yield trials were conducted with 138 lines at Tel Hadya, and 95 lines at Terbol and Douyet. Except for Terbol, yields were severely depressed by the unfavourable weather conditions. The overall determinate line yield mean at Terbol was 2.5 t/ha vs. 1.09 t/ha for the determinate check and 3.94 for the mean of the best indeterminate check of each trial, while the best determinate line yield was 3.34 t/ha. At Tel Hadya and Douyet the C.V's were very high and the best indeterminate check yielded less than 1.5 t/ha. Still the mean of the determinate lines was 0.82 t/ha and 0.55 t/ha at Tel Hadya and Douyet, respectively vs. 0.36 and 0.29 t/ha for the determinate check. The determinate check was the original mutant as received.
Dr. L.D. Robertson.

4.1.4.2. Independent vascular supply and closed flower

Lines with the independent vascular supply have each flower in a raceme with an independent vascular supply (IVS) so that many more flowers in a raceme produce pods and flower shedding is greatly reduced. Work was carried out using the new, earlier flowering 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 and are being screened at Meknes the next year for disease resistance. A total of 403 selections were made in 300 F_3 progeny rows at Tel Hadya which will be tested at Douyet and Meknes, Morocco the coming season. Major work is being carried out to incorporate earliness, disease resistance and large seed size in the IVS background.

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 F_3 and F_4 progeny rows. These will be used in Morocco in 1989/90 for making additional crosses to continue adaptation to the Mediterranean environment.

Dr. L.D. Robertson.

4.2. Faba Bean Diseases

4.2.1. Biological control of Orobanche crenata

A total of 16 fungi were isolated on potato dextrose agar (PDA) from naturally infected O. crenata stem and flower parts. These isolates were purified, grown on PDA at room temperature (18 $^{o}C \pm 4$) for two weeks, then the pathogenicity of only four potential isolates was tested on both O. crenata and Vicia faba.

Pathogenicity tests were carried out on two groups of plants of the Syrian local faba bean cultivar (ILB 1814) grown in an artificially infested soil in the field (10 seeds of O. crenata/1 cc soil). In the first group, plants were inoculated with these fungi at the 1-2% flowering stage, and in the second group plants were inoculated at the 40-50% flowering stage. Inoculations were made at the above two stages to study the susceptibility of both faba bean and O. crenata to these fungi, in relation to the stage of growth and development of crop and parasite. Tubercles of O. crenata were mostly less than one cm in diameter at the time of early inoculation, whereas at the time of late inoculation they became whitish stalks with a diameter of 1.5-3 cm.

A total of four petri dishes of each fungus were mixed separately with 1000 cc of six weeks old autoclaved soil (two times, 3 hrs. each, at 120 ^{o}C). The soil around the base of the stem of each faba bean plant was removed gently, to a depth of 10 cm, and a radius of 20 cm. The soil-fungal mixture was added to the hole around faba bean stems and roots, and plants were irrigated with 2 l of water per plant immediately thereafter and two additional times at weekly intervals. Disease development on local faba beans and O. crenata plants was recorded at the 100% podding stage.

The results of this test (Table 4.2.1) showed that the four fungi were generally more pathogenic on O. crenata at the early as compared to the late stage of development of the parasite. These results showed also that Phomopsis sp. was more pathogenic on O. crenata than on faba bean at the 1-2% flowering stage of the host, compared to the remaining

Table 4.2.1. Pathogenicity of certain fungi on *Vicia faba* and *Orobanche crenata* at different growth stages of faba bean plants in the field.

	Disease reaction [1]			
	1-2% flowering		40-50% flowering	
	V.faba	*O.crenata*	*V.faba*	*O.crenata*
Alternaria infectoria E.	1	2	1	1
Fusarium solani (Mart.) Sacc.	3	3	2	2
Sclerotinia sp.	4	5	2	2
Phomopsis sp.	1	5	1	2

1. Disease reaction was recorded on faba bean stems and roots and on *Orobanche* stalks, where: 1 = 0-5% necrosis, 2 = 6-25% necrosis, 3 = 25-50% necrosis, 4 = 51-75% necrosis, and 5 = 76-100% necrosis.

three fungi and could be used as a potential biological control agent against *O. crenata*. However, more studies are needed before such a use is possible.

Dr. S.B. Hanounik.

4.3. Faba Bean Entomology

4.3.1. Aphid resistance screening

The screening of faba bean lines from Egypt, Sudan, Ethiopia and ICARDA for resistance to *Aphis craccivora* in the Giza aphid laboratory and the field was continued as part of the Nile Valley Regional Program. A total of 1100 lines, including 798 ICARDA material, 281 Egyptian breeding lines and 21 lines from Ethiopia, were tested in the laboratory during the 1988/89 season. Of the 644 BPL's and 154 lines from yield trials from ICARDA, 17 and 4 showed resistance to aphids, respectively (Table 4.3.1). Three lines of the Ethiopian material were found to be resistant. Of the Egyptian material, 5 lines out of the 116 selections from Giza 402 and 11 lines out of 165 F4 lines showed resistance.

Table 4.3.1. Laboratory and field screening of faba bean for resistance to _Aphis_ _craccivora_ in Egypt, 1988/89.

	No. of lines tested	No. of lines resistant
LABORATORY SCREENING		
ICARDA material		
BPLs	644	17
Yield trials	154	4
Ethiopian material	21	3
Egyptian material		
Giza 402 selections	116	5
Breeding lines (F4)	165	11
FIELD SCREENING		
ICARDA material		
Sudanese material	344	36
Egyptian material		
FIELD EXPERIMENT		
Egyptian material	30	11

The field screening of a total of 344 faba bean lines revealed 9 BPLs and 5 lines from ICARDA, 8 lines from the Sudanese material and 14 lines from Egypt with resistance to _A_. _craccivora_.

In two field experiments 15 previously selected genotypes each were grown with and without insecticide application for aphid control and evaluated for aphid infestation and yield reduction. Five and 6 genotypes were identified having low aphid numbers and yield reduction.

Of the most promising lines identified up to date a "Regional Aphid Screening Nursery" is established including 8 lines each from Egypt and Sudan, 3 lines from Ethiopia and the respective local and 1 Ethiopian line as susceptible check. This nursery will be tested at 2 locations in Sudan and one location each in Egypt and Ethiopia.

In Egypt all the material is screened only for A. craccivora, as this is the predominant species. Since in Syria both A. craccivora and Aphis fabae occur together, a total of 144 BPLs were screened for resistance against Aphis fabae at Tel Hadya this season. The screening was carried out in the plastichouse using the same conditions and methodology as in the Giza laboratory. Five BPLs were found to be resistant. One of these was also resistant, and 2 tolerant against A. craccivora (Table 4.3.2).

Table 4.3.2. Screening of BPLs against Aphis craccivora (Egypt) and Aphis fabae (Tel Hadya).

BPLs	No. entries	Resistant entries A. craccivora	Resistant entries A. fabae
Botrytis res.	60	B 88123	B 8810, 8817 88204
Ascochyta res.	54	-	-
Rust resistant	24	-	-
Stem nematode res.	8	BPL 23	BPL 23, 26

Drs. S. Bishara, G. Defrowy, S. Khalil (Egypt), S. Weigand.

4.3.2. Storage pests

4.3.2.1. Control of Bruchus dentipes

B. dentipes is the dominant univoltine storage pest of faba bean in Syria. As its infestation starts in the field, methods should aim of reducing the population in the field before the larvae penetrate the seed.

A faba bean field was selected at Barna village near Tel Hadya where previously high infestations of B. dentipes were found. The application of endosulfan (Thiodan 35 EC at 700 g. a.i./ha) and Deltamethrin (Decis 2.5 Ec at 38 g. a.i./ha) at early pod setting significantly reduced the seed infestation by bruchid larvae with Thiodan being slightly more efficient (Fig. 4.3.1). Of both insecticides however, one application was not sufficient to give

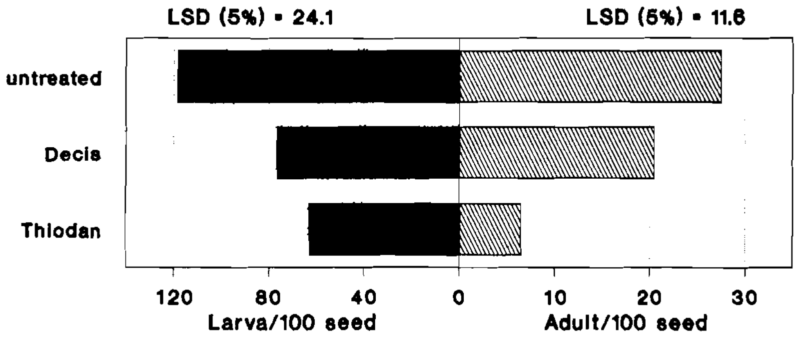

Figure 4.3.1. The Effect of one application of Decis and Thiodan on larval infestation of Bruchis dentipes in faba bean at farmers' field in Barna Aleppo, 1989.

adequate control. Therefore two applications at early pod setting and 10 days later will be tested at farmers' field next season to provide better control of this insect with long oviposition period (30-40 days).

Drs. O. Tahhan, S. Weigand and M. El-Ahmed (ARC, Syria).

4.3.2.2. Stock culture of Bruchus dentipes

The establishment of a stock culture of B. dentipes will provide a continuous supply of the insect to conduct more experiments in a season. Previous work at ICARDA revealed that, when fed on faba bean pollen, gravid females can be obtained in the winter in the laboratory.

This season gravid or virgin females were released separately into cages with faba bean plants at flowering and pod setting stage in the plastic house. In both cases eggs were laid on green pods resulting in larval and adult infestation in the seeds. Next season a test of the optimal number of females per plant for most effective rearing will be conducted.

Drs. O. Tahhan and S. Weigand.

4.4. Faba Bean Microbiology

4.4.1. Strain-cultivar interactions for yield and N accumulation in faba bean

With long term cultivation of the crop in the areas receiving above 450mm annual rainfall, high native populations of rhizobia nodulating faba bean are expected. Though information is sparse, this appears to be true; average viable counts of rhizobia nodulating fababean in the north Africa-west Asia region are in the range of 10^3-10^5 g^{-1} soil. Existence of adequate native rhizobial populations implies that improvement in dinitrogen fixation through manipulation of the symbiosis through inoculation may not be possible. Not a great deal is known regarding specificity of the crop with respect to strain-cultivar interactions.

It is important to establish base-line values for percent plant N derived from the atmosphere (%Ndfa) and N_2 fixed in recommended cultivars of fababean so improvements through rhizobial strain and legume cultivar selection may be quantified. The objective therefore of this study was to determine the variations in yield and nitrogen fixing characters in a number fababean cultivars of differing growth habits inoculated by several strains of Rhizobium leguminosarum. At the present time, 15N analyses results for this experiment have not been received, and will be presented at a later date. Yield data, however, showed interesting variations.

The experiment was conducted in N. Syria on the Tel Hadya field station of ICARDA, during 1987-88 season. Most probable number (MPN) measurement of indigenous faba bean rhizobia populations in the soil was relatively high with 3.3 x 10^4 rhizobia g^{-1} soil, due to faba bean cultivation at the site for a number of years. The experimental design was a randomized split plot design with Rhizobium treatments as main plots and cultivars as subplots replicated four times. Single row subplots 6 m in length were used, with 45 cm between rows and four border rows between main plots; planting density was 20 pl/m^2 with 45 cm between rows. Sowing occurred in early November. Rhizobia treatments comprised uninoculated and three strain treatments; the three single-strain inoculants included strains from Morocco (FB420), Egypt (FB452) and Portugal (FB482). Strains were selected based on prior N_2-fixing performance on the concerned cultivars in aseptic hydroponic culture in greenhouse trials. Seeds were inoculated at planting using liquid application method, at a rate to provide approximately 10^6 viable cells per seed. A nitrogen treatment of 120 kg N/ha applied as split dose of 60 kg/ha broadcast preplant and 60 kg/ha sidedress application at mid-anthesis was included.

Cultivars, large- and small-seeded, included determinate types (FLIP 84-230, 84-239, 84-241), one IVS line (IVS-6), local landraces (Rebaya 40, Giza 4, BPL 1722) and high-yielding commercial varieties (Syrian local large, Lebanese local small, Giza 402, Seville giant, Aquadulce, VD Policoro, Reina blanca).

In the absence of 15N data, the parameters chosen to best evaluate treatment effect on N fixation are total crop N and seed yield. Yield results in Table 4.4.1 show a significant effect of inoculation on the yield of faba bean across all cultivars; strain 420 increased seed yield by an average 250 kg/ha across all cultivars while strain 452 increased biological yield by 780 kg/ha and total crop N by 25 kg/ha. The highest yielding genotypes were Syrian local large, Seville giant, Aquadulce and Reina blanca, while local land races and

IVS and determinate types produced the lowest yields (Table 4.4.1).

Table 4.4.1. Mean yields of 14 faba bean cultivars and 5 treatments, Tel Hadya 1987/88.

Treatment	Seed yield Mg/ha	Biological yield Mg/ha	% N	Total N Kg/ha
Uninoculated	2.95	8.01	2.58	206
Strain 420	3.20*	8.31	2.58	215
Strain 452	3.10	8.79*	2.64	231*
Strain 481	2.82	7.79	2.57	200
120 kg N/ha	2.92	7.97	2.52	201
LSD P= 0.05	0.22	0.55	0.09	14
IVS 6	1.78	6.61	2.69	178
Rebaya 40	2.02	5.54	2.68	148
Giza 4	3.19	8.44	2.50	211
BPL 1722	2.88	7.12	2.39	170
Lebanese l.sm.	3.38	8.57	2.44	210
Giza 402	2.36	6.51	2.69	175
FLIP 84-241	2.56	7.88	2.49	196
FLIP 84-230	1.98	6.71	2.77	185
FLIP 84-239	2.69	8.74	2.51	219
Seville Giant	3.88	9.73	2.53	247
Syrian lg.	4.10	11.26	2.66	300
Aquadulce	3.88	9.89	2.58	256
Reina Blanca	3.68	8.81	2.61	229
VD Policoro	3.55	8.64	2.57	222
LSD P= 0.05	0.36	0.75	0.15	
F test				
Strain	*	*	*	*
Cultivar	**	**	**	**
Interaction	**	**	*	**

* Significant at P = 0.05
** Significant at P = 0.01

Crop nitrogen yields ranged from 120-330 kg N/ha, indicating the large yield potential differences between cultivars (Figure 4.4.1).

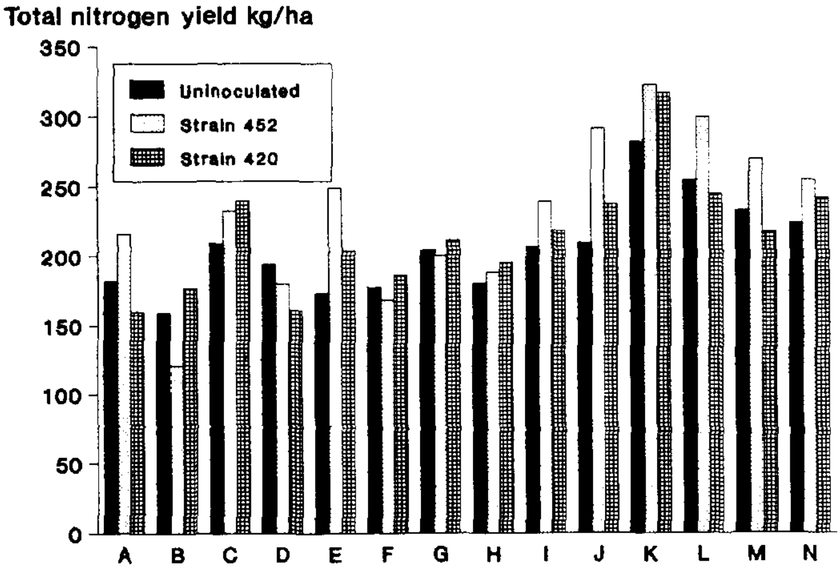

Figure 4.4.1. Total nitrogen yield of 14 genotypes of faba bean in response to inoculation with two strains of Rhizobium Tel Hadya 1987/88. Genotypes: A, IVS 6; B, Rebaya 40; C, Giza 4; D, BPL 1722; E, LLS; F, Giza 402; G, FLIP 84-241; H, FLIP 84-230; I, FLIP 84-239; J, S. Giant; K, SLL; L, Aguadulce; M, R. Blanca; N. VD Policoro.

Many of the cultivars responded significantly to inoculation, though throughout response varied to the different strains. The considerable treatment variation within cultivars, with for example one strain increasing crop N while another decreased it in relation to the uninoculated treatment, highlights the potential importance and complexity of strain-cultivar interactions in faba bean.

The range of variation due to inoculation and N fertilizer application on seed yield is typified by the six cultivars shown in Figure 4.4.2. High yielding commercial cultivars, with the exception of VD Policoro, demonstrated the highest responses to inoculation. The largest response, to strain 452, was observed in Lebanese local small,

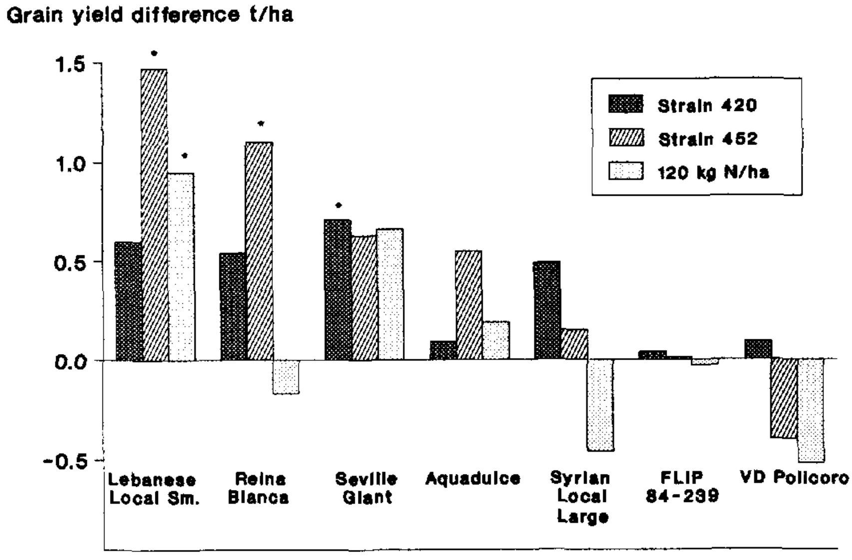

Figure. 4.4.2. Grain yield response of seven selected genotypes of faba bean to inoculation with two strains of Rhizobium and nitrogen fertilizer, Tel Hadya, 1987/88.

with a grain yield increase of nearly 1.5 kg/ha over uninoculated treatment. This cultivar likewise significantly responded to N application, further indicating the lack of symbiotic efficiency with the indigenous rhizobia. Reina blanca and Seville giant also significantly responded to inoculation, giving 1150 and 730 kg seed/ha increases, respectively, over the uninoculated treatment to strains 452 and 420. Other cultivars' responses to treatments were not significant (within cultivars), but the variation of treatment effects, including depression of yield below that of the uninoculated treatment, is apparent (Figure 4.4.2).

Several cultivars significantly responded to inoculation for total crop N (Figure 4.4.3). In all five cultivars responding, strain 452

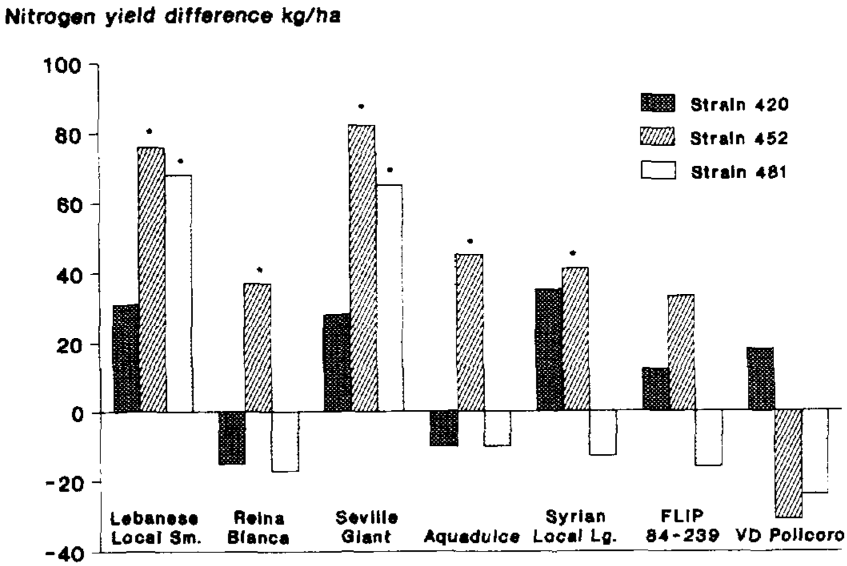

Figure 4.4.3. Nitrogen yield response of seven selected genotypes of faba bean to inoculation with three strains of Rhizobium, Tel Hadya, 1987/88.

significantly increased total N from 38 (Reina blanca) to 83 kg N/ha (Seville giant). Strain 420 increased N yields in cultivars Lebanese local small and Seville giant, but decreased (though not significantly) N yields in Reina blanca and Aquadulce in comparison to the uninoculated treatment. The large variability in response between cultivars is indicated in Figure 3, where inoculation with strain 452 (best strain) also decreased N yield in VD Policoro by more than 30 kg N/ha.

In general, cultivars with the greater yield potential demonstrated the greatest treatment variation. Poorly adapted newer lines and landraces showed little treatment response. Effects of treatments on cultivars showed similar trends for seed and nitrogen

5. DRY PEA IMPROVEMENT

Although peas (Pisum sativum L.) have been cultivated in the ICARDA region for millenia, yields are low because of lack of high and stable yielding well-adapted genotypes and poor crop management. To rectify the problem, an integrated approach to pea improvement was initiated in 1986/87 at ICARDA following the receipt of a grant from Germany (BMZ). Since research has been extensive on improvement of dry pea at a number of institutions in the developed and some developing countries, it was envisaged that ICARDA would capitalize on the existing research and identify dry pea varieties adapted to the farming systems of WANA. The work on pea improvement is therefore concentrated in the following areas:

I. Collection of germplasm/cultivars from institutes working on dry pea in developed and developing countries, test at ICARDA and select superior lines for evaluation in different agro-ecological zones in the region by national programs.

II. Development of the 'best bet' technologies o production and protection practices and their transfer to the national programs for testing and adaptation.

III. Investigate alternative usage of dry peas:

a. As green peas

b. Straw for animal feed

5.1. Germplasm Collection and Evaluation

As in the previous years several elite genotypes and released cultivars were obtained from institutions in developed and developing countries and included in the germplasm collection. The material obtained includes lines with resistance to different abiotic and biotic stresses, varying leaf morphology, seed type and seed colour. Nearly 308 lines were evaluated under 275 mm moisture supply at Tel Hadya in augmented block design. The checks were the widely grown line in Syria, accession 223, and two other cultivars grown extensively around the Mediterranean, accessions 224 and 225. Sowing was carried out on 3 December 1988.

The number of days from sowing to start of flowering varied from 84 days in accessions 31 and 38 to 138 days in accessions 195 and 199. Sixteen accessions did not flower. In 50 highest yielding genotypes, the range was 88 to 109 days.

Compared to the previous years, seed yield was low and ranged from 0 kg/ha to 1033 kg/ha. Fifty highest yielding accessions are presented in Table 5.1.1. Fourteen accessions significantly outyielded (P=0.05) the widely grown local check (accession 223), and pea accessions 180, 216, 239, 263 and 267 produced significantly more yield than the best check (accession 225).

Drs. S.N. Silim, M.C. Saxena and R.S. Malhotra.

5.2. Preliminary Yield Trial

Forty eight superior entries selected from germplasm evaluation in the previous seasons and a high yielding best adapted check were tested in

Table 5.1.1. Days to start of flowering (DSF) and seed yield (kg/ha) (SY) of 50 highest yielding accessions of peas at Tel Hadya, 1988/89.

Accession	DSF	SY	Rank	Accession	DSF	SY	Rank
216	106	1033	1	70	102	791	26
267	95	997	2	177	106	788	27
180	106	991	3	236	106	786	28
239	94	957	4	219	94	786	28
263	104	951	5	280	93	785	30
266	93	936	6	79	107	784	31
74	89	934	7	171	109	778	32
274	97	932	8	53	53	778	32
295	91	929	9	67	105	775	34
107	101	913	10	282	97	775	34
269	91	909	11	73	97	769	36
217	104	906	12	273	93	769	36
*279	97	883	13	151	106	769	36
119	102	876	14	178	105	766	39
278	99	868	15	260	97	761	40
269	90	868	15	264	92	752	41
292	109	857	17	27	101	751	42
135	99	839	18	251	101	745	43
*277	94	839	18	30	105	743	44
24	95	839	18	*287	93	722	45
122	102	816	21	63	106	717	46
284	93	807	22	*275	103	714	47
22	109	804	23	242	88	710	48
234	109	802	24	141	107	708	49
8	109	796	25	248	103	707	50
				<u>Checks</u>			
				225		671	
				223		591	
				224		568	

LSD (5%) between a check and a test material = 279

* semileafless

a Preliminary Yield Trial at Tel Hadya, Syria, and at Terbol, Lebanon, during the 1988/89 season. The objective of the study was to select high yielding entries for sending to the collaborating scientists in the WANA region as an Adaptation Trial. The experiment was conducted in 7x7 triple lattice design with three replications. The lines included both leafed and semi-leafless types.

At Tel Hadya, seed yield was low and ranged from 201 kg/ha (accession 227) to 839 kg/ha (accession 248). Pea accession numbers 248 and 286 produced significantly more seed yield than the well adapted check (accession 8). At Terbol, seed yield ranged from 1170 kg/ha (accession 10) to 2712 kg/ha (accession 216). No pea accession exceeded significantly the check (Table 5.2.1). The twenty best yielding cultivars at each of the location are given in Table 5.2.1.

The pea straw is widely used as animal feed. The straw yield varied significantly among the entries, and ranged from 388 kg/ha (accession 4) to 1196 kg/ha (accession 8) at Tel Hadya, and at Terbol the range was from 986 kg/ha (accession 4) to 5246 kg/ha (accession 123). Straw digestibility and protein content of all the accessions from Tel Hadya trial are being analysed.

Twenty three high yielding accessions from Preliminary Yield Trial were selected and sent to the cooperators as Pea International Adaptation Trial. A total of 45 sets were sent to the national scientists in the region.

Drs. S.N. Silim, M.C. Saxena and R.S. Malhotra.

Table 5.2.1. Seed yield in kg/ha of 20 highest yielding entries in Pea Preliminary Yield Trial at Tel Hadya (Syria) and Terbol (Lebanon) during the 1988/89 season.

Tel Hadya		Terbol	
Accession	Seed Yield kg/ha	Accession	Seed yield kg/ha
248	839	216	2712
286	800	125	2664
291	742	42	2639
278	725	217	2566
227	694	30	2559
25	690	227	2529
24	677	160	2459
264	646	221	2455
288	642	248	2443
290	637	295	2417
283	633	222	2395
267	625	215	2382
226	622	173	2378
287	620	154	2359
271	608	123	2353
282	598	169	2276
216	596	164	2265
217	581	291	2207
30	558	252	2178
4	558	267	2142
Check (accession 8)	554		2654
LSD (5%)	206		436
CV (%)	24.4		13.0

5.3. Pea International Adaptation Trial (PIAT)

Twenty three superior yielding lines that gave high seed yield in the Preliminary Yield Trial, were sent to cooperators within the WANA regions as PIAT. The results reported here are for Tel Hadya (Syria) and Terbol (Lebanon).

Table 5.3.1. Seed yield (kg/ha) and rank (R) in Pea International Adaptation Trial at Tel Hadya (Syria) and Terbol (Lebanon), 1988/89.

	Tel Hadya		Terbol		Overall Mean	
Accession	Seed yield (kg/ha)	Rank	Seed yield (kg/ha)	Rank	Seed yield (kg/ha)	Rank
21	535	13	2833	1	1684	1
167	865	2	2373	4	1619	2
109	731	7	2384	3	1558	3
72	422	21	2556	2	1489	4
221	670	9	2304	5	1487	5
22	783	3	2016	7	1400	6
70	583	12	2183	6	1383	7
62	746	6	1956	10	1351	8
226	776	4	1913	12	1345	9
30	659	11	1992	8	1326	10
7	676	8	1889	13	1283	11
75	524	16	1960	9	1242	12
24	922	1	1484	18	1203	13
65	767	5	1508	16	1138	14
10	493	19	1630	14	1062	16
63	663	10	1407	20	1035	17
38	530	14	1518	15	1024	18
59	528	15	1488	17	1008	19
4	520	17	1424	19	972	20
44	374	22	1385	21	880	21
35	339	23	1237	22	788	22
58	498	18	1067	23	783	23
61	461	20	546	24	504	24
Local check	276	24	1918	11	1097	15
LSD (5%)	208		776			
CV(%)	21.2		26.4			

At Tel Hadya, seed yield in the test entry varied from 339 kg/ha (accession 35) to 922 kg/ha (accession 24). Eleven accessions produced significant (P=0.05) more yield than the local check (Table 5.3.1).

At Terbol seed yield varied from 546 kg/ha (accession 610) to 2833 kg/ha (accession 21) with accession 21 outyielding the significantly (P=0.05) the local check (Table 5.3.1).

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5.4. Response of Pea Plants with Different Leaf Morphology to Varying Population and Moisture Supply

The traditional leafed varieties of pea have poor standing ability and at maturity the haulm lies flat on the ground. Lodging promotes disease development, reduces seed quality through staining, and creates problems in mechanical harvesting. In the last 15 years, major research efforts were devoted in the development of pea plants with small leaflets, leafless and semi-leafless types. The latter two types have their leaflets converted into tendrils, which could improve their standing ability. The optimum density of these new plant types in WANA region is, however, not known. A study was, therefore, conducted during the 1988/89 season to determine optimum density of these new plant types under rainfed and irrigated conditions at Tel Hadya. the varieties were Filby (leafless), Baf (semi-leafless), Progretta (small leaflets) and Onward (conventional leafed variety), sown at 36, 50 and 80 seeds/m2.

Seed yield did not vary significantly between Filby and Baf, but the two varieties produced significantly higher seed yield (P=0.05) than Progretta and Onward (Table 5.4.1). As in 1987/88, the lowest seed yield was form Onward. The mean for optimum seeding density was 50 seeds/m^2, with no further advantage when density was increased to 80

Table 5.4.1. Seed yield (kg/ha) response of peas of varying leaf morphology to plant population at two misture regimes. Tel Hadya, 1988/89.

Moisture (M) and variety (V)	Population/m² (P)			
	80 plants	50 plants	36 plants	Mean
Rainfed				
Filby	932	741	724	794
Baf	1049	844	859	917
Progretta	585	582	413	527
Onward	364	411	376	384
Mean	732	644	593	657
Irrigated				
Filby	1300	1273	1148	1240
Baf	1407	1315	1152	1292
Progretta	1218	1319	917	1151
Onward	851	1224	1102	1059
Mean	1194	1283	1080	1187
Over all Mean	963	964	836	

Population/m² (P)	Variety (V)				
	Filby	Baf	Progretta	Onward	Mean
80	1116	1228	902	608	963
50	1007	1080	951	818	964
36	936	1006	665	739	836
Mean	1019	1104	839	721	

	LSD 5%	SE	CV%
Moisture (M)	64	14.3	10.9
Variety (V)	119	42.5	22
Population (P)	103	36.8	
M X V	158	54.0	
M X P	NS	44.8	
V X P	NS	73.6	
V X P X M	NS		

seeds/m^2. There were trends however, among the genotypes for differential response to plant population; which was significant (P=0.1). In Filby and Baf increase upto 80 seeds/m^2 increased yield, but for the leafed types Progretta and Onward, the optimum was 50 seeds/m^2 and further increase in density reduced seed yield (Table 5.4.1).

Irrigation increased significantly seed yield (Table 5.4.1). In the rainfed treatment, Baf and Filby outyielded Progretta and Onward. With irrigation the seed yield between Baf, Filby and progretta were similar and the first two outyielded Onward significantly (P=0.05). The higher yields of the new plant types, leafless and semi-leafless, in the rainfed treatment, indicate that the plants with reduced leaf size are more suitable to drier environment than the leafed typed.
Drs. S.N. Silim and M.C. Saxena.

5.5. Comparative Performance of Pea Cultivars of Diverse Origin at Different Sowing Dates

The experiments conducted during the 1986/87 and 1987/88 season to test the performance of 20 selected dry pea cultivars of diverse origin at three dates of sowing was repeated in the 1988/89 season. The dates of sowing represented early winter, mid-winter and late winter-early spring and sowings were carried out respectively on December 11, 1986, February 1, 1987 and March 3, 1987 for 1986/87 season; November 24, 1987, January 3, 1988 and February 21, 1988 for the 1987/88 season; and on November 23, 1988, December 29, 1988, and February 1, 1989 for the 1988/89 season. Total moisture supply received during the growing period were 359 mm, 504 mm and 270 mm, respectively for the 1986/87, 1987/88 and 1988/89 seasons.

In the 1986/87 season, early-winter sowing produced highest seed yield (2121 kg/ha), followed by mid-winter sowing (1544 kg/ha) and lowest yield (956 kg/ha) was from early spring sowing. In 1987/88, where rainfall was high, mean seed yield at the three dates of sowing (2153 kg/ha, 2442 kg/ha and 1527 kg/ha, respectively for early-winter, mid-winter and late winter sowings) did not vary significantly, but highest yield was from mid-winter sowing. In 1988/89, seed yield was very low. The highest mean yield was obtained from early winter sowing and the lowest from late winter/early spring sowing (Table 5.5.1). There were significant variations in yield among cultivars. Similar to the results of the 1986/87 season, the highest yielding cultivars were Baf, Frisson and Petit Provincale (Table 5.5.1, ICARDA, 1987). Baf and Frisson were highest yielding in early and mid-winter sowings.
Drs. S.N. Silim and M.C. Saxena.

Table 5.5.1. Seed yield (Y=kg/ha) and rank of pea cultivars as influenced by sowing date, Tel Hadya (Syria), 1988/89.

	Sowing date (D)									
	23.11.1988		29.12.1988		1.2.1989		Mean		Mean rank in	
Cultivar (C)	Y	R	Y	R	Y	R	Y	R	1986/87	1987/88
Baf	861	1	388	2	139	3	463	1	3	20
Frisson	812	2	399	1	76	10	429	2	2	17
Petit Provincale	658	12	362	4	166	1	395	3	1	4
Scout	689	8	372	3	121	4	394	4	12	12
Facima	802	3	341	6	29	15	391	5	14	13
Small Seive Freezer	678	9	346	5	90	7	371	6	9	1
Filby	746	5	307	9	77	9	367	7	7	16
Lincoln	722	6	302	10	42	13	355	8	15	6
Maro	753	4	258	13	24	16	345	9	11	15
Kodiak	655	13	266	12	86	8	336	10	8	3
Syrian Local	666	10	311	7	16	18	331	11	19	10
Dark Skin Perfection	702	7	250	15	37	14	330	12	17	7
Early Onward	628	14	273	11	23	17	308	13	16	9
Progretta	664	11	227	17	16	18	302	14	17	19
Alaska	431	17	309	8	110	5	283	15	4	8
Upton	476	16	255	14	56	11	262	16	10	5
Kelvedon Wonder	406	19	237	17	141	2	261	17	5	2
Despe	532	15	194	19	52	12	260	18	13	11
Sprite	412	18	133	20	109	6	218	19	6	14
Onward	340	20	236	16	11	20	197	20	20	18
Mean	632		289		71					
LSD(5%)	D=26.0,		C=60,		DXC=104					
CV(%)	D=20.4		C=22.5							

6. OROBANCHE STUDIES

The studies on Orobanche are carried out in a collaborative project between ICARDA, GTZ and the University of Hohenheim, FRG. The objective of this project is to find out an effective control measure for Orobanche transferable to national programs and farmers. Orobanche spp. are important angiospermic parasite affecting the productivity of seed legume crops. Efficacy of several single control measures has been tested in the past and the emphasis in the present studies has been on the development of integrated control which is both economical and ecologically safe.

Orobanche infestation in the 1988/89 season was lower than in "normal" years. Underground development of Orobanche was hampered and delayed due to low temperatures early in the season, while afterwards (April to May) most of the crop roots developed in soil layers deeper than 10 cm from where Orobanche emergence is poor and the lateral crop root system including the attached parasites in the top 10 cm of soil dried out because of low seasonal precipitation

6.1. Chemical Control of Orobanche

6.1.1. Screening of herbicides

6.1.1.1. Faba bean

As in the previous year two systemic herbicides, glyphosate (Round-up) and imazaquin (Scepter), were applied. According to the experience from the last season with an extremely high Orobanche incidence (coincidence of favorable weather conditions and highly infested soil) the dosages of the herbicides were slightly increased. Spraying took place at tubercle and bud stage of Orobanche, which was flowering time for faba bean.

Due to the dry weather conditions, the period for Orobanche attack was shorter and Orobanche infestation was light. Orobanche dry weight in the control plots amounted to 1711 kg/ha in 1987/88, but only to 916 kg/ha in 1988/89. This resulted in an increased herbicide effectivity as shown by almost 100% Orobanche control in most of the treatments. Differences between glyphosate and imazaquin were not significant. Phytotoxicity on the crop (chlorosis, reduced size of leaflets) was noticed from the highest imazaquin treatment (2x40 g a.i./ha) but this was not reflected in the yield. Hence, Orobanche control with these herbicides in the present season was excellent (Fig. 6.1.1).

Preliminary tests with additional herbicides indicated good effectivity of imazethapyr (2 x 20 or 2 x 30 g a.i./ha) as well as of a mixture containing imazaquin and glyphosate (2 x 20 and 2 x 80 g a.i./ha) or imazaquin and imazethapyr (each at 2 x 20 g a.i./ha). These treatments will be further tested.

6.1.1.2. Lentil

Lentils proved to be very susceptible to glyphosate application in the past, in that the positive effect of Orobanche control was countered through the phytotoxicity of the product to the crop itself. Therefore, low rates of imazaquin (2 x 7.5 g a.i./ha) were applied for

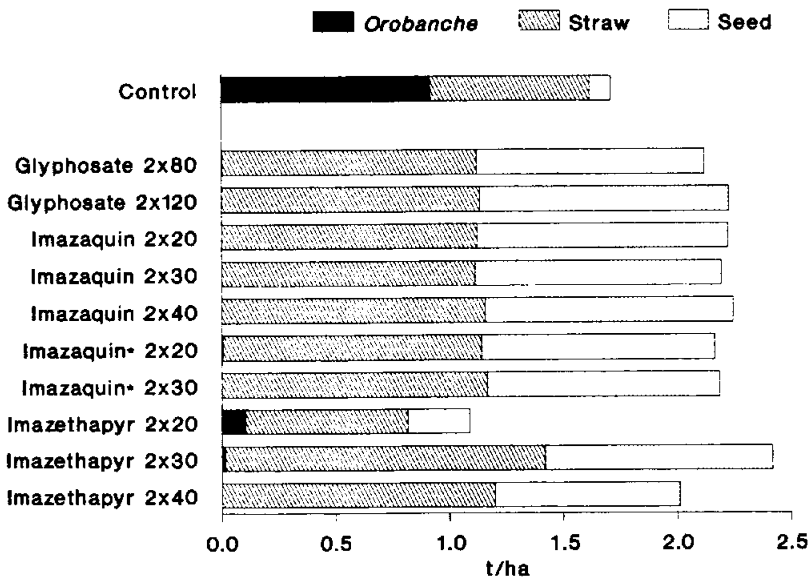

Figure 6.1.1. Effect of different herbicides on the dry weight of Orobanche and seed and straw yield of faba bean, Tel Hadya 1988/89. Imazaquin* was without surfactant.

Orobanche control in lentil. Unfortunately, no Orobanche infestation occurred in that particular part of the field where this trial was conducted and so the effect on the parasite could not be measured. However, no phytotoxicity at all was noticed on lentil and the yield was not reduced significantly by the herbicide treatment (Table 6.1.1).

Table 6.1.1. Effect of imazaquin application (2 x 7.5 a.i./ha) on lentil straw and seed yield.

Treatment	Straw (kg/ha)	Seed (kg/ha)
Control	2312	546
Imazaquin	2237	569
L.S.D. (P = 0.05)	148	74

6.1.1.3. Chickpea

Like lentil, chickpeas also have a low tolerance to these herbicides. Glyphosate (2 x 20 g a.i./ha) had been found most effective in the past. Under the low infestation in the 1988/89 season no crop phytotoxicity was observed and chickpea seed yield was not reduced significantly (Table 6.1.2). However, evaluation of effects on Orobanche was impossible due to the low number of emerged shoots. This herbicide dosage will be tested further.

Table 6.1.2. Effect of glyphosate application (2 x 20 g a.i./ha) on straw and seed yield of chickpea.

Treatment	Straw (kg/ha)	Seed (kg/ha)
Control	1145	1012
Glyphosate	1195	969
L.S.D. (0.05)	211	63

6.1.1.4. Pea

In spite of low to medium Orobanche infestation in this trial (121 kg/ha Orobanche shoot dry weight) the effect of the herbicide was clear. Glyphosate reduced Orobanche, but imazaquin was more effective resulting in almost 100% control of the parasite (Table 6.1.3).

Due to the low Orobanche infestation seed yield was not much affected by the parasite, whereas the higher imazaquin treatment resulted in a slight yield reduction. Imazaquin at a rate of 2 x 20 g a.i./ha gave highest seed yield (946 kg/ha) while the imazaquin formulation without surfactant reduced seed yield significantly. The rate of 2 x 20 g a.i./ha proved effective also in another experiment with a higher Orobanche infestation.

Table 6.1.3. Effect of glyphosate, imazaquin and imazethyapyr applications on Orobanche and pea.

Treatment	g a.i./ha	Orobanche		Pea	
		Number m/2	Dry Wt. kg/ha	Straw kg/ha	Seed kg/ha
Control		6.9	121	1697	855
Glyphosate	2 x 60	4.7	83	1843	895
Glyphosate	2 x 80	3.6	72	1452	827
Imazaquin	2 x 20	0.1	2	1914	946
Imazaquin	2 x 30	0.1	2	2181	709
Imazaquin*	2 x 30	0.1	4	2157	640
Imazethapyr**	2 x 10	3.0	6	2140	1145
Imazethapyr**	2 x 20	0.6	3	2307	990
Imazethapyr**	2 x 30	0.2	1	2125	892
LSD (P=0.05)		3.7	65	365	214

* Formulation without surfactant
** Treatment without replication

The preliminary testing of additional herbicides in peas indicated 100% Orobanche control by a mixture of imazaquin and glyphosate and a good control by imazethapyr. The latter however decreased total biological yield at 2 x 30 g a.i./ha. These treatments will be followed up during next season.

6.1.2. Glyphosate tolerance in faba bean, lentil and pea

A great interaction is usually found between environment and effect of glyphosate treatments. An experiment during the 1987/88 season in an Orobanche free soil (Terbol, Lebanon) demonstrated that a single application of 360 g a.i./ha of glyphosate did not affect faba bean yield. To confirm these results the experiment was repeated in 1988/89 in an Orobanche free (Terbol) and infested (Tel Hadya) soil. A single glyphosate application was made either at vegetative, early flowering

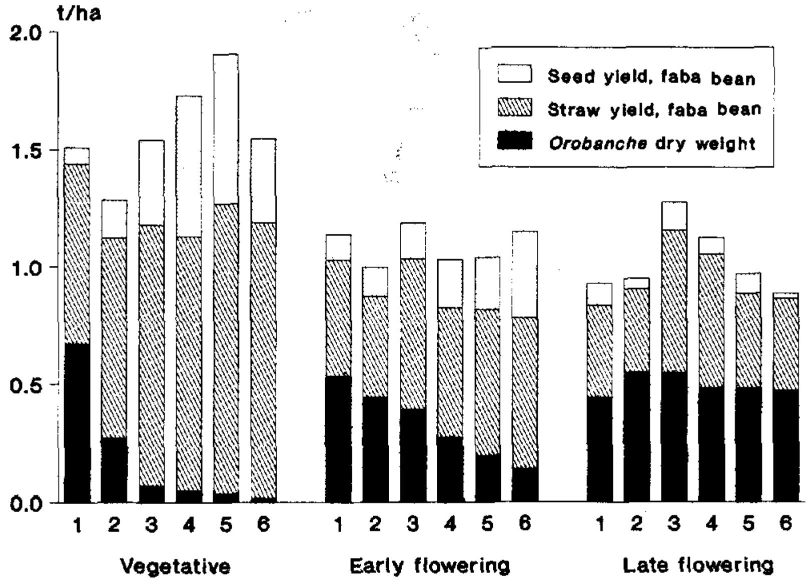

Figure 6.1.2. Effect of glyphosate on Orobanche dry weight and seed and straw yield of faba bean (F 84-239) at 3 growth stages. Rate of application of glyphosate: 1 = control, 2 = 60g, 3 = 120g, 4 = 240g, 5 = 360g, and 6 = 600g a.i./ha.

or late flowering stage of the crops, at 6 different rates (0-360 g a.i./ha in lentil and pea, 0-600 g a.i./ha in faba bean).

Under Orobanche infestation, application at the vegetative stage of faba bean resulted in a higher biological yield and seed yield than at later stages (Fig. 6.1.2). Highest seed yield of lentil was obtained with 120 g a.i./ha at the vegetative stage, with 240 g a.i./ha at the early flowering stage in peas, with 360 g a.i./ha at the vegetative stage in a determinate faba bean (F 84-239) and 600 g a.i./ha at the vegetative stage with faba bean ILB 1814.

Under the _Orobanche_ free situation at Terbol station significant yield reduction in faba bean occured only when glyphosate was applied during the vegetative stage of the crop. No seed yield reduction could be noticed in lentil at that location.

The phytotoxicity was measured on a 1 to 9 scale where 1 means no phytotoxicity and 9 total damage of the crop (EWRS-scale). Highest damage to the crops occured after early applications of glyphosate (vegetative stage). However, a scoring of more than 5, at which recovery of the crop becomes difficult, was reached only in the case of 600 g a.i./ha in faba bean at one location (Fig. 6.1.3). Highest scoring for late applications (late flowering) was only 2.6.

Orobanche control was excellent with the higher rates at the vegetative stage, while effectivity of later applications was low. This confirms that only early applications of glyphosate are useful, and any delay dilutes the effect. Moreover, rates which can be applied to the crops are higher than usually reported in literature. It was in fact surprising that 360 g a.i./ha of glyphosate resulted in highest biological yield with lentil.
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6.2. Selection of Resistant Genotypes

6.2.1. Lentil

The approach to _Orobanche_ control through host-plant resistance offers a long-term solution. However, the necessary level of resistance has still not been found in lentil despite extensive field and laboratory

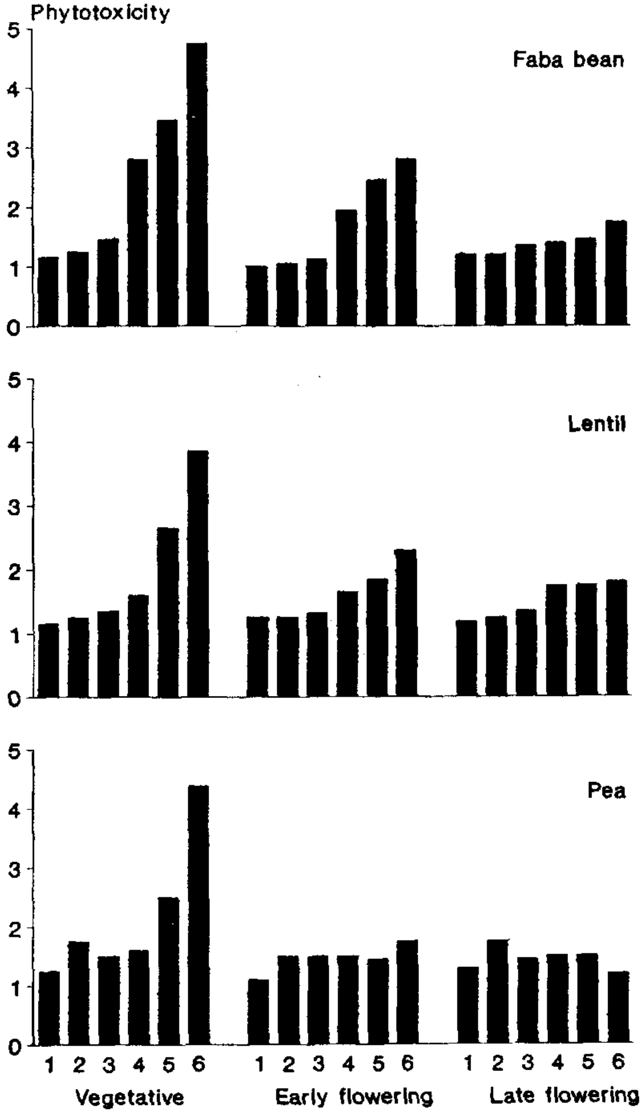

Figure 6.1.3. Summarized results of glyphosate phytotoxicity in faba bean, lentil and pea at three growth stages and at two locations (Phytotoxicity according to EWRS-scale from 1 to 9, where 1 = no phytotoxicity and 9 = complete crop damage; six glyphosate rates, where 1 = control, 2 = 60, 3 = 120, 4 = 240, 5 = 360 and 6 = 600 g a.i./ha of glyphosate in faba bean, and in lentil and pea 1 = control, 2 = 30, 3 = 60, 4 = 120, 5 = 240 and 6 = 360 g a.i.).

screening. The laboratory technique involves growing lentil seedlings in a petri-dish on glass filter paper with Orobanche seed. The technique has less variability than field screening, but has an undesirably low repeatability.

The repeatability in detail was examined by sowing six diverse lines in 20 replicate blocks. There were significant differences between the lines is susceptibility to Orobanche crenata measured as the number of attachments/100 cm root length (Table 6.2.1). These data were then compared with two earlier replicated screenings. The correlations between screening varied from a low of r = -0.017 to a maximum of 0.674.

Table 6.2.1. Variation of selected lentil genotypes to Orobanche attack.

Entry	No. of Orobanche attachments per 100 cm root length
ILL 4400	23.1
ILL 8	19.3
ILL 6042	17.0
ILL 6018	15.7
ILL 5883	12.5
ILL 5748	10.6
L.S.D. (P=0.05)	6.4

Different forage legumes have been screened using the same technique and clear differences, which correspond to field resistance, have been observed. It is clear that the variability in lentil for reaction to Orobanche crenata is limited, because more than 2000 germplasm accessions have been screened either in the field or in the laboratory. This does not preclude the possibility of finding useful resistance in other accessions of the cultigen or in the wild species.

6.2.2. Chickpea

Screening of chickpea was carried out in the plastic house using the polybag - technique to obtain a uniform number of parasite seeds per entry. Hundred entries were chosen from earlier tests and replicated 4 times. According to the number of Orobanche attachments on the root system of the chickpea plants 10 entries were scored as low resistant (>5 Orobanche attachments/host plant), 10 as medium resistant (1-5 attachments), and 10 as highly resistant (<1 attachment). Number of attachments/host root system ranged from 0 to 6.7. These 30 entries will represent a basis for further screening. The ten highly resistant entries are: ILC 200, ILC 848, ILC 1256, ILC 2379, FLIP 85-4, FLIP 82-150, FLIP 85-16, FLIP 81-293, FLIP 85-12, and FLIP 85-17.

6.2.3. Forage legumes

High Orobanche infestation can occur in forage legumes but great differences are observed between different legume species. In order to obtain data on these differences and to compare field and laboratory test methods, two experiments were carried out, one in the field and another in the laboratory. Entries for both trials were the same, consisting of 6 species with 5 accessions each. Laboratory testing was performed using the lentil screening technique with petri dishes in the incubator.

Results of both trials were similar. Lathyrus sativus was identified as the most susceptible species, while L. ochrus was not attacked by the parasite at all (Table 6.2.2).

Table 6.2.2. Variation in Orobanche attack in forage legumes.

Species	Orobanche attachments per 100 cm host root (Lab.)	Emerged Orobanche shoots per m^2 (field)
Lathyrus sativus	21.4	86.7
L. ciceri	21.4	76.7
Vicia narbonensis	6.8	23.7
V. sativa	2.1	3.1
V. dasycarpa	0.6	0.2
L. ochrus	0.0	0.0
L.S.D. (P=0.05)	7.4	17.9

While the differences between species were striking, differences within a species were less. However, some variation occurred: The L. sativus accession No. 201 had significant less attachments than the accession No. 343. The V. narbonesis accession No. 67 was the most susceptible within its group while accessions No. 578 was least affected. No significant variation was detectable within V. dasycarpa and L. ochrus. The correlation between the laboratory and field screening was highly significant (r=0.8541).

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6.3. Soil Solarization

This was the forth year of experiments on solarization at Tel Hadya.

Three trials were carried out during the last season to cover aspects of residual effect of solarization, effectivity of different plastic materials and suitability of solarization for an integrated system. The first two trials were planted with faba bean. Peas were sown in the integrated control trial.

The residual effect of solarization was studied in one of the last year's trials the field of which was not tilled. Treatments were 0, 20, 30, 40 and 50 days solarization in summer 1987. This trial was not irrigated during 1989 and the accumulated rainfall of only 234 mm resulted in poor faba bean growth. No single Orobanche shoot emerged despite a high infestation at that site. Only a low underground infestation was observed. The 50 days treatment showed a higher straw and seed yield compared to the control, but the effect was not significant at the P=0.05 level (Table 6.3.1).

Table 6.3.1. Residual effect of solarization (in the 2nd year).

Solarization	Orobanche Dry weight	Faba Bean Straw (kg/ha)	Faba Bean Seed (kg/ha)
None	0	331	156
20 days	0	476	283
30 days	0	470	240
40 days	0	380	281
50 days	0	515	366
L.S.D. (P=0.05)	-	182	267

The second trial on solarization tested the effectivity of different plastic materials (solarization was done for 40 days in summer 1988). The plastic foils included 1) very thin clear PVC (0.05

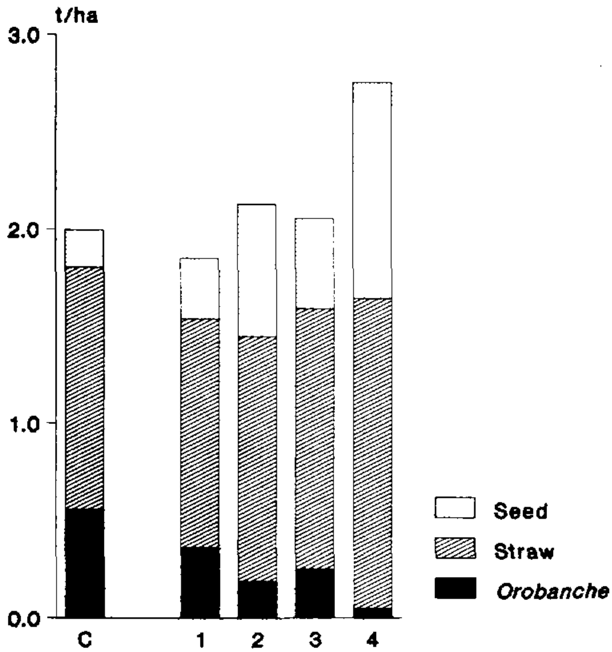

Figure 6.3.1. Effect of solarization (40 days) on Orobanche and faba bean yield at Tel Hadya using different plastic material: C = control, 1 = thin plastic (0.05 mm), 2 = local plastic (0.16 mm), 3 = thick plastic (0.18 mm) and 4 = high quality plastic (0.16 mm).

mm thick), 2) a locally produced clear PVC (0.15 m), 3) yellow PVC which usually is used to cover plastic houses (0.18 mm) and 4) a clear plastic with improved stability and ultra-violet permeability (0.15 mm). All plastic foils significantly reduced Orobanche number and dry weight. This was reflected in an increase in seed yield, which was significant only in the treatments 2 and 4 (Fig. 6.3.1). The partial failure of the other plastic material was due to a low stability of the plastic. Temperature under different plastic treatments did not differ. Thin foil (1) got easily punctured and was therefore blown off by the wind, reducing the efficiency of the treatment. Hence, the lower price for the thin foil does not justify its use.

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6.4. Biological Control

During a survey in 1988 the insect Phytomyza orobanchia was found to occur widely in northwestern Syria and biological control was reported to be promising. Infested Orobanche shoots were collected this season and are now stored to study the diapause and hatching requirements of the adults in relation to the storage conditions

Samples of Orobanche infested by different fungi were also collected during the surveys. Isolation of these fungi on PDA was carried out jointly by the University of Alexandria and ICARDA. The screening of the isolates was done on Orobanche tubercles as well as on emerged and flowering Orobanche shoots.

Results of this study revealed the occurrence of 30 different fungi belonging to 6 different fungal genera. Eight out of these 30 isolates produced rotting of Orobanche tubercles in a bioassay. But one, Ulocladium atrum PRENSS [no. A3(3)], deriving from a flowering shoot of O. crenata at Tel Hadya, was aggressive even on emerged shoots of the parasite. A complete destruction of the Orobanche shoot was obtained provided environmental conditions were suitable, i.e. 50-80% rel. humidity at around 20°C. The results were confirmed in the plastic house as well as in the field. Re-isolation of the isolate and reinfection were performed. No pathogenicity was detected on 11 crop plants tested so far.

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6.5. Manual Control

Hand weeding of *Orobanche* is a labour-intensive method. Hand-pulling of emerged *Orobanche* shoots, although late to reduce damage to the crop, prevents a further increase of the *Orobanche* seed bank in the soil. The effect of date of pulling of *Orobanche* and the time required for pulling on one ha were studied (Tables 6.5.1 and 6.5.2). The best time for hand-pulling was when *Orobanche* flowers were already brownish, but capsules and seed still immature. An earlier pulling increased the number of emerged shoots. Lentil as well as chickpea are crops suited for hand-pulling, as *Orobanche* shoots are quite easy to detect in these crops. Pulling of the shoots, however, was faster when the crop was already removed (Table 6.5.2). It is important to remove the pulled *Orobanche* shoots from the field as they are still able to produce

Table 6.5.1. Effect of hand-pulling on the number of *Orobanche* shoots/m^2 in peas at the end of flowering of the crop.

Treatment	Before pulling	2 weeks after pulling	Total no. emerged by end of flowering
No pulling	17.4	24.0	24.0
Pulling	16.9	15.2	32.1

Table 6.5.2. Time required for hand-pulling of *Orobanche* under low infestation.

Crop	*Orobanche* shoots/m^2	Time for pulling from 1 ha
Faba bean	0.16	3 hours
Pea	0.015	13 minutes*

* After removing the pea crop detecting *Orobanche* was easy.

mature, viable seeds. Viability of seed from shoots pulled and left to dry in the field ranged from 20 to 87%. In case pulled Orobanche shoots are used for feeding animals, the shoots have to be fresh and seed immature. Mature Orobanche seed can survive the passage through a sheeps' stomach and might be spread.

In order to increase the speed of manual control the application of small amounts (0.1, 0.2, 0.5 and 1 ml) of kerosine on the Orobanche shoots was tested. A quantity of 0.1 ml kerosine was sufficient to kill 95% of the parasites without damage to the host plant. Kerosine is phytotoxic to the host plants and therefore has to be applied either by a swab to touch only the Orobanche shoot or by a well-directed application using a special pipe.
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6.6. Crop Rotation

In addition to the natural decay of Orobanche seed in the soil various plants are able to stimulate Orobanche seed germination and thereby can influence the seed bank in the soil. Experimental plots (5 x 3 m) were planted with 10 different crops or kept fallow during the previous season. These plots were then uniformly planted to lentil to assess differences in Orobanche number and dry weight. All Orobanche shoots in the previous season were removed before maturity.

Orobanche dry weight in lentil was significantly reduced after growing flax, Vicia villosa ssp. dasycarpa, faba bean or lentil as a preceeding crop (Fig. 6.6.1). Flax as a preceeding crop was most

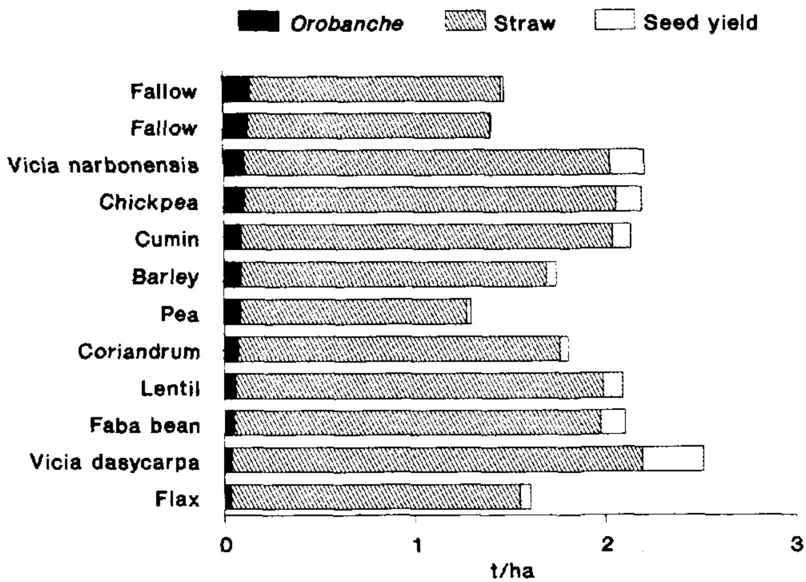

Figure 6.6.1. Effect of different preceeding crops on the Orobanche infestation in subsequent lentil at Tel Hadya, 1988/89.

effective in reducing the Orobanche. Flax is a trap crop for Orobanche i.e. seeds are stimulated to germinate but they are not able to parasitize flax. Although the degree of elimination of Orobanche seed from soil by planting flax might be similar as with faba bean, no crop damage occurs on flax and no shoots need to be pulled. The largest number of Orobanche shoots emerged after keeping the plot fallow. It seems that seed under fallow remain conserved in the soil while in plots planted to other crops a decline in seeds occurs to some extent. Besides stimulating the parasite seed, other factors might also influence seed decay under a plant canopy (e.g. higher activity of microorganisms). Hence, planting a trap crop like flax can be recommended as a means for reducing the Orobanche infestation.

Lentil seed yield in this trial was low due to shortage of water. The same holds for the number of emerged Orobanche shoots, whereas the underground infestation was high.

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6.7. Integrated Control

Of the various control measures tested singly, none provided 100% control of Orobanche spp. in legume crops in a Mediterranean environment in Syria. Combining several single methods into an integrated control system, however, gave an efficient control. The elements of this integrated control include use of less infested and/or early maturing cultivars, slightly delayed sowing, application of herbicide, hand weeding and soil solarization. Experiment on integrated control was continued during the 1988/89 season.

6.7.1. Faba bean

A very striking effect of reduced Orobanche infestation in faba bean was obtained simply by delayed sowing. Under uninfested conditions, delaying the sowing beyond the optimum date normally causes yield reduction. This reduction however, can be minimized if the delay is short (about 10-14 days), which proved sufficient to reduce the Orobanche infestation; its efficiency further improved if it was combined with other methods of Orobanche control. A combination of delayed sowing and herbicide gave results similar to those obtained in the past (Fig. 6.7.1). Crop seed yield was not reduced with delayed sowing, because damage from Orobanche was less.

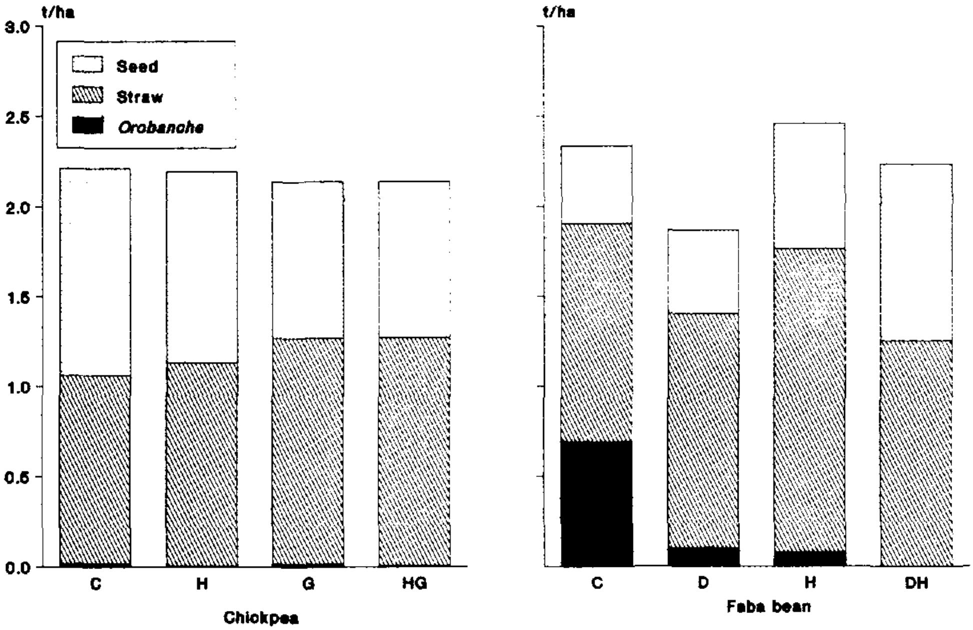

Figure 6.7.1. Integrated Orobanche control methods: Effect of combination of herbicide (H) and less susceptible genotype (G) in chickpea and delayed sowing (D) and herbicide (H) in faba bean as compared to control (C) on Orobanche dry weight and seed and straw yield of the crops.

The effectivity of herbicides (glyphosate or imazaquin) in reducing Orobanche infestation was similar to that of delayed sowing, but varied each year due to weather conditions. Combination of herbicide treatment with delayed sowing resulted in good Orobanche control with highest economic efficiency.

6.7.2. Lentil

The trial on integrated control in lentil could not be evaluated for Orobanche effects as the site where the trial was located was mostly free of Orobanche seed. The number of underground attached Orobanche plants amounted to $0.7/m^2$ without any emerged shoot. Nevertheless, the application of 2 x 7.5 g a.i./ha imazaquin did not affect the straw or seed yield of lentil even without Orobanche. Similarly, slightly delayed sowing of a cultivar which is adapted for late planting did not reduce yield. The combination of both methods is expected to be most economic with lentil and will be further studied.

6.7.3. Chickpea

Conditions for Orobanche infestation are provided only in winter sown chickpea; in the later sown spring chickpeas Orobanche has never been seen as a problem. The general infestation on chickpea was less (by a factor of 5 to 10) when compared to faba bean. Therefore, only low input techniques are justified to control Orobanche in this crop.

Application of 2 x 30 g a.i./ha glyphosate significantly reduced the Orobanche dry weight in other seasons, and this year there was no negative effect on the yield in the absence of the parasite (Fig. 6.7.1). A genotype which showed less Orobanche infestation in a previous study was not different from ILC 482 in the present experiment with a low overall infestation, but had less yield. Upon identification of a moderately resistant genotype, cultivation of chickpea even in heavily infested areas may be possible, if an additional means of control (e.g. herbicide, hand-pulling etc.) is included.

6.7.4. Forage legumes

Forage legumes differ widely in their susceptibility to Orobanche. In a highly infested field use of less affected species would avoid heavy

Orobanche attack and reduce seed bank increase. Studies on herbicides indicated that glyphosate applications (2x60 g a.i./ha) did not prove effective with Lathyrus sativus, however, this needs further studying. Further reduction of attack can be accomplished by delayed sowing. Delayed sowing by 4 weeks resulted in no emergence of an Orobanche shoot, although a lot of small, nonemerged Orobanche attachments were there (Table 6.7.1).

Table 6.7.1. Effect of delayed sowing of Vicia narbonensis* and Lathyrus sativus on Orobanche.

Crop	Sowing date	Emerged Orobanche/m^2	Nonemerged Orobanche/m^2
V. narb.	Nov. 23	90	338
	Dec. 23	0	60
L. sativ.	Nov. 23	80	361
	Dec. 23	0	81

* Accession no. 67, which is very susceptible.

6.7.5. Peas

Peas were the most susceptible to Orobanche of all the crops studied; under heavy infestation the crop was killed by flowering time. Experiments conducted included solarization (40 days), two varieties and herbicide treatments (2 x 20 g a.i./ha of imazaquin).

Solarization reduced Orobanche infestation and increased seed yield. The dry weight of Orobanche decreased from 524 kg/ha without solarization to 9 kg/ha with solarization while crop seed yield increased from 123 kg/ha to 914 kg/ha. The herbicide application showed similar efficacy in controlling Orobanche as solarization but was much cheaper (Fig. 6.7.2). In an earlier season under more severe Orobanche attack, however, the herbicidal effect was low and no seed yield was obtained.

Excluding solarization the combination of delayed sowing plus herbicide gave highest yield (594 kg/ha). The combination of herbicide with a less susceptible genotype and solarization resulted in 1515 kg/ha seed yield and no emergence of Orobanche shoots.

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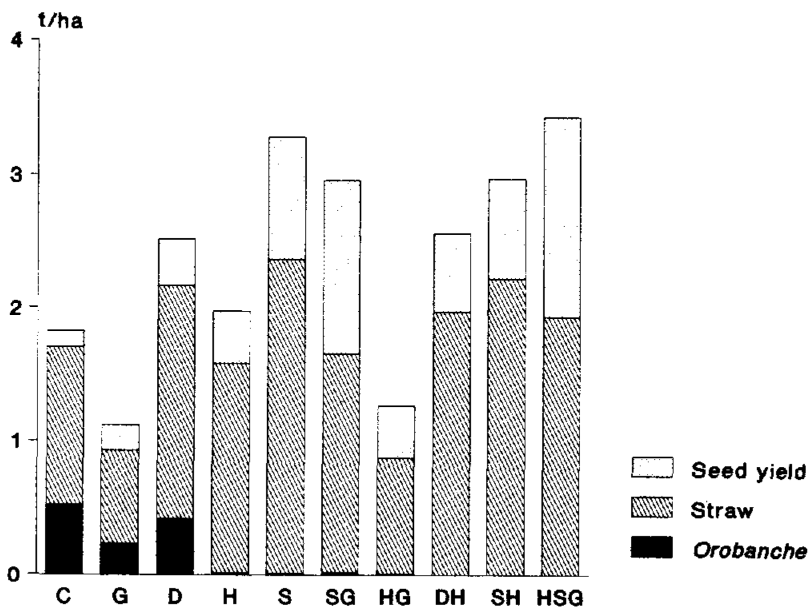

Figure 6.7.2. Effect of Orobanche control methods on Orobanche dry weight and seed and straw yield of peas at Tel Hadya, 1988/89 (C = control, G = less infected genotypes, D = delayed sowing, H = herbicide, S = solarization).

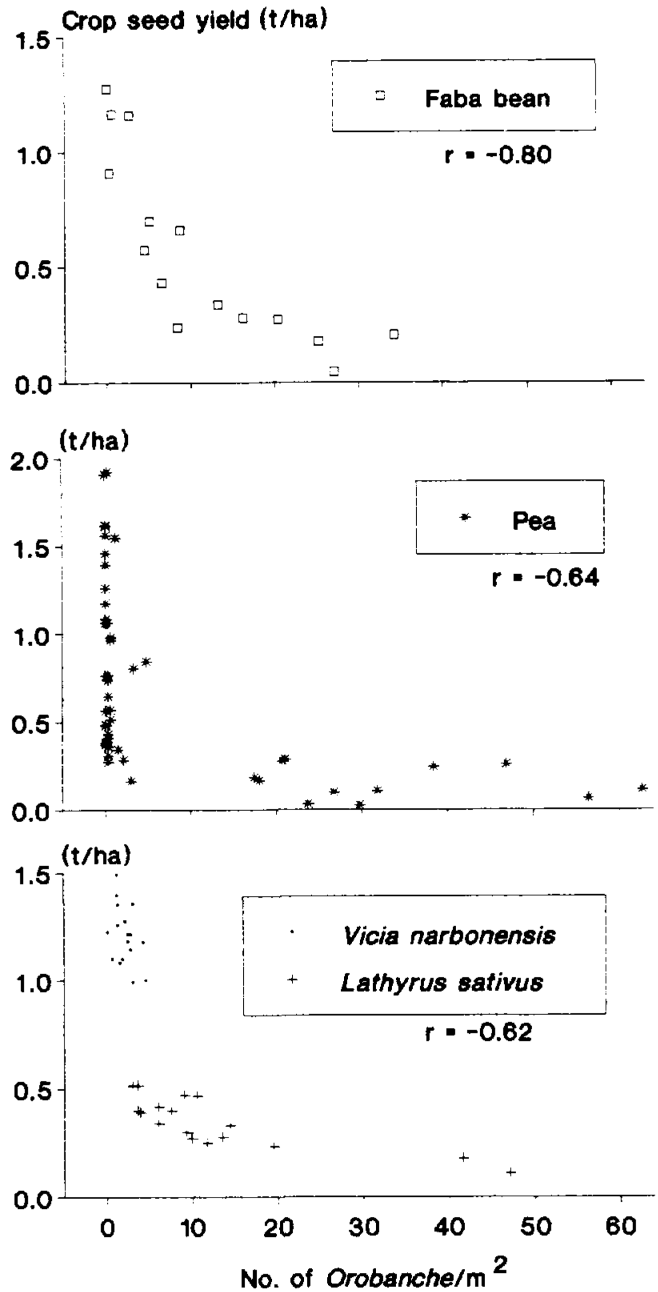

Figure 6.8.1. Relationship between number of <u>Oroabnche</u>/area and crop seed yield (A: faba bean; B: Pea; C: 2 forage legumes differing in susceptibility top = <u>Vicia narbonensis</u>, bottom = <u>Lathyrus sativus</u>).

6.8. Relation between Orobanche Infestation and Crop Yield

A better understanding of the Orobanche - crop yield relation is important for yield loss estimation. An increasing Orobanche infestation results in a reduced crop biomass production. The parasite acts as an additional strong sink on the host plant at the time of reproductive growth of the crop and results in dropping of flowers and reduced seed yield. The typical relation between dry weight of Orobanche and crop yield is demonstrated in (Fig. 6.8.1). The relationship may vary from crop to crop and modified by factors like Orobanche seed bank, weather conditions and control methods. An example for this relation is given for the effect of solarization in faba bean (Fig. 6.8.2).

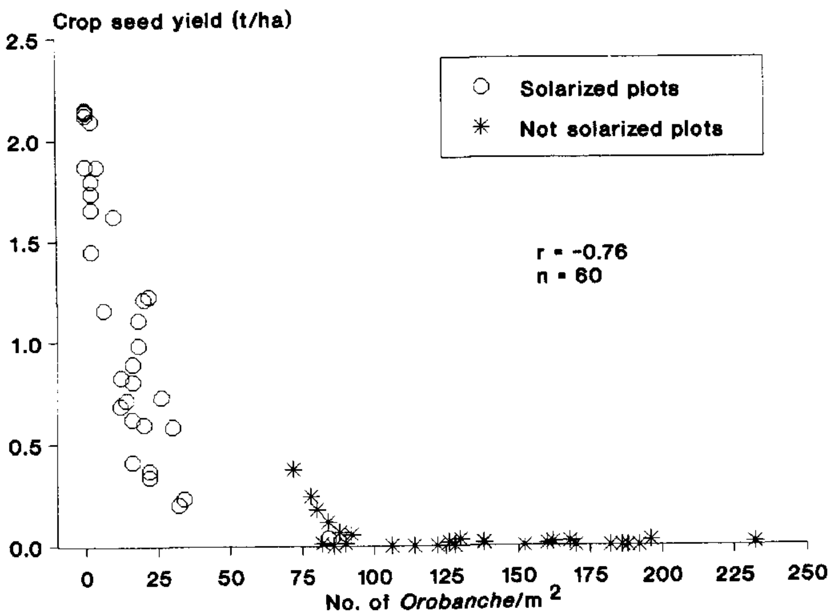

Figure 6.8.2. Relation between Orobanche number and crop seed yield (faba bean) in the solarization experiment (O = solarized plots, ● = not solarized plots).

7. INTERNATIONAL TESTING PROGRAM

The international testing program on faba bean, lentil, and kabuli chickpea 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 generation, and elite lines with wide and specific adaptation, special morphological or quality traits, and resistance to common biotic (diseases, insect-pests and parasites) and abiotic (cold and drought) stresses. The improved production practices include 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 and the performance data permit assessment of gneotype x environment interaction and help in targetting breeding efforts for specific agroecological conditions. Through the agronomic trials, research on optimum agronomic practices for different agro-ecological conditions is encouraged in the national programs to fully realize the yield potential of their cultivars.

With recent shift in emphasis of ICARDA activities as per EPR recommendations, the distribution of all the yield trials and screening nurseries of faba bean to the national programs from ICARDA's headquarters at Aleppo has been stopped and only restricted number of nurseries with special characteristics including determinate types and stress resistance sources have been distributed for the 1989/90 season.

The chickpea nurseries were further diversified during 1989/90 and six new nurseries including F_4 Nursery for Southern Latitudes (CIF_4N-SL), Screening Nursery for Southern Latitudes in Asia (CISN-SL1), Screening Nursery for Southern Latitudes in Africa (CISN-SL2), Screening Nursery with extra large seed size for Latin American countries (CISN-LA), Yield Trial for Southern Latitudes in Africa (CIYT-SL2), and Yield Trial for Latin American countries (CIYT-LA) were added. In lentil, the F_4 nurseries were further diversified to include, segregating populations for large seed size (LIF_4N-L), small seed size (LIF_4N-S), and cold tolerance (LIF_4N-CT). In addition, a new nursery with sources of resistance to _Fusarium_ wilt has been included from this season. Thus in total, more than one thousand sets of 45 different types of nurseries (Table 7.1.1.) were desptached to various cooperators during the 1989/90 season. Several cooperators requested large quanities of seed of some elite lines identified by them from the international nurseries/trials for multilocation yield testing and on-farm trials and we attempted to meet their requests.

The salient features of 1987/88 international nursery results received from coopertors till 31 October, 1989 are presented here.

Table 7.1.1. Food Legume International Nurseries supplied for the 1989/90 season.

International Trial/Nursery	No. of sets
Faba Bean	
Ascochyta Blight Nursery (FBIABN-90)	18
Chocolate Spot Nursery (FBICSN-90)	20
Rust Nursery (FBIRN-90)	20
Determinate Nursery (FBISND-90)	51
Weed Control Trial (FBWCT-90)	8
Need for Inoculation Trial (FBNIT-90)	2
Inoculation Response Trial (FBIRT-90)	3
Orobanche Chemical Control Trial (FBOCCT-90)	5
Lentil	
Yield Trial, Large-Seed (LIYT-L-90)	48
Yield Trial, Small-Seed (LIYT-S-90)	34
Yield Trial, Early (LIYT-E-90)	41
Screening Nursery, Large-Seed (LISN-L-90)	29
Screening Nursery, Small-Seed (LISN-S-90)	26
Screening Nursery, Early (LISN-E-90)	50
Screening Nursery, Tall (LISN-T-90)	34
F_4 Nursery, Large Seed (LIF_4N-L-90)	11
F_4 Nursery, Small Seed (LIF_4N-S-90)	9
F_4 Nursery, Cold Tolerance (LIF_4N-CTS-90)	9
F_4 Nursery, Early (LIF_4N-E-90)	19
Cold Tolerance Nursery (LICTN-90)	15
Ascochyta Blight Nursery (LIABN-90)	16
Fusarium Wilt Nursery (LIFWN-90)	19
Need for Inoculation Trial (LINIT-90)	8
Inoculation Response Trial (LIRT-90)	20
Weed Control Trial (LWCT-90)	22
Chickpea	
Yield Trial Spring (CIYT-Sp-90)	35
Yield Trial Winter, Mediterranean Region (CIYT-W-MR-90)	61
Yield Trial Southernly Latitudes-1 (CIYT-SL1-90)	15
Yield Trial Southernly Latitudes-2 (CIYT-SL2-90)	16
Yield Trial Latin Amiercan (CIYT-LA-90)	9
Screening Nursery Winter (CISN-W-90)	49
Screening Nursery Spring (CISN-Sp-90)	35
Screening Nursery, Southernly Latitudes-1 (CISN-SL1-90)	9
Screening Nursery, Southernly Latitudes-2 (CISN-SL2-90)	10

Cont'd 2/..

Cont'd 2/..

International Trial/Nursery	No. of sets
Screening Nursery, Latin American (CISN-LA-90)	8
F_4 Nursery, Mediterranean Region (CIF_4N-MR-90)	26
F_4 Nursery, Southernly Latitudes (LIF_4N-SL-90)	17
Ascochyta Blight Nursery: Kabuli (CIABN-A-90)	32
Ascochyta Blight Nursery: Kabuli & Desi (CIABN-B-90)	20
Leaf-miner Nursery (CILMN-90)	22
Cold Tolerance Nursery (CICTN-90)	30
Need for Inoculation Trial (CINIT-90)	12
Inoculation Response Trial (CIRT-90)	16
Weed Control Trial (CWCT-90)	25
Peas	
Adaptation Trial (PIAT-90)	38
TOTAL	1022

7.1. Faba Bean

Results of 17 sets of Faba Bean International Yield Trial-Large Seed (FBIYT-L) indicated that only at six locations (Oran in Algeria; Homs and Gelline in Syria; Mosul in Iraq; Perico in Argentina; and Sakha in Egypt) some of the lines outyielded the local check by a significant ($P \leq 0.05$) margin. The five best yielding entries across locations included Reina Blanca (ILB 1270), New Mammoth (ILB 1269), Gemini, 80S 80135 (X79S 171) and FLIP 82-45FB. The ANOVA for stability for seed yield revealed that only the mean squares due to linear (predictable) 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 18 entries out of 23 was predictable.

The entries namely, New Mammoth, FLIP 82-45FB, 80S 44027, FLIP 82-54FB, ILB 1821, FLIP 82-30FB, FLIP 82-28FB, and ILB 1814 in descending order of superiority were with average stability and predictable behaviour. Two other entries namely ILB 9 and 80S 80135, with above average performance, a regression coefficient more than unity and the deviations approaching to zero, were 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 1987/88.

Source of variation	FBIYT-L		FBIYT-S		FBIYT-D	
	DF	MS($x10^4$)	DF	MS($x10^4$)	DF	MS($x10^4$)
Entry	22	105.48*	22	231.97*	12	141.59*
Entry x location + Location	345	224.76*	391	322.66*	234	161.38*
Location (linear)	1	72862.20*	1	115141.00*	1	34157.30*
Entry x location (linear)	22	26.79*	22	107.13*	12	23.45
Pooled deviation	322	12.71	368	23.54	221	15.04*
Pooled error	704	9.97	792	17.19	456	9.85

* Significant at P = 0.05.

The Faba Bean International Yield Trial-Small Seed (FBIYT-S) analysed for 18 locations revealed that at Morokambos in Cyprus, Larissa in Greece, Terbol in Lebanon, Cordoba in Spain, and Tel Hadya in Syria, some entries exceeded the respective local checks in seed yield by significant margins. Across locations, the five highest yielding lines were: FLIP 83-88FB, FLIP 83-106FB, FLIP 84-48FB, FLIP 83-105FB and FLIP 82-9FB. The stability analysis for seed yield (Table

7.1.2) revealed that linear portion of genotype-environment interaction was predominant and important. Six entries namely, FLIP 83-88FB, FLIP 83-105FB, FLIP 83-3FB, FLIP 83-95FB, Giza 3, and FLIP 83-1FB having above average yield, regression coefficient equal to one and deviations approaching to zero had general adaptation. Three more lines namely FLIP 83-106FB, 76TA 56267, and FLIP 82-35FB with above average yield, deviations approaching to zero but regression greater than unity were adaptable and responsive to high yielding environments.

The Faba Bean International Yield Trial-Determinate (FBIYT-D) was reported from 19 locations and at 4 locations (Dijon in France, Domain in Morocco, Elvas in Portugal, and Tel Hadya in Syria) some of 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 86-146FB, FLIP 86-118FB, and FLIP 86-145FB. The heaviest yielding determinate line yielded 17 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 squares due to both Entry x location - (linear) and pooled deviations interaction were significant. Five entries, FLIP 86-107FB, FLIP 86-146FB, FLIP 86-118FB, FLIP 84-244FB, and FLIP 86-145FB, had above average performance, regression coefficient equal to unity, and deviations from regression approaching to zero, and were thus having general adaptation.

In the Faba Bean International Screening Nursery-Large Seed (FBISN-L) out of 15 locations, at two locations (Taiba and Jubeiha in Jordan) 4 and 9 test entries exceeded the respective local checks in seed yield by significant margins (at $P \leq 0.05$). The five best entries across locations included FLIP 84-127FB, FLIP 86-36FB, FLIP 84-76FB, FLIP 84-91FB and FLIP 84-107FB.

In the Faba Bean International Screening Nursery-Small Seed (FBISN-S) out of 11 locations, at two locations (Taiba in Jordan, and Dierab in Saudi Arabia) 22 and 1 test entries significantly exceeded the respective local checks in seed yield. The five best yielders across locations included FLIP 86-80FB, FLIP 85-48FB, FLIP 85-28FB, FLIP 85-7FB and FLIP 85-13FB.

In the Faba Bean International Screening Nursery-Determinate Type (FBISN-D) out of 16 locations reporting the yield data, only at two locations (Domain in Morocco and Dhamar in Yemen) a few entries exceeded the respective local check by a significant margin. The top five yielders across locations included, ILB 1814, FLIP 86-122FB, FLIP 86-123FB, FLIP 86-135FB and FLIP 86-124FB. The top determinate yielder in this nursery gave 14 per cent less yield than the indeterminate high yielding check, ILB 1814.

The results of F_4-Nursery (FBIF$_4$N) were reported from 8 locations and the ANOVA for seed yield revealed that at all locations a large number of the segregating populations were statistically ($P \leq 0.05$) similar or superior to the respective local checks in seed yield. This indicates that the selection of superior plants within these populations was feasible at all these locations. The five best yielding populations across locations included, Cross Nos. S85196, S85065, S85023, S85198, and S85190.

The results on Faba Bean International Ascochyta Blight Nursery (FBIABN) were reported from 7 locations. At Pulway and Radzikow in Poland all the 23 entries were rated between 7 and 9. Based on remaining 5 locations, nine entries namely, Sel.Lat. A87-1 (BPL 74),-175 (S83195), -15 (BPL 818), -17 (A2), -35 (L83129), -36 (L83135), -212 (BPL 2138), -218 (BPL 2144) and -304 (31818-1) exhibited rating between 1 and 5, and had better level of resistance as compared to others.

The results of Faba Bean International Chocolate Spot Nursery (FBICSN) were reported from twelve locations. At eight locations, the susceptible check had the rating between 7 and 9 on 1 to 9 scale (1 = free, 9 = highly susceptible). At Pulway in Poland all the entries were rated at 9. The frequency of occurrence of a line as tolerant with 1-5 rating across locations was highest for Sel. Lat B87-10 (BPL-710), and was followed by Sel. Lat. B87-24 (L83108), -27 (L83114), -118 (L83081), -127 (ILB 3025), -140 (ILB 3025) etc.

The results of Faba Bean International Rust Nursery (FBIRN) were reported from six locations. At Pulawy in Poland there was no infestation. Based on other locations out of 21 lines, seven lines namely Sel Lat R 87-2 (BPL 8), -6 (BPL 261), -27 (L82014), -35 (BPL 552), -54 (BPL 627), -61 (BPL 665), and -15 (BPL 1179) occured most frequently among the tolerant lines.

The Faba Bean Weed Control Trial (FBWCT) results were analysed for

4 locations for seed yield and the treatment effects were significant. The treatments including pre-emergence application of Tribunil and Kerb at Holetta in Ethiopia; Igran and Kerb at Tarquinia in Italy; and Igran at Dhamar in Yemen were significantly superior to the respective weedy check. Also post-emergence treatment of Aretit and Fusilade was promising at Tarquinia in Italy.

The Faba Bean International Rhizobium Inoculation Response Trial (FBIRT) was analysed for Taiba (Jordan) and Dhamar (Yemen) but the ANOVA for seed yield was significant only for Dhamar. The treatment using strain number 481 with application of 60 kg P_2O_5/ha + 60 kg K_2O/ha was significantly superior to all other treatments. This showed that strain number 481 was most effective in fulfilling the nitrogen requirements of crop at Dhamar.

7.2. Lentil

Data from 18 locations were analysed for seed yield for Lentil International Yield Trial-Large Seed (LIYT-L). At twelve locations, namely Horsham, Tam worth and Mallee in Australia; Elvas in Portugal; Dahmoni in Algeria, Marow in Jordan; Terbol in Lebanon; Settat and Marchouch in Morocco; Alcala de Hanares in Spain; Tel Hadya in Syria; and Eskisehir in Turkey 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 78S26002, FLIP 85-38L, FLIP 85-35L, FLIP 85-84L, and 81S30935.

Stability analysis based on Eberhart and Russell (1966) model for seed yield of LIYT-L-entries revealed that only mean square due to pooled deviations (non-linear portion of genotype x environment interaction) was significant (Table 7.2.1). This exhibited the presence of differences among entries for their predictability across environments. The perusal of stability parameters, for individual entries revealed that the entries FLIP 84-59L, FLIP 84-159L, FLIP 84-161L, FLIP 86-31L and FLIP 86-32L had above average mean yield, unit regression coefficient and non-significant deviations from regression and were thus adaptable.

Table 7.2.1. ANOVA for stability for seed yield for the entries in LIYT-L, LIYT-S, and LIYT-E conducted during 1987/88.

Source of variation	LIYT-L		LIYT-S		LIYT-E	
	DF	MS($x10^4$)	DF	MS($x10^4$)	DF	MS($x10^4$)
Entry	22	17.24*	22	15.74*	22	29.31*
Entry x location + Location	483	68.56*	207	42.62*	184	64.10*
Location (linear)	1	28093.80*	1	7122.83*	1	8351.42*
Entry x location (linear)	22	14.34	22	8.83	22	30.38*
Pooled deviation	460	10.23*	184	8.19*	161	17.24*
Pooled error	968	4.53	660	4.07	594	4.56

* Significant at P = 0.05.

The results of Lentil International Yield Trial-Small Seed (LIYT-S) revealed that at 10 (Hassi Bounif in Algeria; Horsham and Walpeup in Australia; Marow in Jordan; Taiba in Jordan; Settat in Morocco; Alcala de Henares in Spain; Tel Hadya in Syria; Eskisehir in Turkey) out of 14 locations analysed 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 84-58L, 78S26013, FLIP 84-29L, FLIP 86-29L and FLIP 84-51L. Stability analysis for seed yield of the entries in LIYT-S, revealed that only mean square due to pooled deviations was significant (Table 7.2.1). Seven entries namely FLIP 84-58L, FLIP 86-29L, FLIP 84-159L, FLIP 84-51L, FLIP 85-31L, FLIP 84-82L, and FLIP 86-32L had above average mean, non-significant deviations from regression, and regression coefficinet equal to unity, and were thus adaptable. A line FLIP 84-59L having above average mean, non-significant deviations from regression, and regression more than one seems responsive to favourable environments.

The results of Lentil International Yield Trial-Early (LIYT-E) revealed that at six locations namely, Faisalabad, Sarai Nawrang, and Islamabad in Pakistan; Bandarawala in Sri Lanka; Tel Hadya in Syria and Gemmeza in Egypt, 1,1,6,5,1 and 4 test entries, respectively, exceeded the respective local check in seed yield by significant margins. The five heaviest yielders across locations included, FLIP 86-39L, Precoz, FLIP 86-38L, L1057 and Pant L639. Stability analysis for seed yield for the entries in LIYT-E (Table 7.2.1) revealed that only two entries, Pant L406 and FLIP 84-112L having above average yield performance, regression coefficient as unity, and non-significant deviations from regression had general adaptation.

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 24, 14, 18, and 19 locations, respectively. The analyses of data revealed that at 13 locations in LISN-L (Karaj and Ghazvin in Iran; Elvas in Portugal, Terbol in Lebanon, Alcala de Henares in Spain; Idleb, Izra'a and Tel Hadya in Syria; Perico in Argentina, Chiangmai and Shanxi in China; Graneros in Chile; and Nubaria in Egypt), 5 locations in LISN-S (Alcala de Henares in Spain; Shanxi in China; Tel Hadya, Izraa and Aleppo in Syria), 9 locations in LIYT-T (Toshevo in Bulgaria; Dromolaxia in Cyprus; Terbol in Lebanon; Settat in Morocco; Elvas in Portugal; Alcala de Henares in Spain; Izra'a, Gelline and Tel Hadya in Syria), 4 locations in LISN-E (Settat in Morocco; Faisalabad and Islamabad in Pakistan; and Perico in Argentina) 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, 1987/88.

	Name of Nursery			
Rank	LISN-L	LISN-S	LISN-T	LISN-E
1	FLIP 88- 6L	FLIP 88-29L	ILL 1939	FLIP 88-34L
2	FLIP 88- 1L	FLIP 88-18L	FLIP 88-51L	FLIP 84-112L
3	FLIP 88- 8L	FLIP 87-48L	FLIP 88-18L	ILL 4605
4	FLIP 87-17L	FLIP 87-28L	FLIP 84-58L	ILL 1983
5	FLIP 88- 4L	FLIP 87-26L	FLIP 86-41L	FLIP 86-39

The results from Lentil International F_3-Trial (LIF$_3$T) and F_3-Trial-Early (LIF$_3$T-E) reported from 9 and 3 locations, respectively, were analysed. Six crosses at Homs in Syria, 4 crosses at Eskisehir in Turkey and one cross at Gemmeza in Egypt in LIF$_3$T; and twenty one crosses at Settat in Morocco in LIF$_3$T-E, gave significantly higher yield than the respective local checks. The five best yielding crosses across locations included X 86S 52 (FLIP 85-37L x UJL 176), X86S 57 (83S99 x ILL 4354), x 86S169 (74TA276 x FLIP 84-184L), x 86S215 (FLIP 84-26L x FLIP 84-82L) in LIF$_3$T; and X86S211 (FLIP 84-78L x FLIP 86-12L), X86S109 (LG41 x FLIP 86-19L), X 86S49 (ILL 4605 x UJC 176), X 86S255 (78S 26013 x FLIP 84-112L) and X86S121 (FLIP 84-112 x FLIP 86-15L) in LIF$_3$T-E.

The results of Lentil International Cold Tolerance Nursery were received from 3 locations namely, Alcala de Henares in Spain, Toshevo in Bulgaria, and Oroumieh in Iran. The susceptible check at these locations took ratings of 5,9 and 7 respectively. One entry, ILL 323 took rating of 1 to 3 at two locations and two more entries, ILL 632 and ILL 662 exhibiting rating between 2 to 5 at three locations were, tolerant to cold.

The results of Lentil International Ascochyta Blight Nursery were received only from Debre Zeit in Ethiopia. Only one entry, FLIP 84-85L with rating of 3 was resistant and all others were susceptible.

Eight locations for which data on seed yield for Lentil Weed Control Trial (LWCT) were reported, only two locations, exhibited significant treatment effects. At Dhamar in Yemen, Bladex (@0.5 kg a.i./ha) or combination of Bladex with Kerb (@0.5 kg a.i./ha); and at AARI Faisalabad in Pakistan Gesagard (@1.5 kg a.i./ha) in combination with Kerb (@0.5 kg a.i./ha) as pre-emergence application were the best.

The Lentil International Rhizobium Inoculation Response Trial (LIRT) was reported from 2 locations, Dobroudja in Bulgaria and Marow in Jordan. None of the treatments with Rhizobium strains excelled the control in seed yield by a significant margin.

7.3. Chickpea

The seed yield data were analysed for 14 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 four locations namely, Debre Zeit in Ethiopia, Montboucher in France, Eskisehir in Turkey and Valdivia in Chile. The five best entries across the locations were FLIP 84-155C, FLIP 84-182C, ILC 482, FLIP 81-293C and FLIP 84-146C.

The seed yield data for Chickpea International Yield Trial-Winter-Mediterranean Region (CIYT-W-MR) revealed that at 11 locations (Dahmoni in Algeria; Laxia in Cyprus; Marow in Jordan; Zememra and Douyet in Morocco; Sevillia and Alcala de Henares in Spain; Tel Hadya, Jableh, Jindiress and Izra'a in Syria) out of 21 locations 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 83-47C, FLIP 83-98C, FLIP 83-48C and ILC 482. The ANOVA for stability for seed yield indicated that mean squares due to pooled deviations and entry x location (linear) were significant (Table 7.3.1). One entry, FLIP 84-92C had regression coefficient greater than 1, non-significant deviations from regression and highest mean yield, and was thus most responsive to favorable environments. Some of the entries, namely FLIP 84-93C, FLIP 83-71C, FLIP 83-48C, FLIP 84-80C, FLIP 84-158C, FLIP 81-293C, FLIP 84-102C and FLIP 85-78C 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.

Table 7.3.1. ANOVA for stability of seed yield for the entries in CIYT-W-MR and CIYT-L conducted during 1987/88.

Source of variation	CIYT-W-MR		CIYT-L	
	DF	MS($x10^4$)	DF	MS($X10^4$)
Entry	22	66.35*	14	93.04*
Entry x location + location	414	77.84*	465	68.96*
Location (linear)	1	28413.30*	1	26323.80*
Entry x location (linear)	22	26.99*	14	43.36*
Pooled deviation	391	8.23*	450	11.41*
Pooled error	836	4.84	896	4.49

* Significant at P = 0.05.

The ANOVA for seed yield for entries in Chickpea International Yield Trial-Large-Seed (CIYT-L) for 33 locations revealed that at 17 locations (Dahmoni in Algeria; Heredia in Costa Rica: Tarquinia in Italy; Douyet, Zememra, and Marchouch in Morocco; Obregon in Mexico;

Alcala de Henares and Sevilla in Spain; Tel Hadya, Homs, Izra'a, and Jindiress in Syria, Mosul in Iraq; La Molina and Canete in Peru) 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 85-60C, FLIP 85-17C, FLIP 85-14C, and FLIP 85-16C. 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. Only two entries namely FLIP 85-14C and FLIP 85-15C 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 7 locations analysed a few test entries exceeded the respective local check in seed yield by a significant margin at four locations (Kabul in Afghanistan; Obregon in Mexico; Tel Hadya and Jindiress in Syria). The five heaviest yielders across locations were FLIP 85-145C, FLIP 83-22C, FLIP 83-73C, FLIP 81-293C and FLIP 84-62L.

The Chickpea International Yield Trial-Early (CIYT-E) was conducted for the first time during 1987/88 season. Results were reported from 4 locations and at none of the locations the test entries exceeded the local check by a significant margin. The five heaviest yielding entries across locations, however, included, FLIP 81-293C, FLIP 82-12C, FLIP 85-108C, FLIP 84-124C and FLIP 85-105C.

The Chickpea International Yield Trial Tall (CIYT-T) was conducted for the second time during 1987/88. The results were reported from 22 locations and ANOVA for seed yield revealed that at Mosul in Iraq; Dahmoni in Algeria; Tabuk in Saudi Arabia; Sevilla in Spain; Izra'a and Idleb in Syria; Marchouch in Morocco; Culiacan in Mexico; Terbol in Lebanon; Montboucher in France; and Amasya in 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 85-12C, ILC 195, FLIP 85-87C, FLIP 85-19C, and FLIP 85-146C.

The adjusted seed yields in Chickpea International Screening Nursery-Winter (CISN-W) revealed that at 19 locations out of 30, 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 86-5C, FLIP 86-7C, FLIP 86-41C, FLIP 86-58C and FLIP 85-90C.

The results of Chickpea International Screening Nursery-Spring (CISN-S) were reported from 20 locations. At 7 locations some of the test entries exceeded the local check in seed yield by a significant (P = 0.05) margin. The five best yielding lines across locations included FLIP 86-23C, FLIP 86-53C, FLIP 86-19C, FLIP 86-28C and FLIP 86-16C.

The results of Chickpea International F_4-Trial reported from 12 locations showed that at three locations some of the F_4 populations were significantly superior to the respective local checks in seed yield. The five highest yielding populations across locations were X85TH116 (ILC 165 x FLIP 83-46C), X85TH278 (ILC 3843 X FLIP 83-13C), X85TH271 (ILC 3779 x FLIP 82-59C), X85TH 123 (ILC 171 x FLIP 82059C), and x 85TH289 (ILC 4291 x FLIP 82-127C). In addition at eight other locations some of the test entries exceeded the respective local check but numerically.

The Chickpea International Ascochyta Blight Nursery (CIABN) results from 11 locations revealed that none of the entries was tolerant to Ascochyta blight infestation across all locations. Considering the frequency of occurrence of an entry among the tolerant (with rating up 4 on 1-9 scale), it was clear that among kabuli lines two entries, ILC 2956 and ILC 3279 occurred 9 times, and were followed by ILC 72, ILC 202 (8 times), FLIP 83-48C, FLIP 84-93C (7 times) etc. These entries thus exhibited broad based resistance to Ascochyta blight. Similarly, among the desi lines, the entries FLIP 85-31C, ICC 3932, ICC 4181 and ICC 9514 exhibited more broad based resistance as compared to others.

The Chickpea Leaf Miner Nursery was reported from Badajoz in Spain. The susceptible check took a maximum score of 7 on 1-9 scale. Out of 40 test entries, 2, 31 and 3 entries took rating of 2, 3 and 4 (on 1-9 scale), respectively. The entries ILC 3828 and ILC 5901 had rating of 2 and were highly resistant.

For Chickpea International Cold Tolerance Nursery (CICTN) the reaction was reported from three locations only. At Alcala de Henares the susceptible check took rating of 5 and the results were not conclusive. At Toshevo in Bulgaria, only ILC 3826 took rating of 5 and all other entries rated between 6 to 9. At Karaj in Iran, FLIP 82-85C and FLIP 85-90C were rated at 3 and were tolerant.

The data on Chickpea Weed Control Trial (CWCT) reported from eight locations revealed that weeds in chickpea caused an over all loss of 43.5% across the locations. The pre-emergence application of Igran @3.0 kg a.i./ha, or Maloran or Tribunil with Kerb @0.5 kg a.i./ha were effective across locations.

The results of Chickpea Need for Inoculation Trial were reported from five locations but the treatment effects were non significant at all the locations. This indicated that natural Rhizobium was sufficient to fulfil the nitrogen requirements of the crop.

The results of Chickpea International Rhizobium Inoculation Response Trial were received from three locations and analysed for seed yield. There were no significant treatment differences.

7.4. Peas

The Peas International Adaptation Trial was initiated for the first time during the 1987/88 season, and sent to 16 cooperators in 13 countries. The results were received for seed yield from 5 cooperators. At Granada in Chile and Holetta in Ethiopia none of the entries exceeded the local check by a significant margin. However, at Shambat (Sudan) one entry (Consort), at La-Molina (Peru) one entry (Derrimut) and at Vallodolid (Spain) 4 entries (Sudan local, Echo, Ballet and Progreta) exceeded the local check by a significant margin.

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 7 varieties of chickpea, ILC 482 and ILC 3279 in Algeria; TS 1009 (ILC 482) and TS 1502 (FLIP 81-293C) in France; ILC 237 in Sultanate of Oman; Elmo (ILC 5566) and Elvar (FLIP 85-17C) in Portugal; six varieties of lentil, ILL 5750 in Australia; Balkan 755 and ILL 4400 in Algeria; Indian head (ILL 481) in Canada; Centinela (74TA470) in Chile, and Telaya 2 in Lebanon; and one variety of faba bean, Favel (80S43977) in Portugal for general cultivation during 1988/89. 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 have been identified from stress tolerance nurseries 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 Project (NVP) on faba bean, which was successfully operated in Egypt and Sudan from 1979 to 1988, and in Ethiopia from 1985 to 1988, was raised to the status of a regional program in 1989 and named the Nile Valley Regional Program (NVRP). In addition to faba bean, research and training activities were expanded to include small cool season cereals (wheat and barley) and three additional cool season food legumes (chickpea and lentil, and field pea for only Ethiopia). ICARDA in collaboration with the three national programs had prepared the project proposals for each country and succeeded in obtaining funding. The Egyptian component of the program is being funded by EEC, that of Sudan by the Government of Netherlands, and that of Ethiopia by SAREC of Sweden. A significant progress in research was achieved in each country during the 1988/89 crop season. Highlights of research in the three countries are presented here:

8.1.1. Egypt

8.1.1.1. Faba bean

Over the last 5 years, the faba bean area in Egypt has continuously increased from 119, 627 ha in 1985 to 157, 776 ha in 1989. Average productivity also increased from 2.52 t/ha to 2.74 t/ha.

In the pilot production plots in Minia and Fayoum governorates seed and straw yields increased on the average by about 25 and 14%, respectively; in Behaira the respective increase was 43 and 24%. The package included recommended variety, seed rate, N and P fertilizer, weed control, and in Behaira control of foliar diseases. High variations in plant populations were found between 'in' and 'out' of demonstration plots primarily due to inappropriate seed rates (below recommended rate in Minia and Fayoum), late sowing, poor seed bed preparation, no weed control and low fertilizer rate. In all governorates, the recommended package resulted in a higher profitability, and in Behaira 70% of the farmers thought that the adoption of the package increased the faba bean production. Control of Orobanche in pilot demonstration plots in Minia and Fayoum by using tolerant variety (Giza 402) and glyphosate resulted in substantial yield increases (70 to 100%) and net benefits by reducing Orobanche infestations.

The faba bean researcher-managed on-farm trials in Behaira and Minia focused on land preparation, planting methods and sowing date. Plant populations and seed yields were higher in the no-tillage system with planting on hills/on old ridges or by reduced tillage involving one roto-tilling before seed broadcasting and then covering the seed by rotovator as compared with the conventional tillage system. The adoption of either method by farmers depends on availability and cost of labor in the first, and availability of rotovators in the villages in the second method. Researcher-managed on-farm trials also identified faba bean genotypes adopted for no-tillage sowing system and assessed the economics of intercropping of faba bean with sugarcane in Minia governorate. The rate of glyphosate needed to control Orobanche could be reduced by about 30% if a foliar spray of N, P and K was done along with the glyphosate.

In the backup research in faba bean breeding some promising material was identified with regard to seed yield, agronomic characters and resistance to chocolate spot, rust, Orobanche and aphids, which will be re-evaluated and/or used for crossing program. Meanwhile, pre-release multiplication of seeds of four lines earlier selected from crosses involving chocolate spot resistance has been done. Also, Reina Blanca has been multiplied for release.

In the evaluation of breeding lines for aphid resistance nine lines previously selected showed consistently low aphid infestation and damage. The laboratory screening also identified some promising material, originating from Egypt, Sudan, Ethiopia and ICARDA. From these, a regional aphid screening nursery will be formed for testing in the three countries.

8.1.1.2. Lentil

In 1988, the area under lentil cultivation in Egypt was 8000 ha. Recently the crop was introduced to the Delta region, and Sharkia and Kafr-El-Sheikh governorates which now amount to 50% of the total lentil production area in the country. Hence pilot production plots were laid out in these governorates. The improved package that included recommended seed rate, N and P fertilizer, irrigation and control of weeds, insect-pests and diseases resulted in 25 and 12% increases in seed and straw yield, respectively, in Sharkia governorate and 17 and 5% in Kafr-El-Sheikh governorate. Seed yields exceeded 3 t/ha in one location and more than 2.5 t/ha at others.

Results of the researcher-managed on-farm trials showed that the minimum tillage system using rotovator for sowing lentil after rice removed the inconsistency in lentil stand due to the variation in seed depth and resulted in better plant stand as well as higher seed and straw yields. Studies on irrigation and sowing methods revealed that broadbed sowing with two irrigations gave significantly higher seed yields than ridge-sowing with one or two irrigations.

Backup research in lentil breeding identified 70 entries that outyielded the check. Of these, 10 showed resistance to aphids, and five showed tolerance to water-logging at one location. None of the Egyptian entries responded to irrigation and only Precoz, an exotic line, showed a good response. The selected promising material will be re-evaluated and/or used in the crossing program. A line source sprinkler system is beeing used to assess the response to moisture supply and a wilt sick plot for screening the lentil material for wilt disease.

8.1.1.3. Chickpea

In the researcher-managed trials productivity of some promising chickpea genotypes was increased by using package of recommended practices including improved sowing method, inoculation with Rhizobium and weed control. Response to inoculation with effective strains of Rhizobium was very striking in the newly reclaimed areas in Nubaria.

In the backup research on breeding some promising material was identified and selected for further evaluation and/or use in crossing program.

8.1.2. Sudan

8.1.2.1. Faba bean in the 'new areas'

In spite of floods and locust infestation, experiments on varietal evaluation of faba bean genotypes permitted identification of suitability of Selaim Medium (SML) faba bean as a cultivar well adapted for the New Areas north of Khartoum, and good in cooking quality and consumer acceptance. The cultivar, which has already been released for the traditional areas, will be proposed for release and an effective program of seed multiplication will be started.

Breeding lines 00564 and 00594 performed well and are being recommended for national varietal trials. These will be demonstrated in the on-farm evaluation. Some 15 genotypes have shown consistently low damage from leaf miner in the last 3 years of testing. These will be now evaluated for their morpho-agronomic characters.

Results from pilot demonstration plots in Rahad, New Halfa and Gezira areas confirmed that introduction of faba bean in these areas was very promising because of high yield and excellent economic returns (Fig. 8.1.1). Yields in Gezira were high (2.3 to 5.5 t/ha) with an average net-return of LS 7779/ha. The technology will, therefore, be promoted in the scheme through full involvement of extensionists and scheme personnel.

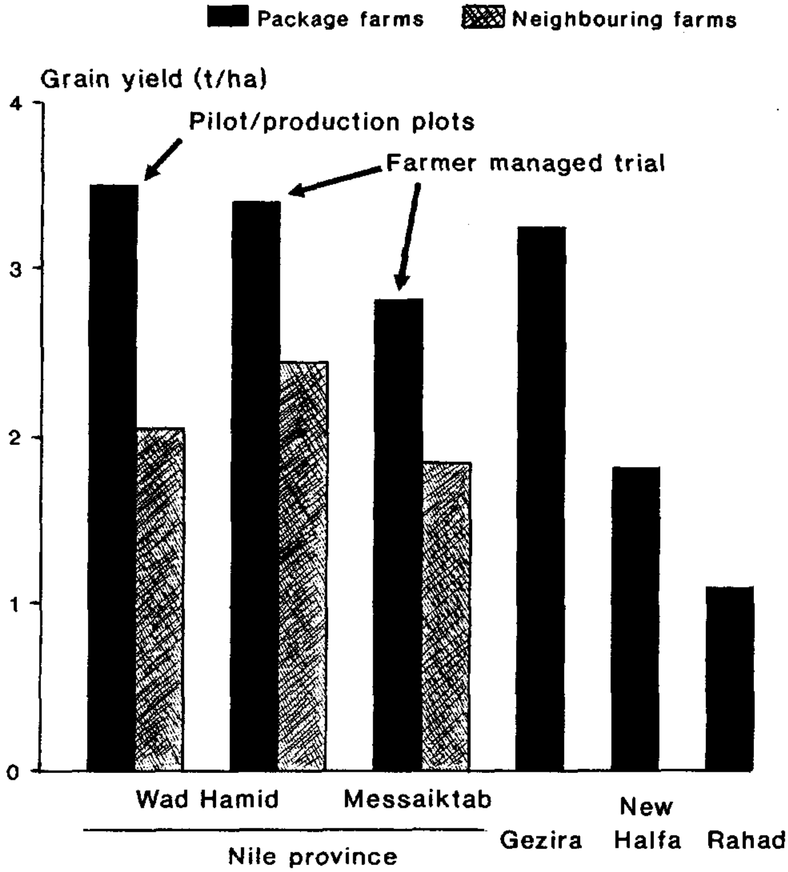

Figure 8.1.1. Grain yield of faba bean in pilot production plots and farmer managed trials in the 'New Areas' south of Khartoum, Sudan, 1988/89.

Backup research on disease resistance helped identify some faba bean breeding lines tolerant to wilt and root rots at Shambat Research Station. These will be included in the NVRP regional root rot/wilt screening nursery.

8.1.2.2. Faba bean in the 'traditional areas'

Impact assessment studies in the Northern Province and in some special schemes in the Nile Province showed good adoption of several components of the recommended package particularly date of sowing and storage methods. Mechanisms will be identified to link the findings of the project with the continued transfer of technology in the traditional areas.

Backup research in the Northern-Province (Selaim and Dongla areas) revealed the importance of weed and pest control and timely sowing. These results will form the basis of further farmer-managed on-farm trials. The Agricultural Research Corporation has assured that research staff at Dongla station will be strengthened so that the progress of transfer of technology will be hastened.

Backup research in the Nile Province revealed the importance of controlling American boll worm, weed control and suitable watering frequency particularly in the Wad Hamid area.

8.1.2.3. Lentil

Lentil crop showed great promise in the Rubatab area in the Nile Province in the pilot production plots involving the best-bet technology developed in the region through previous on-farm trials conducted by the project scientists. The yields exceeded 3 t/ha in one demonstration. This work will be expanded to encourage lentil production as the government is anxious to cut the import to save scarce foreign exchange. Lack of decortication facility for lentil was identified as a major constraint and efforts will be made to resolve this problem.

Backup research on weed control at Rubatab, El-Hassa and Shendi locations revealed the importance of controlling weeds effectively. The mechanical weeding (by hoeing 2x) was most effective method whereas the pre-emergence herbicides testing did not prove effective. New herbicides with more dosage range will have to be tested.

Studies on diseases revealed that Fusarium wilt and powdery mildew could become potential yield retardants in Rubatab and El-Hassa areas. Control measures for these diseases will be investigated in the coming season.

8.1.2.4. Kabuli chickpea

Adoption of a package consisting of improved level of such factors as variety, sowing date, irrigation, seed rate, nitrogen fertilizer and pest control, resulted in significant yield gain of > 1.2 t/ha over the general farmers' practice in the pilot production-cum-demonstration program in Rubatab area.

Researcher-managed on-farm trials in Wad Hamid and Rubatab established the superiority of Shendi-1 (recently released variety) over Baladi (local variety). The responses to variation in seeding rate and application of nitrogen or inoculation with Rhizobium were not present.

Backup research on varietal evaluation revealed that in addition to Shendi, variety NEC 2486 also proved very promising. Fusarium wilt and stunt virus were identified as the potential diseases in the

Rubatab and Wad Hamid areas. Backup research is needed on phosphate fertilization, inoculation and water management in the coming year.

8.1.3. Ethiopia

8.1.3.1. Faba bean

The results of the pilot production-cum-demonstration plots in the central zone of Ethiopia were very encouraging. The improved production package (with an improved cultivar of CS 20 DK, seed rate of 200 kg/ha, diammonium phosphate 100 kg per ha, and two hand weedings at 30-25 and 50-55 days after sowing) increased faba bean yields by 70% in Nitosols of high altitudes (2300-2700 m, Table 8.1.1). A similar package with another improved variety (NC 58) resulted in 65% yield increase in vertisols of mid-altitudes (1850-2000 m, Table 8.1.1). Economic evaluation of the demonstration plots in Nitosols showed that the improved package was highly profitable resulting in an average increase in net benefit of 175 Eth. Birr/ha (Table 8.1.2). Results obtained in Vertisols were better and provided an average net benefit of 630 Eth. Birr/ha. The marginal rates of return were 175 and 335 for Nitosol and Vertisol situations, respectively.

The results of testing the improved faba bean production package on farmers' fields in the 1988/89 season again were very encouraging (Table 8.1.3). Of the four zones in the central and southeastern highlands of Ethiopia where these trials were conducted, highest mean grain yield of 2272 kg/ha was obtained from Yerer-Kereyu zone (Shewa region) followed by 1452 kg/ha from Chilalo zone (Arsi region). Considering the results of 1986-1988 crop seasons, early sowing was the

Table 8.1.1. Grain yield (Kg/ha) of faba bean grown with improved and farmers' methods in Nitosols (red soils) and Vertisols (black soils) of the central zone of Ethiopia, 1988.

Demonstration site	Altitude (m)	Grain yield (Kg/ha) Improved package	Farmers method	Difference (Kg/ha)	(%)
Nitosols (Red soils)					
Hula-Gora	2650	3000	1600	1400	87
Agana-Illu	2550	1710	1560	150	10
Kechema Maru	2500	2400	1560	840	54
Suba Ackedo	2650	1700	1200	500	45
Rob-Gebeya-I	2500	2330	1070	1260	118
Rob-Gebeya-II	2500	930	680	250	37
Telecho	2550	800	400	400	100
Sademo	2400	1470	1210	260	21
Guntuta	2400	1550	800	750	94
Arb-Gebeye	2500	1630	770	860	111
Gohatsion	2500	800	420	380	90
Mean		1670	1020	640	70
LSD (P=0.05)		278			
CV(%)		22			
Verisols (Black soils)					
Kajima	1900	1600	800	800	100
Dibandiba	1850	3100	2000	1100	55
Ada	1950	2200	1200	1000	83
Godino	2000	1330	1080	250	23
Mean		2050	1270	790	65
LSD (P=0.05)		570			
CV (%)		16			

most important factor in faba bean production in Menagesha, Yerer-Kereyu and Salale Zones (all the three in Shewa region). In Chlalo zone, fertilizer was the most important factor followed by variety and weed control.

The breeding program continued to acquire and generate variability in faba bean from indigenous collections and ICRADA (Table 8.1.4), and

Table 8.1.2. Partial budget analysis of the effect of the recommended package of faba bean production in Nitosols of high-altitude and Vertisols of mid-altitude areas of the central zone of Ethiopia 1988.

Factor	Improved package Nitosols	Improved package Vertisols	Farmers' method	Difference Nitosols	Difference Vertisols
Average grain yield (Kg/ha)	1670	2050	1140	530	910
Gross return					
AMC price (Birr/ha)	534	656	365	169	291
LM price (Birr/ha)	1503	1845	1026	477	819
Total variable costs (Birr/ha)	328	343	155	173	188
Net benefits					
AMC Price (Birr/ha)	206	312	210	-4	102
LM price (Birr/ha)	1174	1501	871	303	630
Marginal rate of return (%)					
AMC price	-2	55			
LM price	175	335			

by a hybridization program. The emphasis was to develop early-maturing and disease-resistant high yielding varieties for both high, and mid-altitude areas of the country. For this, attempts have also been in progress to develop pure lines from the Ethiopian landraces. As a result, 434 lines are now in the fourth-cycle of selfing which will be tested for yield and other desirable characters in the coming seasons. Some of the promising varieties in different yield tests were CS 20DK

Table 8.1.3. Average grain yield (Kg/ha) obtained from individual factor and/or combination of factors in the faba bean on-farm trials in Ethiopia, 1988.

Treatment Combinations					ZONE			
	S	F	W	V	Menagesha	Yerer-Kereyu	Salale	Chilalo
T_1	+	+	+	+	1700	2500	289	-
T_2	+	+	-	+	1390	2080	430	-
T_3	+	-	+	+	1740	2640	-	-
T_4	+	-	-	+	1360	2470	-	-
T_5	-	+	+	+	1500	2250	317	-
T_6	-	+	-	+	1310	2130	347	-
T_7	-	-	+	+	1650	2420	-	-
T_8	-	-	-	+	1340	2050	-	-
T_9	+	+	+	-	1080	2340	437	-
T_{10}	-	-	-	-	1090	1840	-	-
T_{11}	+	+	-	-	-	-	452	-
T_{12}	-	+	-	-	-	-	497	-
T_{13}	-	+	+	-	-	-	597	-
T_{14}		-	-	-	-	-	-	790
T_{15}		-	+	-	-	-	-	1090
T_{16}		-	-	+	-	-	-	1030
T_{17}		-	+	+	-	-	-	1420
T_{18}		+	-	-	-	-	-	1290
T_{19}		+	+	-	-	-	-	2040
T_{20}		+	-	+	-	-	-	1660
T_{21}		+	+	+	-	-	-	2300
Mean					1416	2272	421	1452

* Letters S, F, W, and V denote sowing date, fertilizer, weed control and variety, respectively. The plus (+) and minus (-) signs denote test factor at the researchers' and farmers' level, respectively.

4-4-2-6, PGRC/E Acc. No. 027189 (in high-altitudes), NEB 207X74TA 74-6D (in mid-altitudes). Also, the five lines, viz., BPL 710-A-1, -1179-A-1, -1179-B-1, -1179-2 and -1802-1 from ICARDA that were identified resistant to chocolate spot in the past at Holetta maintained their resistance.

National Program Scientists and Dr. S.P.S. Beniwal.

Table 8.1.4. The number of entries from ICARDA in different faba bean trials at Holetta, Ethiopia, 1988.

Trial*	Total entries	Entries from ICARDA	% entries from ICARDA
PSN - stage I	608	224	37
- stage II	127	98	57
- stage III	309	210	67
PYT	32	13	36
PNYT	17	6	30
NYT	8	3	27

PSN = Preliminary screening nursery; PYT = preliminary yield trial; PNYT = pre-national yield trial; and NYT = national yield trial.

8.2. North Africa/ICARDA Food Legume Collaborative Programs

Cooperation continued this season between ICARDA and national food legume improvement programs in Algeria, Morocco, and Tunisia to strengthen research work and transfer important research findings to farmers. The ultimate objective is to increase national production of faba bean, chickpea and lentil. National and regional network development provided complementarity in research efforts through both multidisciplinary and specialized team approach. The back-stopping support from ICARDA home-base program in Aleppo provided all national programs with relevant germplasm, additional technical input and training.

8.2.1. Tunisia/ICARDA cooperative program

In this cooperative program between ICARDA and INRAT (l'Institut National de la Recherche Agronomique de la Tunisie), Tunisian and

ICARDA scientists continued their joint efforts in the improvement of all three food legumes. The Institut National d'Agronomie (INAT) was involved in disease research while the Office des Cereales verified and demonstrated important research findings. IDRC provided financial support to the national program for the on-farm activities.

The 1988/89 season was characterized by the most serious drought since 1900. Rainfall in the main research stations Beja, Oued Meliz and El-Kef were 333, 254 and 208 mm, respectively, which is about 54, 56 and 55 of the mean annual rainfall, respectively. However, rainfall distribution was excellent and crop yields were higher than expected under such dry conditions (Table 8.2.1). Temperature was excessively high towards the end of the growing season and all food legume crops matured 20-25 days earlier than normal. Biotic stresses particularly foliar diseases were minimal due to drought. However, Fusarium wilt was serious on farmers fields causing up to 100% yield losses in Northern Beja (Lafareg area). The disease is spreading to new areas. Orobanche was also a serious problem on faba bean.

8.2.1.1. Faba bean breeding

In both large and small seeded faba bean, main emphasis continued on the development of higher yielding genotypes with durable resistance to common biotic stresses namely Botrytis, Ascochyta, stem nematode and Orobanche. Beside exotic germplasm, the national breeding program utilized local populations very well.

In the large seeded trials, out of 92 breeding lines tested in one

Table 8.2.1. Overall mean yield of trials of food legume crops at different research stations in Tunisia, 1988/89.

Crop/Location	Mean		
	Trial	Best line	Local check
<u>Faba Bean Large-Seeded</u>			
Beja	2366	3600	2512
O. Meliz	2525	4575	2452
Mean	2446	4088	2482
<u>Faba Bean Small-Seeded</u>			
Beja	2602	4050	2731
O. Meliz	2701	4800	2754
Mean	2652	4425	2743
<u>Winter chickpea</u>			
Beja	1109	2150	1142
O. Meliz	1736	3300	2060
El Kef	854	2150	1019
Mean	1233	2533	1067
<u>Lentil</u>			
Beja	914	1286	914
O. Meliz	1401	1953	1366
El Kef	949	1975	824
Mean	1088	1738	1035

1. Rainfall at Beja, Oued Meliz and El-Kef was 333, 254 and 208 mm, respectively.
2. Faba bean received 60 mm of supplementary irrigation at Oued Meliz and three trials received 15 mm irrigation at Beja.

advanced (FBAYT-L1 & L2), one preliminary (FBPYT-L) and 3 international trials (FBIYT-L, -S, -D), 47 and 79 lines exceeded the local check mean at Beja and O. Meliz. However, only 12 lines did so significantly and yield increases up to 38 and 95% were recorded at the two locations. A number of lines showed high yield and wide adaptation: S82 113-8, 80S 44027, 80S 80028, FLIP 84-127FB, FLIP 88-1FB and Reina Blanca with yield advantages of 12 to 36% over the local check. In the preliminary yield trial lines 85/463 and L 83124-8-2-2 outyielded the local by 38 and 31%, respectively at Beja and Oued Meliz. Considering performance over the last three years, the lines Reina Blanca (ILB 1270), Turkish Local (ILB 1820), 80S 80135 and S82113-8 gave consistently higher yields than the local over locations with mean yield advantages of 10, 6, 6 and 4%, respectively.

In small-seeded faba bean, 51 advanced breeding lines were yield tested at two locations and 21 and 14 lines exceeded the local checks at Beja and O. Meliz, respectively. However, none did so significantly. The lines FLIP 83-3FB, FLIP 83-106FB, FLIP 84-59FB, FLIP 87-167FB, S 84132, S 84151 and Feve 305 showed wide adaptation with yield advantages ranging between 3 to 22% at either location. FLIP 83-106FB outyielded the local check by 14% over the last two years in one to two locations.

In segregating populations originating from crosses made for disease resistance at ICARDA, promising selections were made in the F5 generation. These included 38 single plants and 38 bulks for disease resistance at ICARDA, promising selections were made in the F5 generation. These included 38 single plants and 38 bulks for disease resistance. Out of 342 faba bean progenies selected for high and desirable pod and seed characteristics, 219 selections originated from crosses of exotic by local germplasm and 123 selections originated from local populations. Progenies of single plant selections made in local small-seeded populations were very promising in yield potential.

In screening for resistance to Orobanche, neither the advanced breeding lines nor the segregating lines targeted for Orobanche resistance showed any tolerance in a uniformly and highly infested farmer's field in Beja area.

8.2.1.2. Chickpea breeding

The chickpea breeding program involved yield testing of advanced breeding, screening for resistance to ascochyta blight and wilt and combining resistance to both diseases in addition to high yield and good seed quality.

In yield testing, 145 advanced breeding lines were evaluated for winter and spring sowing at three and one location, respectively in 7 replicated yield trials (2 advanced: CAYT-W1 & W2; 5 international: CIYT-MR, -T, -L, -DS, -SP). In winter sowing, 17, 72 and 48 lines outyielded local and improved checks at Beja, Oued Meliz and El-Kef. However, only one line (FLIP 84-164C) did so significantly at Beja. In spring sowing, out of the 145 advanced lines only 6 lines outyielded the local check Amdoun at Beja and just one line did so significantly. This reflects the good adaptation of the local check for spring planting. In winter chickpea, 82, 11 and 51 lines exceeded the local check at Beja, O. Meliz and El Kef. Inspite of the serious drought, the best advanced breeding lines yielded 2.2 t/ha at both Beja (333 mm) and El-Kef (208 mm) and 3.3 t/ha at O. Meliz (254 mm). The highest yielder across locations was FLIP 87-54C with mean yield of 2.13 t/ha while the highest yielder at any one location was the large seeded FLIP 87-54C (3.3 t/ha).

In advanced yield trials, all lines were resistant to local strains of Ascochyta blight (a score of 4 or less in 1 to 9 rating scale). A number of these lines had high yield with wide adaptation across locations (Table 8.2.2). The two lines FLIP 83-47C and FLIP 84-92C performed well in both winter and spring sowing with a yield advantage of 13 and 68% over 'Kessab' (FLIP 83-46C) and local Amdoun, respectively. In addition, FLIP 84-92C performed exceptionally well in the verification trials and thus both lines will be in the pre-release multiplication next season.

In the international trials only few lines showed wide adaptation, these included FLIP 84-19C, FLIP 84-164C and FLIP 84-182C in addition to FLIP 84-92C. Yield advantages across locations ranged between 8 to 30% over the high yielding 'Kasseb' (FLIP 83-46C). These lines also showed high yield in Morocco and thus confirming their wide adaptation. They are also resistant to Ascochyta blight. FLIP 84-80C showed specific adaptation to the drier area of El-Kef although it also did well at Beja (Table 8.2.3).

In breeding for resistance to both wilt and Ascochyta blight, crosses were made to combine resistance to both diseases in one genotype along with high yield and desirable agronomic characters. F4, F5, F6 progenies were screened for both diseases using the 'shuttle' breeding method. This is being done by alternating screening against wilt (<u>Fusarium</u> spp. and <u>Verticilium</u> spp.) in the wilt sick plot (WSP) at Beja and against <u>Ascochyta</u> <u>rabiei</u> under artificial conditions using a mixture of isolates.

Table 8.2.2. Grain yield of promising winter chickpea lines in advanced yield trials with their relative performance with respect to the best released winter cultivar (FLIP 83-46C or 'Kessab') at three locations in Tunisia, 1988/89.

Pedigree	El Kef		O. Meliz		Beja		Mean	
	yield (kg/ha)	% of F83-46C	yield (kg/ha)	% of F83-46C	yield (kg/ha)	% of F83-46C	yield (kg/ha)	% of F83-46C
CAYT-W								
FLIP 83-47C	988	118	1725	88	1783	109	1499	101
FLIP 84-81C	645	77	1582	81	1883	115	1370	92
FLIP 84-92C	920	86	1829	93	1775	108	1441	97
S. INRAT-87	580	69	1612	82	1792	109	1329	90
Local Amdoun	775	92	1512	77	842	51	1043	70
ILC 3279	688	82	1470	75	1342	82	1167	85
FLIP 83-46C	840	100	1960	100	1642	100	1481	100
C.V. (%)	19.2		18.4		10.4			
SE+	118		281		137			
CAYT-W2								
FLIP 83-47C	1192	115	1929	106	2117	147	1746	122
FLIP 83-93C	918	89	1891	104	1508	105	1439	101
FLIP 84-92C	975	94	1850	102	1566	109	1464	102
FLIP 84-155C	743	72	2338	128	1400	98	1494	105
FLIP 84-164C	1032	100	1663	91	1642	115	1446	101
FLIP 84-184C	1307	126	1875	103	1547	108	1576	110
S. INRAT-87	1025	99	1759	97	1838	128	1539	108
Local Amdoun	1458	141	1825	100	908	63	1397	98
ILC 3279	958	93	1616	89	1067	74	1214	85
FLIP 83-46C	1032	100	1821	100	1433	100	1429	100
C.V. (%)	22.7		19.1		18.8			
S.E.+	234		321		252			

Table 8.2.3. Multilocation yield performance of chickpea lines in international yield trials and their relative performance with respect to 'Kasseb' (FLIP 83-46C) in Tunisia, 1988/89.

Pedigree	El Kef		O. Meliz		Beja		Mean	
	yield (kg/ha)	% of F83-46C	yield (kg/ha)	% of check	yield (kg/ha)	% of F83-46C	yield (kg/ha)	% of F83-46C
CAYT-W-MR[1]				Amdoun				
FLIP 84-33C	600	86	2200	154	1075	85	838	85
FLIP 84-80C	1200	171	875	61	1350	107	1275	130
FLIP 84-92C	750	107	1600	112	1375	109	1063	108
Local Amdoun	800	114	1425	100	1150	91	975	99
FLIP 83-46C	700	100	-		1263	100	982	100
C.V. (%)	N.A.		N.A.		18.1			
S.E.+	N.A.		N.A.		167			
CAYT-L			F83-46C					
FLIP 84-19C	1025	103	2250	103	1363	109	1546	105
Local Amdoun	1150	115	1975	91	963	77	1363	92
FLIP 83-46C	1000	100	2175	100	1250	100	1475	100
C.V. (%)	N.A.		N.A.		16.7			
S.E.+	N.A.		N.A.		141			
CIYT-SP (Winter planted)			F83-46C					
FLIP 84-164C	750	91	2250	102	2075	164	1692	117
FLIP 84-182C	825	94	2775	126	1238	98	1613	112
Local Amdoun	825	94	975	44	1025	81	941	65
FLIP 83-46C	875	100	2200	100	1263	100	1446	100
C.V. (%)	N.A.		N.A.		34.9			
S.E.+	N.A.		N.A.		375			

1. Mean for CIYT-W-MR exclude O. Meliz where the check was local Amdoun.

8.2.1.3. Lentil breeding

The lentil breeding program focused on yield improvement, early maturity, acceptable seed quality and desirable traits for mechanization (tall, erect, non-lodging, resistance to seed shattering and good pod retention). This is done mainly through evaluating introduced advanced breeding lines and segregating populations.

During this season, lentil once again proved its good tolerance to drought. Yield testing of 82 small and large-seeded lines in two advanced trials (LAYT-L1 & L2) and two international trials (LIYT-L & S) at 2 to 3 locations indicated that 63, 65 and 14 lines exceeded the local check at Beja, El Kef and O. Meliz, respectively. However, only 2 and 7 lines did so significantly at the first two locations, respectively. In advanced yield trials, several lines showed high yield and wide adaptation (Table 8.2.4 and 8.2.5). FLIP 84-103L, FLIP 84-106L, 78S 26002 and Nesir (ILL 4606 released line) gave significantly higher yield compared to the local 'Ouselatia' and the yield advantage ranged between 17 to 40% over two seasons across 2 to 3 locations (Table 8.2.4). Several other lines showed high yield and wide adaptation. At El Kef, FLIP 84-82L, FLIP 86-5L, FLIP 87-48L, FLIP 87-49L and 78S 26002 also significantly outyielded 'Ouselatia' with yield increments between 41 to 68% across two locations (Table 8.2.5). FLIP 84-103L and 78S 26002 had consistently good performance over the past three years and thus will be in pre-release multiplication next season. The first line has wider adaptation while 78S 26002 has specific adaptation to drier conditions.

Table 8.2.4. Multilocation yield performance (kg/ha) of promising lentil lines in advanced yield trial (LAYT-L1) at three locations over two dry seasons, 1987/88 and 1988/89.

Pedigree	El Kef	Beja		O. Meliz		Mean	
	88/89	87/88	88/89	87/88	88/89	yield (kg/ha)	% over Oueslatia
LAYT-L1							
81S 154	933	-	888	-	1796	1206	111
81S 186	712	-	1060	-	1371	1048	97
FLIP 84-103L	721	1933	975	2362	1613	1521	140
FLIP 84-106L	837	1520	883	2207	1609	1411	130
FLIP 84-114L	778	1142	1063	1328	1563	1175	108
FLIP 88-2L	683	-	833	-	1954	1157	107
78S 26002	981	1312	925	1712	1384	1263	117
Nesir (ILL 4400)	662	1064	804	-	1259	947	87
Nefza (ILL 4604)	575	1429	838	2187	1646	1335	123
Ouselatia (local)	637	880	846	1691	1366	1084	100
C.V. (%)	27.3	23.2	12.4	27.1	24.8		
S.E.+	199	260	180	733	347		

1. Values underlined significantly higher than those of the local Ouselatia.

In the international trials (LIYT-S & L), several other lines showed high yield and wide adaptation with yield increase up to 61% at El-Kef and 45% at Beja (Table 8.2.6). Across locations, the large-seeded FLIP 87-2L outyielded 'Oueslatia' by 44% while the small-seeded FLIP 84-58L and FLIP 84659L had a yield advantage of 34 and 33%, respectively. In observation international nurseries for large and small-seeded (LISN-L & S), earliness (LISN-E) and tall habit (LISN-T), several lines were selected for further testing in replicated trials.

A lentil germplasm collection was carried in southern and central Tunisia and 16 diverse accessions were collected. All accessions had a seed size equal to or less than 2 g/100 seeds.

Table 8.2.5. Multilocation yield performance of widely adapted lentil lines in advanced yield trial (LAYT-L2) at two locations, 1988/89[1].

Pedigree	El Kef		Beja		Mean	
	yield (kg/ha)	% of local	yield (kg/ha)	% of local	yield (kg/ha)	% of Local
81S 15	728	146	993	131	861	137
FLIP 84-29L	566	113	1008	133	787	125
FLIP 84-44L	737	147	943	124	840	134
FLIP 84-82L	787	157	993	131	890	141
FLIP 84-103L	608	122	983	130	796	127
FLIP 86-5L	837	167	943	124	890	141
FLIP 86-35L	766	153	1293	171	1030	164
FLIP 87-48L	837	167	1075	142	956	152
FLIP 87-49L	916	183	1183	156	1050	167
78S 26002	987	197	1132	1490	1060	168
Nesir (ILL 4400)	540	108	833	110	687	109
Nefza (ILL 4604)	575	115	825	109	700	111
Local Oueslatia	500	100	758	100	629	100
C.V. (%)	18.8		20.6			
S.E.+	125		196			

1. Values underlined are significantly greater than those of local Oueslatia.

8.2.1.4. Agronomy

Agronomy studies during the 1988/89 season included weed control, dates of sowing, population density, fertilization and N2-fixation. Based on results the following conclusions can be made:

- Weeds reduced yield by 48% in faba bean, by 43% in lentil and 75% in chickpea averaged over 2 to 4 locations. Effective weed control was best with two hand weedings, 45 and 90 days after emergence. The second best treatment was a combination of pre-emergence herbicide and one hand weeding at a later stage. Effective herbicides treatments included Kerb (0.5 kg a.i./ha), for all crops as a grass

Table 8.2.6. Grain yield (kg/ha) of promising large and small-seeded lentil lines in international trials at El Kef and Beja in Tunisia, 1989/89[1].

Pedigree	El Kef		Beja		Mean	
	yield (kg/ha)	% of local	yield (kg/ha)	% of local	yield (kg/ha)	% of Local
LIYT-Large-Seeded						
FLIP 87-2L	1012	153	1267	138	1140	144
FLIP 87-5L	737	111	1075	114	906	115
FLIP 87-17L	691	104	942	103	817	103
81S 38326 FB	700	106	1117	122	909	115
78S 26002	875	132	1033	113	954	121
Nesir (ILL 4400)	687	104	854	93	771	98
Nefza (ILL 4606)	743	112	983	107	863	109
Local Oueslatia	662	100	917	100	790	100
C.V. (%)	19.5		17.0			
S.E.+	149		158			
LIYT-Small-Seeded						
FLIP 84-29L	853	100	1050	130	952	107
FLIP 84-58L	1043	122	1342	145	1193	134
FLIP 84-59L	1375	161	1000	108	1187	133
FLIP 87-36L	991	116	1033	112	1012	114
FLIP 87-48L	925	108	1158	125	1042	117
FLIP 87-53L	887	104	1283	139	1085	122
FLIP 87-57L	1228	143	8082	87	1018	114
Nefza (ILL 4604)	753	88	Mis.	-	-	
Local Oueslatia	856	100	925	100	981	100
C.V. (%)	20.7		15.5			
S.E.+	184		147			

1. Values underlined are significantly greater than those of Oueslatia.

killer, in addition to Igran in faba bean (3.0 kg a.i.) and chickpea (4 kg a.i./ha), Maloran (2.0 kg a.i./ha) for lentil and Tribunil (2 kg a.i./ha) for pea. The traditional inter-row cultivation with animal-drawn cultivators to control weeds was found ineffective and caused reduction in yield. Farmers should be discouraged from using this technique and encouraged to replace it by the above recommendation.

- Early sowing of chickpea continued to give higher yields compared to the traditional spring sowing. Yield gains up to 150% may be achieved by advancing sowing date from March to January or earlier.
- Studies on population density showed that lower seeding density gave better yields in both chickpea and lentil under the dry conditions which prevailed this season.
- In N2-fixation studies, a number of local Rhizobium spp. strains were collected in faba bean, dry pea and beans. Highly efficient faba bean strains were identified in the microbiology laboratory at ICARDA.

8.2.1.5. Pathology

Disease work concentrated on A. rabiei and wilt (Fusarium spp. and Verticilium spp.) of chickpea although there are other serious diseases particularly in faba bean.

For Botrytis fabae 38 single plants and 38 segregating bulks of faba bean were selected for disease resistance under natural infestation. These will be re-evaluated for disease resistance under artificial disease conditions next season.

In chickpea wilt, about 2000 accessions from the world germplasm collection of ICARDA were screened at Beja wilt sick plot (WSP) and 183 accessions were confirmed for their resistance after a minimum of two cycles of disease screening. The resistant accessions will be evaluated agronomically and an evaluation catalogue will be developed.

In addition, several progeny rows selected from segregating populations were screened for wilt to combine both wilt and ascochyta blight in one genotype. Work on the disease variability of wilt continued as a part of a Ph.D. thesis. Already several isolates of F. oxysporum and V. alboatrum were identified with different morphological and pathogenic characteristics.

In chickpea blight (A. rabiei) 394 advanced breeding lines were screened against the disease under artificial inoculation and 56% of those lines were resistant to tolerant. However, only one was fairly resistant to wilt. Lines which were resistant to blight in Tunisia as well as in Morocco are FLIP 83-47C, FLIP 83-48C, FLIP 84-60C, FLIP 84-92C, FLIP 84-93C, FLIP 84-102C, FLIP 84-109C, FLIP 84-144C, FLIP 84-182C. Under heavy disease pressure, several F4, F5 and F6 progenies were also screened against ascochyta blight and a number of resistant single plant selections were made to be screened for wilt during the next season in the 'shuttle' breeding method to combine resistance for both diseases.

Research on disease variability of A. rabiei continued under controlled conditions. Using a differential host set, three isolates showed different reaction compared to that of the six known races of A. rabiei. These isolates also showed different morphological and cultural characteristics. El-Kef isolate was the most virulent while a different biotype was apparent in the Beja isolate. Work continued also on isolating the toxin(s) induced by A. rabiei in the plant and on the biochemistry of disease reaction.

8.2.1.6. On-farm activities

On-farm work included verification and demonstration of promising and newly released cultivars as well as yield maximization plots with several cultural practices. Yield levels and response to various levels of input were seriously affected by drought in three out of four on-farm sites.

In chickpea, the newly released and potential cultivars did well at all locations compared to the local cultivar. In particular 'Kessab' (FLIP 83-46C) and FLIP 84-92C yielded 1.13 and 1.39 t/ha, respectively, compared to 0.78 for local Amdoun across locations thus a yield increase of 50 and 84%, respectively (Table 8.2.7). At Mateur, where ascochyta developed, the local cultivar yielded less than 0.15 t/ha in contest to 'Kessab' and FLIP 84-92C which yielded 1.28 and 1.55 t/ha, respectively. Both confirmed their high level of resistance to blight. However, the second genotype performed better in most locations and was the highest yielder in both winter and spring sowing. Thus it will be released as a dual season cultivar.

Table 8.2.7. Yield performance (kg/ha) of newly released and potential chickpea cultivars in on-farm trials at four locations in Tunisia during the winter and spring seasons of 1988/89.

Cultivar	Mateur		Beja		O. Zarga		M. Temim		Mean	
	Winter	Spring	Winter	Spring	Winter	Spring	Winter	Spring	Winter	Spring
					kg/ha					
Local Amdoun	143	311	1517	426	813	545	547	503	755	446
Amdoun[1]	154	313	1373	652	748	450	574	544	712	448
Kesseb (FB3-46C)	1279	443	1746	430	1037	275	465	324	1132	368
Chetwi (ILC 3279)	1042	156	836	225	506	275	496	357	720	253
FLIP 84-92C	834	345	1582	502	789	382	564	392	942	408

1. Ascochyta blight developed seriously.

'Chitwie' (ILC 3279) being late in maturity, had low yield under the drought stress conditions.

In lentil, the local Ouselatia (0.61 t/ha) had similar yields as the newly released Nefza (ILL 4606, 0.60 t/ha) and slightly more than Nesir (ILL 4606, 0.54 t/ha) across locations under dry conditions of this season. The potential cultivar FLIP 83-103L also had similar yield (0.61 t/ha) to Ouselatia. These lines are expected to perform better than the local under more favorable conditions.
Tunisian National Scientists and Dr. M. Solh.

8.2.2. Morocco/ICARDA food legume cooperative program

In the cooperative project between ICARDA and INRA (l'Institut National de la Recherche Agronomique), Moroccan and ICARDA scientists worked together on the improvement of major food legume crops. Beside INRA, other national institutions (e.g. I.A.V. Hassan II, ENA-Meknes, Faculty of science Rabat) contributed to back-up research in a multi disciplinary and multi-institutional approach. Transfer of important research findings to farmers was done mainly in collaboration with the Department of Field Crops (D.P.V./MARA) and Extension Service in addition to INRA. ICARDA contributions were in providing technical input in research, relevant germplasm material, improving research capabilities of national scientists through training, workshops and networks, and follow up on technology transfer to farmers.

Research on food legumes was conducted on 9 research stations: Jema'a Shim, Khemis Zemamra, Sidi Laidi, Dar Bouazzeh, Guich, Merchouch, Alal Tazi, Douyet and Annaceur. Because of differences in adaptation and in the distribution of food legume crops, research work on faba bean was concentrated in the more favorable conditions (Douyet, Guich, Alal Tazi). Research work on chickpea was on the less favorable conditions in Merchouch, Jema'a Shim, Khemis Zemamra; while that for lentil was in Merchouch and Sidi Laidi. Dar Bouazzeh Station was the site for disease work being a coastal site.

Climatically, contrary to last season, the 1988/89 was characterized by a serious moisture stress in December and January and heavy rains in March and April. In Merchouch, 50% of the total rainfall was received in March and April. Nevertheless, annual rainfall was generally comparable with mean annual average precipitation in the main stations except for the southern stations (Jema'a Shim and Khemis Zemamra) where rainfall was much higher (see below) than the long-term average for a second year in a row. Faba bean was most affected by the early moisture stress and plants flowered about six weeks earlier than usual and before sufficient vegetative growth. In addition, the dry hot eastern wind during pod filling at Douyet reduced yield drastically.

Stations	1988/89 rainfall	Annual Average
J. Shim	431	282
K. Zemamra	409	320
S. Laidi	304	311
Merchouch	376	388
Douyet	436	451

Table 8.2.8. Summary of results of faba bean yield trials at Douyet (DYT) and Jema'a Shim (JSM) research stations in Morocco during the 1988/89 season[1].

Trials/ Nurseries	Location	No. of entries	No. of selections	No. of entries >check	Sign>check	Mean yield (kg/ha) Trial	Best	Aguadulce	C.V. (%)
Trials-89									
FBNYT-L	DYT	12	10	10	0	2082	2923	1376	46.4
FBNYT-L	JMS	12	11	11	0	2953	2596	2156	12.8
FBIYT-L	DYT	24	4	9	0	979	1733	1000	55.4
FBIYT-L	JSM	24	9	9	0	2370	2625	3333	29.2
FBIYT-D	DYT	20	11	11	0	1158	1222	827	44.8
FBAYT-L-A	JSM	16	12	12	0	2483	1828	1828	18.9
FBAYT-L-B	DYT	20	14	17	2	2290	3249	1430	34.5
FBAYT-D	DYT	13	2	0	0	1208	1656	1783	49.5
FBYT-L1 & L2	DYT	44	10	22	0	797	1277	703	41.7
FBF8PYT	DYT	24	3	3	0	708	1249	990	34.9
FBF5PYT-A	DYT	24	19	18	0	2609	3982	1665	35.8
FBF5PYT-B	DYT	20	19	19	0	1589	2443	634	39.2
FBPYT-A-D	DYT	5	3	2	0	610	735	629	46.9
FBIYT-L	DYT	24	9	9	0	1083	1926	1111	55.5
FBIYT-D	DYT	20	11	11	0	834	1222	827	48.0
Total or Mean		250	126	147	2	1583	2044	1353	

On the biotic stress, the 1988/89 season in Morocco was characterized by three disease epidemics due to the early moisture stress and the late heavy rains. Ascochyta blight on chickpea was very serious in Khemisset (Merchouch, Ghaouia (Settat), Doukala and parts of Abda while lentil was wiped out by rust in major production areas. Faba bean was seriously affected by viruses. Orobanche was serious in faba bean as in previous seasons. Similarly Sitona weevil and aphids also affected the crop.

8.2.2.1. Faba bean breeding

The faba bean breeding program focuses on high and stable yield with large seed, early maturity, and resistance to Orobanche, Botrytis, rust and stem nematodes. Improvement activities this season included maintenance of germplasm collections (273 accessions); yield testing and observation nurseries of advanced breeding lines, F5 and F8 progeny rows; evaluation of bulks of F3, F5 and F8 of segregating populations; and screening for resistance to Orobanche, Botrytis, rust, and stem nematodes.

In replicated trials,176 large-seeded lines were yield tested in one national, 3 advanced, 5 preliminary and 2 international trials in 1 to 3 locations (Table 8.2.8). A total of 147 lines (70%) exceeded the local check considering all locations but only 2 lines did so significantly. However, results of yield trials at Douyet, where the bulk of the faba bean program was conducted, were inconclusive due to the high coefficient of variability values (34.5 to 55.5%). This is mainly due to the early excessive moisture stress, the heavy non-uniform virus infestation and the strong and dry Eastern winds during pod filling which contributed to the low yield. Nevertheless, the high yielding check 'Aguadulce' was outyielded considerably in almost all trials and yield differences were up to 4 times (Table 8.2.8). A number of lines gave high yield and wide adaptation over years and locations. (Table 8.2.9 and 8.2.10). 74TA 22, 805 44027 and FLIP 82-30FB outyielded 'Aguadulce' by 15 to 24% averaged over three years in Douyet and one year in Jema'a Shim. Yield increases achieved by New Mammoth, Gemini and PAM1 averaged 20, 33 and 36% over three environments (two years at Douyet and one year at Jema'a Shim). The highest yields were obtained by F5 and F8 lines selected under local conditions. The F5 line 621-2 yielded almost 4 ha at Douyet inspite of the adverse conditions mentioned earlier.

In determinate type, FLIP 86-107FB and FLIP 86-118FB outyielded 'Aguadulce' by 23 and 19%, respectively, and averaged about 2 t/ha over

Table 8.2.9. Yield performance (kg/ha) of advanced large-seeded faba bean lines in the national trial (FBNYT-L-89) over years and locations, 1986-89.

Pedigree	Douyet 1986/87	Douyet 1987/88	Douyet 1988/89	J. Shim 1988/89	Mean	% of local
				Kg/ha		
74 TA 22	1310	2889	2484	2830	2378	115
79S 4	1111	2667	2706	2640	2281	111
80S 44027	1329	3333	2036	2830	2382	115
FLIP 82-28FB	1274	3500	2127	2450	2338	113
FLIP 82-30FB	1400	3000	2923	2950	2568	124
Turkish Local (ILB 1821)	1226	3444	2108	2390	2292	111
Aguadulce (Local check)	992	3722	1376	2160	2063	100
LSD (5%)	392	723	N.S.	N.S.		
C.V. (%)	22.2	14.2	46.4	12.8		

two years and two locations (Table 8.2.11). FLIP 86-125FB and FLIP 88-8FB gave comparable yields to 'Aguaducle' at two locations.

Table 8.2.10. Yield performance (kg/ha) of large-seeded faba bean lines in the advanced trial (FBYT-L-A-89) over years and locations in Morocco, 1986-89.

Pedigree	Douyet 1986/87	Douyet 1987/88	Douyet 1988/89	J. Shim 1988/89	Mean	% of local
			Kg/ha			
FLIP 82-27FB	1032	3111	1149	2880	2043	111
FLIP 82-45FB	1032	3056	1873	2510	2118	116
FLIP 82-54FB	1012	3111	1158	2510	1948	106
FLIP 83-43FB	1210	3222	1629	2580	2160	118
80S 80135	1187	3622	1044	2210	2017	110
New Mammoth	-	3389	1058	2170	2206	120
Gemini	-	3222	1420	2660	2434	133
PAM 1	-	3611	1122	2718	2484	136
Aguadulce	992	3722	796	1820	1833	100
LSD (5%)	392	723	N.S.	N.S.		
C.V. (%)	22.2		14.2	44.8	18.9	

Table 8.2.11. Yield of faba bean determinate genotypes at two locations in Morocco, 1988/89.

Pedigree	Douyet 1988	Douyet 1989	Jema'a Shim 1988	Jema'a Shim 1989	Mean	% of local
			kg/ha			
FLIP 86-107FB	3067	1025	1796	2500	2097	123
FLIP 86-118FB	2744	1000	1858	2460	2016	119
FLIP 86-125FB	-	913	-	2540	1727	105
FLIP 88-8FB	-	1123	-	2420	1772	108
Aguadulce	2400	827	1104	2460	1698	100
LSD (5%0	756	N.S.		N.S.		
C.V. (%)	17.5	48.0	43.0			

In the progeny testing 461 out of 1089 progenies were selected. High yielding 12 F3 and 6 F5 bulks were selected for advanced generations. It was apparent that the progenies selected under local conditions had generally better yield performance compared to the introductions of advanced breeding lines.

Screening for Orobanche resistance revealed three accessions (FH 889, F 1285, F1350-9) showing tolerance. Progeny rows selected for resistance at ICARDA-Syria showed good resistance levels (two progenies were completely free and 35 progenies showed high level of tolerance) based on the number of Orobanche plants per row.

8.2.2.2. Chickpea breeding

The chickpea breeding program focuses on the development of high yielding cultivars adapted to winter and spring seasons with good seed quality. The program puts more emphasis on winter and dual season types with high level of resistance to Ascochyta rabiei, large seed size and early maturity. Additional emphasis is put on wilt and leaf minor which are important in both seasons.

In varietal improvement, three lines were recommended to the pre-release catalogue trials: FLIP 83-47C, FLIP 83-48C, and FLIP 84-92C. These lines are high yielding, dual season types with semi-erect growth habit, high level of resistance to blight (3 rating on 1 to 9 scale) and good seed quality. Out of six lines which were in catalogue, only two (FLIP 82-150C, FLIP 82-152C) were kept because of their good resistance under the severe ascochyta epidemic which prevailed during this season in certain areas in Morocco. Yield levels were low in areas where the blight was more virulent and conditions were favorable for disease spread such as at Merchouch where the highest yielder, FLIP 83-47C, produced 862 kg/ha. However, inspite of the early moisture stress, yields of 3.4 and 3.3 t/ha were obtained in Jema'a Shim and Douyet where the blight was less virulent and affected mainly the local cultivars.

Performance of winter chickpea over locations and years indicated that six lines in the advanced national trial (CNYT) were superior to the local (gave 16 to 27% more yield) and comparable to the high yielding and widely adapted ILC 482 (Table 8.2.12). The lines FLIP 84-92C, FLIP 84-109C, FLIP 84-144C, FLIP 84-145C also showed high level of resistance to Ascochyta blight (3 score) where the disease was most virulent. These lines yielded 2 to 3 times as much as ILC 482 in that location while the local was completely killed early in the season. Yield levels ranged between 2.4 to 2.6 t/ha across locations and over the last two seasons. Additional lines (FLIP 83-98C, FLIP 84-80C, FLIP 85-93) also showed high yield, wide adaptation and resistance to Ascochyta blight. In spring chickpea, 34 and 59 advanced breeding lines were evaluated in replicated trials and observation nurseries, respectively. The best local checks were outyielded by 30 and 34 lines at two locations where ascochyta blight was serious but only 1 line outyielded at the third site which had no Ascochyta blight. Across locations the best yielding spring chickpea lines were FLIP 82-150C, FLIP 84-182C, FLIP 84-92C and FLIP 84-120C with yields between 1.8 to 1.9 t/ha and 16 to 24% yield advantage over the local PCH 37.

Table 8.2.12. Multilocation yield performance (kg/ha) of superior chickpea lines resistant to Ascochyta blight in national trial at five locations and two seasons, in Morocco, 1987/88 and 1988/89.

Pedigree	K. Zememra	A. Nizeh	J. Shim	Douyet	Merchouch			Mean	% of local	
	1987/88	1987/88	1987/88	1988/89	87/88	88/89	Ascochyta[2]		ILC 482	local
				kg/ha						
FLIP 83-71C	3740	1812	3030	1778	3229	545	5	2356	94	116
FLIP 83-92C[3]	4312	2250	3000	1951	3281	710	3	2584	104	127
FLIP 84-93C	4062	2031	3410	1785	3411	756	3	2576	103	127
FLIP 84-109C	3842	1718	3130	1729	3151	634	3	2367	95	116
FLIP 84-144C	3092	2500	3060	2014	3098	808	3	2429	97	119
FLIP 84-145C	3912	2500	3160	1743	2734	730	3	2463	99	121
ILC 482	4325	2281	3130	2167	2838	230	7	2495	100	123
PCH 46 (local)	3437	1562	2750	1771	2682	0	9	2034	82	100
LSD (5%)	641	N.S.	N.S.	457	415	211				
C.V. (%)	8.1	32.2	14.6	12.6	10.1	28.7				

1. Ascochyta blight epidemic was most serious at Merchouch
2. Ascochyta was scored using 1 to 9 rating scale with 1 as disease free and 9 completely killed.
3. Recommended for pre-release catalogue trials.

The development of dual season chickpea is a regional objective in Morocco. After two years of evaluations at 3 locations, 11 lines showed wide adaptation and high yield in both winter and spring seasons (Table 8.2.13). The 1988/89 season was favorable for spring sowing due to the conditions mentioned earlier. Mean yields of the dual season lines ranged between 2.8 to 3.2 t/ha in winter sowing and between 2.0 to 2.6 t/ha in spring sowing. The best dual purpose lines were FLIP 84-47C, FLIP 84-92C and FLIP 84-182C yielding 3.2, 3.1 and 3.0 t/ha in winter, and 2.1, 2.6 and 2.4 tons in spring, respectively, over 2 years and 3 locations.

8.2.2.3. Lentil breeding

In both small and large seeded lentil, the breeding program focuses on high and stable yield, early maturity, acceptable seed quality and mechanical harvesting characteristics (tall, erect, non-lodging types with good pod retention).

This season the rust epidemic, for a second year in a row, affected seriously both lentil production in Morocco and research work at Sidi Laid and Merchouch Stations. The heavy late rains and the relatively high temperature contributed to the out-break of the rust epidemic, which provided an excellent opportunity to screen the breeding lines several of which showed high levels of resistance.
Precoz (ILL 4605) and FLIP 86-16L (ILL 6002) confirmed their resistance for a second season. The former line has been officially approved to be released after performing very well during the last two seasons at five locations (Table 8.2.14). Beside being a high yielder and rust

Table 8.2.13. Multilocation yield performance of dual season chickpea lines in the regional dual season trial at three locations in winter (W) and spring (S) sowing in two season, 1987/88 and 1988/89.

Pedigree	Jema'a Shim				Merchouch				Douyet				Mean (rank)	
	W-88	S-88	W-89	S-89	W-88	S-88	W-89	S-89	W-88	S-88	W-89	S-89	Winter	Spring
								kg/ha						
FLIP 82-150C	3483	3417	3000	1833	3229	1875	643	1187	5115	2727	2431	2703	2984 (9)	2291 (6)
FLIP 83- 47C	4333	2917	3542	1667	3506	2014	862	845	5060	2822	1967	2498	3212 (1)	2127 (9)
FLIP 83- 48C	4042	3083	3208	1467	3784	1632	843	681	4125	2800	2039	2993	3007 (8)	2110 (10)
FLIP 84- 8C	4400	3500	3042	1542	3298	1875	428	438	4785	3374	2112	3186	3011 (7)	2319 (4)
FLIP 84- 60C	3942	3250	2875	1350	3194	1701	630	844	5280	2655	2618	2196	3090 (4)	1999 (12)
FLIP 84- 72C	3383	4167	3125	1375	2951	1875	456	662	4950	2816	2329	2618	2866 (10)	2253 (7)
FLIP 84- 92C	4042	5167	2583	1433	3576	2083	464	777	5005	2727	2413	2437	3113 (3)	2563 (1)
FLIP 84-109C	3833	2917	2933	1550	2673	1805	489	867	4125	2833	1617	2353	2734 (13)	2054 (11)
FLIP 84-144C	3167	4333	3042	1892	3368	1944	726	727	4675	2633	1882	2570	2810 (12)	2350 (3)
FLIP 84-145C	3967	2750	3333	1417	3229	1736	531	969	4895	2500	2727	2570	3114 (2)	1991 (13)
FLIP 84-182C	4042	3917	3250	1625	3472	2048	768	815	4620	2488	2136	3282	3048 (5)	2363 (2)
ILC 195	3725	4583	2667	1350	3402	1875	639	776	4785	2866	1991	2450	2869 (10)	2317 (5)
ILC 482	4008	2500	2542	1167	3576	1875	333	727	5060	3053	2667	2389	3031 (16)	1952 (14)
PCH37 (local)	2750	3250	1833	2017	1771	2014	23	70	0	2777	0	2824	1439 (15)	2159 (8)
PCH46 (local)	3125	3833	1792	1583	1354	1736	4	57	1238	1855	2353	2486	1622 (14)	1925 (15)
Trial Mean	3550	3694	2746	1524	2912	1843	376	568	4127	2733	2110	2527	2670	2149
LSD 95%)	1241	N.S.	1119	709	1075	518	284	486	1829	721	1315	1223		
C.V. (%)	13.6	30.0	15.9	18.2	14.4	11.0	29.5	33.4	17.3	16.2	24.3	18.9		

Table 8.2.14. Multilocation yield performance (kg/ha) of Precoz in the pre-release catalogue trials at five locations and two seasons in Morocco, 1987/88 and 1988/89[1].

Pedigree	Merchouch		Sidi Laidi		Jema'a Shim		Annaceur		Douyet	Mean
	87/88	88/89	87/88	88/89	87/88	88/89	87/88	88/89	88/89	
					kg/ha					
Precoz (ILL 4605)	2250[1]a	1063a	2870a	1383a	2342a	1450a	947a	957b	991	1687
L 24 (local small)	2042a	1021a	161c	50b	683c	391b	1294a	1377a	875	989
L 56 (local large)	2146a	938a	768b	101b	1104b	652c	958a	901b	533	1009
Mean	2046	1007	1266	511	1376	831	1100	1078	799	1228
C.V. (%)	12.5	26.7	24.9	28.2	15.3	17.4	22.9	16.9	12.1	

1. Values followed by different letters are significantly different from each other at 5% probability.

resistant, Precoz is 3-4 weeks earlier than the local cultivars and has large seed and desirable seed-coat colour. The two selections from national germplasm L24 and L56 were also officially released for their specific adaptation and good seed quality. L24 is well adapted to high elevation areas while L 56 had a better general performance.

In the lentil breeding program, 156 advanced breeding lines were evaluated in 11 replicated yield trials: 3 national (ENR-89, LNYT-S-89, LNYT-L-89), 4 advanced (LAYT-A-89, LAYT-B-89, LAYT-L1, LAYT-L2), one preliminary (LPYT-89), one regional (LRYT-89) and two international (LIYT-S-89, LIYT-L-89). The coefficient of variability values were very high (range 23.5-72.5%, average 39.3) due to the rust epidemic. The resistant or tolerant lines gave considerably better yields than the susceptible local cultivars (Nylon, L24, L56) which yielded 0 to 0.46 t/ha compared to rust resistant lines yielding up to 1.78 t/ha.

In advanced yield trial (LAYT-L2), FLIP 86-16L confirmed its rust resistant and yielded 0.98 t/ha which is more than 3 times the highest yielding local Nylon (0.28 t/ha). In the previous season, the same line yielded 1.5 and 0.92 t/ha compared to 240 and 28 kg/ha for the local, respectively, at Merchouch and Sidi Laidi under rust epidemic and heavy Orobanche infestation. In the national trial at two locations, FLIP 86-15L, FLIP 87-17L and FLIP 87-22L were also rust resistant or tolerant and yielded between 311 to 615 kg/ha compared to 0 to 244 kg for the locals (Table 8.2.15). Additional large and small-seeded lines also showed resistance or tolerance to rust and outyielded the best local cultivars (Nylon, L24, L56) by 2 to 4 times. Some of

Table 8.2.15. Grain yield (kg/ha) of rust resistant lines in lentil national trial at two locations in 1 to 2 seasons in Morocco, 1989.

Pedigree	Sidi Laidi	Merchouch			Rust
	1988/89	87/88	88/89	Mean	Score[1]
FLIP 86-15L (ILL 6001)	466	-	615	541	3
FLIP 87-17L (ILL 6209)	361	1513	396	379	3
FLIP 87-22L (ILL 6212)	311	1513	607	459	1
Precoz (ILL 4605)	477	1533	460	469	3
Local check	0	642	244	122	7
Specific local check	L24	L24	Nylon		
Trial Mean	179	1118	345	262	
LSD (5%)	263	282	165		
C.V. (%)	72.5	11.5	23.5		

1. Rust was scored in 1989 at Merchouch using the 1 to 9 scale with a having no postules visible, 3 moderately resistant, 5 average reaction, 7 moderately susceptible and 9 highly susceptible.

the large seeded-selections performed very well in the 1987/88 season as well: FLIP 86-21L and FLIP 87-21L outyielded the local (L56) by 48 and 59%, respectively, in the 1987/88 and 196 and 136% in 1988/89. In the small-seeded lines, three selections (LV265, LV150A, LV155A) from the national collection outyielded the local L24 by 4 to 7 times in the rust epidemic conditions of 1988/89 at Merchouch. However, they yielded slightly less than the local in 1987/88.

Based on their performance over years and locations, FLIP 86-16L, FLIP 87-17L and FLIP 87-22L were recommended to the pre-release catalogue trials next season due to their high yield, resistance to rust and good seed quality. Selections were also made in early-maturity screening nursery LISN-E where the local ranked 16 and 36 at

Merchouch and Sidi Laidi, respectively. Selected F4 populations were advanced for single plant selections. Screening for rust resistance was initiated in 1988/89 using 100 accessions of the lentil national collection.

8.2.2.4. Agronomy

The agronomy research work during the 1988/89 season included studies on population density, weed and orobanche control, need-for-rhizobium inoculum and mechanical harvesting. The population density studies in faba bean confirmed earlier results that high density through narrow inter-row spacing (40 cm) gave higher yields compared to wider spacing (60 and 100 cm). However, the feasibility of such high density and planting pattern under farmers conditions will depend on weed control practices followed.

In weed control studies at Douyet, yield losses due to weeds were 50% in faba bean, 62% in winter chickpea and 37% in lentil. In lentil, pre-emergence applications of Bladex (0.5 kg a.i./ha) and Tribunil (2.0 kg a.i./ha) plus Kerb (0.5 kg a.i./ha) yielded 1.53 and 1.59 t/ha, respectively, and were as effective as the weed free treatment (1.55 t/ha). In chickpea, pre-emergence application of Igran (3.0 kg a.i./ha) plus Kerb (0.5 kg a.i./ha) resulted in twice as much yield (1.85 t/ha) as the weedy check (0.99 t/ha), but it yielded 40% less than the weed-free treatment (2.59 t/ha). Based on previous studies, Igran seems to be more effective in the southern region (Abda-Chaouia areas) compared to the northern areas. The main limitation of Igran is its inability to control late coming weeds. With one inter-row cultivation later in the season, Igran may be very effective in an integrated weed control system.

Orobanche was controlled completely in faba bean by three applications of glyphosate (0.08 kg a.i./ha) at two-week intervals after flowering. The most critical time for application was the tubercle stage of Orobanche development. The results will be verified at farmers fields. Sceptor did not give as good a control of Orobanche as the glyphosate treatment.

In the need-for-inoculation studies on chickpea, the excessive moisture stress in December and January seriously affected crop growth and nodule development. However, the positive response of winter chickpea to inoculation in farmers field was apparent in the non-traditional production areas through higher biological yield and greater nodule biomass. The non-inoculated check had no nodules.

8.2.2.5. Pathology

The 1988/89 season in Morocco had several disease epidemics: ascochyta blight in chickpea, rust in lentil and virus diseases (particularly BLRV) in faba bean. Yield losses up to 100% were observed due to the first two diseases. Pathology work in Morocco during the 1988/89 season included screening for disease resistance, disease surveys and studies on variability in Ascochyta rabiei and chickpea wilt.

Screening for disease resistance: Artificial disease screening work was expanded to include rust of lentil and stem nematodes of faba bean in addition to the screening for Botrytis fabae, Ascochyta fabae and rust in faba bean and A. rabiei and wilt in chickpea.

In faba bean, introduction from ICARDA which showed moderate resistance to Botrytis were R40, L83108, BPL 710 and BPL 1179. The first two showed similar reaction in the previous season. Six lines out of 100 accessions of the national faba bean collection showed high level of resistance to rust (1 rating in a 1 to 9 rating scale): F 269, F 294, F 327, F 334, F 348, and F 353. Several other lines showed moderate reaction to rust (3 rating score). Two lines (15563-2, L82014) in the FBIRN-R-89 showed also a good level of resistance to rust. In ascochyta blight, disease development was not satisfactorily uniform, although several lines seemed to be resistant in the FBIAN-A-89.

In chickpea, the A. rabiei pathotypes at Merchouch Research Station were more virulent than those used for artificial screening at Dar Bouazzeh. The heavy late rains in March and April contributed to the uniformity of the disease development and opportunity was taken at Merchouch to screen all tested lines for resistance. A total of 21 lines showed a high level of resistance with disease rating of 3 or 4 on 1 to 9 scale. These were ILC 72, ILC 195, ILC 202, FLIP 82-91C, FLIP 82-93C, FLIP 82-150C, FLIP 82-152C, FLIP 83-47C, FLIP 83-48C, FLIP 84-19C, FLIP 84-60C, FLIP 84-72C, FLIP 84-80C, FLIP 84-92C, FLIP 84-93C, FLIP 84-102C, FLIP 84-109C, FLIP 84-144C, FLIP 84-145C, FLIP 84-182C, FLIP 85-93C.

The wilt disease development in the wilt-sick plot in Khemis Zemamra was not uniform since climatic conditions were not favorable for the disease development. There is a need to increase the level of the inoculum population in the soil to have uniform disease spread irrespective of climatic conditions. However, three lines (ILC 851, ILC 904, ILC 911) in the regional INACFWN-89 showed resistance to wilt under the prevailing conditions.

In lentil, screening of 100 accessions from the national germplasm collection for resistance to rust under artificial conditions revealed five highly resistant lines (L 215, L 255, L 234, L 275, L 277). These scored 1 in the 1 to 9 rating scale while 17 others scored 2 to 3.
At Sidi Laidi, where rust epidemic developed, the introductions from ICARDA ILL 5815, FLIP 86-15L (ILL 6001), FLIP 86-16L (ILL 6002), FLIP 87-19L (ILL 6209), Precoz (ILL 4605) and Nablus (ILL 4606) showed a high level of resistance or tolerance. Thus FLIP 86-16 L and Precoz confirmed their resistance to rust over two seasons at Sidi Laidi. Under similar conditions at Merchouch ILL 6001, ILL 6002, ILC 6209, ILL 6212 and Precoz showed also high level of resistance in addition to LV 265, LV 150A, LV155A, LV 151 and LV 236 from the national collection.

Disease surveys: Diseased-samples of chickpea were collected from Khmisset-Romani, Settat-Chaouia and in restricted areas in Abda to study the variability in A. rabiei in the 1989/90 season. Fusarium oxysporum var cicera and F. solani were found to be the causal organisms of chickpea wilt in a survey restricted in Khemisset, Abda and parts of Fes province. In a comprehensive survey on stem nematodes of faba bean, 142 soil and plant samples were collected and nematodes were present in all the areas where faba bean is grown in Morocco. Of all the fields sampled, 60% were infested with Ditylenchus dipsaci. Severe nematode attacks was observed in Zemmour (Khemisset region), Doukala, Chaouia and Abda. In some heavily infested fields, up to 21% of the seeds produced were infested with nematodes. Both the normal and the giant races were present, but the latter was dominant and it showed in 69% of the infected samples.

8.2.2.6. Entomology

Entomology studies covered the control of three insect pests: Sitona sp. and Bruchus rufimanus in faba bean and leaf minor (Liriomyza cicerina) in chickpea. Promet (@25 ml a.i./kg of seeds) as a seed dressing in faba bean gave almost complete control (99%) of Sitona spp. damage to nodules. This was reflected in about 20% increase in yield. Carbofuran (@1 kg a.i./ha) at sowing and in mid February reduced damage up to 22 and 23%, respectively. Endosulfan (@0.7 kg a.i./ha) applied once at the beginning of pod formation in faba bean reduced bruchid damage by 45% but the damage was still high (26.9%), and even with 5 applications of Endosulfan (from beginning of flowering to grain maturity) the seed damage was further reduced only slightly (24.3%). In screening chickpea germplasm for tolerance to leaf minor, five lines (FLIP 84-92C, ILC 5594, ILC 5600, ILC 5655, ILC 5901) confirmed their resistance/tolerance expressed in the previous season. ILC 5901 and FLIP 84-92C showed relatively higher level of resistance. The later line has good agronomic characteristics and high level of resistance to Ascochyta blight and thus was recommended to the pre-release catalogue trial.

8.2.2.7. On-farm demonstration of winter chickpea and the adoption study

The demonstration of the winter chickpea package was extended in the 1988/89 season to 111 farmers across Morocco. Though climatic conditions (early drought and late heavy rains) favoured spring sowing and the development of Ascochyta blight, the winter crop, on the average, gave higher yields (Table 8.2.16). The Ascochyta disease epidemic affected both winter and spring sown crops and the newly released line ILC 482 was seriously affected in Settat and Khemisset. However, ILC 195 showed a high level of resistance and yield levels up to 2.2 t/ha were achieved.

Table 8.2.16. Summay of yield results (quintals/ha) of winter and spring chickpea in on-farm demonstration plots in four provinces in Morocco during the 1988/89 season.

Province	No. of farmers[1]	Yield range		Average yield[2]		No. of farms having Ascochyta blight
		Winter	Spring	Winter	Spring	
Asfi [3]	13	0-22	(15)	13.5	-	3
Settat [4]	11	0-12	0-16	8.0	11.6	10
Khemissat [5]	18	0-20	5-10	6.3	8.1	8
Fes-Taounate	10	4.4-20	2-11	10.1	7.4	7
Total/Mean	52			9.5	8.4	28

1. Number of farmers interviewed growing winter chickpea in 1988/89.
2. Farmers with harvest completed.
3. Yield data not available from one farmer at time of interview. Only one spring chickpea farmer with yield data inteviewed.
4. Four farmers interviewed had no harvest due to blight and two had not harvested at time of interview.
5. Two out of 18 farmers had no yield because of blight.

After two years of demonstrating the winter chickpea packages throughout the country, an adoption study was conducted in cooperation with the Farm Resource Management Program (FRMP) of ICARDA and DPV/MARA and INRA in Morocco. The study took into consideration the perceptions of the Moroccan farmer to the adoption of the winter chickpea package, production problems, and constraints to expand the new technology. A total of 112 farmers were interviewed. Four categories of farmers were included: I, adopters; II, farmers having 1988/89 demonstrations; III, non-adopters (farmers who had demonstrations in the past) and IV, farmers in the neighbourhood of winter chickpea demonstrations. The major problems encountered in producing winter chickpea in order of importance were the small seed size of cultivars released (ILC 195, ILC 482), susceptibility to Ascochyta blight, heavy weed infestation and marketing (Table 8.2.17). The major constraints for expanding the area under winter chickpea, in order of importance were again the small seed size of available cultivars, the lack of information on the agronomy of winter sowing, seed availability and marketing/prices (Table 8.2.17). The first three problems are being resolved through back-up research. Already three new winter cultivars with high level of resistance to Ascochyta and good seed size were recommended for the pre-release catalogue trials. These lines are also in the pre-release multiplication. For weed control, pre-emergence application of Igran (3 kg a.i./ha) will be extended in all demonstrations in the 1989/90 season. In the previous two years, Igran was included in the package with very few farmers. The adoption/impact study on winter chickpea will be followed up as an important source of feed-back for backup research. More details are presented in the FRMP report.

Moroccan National Scientists, Dr. M. Solh and Dr. R. Tutwiler.

Table 8.2.17. Summary of results on the adoption study of winter chickpea production package in Morocco, 1988/89.

Problem/constraint/ limiting factor	Most serious	Somewhat serious	Least serious	Frequency mentioned	Weighted value
A. Problems encountered in producing winter chickpea (category I, II, III)					
Small seed size	27	17	2	46	117
Disease and pests	22	7	1	30	81
Weeds	11	1	8	20	43
Market and prices	2	14	6	22	40
Labor costs	4	1	1	6	15
Uncertain yield	3	3	0	6	15
Conflict w/cereals	1	2	1	4	8
Need information	1	2	1	4	8
Seed availability	1	1	0	2	5
Need new equipment	0	0	1	1	1
No problem given	9	32	59		
B. Constraints to expand area sown to winter chickpea (category I, II, III)					
Small seed size	18	7	2	27	70
Need information	16	8	0	24	64
Seed availability	12	4	0	16	44
Market and prices	6	9	3	18	39
Labor costs	7	3	0	10	27
Diseases and pests	4	4	1	9	21
Conflict w/cereals	5	1	0	6	17
Land availability	3	2	0	5	13
Uncertain yield	1	1	1	3	6
Weeds	0	1	1	2	3
No problem given	9	41	73		
C. Factors limiting adoption of winter chickpea (category I, II, III, IV)					
More information	43	9	0	52	147
Small seed size	14	11	1	26	65
Seed availability	7	12	1	20	46
Market and prices	6	6	1	13	31
Disease and pests	4	2	2	8	18
Land availability	2	3	0	5	12
Labor costs	3	1	0	4	11
Uncertain yield	1	1	1	3	6
Conflict w/cereals	2	0	0	2	6
Weeds	0	1	3	4	5
No factors given	27	66	103		

Weighted values computed with most serious or limiting considered as "3" times, somewhat serious or limiting as "2" and least serious or limiting as "1".

8.2.3. Algeria/ICARDA cooperative project

The cooperation between ITGC (Institut Technique des Grandes Cultures) of Algeria and ICARDA continued during the 1988/89 to strengthen food legume research and technology transfer to farmers. In the project, Algerian and ICARDA scientists worked together at three levels of experimentation at Wilayet Sidi Bel Abbes (SBA): Level I, back-up research; Level II and III, on-farm verification and demonstration of important research findings, respectively. Work on back-up research which included both agronomy and breeding was also conducted at other research stations (Tiaret, Setif, Khroub, Guelma and Oued Smar and Saida).

SBA station, in the north-west represents semi-arid low rainfall areas, Tiaret and Setif represent semi-arid high plateau areas and Khroub and Guelma represent higher rainfall areas. During the 1988/89 season, serious drought characterized the seasons in Algeria particularly at SBA and Tiaret. Annual rainfall was 230, 273, 376, 403 and 376 at SBA, Tiaret, Setif, Khroub and Guelma, which represented 57, 66, 80, 89 and 63% of the respective mean annual precipitation of these stations in the same order. The distribution of rainfall at Setif, Khroub and Guelma were fairly good and thus better yield levels were obtained. However, at Khroub as in SBA and Tiaret moisture stress was early in the season and very little rain was received in November, December and January. Because of drought, results at SBA and Tiaret were mostly inconclusive as reflected by the high coefficient of variability. Biotic stresses, particularly foliar diseases, were generally not favoured this season because of drought. However, root diseases were very common in chickpea and lentil and serious losses were incurred at SBA and Tiaret. In faba bean, stem nematode (Ditylenchus dipsaci) and Sitona spp. were serious. At Khroub where rainfall was relatively higher in the second half of the season, Ascochyta blight developed affecting most seriously the local cultivar Rabat 9. Heavy weed infestation affected yield seriously.

8.2.3.1. Back-up research (Level I)

Back-up research in faba bean, chickpea and lentil included breeding for high and stable yield mainly through the evaluation of ICARDA germplasm. National hybridization programs in chickpea exists at both Khroub and SBA. In the breeding program, artificial screening for diseases of economic importance had been initiated for the first time under field conditions. Work on disease variability of Ascochyta rabiei was strengthened. Agronomic studies were also conducted.

Faba bean breeding: During the 1988/89 season, 129, 23 and 19 advanced faba bean breeding lines were yield tested in replicated trials, respectively, at SBA-Tessala (51 large-seeded, 55 small-seeded and 23 determinate), Khroub (all large-seeded) and Guelma (15 large-seeded, 4 small-seeded). These were tested in 4 national and 3 international trials (FBIYT-L, -S, -D-89). Three of these trials were discarded because of severe drought effect. A total of 57 lines outyielded the check considering all three locations (25 at SBA, 19 at Khroub and 13 at Guelma) and 20 lines did so significantly. Yield advantages ranged between 14 to 61% at Khroub and 31 to 54% at SBA-Tessala. In large seeded lines, yields at Khroub (2.2 to 3.7 t/ha) were about 5 times those at SBA (0.4 to 0.6 t/ha) due to the severe drought at the second site. 74TA 2279S 4, FLIP 82-30FB, FLIP 82-54FB and PAM I showed high yield and wide adaptation at 2-3 locations over the last two seasons. Similar was the case with 'Reina Blanca' and 'New Mammoth'. In small seeded lines, FLIP 82-92FB, FLIP 82-88FB, FLIP 83-127FB and 76TA 56267 showed high yield and wide adaptation.

In observation nurseries, 58 F4 selected bulks (FBIF4N-89) and 28 determinate types (FBISN-D-89) were evaluated for adaptation. Inspite of the serious drought at SBA (231 m) yield levels of the best 16 F4 selections ranged between 1.6 to 1.57 t/ha with a yield advantage of 45 to 96% over the local 'Aguadulce' (0.8 t/ha). These lines were significantly (P=0.05) better yielders than 'Aguadulce'.

Chickpea breeding: Breeding work on chickpea in Algeria focuses on high yield with resistance to Ascochyta rabiei, wilt and adaptation to winter and spring sowing. More emphasis is put on winter chickpea because of its considerable yield advantage over the traditional spring crop.

In winter sown chickpea, 260 advanced breeding lines were tested in international (CIYT-MR-W and -T, -L, -DS, -SP), preliminary (CPYT-A to D, and DS) and multilocation (CMYT-IA and B, CMYT-II) trials in 1 to 5 locations. Several lines exceeded the local check at various locations: 173 lines at Khroub, 71 lines at Tessala (SBA), 61 lines at Tiaret, 28 lines at Setif, 22 lines at Guelma and 8 lines at Zeidane (SBA). The local cultivar Rabat 9 was mostly used as a check in eastern Algeria (Setif, Khroub, Guelma) while Sebdou was the check at

SBA and ILC 3279 at Tiaret. Only at Khroub, Rabat 9 was seriously affected (completely killed in most plots) by ascochyta blight. As of next season lines released for winter sowing should be used as checks in winter trials rather than the local spring cultivars. Chickpea yield levels were very low at both SBA and Tiaret because of drought; and mean yields of replicated trials ranged between 0.22 to 0.60 and 0.23 to 0.82 t/ha in the two stations. However, the maximum yields at these stations, 1.09 and 1.29 t/ha, were obtained by FLIP 85-16C and FLIP 84-144C at SBA and Tiaret, respectively. Yields in eastern Algeria were much higher and yield of 3.5 t/ha was obtained by FLIP 84-182C at Khroub.

Multilocation performance of chickpea lines revealed lines with wide adaptation and high yield (Tables 8.2.18 and 8.2.19). In CIYT-W-MR-89, yield ranged between 1.10 to 1.68 t/ha over 5 environments inspite of drought while the local check averaged 0.62 t/ha giving a yield advantage of 77 to 158%. The best six lines are FLIP 84-79C, FLIP 84-80C, FLIP 84-92C, FLIP 84-98C and FLIP 84-99C and FLIP 84-102C with yield ranging between 1.4 to 1.5 t/ha over 8 environments considering both locations and years. All these lines showed resistance to ascochyta blight while the first line also showed resistance to wilt at Guelma. Similarly in CIYT-L-89, yields of widely adapted lines ranged between 1.14 to 1.48 t/ha with yield advantages of 51 to 96% over the mean of local checks. FLIP 84-19C, FLIP 85-54C, FLIP 85-55C, FLIP 85-60C, FLIP 86-5C were the best lines with yields of 1.3 to 1.4 t/ha over 5 locations in 1988/89 inspite of the dry season. Most of these lines were also tolerant to wilt at Guelma.

Table 8.2.18. Multilocation yield performance (kg/ha) of widely adapted chickpea lines in CIYT-MR international trial at 5 locations over seasons, 1986/87-1988/89.

Pedigree	Guelma	Khroub	Setif		Sidi-Bel-Abbes		Tiaret		Mean	
	86/87	88/89	86/87	88/89	86/87	88/89	87/88	88/89	8 Envir.	5 Envir.
FLIP 81-293C	929	2484	925	1561	958	356	2020	430	1208 (8)	1370 (7)
FLIP 84-79C	2941	2630	1153	1301	792	582	1980	328	1463 (2)	1364 (8)
FLIP 84-80C	2556	2804	1000	1635	719	676	2430	486	1538 (1)	1606 (1)
FLIP 84-92C	2285	2804	1000	1635	719	676	2430	486	1538 (1)	1502 (5)
FLIP 84-102C	1445	2783	882	1514	891	756	2680	254	1401 (5)	1597 (2)
FLIP 84-158C	1441	2801	1059	1269	1026	490	1330	267	1210 (7)	1231(13)
FLIP 85-43C	-	2476	-	1400	-	294	1470	787	-	1285(12)
FLIP 85-63	-	2010	-	1136	-	611	2790	749	-	1459 (6)
FLIP 85-93C	-	2174	-	936	-	704	1390	310	-	1103(14)
FLIP 85-118C	-	2569	-	926	-	588	1880	430	-	1293(10)
FLIP 85-148C	-	2268	-	1297	-	812	2140	307	-	1345 (9)
FLIP 86-42C	-	2520	-	1472	-	168	2000	278	-	1288(11)
ILC 482	1015	2930	1014	1570	896	234	2580	231	1309 (6)	1509 (4)
Check	789	195	764	1083	880	491	1110	229	693 (9)	622(15)
Check name	Rabat 9	Rabat 9	Rabat 9	Rabat 9	Sebdou	ILC 3279	-	ILC 3279	-	-
Location Mean	1822	2358	1001	1179	880	530	1983	429	-	-
LSD (5%)	1004	303	284	520	N.S.	N.S.	739	1054	-	-
C.V. (%)	39.1	15.2	20.1	26.0	25.1	35.7	14.9	21.8		

Table 8.2.19. Multilocation yield performance (kg/ha) of widely adapted chickpea lines in CIYT-L international trial at 5 locations over seasons, 1986/87 to 1988/89.

Pedigree	Guelma		Khroub			Setif		S.-Bel-Abbes		Tiaret		Mean (Rank)	
	86/87	88/89	86/87	87/88	88/89	86/87	88/89	86/87	88/89	87/88	88/89	88/89	8 Environ-ments
								kg/ha					
FLIP 83-77C	2630	2047	1718	-	2640	898	1038	597	654	-	180	1312 (7)	1222 (6)
FLIP 84-15C	-	969	2127	-	2601	1127	1488	875	560	-	171	1158 (11)	1240 (5)
FLIP 84-19C	1120	2619	2359	2964	2101	1130	1056	972	614	1140	324	1343 (5)	1242 (4)
FLIP 85-4C	-	859	-	3499	2192	-	1592	-	778	750	264	1137 (12)	
FLIP 85-46C	-	2052	-	2629	2148	-	778	-	500	530	232	1142 (13)	
FLIP 85-54C	3109	2255	1687	-	2372	938	1136	1076	624	-	329	1342 (6)	1302 (2)
FLIP 85-55C	2854	2291	1937	2559	2505	933	1194	632	697	1700	216	1381 (3)	1301 (3)
FLIP 85-56C	2781	2337	1875	2505	2567	868	1124	1319	619	710	206	1371 (4)	1364 (1)
FLIP 85-60C	-	2384	-	2616	2468	-	1017	-	1006	1440	185	1412 (2)	
FLIP 85-75C	-	2328	-	-	2127	-	1074	-	772	-	154	1291 (7)	
FLIP 85-134C	-	1958	-	-	2158	-	903	-	625	-	423	1213 (9)	
FLIP 86-5C	-	1489	-	-	2512	-	1704	-	-	-	219	1481 (1)	
FLIP 86-13C	-	2244	-	-	2280	-	1188	-	550	-	180	1288 (8)	
Check	0	1791	749	1968	208	794	1269	993	400	1200	114	756 (14)	790 (7)
Check name	Rt.9[1]	ILC 3279	Rt.9	Rt.9	Rt.9	Rt.9	Rt.9	Sebdou	Sebdou	ILC 3279	ILC 3279		
Trial Mean	1885	1859	2012	2659	2131	992	1076	860	599	842	225		
LSD (5%)	1074	N.S.	736	N.S.	282	N.S.	278	329	N.S.	499	208		
C.V. (%)	26.0	40.4	16.0	19.1	15.6	16.6	21.8	22.9	30.1	24.4	29.1		

1 : Rt. 9: Rabat 9 cultivar

Preliminary yield trials and multilocation trials within the various provinces revealed lines having wide adaptation. The additional lines, other than those mentioned above, which showed superior performance across locations included FLIP 83-47C, FLIP 84-109C, FLIP 84-149C, FLIP 84-182C, FLIP 85-146C.

Lentil Breeding: Lentil breeding in Algeria emphasizes high yield, early maturity, acceptable seed quality and mechanical harvesting traits. In both large and small seeded lentil, a total of 149 advanced breeding lines were yield tested considering all the research stations of SBA (78 lines), Tiaret (44 lines), Setif (56 lines), Khroub (52 lines), Ben Slimane (34 lines) and Guelma (23 lines). These were tested in two international trials (LLYT-L, -S), one national preliminary trial and 8 national multilocation trials (1 st and 2nd year) at various stations. The number of lines outyielding the local checks (mostly the newly released Syrie 229) were 44, 18, 14, 9 and 7 at SBA, Tiaret, Khroub, Setif and Guelma, respectively. However, only few lines did so significantly because of high C.V. due to drought and wilt particularly in eastern Algeria (SBA and Tiaret). At SBA station where soil is shallow and calcareous no grain yield was harvested in LIYT-L, LITY-S, LISN-L, LISN-S and LISN-T. However, at the deep vertisols of Tessala Pilot Farm in SBA, grain yields up to 3.26 t/ha were obtained in LISN-T with an average yield of 2.20 t/ha inspite of drought (213 mm). Yields in western Algeria were much higher reaching up to 4.5 t/ha at Guelma because of the relatively higher and better distributed rainfall (376 to 403 mm).

In the International Trials, multilocation yield performance of large-seeded lines indicated that only 81S 38326 was widely adapted in LIYT-L-89 with an average yield of 1.77 t/ha over 4 locations with yields ranging between 0.28 to 4.20 t/ha at Geulma and Tiaret (Table 8.2.20). In the same trial, FLIP 87-5L and FLIP 87-17L were high yielders and well adapted to eastern Algeria (Khroub and Guelma) with a yield advantages of 3 to 63% over the newly released cultivar Syrie 229. At Guelma, FLIP 87-16L and FLIP 87-17L produced a record yield of 4.6 t/ha compared to Syrie 229 (4.2 t/ha). At Khroub, FLIP 85-35L, FLIP 87-5L and FLIP 87-16L gave significantly higher yields (more than 2.0 t/ha) than Syrie 229 (1.4 t/ha) with yield advantages of 52 to 63%.

Table 8.2.20. Multilocation yield performance of large seeded lentil lines with respect to the local chekcs in the international the yield trial LIYT-L-90 at four locations in Algeria, 1989/90.

Pedigree	Guelma		Khroub		Setif		Tiaret		Mean	
	Yield kg/ha	% of check	Yield kg/ha	% of check	Yield kg/ha	% of check	Yield kg/ha	% of check	Yield (kg/ha)	
78S 26002	4259	101	1653	119	709	68	122	50	1686	98
81S 38326	4197	100	1565	113	1040	100	277	113	1770	103
FLIP 84-148L	4375	104	1262	91	825	80	119	48	1645	96
FLIP 85-35L	3531	84	2119	152	811	78	128	52	1647	96
FLIP 85-38L	4362	104	1254	90	765	74	212	86	1648	96
FLIP 86-5L	4000	95	1241	89	916	88	323	131	1620	94
FLIP 87-3L	3831	91	1416	102	872	84	284	115	1601	93
FLIP 87-5L	4312	103	2270	163	799	76	211	86	1898	110
FLIP 87-12L	4487	107	1275	92	783	76	260	106	1701	99
FLIP 87-16L	4562	108	2127	153	844	81	163	66	1924	112
FLIP 87-17L	4572	109	1640	118	841	81	136	55	1797	104
Local Check	4206	100	1391	100	1037	100	246	100	1720	100
Check Name	Syrie 229		Syrie 229		L.B. Chile		Metropole			
Trial Mean	3950		1418		825		207			
LSD (5%)	N.S.		392		N.S.		N.S.			
C.V. (%)	15.1		32.6		14.1		56.5			
Annual Rainfall (mm)	376		402		376		273			

Values underlined are significantly higher than the local check.

In the small-seeded lentil, FLIP 84-29L, FLIP 84-105L, FLIP 85-15L and FLIP 87-48L outyielded Syrie 229 (0.76 t/ha) by 3 to 12% at Setif.

The multilocation trial II (I and II at Setif) had superior lines compared to the check only at Setif. Average yields were 2.1, 1.4 and 0.2 t/ha at Khroub, Setif and Tiaret, respectively. At Setif, all lines tested were superior to Syrie 229 in contrast to their performance at Khroub. In multilocation trial I at Khroub, FLIP 86-16L, FLIP 87-17L, FLIP 87-20 and ILL 707 performed well yielding 2.41 to 2.85 t/ha compared to 2.49 t/ha for Syrie 229. Based on its superior performance over seasons, FLIP 86-20L is in the pre-release multiplication at Khroub.

The adaptation screening nurseries evaluated 264 lentil lines in 1 to 4 locations. A number of these lines showed good adaptation high yield, early maturity and good seed quality at various locations. At SBA, 7 tall lines (78S 26052, FLIP 84-58L, FLIP 86-33L, FLIP 86-35L, FLIP 87-49L, FLIP 88-31L and FLIP 88-50L) in LISN-T (C.V. = 18.9%) yielded 2.7 to 3.3 t/ha with a yield advantages of 11 to 31% over the improved Syrie 229 (2.5 t/ha). In Setif, the large seeded FLIP 88-12 outyielded the check by 27% in LISN-L while the tall lines ILL 468, FLIP 84-51L, FLIP 86-56L, FLIP 87-52L, FLIP 88-51L did the same by 27 to 73%. Several lines were selected at Khroub for high yield, early maturity and good seed quality. All selections in adaptation nurseries will be yield tested in replicated trials next season.

Agronomy: Agronomic research included studies on date of sowing, seeding rate and row spacing, fertilization, N2-fixation, weed control and harvest mechanization. These studies were mainly conducted on the newly released chickpea and lentil cultivars.

Delaying sowing beyond early January at Tiaret reduced yield of ILC 3279 chickpea by 75% compared to mid February sowing and by more than 300% compared to mid March sowing (Table 8.2.21). Seeding density of 30 plants/m^2 produced the highest yields compared to 50 or 70 plants/m^2 in the December and January sowing. However in March sowing 70 plants/m^2 gave higher yield. In a similar study at Setif on ILC 3279 and Rabat 9, the narrower spacing of 15 and 30 cm were better yielding than 45 cm with a yield advantage of at least 11% while increasing the plant density above 50 plants/m^2 had no effect. At Tiaret also delaying sowing after the first half of January also reduced yield significantly. In other locations in Algeria, both winter sowing and narrow row spacing (even up to 20 cm at Guelma) gave higher yield than the traditional spring sowing and wide row spacing. At Guelma, the newly released lentil cultivar Syrie 229 yielded 2.68 t/ha at 20 cm spacing with 80 kg/ha seeding rate compared to 2.05, 2.04 and 2.23 t/ha at 40 cm row spacing with 30, 50 and 80 kg/ha seeding rates, respectively.

Studies on N2-fixation revealed striking results in chickpea and lentil at both Setif and Tiaret. In chickpea, the need-for-inoculation trials (CIRT-89 and CIFRT89) indicated that the response to N fertilizations was up to 14 and 22% at the two locations. Introducing efficient chickpea rhizobia strains increased yield by 33% at Setif

(Strain no. 44 gave 2.03 t/ha compared to 1.65 t/ha with control) and by 21% at Tiaret (Strain No. 31 gave 0.53 t/ha compared to 0.43 t/ha for control). At both locations, plants had no nodulation in the non-inoculated treatments while plants were well nodulated in the inoculated treatments. In lentil international _Rhizobium_ inoculation trial (LIRT-89) at Tiaret, N fertilization more than doubled the yield as compared to zero-N treatment and introducing the efficient lentil _Rhizobium_ strains Nos. 719, 735 and 758 increased yield by 44, 106 and 63%, respectively. However, at Setif the response to N fertilization was only 9% in the LIRT-89 trial and only _Rhizobium_ No. 758 increased yield by 12%.

Table 8.2.21. Effect of date of planting and seeding density on the chickpea ILC 3279 (newly released) in Tiaret in Algeria, 1988/89.

Date of Panting[1]	Seeding Density[2]			Mean
	30 Plts/m^2	50 plts/m^2	70 plts/m^2	
Dec. 13	2885	2493	2349	2576
Jan. 12	2909	2790	2764	2827
Feb. 13	1393	1716	1740	1716
March 11	500	683	702	629
Mean	2001	1921	1889	

1. Date of planting
   - C.V. (%) = 9.6%
   - LSD (5%) = 171 kg/ha

2. Seeding density
   - C.V. = 8.1%
   - LSD (5%) = 223 kg/ha

Weed control trials were conducted in Sidi-Bel-Abbes (SBA), Setif and Kharoub. The pre-emergence application of herbicide Igran (3.6 kg a.i./ha) and Kerb (0.5 kg a.i./ha) was effective in winter chickpea. Igran is already submitted for official registration as an effective herbicide on chickpea in Algeria. In lentil at Setif, the pre-emergence application of Gesagard (prometryne) at 1.5 kg a.i./ha increased yield by 142% (from 0.38 t/ha with weedy check to 0.92 t/ha) while the weed free (manual weeding) treatment yielded 0.81 t/ha. Other treatments as effective as manual weeding were: pre-emergence Maloran (1.5 kg a.i./ha) plus Kerb (0.5 kg a.i./ha), postemergence Aretit (1.0 kg a.i./ha) plus Fusilade (0.5 kg a.i./ha), and pre-emergence Bladex (0.5 kg a.i./ha). The results on lentil need to be confirmed one more season.

Pathology: The work in pathology during the 1988/89 in Algeria included assessment of the disease situation, screening for disease resistance, and studies on the pathogen variability of Ascochyta rabiei. An achievement in pathology this season was the development of field screening method for resistance to A. rabiei through artificial inoculation at SBA. Screening for resistance was done earlier under controlled conditions and on a small scale.

The disease survey conducted in Algeria (Khroub-Guelma and Tiaret) in April 22-29, 1989 showed that wilt/root rot, nematodes and phoma blight were major problem. Based on the chickpea and lentil diseased plant samples collected in various regions Dr. Bouznad (INA) reported the following diseases and their frequency:

Region (Areas)	Crop	Fusarium spp.	Phoma medicaginis
Khemis Miliana	Chickpea	45%	20%
	Lentil	100%	0%
Sidi-Bel-Abbes	Chickpea	45%	55%
Tessala	ILL 3279		
Zeidane	Chickpea	35%	65%
Tiaret			
Zakaria	Lentil	40%	5%
Hattab	Lentil	90%	10%
Oued Smar	Chickpea		
El-Harrach	ILL 3279	20%	80%

The common causal organisms for wilt and root rot were Fusarium oxysporium f.sp. ciceri and F. solani and the damage was more than 75% in certain fields of chickpea and lentil. The other serious disease on chickpea was phoma blight Phoma medicaginis). A. rabiei was observed in winter sown chickpea at Khroub Research Station and on ILC 482 in seed multiplication fields in Hattab Farm (at serious level) and at farmers field (low infestation level). Nematodes were common on faba bean and chickpea. Both stem (Ditylenchus dispaci) and root lesion nematodes (Pratylenchus spp.) were present. In chickpea, root lesion nematode (Pratylenchus spp.) was also common while root knot nematode (Medloidogyne spp.) was found in one field near Tiaret. BLRV virus was serious in one area (Ain Fekan) on the way to Tiaret with about 50% infestation in certain fields.

Screening for resistance to local isolates of Ascochyta rabiei under field conditions was successful for the first time at SBA due to sprinkler irrigation used to create favorable conditions for disease spread. The susceptible spreader rows (ILC 263) were completely killed (scored 9) throughout the nurseries. Material screened for resistance included CIABN-A, ascochyta disease screening nursery (ADSN), and F_2 nursery. Screening under laboratory controlled conditions included the ADSN and selected lines to evaluate disease virulence of four isolates. In CIABN-A, 16 lines showed high level of resistance (1 to 4 score in two replications). These included:

ILC 72*	ILC 4421	FLIP 83-47C*	FLIP 84-92C*
ILC 2506	ILC 5913	FLIP 83-97C	FLIP 84-93C*
ILC 2956	ILC 6840	FLIP 84-79C	FLIP 84-137C
ILC 3868	FLIP 82-150C*	FLIP 84-80C*	FLIP 85-94C

Lines with an asterisk showed also good level of resistance to Ascochyta blight in Morocco and Tunisia. Other lines with fairly good level of resistance (average 3.5 score or less in two replications) were: ILC 200, ILC 202, ILC 5889, ILC 5894, ILC 6090, FLIP 83-46C, FLIP 83-48C, FLIP 84-83C, FLIP 84-91C, FLIP 84-133C, and FLIP 84-182C.

In the ADSN 3 lines, FLIP 83-49C, FLIP 83-97C and FLIP 83-98C, were resistant under both field and laboratory conditions. Under lab conditions, the most virulent isolates were used while a mixture of isolates was used under field conditions.

Screening for wilt resistance was carried out at Guelma and SBA in the disease sick plots. Lines which showed resistance at one or two locations (underlined) were: ILC 873, ILC 4090, FLIP 850-20C, FLIP 85-29C, FLIP 85-33C, and FLIP 85-35C, in ARFWN (Kabuli) and ILC 857, ILC 860, ILC 911, ILC 4090, FLIP 82-78C, FLIP 84-32C, FLIP 84-88C, and FLIP 84-97C in INACFWN. ICRRWN (Desi) was also evaluated. Since the susceptible check ICC 4951 (JG-62) was resistant to wilt at both Guelma and SBA, the prevailing race or races in SBA and Guelma are different than races 1-4. JG-62 is known to he highly resistant to race 0 which prevails in Spain thus race 0 may also be present at Guelma and SBA.

After 2 to 3 cycles of screening for resistance to wilt at Guelma, the following lines confirmed their resistance and high yield in large plots: ILC 195, ILC 3279 (some symptoms of very late wilting were apparent), FLIP 84-79C, FLIP 85-17C, FLIP 85-55C and FLIP 85-56. In the same area, both ILC 482 and the local Rabat 9 were completely killed.

Work on disease variability continued at INA and the virulence of the four isolates Tessala, Tizi Ouzou (T.O.), Ain Temochent 16/14 (A.T.) and Sig were tested on several lines already known for their high level of resistance. Differential reaction was shown by various genotypes to different isolates (Table 8.2.22) and the Tessala isolate was confirmed as being the most virulent followed. by T.O., A.T. and Sig. FLIP 83-97C confirmed its resistance to all 4 isolates while FLIP 83-49C and FLIP 84-109C were resistant to 3 and tolerant to the fourth.

Entomology: During the regional travelling workshop in late April, several insect pests were noticed to be causing damage on faba bean, chickpea and lentil. In faba bean, the most serious insect was the Sitona spp. damaging nodules, the damage reaching up to 100%. Black aphids were serious in few faba bean fields while Phytytonomus spp. (coleoptera) was serious on new vegetative growth and unfolded terminal buds in Beni Hamidan-Khroub area. In spring chickpea, leafminer (Liriomyza spp.) was very common reaching serious level in few fields. In lentil, the most striking insect damage was caused by cutworms (both Phyllognatus excavates and Agrotis spp.) which wiped out 90% of the seed multiplication field in Hattab Pilot Farm. Considerable damage by the cutworms was also observed in Zakaria Farm on yield trials, nurseries and lentil mechanization experiments. Bruchids were the most serious storage pest in all food legumes, particularly in lentil. Screening chickpea lines for resistance/tolerance to leaf miner revealed one resistant (ILL 394) and 5 tolerant lines (ILC 655, ILC 1003, ILC 5614, ILC 5615, ILC 5648).

8.2.3.2. On-farm Verification Trials (Level II)

On-farm trials were conducted on varietal performance and chemical weed control at three sites representing the different agroclimatic zones in Wilayet Sidi-Bel- Abbes (SBA): Zone I (Tessala Pilot Farm), Zone II (SBA Station) and Zone III (Zeidane Farm). Rainfall is the highest in zone I.

Table 8.2.22. Differential reaction of chickpea lines to four isolates of Ascochyta rabiei in Algeria, 1988/89.

Pedigree	Isolates			
	Tessala	Tizi Ouzou T.O.	Ain Temouchent (A.T. 161/14)	Sig
ILC 190	S	S	(R)	S
ILC 195	S	S	S	S
ILC 202	T	T	T	T
ILC 263	S	S	S	S
ILC 482	S	S	(R)	S
ILC 3279	S	T	(R)	(R)
FLIP 81-293C	S	(R)	S	(R)
FLIP 83-49C	(R)	(R)	(R)	(R)
FLIP 83-97C	(R)	(R)	(R)	(R)
FLIP 83-98C	T	S	(R)	S
FLIP 84-19C	R or T	T	S	T
FLIP 84-32C	S	S	S	S
FLIP 84-53C	S	R or T	(R)	S or T
FLIP 85-55C	S	T	S	(R)
FLIP 84-109C	(R)	(R)	T	(R)
FLIP 84-144	S	S	S	S
FLIP 84-145C	S	S	S	T or S
ILC 72 X ILC 897	R or T	(R)	S	(R)
ILC 201 X ILC 3279 X 79TH 101.1	S	T	S	T
ILC 523 X ILC 183 X 79TH 101.2	(R)	T	(R)	S
ILC 523 X ILC 183	S or T	T	T	T
ILC 630 X ILC 200	S	S	S	S

R = Resistant T = Tolerant S = Susceptible
Reactions in parentheses are confirmed.

In the multilocation chickpea trial (2nd year), a number of lines showed fairly acceptable performance considering drought and their resistance to Ascochyta blight. Yield advantages ranged between 18 and 42% over the newly released spring cultivar Sebou. However, none outyielded the newly released winter cultivar ILC 482 but some lines had higher level of resistance to Ascochyta blight. For example, lines

X79TH 101.1 and X79TH 101.2 were respectively resistant or tolerant to the most virulent three isolates while ILC 482 was resistant only to one isolate. Thus, these two lines would be multiplied to be tested in larger plots. In the verification trials, ILC 190 was compared with the newly released ILC 482 and ILC 3279 and it yielded 43 and 143% more than the two cultivars, respectively, over two locations.

In lentil, the multilocation trial for a second season had lines comparable with the newly released Syrie 229. Ent. 21 (unknown FLIP pedigree) and 76S 26004 outyielded Syrie 229 over 4 environments although the yield advantage was small. The lentil verification trials at 5 sites were affected by drought. The coefficient of variability (C.V.) was 33.5% and results were inconclusive although all tested lines, (NEL 468, ILL 4400 and Balkan 755) had comparable performance with the newly released Syrie 229.

Pre-emergence application of Igran (2.5 kg a.i./ha) and Kerb (0.5 kg/ha) increased the yield of lentil more than five times compared to the weedy check (699 kg/ha) in the verification trials. However, the hand weeded treatment produced 22% more yield than the Igran plus Kerb treatment.

8.2.3.3. On-farm demonstration of important research findings (Level III)

Demonstration plots were laid out on farmers fields in various agroclimatic zones in Wilayet Sidi-Bel-Abbes to transfer to farmers improved production packages in both chickpea and lentil.

The chickpea improved package included new varieties (ILC 482 and ILC 3279 for winter sowing, Sebdou for spring sowing), date of sowing (winter and spring), phosphors fertilization (60 kg _$_2O_5$/ha) and chemical weed control (Igran 3 kg a.i./ha). Of the six sites planted, grain yield was reported from 4 sites in winter chickpea and 3 sites in spring chickpea. Inspite of the serious drought, economic yields were obtained by both recommended packages (Table 8.2.23). However, the yield advantage of winter over spring sowing was only 71% compared to 3 to 4 folds advantage in the last season. Comparing yields obtained in demonstration packages and those reported by the seed distribution centers (based on farmers yield) in Wilayet Sidi-Bel-Abbes, the improved production packages were at least 6 to 7 times more productive.

Table 8.2.23. Yield performance (kg/ha) of improved winter and spring chickpea cultivars and recommended cultural practices in demonstration plots in Wilayet Sidi-Bel-Abbes, Algeria, 1988/89.

	Tessala	Tchouar	Boubarka	Zeidane	Alfrid	Mean
<u>Winter</u>						
ILC 482	1430	370	2050	-	910	119
ILC 3279	1250	-	860	-	-	109
Mean	1340	-	1460	-	-	1120
<u>Spring</u>						
Sebdou	1130	930	1460	1090	-	1050
Local (Moroccan type)	1100	890	-	600	-	860
Mean	1120	910	-	845	-	955

Rainfall in Sidi-Bel-Abbes was 213 to 231 mm in Zones I and II, respectively.

The improved production package in lentil involved the newly released cultivars (Syrie 229, Balkan 755 and ILL 4400), early sowing, narrow row spacing (only in Syrie 229), chemical weed control (Igran 2.5 a.i. kg/ha) and combine harvesting. Yields were generally low and uneconomical (less than 200 kg/ha) due to drought, wilt and weed infestation. However, Syrie 229 sown at different row spacings gave fairly good yields. The 13 cm inter-row spacing gave 45% more yield than 26 cm spacing across four locations through better weed control. Algerian National Program and Dr. M. Solh.

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 assist in transfer of technologies. Table 9.1.1. summarizes the activities undertaken by FLIP during 1989 to meet the above objectives. This was done in some cases in collaboration with the NARS's and other ICARDA programs. A total of 154 participants received training in the improvement of lentil, Kabuli chickpea, and faba bean.

9.1. Group Training

Details of group training are summarised in Table 9.1.2.

9.1.1. Food legume residential course, March 1 - June 30

The annual long term residential course was attended by 18 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 plastichouse 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 experimental planning, computer and manual analysis of data, data interpretation, and report writing.

9.1.2. Lentil harvest mechanization

The fourth Lentil Harvest Mechanization Course was held from 14-24 May,

Table 9.1.1. Summary of training courses in 1989.

Type of training/topics	No. of participants	No. of countries represented
<u>Training at Aleppo</u>		
1. <u>Group Courses</u>		
1.1. Residential	18	12
1.2. Insect control	12	8
1.3. Disease methodologies	9	7
1.4. Lentil Harvest Mechanization	6	2
1.5. Legume Inoculant Production	10	7
2. <u>Individual Non-degree</u>	36	8
2.1. Microbiology		
2.2. Agronomy		
2.3. Entomology		
2.4. Pathology		
2.5. Trial management		
2.6. Nematology		
2.7. Quality		
2.8. Mechanization		
2.9 Breeding		
3. <u>Graduate research</u>	3	3
3.1. Entomology		
3.2. Crop Physiology		
3.3. Orobanche		
4. <u>Visiting Scientist</u>	1	1
4.1. Biological Nitrogen Fixation		
<u>In-country training courses</u>	59	7
1. Breeding methodologies and Hybridization Techniques (Pakistan)		
2. Hybridization Techniques (Morocco)		
4. Food Legume Seed Technology (Morocco)		
5. Hybridization Techniques (Egypt)		

1989, with funding from the International Development Research Center (IDRC), Ottawa, Canada and co-sponsorship with General Organization for Agricultural Machinery (GOAM), Syria. Six trainees from Jordan and Syria attended the course. Three of the participants were mechanical engineers, one breeder and two trainers in the national programs.

Table 9.1.2. Participation in group training in the Food Legume Improvement Program, 1989.

Type of training	Schedule	Countries represented	No. of participants
Residential			
Food legume improvement	1/3-30/6	Algeria, China, Egypt Sudan, Morocco, Turkey Syria, Ethiopia, Iran PDR Yemen, Somalia, Yemen Arab.	18
Short course-Aleppo			
Insect control	16/4-29/4	Syria, Ethiopia, Turkey, Iran, Tunisia, Morocco, Suadn, Egypt, Lebanon.	12
Lentil harvest mechanization	14/5-24/5	Syria, Jordan	6
Legume inoculant production	20/3-30/3	Sudan, Ethiopia, Egypt Syria, tunisia, Cyprus, Algeria.	10
Disease methodologies	2/4-20/4	Peru, Tunisia, Syria, Ethiopia, Egypt, Sudan, Yemen AR, Morocco	9
Short courses-In-country			
Breeding methodologies & hybridization techniques-Pakistan	15/3-21/3	Pakistan	17
Hybridization techniques-Egypt	12/3-22/3	Egypt, Sudan, Ethiopia	12
Hybridization techniques-Morocco	12/3-17/3	Morocco	11
Food legume seed technology-Morocco	27/3-7/4	Morocco, Algeria, Tunisia	19

Unlike the previous courses, this course was held at Aleppo as well as Kamishly, which developed recently in a major lentil producing area in Syria. (GOAM, for example harvested 2400 ha of farmers' lentils by swathe-mower and a further 600 ha by direct combining in the Kamishly area in the 1988 season).

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 problem in an integrated manner and on ways to transfer the available technologies, through on-farm trial research, to farmers. Evaluation of the course revealed the need to conduct the course in other WANA countries. Jordan will have the first of the series of in-country courses in lentil harvest mechanization during 1990.

9.1.3. Insect control

Food legume crops are attacked by many insect pests which result in sizable yield reductions and post harvest losses. The same applies for cereal crops, as well. Realising the need of NARS's for strengthening the research skills in this field, the FLIP and Cereals Program conducted a joint training course on "Insect Control in Food Legumes and Cereals" during April 16-29, 1989 at Aleppo. The course was attended by 12 participants from 9 counties (Syria, Ethiopia, Turkey, Iran, Tunisia, Morocco, Sudan, Egypt, and Lebanon). The course covered topics such as sampling and identification of insects and monitoring of insect populations, screening for host plant resistance, use of pesticides, collection of insects, and application of biological control. Theoretical background was given in the general areas of insect control with a focus on assessment of insect infestation and damage. The course will continue to be offered in the future with increased time allocated for practical skills such as planning of experiments and use of advanced techniques.

9.1.4. Disease methodologies

A "Food Legume Disease Methodologies" course was conducted during April 2-20, 1989 at Aleppo in which 9 trainees from 8 countries participated. Integrated control of diseases in faba bean, lentil, chickpea was the main theme of the course. The course content included identification of major diseases; propagation of pathogens for artificial inoculation in the fields; use of disease scales; and use of integrated control methods. This allowed a review of common disease rating scales, and monitoring procedures which are a pre-requisite for effective networking. Comparison of disease problems across the region was done by the participants.

9.1.5. Legume inoculant production

In many locations in WANA, significant increase in yield can be obtained by inoculating legumes with selected strains of rhizobia. It is therefore necessary that local capability for the production of rhizobia inoculant be developed. To achieve this objective FLIP conducted the "Legume Inoculant Production" course during March 20-30, 1989, at Aleppo. The course was supported financially by the IDRC. It was attended by 10 participants of high academic background (B.Sc. to Ph.D.) working in BNF research in their countries. The level of participants allowed the course organizers to offer advanced technology in legume inoculant production to cover the following topics: culture media, systems of screening and culturing *Rhizobium* spp., selection and processing of carrier materials; preparation, processing and packaging of legume inoculant, inoculant production facilities and equipment, quality control, and proper application of inoculant to legume seeds.

9.1.6. In-country courses

9.1.6.1. Hybridization techniques in-country courses in Egypt, Morocco, and Pakistan.

NARS's have shown showed increasing interest in initiating their own germplasm enhancement program as part of their food legume improvement research. FLIP responded to the request of NARS's for improving the crossing skills of technicians in their programs by conducting a series of in-country courses on the subject. Courses were held in Egypt, Morocco and Pakistan during 1989.

The Food Legume Hybridization Techniques course held in Egypt was funded by the Nile Valley Regional Program and co-sponsored by the Agricultural Research Center (ARC), Egypt. The course was held at Giza and Sakha research stations and was attended by 12 participants from Egypt, Sudan, and Ethiopia. The major responsibility of training was taken by the food legume scientists of ARC, Egypt and ICARDA only played a catalytic role.

A similar course, held in Morocco during March 12-17, was attended by 11 trainees from Morocco. Assistance was given in the instructions by the ICARDA Food Legume Breeder in north Africa and a faba bean research assistant from Aleppo. The performance of trainees was evaluated based on the successful crossing of specified number of flowers per day. The outcome matched the level anticipated by the course organizers.

The third course in this series was held in Islamabad, Pakistan, during 15-21 March. 17 technicians from all provinces of Pakistan attended the course and the Pakistani breeders joined in conducting the course. The well equipped training institute at NARC facilitated the conduct of the course. As in Morocco evaluation, based on performance objective, was conducted. Appreciation awards were given to the 3 highest ranking participants in view of the outstanding performance.

9.1.6.2. Breeding methodologies training workshop

As part of the in-country course in Pakistan the last day was used as a workshop on breeding strategies in Pakistan. Representatives of various provinces, NARC, seed institute, and NIAB presented papers which were discussed. Manpower development in breeding was presented with a focus on follow-up assessment. The discussion led to the recommendations for future strategies and collaboration among Pakistani institutes and ICARDA. The proceedings of the workshop will be edited by the course organizers and published.

9.1.6.3. Seed technology

The objective of the course was to strengthen manpower in seed technology in the north African countries, where availability of quality seed is a bottleneck in food legume production. The course was jointly conducted by INRA (Morocco), Seed Production Project, and FLIP. It was attended by 19 participants from Morocco, Algeria, and Tunisia. It covered aspects of maintenance breeding, varietal description, and seed production, quality control, processing, storage, and marketing. Instruction was given by ICARDA scientists, consultants from INRA Seed Testing Station in Paris, and Moroccan scientists and the medium of instruction was mainly French.

9.2. Individual Non-degree Training

As per the request of NARS's training on individual basis was offered in FLIP for 36 participants from 8 countries. Skills covered and countries represented are given in Table 9.1.3. The syllabi were tailored to meet the need expressed by NARS,'s and the academic background and the performance objectives of the participants.

Table 9.1.3. Participation in the individual non-degree training, 1989.

Topic	No. of participants	Countries
1. Biological nitrogen fixation	1	Morocco
2. Agronomy & crop physiology	5	Sudan, Ethiopia
3. Insect control	2	Syria, Morocco
4. Trial management	7	Syria, Tunisia
5. Orobanche	2	Morocco
6. Nematology	1	Morocco
7. Quality	1	Sudan
8. Breeding	14	Syria, Morocco, Ethiopia Yemen AR, Tunisia, Jordan
9. Virology	3	Sudan, Morocco, Peru

9.3. Graduate Research Training

As part of the Graduate Research Training Program (GRTP), funded by the Ford Foundation and other donors, 3 graduate students joined FLIP during 1989. Thesis research titles are shown in Table 9.1.4. The total number of the graduate students in FLIP during 1989 was 9. Four of the students from the list of 1988 were awarded degree and 7 are writing their thesis at their universities.

9.4. Advanced Training

Dr. Hassan Moawad, from NRC-Egypt, joined FLIP as a visiting regional scientist during the 1988/89 cropping season for a period of 10 months and worked on BNF in collaboration with FLIP senior microbiologist. His major research work was on collection, purification, evaluation and conservation of different strains of Rhizobium for lentil in Turkey, Syria, Jordan and Egypt. In addition, Dr. Moawad participated in the conduct of the inoculant production training course and presented seminar.

Table 9.1.4. Participation in graduate research training, 1989.

Name	Degree	University	Country	Thesis
Registered in 1989				
Fatima Ahmad Mustafa	M.Sc. Physiology	Gezira	Sudan	Heat stress in food legumes
Christiane Scheibel	M.Sc. Orobanche	Hohenheim	Germany	Biological Control of Orobanche by Fungi
Ahmed Saoud	Ph.D. Entomology	Damascus	Syria	Studies on some aspects of integrated control for Heliothis spp on chickpea in Southern Syria
Registration continuing from 1988				
Ghada Hanti	M.Sc. Agronomy	Aleppo	Syria	
Stefan Schlingloff	Ph.D. Agronomy	Giesen	Germany	
Edwin Weber	Ph.D. Agronomy	Hohenheim	Germany	
Bashir Ahmed Malik	Ph.D. Breeding	Quaid Azam	Pakistan	
Mohamed El-Bashir	M.Sc. Crop Physiology	Khartoum	Sudan	
Ahsanul Haq	Ph.D.	Punjab Breeding	Pakistan	

9.5. Workshops

9.5.1. Chickpea in the Nineties

ICARDA and ICRISAT jointly organized the Chickpea in the Nineties Workshop at the ICRISAT Center, India from 4-8 December 1989. Major objectives were to summarize the recent findings of research on different aspects of chickpea production and utilization and to develop collaborative research proposals on constraints impeding progress. This workshop was attended by over 100 participants, including 8 from ICARDA and 12 from the ICARDA region. Proceedings will be jointly published.

9.5.2. Consultancy meeting on Breeding for Disease Resistance in Kabuli Chickpea

A consultancy meeting on breeding for disease resistance in chickpea was jointly organized by ICRISAT and ICARDA at ICARDA, Aleppo, Syria from 6 to 8 March 1989. The objectives of the workshop were to review the past research and formulate future strategies. It was attended by 25 specialists. Sixteen major presentations were made. Recommendations were made for future breeding strategy and disease control. Proceedings will be published soon.

9.5.3. West Asian seminar on food legumes

The Second Food Legume West Asian Travelling Seminar was organized jointly with the Ministry of Agriculture and Forestry, Turkey from 21-27 May 1989. The objectives of the seminar were to review the past season's work in West Asian countries and ICARDA and to see the ongoing research projects in Turkey. Twenty scientists from Iraq, Jordan, Turkey, and ICARDA participated in the seminar. The program started at South Eastern Regional Research Institute, Diyarbakir, Turkey first by visiting the experiment station and then by making presentation of the research findings by the scientists. The group travelled to Aegean Research Institute, Izmir and on the way saw a few experiment stations and farmers' fields. At Izmir, experiments were shown to the delegates in the forenoon and presentations were made by the scientists in the afternoon. Since the entire group stayed together for five days, there were good discussion among them. The group decided to hold the third workshop in Jordan.

9.5.4. International symposium on "Faba Bean Production and Improvement in China"

As part of the agreement concluded between the Chinese Academy for Agricultural Sciences (CAAS) and ICARDA, a symposium on Faba Bean Production and Improvement was held at Hangzhou, China 24-26 May. Approximately 25 scientists from throughout China, as well as senior representatives of the CAAS, the Zheijiang Commission of Science and Technology and the Zheijiang Academy of Agricultural Sciences participated. The entire range of faba bean research was presented and discussed at the symposium. As this was the first such meeting to bring together Chinese faba bean scientists from around the country, it provided an excellent opportunity to review the current status of production and research, and also to develop a strategy for future research activities. The constructive and interesting discussions will foster the development of closer collaboration and exchange of germplasm material between Chinese scientists, thereby forming the basis for the creation of a regional network. At the end of the meeting the participants agreed on the development of coordinated trials for yield testing and disease resistance for the autumn planted area, which currently accounts for over 90% of the total faba bean production in China.

9.5.5. International workshop on "Present Status and Future Prospects of Faba Bean Crop Improvement in the Mediterranean Countries"

The workshop was jointly organized by CIHEAM, EEC and ICARDA at Zaragossa, Spain, 27 to 29 June. Scientists from the Mediterranean countries attended the workshop, presented the research results of their work and shared information on the major constraints to production of faba bean in their respective countries. Priorities for research were identified and research networks were developed. The proceedings of the workshop will be published.

10. PUBLICATIONS

10.1. Journal Articles

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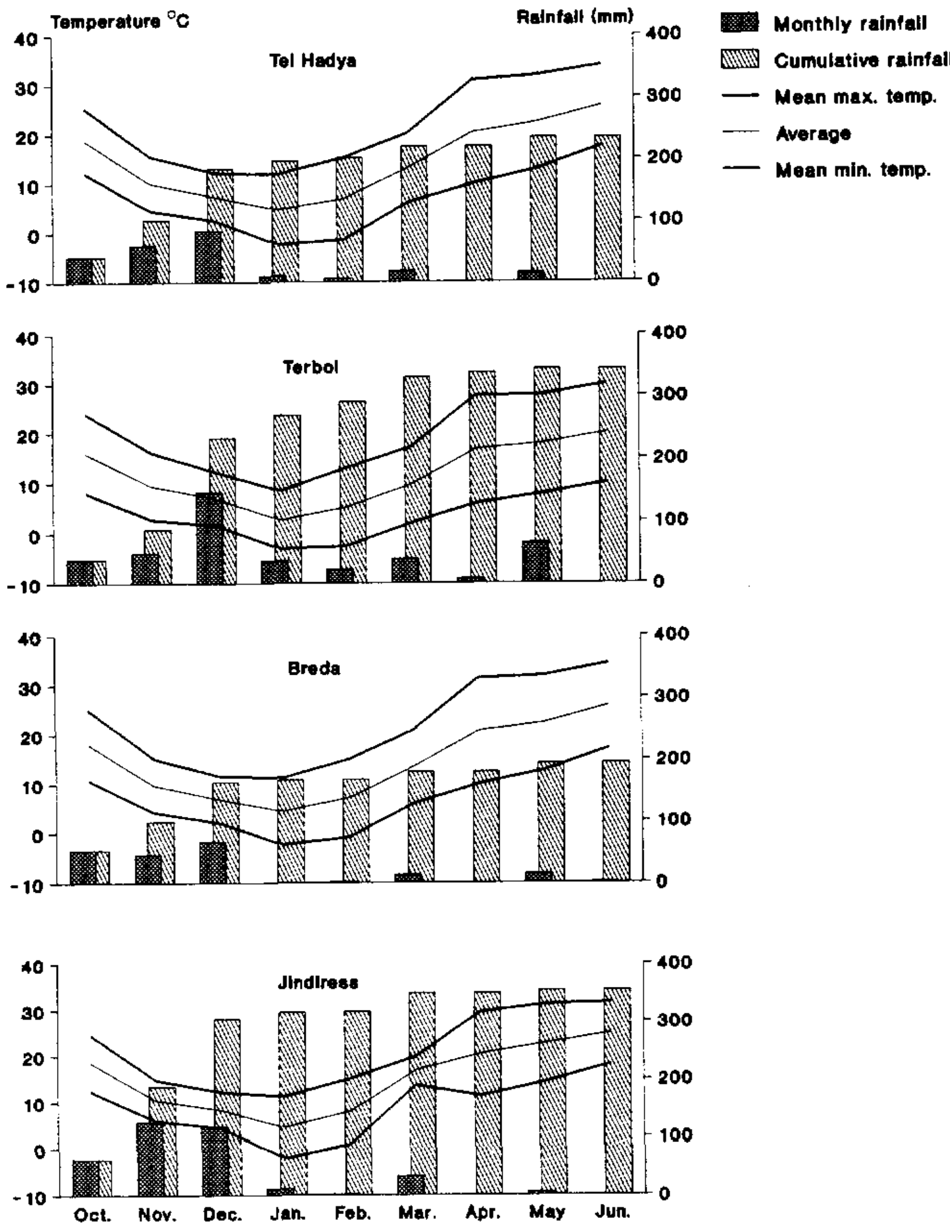
11. WEATHER DATA



12. STAFF LIST

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W. Erskine	Lentil Breeder
S.B. Hanounik	Faba Bean Pathologist (Morocco)
M. Habib Ibrahim	Senior Training Scientist (on sabbatic from August)
L.D. Robertson	Faba Bean Breeder (Morocco)
K.B. Singh	Chickpea Breeder (ICRISAT)
M. Solh	Plant Breeder (Morocco)
S. Weigand	Entomologist
R.S. Malhotra	International Trial Scientist
Geletu Bejiga	Post. Doc. Fellow Chickpea Breeding
K-K. Linke	Post. Doc. Fellow Orobanche (GTZ)
S.N. Silim*	Post. Doc. Fellow Agronomy/Physiology
O. Tahhan	Post. Doc. Fellow Entomology
F. Weigand	Post. Doc. Fellow Pathology
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Stefan Schlingloff	Research Associate
Edwin Weber	Research Associate
Andreas Gross	Visiting Research Associate
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Hasan Al Hasan	Research Assistant
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Gaby Khalaf	Research Assistant
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Diab Ali Raya	Research Technician
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Ahmed Samara	Research Technician (Terbol)
Ziad Sayadi	Research Technician
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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
Kokab Hammoud*	Laboratory Attendant (Lattakia)
Abdullah El Khaled	Store Attendant
Ali Deeb Zahlout*	Guard/Fieldman (Lattakia)

* Left during the year

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