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FOOD LEGUME IMPROVEMENT PROGRAM

Annual Report 1988

FOOD LEGUMES IMPROVEMENT PROGRAM

Annual Report for 1988

International Center For Agricultural Research In the Dry Areas
ICARDA
Box 5466, Aleppo, Syria

FLIP Annual Report

INTRODUCTION

GENERAL

Agriculture in the dry rainfed low altitude areas in West Asia and North Africa (WANA) is dominated by the 'wheat based' and 'barley-livestock' farming systems. In the high altitude areas production systems are similar, although more heavily oriented towards raising livestock and winter cereals. In all these systems, food and forage legumes play an important role in sustaining the productivity of cereals and livestock. Their ability to fix atmospheric nitrogen, to improve soil structure and to serve as a 'break' in the cereal dominated cropping systems are key to the systems' sustainability. In addition, the seeds of the food legumes contribute to dietary protein, particularly for the resource-poor, and to national exports; crop residues are an important livestock feed.

The Food Legumes Improvement Program (FLIP) continued its efforts during 1988 on the improvement of lentil, kabuli chickpea and faba bean because of their importance in the rainfed farming system of WANA - where the three legumes together account for 72% of the total pulse production. Their contrasting adaptations are complementary within the various cropping systems of WANA with faba bean, kabuli chickpea, and lentil in turn being grown under progressively lower rainfall environments.

Research into crop improvement and activities in training and information dissemination were undertaken with a view to enhance the capability of the national programs in WANA, and to encourage and assist them in conducting their own research for improving the productivity and yield stability of lentil, kabuli chickpea and faba bean and in transferring the appropriate technology to their farmers.

Multidisciplinary teams of scientists from FLIP and other Programs worked on specific research projects in each of the three crops, with full involvement of national program scientists wherever possible. The research work on kabuli chickpea was jointly conducted with the International Crops Research Institute for Semi-Arid Tropics (ICRISAT), research on adapting dry peas to the dry rainfed farming systems of the WANA region, under a restricted core grant from the BMZ, Federal Republic of Germany, was also carried out.

The crop improvement research was done at the principal research station of ICARDA at Tel Hadya, as well as at several subsites in northern Syria (Breda, Jinderess, and Lattakia) and Lebanon (Terbol). Weather condition prevailing during the season at each of these sites is depicted in Figures 11.1 to 11.5. In general, the season was wetter than the long-term average at all the test sites. For advancement of breeding material by an additional generation during summer, the high altitude research site of the Jordanian Ministry of Agriculture in Shawbak and the Terbol research station were utilized. Research sites of different national programs were also used for strategic joint research on development of breeding material with specific resistance to various abiotic and biotic stresses. In pursuance of the policy of decentralisation of breeding efforts, activities expanded in the North African Regional Project and the FLIP scientist located at Morocco worked closely with the national programs in Algeria, Morocco and Tunisia and coordinated the activities of this regional network. The

Nile Valley Project on faba bean provided excellent opportunity for net-working to the faba bean researchers in the countries of Egypt, Sudan and Ethiopia as a self reliant group. We worked closely with the national programs in Turkey, Pakistan and Ethiopia in developing a strong local crop improvement effort. Collaboration with several institutions in the industrialised countries in Europe and North America continued for basic research, permitting us to improve the efficiency of our breeding efforts and our understanding of the basis for host resistance to various stress factors. Two new collaborative projects in this category - one dealing with mechanism of resistance in chickpea for leafminer and the other on Orobanche control, were approved by the donors this year, and research work was started.

ACHIEVEMENTS

Some of the highlights of the research, training and networking activities undertaken by FLIP during the 1987/88 season are given below:

Faba bean

Increased focus on development of genetic stocks and early generation material proved successful in increasing the useful variability available to national programs. In Egypt four lines developed from a cross of Giza 3 x ILB 938 are in multiplication for release in the North Delta. A bulk population supplied to Ethiopia has been selected and purified for submission to the variety release committee because of its superiority in yield and seed size. ILB 1814 is in demonstration in Algeria, 80S-44027 in Syria and FLIP 87-26FB in Lebanon. One determinate line (FLIP 84-146FB) has been selected for on-farm testing for intercropping with cotton in China. In Morocco ten lines were selected for verification trials. Other national programs are now using our disease resistance sources in crossing blocks and have received segregating populations for the independent vascular supply trait (IVS) and determinate plant types for local adaptation breeding. Use of faba bean germplasm should increase now that the first pure line (BPL) evaluation catalog has been published and distributed to the national scientists.

Results from local and international testing of our material at more than 25 locations during 1980-87 confirmed the durability of resistance to chocolate spot, ascochyta blight, rust and stem nematode resistance in several lines. Efforts to develop multiple disease resistance have been successful, leading to the identification of several breeding lines with resistance to the complex of diseases prevailing in the major production regions. Sources of resistance to Orobanche crenata and bean leaf-roll virus (BLRV) have been identified.

Studies on host-pathogen interactions revealed the presence of strong inhibitory effects against Botrytis fabae in the phyllosphere of resistant genotypes of faba bean. The effect appears to be a combination of some fungistatic leaf exudates and at least three antagonistic fungi naturally occurring in the phyllosphere of these lines. The use of these antagonists as potential biological control agents suppressed the necrosis due to B. fabae in detached-leaf test on faba bean as effectively as the widely used fungicide vinclozoline.

Growth analysis of determinate faba bean lines, in contrast to the indeterminate lines, revealed that yield was limited due to low total dry matter production because of lower leaf area index. Appearance of late branches was another constraint. Improvement efforts in future should take these aspects in consideration. Both constraints can be partly removed by using plant population levels higher than 40 plants/m^2.

Work on aphids, the most important insect pest of faba bean, was carried out primarily in the Aphid Screening Laboratory in Egypt in collaboration with Egyptian national scientists. A field study of seven breeding lines previously selected for some degree of resistance revealed that one line has traits of tolerance/ resistance and should be further studied. An aphid screening research net-work has been developed covering the Nile Valley Region with a potential link with the North African Regional Program. Considerable progress was made in developing a good understanding of the biology of leafminer and its control through work in the Nile Valley Project in Sudan.

On-farm research in the Nile Valley Project conducted on faba bean has demonstrated the economic feasibility and great potential for improvement in the productivity of faba bean in all the three participating countries - Egypt, Sudan and Ethiopia, through adoption of improved agronomic practices. Based on the success of research efforts in introduction of faba bean in the Gezira area of the Sudan, the Crop Advisory Committee of the Gezira Research Station has recommended to the Gezira Board the incorporation of faba bean in their rotation. The economic analysis of results has shown that faba bean was the most profitable winter crop in Gezira under varying price situations.

Lentil

Lentil yields are generally low because of poor crop management and the low yield potential of land races. In South Asia and East Africa diseases are also a major constraint to production. Accordingly an integrated approach to lentil improvement is being followed covering the development of improved genetic stocks as well as production technology. The breeding work aims to increase biomass yield and remove other limiting factors specific to each of three major agro-ecological regions: Mediterranean low-mid altitude region; high elevation area in Iran and Turkey; and S. Asia and E. Africa. In 1988 a total of 350 single crosses were made to cover specific needs of each of these target areas.

Selections from the breeding program for the Mediterranean region were tested in 17 trials at three rainfed locations differing widely in average rainfall. Progress was reflected by the large number of lines which ranked above the best check or yielded significantly more than the best check.

In addition to the six lentil lines already released by national programs, Mediterranean region national programs have selected lines from international trials for on-farm trials or pre-release multiplication in Algeria, Egypt, Lebanon, Jordan, Morocco, Spain, Syria, Tunisia, and Turkey. In the high elevation region of Iran and Turkey a large-seeded red cotyledon line with cold tolerance allowing winter sowing is in pre-release multiplication with the Turkish program.

In the lower latitude regions of the Indian sub-continent and E.

Africa, rust and Ascochyta blight diseases cause major yield losses. The national programs of Ethiopia and Pakistan have screened for resistance to both diseases in a cooperative program and sources of combined tolerance have been identified.

The most important disease of lentil in the Mediterranean region is vascular wilt, caused by Fusarium oxysporum f.sp. lentis. A study of the effects of temperature and growth media on fungal development indicated optimum growth at 23°C on lentil dextrose agar (LDA). A greenhouse screening method for resistance to wilt has been developed and 29 lines out of 162 screened were found promising.

The economic importance and damage levels of Sitona spp. in lentil were related to rainfall and time of sowing. Early sowing increased damage. Increase in yield because of control of Sitona spp. damage through use of Carbofuran was curvilinearly related to rainfall in the range from 250-700 mm with maximum response occurring at 525 mm. This information will be of help in developing an economic control schedule for Sitona spp.

A survey in Syria for bruchid pest infestation of lentil seed revealed that infestation ranged from 0-38% and the price of the infested seed could drop by 40%. Efficacy of traditional protection methods is being tested to develop safe and practical methods.

A predictive model for the response of time to flower to variation in temperature and photoperiod, developed in an ODA-funded collaborative project with the University of Reading using six contrasting genotypes in controlled environments, was tested on a wide range (240 accessions) of germplasm in glasshouse. The model fitted the data well (r^2=0.915), and can therefore be used for assessing the phenological adaptability of a genotype to different locations.

The adaptation of lentils to rainfed environments in the Mediterranean region was studied and the importance of early to mid-season vigor and early maturity to produce high crop biomass were highlighted. For irrigated Mediterranean environments such as are found in Egypt, considerable genetic variability in response to irrigation was seen and also found heritable. Those genotypes most responsive to irrigation produced interstitial airspaces in their roots as an adaptation.

Since the increasing cost of hand harvest is a major constraint to lentil production in the Mediterranean region, the mechanization of lentil harvest received emphasis in our program. For the harvest of traditional lentil crops with ridges and short, lodging land races, prototype pullers have been developed and tested on farmers' fields. A tractor-mounted, double-knife mower has been extensively tested with national programs on drill-planted farmers' fields giving only 8% seed and 16% straw losses, compensated for by a lower harvest cost than hand harvest. For fields with few stones and good seed bed preparation, harvest by cereal combine is feasible. In Syria 2600 ha were combine harvested by the NARS with part of the area sown to the newly-released line 'Idleb 1' with reduced lodging.

Kabuli chickpea

Emphasis was placed on both winter- and spring-sown kabuli chickpeas. A comparison of the performance of newly bred lines sown during winter and spring for five years (1983/84 to 1987/88) at three test sites differing in seasonal rainfall and thermal regimes revealed that winter-sown chickpeas gave on average 54% higher seed yield than the spring sown crop. The study also confirmed that winter sowing was more advantageous than spring sowing during the years when seasonal precipitation was sub-normal, and its advantage was decreased when the severness of cold increased.

Economic feasibility of winter sowing was assessed on 22 farms in Syria by interviewing farmers and using data from on-farm trials conducted with them on large plots. Winter sowing resulted in an average yield increase of 600 kg/ha (about 50%) compared to spring sown crop and gave nearly 70% more profit.

Algeria, Morocco and Italy released two cultivars each for winter sowing using ICARDA enhanced germplasm. Nine countries (Algeria, Cyprus, France, Jordan, Lebanon, Morocco, Syria, Tunisia and Turkey) identified 37 lines from international nurseries for pre-release increase and/or on-farm trials; thirteen of these cultivars were chosen for spring sowing.

Emphasis in screening germplasm and breeding lines for resistance to Ascochyta blight and cold tolerance continued toward development of stable yielding chickpea genotypes for winter sowing in the Mediterranean region. Lines found tolerant/resistant to Ascochyta blight in field screening are rescreened in plastichouse trials against individual races of differing virulence to identify superior lines. Screening has revealed that few lines are presently available with resistant reaction against race 6 or isolate 'F', two highly aggressive isolates, although a large number of accessions have resistance to more common less aggressive isolates.

In an investigation into the genetic variability in wild species, 137 accessions of eight wild species of Cicer were evaluated for their reaction to various biotic and abiotic stresses. A high level of resistance was observed in some accessions for Ascochyta blight, leafminer, seed beetle and cold and a moderate resistance to cyst nematode. Cytogenetic investigation revealed that all the eight wild species studied had 2n=16 chromosomes and, therefore, any crossing barrier between these and the cultivated species should be because of factors other than chromosome number.

Disease surveys in Algeria, Morocco, Syria and Tunisia revealed that along with Ascochyta blight, Sclerotinia stem rot was observed in winter-sown chickpea in Morocco and Algeria and Fusarium wilt and stunt in the spring sown crop in North Africa. Epidemiological studies confirmed that the Ascochyta blight inoculum could be disseminated by wind and that the length of incubation period at nearly 100% RH determined the severity of disease development in moderately susceptible and resistant genotypes. A miniaturized inoculation technique was developed that ensures precisely controlled duration of incubation. This technique was used to study the role of lignification and phytoalexin accumulation as active defence mechanisms and would be used in future for studying biochemical resistance mechanisms in chickpea to Ascochyta rabiei.

Methods for assessment of population and damage levels for leafminer, the major pest of spring-sown chickpea in the Mediterranean region, were further refined. Of the lines screened this season, 10 rated nearly resistant and deserve further examination.

Studies on drought tolerance using the line-source sprinkler system to vary moisture availability were continued and results confirmed that the method could be used for routine screening. Early flowering and early maturity appeared as the most important attributes for high yield under drought stress.

Studies on supplemental irrigation confirmed the yield advantage occurring from this practice in both spring- and winter-sown chickpea. Genotypic differences in response to supplemental irrigation were detected.

Biological nitrogen fixation

Within the region, defining the necessity for inoculation is an essential component of legume nitrogen fixation research for national programs, as it allows concentration of resources toward inoculum response demonstration only where potential for response exists. In response to this need, we developed a simple methodology which involves yield comparison of symbiotic plants wholly dependent on nitrogen fixed with native rhizobia, and plants fully supplied with nitrogen fertilizer adequate to produce high yield. Regression studies between nitrogen and inoculation responses for the three crops indicated a strong positive correlation over a range of cultivars in multilocation trials (r=0.73, 0.62 and 0.58 for chickpea, lentil and faba bean, respectively), thus validating the methodology.

Strain selection research has yielded sets of highly effective, competitive strains for the three crops, with complimentary antisera for serological identification of strains in field situations. Testing of these strains at ICARDA stations with a wide range of elite germplasm gave a clear indication of the success of the screening program. Seed yield increases due to inoculation were as high as 116% in chickpea, 47% in lentil and 54% in faba bean. Average yield increases across 12 cultivars of each legume species were 13, 14 and 15 percent for chickpea, lentil and faba bean, respectively, with inoculation using best strains. The results indicate a potential role for inoculation of all three crops, even in traditional production areas where high native rhizobial populations exist.

International Food Legume Testing Program (IFLTP)

The IFLTP was developed in response to the needs and requests of national programs for an efficient distribution system of improved genetic material and production practices. In 1988, IFLTP supplied 1223 sets of 45 different types of nurseries on the three crops to cooperators in major production areas both within and outside WANA. Nurseries were targetted to the specific needs of different agroecological regions. From the breeding material disseminated through IFLTP in the past, national programs in Algeria, Ecuador, Italy, Morocco, Sudan and Turkey made their own selections and tested and released, during 1988, a total of eight cultivars of chickpea and three of lentil for use by their farmers. In addition a large number of lines were identified for multi-location trials and pre-release multiplication.

Training and networking

In order to strengthen the research skills in the national programs we continued group-training and individual non-degree training as well as degree training programs at ICARDA during 1987/88. A total of 69 participants utilized these opportunities. Group training included the 'Residential Training Course' as well as specialised short courses on 'Insect Control', 'Disease Methodologies' and 'Lentil Harvest Mechanization'. Individual non-degree and degree training programs covered various subject areas depending upon the specific needs of individuals and NARS.

A major component of our training activity during the 1987/88, season were the 'In-Country Training Courses', some of which were regional in nature. Thus we assisted in-country training in Tunisia and Turkey on 'Hybridization Techniques', in Morocco on 'Field Experimentation', in Ethiopia on 'On-farm Trial Methodology' and in Ecuador and Colombia, in collaboration with the Regional Program for Improvement of Food Legumes in the Andean Countries (PROCIANDINO), on 'Food Legume Improvement Methods'. These in-country courses included 101 participants and mostly national scientists served as instructors.

To increase the interaction between the food legume scientists within WANA and outside we organized two meetings. The 'West Asian Seminar on Food Legumes' was held at Aleppo, 2-5 May, 1988. A 'Workshop on Role of Legumes in the Farming Systems of Mediterranean Areas' was held at Tunis, Tunisia, 20-24 June, 1988, in collaboration with the Pasture, Forage and Livestock Improvement Program.

LOOKING AHEAD

In partnership with the national programs, we aim at a sustainable increase in the production of cool season food legumes and an enhancement in the contribution of these and other legumes to sustainable production of cereal and livestock in the farming systems in the dry rainfed areas of WANA. While developing medium-term plans to achieve this we are taking full cognizance of the CGIAR recommendations with respect to shifts in research thrust on faba bean and on studying the potential pay-off from future investment in lentil research.

The strategy we have adopted for achievment of our objective necessitates strengthening of our strategic research, development and consolidation of collaborative networks and strengthening of national program capability in research and in transfer of technology to farmers through joint research and training. Strategic research will be directed to (a) increase yield potential, (b) narrow the gap between potential yield and farm yields, (c) improve sustainability of yield, and defend against erosion of by pests and pathogens, and (d) sustain cereal and livestock production in the farming systems.

As recommended by CGIAR we will transfer the faba bean improvement research from ICARDA to Morocco and conduct it as a special project with the national programs in the North African region, ensuring that research gains made so far in faba bean improvement are not lost and that the concerned national programs take the main responsibility for carrying that through. We will encourage development of regional net-works of scientists to share their breeding material and research methodologies for faba bean improvement and assist them with training and information dissemination.

Breeding efforts at ICARDA headquarters will see a gradual reduction in the production of cultivars as this will increasingly be done by the national programs with growing decentralization of breeding efforts and development of regional networks. Thus greater efforts will be devoted to development of more efficient breeding methodologies and screening techniques. Research on abiotic stresses will increase and will compliment breeding for improved plant architecture and resistance to pests and disease; efforts will be increasingly directed to the development of parental material and early generation segregating populations with combinations for desirable traits and stress resistance. Collaboration with centers of excellence in the industrialized countries will be used for developing novel crop improvement techniques and for understanding basis for stress tolerance, to assist crop improvement efforts. Superior biological nitrogen fixation technology for transfer to the national programs will be developed and the effects of new legume technology on the cereal and livestock phase of the system will be studied with a view to increase the sustainability of the farming systems. Nitrogen balance studies will be a key component in this research.

Efforts in training will aim to facilitate and support national programs in becoming more self reliant in crop improvement research. Emphasis will shift from residential general courses to short, subject-specific courses at ICARDA. General, production oriented training will be done through in-country and sub-regional courses away from the headquarters. Using the links with the Universities within the region and in the industrialised countries, degree related training programs will be encouraged.

1. FABA BEAN IMPROVEMENT

Faba bean is predominately grown in wheat-based farming systems in the WANA region, mainly in medium rainfall environments (above 450 mm). Research efforts were assigned to development of genotypes and production and plant protection techniques to address the constraints limiting faba bean production in this farming system. The goal of faba bean improvement research has been to make it more competitive with other crops, thereby halting the decline in faba bean area over the past twenty years. With faba bean as a more appealing alternative to continuous cereals a more sustainable farming system could be developed in the medium rainfall areas of WANA. Improvement research focused on stabilizing yield through resistance to major pests (Orobanche, chocolate spot, rust, and Ascochyta blight) and to improve plant response to productive environments through altering the plant type. Rhizobium research concentrated on defining the need to inoculate in the region and development of superior strains for use where needed.

ICARDA is taking steps to fully implement the decision of the Consultative Group on International Agricultural Research (CGIAR) to phase-out core faba bean research activities and transferring the work to a North African National Program Base using special project funding. A project proposal has been drafted and is to be submitted to donors for funding. Core activity on faba bean research will be completely phased out by the end of 1991, except that collection, conservation, evaluation and distribution of germplasm will be continued in the Genetic Resources Unit and dissemination of infomation through the Scientific and Technical Information Unit. Remaining core activity in the interim period will be to ensure a smooth transfer of research to a special project in North Africa (Morocco). The shift to North Africa of faba bean improvement research that is being implemented is shown in Fig. 1.1.1.

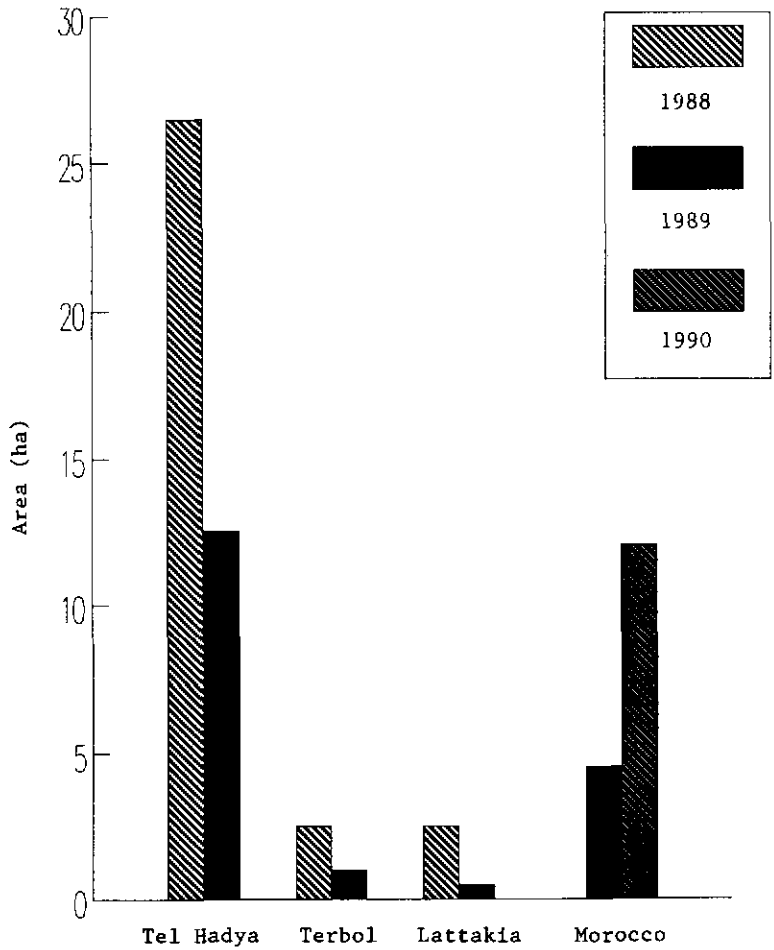

Figure 1.1.1. Shift in area used for faba bean research from West Asia (Tel Hadya, Terbol, and Lattakia) to national program sites in Morocco.

1.1. 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. 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.

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.

1.1.1. 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. In Egypt ILB 1270 is in pre-release multiplication and 400 kg of ILB 1814 has been given to both Iraq and Chile for multiplication for release. All of these were selected because of large seed size for vegetable use.

In Syria 80S 44027 has been selected for on-farm trials and will be tested along with FLIP 84-239FB, a determinate line. In Algeria ILB 1269 has been selected for demonstration plots and in China FLIP 86-146FB, a determinate line, has been selected for on-farm trials in a cotton intercropping system. In Morocco ten lines were selected for verification trials and in Jordan and Lebanon several lines are in the second year of testing in on-farm trials. Additionally, seed of 58 lines selected by national programs from the International Testing Network was provided for further multi-locational testing. A summary of the use of ICARDA lines for multi-locational, on-farm, verification trials, and demonstration plots is given in Table 1.1.1.

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 because of lack of wide adaptability in faba bean. With the transfer of faba bean improvement to a specially funded project, the pace of this change will hasten.

Table 1.1.1. Use of ICARDA lines by National Programs.

Country	Line	Use
Algeria	ILB 1269 25 lines	On-Farm Trials Multi-location testing
Chile	ILB 1814	For large scale pre-release multiplication
China	FLIP 86-146FB[1] 22 lines	On-Farm Trials Multi-location testing
Egypt	ILB 1270	Pre-release multiplication
Ethiopia	74TA 12050 x 74TA 236	Purified for submission to variety release committee
Iran	ILB 1269	Released as 'Barakat'
Iraq	ILB 1814	Large scale demonstration, pre-release multiplication
	79S4	Pre-release multiplication
	8 lines	On-Farm Trials
Jordan	FLIP 86-146FB[1] FLIP 87-136FB FLIP 87-138FB	On-Farm Trial
Lebanon	FLIP 87-26FB	On-Farm Trial
Morocco	80S 44027, 74TA 22 FLIP 87-140, 141, 142FB FLIP 84-127, 128FB FLIP 82-30FB B87238, B87253	Verification Trials
Syria	80S44027, FLIP 84-239FB[1]	On-Farm Trial
Tunisia	FLIP 83-89FB, 74TA 22, 80S43238	Multi-location testing

[1] Determinate line.

Resistance to pests constitutes the bulk of specific requests of national programs, namely, resistance to Orobanche, chocolate spot, stem nematodes, ascochyta blight, and rust. Egypt has used ILB 938, a disease resistance source, for production of four lines which are to be released with resistance to chocolate spot and rust (Table 1.1.2.). Segregating material "pre-selected" for resistance, only, is now being provided to national programs. In 1988 segregating nurseries for chocolate spot and for ascochyta blight were provided through the International Testing Network.

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 1.1.2.). In 1988 F_3 populations with the IVS (independent vascular supply) trait have been supplied to China, Egypt, Sudan, and Morocco at their request. Populations of crosses between Sudanese and Chinese lines have been provided to both countries and are beneficial in increasing the variability available to both. In Ethiopia, one bulk population from cross 74TA 12050 x 74TA 236 has been purified for submission to the variety release committee. This population has the advantage of higher yield and larger seed size.

The main emphasis in faba bean breeding in the coming years will be on producing enhanced germplasm for NARSs and following through with visits to national programs to assist and work with colleagues there in exploiting the full potential of the enhanced germplasm.

Dr. L.D. Robertson.

Table 1.1.2. Use of ICARDA germplasm, resistance sources, populations, and early generation lines by National Programs in 1987 and 1988.

Year	Country	No. of lines/crosses	Type of material
1987	Morocco	200	F_2 populations and F_3 derived progenies
1987	Tunisia	195	Lines for PSN-disease resistant
1982-1988	Egypt	1	ILB 938 used with crosses to develop disease resistant varieties
1987	Egypt	1250	BPL's - aphid screening
1988	China	617,33	F_3 progenies; F_3 Bulks Chinese x Disease resist.; IVS, deter. populations and progenies
1988	Egypt	600	BPL's - aphid screening
1988	Egypt	200	Early generation lines for screening
1988	Egypt	19	F_2 populations - IVS
1980-1988	Ethiopia	1	74TA 12050 x 74TA 236, cross bulk purified for variety release
1988	Sudan	19	F_2 populations - IVS
1988	Sudan	10	F_2 populations Chinese x Sudanese-earliness
1988	Tunisia	190	Lines for disease screening nursery

1.1.2. 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 was done on screening F_2 populations so as to produce "pre-selected" F_4 populations for distribution for disease resistance selection and for selection for F_3 to F_6 progenies with disease resistance and yield for use in the breeding program.

1.1.2.1. Development of pure line collection

The faba bean germplasm collection at ICARDA is maintained in two different forms. The first is the ILB collection which comprises the original germplasm accessions as received (usually heterogenous, heterozygous populations), and is handled by the Genetic Resources Unit. The other collection is a set of inbred lines developed from the ILB collection. These BPL accessions are derived by a process of selfing and selection and single plant progenies to produce inbred line sources for use in the breeding program. In the future this will also be handled by the Genetic Resources Unit.

A catalog was published in 1988 listing information for 43 descriptors of 840 BPL accessions. This catalog includes a statistical summary of each evaluation descriptor, and histograms for variables with continuous variation. For important morphological and agronomic characters, a listing of accessions at the upper and/or lower extremes is given. A correlation matrix is included for assisting in querying the database. Analysis by country of origin is also presented.

Although pod length, 100-seed weight, and seed yield were correlated with each other, there was, surpisingly, no relationship between pods per plant and seed yield. Even though the relationship between seed yield and 100-seed weight is high (r=0.68**), "correlation breakers" such as BPL 787 from Afghanistan with a seed yield of 6100 kg/ha and a 100-seed weight of only 56g can be found. Analysis by country of origin revealed that Egyptian accessions combined earliness, high yield, medium seed size and the highest autofertility (a ratio of seeds without tripping/seeds with tripping of flowers, SI = 0.99).

This database is in computerized form and customized searches for accessions combining several characteristics can be made upon request.

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

1.1.2.2. Germplasm for disease resistance

1.1.2.2.1. Orobanche crenata

Broomrape (Orobanche crenata) is considered to be the most important limiting factor in faba bean production throughout North Africa. With the planned transfer of faba bean improvement research to North Africa, 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 INIA06) x F402 were screened at Lattakia. In general, these progenies expressed more resistance to Orobanche than previously seen. Three of these progenies showed very uniform resistance to Orobanche compared to the local checks in adjacent rows which were killed. Additionally, one F402 selection over several cycles at Aleppo and Lattakia showed a similar resistance. From the (F402 x INIA06) x F402 progenies 100 single plant selections were made for screening next year at Douyet, Morocco. These progenies were selected originally by Drs. J.I. Cubero and L. Hernandez at Cordoba, Spain.

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

1.1.2.2.2. 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, 450 BPL accessions have been screened for BLRV resistance and 250 BPL accessions for BYMV resistance. No resistance has been found for BLRV, however, four BPL's were found with moderate resistance to BYMV. 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. Twelve crosses were made between these BPL's and Sudanese material for use in Sudan where BYMV can be devastating in some years.

Drs. K. Makkouk and L.D. Robertson.

1.1.2.3. Development of disease-resistant inbred lines

In the 1987/88 season the inbred collections for chocolate spot, ascochyta blight, rust, and stem nematode were increased under mesh-covered screenhouses 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 1.1.3.). These selections will be evaluated for agronomic and morphological traits in 1988/89 in a germplasm evaluation trial to improve the usefulness for use by national programs.

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

Table 1.1.3. 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.

1.1.2.4. Recombination of disease resistance with local adaptation

At Tel Hadya 42 crosses were made with local germplasm from China, Morocco, Tunisia, and Sudan to recombine with disease resistance sources. Distribution of this material can be seen in Table 1.1.2.

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1.1.3. Development of improved cultivars and genetic stocks for wheat-based farming 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 requirements 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 for animal feed. To be competitive with other crops in this farming system faba bean has to have high and stable yield. This necessitates genotypes with resistance to Orobanche crenata, Botrytis fabae, Ditylenchus dipsaci, Ascochyta fabae, and Uromyces fabae. Emphasis was therefore placed on developing such germplasm, and for 1987/88 most crosses involved at least one pest resistant parent.

1.1.3.1. Yield potential of indeterminate faba bean

The breeding program that has been followed at ICARDA for faba bean and its linkage with the National Programs is schematically presented in Figure 1.1.2. This scheme has made use of an off-season nursery at Shawbak, Jordan for F_1 crosses and F_4 progeny rows resulting in a two year time saving. Brassica napus was used to prevent outcrossing for segregating populations, progeny rows, preliminary screening nurseries (PSN), and preliminary yield trials. Single plant selections were made within the F_2 populations (at Tel Hadya for plant type and at Lattakia for disease resistance) and F_3 progeny rows were grown where selections were made for yield, frost resistance and disease resistance. These selections were grown in Lattakia as F_4 progeny rows where selections were made for increase for preliminary screening nursery (PSN). Lines

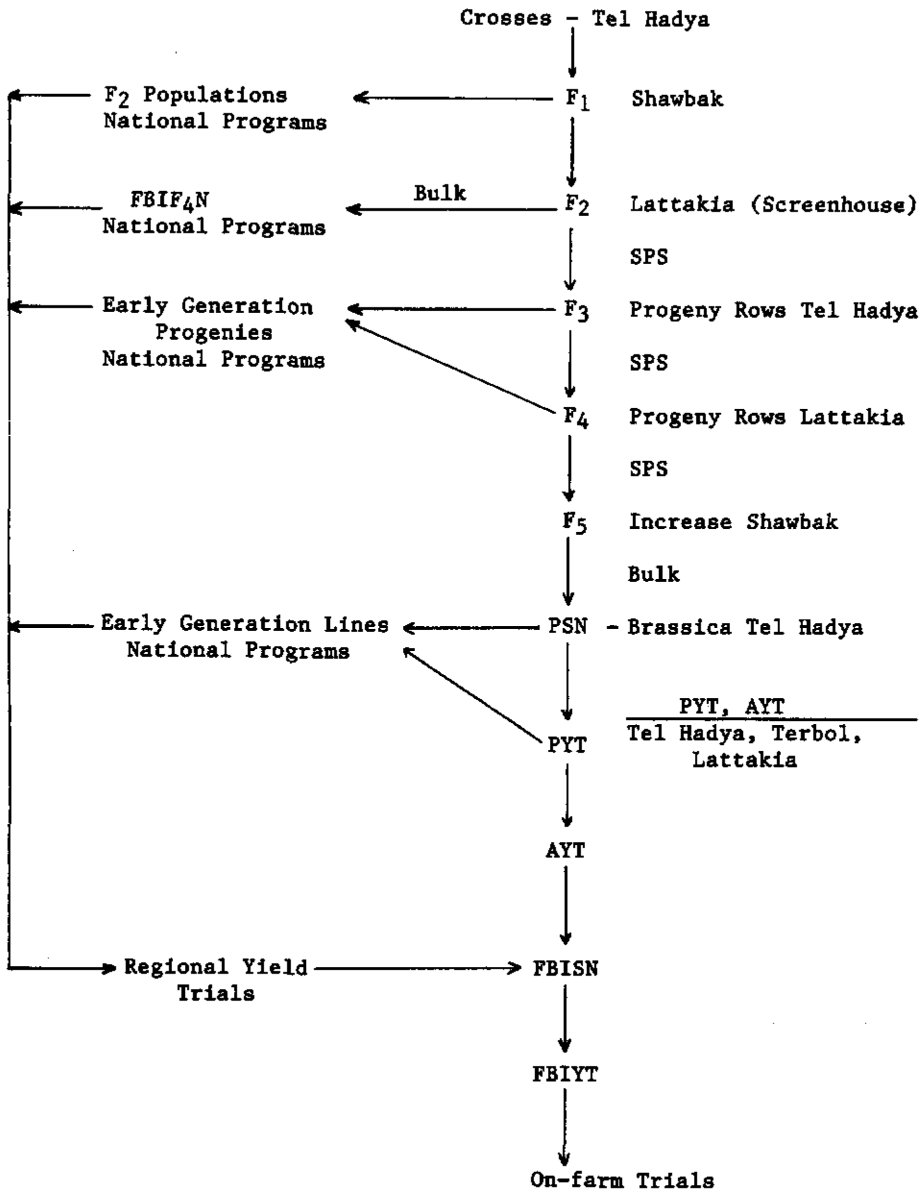

Figure 1.1.2. The Faba Bean Breeding Program at ICARDA.

were then advanced through PSN's and preliminary, advanced, and international trials using multilocation testing.

With the move to a special project in Morocco, breeding activity will concentrate more in generating variability for national breeders and working with them to make better use of this variability. Therefore, the majority of the steps in the breeding scheme will be transferred after the early stages to national programs. Research will concentrate on back-stopping national programs on strategic issues such as alternative plant types, inheritance of pest resistances, breeding methodologies, etc.

Replicated yield trials of 362 lines were conducted at Tel Hadya (Table 1.1.4.). The highest seed yield in the 1987/88 season was 5.1 t/ha compared to 5.8 t/ha in the 1986/87 season. 116 entries exceeded the best check (or best small seeded check in small seeded trials) and 13 of these were significantly better than the check at the 5% probability level.

At Terbol, Lebanon, a total of 362 lines were yield tested in the 1987/88 season with the highest yield of 4.2 t/ha (Table 1.1.5.). 177 lines outyielded the best check (or best small seeded check in small seed trials) with 10 lines significantly better at the 5% probability level.

Because of the importance as vegetable, green pod yield was measured in the large seeded yield trials. The highest vegetable yield recorded was 31 t/ha at Terbol. In replicated yield trials of 208 lines at Tel Hadya and Terbol, 87 lines exceeded the check, nine significantly at the 5% probability level (Table 1.1.6).

Table 1.1.4. Results of faba bean yield trials grown at Tel Hadya, 1987/88.

Trial	No. of test entries	No. of lines exceeding best check: Total	No. of lines exceeding best check: Significantly (P=0.05)	Grain yield (t/ha): Trial mean	Best line mean	Best check mean	L.S.D. check vs. line (P=0.05)	C.V. (%)	Checks
FBIYT-L	23	19	0	4.26	5.07	3.95	1.136	16.2	ILB 1814
FBIYT-S	23	21	4	3.69	4.67	3.17	0.950	15.7	ILB 1814
FBISN-L[1]	36	10	0	2.85	4.10	3.18	1.296	28.0	ILB 1814, ILB 1270
FBISN-S[1]	36	11	0	3.24	4.24	3.45	1.265	24.0	ILB 1814, ILB 1270
AYT-L	45	7	0	3.48	4.72	3.85	1.282	22.7	ILB 1814, ILB 1817
AYT-S	45	15(36)[a]	0(2)[a]	3.21	4.40	3.35(2.88)[b]	1.201	23.0	ILB 1814, ILB 1816
PYT-L	77	23	0	3.94	5.04	4.13	1.119	17.8	ILB 1814, ILB 1817
PYT-S	77	10(61)[a]	0(7)[a]	3.22	4.45	3.86(2.70)[b]	1.307	25.4	ILB 1814, ILB 1816

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.

Table 1.1.5. Results of faba bean yield trials grown at Terbol, 1987/88.

Trial	No. of test entries	No. of lines exceeding best check: Total	No. of lines exceeding best check: Significantly (P=0.05)	Grain yield (t/ha): Trial mean	Grain yield (t/ha): Best line mean	Grain yield (t/ha): Best check mean	Grain yield (t/ha): L.S.D. check vs. line (P=0.05)	Grain yield (t/ha): C.V. (%)	Checks
FBIYT-L	23	12	0	2.90	3.22	2.96	0.617	13.0	ILB 1814
FBIYT-S	23	19	3	2.63	3.13	2.46	0.588	13.6	ILB 1814
FBISN-L[1]	36	2	0	2.94	3.29	3.26	0.617	12.9	ILB 1814, ILB 1270
FBISN-S[1]	36	25	0	2.95	3.48	2.78	0.760	15.9	ILB 1814, ILB 1270
AYT-L	45	18	0	2.95	3.57	2.98	0.698	14.6	ILB 1814, ILB 1817
AYT-S	45	31	1	3.35	4.16	3.28	0.747	13.7	ILB 1814, ILB 1816
PYT-L	77	15	0	2.73	3.38	2.93	0.542	12.4	ILB 1814, ILB 1817
PYT-S	77	5(55)	0(7)	2.90	3.71	3.42(2.72)[b]	0.561	12.1	ILB 1814, ILB 1816

[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.

Table 1.1.6. Vegetable yields of large seeded faba bean yield trials grown at Tel Hadya and Terbol, 1987/88.

Trial	Location	No. of test entries	No. of lines exceeding best check		Grain yield (t/ha)					Checks
			Total	significantly (P=0.05)	Trial mean	Best line mean	Best check mean	L.S.D. check vs. line (P=0.05)	C.V. (%)	
FBIYT-L	Tel Hadya	23	5	0	20.92	30.38	22.59	7.920	23.0	ILB 1814
FBIYT-L[1]	Terbol	23	0	0	19.39	27.19	27.19	4.147	13.0	ILB 1814
FBISN-L[1]	Tel Hadya	36	3	0	23.22	31.09	28.02	8.148	21.6	ILB 1814, ILB 1270
FBISN-L[1]	Terbol	36	34	9	20.00	24.52	17.15	4.408	13.5	ILB 1814, ILB 1270
AYT-L	Tel Hadya	45	22	0	24.38	29.74	24.69	7.160	18.1	ILB 1814, ILB 1817
AYT-L	Terbol	45	23	0	24.75	30.34	24.72	5.923	14.7	ILB 1814, ILB 1817

[1] Results of replicated trial

Table 1.1.7. Coefficient of correlation of dry seed yield with green vegetable yield at Tel Hadya and Terbol.

Trial	Location	
	Tel Hadya	Terbol
FBIYT-L	0.51*	0.50*
FBISN-L	0.18	0.30
AYT-L	0.10	0.34

* Singificant at P = 0.05

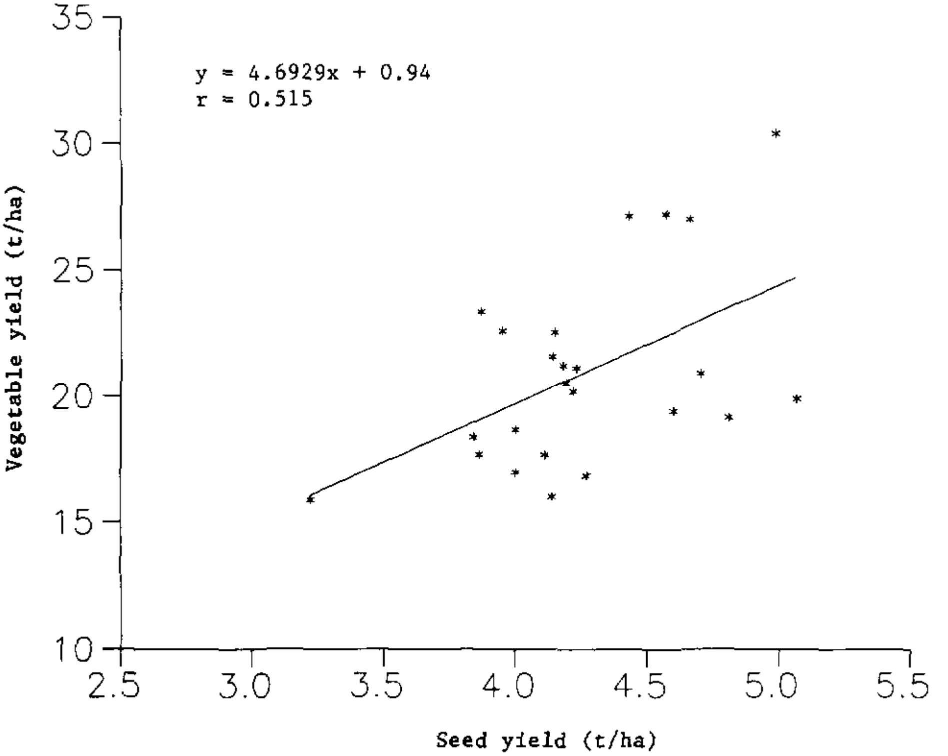

Figure 1.1.3. Relationship of vegetable yield and seed yield in faba bean in the FBIYT-L at Tel Hadya, 1987/88.

Correlations of green vegetable yields with dry seed yields were non-significant in four of six trials at Tel Hadya and Terbol (Table 1.1.7.). Only in the FBIYT-L trial was the correlation significant, at both Tel Hadya and Terbol (Figure 1.1.3.), but the result even in this case still leads to low predictive value. This has implications in selection for green vegetable yields as in many cases the green vegetable yield is more important then dry seed yield. One reason for the significant correlation in the FBIYT-L may be that it includes many lines directly derived from landraces long developed for green vegetable yield, whereas the other trials include mostly lines recently developed from crosses and selected at ICARDA based on dry seed yield only.

The top seven lines for green vegetable and the top seven lines for dry seed yield in the FBAYT-L at Tel Hadya are given in Table 1.1.8. Only three lines of the 12 given, combine top yields for both dry seed and green vegetable. From this and the correlations (Figure 1.1.4) it can be seen that selection for dry seed yield will not necessarily allow the best green vegetable types to be selected.

Table 1.1.8. Vegetable and dry seed yield of some entries in the AYT-L trial at Tel Hadya, 1987/88.

	Yield (t/ha)	
Line	Dry Seed	Vegetable
FLIP 87-24FB	3.43	29.74
FLIP 87-28FB	3.05	29.74
FLIP 87-10FB	4.11	29.71
FLIP 87-17FB	4.72	29.59
FLIP 87-4FB	3.43	29.19
FLIP 87-13FB	3.29	29.15
FLIP 87-18FB	3.26	29.09
FLIP 87-34FB	4.21	25.81
FLIP 87-22FB	4.10	28.06
FLIP 87-38FB	4.00	22.88
FLIP 87-36FB	4.00	25.57
FLIP 87-16FB	3.88	23.56
ILB 1817	3.58	24.69
ILB 1814	3.85	17.00
LSD (P=0.05)	1.282	7.160

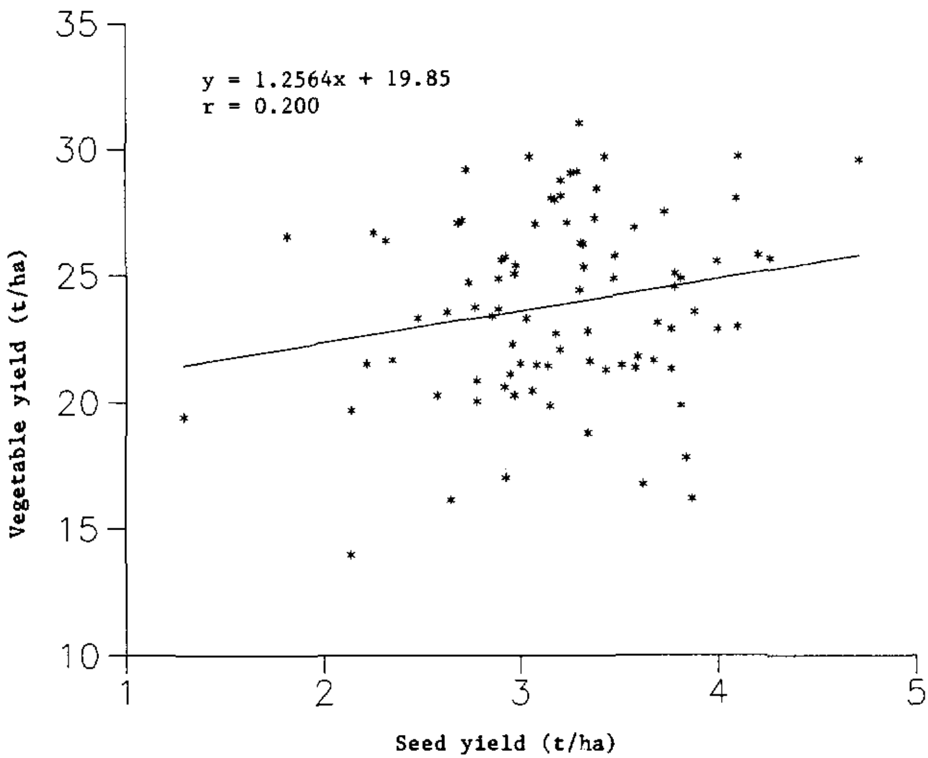

Figure 1.1.4. Relationship of vegetable yield and seed yield in faba bean in the FBAYT-L at Tel Hadya, 1987/88.

However, it is possible to find lines with high green vegetable yield and dry seed yield, for example FLIP 87-17FB gave a dry seed yield of 4.7 t/ha and a green vegetable yield of 29.6 t/ha. In general, however, the correlation of green vegetable yield with dry seed yield is low as exemplified by FLIP 87-24FB and FLIP 87-34FB.

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1.1.3.2. Segregating populations

This year 1814 single plant selections (SPS) were made in 198 F_2 populations for the determinate plant type and 846 selections were made in 35 F_2 populations for the IVS type using Brassica isolation. Most of these will go as F_3 progeny rows at Lattakia for disease resistance selection. In 1218 F_3 and F_4 progeny rows of determinate type, 400 SPS were made for F_4 progeny rows and PSN'S. In 870 F_3 progeny rows from F_2 selections made for disease resistance at Lattakia, 731 selections based on yield were made to send to Lattakia for a second cycle of disease resistance selection.

Also 1478 SPS were made for chocolate spot and 365 for ascochyta blight resistance at Lattakia in 230 F_2 populations. 1458 SPS for chocolate spot and 1160 selections for ascochyta blight resistance were made in F_3, F_4 and F_5 progenies, including the determinate and IVS types. These selections are being taken both to Tel Hadya and to Morocco in the 1988/89 season.

At Tel Hadya 140 SPS for the closed flower type were made in F_2 populations and 67 selections in F_3 progeny rows. These were grown in the offseason nursery at Shawbak, Jordan and were reselected for tightly closed flowers.

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1.1.4. Development of alternative plant type and breeding methodology.

1.1.4.1. Determinate faba bean genetic stocks

The determinate habit is of potential importance in faba bean production areas which are either irrigated or are highly fertile. Its use will curtail 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. Crosses involving at least one determinate parent numbered 108 this season. These were increased in the offseason and F_2 populations will be screened for determinate plants in the 1988/89 season. Emphasis was given to developing disease resistant determinate lines as this was one of the major drawbacks of the original determinate mutant.

Replicated yield trials were conducted with 187 lines at Tel Hadya, Lattakia, and Terbol. The best determinate line yielded 3.74 t/ha. The yield of the original mutant averaged 1.15 t/ha over the three sites versus 2.03 t/ha for all developed determinate lines.

Results reported back from eleven locations of the FBIYT-Det.-88 were analyzed by the Eberhart and Russell method for stability. From this analysis the F-values for linear and non-linear portions of genotype by environment interaction were non-significant, indicating that the determinate lines had average stability ($b=1$) and that they were predictable (non-significant deviations from regression).

In 1988 a new nursery of segregating populations "pre-selected" for determinacy was distributed through the International Nursery Network.

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1.1.4.2. Independent vascular supply stocks

These are lines where each flower in a raceme has an independent vascular supply (IVS), so that many more flowers in a raceme produce pods and flower shedding is greatly reduced. Until now this work has been hampered because of the poor adaptation of the source of this trait. F_2 populations were very late and few selections could be made. However, now a new source based on Sudanese Triple White has been used and the populations so developed are better adapted. This year 846 single plant selections were made from 35 F_2 populations. Major work is being carried out to incorporate earliness, disease resistance and larger seed size in the IVS background.

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1.1.4.3. Closed flower

This type has a closed flower with no scent and nectar. With tightly closed flower, outcrossing can be as low as 5%. The original stocks received were heterogenous and varied for the degree of tightness of closed flower. These have been selected for uniform tightly closed flowers and used in the crossing program. This year 140 single plant selections were made in 5 F_2 populations for closed flower and these were grown as F_3 progenies in the off-season and re-selected for closed flower.

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1.1.4.4. Efficiency of lattice design

In a breeding program the ability to distinguish mean differences is important for selection. This is influenced by (a) the experimental error and (b) the number of replications used. In most cases the ability to increase replications is limited. Therefore, the way a breeder can increase the ability to distinguish mean differences is to reduce error. The most common way to do this is to control variation within blocks. Breeders of most crops use some type of lattice to reduce experimental error when testing yield of many lines. In 1986, 1987, and 1988 at Tel Hadya, Lattakia and Terbol, 64 faba bean breeding trials were grown in simple and triple lattices. The majority of these trials were with 49 to 121 entries. The average relative efficiency over years and locations was 134%. In terms of the least significant difference (L.S.D.) for mean differences, a breeder could get the same L.S.D. using a triple lattice as he would with four replications of a randomised block design (RBD). Figure 1.1.5. illustrates the relative efficiency of lattices over RBD's for the three years and three locations.

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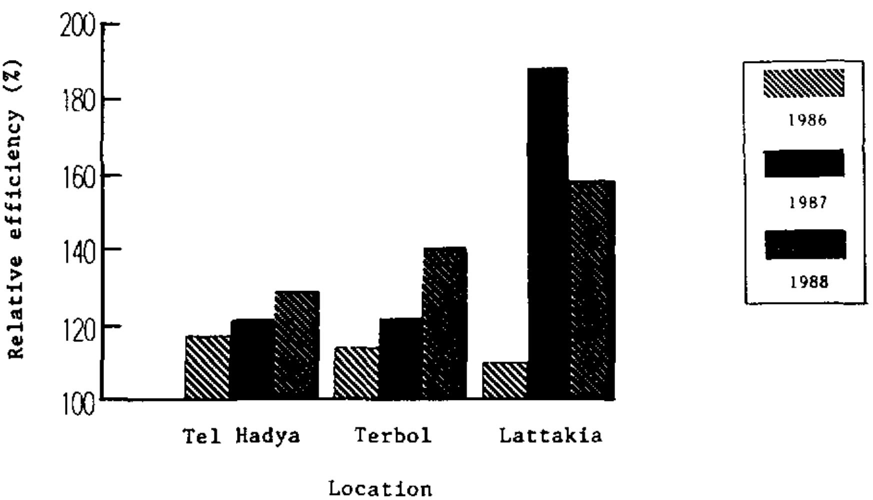

Figure 1.1.5. Relative efficiency of the lattice design over the randomized complete block design at Tel Hadya, Terbol, and Lattakia for the 1986, 1987 and 1988.

1.2. Faba Bean Diseases

1.2.1. Mechanisms of resistance to Botrytis fabae

Although studies on host-pathogen interactions indicated that the invasion of faba bean cells by B. fabae and B. cinerea activates the production of high levels of phytoalexins, reports concerning passive mechanisms of resistance that occur in the phyllosphere, before the invasion of leaf tissue, are fragmentary. Such studies were made, in the past, mostly with B. cinerea, in the absence of host resistance.

Results from our 1985 and 1986 experiments revealed that leaflet washings from chocolate spot-resistant lines suppressed significantly spore germination and germtube development of B. fabae, compared to those from susceptible lines. These inhibitory effects indicated the presence of water soluble, antagonistic substances, that may have their origin in the host and/or epiphytic microorganisms occurring naturally in the phyllosphere of leaves. These substances seemed to govern important passive mechanims of resistance before the penetration of the pathogen into leaf tissues. In 1987, additional experiments were conducted to compare the inhibitory effects of different components in the phylloshphere of faba bean leaves.

1.2.1.1. The whole phyllosphere effects

Healthy and physiologically uniform leaves, at the fifth and sixth node positions, were detached from the chocolate spot-resistant faba bean lines BPL 1179 and 261, and from the susceptible line R-40, grown in the field. Fifty leaflets per lines were submerged side by side, with petioles up in sterilized 100 ml-beaker containing 80 ml of distilled water. They were then incubated at 20^oC for 48 hr to enhance the leakage of leaflet diffusates and to help the production of possible antagonistic metabolites by epiphytic micro-organisms that may occur on leaflet surface.

After incubation, beakers were shaken carefully in a circular direction, for five min, to help bring extraneous substances, leaflet diffusates and epiphytic micro-organisms and their by-products from the surface of immersed leaflets into distilled water. Leaflets were then removed and the water remaining in the beaker was used to prepare a spore suspension containing 500,000 spores of B. fabae per ml of water. Spore suspensions with materials from the phyllosphere of leaflets of different lines were plated separately on PDA (potato-dextrose-agar) medium, incubated for 36 hrs at 20^oC and the percent spore germination and length of germtube were measured under the microscope. A spore suspension in distilled sterilized water was plated on PDA as a check. A complete randomized block design with four replicates was employed.

The results of this test (Fig. 1.2.1) indicated that materials from the phyllosphere of the resistant lines (BPL 261 and 1179) suppressed significantly (P = 1%) spore germination and germtube development of B. fabae, compared to materials from the phyllosphere of the susceptible line (R40) or water.

1.2.1.2. Effects of leaflet diffusates alone

The first experiment showed the combined effects of different components of the phyllosphere on B. fabae. The second experiment was conducted using leaflets from plants grown under gnotobiotic conditions

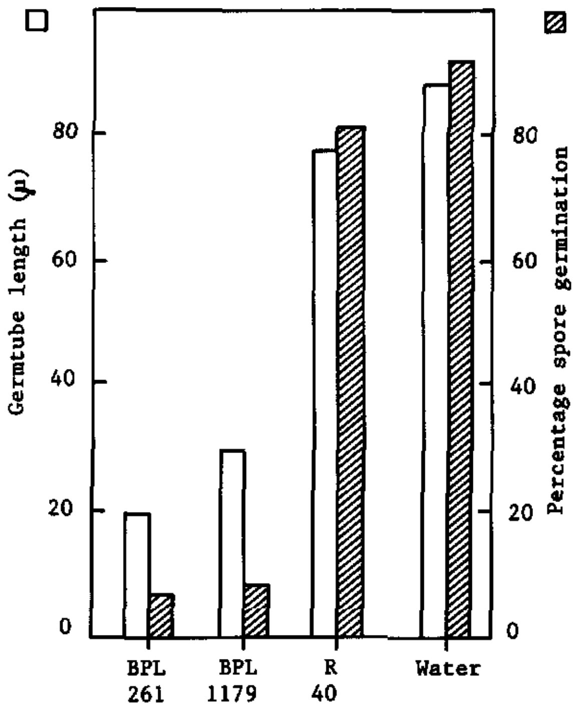

Fig. 1.2.1. Effect of different water soluble components in the phyllosphere of chocolate spot resistant (BPL 261 and BPL 1179) and susceptible (R 40) faba bean lines on spore germination and germtube length of Botrytis fabae.

to study the effects of leaflet diffusates alone against B. fabae. Checks were made to confirm that no contamination of any sort occurred during the whole experiment.

At the end of 92 days of growth, physiologically uniform leaves were detached from the faba bean lines BPL 261, BPL 1179 and R40. Twenty five leaflets per line were used to study the effects of leaflet diffusates alone on spore germination and germtube development of B.

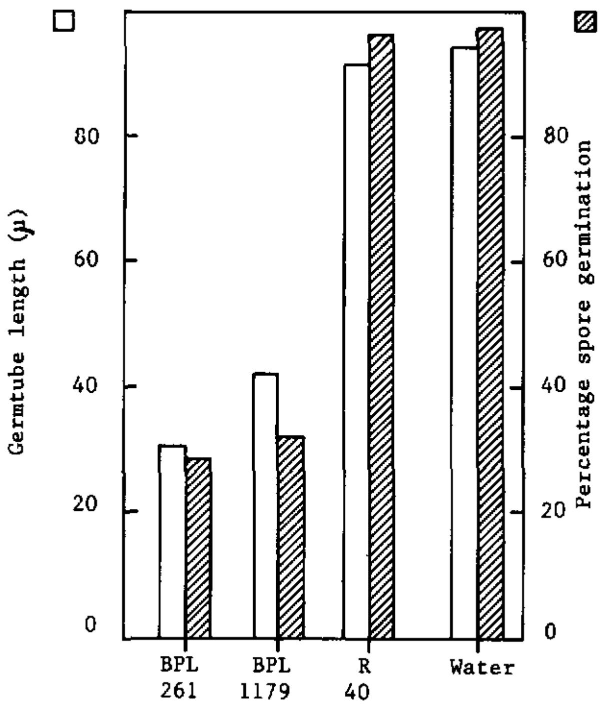

Fig. 1.2.2. Effect of leaflet diffusates from the chocolate spot resistance (BPL 261 and BPL 1179) and susceptible (R40) faba bean lines on the spore germination and germtube growth of Botrytis fabae.

faba, as described earlier. A complete randomized block design with four replicates per treatment was employed.

The results of this test are shown in Fig. 1.2.2. Materials from the phyllosphere of the resistant lines BPL 261 and 1179 were significantly (P = 1%) more inhibitory against B. fabae compared to materials from the phylloshphere of the susceptible line R40. These effects, however, were less dramatic than those obtained with materials from the phyllosphere of plants grown in the field (Fig. 1.2.1).

Therefore, it appears that the removal of naturally occrring extraneous substances and epiphytic mocro-organisms decreased the phyllosphere inhibitory effects of BPL 261 and 1179 against B. fabae, and that the combined effects of these phyllospheric components with leaflet diffusates are greater than the effect of leaflet diffusates alone.

1.2.1.3. Effects of certain epiphytic micro-organisms

The first and second experiments employing leaflets from plants grown under field and gnotobiotic conditions, respectively, indicated that the phyllosphere inhibitory effects of BPL 261 and 1179 against B. fabae were greater in the presence than in the absence of epiphytic micro-organisms. The third test was therefore carried out to study the inhibitory effects of certain epiphytic micro-organisms that may occur naturally in the phyllosphere of BPL 261 and 1179, against B. fabae.

Isolations of bacteria, filamentous fungi and yeasts were made from 50 leaflets harvested from plants of BPL 261 and 1179 grown under field conditions. The surface of leaflets was rubbed while submerged in 250 ml of distilled sterile water, using a gentle brush. Isolations from leaflet washings were made on the following media, using the dilution plate technique: nutrient-agar (NA), acidified potato-dextrose-agar (APDA), and yeast-malt extract-agar (YMEA). A total of 150 subcultures of common bacterial, filmantous fungi and yeasts were purified and maitained to test their antagonistic activities against B. fabae. These micro-organisms were placed separately against B. fabae, at a distance of 2cm, on the surface of non-acidified PDA medium in petri dishes. These dishes were then incubated at room temperature ($20^{o} \pm 2^{o}C$). After two weeks, plates were examined for inhibition zones between any of these micro-organisms and B. fabae. Of the 150 epiphytic micro-organisms studied only three filamentaous fungi showed clear inhibition zones against B. fabae. These potential antagonists were identified by the C.A.B. International Mycological Insitute (IMI), Surrey, England as Fusarium solani (Mart.) Sacc., Penicillium citrinum Thom., and P. cyclopium Westling, under the IMI, herbarium numbers 316309, 316312, and 316311, respectively. The inhibitory effects of metabolites of these potential antagonists on spore germination and germtube development of B. fabae were therefore evaluated.

Each of the three potential antagonists was grown separately on 10 PDA plates at room temperature, for two weeks. The contents of the 10 plates of each antagonist were suspended in 500 ml of distilled sterile water, blended for five minutes in a blender, then vacuum-filtered through two filter papers and two layers of cheese cloth. These filtrates were used to prepare spore suspensions containing 500,000 spores of B. fabae per ml. Suspensions were plated separately on PDA, incubated for 36 hr at 20^{o}C, then the percent germination and germtube development of B. fabae were measured. A spore suspension in distilled sterile water was plated on PDA and used as a check. A complete randomized block design with four replicates was employed.

The results of this test (Fig. 1.2.3) indicated that the inhibitory effects of filtrates of F. solani on spore germination and germtube development of B. fabae were significantly (P = 1%) greater than those of P. citrinum or P. cyclopium. No inhibitory effects were observed in water.

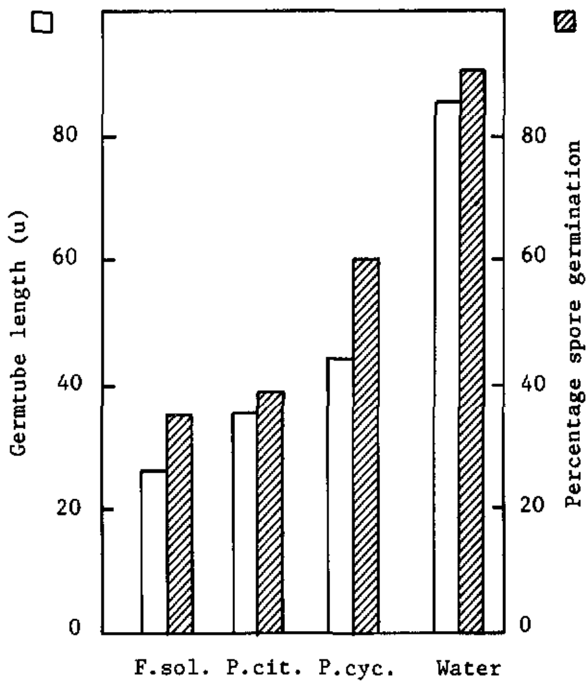

Fig. 1.2.3. Effect of metabolities of epiphytotic fungi Fusarium solani (F.sol.), Penicillium citrinum (P.cit.) and P. cyclopium (P.cyc.) on spore germination and germtube growth of Botrytis fabae.

1.2.1.4. Biological control of Botrytis fabae

The two most antagonistic, non-pathogenic, fungi Penicillium citrinum and P. cyclopium were further tested for their ability to control B. fabae on faba beans employing the detached leaf technique. Culture filtrates of each of P. citrinum and P. cyclopium were prepared separately as described earlier. The fungicide vincolzoline, which is recommended for the control of a wide range of Botrytis-diseases, was used in this test at the rate of 1.0 g a.i./l of distilled sterilized water for comparison. Droplets (0.1 ml) of each of the cultural filterates of P. citrinum and P. cyclopium, and of the vinclozoline-water mixture were deposited on the upper laminal surface of each of the faba bean leaflets. Another treatment combined filtrates of both antagonistic fungi in 0.1 ml droplets at a ratio of 1:1 (V:V). Droplets of distilled sterilized water served as a control. Twelve hr later 0.1 ml droplets of a spore suspension containing 500,000 spores of B. fabae prepared as decribed earlier, were added on the top of the droplets which comprised all of the original five treatments of this test. Droplets of the same treatments, but without spores of B. fabae, were deposited on an additional set of leaflets to serve as a control for possible necrosis in the absence of the pathogen. The metal pans carrying detached leaves were then covered immediately and incubated at room temperature ($20 \pm 2^{o}C$). The test was conducted two times employing a randomized complete block design with four replicates per treatment. Disease readings were made six days after inoculation.

The results of this study (Fig. 1.2.4) showed no significant differences between the percentage of necrosis induced by B. fabae on faba bean leaflets in the presence of vinclozoline and that obtained with the combined filtrates of P. citrinum and P. cyclopium. Necrosis in these treatments was, however, significantly lower than that in the presence of water or either of P. citrinum, P. cyclopium alone. No necrosis was observed in the control treatments in the absence of B. fabae. The ability of P. citrinum or P. cyclopium to reduce necrosis induced by B. fabae is apparently due to their inhibitory effects on spore germination and germtube development of the pathogen as shown earlier. Additional research is needed to determine the chemical nature of inhibitory substances in flitrates of these antagonistic fungi. Further work is also needed to study the population dynamics of these antagonists in the phyllosphere of faba bean leaflets under field conditions to help achieve effective biological control of B. fabae.

Dr. Salim Hanounik.

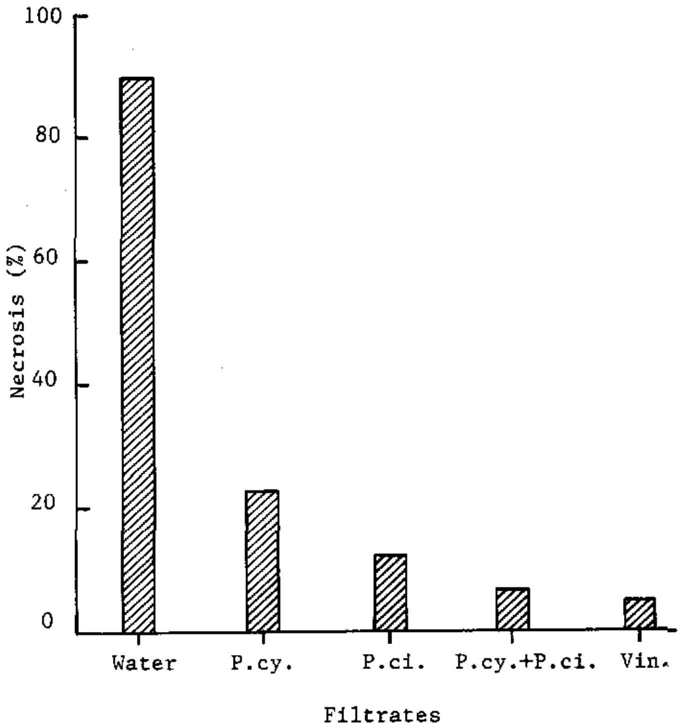

Fig. 1.2.4. Reduction in Botrytis fabae necrosis on leaflets of the faba bean line R40 in the presence of the filtrates of Penicillium cyclopium (P.cy.), P.citrinum (P.ci.) and combination of both, as compared to that with the standard fungicide vinclozoline (Vin.).

1.3. Faba Bean Insects and their Control

Studies concentrated on resistance screening for aphid and the development of control recommendations for storage pests.

1.3.1. Aphid resistance screening

Most of the aphid screening work is carried out in the Aphid Screening Laboratory at the Giza Research Station, Egypt. Over the past 3 years nearly 5000 faba bean breeding lines from Egypt, Sudan and ICARDA have been screened for resistance to Aphis craccivora and several lines with lower aphid infestations have been found which will now be tested in the field.

This season 7 breeding lines which have been selected previously for some degree of resistance plus Syrian local as susceptible check were planted in Tel Hadya with and without chemical protection following artificial aphid infestation (ca. 5 aphids/plant) in the end of March in the unprotected plots. At all 3 sampling dates differences in the number of aphids/plant were found between the faba bean lines grown under unprotected condition (Fig. 1.3.1). The highest number of aphids was present on Hudeiba 72 and FLIP 85-86, whereas on the Egyptian line 30/18/82 aphid populations were lowest indicating that this line might have some traits of tolerance/resistance. However, the yield was not correlated with the numbers of aphids, because there was a pronounced yield increase in 30/18/82 when protected and little increase in Houdeiba 72. Thus, these lines and others found to be promising in laboratory testing up-to-date need to be studied further in the field, which will be carried out by the national programs in the

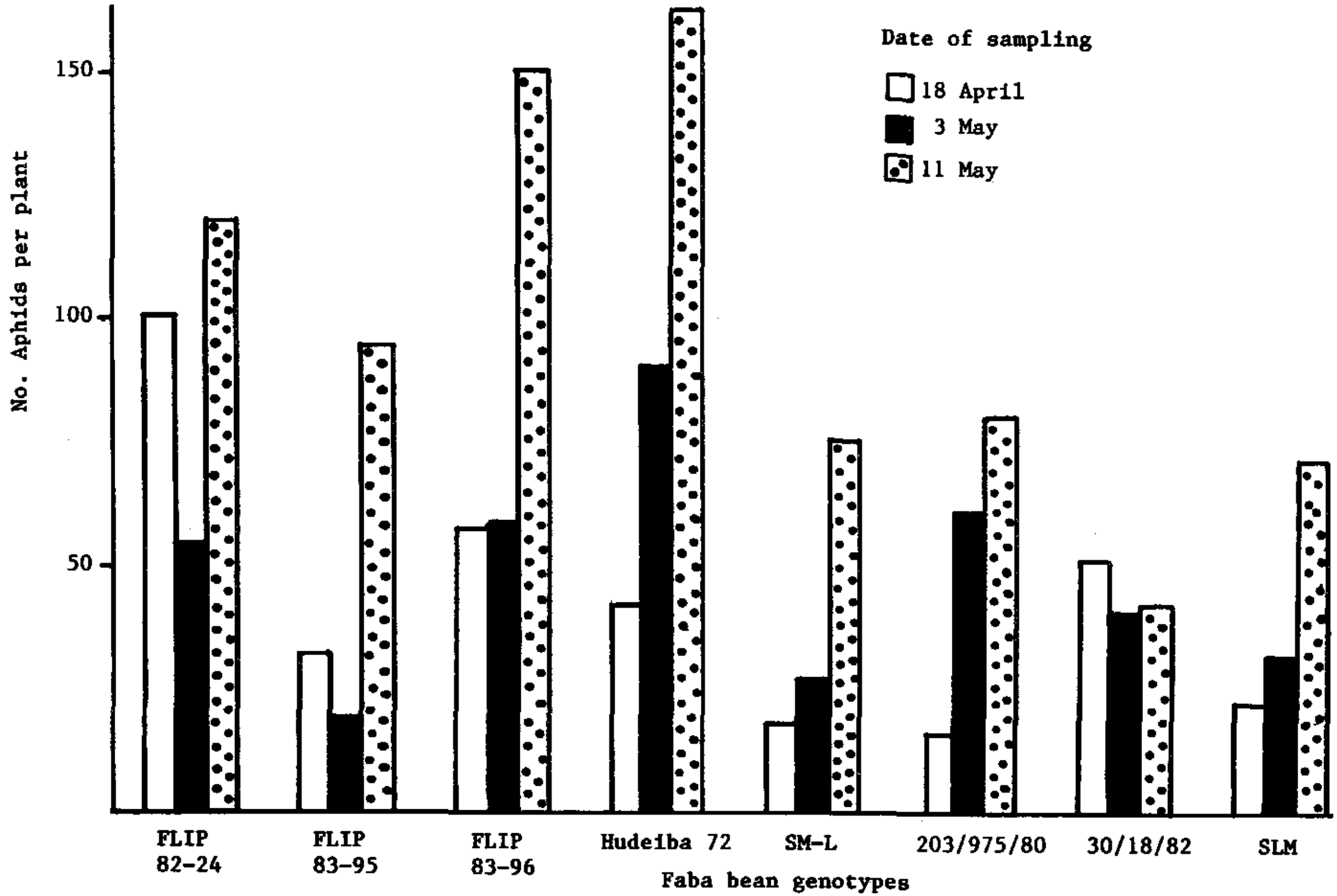

Figure 1.3.1. Number of aphids per plant at three different sampling dates on seven faba bean lines and a susceptible check (Syrian Local Medium) Tel Hadya, 1987/88.

respective country of origin of the faba bean lines.

Drs. S. Weigand, O. Tahhan. L.D. Robertson (ICARDA), S. Bishara, G. Defrawy (Egypt).

1.3.2. Storage pests

In previous studies Bruchus dentipes was found to be the dominent storage pest of faba bean in Syria with up to 90% seed infestations. Fumigation of harvested seeds is a common practice of farmers and merchants. This however, only kills the larvae in the seeds, but does not reduce infestation, which originates from the field. Studies on host plant resistance revealed that resistance alone will not be an effective control method, since in the screening of more than 1000 BPL's no real resistance was found. Therefore, an integrated control approach is suggested combining the following different methods: a) Sowing of uninfested seeds, b) ploughing down of the dropped pods and seeds after harvest, c) monitoring of adult populations to properly time an insecticide application before oviposition, and d) fumigation of seeds after harvest, if necessary. These recommendations can be transferred to the national programs for further evaluation under their conditions. Next season an experiment will be conducted in farmers' fields to test the optimal time and number of applications of 2 insecticides and their economic feasibility.

Drs. O. Tahhan and S. Weigand

1.4. Faba Bean Crop Physiology and Agronomy

1.4.1. Growth, dry matter build-up and yield of faba bean genotypes of different plant type

The traditional varieties of Vicia faba L. with indeterminate growth habit are characterized by low and unstable yield. One of the major causes of yield instability is the excessive flower and pod shedding which can reach upto 97%. Among the factors responsible for the high level of flower and young pod shedding is the intra-plant competition for assimilates between reproductive and vegetative organs, the latter a result of the apex remaining a significant sink during and after flowering period. To overcome this problem, the faba bean improvement program has laid strong emphasis on the development of alternative plant types which include determinate growth habit and plants with independent vascular supply (IVS) to each flower. The potential advantage of determinate growth is the reduction in the competition from vegetative sink to the reproductive sink for assimilates, resulting in improved podding; and in IVS, increased podding would result because of lack of competetive interaction between the early and late formed flowers on the same node.

A study was initiated in 1985/86 and repeated in 1986/87 and 1987/88 to determine whether the major constraints associated with the indeterminate faba bean have been removed in the new plant type and whether the development of the alternative plant type has resulted in new contraints in attaining high seed yield. In 1985/86, the indeterminate cultivar ILB 1814 (Syrian Local Large), the determinate line FLIP 84-230F and indeterminate line but with independent vascular supply IVS 6 were used in the study. In 1986/87, a second determinate line, FLIP 84-239F was added and in the 1987/88 season, three determinate lines; FLIP 84-239F, FLIP 84-240F and FLIP 84-241F in addition to ILB 1814 and IVS 6 were used. Density used were 22 and 44 plants/m^2.

The number of branches/plant was low during early vegetative growth and increased reaching a maximum at flowering in ILB 1814 and IVS 6 (March), but the determinate lines continued producing branches late into the season (Figure 1.4.1). At its maximum, the number of branches was higher in the determinate than in the indeterminate ILB 1814 and the IVS 6 (Figure 1.4.1). This suggests that the advantage of determinate growth habit is partly lost by continued production of new branches after flowering, because these late formed branches become sinks competing with reproductive growth for assimilates. It is however, possible to suppress the late formed branches by planting at high density (Figure 1.4.1).

Leaf area index (PAI) and dry matter production followed the same pattern; low at the beginning of the season, and increasing to a maximum later on (Figures 1.4.2 and 1.4.3). As in the past, ILB 1814 had the highest LAI throughout the season and produced the highest total dry matter; and IVS 6 which during all the growth stages attained lowest LAI also produced lowest dry matter. The determinate lines attained intermediate LAI and produced intermediate amount of dry matter. Differences in dry matter production were therefore a reflection of differences in LAI. Planting at higher density of 44 plants/m^2 resulted in higher LAI and increased dry matter production (Figures 1.4.2 and 1.4.3).

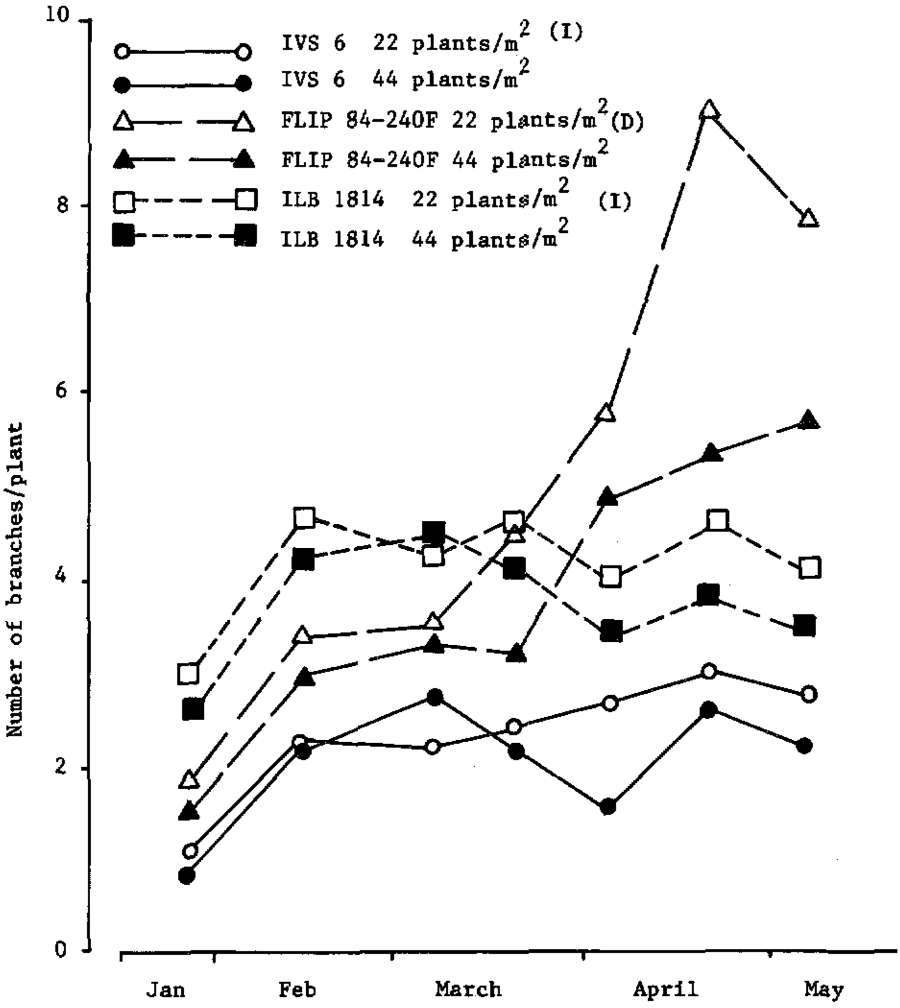

Fig. 1.4.1. Number of branches/plant at different growth stages for indeterminate (I), IVS & determinate (D) faba bean plant type grown at 22 and 44 plants/m^2, Tel Hadya, 1987/88.

In both 1986/87 and 1987/88, dry matter partitioning to the stems, leaves and reproductive parts were investigated (Figure 1.4.4). The percentage dry matter partitioning to the leaves exhibited a gradual decline with time. Determinate faba bean lines partitioned

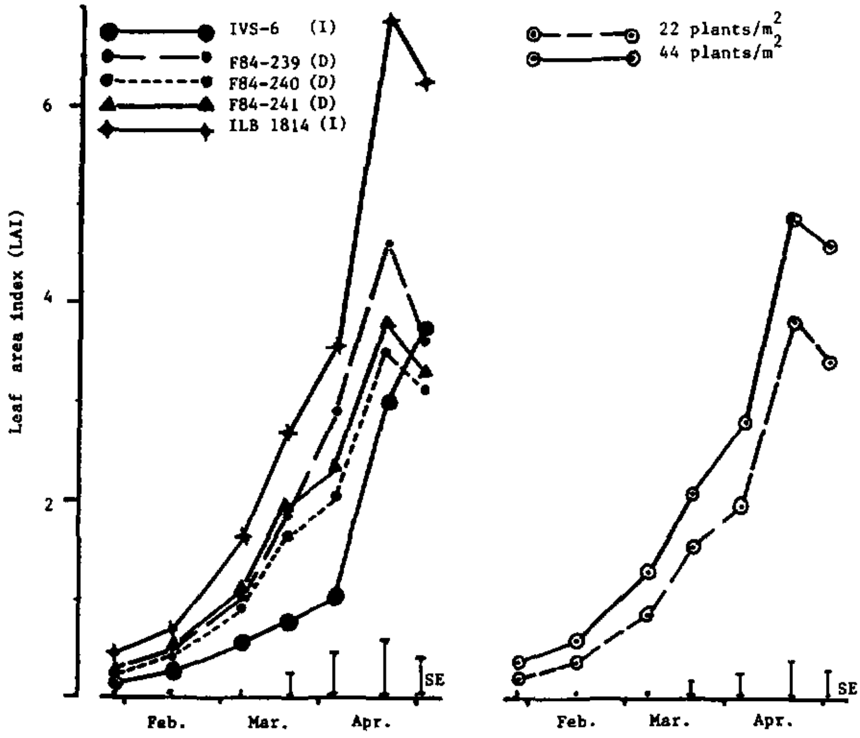

Figure. 1.4.2. Build up of leaf area index of faba bean (LAI) as affected by plant types and population, Tel Hadya, 1987/88.

proportionately more of their dry matter to the reproductive part than the indeterminate ILB 1814, however IVS 6 partitioned even less. Amongst determinate lines in 1986/87 and 1987/88 FLIP 84-239F partitioned highest percentage dry matter to reproductive growth (Figure 1.4.4).

In 1986/87 and 1987/88, ILB 1814 had highest LAI, produced highest dry matter and attained highest seed yield (Tables 1.4.1 and 1.4.2). On an average of two population densities, in 1986/87 ILB 1814

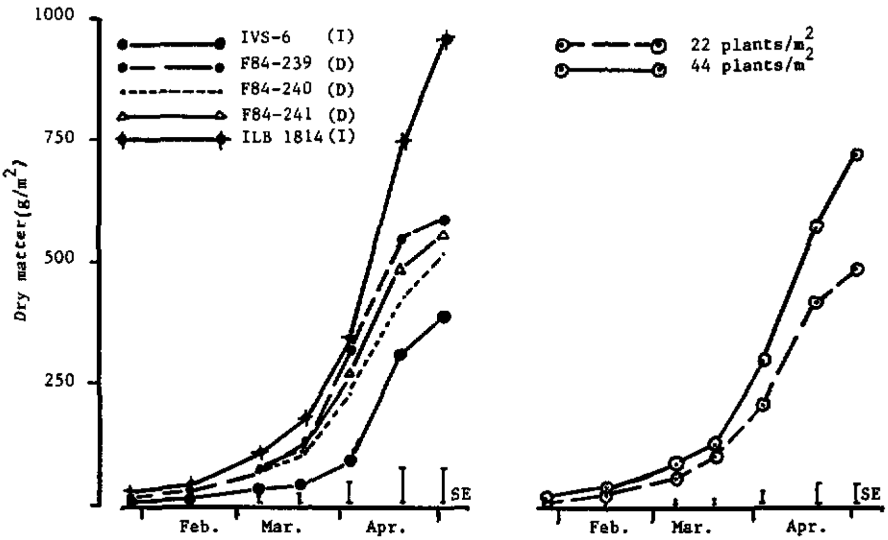

Fig. 1.4.3. Total dry matter in g/m^2 at different growth stages for:
a) Five faba bean genotypes
b) Two plant populations, Tel Hadya 1987/88.

outyielded FLIP 84-230F by 26% and FLIP 84-239F by 14%. In 1987/88 the yield advantage in ILB 1814 compared to FLIP 84-239F, FLIP 84-240F and FLIP 84-241F were 22%, 27% and 17% respectively. IVS 6 which attained lowest LAI and total dry matter gave the lowest seed yield. Sowing at 22 compared to 44 plants/m^2 did not improve seed yield of ILB 1814 but increased yield of IVS 6 and determinate lines. In 1986/87, sowing at high density of 44 plants/m^2 increased seed yield by 5% in FLIP 84-230F and 14% in FLIP 84-239F. In 1987/88, the respective yield increases due to sowing at 44 plants/m^2 were 17% for FLIP 84-239F, 3.1% for FLIP 84-240Fand 6% for FLIP 84-241F. Seed yield was strongly correlated with biological yield (r=0.92); clearly suggesting that when developing

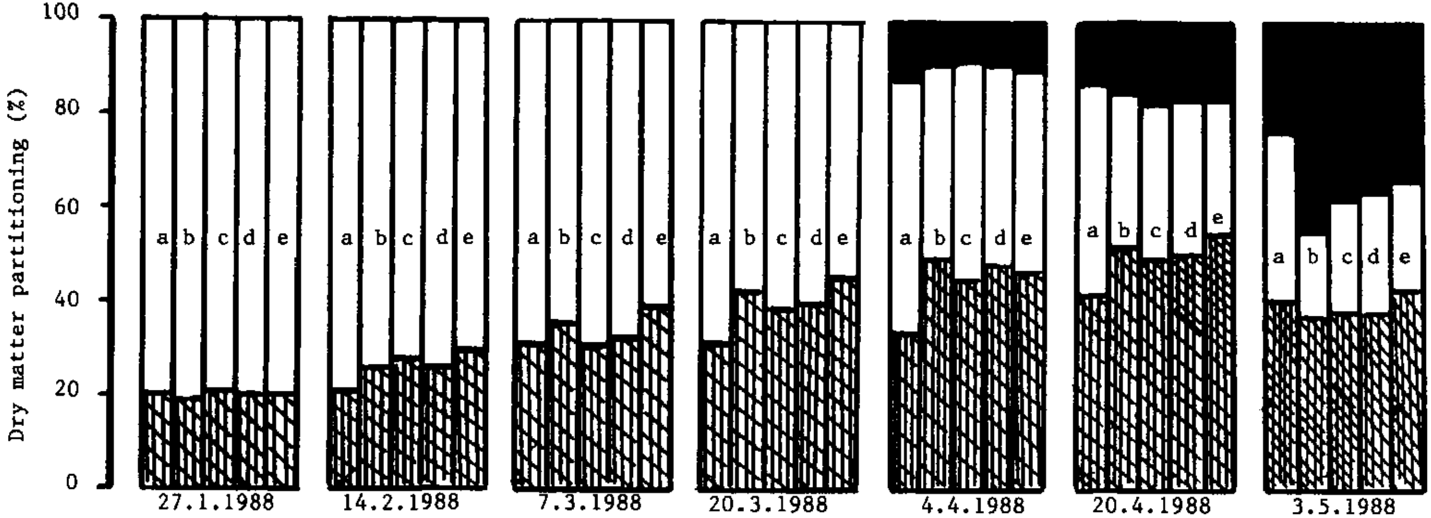

Fig. 1.4.4. Percentage dry matter partitioning in stems, leaves, and reproductive parts in five faba bean genotypes, Tel Hadya 1987/88.

a = IVS-6; b = F84-239; c = F84-240; d = F84-241; e = ILB 1814

Table 1.4.1. Seed yield (kg/ha), biological yield (kg/ha) and frost damage score of four faba bean lines sown at two populations, Tel Hadya, 1986/87.

Genotypes	Seed yield Plant population/m²			Biological yield Plant population/m²			Frost damage score*
	22	44	mean	22	44	mean	
IVS 6	2512	2529	2520	5294	5443	5369	2.1
FLIP 84-230F	3164	3331	3247	5262	5608	5435	4.6
FLIP 84-239F	3428	3892	3660	5931	6878	6404	3.0
ILB 1814	4419	4332	4375	8032	8026	8029	2.1
Mean	3381	3521		6130	6404		
	G	P	GxP	G	P	GxP	
LSD (.05)	428.9	NS	NS	749.5	NS	NS	0.54
SE	134.1	84.9	180.0	234.3	134.1	301.4	0.17
CV (%)	11.0	9.8		10.5	8.5		16.0

G = genotypes, P = population.

* Frost damage score of flowers taken 10 days after end of frost occurrence. Sacle: 1-5, where 1 = no damage; and 5 = complete flower kill.

Table 1.4.2. Seed yield (kg/ha) and biological yield (kg/ha) of five faba bean lines sown at two populations, Tel Hadya, 1987/88.

Genotypes	Seed yield Plant population/m²			Biological yield Plant population/m²		
	22	44	Mean	22	44	Mean
IVS-6	1822	2295	2059	3747	4817	4282
F 84-239F	2380	2787	2583	4968	6061	5514
F 84-240F	2387	2461	2424	4703	5407	5055
F 84-240F	2663	2831	2747	5031	6334	5683
ILB 1814	3372	3249	3310	6967	7403	7185
Mean	2525	2725		5083	6004	
	G	P	GXP	G	P	GXP
LSD 5%	263.8	166.8	NS	497.9	314.9	NS
SE	90.9	57.5	128.5	171.6	108.5	242.60
CV%	9.79			8.75		

G = genotypes, P = population.

determinate plant type, emphasis should be to maintain high biomass without losing lodging resistance.

The results of the study conducted over the three year period indicated clearly that the development of alternative plant type, such as determinate lines, can lead to high seed yield only when high biomass and high harvest index are incorporated in the breeding strategy, with selection of lines that stop producing new branches by start of flowering. The study also showed the importance of increased plant density for realising full yield potential of the determinate type faba bean. In this study only 22 and 44 plants/m^2 were tested. In 1988/89 season, therefore, higher densities than 44 pants/m^2 will also be tested.

Drs. S.N. Silim and M.C. Saxena.

1.4.2. Faba bean chemical weed control trial

An experiment on irrigated faba bean was conducted at Tel Hadya to evaluate the effect of recommended herbicides as well as those promoted from the previous season's experiment on weed control. The experimental design was radomized block with 4 replications. One hundered and twenty mm of water was applied in addition to the 504 mm rainfall received in the season.

Weed infestation was high especially, broadleafed weeds such as Sinapis arvensis, Vaccaria pyramidata, Carthamus syriacus and Cephaloria syriaca. Low infestation of Phalaris brachystachys, Avena sterilis and volunteer cereals was observed. These weeds caused 35% reduction in grain yield (Table 1.4.3).

Table 1.4.3. Effect of weed control on seed yield of irrigated faba bean and on weed dry matter (TDW), Tel Hadya 1987/88.

Treatment	Rate of application (kg a.i./ha)	Grain yield (kg/ha)	TDW (kg/ha)
Weedy check		2482	942
Hand weeding		3792	-
Cyanazine+Pronamide, pre-emergence	1.0+0.5	3254	452
Terbutryne+Pronamide, pre-emergence	1.0+0.5	2217	249
Codal, pre-emergence	2.0	1768	1208
Carbetamide, pre-emergence	1.5	2381	1546
Carbetamide, post-emergence	1.5	2955	838
Dinoseb acetate + Fenoxaprop ethyl, post-emergence	1.0+0.25	2911	728
Bentazone + Fluazifop butyl, post-emergence	1.0+0.25	2436	367
Dinose-acetate + Monolinuron (Aresin Combi), post-emergence	1.0	2211	314
LSD (5%)		790	743.1
C.V. (%)		20.6	77.1

A combination of Cyanazine (1.0 kg a.i./ha) + Pronamide (0.5 kg a.i./ha) applied pre-emergence was the best among the herbicide treatments, but hand weeding gave the best result. Post-emergence application of Dinoseb acetate (1.0 kg a.i./ha) + Fenoxaprop ethyl (0.25 kg a.i./ha) was good as also carbetamide (1.5 kg a.i./ha) especially when used as pre-emergent application. Combination of Terbutryne (1.0 kg a.i./ha) + Pronamide (0.5 kg a.i./ha) did not give good results due to phytotoxicity (score of 4.5, when scored on 1-9 scale, where 1 is no damage and 9 complete crop kill). Codal (2 kg a.i./ha) was also phytotoxic (phytotoxicity rating 6.3) and ineffective in controlling weeds.

Drs. M. Pala, M.C. Saxena, S.N. Silim and Mr. M. El-ALi

1.5. Faba Bean Microbiology

Following nearly one year of greenhouse Rhizobium strain selection in hydroponic and soil core trials, a set of 3 superior strains was chosen for regional inoculation response trials in faba bean. In 1987/88, ten of these trials, designed to be conducted using locally adapted cultivars and ICARDA-produced inoculants, were sent to seven countries. In addition the trial was conducted at Tel Hadya station with two locally adapted cultivars, Syrian Local Large and Lebanese Local Small. Biological and grain yields were increased significantly with inoculation in both cultivars. With Syrian local large, inoculation increased grain yield by 793 kg/ha with a biological yield increase of 3,300 kg/ha. The yield increase due to inoculation with the best Rhizobium strain in Lebanese Local Small was of smaller magnitude, 550 and 1020 kg/ha for seed and biological yields, respectively. No results have yet been received from regional cooperators.

The same selected strains were tested against 12 improved cultivars in a field trial at Tel Hadya station, which incorporated ^{15}N subplots designed to measure quantities of nitrogen fixed in the treatments. In this trial, grain yield differences due to cultivar were largest, as might be expected when dealing with diverse plant types such as determinate and IVS, but differences due to strain as well as cultivar x strain interactions were also significant.

The effect of inoculation with the best strain on seed yield can be seen in Figure 1.5.1, where only the differences between uninoculated and inoculated treatments are indicated. Significant increases in grain yield over uninoculated treatments were seen in Lebanese Local Small, Seville Giant, Syrian Local Large and Reina Blanca, with an average increase of about 600 kg/ha in these highly productive commercial cultivars. The average seed yield increase over all 12 cultivars, due to inoculation with best strain, was 15%.

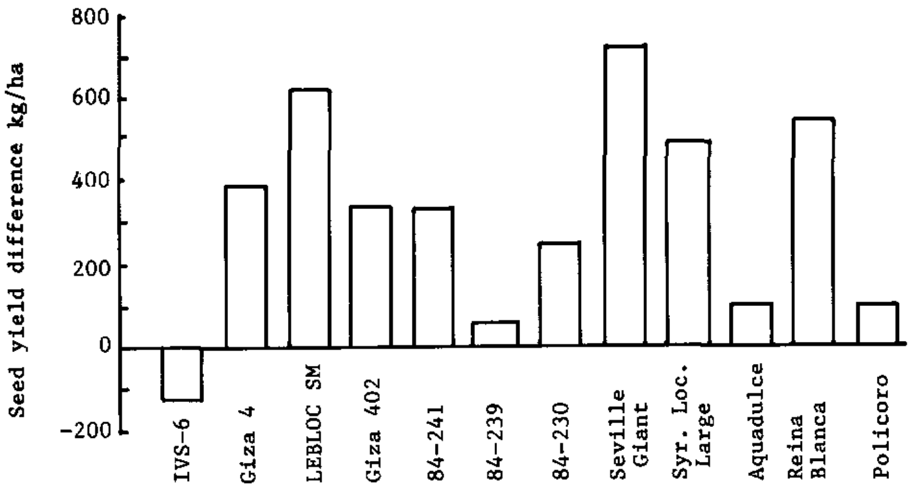

Fig. 1.5.1. Seed yield advantage from inoculation of 12 faba bean lines over uninoculated treatment (soil containing $>10^4$ native rhizobia per g soil) by strain FB452, Tel Hadya, 1987/88.

Results from a collaborative trial with INRA scientists at Montpellier indicate that faba bean can fix between 76 and 94 percent of its total nitrogen requirement, depending on environmental conditions. Nitrogen fixed in cultivar Syrian Local Large varied from 90 to 183 kg N/ha. Forthcoming ^{15}N results from the 1987/88 cultivar evaluation trial will show more clearly the N fixing ability of faba bean, and indicate which cultivars are able to obtain a greater proportion of total plant N from the atmosphere.

Dr. D. Beck

2. LENTIL IMPROVEMENT

Average lentil yields are low because of poor crop management and the low yield potential of land races. 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 biologically - fixed nitrogen in the wheat-based cropping system is the aim of activities in Rhizobium research and Sitona weevil control.

2.1. Lentil Breeding

Lentil breeding at ICARDA focuses on three different agro-ecological regions. The importance of the regions in terms of lentil production and the allocation of resources in breeding are summarised together with the respective breeding aims in Table 2.1.1.

2.1.1. Base program

2.1.1.1. 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 2.1.1. 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, cold tolerance, attributes for mechanization

Approximately 350 simple crosses are made annually and handled in a bulk-pedigree system using off-season generation advancement. Five percent of the crosses are with the wild lentil L. orientalis, for increasing stress tolerance. This work is supported by research carried out in the Genetic Resources Program.

Segregating populations targetted for the different regions are distributed with emphasis placed on relevant constraints, providing breeding material for national programs in the high altitude and lower latitude regions for selection and cultivar development. 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 characteristics are supplied through the International Testing Network (2.1.1.4).

2.1.1.2. 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 widely in their annual rainfall namely Breda (annual average rainfall 281 mm) and Tel Hadya (328 mm) in Syria and Terbol (545 mm) in Lebanon. During the 1987/88 season the rainfall was above the long-term average at all three sites with 400, 504 and 710 mm received at Breda, Tel Hadya and Terbol, respectively. The highest yields of seed and biomass were obtained at the driest site-Breda where water was not the limiting factor to growth this season. The average biomass realized at Breda was 6 t/ha with a mean seed yield of 2 t/ha. This contrasts with the wettest location Terbol where only 3.7 t/ha dry matter were produced giving 1.4 tons/ha seed on average.

For the first season improved lines, 'Idleb 1' for large-seeds and 78S26013 for small-seeds, were included as checks alongside the long-term checks ILL 4400 and 4401 (Syrian Local Large and Small, respectively). A summary of the yield trials for seed and biomass yields is given in Table 2.1.2. For seed yield at Terbol, Tel Hadya and Breda the percentages of lines yielding significantly more than the best check were 11, 18 and 2% respectively. An additional 41, 40 and 25% of other test entries ranked above the best check. A similar pattern emerged for biomass. Clearly, some advance from selection is being observed.

Table 2.1.2. 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 1987/88 season.

Rainfall (mm)	710		504		400	
Location	Terbol		Tel Hadya		Breda	
	S	B	S	B	S	B
Number of trials	17	17	17	17	17	17
Number of test entries*	383	383	383	383	383	383
% of entries sig. (P<0.05) exceeding best check**	11	19	18	27	2	6
% of entries ranking above best check (excluding above)	41	59	40	36	25	31
Yield of top entry (kg/ha)	1859	4685	2865	7702	3325	9300
Check mean yield (kg/ha)***	1415	3495	1629	4811	2497	6831
Location mean (kg/ha)	1394	3687	1654	4979	2054	6094
Range in C.V.(%)	7-11	6-15	12-44	11-21	9-21	9-18
Mean advantage of lattice over RBD	112	116	128	121	107	104

* 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

Increasing attention is being paid to selection for biomass for seed and straw and the relationship between seed and straw yield was examined across the trials. Previous research on both the world lentil collection and yield trials had indicated a positive correlation between seed and straw yield. In this season the mean phenotypic correlation over the 17 trials between seed and straw yields ranged from $r = 0.18 \pm 0.04$ at Terbol to $r = + 0.61 \pm 0.03$ at Breda and r =

+0.61 ± 0.02 at Tel Hadya. This strong positive association between seed and straw yield at Breda and Tel Hadya shows that an advance from selection for either character will result in an increase in the other character. But under very high rainfall conditions of Terbol this association is rather weak.

A lattice design (7x7) was used in all these trials and the average advantage of the lattice design over randomized complete block design varied from 7% in Breda to 28% at Tel Hadya.

Dr. W. Erskine.

2.1.1.3. Development of a screening technique for vascular wilt

Vascular wilt caused by Fusarium oxysporum f.sp. lentis is the major disease of lentil in Syria causing an average of 12% crop loss in North-West Syria (Annual Report, 1985). The use of resistant varieties is the most efficient way to reduce crop losses. A study was made to determine factors affecting fungal growth in vitro to enable sufficient inoculum production for the development of a screening technique for resistance, as well as to study some aspects of the epidemiology of the disease.

The effects of three growth media (potato dextrose agar, lentil dextrose agar and Czapek) and temperatures from 10–30°C on fungal growth were examined. The results in Figure 2.1.1. show that fungal growth was better on lentil dextrose agar above 15°C. The response of fungal growth to temperature on lentil dextrose agar was well described by the quadratic equation $y = -169.8 + 22.31x - 0.49x^2$ with a coefficient of determination (r^2) of 0.86. The optimum temperature for

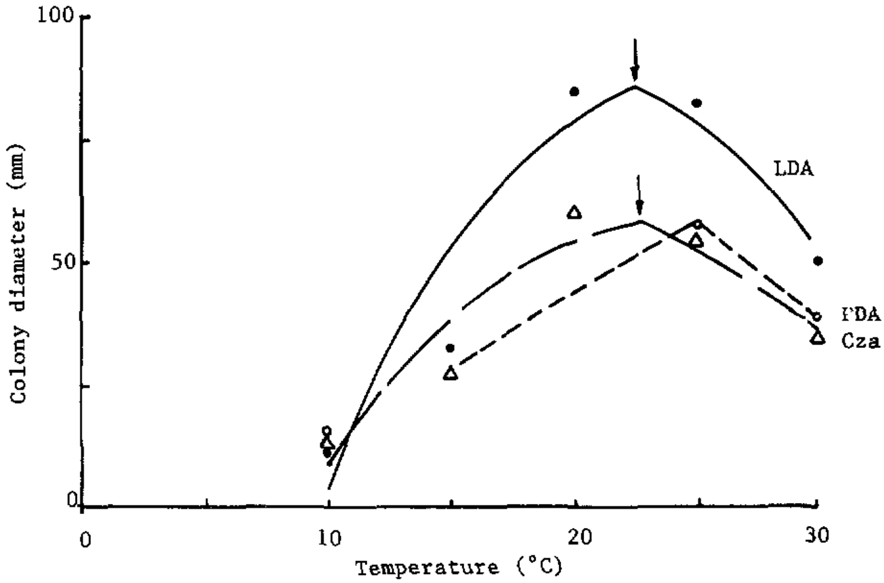

Fig. 2.1.1. The effect of temperature on fungal growth as measured by colony diameter (mm) nine days after incubation on three growth media (LDA, PDA, Czapek). The quadratic equations for LDA and Czapek are drawn and the temperature optima indicated by arrows.

fungal growth was calculated as 23°C from the quadratic equation.

The transmissibility of the fungus via seeds was examined using surface sterilized seeds of a known-susceptible cultivar from a wilty field grown on synthetic and semi-synthetic media at different temperatures. Lentil seeds were soaked in 5% NaOH solution for 36hr, stained with 1% aniline blue and examined microscopically. The results indicated that the fungus was not present in the seeds - neither in the endosperm nor under the seed coat.

In vitro studies revealed an antagonistic effect of a Pseudomonas sp. isolated from infected soil on the growth of F. oxysporum.

The following nematode genera were associated with wilt incidence in the field: Ditylenchus dipsaci, Meloidogyne spp., Heterodera spp., Aphelenchus spp., Pratylenchus spp., Helicotylenchus spp., Tylenchorhynchus spp. and Aphelenchoides spp.

A simple, rapid and repeatable technique was developed in the plastic house to screen lentil germplasm at the seedling stage for resistance to wilt, because previous field screening had been necessarily opportunistic due to the uneveness of wilt distribution in the soil. The technique involves the use of 1) field soil in metal trays each sown with rows of a susceptible check and five test lines and ii) inoculation with 14-day old liquid culture of F. oxysporum, isolated from the stems of wilted plants and applied two weeks after sowing. Final disease incidence was recorded eight weeks after sowing.

Using this technique 25 lines were grown in two successive sowings. The lines ranged from resistant to highly susceptible. There was good agreement between the results of the sowings with a correlation of $r = 0.86$ ($P<0.01$) between the respective disease indices (Figure 2.1.2), showing clearly the repeatability of the technique.

A total of 18 lines were screened for disease reaction in both the field (at the reproductive stage of growth) and in the plastic house (at the seedling stage). The field results were based on a mean of eleven replicates per line, and the highest wilt incidence on a line over replicates was used to avoid values representing disease escape. The correlation between the wilted plants score in the field and the disease index score in the plastic house was $r = 0.76$ ($P<0.01$) indicating agreement between field and plastic house results (Figure

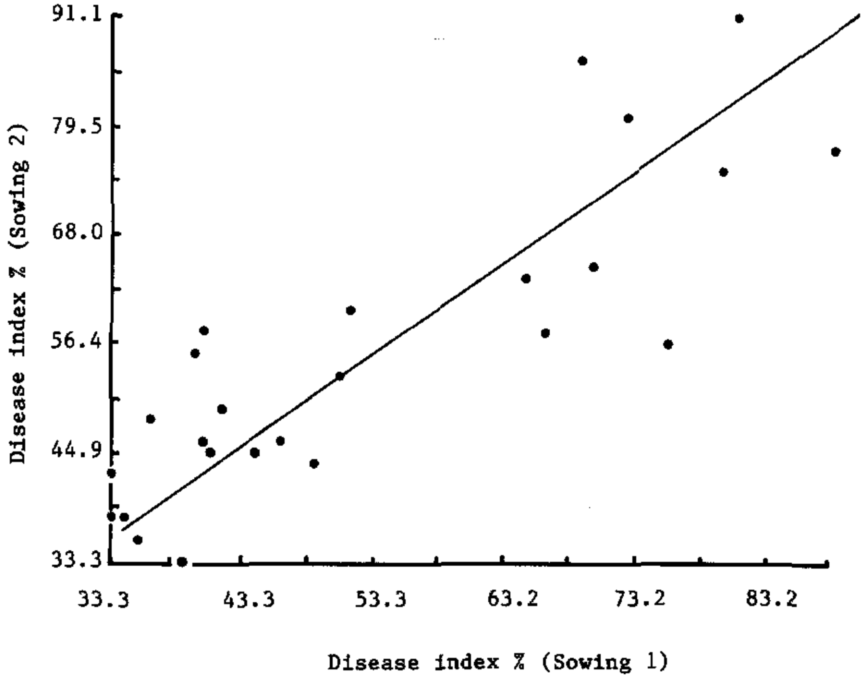

Fig. 2.1.2. Relationship between vascular wilt disease index score in the first sowing with that in the second sowing.

2.1.3). Since the disease distribution in the field was not uniform, the field data may be overestimates of resistance. However, all lines showing susceptibility in the field (≥5 score) were also susceptible (≥5) in the plastic house.

Subsequently 162 lines were screened in the plastic house, amongst which 29 lines were promising with no wilt symptoms.

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

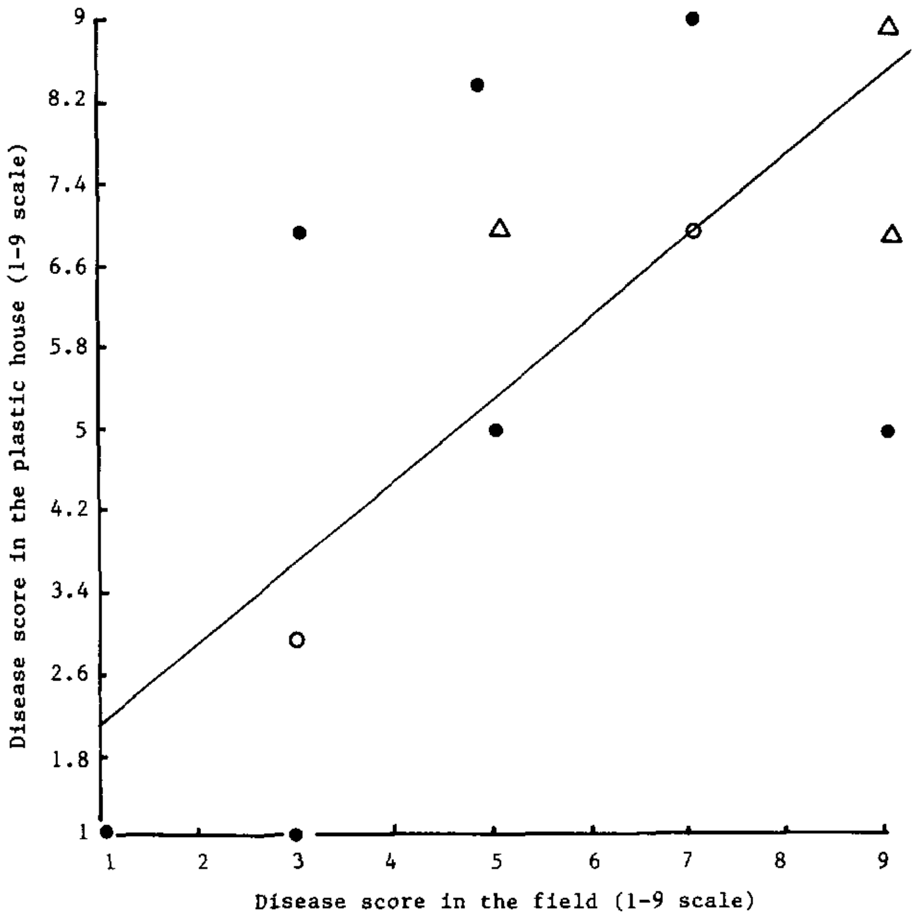

Fig.2.1.3. Relationship between the vascular wilt disease index score in the plastichouse and that in the field. Number of observations • = 1, Δ = 2 and o = 3.

2.1.1.4. International nurseries

The lentil international nurseries have evolved from the stage of provision of yield trials only earlier to now supplying a range of targeted crossing blocks/resistant sources, segregating populations and yield trials for the three major agro-ecological regions of production (Table 2.1.3).

Table 2.1.3. Lentil international breeding nursery program showing target regions and type of material for distribution.

Type of nursery	Regions		
	Mediterranean low-med. elevation	Lower latitudes	High elevation
Crossing blocks/ Resistant sources	Tall nursery Large seeded nursery Small seeded nursery * Wilt nursery	Asochyta 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	

* To be launched in 1989

Our strategy is to encourage national breeding programs to undertake more selection locally within segregating populations. The aim is to start three new targeted F_3 nurseries comprising segregating populations from crosses with parents with the specific traits listed in section 2.1. These will be F_3 nurseries - 1, Small seeded and 2, Large seeded for the Mediterranean environment and 3, Cold tolerant for the highland environment. Additionally, a wilt resistant nursery will be initiated.

Another converse way to encourage the use of segregating populations by NARSs is to discourage the direct use of finished material by limiting the distribution of sets of international yield trials. In Table 2.1.4 the distribution of yield trials in the last set of international trials was limited to the previous year's level of 130 representing only 64% of requests from NARS despatched; whereas 98% of requests for segregating populations were despatched. Increased follow-up to assist NARS scientists in selection is planned.

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

Table 2.1.4. Number of sets of international trials and segregating populations requested by and sent to NARSs in 1988/89 sesaon.

	Types of nursery	
	Yield trials	Segregating populations
No. sets requested by NARS	207	41
No. sets despatched to NARS	130	39
% requests sent	63	95

2.1.2. Use of germplasm by NARSs

2.1.2.1. 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.

In Syria following the release of the country's first lentil variety 'Idleb 1' in 1987 (Table 2.1.5), use is already being made of the variety in production (section 2.3.2) and it is also in multiplication with the Syrian Seed Production Institute. Meanwhile,

Table 2.1.5. National program releases of lentil selected from international trials.

Country	Cultivars released	Year of release	Specific features
Ecuador	INIAP-406 (FLIP 84-84L)	1987	Rust resistance, high yield
Ethiopia	ILL 358	1984	Rust resistance, high yield
Syria	Idleb 1 (78S 26002)	1987	High yield, reduced lodging
Tunisia	Neir (ILL 4400)	1986	Large seeded, high yield
	Nefza (ILL 4606)	1986	Large seed, high yield
Turkey	Firat '87(75kf 36062)	1987	Small seeds, high yield

Table 2.1.6. Mean seed yield (kg/ha) in on-farm trials conducted with ARC (Douma) from 1982/83 to 1987/88 in Syria.

Season	Entry: Hurani 1 (Local check)	Entry: 78S26013	Advantage over check (%)	S.E.±	No.of sites
1982/83	823	1054	28.1	73.2	6
1983/84	855	990	15.8	60.1	7
1984/85	998	931	-6.7	34.5	13
1985/86	993	1281	29.0	38.0	9
1986/87	1687	2013	19.3	79.3	11
1987/88	1759	2023	15.0	59.7	11
Mean	1186	1382	16.5		

amongst smaller seeded material the entry 78S26013 is to be recommended for release. It has been in on-farm trials since 1982/83 and has shown an average yield advantage over Hurani 1 (the local check) of 17% across 57 sites (Table 2.1.6). The line 78S26013 has additional advantages over the check in that it lodges less, an important attribute in harvest mechanization, and is more resistant to both vascular wilt and ascochyta blight.

Regional yield trials, which were the source of lines for on-farm trials and were jointly run by ICARDA and ARC (Douma), have been discontinued. A national yield trial system entirely the responsibility of ARC (Douma) has now taken its place.

In Lebanon the same small-seeded line 78S26013 as identified in Syria has been named Talya 2 by the Agriculture Research Institute (ARI) in anticipation of its release in 1989. Another line FLIP 84-76L, with larger seed, will also be included in the pre-release multiplication of ARI in the 1988/89 season.

In Jordan following the release of the local selection UJL 176 by the national program, attention has shifted to large scale testing of several lines resulting from hybridization using FLIP 84-77L, FLIP 84-83L, FLIP 85-38L and FLIP 86-5L. Selections from crosses, made at ICARDA on the request of Jordan and supplied as segregating populations, may yield the next generation of cultivars.

Progress in lentil breeding within the national programs in N. Africa is discussed in detail in section 7. Briefly, in Algeria based on previous year's results and the performance in the last two years demonstration plots, Syrie 229 and Balkan 775 have proved their superiority over the local, 'Large Blanche de Chili' (LB Chili) and thus they will be recommended to farmers. Already this was done informally for Syrie 229. ILL 4400 is doing better than both in one location and similar to them at two other locations. However it will not be recommended for release before at least a second year in demonstration plots.

In Morocco 78S26002 will be added to the catalog trials next season, to join ILL 4605. In Tunisia the drought conditions precluded major breeding advances in the 1987/88 season.

In Spain two lentil lines are in registration.

National Agricultural Research Systems.

2.1.2.2. Advances for southern latitudes

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.

Screening for Ascochyta blight reaction is being conducted by the national program of Pakistan at NARC, Islamabad and at the Agricultural University, Faisalabad. The resistant reactions of ILL 358, 5480, 5871 and 6024 to Ascochyta have now been reconfirmed in Pakistan. Two of these lines ILL 358 and 6024 were also screened for reaction to Ascochyta blight at Debre Zeit, Ethiopia, where they were found tolerant (Table 2.1.7). In Canada ILL 358 has been confirmed resistant to Ascochyta blight and is the basis of the breeding program for resistance to Ascochyta blight in Saskatoon.

Screening for rust was conducted at both Akaki and Debre Zeit by the University of Alemaya, Ethiopia and a range of lines were resistant in both locations. Some lines are showing resistance to to rust and tolerance to Ascochyta blight (Table 2.1.7).

Table 2.1.7. Reaction of selected lentil lines to Ascochyta blight at NARC, Islamabad, Pakistan and Debre Zeit, Ethiopia and to rust at Debre Zeit and Akaki, Ethiopia on 1-9 scales.

Selection	ILL	Ascochyta score		Rust score	
		NARC	Debre zeit	Debre Zeit	Akaki
-	358	1	5	2	3
78S26052	5604	2	6	1	1
FLIP 84-78L	5748	3	5	3	1
FLIP 85-33L	5871	1	-	1	-
FLIP 86-21L	6007	3	5	1	1
FLIP 86-38L	6024	-	5	3	1

Turning to the exploitation of breeding material for production, in Ethiopia the advent of the Nile Valley Regional Program will ensure the timely multiplication and distribution to farmers of the released lentil line ILL (NEL) 358.

In Pakistan ILL 2573 continues to out-perform the local check in both on-farm trials in the north of Punjab Province and the national uniform yield trial. Seed of ILL 4605 is being distributed to extension groups and farmers around Islamabad, and the line is being considered for release for the wettest area of lentil production in Pakistan - Chakwal and National Capital Territory.

In Nepal ILL 4402 and 4404 are in on-farm trials in the Terai area, where most of the country's production on 100,000 ha is sown.

National Agricultural Research Systems.

2.1.2.3. Advances for high altitude region

The high altitude area consists of the plateau regions of Iran and Turkey, where lentil is normally spring sown because of the severe winter. It has been shown by the Turkish program that winter sowing of cold tolerant lentil results in large increases in yield. The line 1066-1, which is a single plant selection, made at Eskisehir from ILL 854, is a large-seeded, red cotyledon lentil with cold tolerance that is being considered for release for winter sowing. We plan to launch an international trial in 1989 of segregating material with one cold tolerant parent to encourage selection locally by national program.

National Agricultural Research Systems

2.2. Adaptation

2.2.1. Geographic distribution of variation in the ICARDA world lentil collection

The geographic distribution of variation in the ICARDA world lentil collection was studied to understand the local adaptation in the crop, in collaboration with the Genetic Resources Unit. The variation in ten quantitative morphological characters of accessions from 14 major lentil-producing countries was examined by stepwise discriminant analysis followed by canonical variate analysis. Major differences between accessions from different countries were revealed by the analysis. Three regional groups were apparent namely 1, a levantine group (Egypt, Jordan, Lebanon and Syria) 2, a more northern group composed of Greece, Iran, Turkey and USSR and 3, accessions from India and Ethiopia with similar quantitative morphological characters within groups. Mis-classifications were frequent within groups. Characters useful in discriminating between accessions from different countries, in descending order of importance, were: time to maturity, lowest pod height, and 100-seed weight.

The grouping by country of origin is summarized visually in a scatter diagram from the canonical variate analysis (Figure 2.2.1). Canonical variate analysis reduces the multivariate data set into fewer orthogonal axes. In this case the first two variates (shown in Fig. 2.2.1) accounted for 84.6% of the variability in quantitative characters.

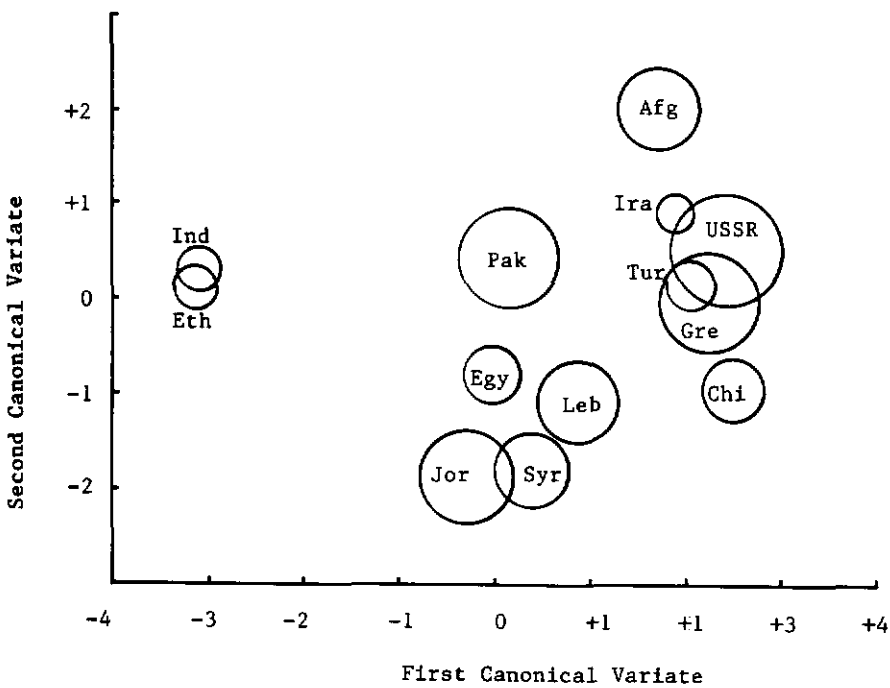

Fig. 2.2.1. Scatter diagram of the first two canonical variable mean values for the 13 countries of origin. Country names are abbreviated to their first three letters (except USSR). Circles represent confidence limits at P = 0.95.

The close resemblance between germplasm from adjacent countries, climatically similar such as within the levantine group, indicates that the ecological environment has been the major evolutionary force in the cultivated lentil. Furthermore, with the character time to maturity as the most important trait in the classification, it appears that phenological adaptation to the ecological environment has been central to the evolution of the crop.

The regional grouping in lentil has a practical use in the utilization of germplasm by breeders. Collections often contain so many entries and such a multiplicity of potentially interesting characters that they are formidable to potential users. The grouping found in this study could be used in the selection of parental stocks from the germplasm collection and in establishing a core collection. The aim of a core collection is to include, with minimum redundancy, the genetic diversity of a species in a condensed (and hence manageable) yet representative assembly of accessions.

Drs. W. Erskine, Y. Adham and L. Holly.

2.2.2. Variability in response to temperature and photoperiod

Study to understand the phenological adaptation of lentil is being conducted with the University of Reading, U.K. in an ODA-sponsored project. The response of lentil genotypes to different temperatures and photoperiods in time to flower can be quantified with the equation $1/f = a + bT$ and cP, where flowering ($\underline{f}$) is transformed into the rate of progress ($1/f$) towards flowering by taking the reciprocal, T is the mean temperature and P is the mean photoperiod. This equation described the response of six varied lentil genotypes to a wide range of photo-thermal combinations created in controlled environments (FLIP Annual Report, 1986).

The model was then tested on a wider range of germplasm accessions, a total of 240 lines, in the glasshouse in Reading in a total of four photo-thermal environments. The average time to flower in the four factorial combinations of two photoperiods (14 and 16 hours) and two mean temperatures (13.5 and 18.5°C) are shown in Table 2.2.1. The time to flower was reduced with increasing temperatures and photoperiods. There were, however, large differences between the accessions in response to temperature and photoperiod, which were described by the equation given earlier. The average coefficient of determination (r^2) over germplasm for the multiple linear regression was 0.915. Clearly, the model derived from a few genotypes in many different photo-thermal regimes in controlled environment chambers fitted the data of a wider range of germplasm in a more limited set of environments in the glasshouse.

Table 2.2.1. Mean time to flower (days) of 240 lentil germplasm accessions grown in the glasshouse in Reading University under different temperature and photoperiod regimes.

Temperature (°C)	Photoperiod (hours)		Mean
	14	16	
13.5	67.5	47.0	48.7
18.5	59.8	37.6	57.3
Mean	63.7	42.3	
Standard Error	Temp. and Photo. means ± 0.21		
Standard Error	Interaction means ± 0.29		

The range over accessions of response to temperature (b) was from 0.0018 to a negative response of 0.0005. For response to photoperiod (c) the range over accessions was from 0.0014 to 0.0064. The variability amongst accessions for both responses c and b is illustrated in Figure 2.2.2. It is clear that response to temperature is independent of response to photoperiod.

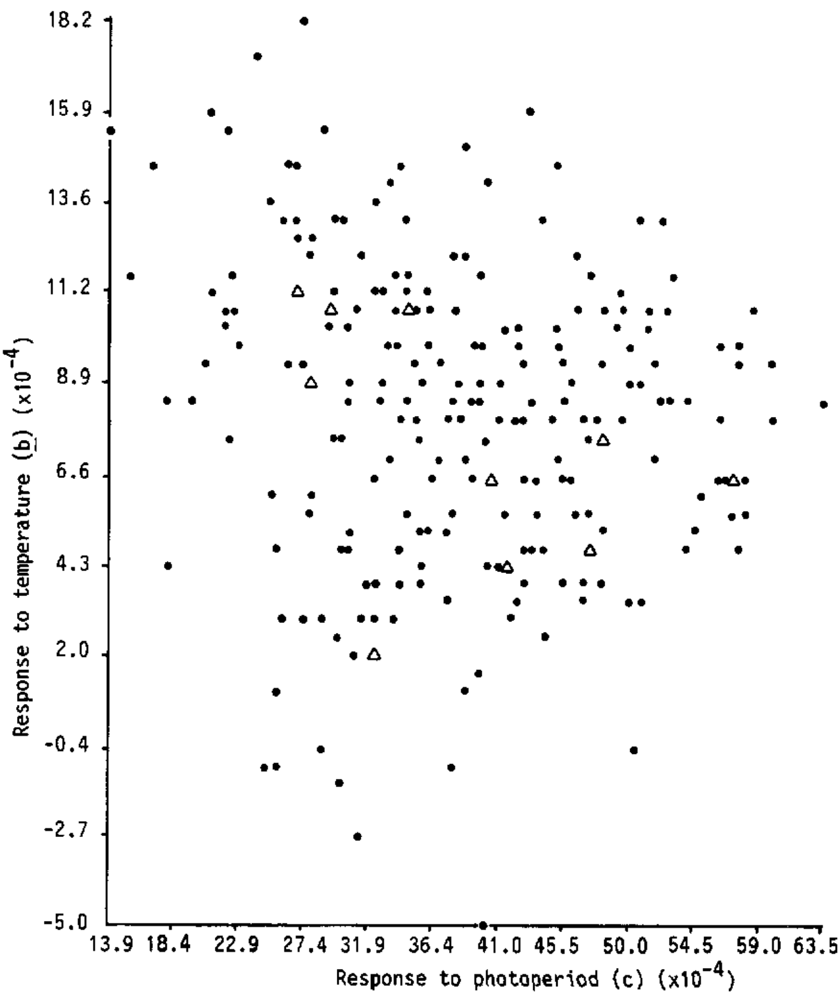

Figure 2.2.2. Response to temperature (b) and photoperiod (c) of 240 lentil accessions in the glasshouse in U.K. △ represents two points.

The genetic variability in response to both temperature and photoperiod was related to the origin of the accessions. The tested germplasm included 25 randomly selected accessions from each of eight major lentil producing countries and from ICARDA. An analysis of variance based on country of origin revealed significant differences between the average time to flower of accessions from each country. Similar ANOVAs based on country of origin of the average response to temperature (b) and the average response to photoperiod (c) of accessions from various countries also showed significant differences between country means. The mean values of response to temperature (b) and photoperiod (c) of accessions from the eight countries are shown in Figure 2.2.3.

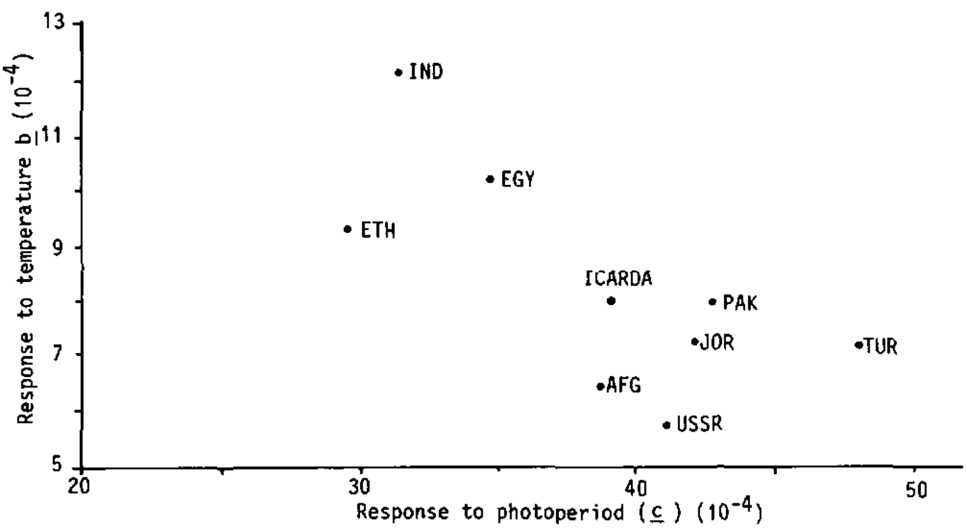

Figure 2.2.3 Mean response to temperature (b) and photoperiod (c) of 25 random accessions from eight lentil-producing countries and ICARDA.

The earliest flowering accessions came from Ethiopia and India, but there was a difference between the respective averages for response to temperature and photoperiod of accessions from these two countries. Accessions from India were more responsive to temperature, in general, than accessions from Ethiopia. By contrast, the latest flowering accessions, on an average, come from Afghanistan, Turkey and USSR. However, within this group the Afghan material is least sensitive to photoperiod whereas the Turkish accessions are highly sensitive to photoperiod.

The model was further tested in the field in Tel Hadya, Syria and Islamabad, Pakistan, in cooperation with the national program on the same set of germplasm, which was supplemented with 25 randomly selected lines from each of Chile, Greece, Iraq, Lebanon and Syria. The average time to flower of accessions from these countries is shown in Figure 2.2.4 drawn from data from Tel Hadya. The time to flower was lower in Tel Hadya than in the glasshouse in U.K. because of the inductive warm temperatures and long days in the glasshouse.

We are now testing the usefulness of the model for photothermal response on the field data.

Dr. R. Summerfield and Prof. E. Roberts (University of Reading), Mr. M. Bashir and A. Boux (NARC, Islamabad); and Drs. A. Hussain and W. Erskine.

2.2.3. Adapation to Mediterranean environment: 1. Rainfed

In low to middle elevation areas (below 1,000 m altitude) of West Asia

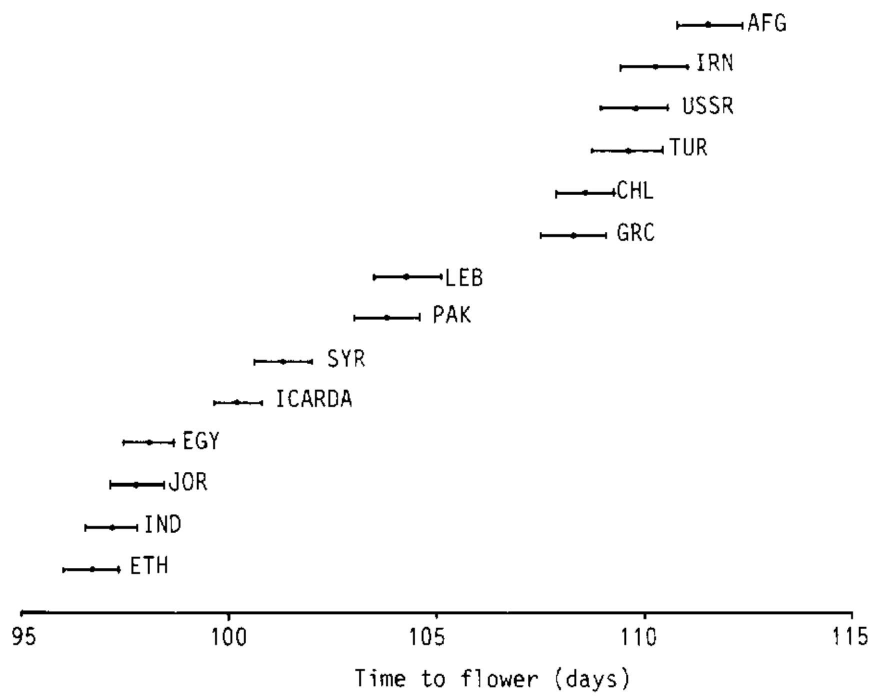

Figure 2.2.4. Mean time to flower (days) at Tel Hadya of 25 randomly selected germplasm accessions from each of 13 countries of origin (designated by a three-letter code) and ICARDA with the standard deviation indicated as a bar.

and North Africa, lentil is grown under rainfed conditions largely between the rainfall isohyets of 300-400 mm. The crop is sown in December and its vegetative growth occurs in the winter months when low temperature and radiation limit growth. From March onwards, the crop experiences increasingly strong sunshine and high temperatures up to maturity. The period of increasing temperatures coincides with cessation of rains and increasing evaporative demand on the crop when it is in the reproductive stage. Consequently, the yields are low.

There is a need, therefore, to determine attributes contributing most to high and stable yield in the rainfed Mediterranean environment.

A field trial was conducted at Breda which has an annual average rainfall of 281 mm. Twenty five diverse genotypes differing in origin, vigour, phenology, yield potential, height and seed size were used. Repeated observations of phenology, percentage ground cover, plant height, leaf colour, leaf hairiness, vigour (as dry matter produced/m^2 and as visual score, on 1-5 scale, with 1 being most and 5 least vigorous) were made and, at maturity, biological and seed yields were measured. In the 1987/88 season, the trial received 400.4 mm of rainfall, an amount representing 43% more than the long-term average.

Seed yield, biological yield and harvest index varied significantly ($P<0.05$) amongst genotypes and seed yield ranged from 1022 kg/ha in ILL 4349 to 2193 kg/ha in ILL 6004 (Table 2.2.2). The range for biological yield was from 3363 kg/ha in ILL 5754 to 6269 kg/ha in ILL 5582 (Table 2.2.2).

In West Asia and North Africa, both lentil straw and seed are important sources of income and the major objective of lentil improvement is to increase yield through the production of high biomass. An important prerequisite for a high seed yield is the attainment of high biomass accompanied by improved partitioning of the assimilates produced to the seeds. In this study, therefore, all variables that were measured were correlated with biological yield and the important correlations are presented in Table 2.2.3. The genotypes are grouped into early and late flowering. Within the early flowering lines, preliminary results indicate that early and mid-season vigour

Table 2.2.2. Number of days to flower and physiological maturity and seed yield, total biological yield and harvest index of lentil genotypes, Breda, 1987/88.

Genotype (ILL)	Time to		Yield (kg/ha)		Harvest index
	flower	maturity	seed	biological	
5754	124	159	1107	3363	0.34
5989	117	152	1975	5583	0.36
5991	117	152	2019	5475	0.39
5994	120	157	1824	5239	0.34
6011	120	159	2140	5351	0.40
1939	123	157	1960	5189	0.38
5715	123	152	1845	5419	0.34
5775	123	151	1917	5549	0.35
5860	124	151	2026	5555	0.36
5863	124	153	1651	4841	0.34
6049	123	155	1939	5146	0.38
5604	123	155	2163	5939	0.36
6024	116	151	1974	4267	0.46
6035	109	151	1872	5368	0.35
4403	116	155	1728	4201	0.42
5782	116	159	1671	4005	0.42
2126	111	159	1393	4101	0.34
6004	109	153	2193	5785	0.38
481	126	163	1100	3559	0.30
5582	118	154	2035	6269	0.33
5586	123	154	2093	5343	0.39
4349	127	161	1022	4948	0.21
4354	118	159	1759	4297	0.41
4400	120	161	1409	3612	0.39
4401	120	155	1945	6043	0.32
LSD (5%)			403	1017	0.068
CV (%)			16.0	14.5	13.3

(i.e. fast dry matter build-up), early maturity and a short reproductive period ensured a high total biomass production, which in turn resulted in high seed yield as shown by ILL 6004 in Figure 2.2.5a (Tables 2.2.2 and 2.2.3). For late flowering lines early vigour did not appear as an important attribute (Tables 2.2.2 and 2.2.3).

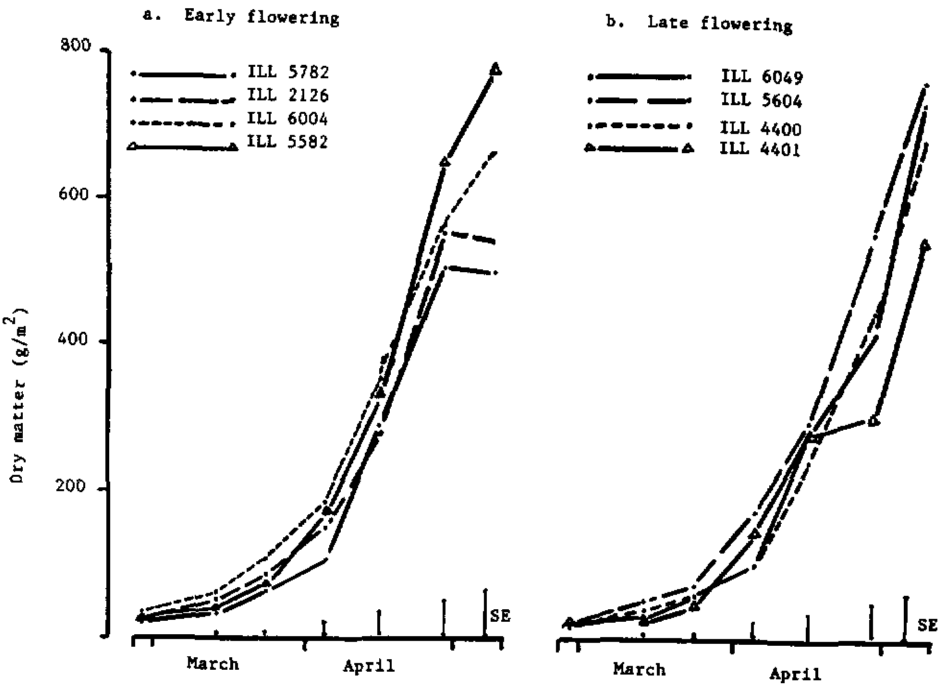

Fig. 2.2.5. Dry matter build-up (g/m^2) of lentil genotypes varying in vigour, time of flwoering and maturity.

Studies conducted between 1982 and 1985 with six lentil genotypes had indicated that vigour during the vegetative phase is an important attribute contributing to high seed yield. This was tested on 383 lines growing in 17 yield trials at Tel Hayda and at Breda. The average phenotypic correlation between early vigour (recorded on a 1-5 scale; 1= most vigorous, 5= poorest) and biomass yield was $r = 0.69 \pm 0.02$ at Tel Hadya and 0.49 ± 0.04 at Breda.

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

Table 2.2.3. Correlation of growth and reproductive traits with biomass yield at maturity in early and late flowering lentil genotypes, Breda 1987/88. Early genotypes reached 50% flowering stage between 23 March and 4 April and late flowering genotypes reached this stage between 4 and 15 April.

Traits		Biomass (kg/ha) at harvest	
		Early flowering genotypes	Late flowering genotypes
Dry matter/m^2 on	27.2.1988	0.496*	0.274*
Dry matter/m^2 on	13.3.1988	0.465*	0.147
Dry matter/m^2 on	23.3.1988	0.496*	0.257*
Dry matter/m^2 on	4.4.1988	0.504*	0.396*
Dry matter/m^2 on	15.4.1988	0.349*	0.421*
Days from sowing to flowering		-0.064	-0.219
Days from sowing to maturity		-0.467*	-0.500*
Reproductive period (days)		-0.418*	-0.339*
Seed yield		0.625*	0.804*

* Significant at $P<0.05$

2.2.4. Adaptation to Mediterranean environment 2. Irrigated

Although only on a limited scale, lentils are also produced under irrigated conditions in some parts of ICARDA region. In Egypt before the construction of the Aswan Dam, lentil was grown on soil moisture left by the annual flood of the Nile. Irrigation became widely available when the dam was constructed, but Egyptian lentils are ill-adapted to the extra irrigation. Possibly most introductions to Egypt come from rainfed areas with mal-adaptation. A Ph.D. study funded by the Nile Valley Project, aimed to investigate the response of lentil genotypes to different water regimes, providing guide lines, through partitioning the variation, for a local selection program for adaptation to irrigated conditions in Egypt. The research was divided into two main areas; 1) The overall variation in the crop was partitioned into genotypic, environmental and genotype-environmental components in an analysis of adaptation over seasons, irrigation regimes and locations; 2) The genotypic variation was partitioned into its various genetic components in an inheritance study using the diallel crossing system.

Pronounced progress should be expected from selection for traits such as number of pods/plant, 100-seed weight and straw yield/plant which showed high estimates of $h^2_{b.s.}$, C.G.V. and G.S. The two former traits correlated strongly and positively with seed yield, which allowed their use in indirect selection for seed yield. The 35 genotypes used in this study showed wide genetic diversity, allowing selection of high yielding genotypes under irrigation. Variation in water supply, temperature and soil type was found to exert a profound effect on variation in characters measured. This suggests the possibility of raising yield levels through improved management practices. In this study, irrigation repeated twice increased seed yield by 19% over no irrigation, at the same location (Tel Hadya), and increased the yield by 300% in comparison with a dry location (Breda). Seed protein quality was influenced by environments and genotypes. Electrophoretic studies showed that the number and position of the bands could be used to identify genotypes.

Four genotypes showed response to irrigation and could be recommended as promising entries. An anatomical study showed that large air spaces formed in the roots of responsive genotypes, which could be used as a selection criterion for response to irrigation.

Seed yield/plant exhibited 31.8% heterosis and showed a predominant role of non-additive genetic variance. Due to the significance of the non-additive effect, the superior F_1's may be expected to result in transgressive segregants, provided that the complementary genes and epistatic effects included in the non-additive component are coupled in the same direction to maximize seed yield. Five F_2 crosses showed superiority in seed yield and SCA effects. These crosses are being carried forward in breeding programs in Egypt.

Dr. A. Hamdi and Dr. P. Gates (Durham University, U.K.) and Dr. W. Erskine.

2.3. Lentil Harvest Mechanization

Lentil harvest is the major production problem in the Mediterranean region because of the high cost of harvest labour. Systems of mechanically harvesting the crop have been developed; they include the use of: 1) a lentil puller for existing cultivars and production practices, 2) mowers on a flattened seed bed preferably with a non-lodged cultivar, and 3) combine harvesters on a well prepared seed bed sown with a tall, non-lodging cultivar.

2.3.1. Development of a puller harvester for lentil and its comparison with other harvest methods

As a continuation of last year's trials two prototype lentil pullers were tested at Tel Hadya under the GTZ-financed project with the Institute of Agricultural Engineering of the University of Gottingen, FRG. The pullers were tested on both ridged and drilled fields at different crop moisture levels. The main application for the puller harvester is for planting on ridges, which is the traditional method of lentil cultivation and where no other equipment can be used for mechanical harvest. On the drilled field the pullers were compared with the double-knife cutterbar and with the modified Clayson combine harvester.

Consistent with last year's results (see FLIP Annual Report 1987) the harvest losses for the double-knife cutterbar amounted to an average of 12% for seed and 30% for straw. The attachment of a collecting-box to the double-knife cutter bar did not change the harvest losses. However, the lentil heaps from the box were too bulky to pass easily under the tractor on its next pass around the field. A modification to the collecting-box system is required.

Averaged over two years, the modified combine harvester gave seed losses of 20% and straw losses of 41% in a local cultivar. A major problem with the combine used was the high speed of the threshing drum resulting in the considerable grain damage of 11%. In order to assess the full capacity of the combine, it is planned to test a new machine with a reduced drum speed with a recommended cultivar with reduced lodging in the next season.

Additionally, mechanical harvest in two stages using a Draper pick-up mounted on a prototype of the SILSOE-whole-crop-harvester (low-cost combine) was tested for both cut and pulled lentils.

The picking action of the Draper pick-up was good. As the number of trials was low, and the lentil crop in the test area was poor, the results are not reliable. In spite of the unfavourable test situation, the total losses including machine pulling, pick-up and threshing for the two-stage harvest of pulled lentils were about 20%.

However, the main focus of this year's activities was to test the pullers on lentil in farmers' fields outside the experimental station and on a range of other crops. Two lentil pullers were used, both working with a reel and contra-rotating steel roller. The machines pull the crop out of the ground and place it in a swathe on the field. One of the pullers had been previously used but was modified for this season. This reduced the total seed losses to around 11% for lentil crop moisture levels between 60 and 35%, which is the best harvest period for pulling mechanically and by hand. The total straw losses were reduced to around 6%.

The second puller was newly constructed with the pulling geometry and dimensions of the pulling reel and steel roller optimized on the basis of the 1987 results. With this puller the total seed losses amounted to around 4% at a crop moisture level of 60%, rising at 35% moisture to 7% and at 20% moisture to 10%. The straw losses were about 4% for moisture levels over 35% (Fig. 2.3.1).

This year most of the losses occured after pulling but inside the machine. The real pulling losses for both machines range between 1 and 2% for seed and 2 and 4% for straw in the recommended harvest period, hardly exceeding 5% in a drier crop.

In addition to the field experiments the pullers harvested lentil fields of farmers from the villages of Tel Hadya, Bawabie, Gamari and Barkoum. The total harvested area was 8 ha of lentil, 1 ha winter chickpea and 0.25 ha barley, in addition to 2 ha of lentil and 1 ha of spring-chickpea at Tel Hadya. The performance of the puller was well accepted by farmers on lentil and in winter chickpea, though in chickpea the pod losses were higher than in lentil. Problems occured on fields heavily infested by wild mustard which was too bulky for the machines.

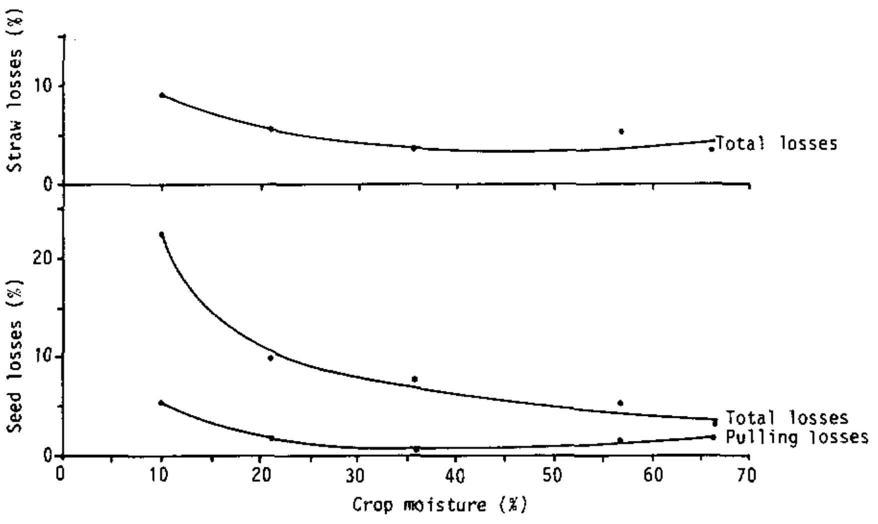

Fig. 2.3.1. Losses with the lentil puller.

The pulling of spring chickpea, especially local varieties, resulted in excessive pod losses. The puller was successfully used in short barley crops on stony fields, which cannot be harvested by combine and are now pulled by hand.

The project is ending this year. Further necessary modifications to the puller will now be carried out by the company van Lengerich, which has been requested to offer a modified version for commercial testing in Syria in 1989.

Dr. T. Friedrich, Professor F. Wieneke (University of Gottingen) and Drs. J. Diekmann and W. Erskine.

2.3.2. Economic survey and partial budget analysis of mechanization trials

Since 1985 mini-surveys of about 20 farmers have been conducted annually to update the economic data and to ask farmers specific questions on lentil harvest.

Dramatic changes have occurred in lentil prices over the period 1985-1988 to make lentil among the most profitable winter crops in Syria. The grain price increased by 310% from 1870 SL/t in 1985 to 7660 SL/t in 1988 (Table 2.3.1). Therefore, considering normal grain yield, as revealed by this year's mini-survey, of 1440 kg/ha the average grain revenue increased from 2690 to 11,030 SL/ha.

Table 2.3.1. Comparison of economic profitability of lentil production for farmers between 1985 and 1988 in Syria.

	1988	1985	% increase
Grain yield (kg/ha)	1440*	1440	-
Straw yield (kg/ha)	2190	2190	-
Grain revenue (SL/ha)	11,030	2,693	310
Straw revenue (SL/ha)	2,256	1,927	17
Total gross benefit (SL/ha)	13,286	4,620	188
Total cost of production (SL/ha)	7,530	2,360	219
Net revenue or profitability (SL/ha)	5,756	2,260	155

* Yield data are from 1988 mini-survey estimates from farmers for average lentil production over years.

The cost of hand harvest also rose in this period from about 1180 SL/ha in 1985 to 3880 SL/ha in 1988, but less rapidly than the grain price. Consequently, although the total production cost was 2360 SL/ha in 1985 and 7530 SL/ha in 1988, the profit increased by 155% from 2260 SL/ha to 5760 SL/ha.

The straw price increased in the period 1985-1988 by only 17% from 880 SL/t to 1030 SL/ha, a much lower rate than the grain price. The relative price change of seed versus straw suggests that harvesting solutions with straw losses are more acceptable than those with seed losses.

The mini-survey also revealed that all the farmers surveyed consider hand harvest as the largest production constraint in lentil.

They would all accept new varieties which can be harvested mechanically. 94% of the farmers would use a heavy bar to level their land to facilitate harvesting and 75% of the farmers would use seed drills if available.

In Syria field testing of the double-knife mower was initiated on farmers' fields during the 1985/86 season. The testing continued in a cooperative program with the Agricultural Research Center for the Syrian Ministry of Agricultural Research and Agrarian Reform over the 1986/87 and 1987/88 seasons in which site selection, sowing and harvesting were done jointly.

Hand harvest was compared with mechanical harvest by double-knife mower in three villages spread through the main lentil growing areas of Syria during the 1986/87 season and two villages in the 1987/88 season. At each site the local red-cotyledon, small-seeded land race 'Hurani 1' was compared to the ICARDA selection 78S26013 in large plots of 0.5 hectare/cultivar following seeding with a locally-made tine drill.

The yields of grain and straw were higher in the 1986/87 season than in the 1987/88 season. The overall mean for grain yield with a hand harvest was 1579 kg/ha, as compared to 1455 kg/ha following the harvest by mower representing a mean grain loss from mechanization of 124 kg/ha or 8% (Table 2.3.2). For straw yield, the overall mean with a hand harvest was 2096 kg/ha. The mower resulted in a mean straw yield of 1752 kg/ha, giving straw losses of 344 kg/ha or 16% compared to hand harvest. Losses from a mechanical harvest were lower for grain in the 1986/87 season, whereas for straw the losses were lower in the subsequent, 1987/88 season.

Table 2.3.2. *Mean yield (kg/ha) of grain and straw from harvests by hand and by double-knife mower averaged over two cultivars and seasons with three locations in the 1986/87 season and two locations in the 1987/88 season.*

Harvest method	Season 1986/87		Season 1987/88		Mean over seasons	
	Grain	Straw	Grain	Straw	Grain	Straw
Hand	1809	2441	1349	1751	1579	2096
Mower	1724	1919	1185	1585	1455	1752
Loss (%)	4.7	21.4	12.1	9.5	7.9	16.4
S.E. ±	79.9	105.0	76.5	110.1		

A partial budget analysis of the last two seasons yield data revealed a 4% increase in net benefit over a hand harvest with the mower harvest (Table 2.3.3). This shows the economic viability of the harvesting system proposed.

Mr. A. Salkini, W. Erskine and J. Diekmann.

Table 2.3.3. Partial budget analysis of mean yield data from the 1986/87 and 1897/88 seasons.

	Harvest method		
	Hand	Mower	% change
Grain yield (kg/ha)	1579	1455	-7.9
Straw yield (kg/ha)	2096	1752	-16.4
Grain revenue (SL/ha)	12,095	11,145	-7.9
Straw revenue (SL/ha)	2,159	1,805	-16.4
Gross revenue (SL/ha)	14,254	12,950	-9.1
Harvest cost (SL/ha)	2220	400	-82.0
Net benefit	12034	12550	+4.3

2.3.3. Exploitation of lentil harvest mechanization for production in Syria

At the Syrian Libyan Company (SYLICO), Ras el Ain, Syria a total of 95 ha of lentil were grown rainfed and harvested by John Deere combine harvester with an average seed yield of 1630 kg/ha and seed losses estimated at below 5%. Careful attention was paid to seed bed levelling. In a comparison covering 70 ha the cultivars 'Idleb 1' and 78S26013 yielded more than 40% the local check (Table 2.3.4). SYLICO plans to combine harvest 300 ha of the improved lines next season.

Table 2.3.4. Area harvested and yield results in a comparison between three lentil varieties harvested by combine at Syria.

Variety	Area harvested (ha)	Average seed yield from combine (kg/ha)	Mean plant height(cm)
'Idleb 1'	23	1890	54
78S26013	25	1846	52
Hurani 1 (local)	22	1281	45

In Kameshly Province, the General Organization of Agricultural Mechanization harvested 1800 ha of lentil by swathe-mower and 2600 ha by combine harvester. Clearly the mechanical harvesting of lentil is becoming a reality on farmers' fields in Syria.

National Agricultural Research System.

2.3.4. The effect of lentil harvest methods and soil tillage on the response of a succeeding barley crop to nitrogen

Lentil harvest in the Middle East is traditionally done by hand-pulling plants from the soil with some roots attached. Alternative systems for harvesting lentil are now available using either a mower or combine harvester or lentil puller. Lentil harvest by mower leaves a stubble in the field and harvest by a combine harvester additionally leaves the straw and chaff on the field. These residues may either be grazed by sheep or incorporated into the soil. A study was undertaken to examine the effects of various lentil harvesting techniques and tillage regimes on the response to N fertilizer application of a succeeding cereal crop.

The experiment was initiated during the 1987 lentil harvest by comparing a hand harvest with harvests by double-knife mower and combine, both with and without lentil stubble grazing by sheep. These comprised the main plot treatments, upon which deep tillage by chisel and sweep ploughs and shallow tillage by sweep plough alone were superimposed as subplots to incorporate stubble at different depths. Thereafter, barley was sown uniformly over the experimental area and the split-split plot arrangement completed by two rates of N fertilizer application (0 kg N/ha and a total of 60 kg N/ha in a split application).

The application of 60 kg N/ha increased barley biomass from 10.8 to 13.7 t/ha and seed yield from 4.3 to 5.5 t/ha. The concentration and total amount of N in seed and straw increased with fertilizer application. The interaction of harvest method and fertilizer was significant only for biological yield and the highest yields were from hand and mower harvest treatments; the same treatments also showed the largest response to N fertilizer application. Superimposed on the overall response to N application in barley seed yield was a significant three-way interaction showing that deep tillage increased the response to nitrogen application for hand harvest and mowing treatments.

These results show no advantage to the succeeding barley crop of incorporating extra lentil residues from harvesting by machine compared to hand pulling in the first crop cycle. Probably this is due to the slow degradation of the residues.

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2.4. Lentil Insects and their Control

In West Asia (Syria, Turkey, Lebanon) Sitona macularius (Marsham) is the primary insect pest of lentil. The main damage is induced by the larvae feeding in the nodules thereby affecting the nitrogen fixation ability of the plants. Studies concentrated on the evaluation of the economic importance and control methods of Sitona spp. In addition to Sitona spp. storage pests, especially Bruchus ervi cause severe damage to lentil as was found in a survey which was conducted in Syria and Jordan.

2.4.1. Importance and control of Sitona spp.

To further relate the economic importance of Sitona spp. to meterological data and cultural practices damage levels and yield were studied at 3 locations with different rainfall using 2 planting dates (early November 15 and late- January 10) and 4 treatment levels of Carbofuran (2, 5, 10, 20 kg/ha 5% G). This season rainfall was exceptional high at all locations in Syria. At Breda (dry site, but 404 mm rain this year) a high infestation of 82% nodules damaged was found in the early planting (Fig. 2.4.1.1). The carbofuran treatment, even at the lower rates, greatly reduced the nodule damage. At the dosage of 10 kg and 20 kg Carbofuran the nodule damage was only 1.6 and 0.7%, respectively. Seed yields however, did not increase. Biological yields had a tendency to increase but non-significantly. In the late sown crop nodule damage was much lower, and again no yield response to Carbofuran was found (Fig. 2.4.1.1). Because of the shorter growing period seed and straw yields were less than half of the early planting despite the lower Sitona infestation.

At Tel Hadya (intermediate rainfall, 505 mm this season) the Carbofuran treatments significantly reduced the nodule damage but did not increase seed yield in early sown crop (Fig. 2.4.1.2). Biological yield, however, was significantly higher in the 10 and 20 kg/ha

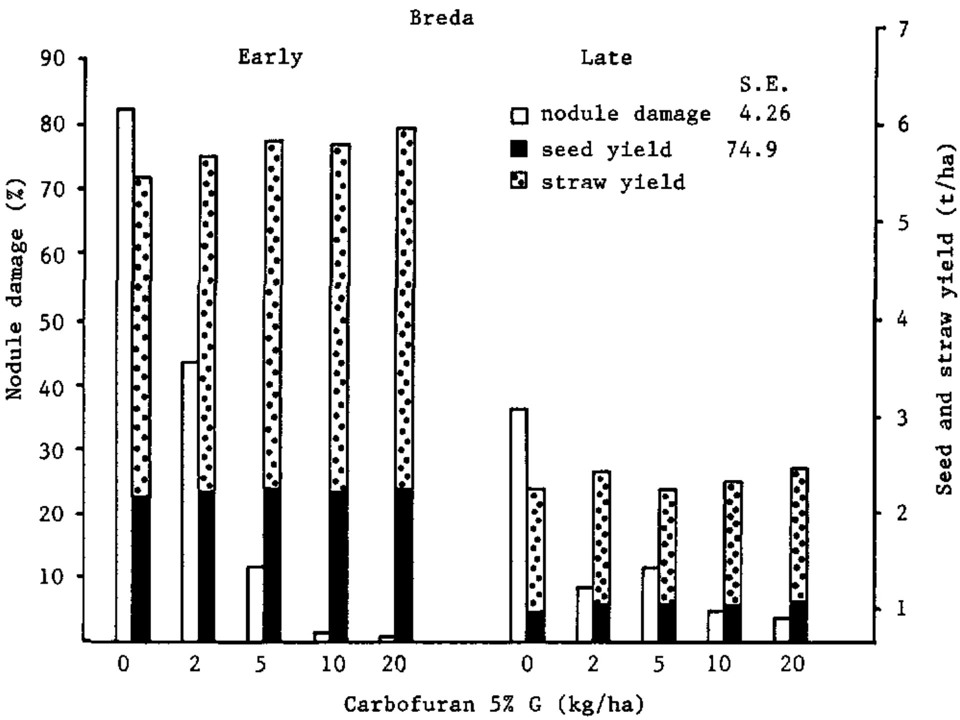

Fig. 2.4.1.1. Effect of planting date and 4 treatment levels of Carbofuran on Sitona spp. damage, and lentil seed and straw yield at Breda (low rainfall), 1987/88.

Carbofuran treatments than in the check. In the late planting nodule damage was lower, as were seed and straw yields and no significant response to Carbofuran was found.

At Jinderess (high rainfall, 700 mm) also nodule damage was higher in the early planting, reduced by carbofuran treatment with only biological yields tending to increase but nonsignificantly (Fig. 2.4.1.3).

At all the three locations early sowing of lentil increased Sitona infestation and nodule damage. However, because of the longer growing

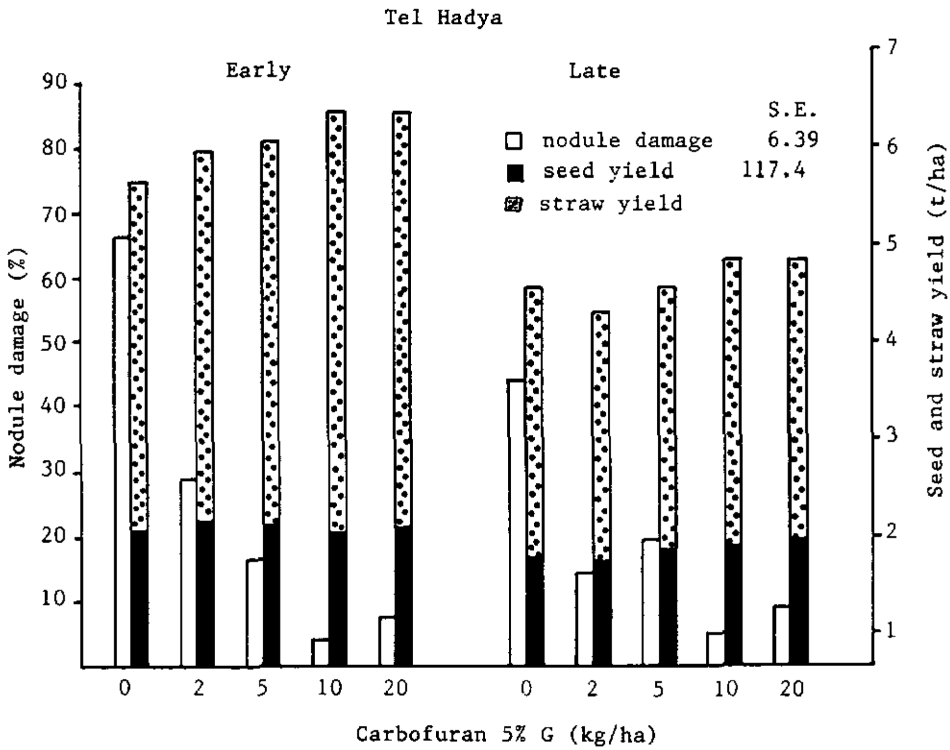

Fig. 2.4.1.2. Effect of planting date and 4 treatment levels of Carbofuran on Sitona spp. damage and lentil seed and straw yield at Tel Hadya (intermediate rainfall), 1987/88.

period seed and straw yields were significantly higher, with and without Carbofuran treatment, than in the late sowing. In all cases Sitona control significantly reduced nodule damage but did not increase lentil grain yield. Only biological yield showed some increase (more in early planting). No differences in nodule damage existed between the 10 kg and 20 kg/ha Carbofuran (5%G) treatments, and even the lower dosages were effective.

Based on this year's price of 8 S.L./kg lentil grain and 1 S.L./kg straw, an economic assessment of the yield response of lentil to the

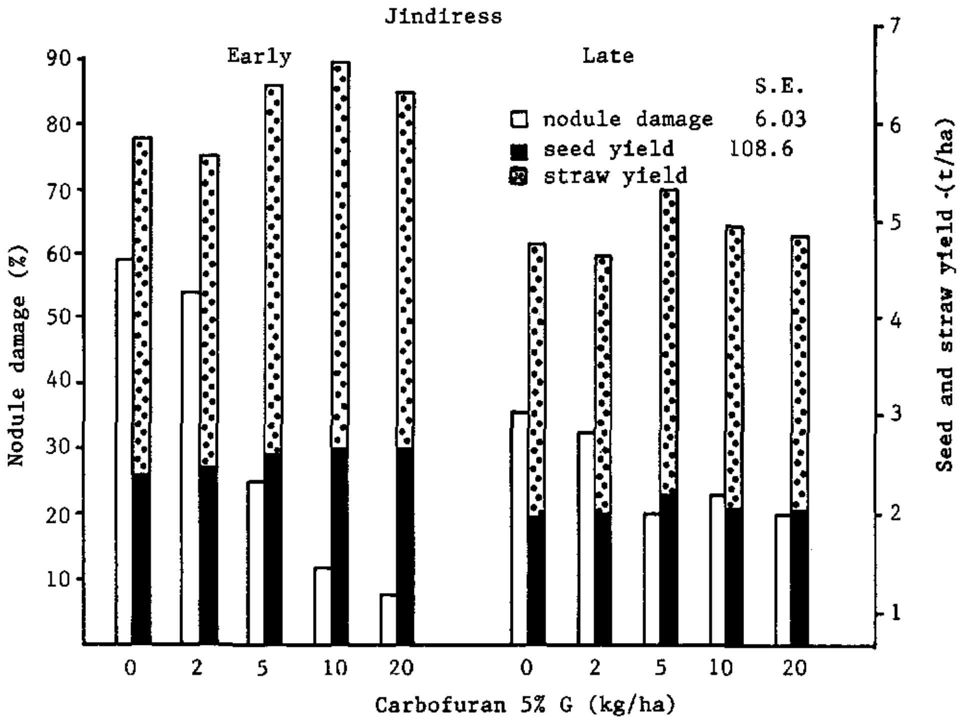

Fig. 2.4.1.3. Effect of planting date and 4 treatment levels of Carbofuran on Sitona spp. damage and lentil seed and straw yield at Jindiress (high rainfall), 1987/88.

application of different dosages of Carbofuran at the three locations for the last 2 seasons is shown in Figure 2.4.2. At Breda in 1987 no response was found whereas this year with higher rainfall the Carbofuran had some effect, but no difference existed between the lowest and highest dosage. At Tel Hadya the response to Sitona control was high in 1986/87, but low this season, and at Jinderess in both years a high response to Carbofuran trearment was found. At all locations and in both years no differences existed between the 10 kg/ha

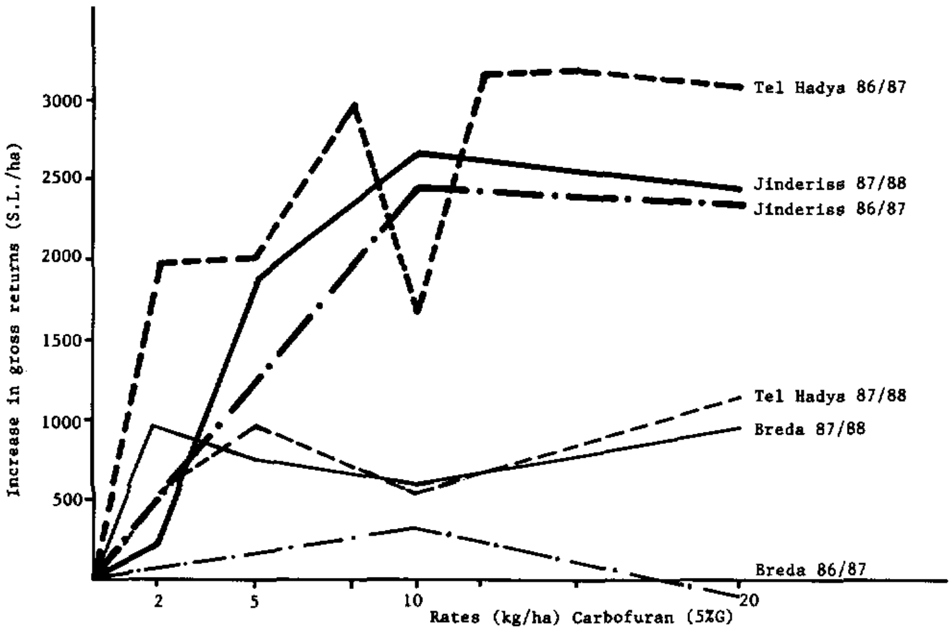

Fig. 2.4.2. Response of lentil yield in S.L. to different treatment levels of Carbofuran for Sitona control at 3 locations in 2 seasons.

and 20 kg/ha Carbofuran (5%G) application, indicating that the lower dosage provides sufficient control and is thus more economical. These results also suggest that Sitona control is more important and effective in terms of yield increases in areas with higher rainfall, as Jinderess. At Breda, although Sitona infestation was high and soils low in nitrogen, lentil yield response to Carbofuran application was low, indicating that some other factors limited the yield.

Using the data from 9 different locations in Northern Syria for 1986/87 and 1987/88 the relationship between the rainfall (mm) and the biological yield response of lentil to application of 20 kg/ha Carbofuran (5%G) was developed (Fig. 2.4.3). The relationship could be

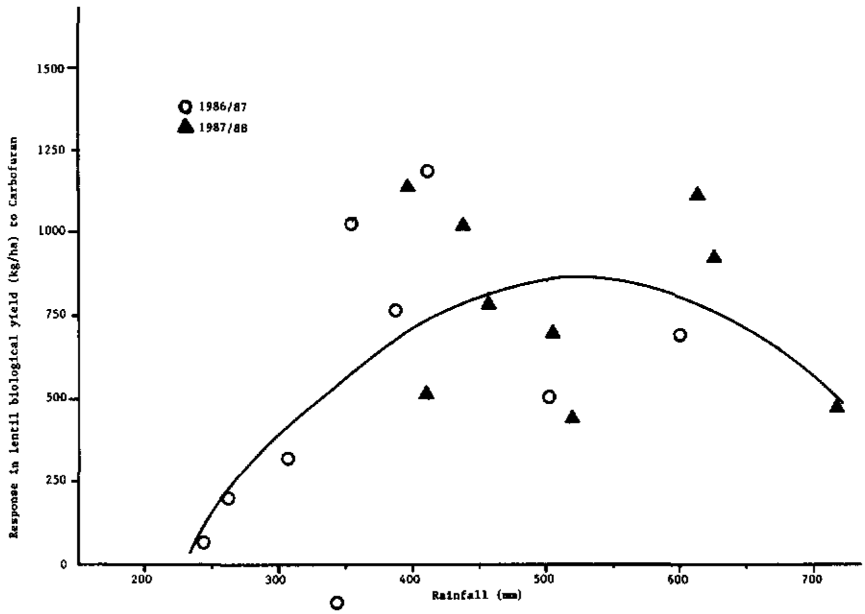

Fig. 2.4.3. Response of lentil biological yield to Sitona control (20 kg/ha Carbofuran 5% G) at locations with different rainfall during 2 seasons, 1986/87 and 1987/88.

described by the quadratic equation $y = -1791.94 + 10.10\ x - 0.0096\ x^2$ where x= seasonal rainfall (mm), and y= total biological yield increase (kg/ha). The coefficient of determination (r^2) was 0.34 (P<0.5). From this equation, maximum response to Carbofuran application was predicted at 525 mm rainfall.

Dr. S. Weigand

2.4.2. Storage Insect Pests

2.4.2.1. Control recommendations for *Bruchus* spp.

In many countries of the ICARDA region univoltine bruchid species cause considerable damage in lentil. Since infestation starts with the oviposition on the green pods in the field and the larvae then develop in the seeds, fumigation after harvest will only kill the insects but not reduce the damage and instead, treatment of the adult bruchids before oviposition in the field would be more efficient. The application of Thiodan 35% EC (700 g. a.i./ha) at flowering resulted in significant reduction of seed infestation, although infestation in general was low and less than 3% in the check. Next season this experiment including Deltamethrin as another insecticide will be conducted in farmer's field in an area, where high infestation levels were found previously.

Drs. O. Tahhan and S. Weigand

2.4.2.2. Bruchus spp. infestation in relation to different cultural practices

From the Sitona experiment (2.4.1.), samples of 15 g seeds were checked for the percent seed infestation with Bruchus spp. Carbofuran treatment had no effect on the Bruchus infestation since this only starts at flowering. Seed infestation was significantly lower in the late planting both in Breda and Tel Hadya (Fig. 2.4.4) which might be due to the escape of late formed pods from oviposition. In Jinderess, where infestation was lowest, no difference was found between planting dates.

Infestation levels of 5 lentil accessions planted in breeders On-farm trials at 5 locations were also studied. The highest infestation with a mean of 10.2% was found in Atareb and accession ILL 5883 showed the highest infestation with a mean of 6.0% (Table 2.4.1). Infestation levels in advanced lentil accessions at different locations will be continuously evaluated over the next years.

Table 2.4.1. Seed infestation of 5 lentil accessions with Bruchus spp. at 5 locations in northern Syria, 1987/88.

Accession	Atareb	Souran	Breda	Taftanaz	Tel Hadya	Mean
ILL 16	8.0	1.9	1.6	4.6	0.8	3.4
ILL 2130	7.7	3.4	2.7	5.6	4.2	4.7
ILL 5858	6.2	1.3	0.8	0.7	0.5	1.9
ILL 5883	17.0	3.2	2.8	3.5	3.7	6.0
ILL 6015	11.9	3.2	3.0	2.9	5.5	5.3
Mean	10.2	2.6	2.1	3.4	2.9	4.2
LSD at 5%	4.9	n.s.	n.s.	n.s.	2.0	
C.V.	17.3	46.1	54.2	36.4	25.0	

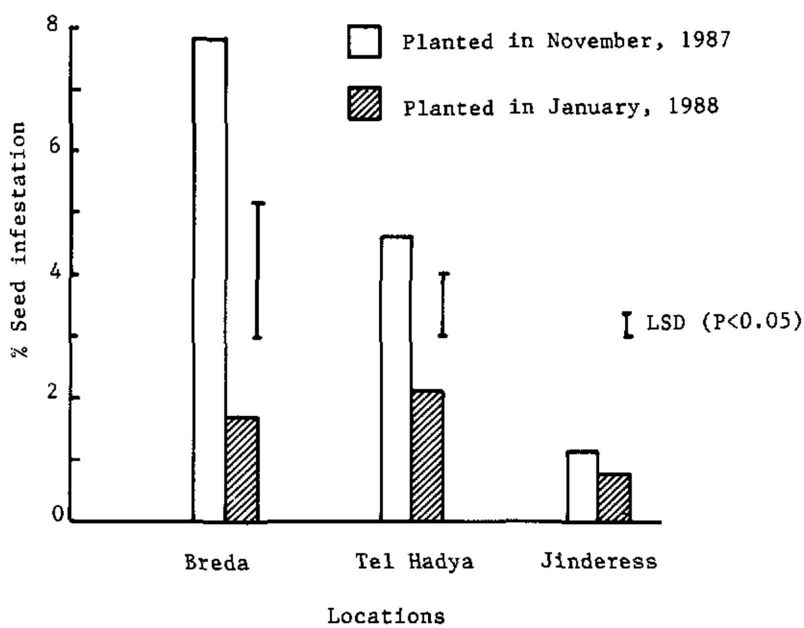

Figure 2.4.4. Seed infestation by Bruchus spp. in early and late planted lentil (ILL 4401) at Breda, Tel Hadya and Jinderess, 1987/88. Data mean of 20 samples for each treatment/location.

2.4.2.3. Survey of lentil storage pests in Syria

A survey was conducted to identify the importance and distribution of actual and potential storage pests. Bruchus ervi Froel. and Bruchus lentil Froel., both univoltine, were found to be the main bruchid species in lentil, with B. ervi being more dominant. In 1987, 220 samples from farmers stores were taken in 12 provinces in Syria of which 77.6% were infested (Table 2.4.2). The mean seed infestation was 1.3% with a range from 0-18%. The highest infestation occurred in villages located between Aleppo and northern Idleb.

Table 2.4.2. Percent Bruchus spp. infestation of lentil seeds in farmers stores found in a survey of 12 and 2 provinces in Syria in 1987 and 1988.

Survey	No. of samples	% infested samples	% seed infestation Mean	Range
1987/12 provinces	220	77.6	1.3	0-18
1988/2 provinces	81	98.8	11.0	0-38

Samples collected again from these two provinces in 1988 were almost all (81) infested with a mean seed infestation of 11%. The widely used traditional method of seed storage is to fill the seeds in jute sacks which are placed inside cement stores. Phostoxin is the most commonly used fumigant for seeds for planting, whereas seeds for consumption are traditionally protected by mixing them with olive oil or salt or a mixture of both. Farmers and merchants are often not aware of possible methods to control the Bruchus spp. in the field. When asked for factors affecting the selling price of lentil according to their importance, both farmers and merchants named the insect presence first, followed by seed size, cleanliness, colour and cooking ability. In the 1987 survey the average reduction in price for lentil grain due to the insect infestation from all locations was 40%.

Drs. O. Tahhan and S. Weigand

2.4.2.4. Protection of lentil seeds

In storage lentil seeds are attacked by Callosobruchus chinensis often causing considerable losses. Seeds for planting can be protected by insecticides, but for the seeds for human consumption, other methods need to be used. Since the survey revealed the use of olive oil and salt and a combination of both as the traditional method of seed protection a laboratory experiment was conducted to compare the effectiveness of oils of olive, cotton seed, sunflower and corn, salt, and olive oil + salt with two insecticides, K-Othrin and Actellic as checks. Every 2 months 15 g lentil seeds were infested with each 4 female and 4 male adult C. chinensis. All treatments were 100% effective on the progeny emerging from infestations imediately after treatment. After 2 months cotton seed, sunflower and corn oil were less than 50% effective and thus these treatments were dropped from the experiment. The insecticides showed 100% efficiency even after 8 months when the effectiveness of olive oil was 50%. Thus both K-Othrin and Actellic are effective insecticides for the control of C. chinensis in seeds for planting and should be used alternately to prevent the development of resistance in insects to common control measures.

Studies on the effectiveness of oils and other substances in seed protection and their effect on seed quality will be continued to develop an economical, practical and safe method to protect lentil grain stored for human consumption.

Drs. O. Tahhan and S. Weigand

2.5. Lentil Agronomy

2.5.1. Response of lentil to seeding density and row spacing

Studies were conducted between 1979 and 1986 at Tel Hadya (mean annual rainfall 331 mm) and Breda (mean annual rainfall 281 mm) in north Syria and Terbol (mean annual rainfall 512 mm) in Lebanon. The seeding density ranged from 100 to 400 seeds/m^2 and row spacing 20 to 50 cm. The total rainfall during the growing seasons was 370, 338, 323 and 230 mm, respectively for 1979/80, 1981/82, 1982/83, 1983/84 and 1985/86 at Tel Hadya; 271 and 218 mm, respectively for 1984/85 and 1985/86 at Breda; and 597 and 444 mm, respectively for 1983/84 and 1984/85 at Terbol.

The interaction between seeding density and row spacing was not significant in any trial. Consequently, only the main effects of seeding density and row spacing are considered.

Seeding density influenced yields significantly. Quadratic equation passing through the origin (i.e. no plants, no yield) better described yield response to seeding density than linear (Table 2.5.1). In general yield increased with seeding density to reach a maximum at intermediate densities and thereafter declined (Figures 2.5.1 and

2.5.2). The seed rate for maximum yield was determined for each site using first partial derivative of the quadratic equation. The seeding densities for maximum yield were lower at Tel Hadya and Terbol than Breda; they were, respectively, 293, 302 and 345 seeds/m^2 for total biological yield (Figure 2.5.1) and 277, 278 and 331 seeds/m^2 for seed yield (Figure 2.5.2). The optimum densities were 280 seeds/m^2 at Tel Hadya and Terbol and 320 seeds/m^2 at Breda (Figure 2.5.3). This suggests that in conditions which produce restricted vegetative growth such as Breda, higher densities should be used to convert greater proportion of to total water use to transpiration and reduce the proportion lost as evaporation.

Table 2.5.1. Regression equations of seed and total biological yields in response to variation in plant density.

Location and season	Seed yield Regression equation	r^2	Total biological yield Regression equation	r^2
Tel Hadya				
1979/80	$y=0+5.112x-0.0094x^2$	0.98	$y=0+19.961x-0.0343x^2$	0.98
1981/82	$y=0+16.684x-0.0287x^2$	0.99	$y=0+39.073x-0.0619x^2$	0.99
1982/83	$y=0+15.122x-0.0302x^2$	1.00	$y=0+37.198x-0.0731x^2$	1.00
1983/84	$y=0+13.554x-0.0239x^2$	0.99	$y=0+37.350x-0.0643x^2$	0.99
1985/86	$y=0+7.927x-0.0128x^2$	0.99	$y=0+23.265x-0.0390x^2$	1.00
Combined	$y=0+11.796x-0.0213x^2$	0.87	$y=0+31.054x-0.0529x^2$	0.93
Terbol				
1983/84	$y=0+13.552x-0.0254x^2$	0.98	$y=0+52.716x-0.0852x^2$	0.99
1984/85	$y=0+7.636x-0.0142x^2$	0.98	$y=0+23.443x-0.0410x^2$	0.98
Combined	$y=0+10.594x-0.0198x^2$		$y=0+38.080x-0.0638x^2$	0.84
Breda				
1984/85	$y=0+4.437x-0.0066x^2$	0.99	$y=0+10.648x-0.0154x^2$	0.99
1985/86	$y=0+2.580x-0.0039x^2$	1.00	$y=0+13.202x-0.0191x^2$	0.99
Combined	$y=0+3.504x-0.0053x^2$	0.92	$y=0+11.925x-0.0173x^2$	0.98

y = yield (kg/ha); x = number of seeds/m^2

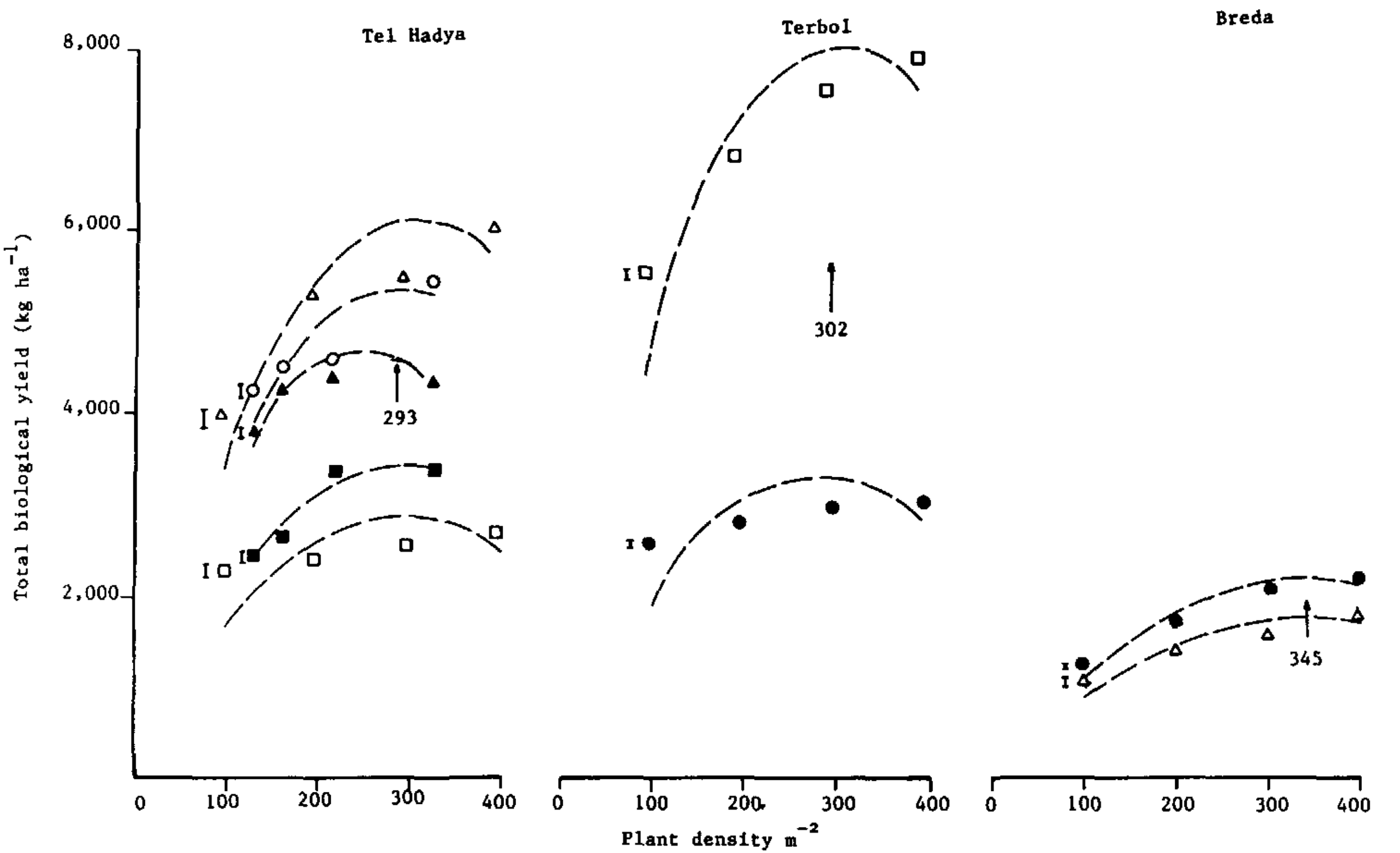

Figure 2.5.1. Relationship between plant density and total biological yield (kg ha^{-1}): ▲ = 1979/80, ○ = 1981/82, ■ = 1982/83, □ = 1983/84, ● = 1984/85, and △ = 1985/86. ↑ = maximum density. Quadratic regression for individual seasons = — — — and combined ———— . Vertical bars are standard errors.

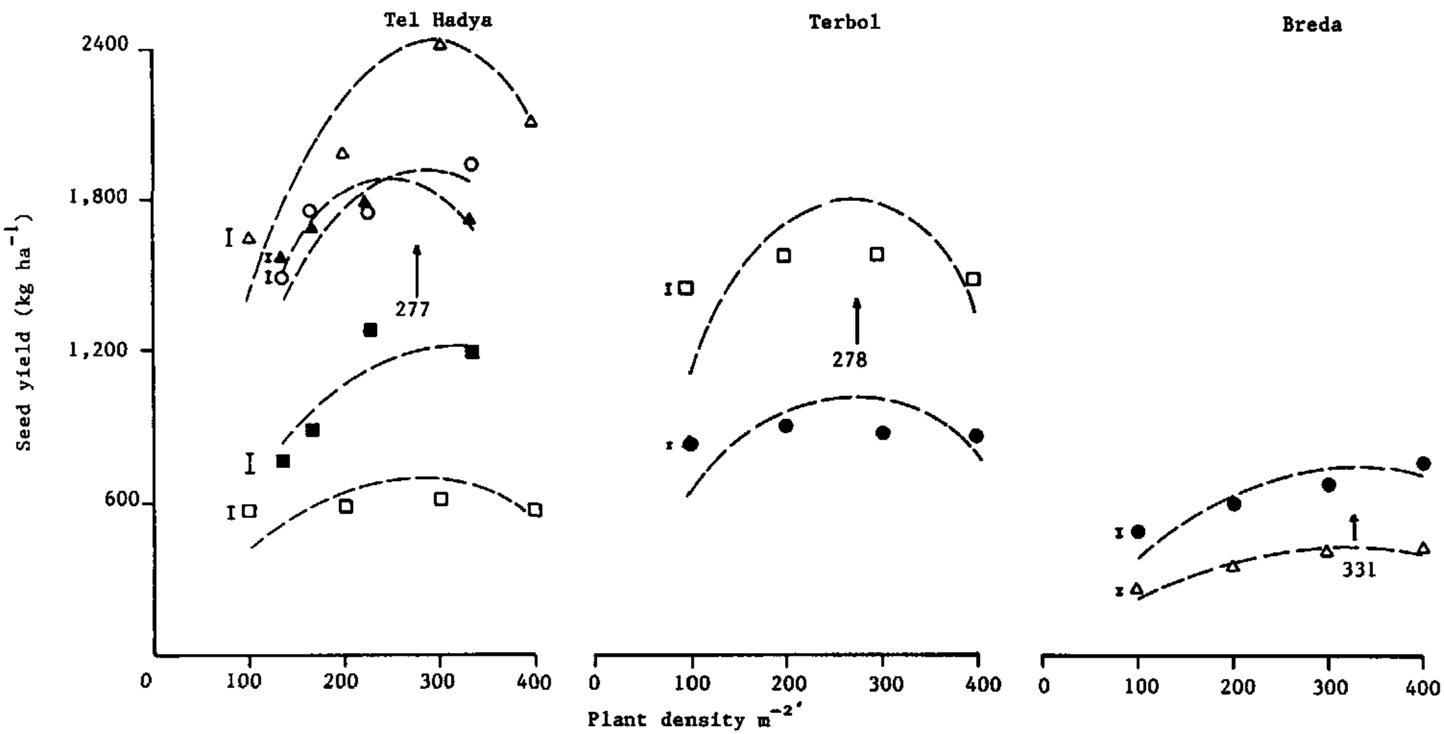

Figure 2.5.2. Relationship between plant density and seed yield (kg ha^{-1}) : ▲ = 1979/80, ○ = 1981/82, ■ = 1982/83, □ = 1983/84, ● = 1984/85, △ = 1985/86, ↑ = maximum density. Quadratic regressions for individual seasons — — — and combined = ———. Vertical bars are standard errors.

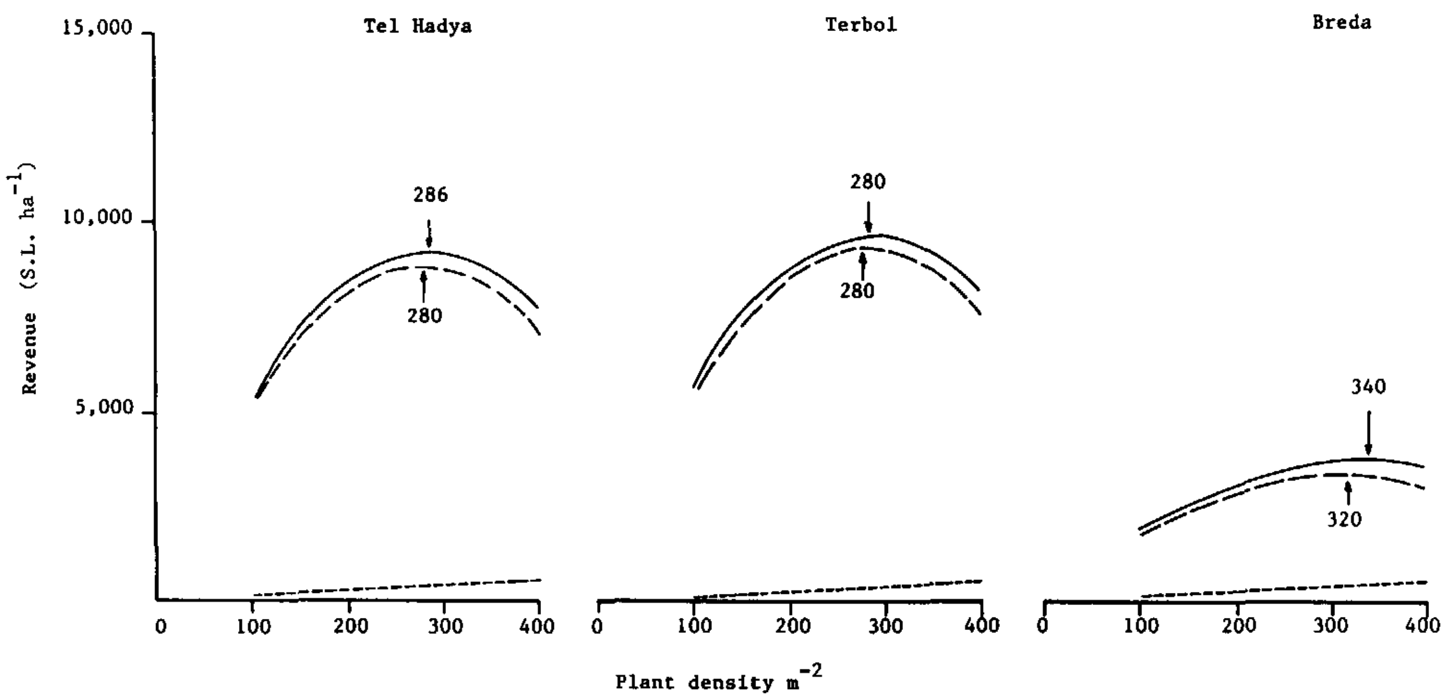

Figure 2.5.3. The relationship between plant density and revenue. ——— gross revenue, ------ seed cost and — — — gross revenue less seed cost. The density for maximum gross revenue and optimum densities for gross revenue less seed cost are indicated by arrows.

Yield response to changes in row spacing was lesser than to variations in seeding density. The linear regression fitted to the yield data suggests that narrower planting improves yield (Table 2.5.2) and this has the additional advantage of controlling weeds.

Drs. S.N. Silim and M.C. Saxena.

Table 2.5.2. Regression equations of seed and total biological yields in response to variation in row spacing.

Location	Seed yield Regression equation	r^2	Total biological yield Regression equation	r^2
Tel Hadya				
1983/84	y=717.5-3.75x	0.63	y=2846.0-10.6x	0.65
1985/86	y=2532.3-16.8x	0.97	y=6199.8-28.23x	0.86
Terbol				
1983/84	y=1662.3-4.03x	0.65	y=6328.0+16.8x	0.76
1984/85	y=1204.8-6.78x	0.99	y=3329.7-13.37x	0.96
Breda				
1984/85	y=705.2-2.27x	0.99	y=1707.4-5.09x	0.78
1985/86	y=361.4-0.09x	0.03	y=1681.5+5.9x	0.51

y = yield (kg/ha); x = row spacing (cm)

2.5.2. Lentil chemical weed control trial

The experiment was conducted at Tel Hadya station to evaluate the effect of recommended herbicides as well as those promoted from the previous season experiment. The experimental design was randomized block with 4 replications.

Weed infestation was low due to delayed planting. For example in the weedy check, total dry weight of weeds was 138 kg/ha. None of the herbicides showed any severe phytotoxicity on the lentil crop. No significant differences in grain yield were obtained between weedy check and herbicide treatments (Table 2.5.3).

Drs. M. Pala and S.N. Silim.

Table 2.5.3. Effect of weed control treatments on grain yield of lentil and dry weight of weeds (DWW). Tel Hadya 1987/88.

Treatment	Rate of application (kg a.i./ha)	Grain yield (kg/ha)	DWW (kg/ha)
Weedy check	-	1479	138
Hand weeding	-	1723	10
Cyanazine+Pronamide, pre-emergence	0.5+0.5	1403	56
Terbutryne+Pronamide, pre-emergence	2.0+0.5	1576	44
Codal*, pre-emergence	2.0	1492	110
Carbetamide, pre-emergence	1.5	1618	48
Carbetamide, post-emergence	1.5	1482	73
Dinoseb acetate + Fenoxaprop ethyl, post-emergence	1.0+0.25	1419	28
Dinoseb acetate + Fluozifop methyl, post-emergence	1.0+0.5	1538	10
Aresin Combi**, post-emergence	1.0	1304	23
S.E (5%)		86.75	45.31
C.V. (%)		11.7	169.1

* Codal = Combination of prometryne and metolachlor
** Aresin Combi = Combination of Dinoseb acetate and monolinuron

2.6. Lentil Microbiology

Following one year of greenhouse <u>Rhizobium</u> strain selection in hydroponic and intact soil core trials, in which over 40 strains were evaluated on 3 cultivars, a set of 3 superior strains was chosen for regional inoculation response trials in lentil. In 1987/88, 17 of these trials, designed to be conducted using locally adapted cultivars and ICARDA-produced inoculants, were sent to 12 countries. In addition, the trial was conducted at Tel Hadya and Breda stations with two cultivars, Idleb 1 (ILL 8) and ILL 16.

One of the selected strains, LE 719, was first tested with the two cultivars at Tel Hadya in 1986/87 season, giving 73 and 70 percent grain yield increases on Idleb 1 and ILL 16, respectively (Table 2.6.1). In 1987/88 season which was wetter than 1986/87, inoculation with this strain on Idleb 1 gave no significant yield response, but a significant 47 percent seed yield increase over uninoculated treatment was obtained on ILL 16. At Breda, only ILL 16 responded to inoculation with a 23 percent increase in grain yield. No results have yet been received from regional cooperators.

In order to evaluate inoculation response of a wide range of plant germplasm, 12 cultivars were inoculated with 3 strains in a field experiment at Tel Hadya, which incorporated ^{15}N subplots for quantification of nitrogen fixed. In this trial, straw and grain yield differences due to cultivar were largest, as might be expected when dealing with a wide range of plant types. However, differences due to strains and the interaction between strains and cultivars were also significant.

The effect of inoculation with the best strain, LE735, on straw and seed yields can be seen in Figure 2.6.1, where only the differences

Table 2.6.1. Seed and straw yields of two important lentil cultivars, with and without inoculation by a selected *Rhizobium* strain, during two seasons, Tel Hadya. Figures followed by asterisk are significant at P = 0.05 level.

		Straw yield		Grain yield	
Cultivar	Season	Uninoculated	Strain 719	Uninoculated	Strain 719
Idleb 1	1986/87[1]	4745	5023	745	1290*
	1987/88	4656	4035	2353	2927
ILL 16	1986/87	3653	4409*	697	1183*
	1987/88	4414	4161	1940	2851*

1) 1986/87 crop severely infested with *Orobanche*

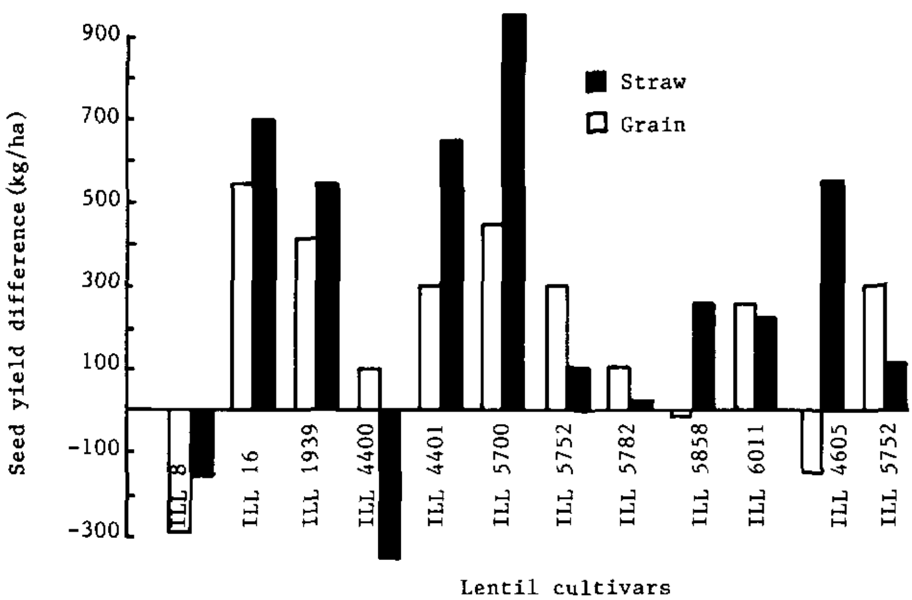

Figure 2.6.1. Seed and straw yield advantage from inoculation of 12 promising lentil cultivars by ICARDA strain LE 735 over uninoculated treatment (soil containing $>10^4$ native rhizobia per g soil). Tel Hadya, 1987/88.

between uninoculated and inoculated treatments are indicated. Significant yield response to inoculation occurred only in cultivars ILL 16 and ILL 5700, as standard error was high due to use of single-row plots. However, inoculation with best strain increased grain and straw yields by 13.5 and 9 percent respectively over all cultivars, and total nitrogen yield per hectare by 12 percent.

Results indicate a potential role for inoculation of lentils, even in traditional lentil production areas where high native rhizobial populations exist. Future work will focus on selection of highly effective Rhizobium strains which remain competitive over years for nodulation in elite plant germplasm lines.

Collaborative trials conducted in 1986/87 and 1987/88 seasons with INRA scientists at Montpellier, France, and at Tel Hadya, indicate that lentil can fix between 68 and 79 percent of its total nitrogen requirement, depending on environmental conditions. Nitrogen fixed in cultivar Idleb 1 varied from 88 to 169 kg N/ha (Table 3.5.2). Forthcoming ^{15}N results from the 1987/88 cultivar evaluation trial will show more clearly the N fixing ability of lentil, and indicate which cultivars are able to obtain a greater proportion of total plant N from the atmosphere.

Dr. D. Beck.

2.7. Lentil Quality

Lentil improvement aims to increase biomass to provide seed and straw for food and feed. Our research on seed and straw quality is geared to maintaining the current nutritional status of the crop. To this end a range of quality tests are routinely conducted on both breeding and agronomic trials. The tests include for seed - seed size, cooking quality, protein content and dehulling percentage (small seeds only) and for straw - protein content, in vitro digestibility and fibre content.

Dr. P.C. Williams and W. Erskine.

3. KABULI CHICKPEA IMPROVEMENT

The kabuli chickpea improvement is a joint project with ICRISAT. Of the four main regions where chickpea is grown, the Mediterranean region and Latin America produce mostly kabuli type chickpea. Of course, a small percentage of area under chickpea in the 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 and Iran. Ascochyta blight and Fusarium wilt are major diseases of chickpea. Leafminer in the Mediterranean region and pod borer in other regions are major insect pests. Kabuli chickpea is mainly grown as a rainfed crop in the wheat based farming system in areas receiving >400 mm rainfall in the ICARDA region. In Egypt and Sudan and parts of South Asia, West Asia and Central America, the crop is grown with irrigation.

In West Asia and North Africa, where the crop is currently spring sown, yield can increase substantially by winter sowing. Major efforts are underway to stabilize chickpea productivity by breeding for resistance to various stresses, such as diseases (blight and wilt), leafminer, cold, and cyst nematode. Efforts are underway to collect basic information for generating input responsive cultivars, especially those that respond to application of phosphate and supplemental irrigation.

3.1. Development of Cultivars and Genetic Stocks

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 (50% of resources); (b) spring sowing: resistance to Ascochyta blight and Fusarium wilt, tolerance to drought, early maturity, medium to large seed size (30% of resources);

2. Indian subcontinent and East Africa: Resistance to Ascochyta blight and/or Fusarium wilt, heat tolerance, early maturity, small seed size, responsive to supplemental irrigation (5% of resources);

3. Latin America: Resistance to Fusarium wilt,large seed size (5% of resources);

4. High elevation areas: Spring sowing, cold tolerance at seedling stage and heat tolerance at maturity, resistance to Ascochyta blight, early maturity, and medium seed size (10% of resources).

During 1988 several collaborative research projects were initiated. 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 are collaborating. The screening on cyst nematode is being carried out in association with the Istituto di Nematologia Agraria, C.N.R., Bari, Italy. Fusarium wilt resistance screening is being done in association with INRAT, Tunisia and the Department de Patologia Vegetal, Cordoba, Spain. Screening for tolerance to cold is being done in cooperation with the Central Anatolian Agricultural Research Institute, Ankara, Turkey. Genetics of phosphate uptake is being investigated in association with the University of Hohenheim, F.R.G. and a program on mutation breeding is underway with the Nuclear Institute for Agricultural Biology, Faisalabad, Pakistan.

3.1.1. Release of cultivars by national programs

One of the major objectives of the program is to strengthen the resources of national programs by providing diverse nurseries to enable them to develop and release cultivars for their farmers. National scientists have released 21 lines in nine countries by selecting appropriate types mainly from the international nurseries provided in the International Testing Program (Table 3.1.1.). Eighteen of these have been released for winter and two for spring sowing in the Mediterranean region. One cultivar was released in Sudan indicating that material generated in a Mediterranean environment at ICARDA can also be useful in a sub-tropical location.

National Scientists and Dr. K.B. Singh.

3.1.2. Prerelease multiplication of cultivars by national programs

National programs in Algeria, Cyprus, France, Jordan, Lebanon, Morocco, Syria, Tunisia, and Turkey selected, tested, and identified 37 cultivars (24 for winter and 13 for spring sowing) for prerelease multiplication and/or on-farm trials (Table 3.1.2.). Many of these cultivars have 100-seed weight exceeding 40 g. The programs in the Indian subcontinent and East Africa require early maturing lines and those in Latin America very large seeded lines. Future efforts would be directed to satisfy these requirements also.

National Scientists and Dr. K. B. Singh.

Table 3.1.1. Kabuli chickpea lines selected from international nurseries and released as cultivars by national programs.

Country	Cultivars released	Year of release	Specific features
Algeria	ILC 482	1988	High yield, wide adaptation
	ILC 3279	1988	Tall, high yield
Cyprus	Yialousa (ILC 3279)	1984	Tall
	Kyrenia (ILC 464)	1987	Large seeds
Italy	Califfo (ILC 72)	1987	Tall, high yield
	Sultano (ILC 3279)	1987	Tall
Morocco	ILC 195	1987	Tall
	ILC 482	1987	High yield, wide adaptation
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 (ILC 1335)	1987	High yield
Syria	Ghab 1 (ILC 482)	1982	High yield, wide adaptation
	Ghab 2 (ILC 3279)	1986	Tall, cold tolerant
Tunisia	Chetoui (ILC 3279)	1986	Tall
	Kassab (FLIP 83-46C)	1986	Large seeds, high yield
	Amdoun 1 (Be-sel-81-48)	1986	Large seeds, fusarium wilt resistant
Turkey	ILC 195	1986	Tall, medium seed, cold tolerant
	Gunej Sarisi 482 (ILC 482)	1986	High yield, wide adaptation

All cultivars 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. Also Gunej Sarisi 482 is released for spring sowing in Turkey.

Table 3.1.2. Chickpea cultivars identified for prerelease increase and/or included in the on-farm trials by national programs.

Country	Cultivar
Algeria	FLIP 84-145C, ILC 190
Cyprus	FLIP 85-16C, FLIP 85-17C, FLIP 85-55C, FLIP 85-12C
France	FLIP 81-293C
Jordan	ILC 482, ILC 3279
Lebanon	ILC 482, FLIP 85-5C
Morocco	FLIP 81-293C, FLIP 82-91C, FLIP 82-92C, FLIP 82-127C, FLIP 82-128C, FLIP 82-161C
Syria	FLIP 82-150C, FLIP 83-47C. FLIP 83-48C, FLIP 83-71C, FLIP 83-98C, FLIP 84-15C
Tunisia	FLIP 83-93C, FLIP 84-145C
Turkey	87 AK 71112, 87 AK 71113, 87 AK 71114, 87 AK 71115, FLIP 83-47C, FLIP 83-77C, FLIP 85-4C, FLIP 85-63C, FLIP 85-92C, FLIP 85-118C, FLIP 85-134C, FLIP 86-11C

3.1.3. Winter Sowing

Chickpea is spring-sown in the Mediterranean region but by sowing in early winter using Ascochyta blight and cold tolerant lines, the yield can be substantially increased. A comparison of spring versus winter sowing has been made over five years (1983/84 to 1987/88) at three sites (Tel Hadya, Jindiress and Terbol), using common breeding 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, especially at Tel Hadya, was the driest. Tel Hadya is the driest of the three sites, Terbol the wettest and Jindiress the intermediate, with long term average seasonal rainfall of 330, 575 and 475 mm, respectively. Tel Hadya, Jindiress and Terbol are located at 282, 210 and 980 m above sea level. The seed yield data in Figure 3.1.1 permit several conclusions:

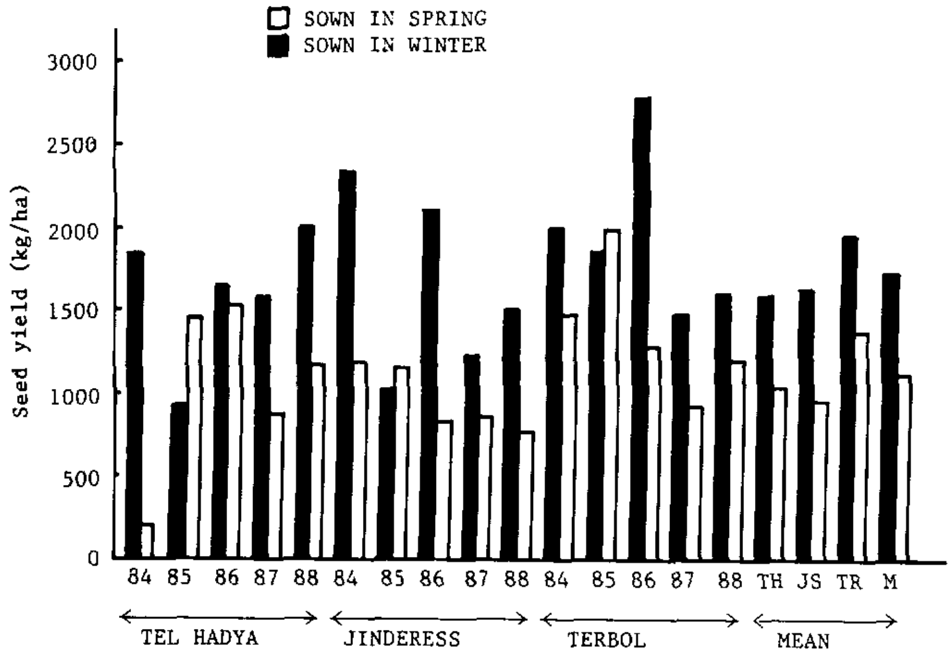

Figure 3.1.1. Mean seed yield of 72, 96, 96, 98 and 284 entries of chickpea grown during winter and spring at Tel Hadya, Jinderess and Terbol from 1983/84 to 1987/88.

The winter-sown trials produced a mean yield of 1744 kg/ha against 1134 kg/ha of spring sown trials, giving an average increase of 54% or 600 kg/ha. The advantage of winter sowing over spring was larger during years of sub-normal rainfall as was the case during 1983/84 at Tel Hadya. In years with exceptionally low temperatures, as in 1984/85, winter-sown chickpea can produce less yield than spring crop. There is a need to breed drought tolerant cultivars for spring sowing and cold tolerant cultivars for winter sowing to stabilize chickpea production.

Dr. K.B. Singh.

3.1.4. Screening for multiple stresses

3.1.4.1. Evaluation of cultivated species

Identification of resistant sources various biotic and abiotic stresses and their use in the breeding program to stabilize chickpea production receive high priority in our program. Screening of germplasm lines was initiated for Ascochyta blight (Ascochyta rabiei) in 1978, cold in 1979, leafminer (Liriomyza cicerina and Phytomyza lathyri) in 1981, wilt (Fusarium oxysporum) in 1982, seed beetle (Callosobruchus chinensis) in 1983, and cyst nematode (Heterodera ciceri) in 1986. Reliable and simple screening techniques and rating scales for all the six stresses have been developed.

Evaluation of large number of germplasm lines has helped in identification of resistant sources to Ascochyta blight, cold, leafminer, and Fusarium wilt (Table 3.1.3.). But no source of resistance was found for cyst nematode and seed beetle despite screening nearly 4000 of more than 6000 germplasm lines available at ICARDA.

Drs. K.B. Singh, M.P. Haware, S. Weigand, R.S. Malhotra, M.C. Saxena, O. Tahhan (ICARDA), Mr. H. Halila and Dr. M. Harabi (Tunisia), Drs. M.Di. Vitto, and N. Greco (Italy), and Professor J. Diaz (Spain).

Table 3.1.3. Resistant sources to different biotic and abitoic stresses in chickpea.

Stress	Lines screened	Resistant sources
Ascochyta blight	15,000	ILC - 182, - 200, -2506, -2956, -3274, -3856, -3866, -3870, -4421, -5586, -5921, -6188.
Cold	5200	ILC - 794, -1071, -1251, -1256, -1444, -1455, -1464, -1875, -3465, -3598, -3746, -3747, -3791, -3857, -3861.
Leafminer	6200	ILC 5901.
Fusarium wilt	2500	ILC - 857, - 848, - 850, - 851, - 857, - 858, - 860, - 871, - 904, - 911, -5032, -5411.
Cyst nematode	3800	None
Seed beetle	4000	None

3.1.4.2. Evaluation of wild species

In chickpea, 43 Cicer species have been reported. ICARDA collection includes 10 Cicer species including nine wild species (eight annual and one perennial) besides the cultivated species. In other major crops, genes for resistance to diseases and pests have been transferred from wild to cultivated species. This has not been the case in chickpea for two reasons: (a) lack of systematic evaluation of wild species and (b) crossability barrier between species. ICARDA holds 137 collections of eight wild annual species. These were evaluated against five stresses. The results are presented in Table 3.1.4.

High level of resistance was present in wild types for all the five stresses, including cyst nematode and seed beetle. C. bijugum possessed genes for resistance to all the five stresses and C. judaicum

Table 3.1.4. Evaluation of *Cicer* species to biotic and abiotic stresses at Tel Hadya, 1987/88.

Cicer species	Ascochyta blight	Leaf miner	Cyst nematode	Seed beetle	Cold
C. bijugum	R	R	R	HR	HR
C. chorassanicum	S	HR	S	S	S
C. cuneatum	R	HR	S	HR	S
C. echinospermum	S	R	S	HR	HR
C. judaicum	HR	HR	S	HR	R
C. pinnatifidum	HR	R	S	R	R
C. reticulatum	S	S	R	HR	HR
C. yamashitae	S	–	S	S	S

HR = Highly resistant; R = Resistant; S = Susceptible.

to four stresses. *C. reticulatum* which crosses freely with *C. arietinum*, possessed resistant genes for cyst nematode, seed beetle and cold. Crossed seeds between *C. reticulatum* and *C. arietinum* have been produced and thus efforts initiated to transfer genes for resistance to cyst nematode, seed beetle and cold from this source. Work on other species is described later in the report.

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

3.1.4.3. Combined resistance to Ascochyta blight and cold

Winter chickpea must possess resistance/tolerance to Ascochyta blight and cold. In screening germplasm lines to these stresses, no single line was found resistant to both stresses. We initiated a large program to develop disease resistant cultivars. In the absence of a suitable technique for breeding cold tolerant chickpea, we adopted negative selection procedure. Plants in F_2 populations and F_3-F_6 progenies showing cold injuries were rejected. Further, newly bred lines were evaluated in cold nursery for assessment of cold tolerance. Following this procedure, lines resistant to both stresses or resistant to one and tolerant to another stress have been developed. Lines found resistant or moderately resistant to both stresses are shown in Table 3.1.5.

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

Table 3.1.5. Some of the breeding lines resistant to Ascochyta blight and cold developed at ICARDA, Syria.

Line	Reaction to	
	Ascochyta blight	Cold
FLIP 82- 97C	3	4
FLIP 82-131C	4	3
FLIP 82-150C	3	4
FLIP 82- 22C	3	4
FLIP 82- 4C	3	4
FLIP 85- 84C	4	4
FLIP 85- 87C	3	4
FLIP 85- 90C	4	4
FLIP 85-133C	4	4
FLIP 85-141C	4	4

Scale: 1 = Free from damage, 5 = Intermediate, and 9 = Killed due to the stress.

3.1.5. Screening genotypes for response to supplemental irrigation

Kabuli chickpea is grown with supplemental irrigation in the Nile

Valley, South Asia, parts of West Asia, and Central America. Irrigation responsive cultivars have not been identified under the West Asian conditions. Therefore, an effort was made to develop screening technique and screen chickpea lines responsive to supplemental irrigation. Forty-eight genotypes of diverse origin were selected and two trials comprising 24 genotypes were grown rainfed and with supplemental irrigation during winter seasons of 1985-86, 1986/87 and 1987/88. The plot size was 4 rows, 4 m long spaced at 0.45 m apart. A randomized block design with three replications was used.

An efficient implementation of supplemental irrigation requires scheduling by consumptive use with the quantity of water required for continued plant growth based on minimal demand. For supplemental irrigation of chickpea, different quantity of water was added in three seasons as scheduled by daily water balance computations of rainfall and pan evaporation and verified by soil moisture measurements using the neutron probe.

On an average of 24 genotypes in three seasons, the mean yield under rainfed conditions was approximately 2000 kg/ha against 3000 kg/ha with supplemental irrigations in both trials (Figs. 3.1.2. and 3.1.3.). Thus an increase of 50% or 1000 kg/ha was obtained with supplemental irrigation over rainfed condition. The study also helped in identification of lines that are responsive to supplemental irrigation (Table 3.1.6.). It is important to study the genetics of response to supplemental irrigation besides screening a larger number of genotypes in future.

Drs. K.B. Singh, E. Perrier and M.C. Saxena

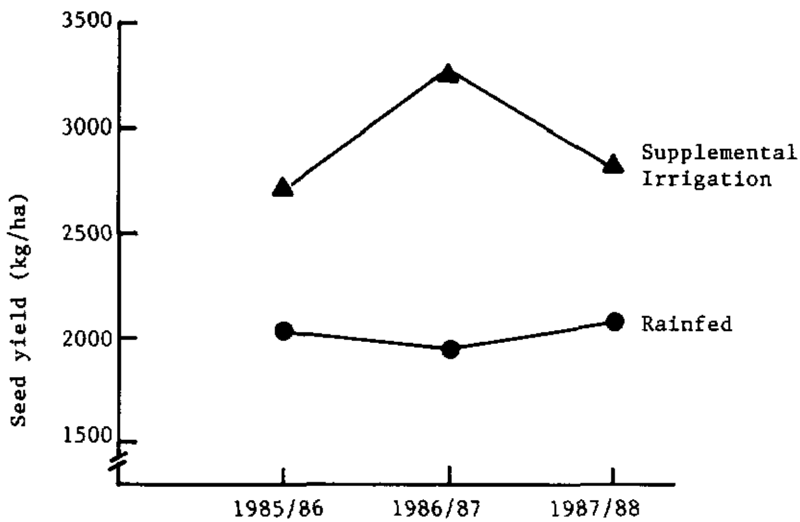

Figure 3.1.2. Mean yield of 24 chickpea genotypes as affected by supplemental irrigation in Trial 1.

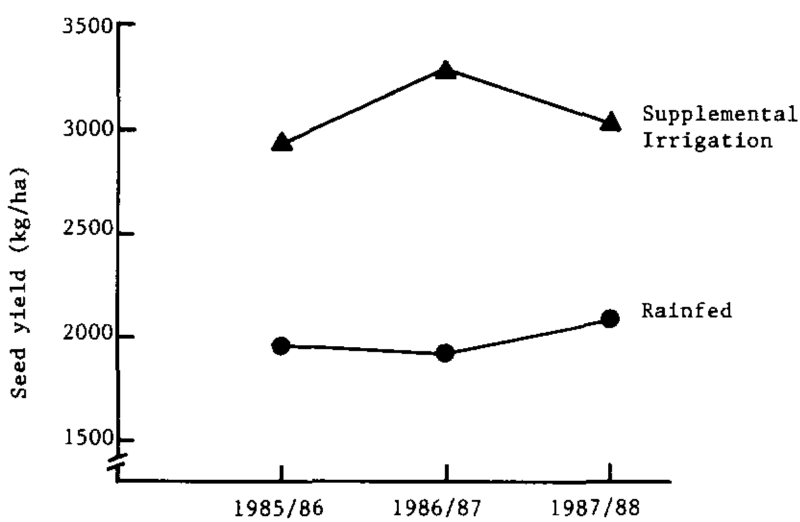

Figure 3.1.3. Mean yield of 24 chickpea genotypes as affected by supplemental irrigation in Trial 2.

Table 3.1.6. Mean seed yield (kg/ha) under rainfed and supplemental irrigation of three lines most responsive to irrigation and three chickpea lines yielding highest under rainfed condition from each of the two trials at Tel Hadya, Syria during 1985/86 to 1987/88.

Genotype	1985/86			1986/87			1987/88			Mean		
	Rainfed	Irrigated	% Increase	Rainfed	Irrigated	% Increase	Rainfed	Irrigated	% Increase	Rainfed	Irrigated	% Increase
Most responsive lines												
Trial 1												
ILC 202	1048	2152	105	1333	2825	112	1513	2159	43	1298	2379	83
Ghab 1	1929	2849	43	1630	3810	134	1831	2392	31	1797	3017	70
FLIP 84-116C	1381	2997	117	2116	3069	45	1852	2508	35	1783	2858	60
Mean [a]	2047	2686	31	1931	3387	75	2171	2788	28	2050	2954	44
LSD at 5%	893	1029		599	1007		446	972				
Trial 2												
ILC 104	1079	2095	94	1418	1852	31	698	1065	262	1065	2159	103
FLIP 83- 71C	1310	2556	95	1852	3333	80	1894	3423	81	1685	3105	84
FLIP 83- 69C	1254	2452	96	1683	3153	87	1672	3063	83	1536	2889	88
Mean	1965	2817	43	1974	3365	71	2027	3139	55	1989	3107	56
LSD at 5%	629	640		561	581		367	731				
Highest yielding lines under rainfed conditions												
Trial 1												
ILC 1272	3127	3254	4	2265	4275	89	2937	3492	19	2776	3674	32
ILC 464	2103	3310	57	2392	4296	80	2910	3836	32	2468	3814	55
ILC 613	2556	2754	8	2434	3704	52	2392	3455	44	2461	3304	34
Mean	2047	2686	117	1931	3387	75	2171	2788	35	1783	2858	60
LSD at 5%	893	1029		599	1007		446	972				
Trial 2												
ILC 100	2437	2660	9	2582	3947	53	2485	3169	28	2501	3259	30
ILC 1929	2754	3175	15	2095	3397	62	2529	3344	32	2459	3305	34
ILC 3777	2135	2351	10	2122	4063	91	2027	4032	48	2326	3482	50
Mean	1965	2417	43	1974	3365	71	2027	3139	55	1989	3107	56
LSD at 5%	629	640		561	581		367	731				

[a] Mean of 24 genotypes.

3.1.6. Breeding methods

Of several breeding methods tried in the past "bulk-pedigree" proved the best under our conditions (Fig. 3.1.4.). The off-season site at Terbol, (980 m elevation) has been used to grow F_1 generation to produce F_2 seeds, grow F_3 generation and select for reduced photoperiod sensitivity, and purify and increase seed of newly bulked lines (F_6 generation). This has helped accelerating the pace of cultivar development.

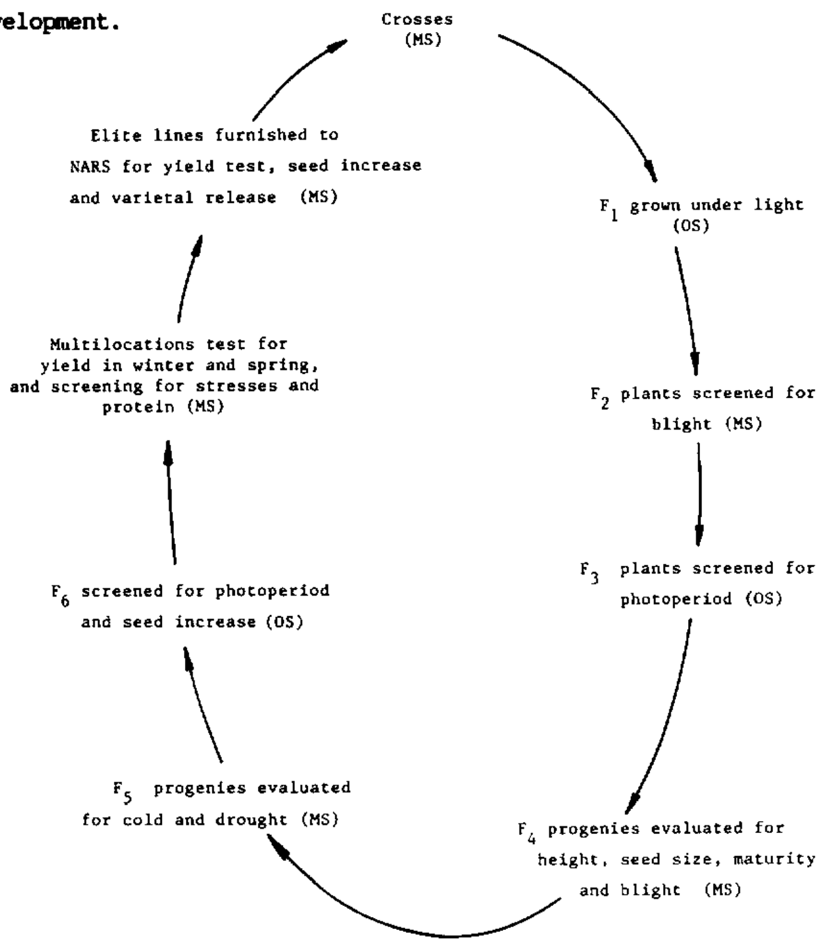

Figure 3.1.4. Varietal development scheme in chickpea jointly implemented by ICARDA and National Programs.

Using the bulk-pedigree method the material susceptible to *Ascochyta blight* is eliminated in the F_2 generation and that highly sensitive to photoperiod in the F_3 generation. Progenies are systematically evaluated for reaction to cold, leafminer, cyst nematode, and drought, and susceptible material is rejected. Protein content is monitored and lines with content less than the standard cultivar are discarded. Positive selection for plant height, maturity and seed size is made.

Advanced generation (F_5) material and preliminary yield trials are grown during both winter and spring, and selections are made in both seasons. Generally, the performance of lines is different in the two seasons because of the differences in temperature, available moisture, photoperiod, length of growing period, disease and insect incidence. Consequently, the breeding for winter and spring chickpea has to be handled separately.

3.1.7. Segregating populations

Five hundred crosses including 440 in the main season and 60 in the off-season were made. Four hundred F_1 hybrids were grown in the off-season under continuous light and F_2 seeds produced from 358 crosses. The F_2 populations of these 358 crosses were grown in the Ascochyta blight disease nursery at Tel Hadya. The blight resistant plants from each cross were bulk harvested. Two hundred and ninety-two F_3 bulks were grown in the off-season and 6000 less photoperiod sensitive plants were selected. Approximately 12,000 F_4 to F_6 progenies were grown in the Ascochyta blight nursery and 3000 F_5 to F_6 progenies grown during spring. Three hundred and forty uniform, blight resistant and promising lines were bulked from F_5 and F_6 generations. While bulking during winter consideration was given to cold tolerance, tall type and large seed size. During spring, drought tolerance, large seed size and early maturity received major consideration. Three thousand promising single plants were selected.

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3.1.8. Yield performance of newly bred lines

Between 226 and 387 lines were evaluated for yield during winter and spring at Tel Hadya and Jindiress in Syria and Terbol in Lebanon. A large number of entries exceeded the check but only a few at significant ($P<0.05$) level (Table 3.1.7.). In general, coefficient of variation was small reflecting good trial management.

Table 3.1.7. Performance of newly developed lines during winter and spring at Tel Hadya, Jindiress and Terbol, 1987/88.

Location and season	No. of trials	Entries			Range for		
		tested	exceeding check[a]	significantly exceeding check	Yield of best entries (kg/ha)	C.V. (%)	L.S.D. (kg/ha)
Tel Hadya							
-winter	17	387	44	3	2233-2881	7-17	306-674
-spring	14	318	117	30	1351-1889	9-21	198-485
Jinderess							
-winter	12	272	66	0	1915-2948	16-44	512-1394
-spring	12	272	99	9	805-1605	14-29	240-458
Terbol							
-winter	17	387	186	12	1810-3369	11-34	323-1112
-spring	10	226	94	8	905-1926	13-24	218-508

[a] The check was ILC 482

The original sources of resistance to Ascochyta blight identified from the germplasm had late maturity, intermediate seed type with small size, and poor yield. Therefore, they did not meet acceptance from growers. ILC 482, a medium-seeded Ascochyta blight tolerant line, was accepted widely in the WANA region because of its high yield potential, but demand-continued to develop lines with early maturity, large seed size, tall type, resistance to Ascochyta blight. The progress made in this direction is described below:

Large seed size and Ascochyta blight resistance: Many lines with large seed size (35 to 37g/100 seeds) and high level of resistance to Ascochyta blight have been bred (Fig. 3.1.5.). These lines have equal or slightly higher seed yield than ILC 482.

Early maturity and large seed size: For the first time, it has been possible to breed lines that flower six to eight days earlier than ILC 482 with 100-seed weight of 37 to 51g (Fig. 3.1.6.). These lines produced equal or higher yield than ILC 482.

Large seed size and tall plant: Figure 3.1.7. shows lines with 36 to 48g/100 seeds and a height of 54 to 70 cm. These lines are superior to ILC 482 in seed yield also. Several lines with similar height and yield as that of ILC 3279 but with large seed size (33 to 41g/100 seeds) have been bred (Fig. 3.1.8.).

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3.1.9. Genotypic difference in the protein content in chickpea seed as consumed

The whole chickpea seed is consumed in various forms, more commonly as green unripe, soaked, boiled, or roasted seeds. It was considered

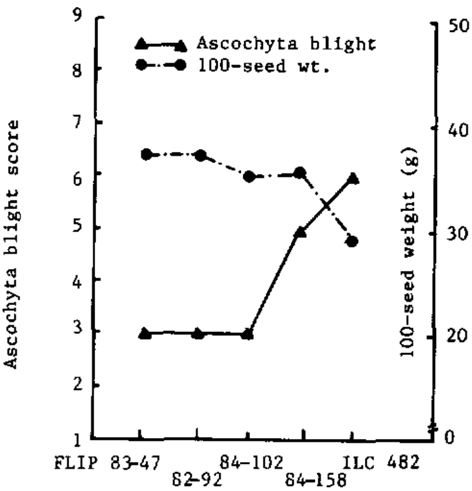

Fig. 3.1.5. **New chickpea lines with** large seed and Ascochyta blight resistance.

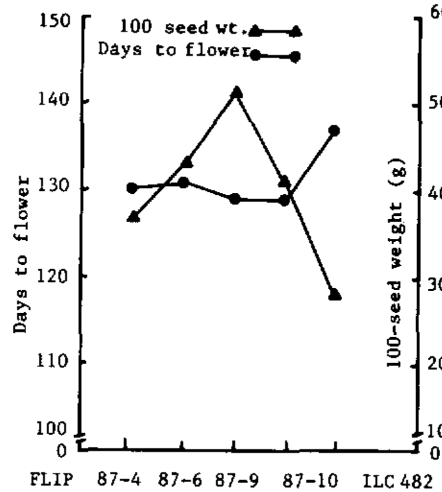

Fig. 3.1.6. New chickpea lines with early flowering and large seed.

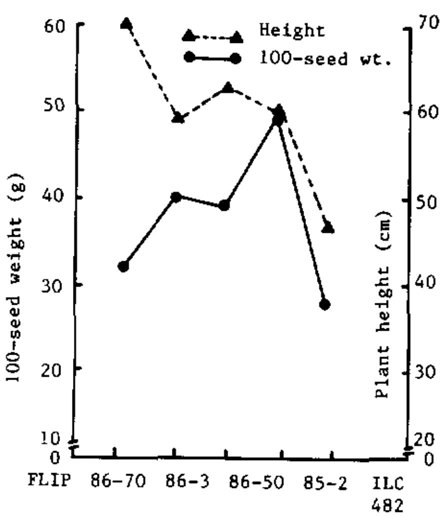

Fig. 3.1.7. New chickpea lines with large seed and tall stature.

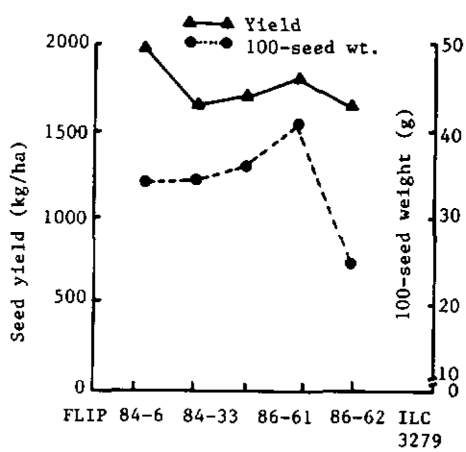

Fig. 3.1.8. New chickpea cultivars with large seed and high yield.

important to find out genotypic variation in the protein content in the whole seed as consumed. The variation was large (Table 3.1.8). The protein content on dry weight basis in green seed, soaked seed and boiled seed was lower than the dry mature seed. It is understood for green seed because accumulation of protein content in seed continues as the green seed further develops and reaches physiological maturity. Reduction in the protein content in the soaked or boiled chickpea must be due to the loss during soaking or boiling.

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Table 3.1.8. Mean and range in protein content in seeds as consumed in 24 lines of chickpea.

	Range	Mean	SD	LSD (5%)
Protein content whole seed DB%	20.8-23.5	21.9	1.02	1.44
Protein content soaked seed as is %	8.9- 9.9	9.4	0.55	0.78
Protein content soaked seed DB%	22.0-24.2	23.0	1.31	1.85
Protein content soaked cooked seed as is %	6.5- 7.5	6.9	0.55	0.77
Protein content soaked cooked seed DB%	21.1-24.4	22.6	1.14	1.62
Protein content unsoaked cooked seed as is %	6.1- 7.1	6.6	0.45	0.63
Protein content unsoaked cooked seed DB%	21.6-24.8	23.2	1.11	1.56
Protein content green seed as is %	5.5- 6.3	5.9	0.50	0.70
Protein content green seed DB%	19.7-22.4	21.0	0.79	1.11
Protein content roasted cooked seed DB%	21.1-24.4	22.8	1.07	1.51
Moisture content sooked seed %	57.7-61.6	59.1	0.96	1.35
Moisture content soaked cooked seed %	65.2-73.8	69.4	2.25	3.17
Moisture content unsoaked cooked seed %	63.5-76.0	71.6	1.88	2.65
Moisture content green seeds %	67.3-76.0	72.1	2.04	2.87

3.1.10. Pure line selection for cold tolerance

Approximately 650,000 plants of each of ILC 482 and ILC 3279 were grown on two hectares during 1984/85. Between February 20 and March 12, temperatures below zero were recorded on most days. The crop was in the advanced vegetative stage and suffered badly. All above ground portions of plants in ILC 482 were killed. But when warm weather returned many plants began to grow and a few were very productive. Five hundred most productive plants were selected during June and harvested individually. On the other hand, plants of ILC 3279 were not killed, but had variable level of damage. Five hundred plants that had least effect from cold injury and were productive were selected in June 1985.

During 1985/86 and 1986/87 seasons, plant-rows were grown in cold tolerant nursery. Since Ascochyta blight is another pre-requisite for winter sowing, plant-rows of each selected material were also grown in Ascochyta blight nursery. Lines found tolerant of cold and/or to Ascochyta blight were grown again in cold and blight tolerant nurseries with two replications during the 1987/88 season. Also cold tolerant lines were evaluated for yield in two preliminary yield trials (one for selections from ILC 482 and another for selections from ILC 3279) at two locations. The plot size was 4 rows, 4 m long at 45 cm apart with 2 replications.

The 1985/86 season had mild winter. Also, disease severity was less during 1986/87. Results of screening for cold and Ascochyta blight and data for some phenological and yield traits for some selections of ILC 482 and ILC 3279 are presented in Tables 3.1.9. and 3.1.10., respectively.

Table 3.1.9. Performance of 28 plant selections from *ILC* 482 to cold, Ascochyta blight, and other traits at Tel Hadya.

	Ascochyta rating		Cold rating		100-seed wt.(g)	Days to flower (no.)	Height (cm)	BYD (kg/ha)	SYD (kg/ha)	Protein content (%)
	1985/86	1987/88	1986/87	1987/88	1987/88					
ILC 482-10	6	6	4	4	25	138	47	5127	2524	21.7
ILC 482-11	2	6	5	5	26	137	47	4333	1913	21.7
ILC 482-41	3	5	5	5	25	135	46	5397	2492	21.4
ILC 482-80	3	5	4	6	22	140	46	3810	1595	23.7
ILC 482-81	3	5	5	6	25	136	45	4825	2317	21.5
ILC 482-85	3	6	5	6	27	137	44	4524	2095	21.2
ILC 482-89	3	5	5	5	26	137	46	5587	2667	22.5
ILC 482-147	3	6	5	5	25	136	41	5317	2397	22.2
ILC 482-166	3	5	5	6	26	135	48	5063	2444	23.5
ILC 482-167	3	5	4	4	24	142	48	4302	1841	24.0
ILC 482-168	4	6	5	6	42	139	44	46/9	1778	21.7
ILC 482-175	3	5	5	5	19	138	49	4238	1722	22.7
ILC 482-176	3	6	5	5	25	136	47	5667	2627	22.1
ILC 482-205	4	8	3	4	41	139	50	5794	1889	20.5
ILC 482-213	3	6	5	5	25	136	46	4476	2032	23.7
ILC 482-288	4	6	5	5	26	136	43	5317	2508	21.4
ILC 482-296	4	5	5	4	26	138	44	4540	2206	22.2
ILC 482-309	3	4	5	4	25	136	43	4048	1897	21.3
ILC 482-335	3	5	5	5	25	136	46	5175	2413	22.7
ILC 482-355	4	5	5	5	26	137	45	4381	2048	21.2
ILC 482-369	3	5	5	6	25	136	46	4905	2373	22.3
ILC 482-406	3	5	5	5	25	136	44	4635	2159	21.9
ILC 482-411	3	5	5	5	26	136	47	5952	2706	21.9
ILC 482-421	9	8	4	6	23	136	41	4175	1905	23.4
ILC 482-441	3	6	5	5	25	135	47	4302	2000	21.5
ILC 482-450	3	5	5	4	27	136	45	4825	2214	21.8
ILC 482-467	9	9	4	6	23	136	43	3667	1611	24.2
ILC 482-494	3	5	5	6	27	136	46	5460	2611	22.3
ILC 482	5	5	8	6	26	136	48	5460	2349	21.3
Mean					26.2	136.6	45.4	4830	2190	
C.V. (%)					3.15	0.69	4.5	13.0	13.4	
L.S.D. (P = 0.05)					1.68	1.93	4.2	1289.3	601.6	

Rating scale: 1 = Free; 5 = Intermediate; 9 = Killed.
BYD = Biological yield; SYD = Seed yield.

Table 3.1.10. Performance of 31 plant selections from ILC 3279 to cold, Ascochyta blight, and other traits at Tel Hadya.

	Ascochyta rating		Cold rating		100-seed wt.(g)	Days to flower (no.)	Height (cm)	BYD (kg/ha)	SYD (kg/ha)	Protein content (%)
	1985/86	1987/88	1986/87	1987/88	1987/88					
ILC 3279-30	4	3	4	4	25	157	67	4349	1476	25.3
ILC 3279-39	3	4	4	4	26	157	69	4095	1294	25.3
ILC 3279-40	5	3	4	5	25	156	66	3365	1127	23.8
ILC 3279-74	4	4	4	5	24	155	67	4905	1437	23.4
ILC 3279-144	3	3	4	4	25	156	65	3524	1262	24.6
ILC 3279-147	3	4	4	4	23	157	68	4984	1556	25.2
ILC 3279-156	3	4	4	4	26	156	69	4302	1421	24.6
ILC 3279-170	4	4	3	3	26	156	72	4683	1365	26.8
ILC 3279-226	3	3	4	5	26	156	65	4111	1444	24.2
ILC 3279-231	5	7	4	6	29	142	52	4127	1667	23
ILC 3279-232	3	3	4	4	24	156	66	3778	1190	24.4
ILC 3279-233	4	3	4	4	26	157	65	3127	1087	24.4
ILC 3279-296	4	3	4	4	23	156	67	4524	1476	24.4
ILC 3279-302	4	3	4	4	25	156	65	2190	754	25.0
ILC 3279-330	3	3	4	4	24	157	63	3683	1254	24.3
ILC 3279-339	3	3	4	4	25	156	68	5222	1611	24.2
ILC 3279-361	3	3	4	5	24	157	66	3857	1357	24.1
ILC 3279-397	3	5	4	4	24	156	68	4508	1571	24.6
ILC 3279-398	4	4	4	4	25	155	66	4524	1492	25
ILC 3279-399	4	4	4	4	24	155	71	6016	1873	24.6
ILC 3279-408	3	3	4	4	25	155	69	5063	1627	25.2
ILC 3279-409	3	5	4	5	26	157	68	4095	1397	24
ILC 3279-410	3	3	4	4	22	155	64	3651	1397	23.7
ILC 3279-428	4	3	4	4	24	155	66	5190	1611	23.5
ILC 3279-430	3	3	4	4	24	156	68	3841	1278	23.8
ILC 3279-431	3	4	4	4	25	155	67	4460	1508	24.8
ILC 3279-433	3	3	4	5	25	157	68	4762	1540	22.3
ILC 3279-456	5	3	4	4	25	156	65	3913	1373	23.1
ILC 3279-468	3	5	4	4	24	143	65	3143	1167	23.5
ILC 3279-478	4	3	4	4	25	156	67	4746	1579	24.2
ILC 3279-487	3	3	4	4	25	138	64	3810	1714	24
ILC 3279	3	3	7	4	23	155	70	4929	1563	23.9
Mean					24.7	154	66	4234	1421	
C.V. (%)					3.26	0.6	3.1	17.0	17.5	
L.S.D. (P=0.05)						1.64	1.8	4.3	1468.9	508.9

Rating scale: 1 = Free; 5 = Intermediate; 9 = Killed.

BYD = Biological yield; SYD = Seed yield.

As far as ILC 482 is concerned, only three selections, ILC 482-10, ILC 482-167 and ILC 482-205, proved cold tolerant. But from these one selection namely ILC 482-205 seems to be either a mechanical mixture or a mutant because the seed size of this selection was 41 g/100 seeds against 26 g of ILC 482. Based on tolerance to both cold and blight, five selections, ILC 482-167, ILC 482-175, ILC 482-335, ILC 482-406, and ILC 482-411, appear promising and will be evaluated for one more season in multilocation tests for yield and reaction to stresses.

In ILC 3279, a higher level of cold tolerance than ILC 482 was identified. One line, ILC 3279-170 had a rating of 3 on a 1-9 scale. This line was similar to the original parent ILC 3279 in other characteristics. Another group comprised three selections, ILC 3279-330, ILC 3279-339 and ILC 3279-361. They had higher level of cold tolerance and disease resistance than ILC 3279. The third group comprised of five lines and had higher level of tolerance to cold than ILC 3279 but the same level of blight resistance. Individual lines would be reevaluated for yield and reaction to cold and blight at three locations. The cold tolerant version of ILC 3279 would be provided to cooperators next year.

Conclusions from this study are: (a) that genetic variability for cold tolerance existed in original populations of ILC 482 and ILC 3279 and (b) that cold tolerant versions of ILC 482 would be useful in Algeria, Morocco, Syria and Turkey and of ILC 3279 in Algeria, Cyprus, Italy, Syria and Tunisia where these cultivars have been released for commercial cultivation.

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3.1.11. Genetics

3.1.11.1. Heterosis

Fifty-three F_1 hybrids and their 47 parents were grown at Tel Hadya during winter 1987/88. These were sown in single-row plots of 2 m, using a triple lattice design, with a distance of 45 cm between rows and 10 cm within row. Observations were recorded on ten characters. Heterosis (%) over better parent and standard check (ILC 482) was estimated for each character.

The highest heterosis over better parent was obtained for primary branches followed by number of pods per plant, seed yield, and biological yield (Table 3.1.11.). The highest heterosis (49.5%) for seed yield was obtained from a cross FLIP 81-293C X FLIP 84-78C. Two crosses FLIP 81-293C X FLIP 83-72C and FLIP 81-293C X FLIP 84-78C gave significantly higher yield than their respective better parents. Heterosis was also computed in comparison to the best check to assess the real gain being made. The highest heterosis of 116.9% was obtained for the biological yield from a cross FLIP 81-293C X FLIP 84-93C when compared to ILC 482. No hybrid had higher harvest index than ILC 482. Heterosis for seed yield appeared to be influenced by the number of branches and pods per plant and biological yield. Although the possibility of using the heterosis in hybrid seed production in the immediate future seems limited, such information could be useful in a future crop improvement program.

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Table 3.1.11. Range of heterosis (%) in chickpea for growth, phenology and yield and its components over better parent and best check (ILC 482) at Tel Hadya, 1987/88.

Character	Range of heterosis (%) over	
	Better parent	Best check
Days to flower	-6.5 to + 7.0	0.0 to + 7.8
Days to maturity	-3.2 to + 8.0	-1.1 to + 2.3
Plant height	-27.8 to + 18.6	-13.3 to + 48.9
Primary branches	-25.0 to + 66.6	-25.0 to + 50.0
Secondary branches	-58.3 to + 42.9	-42.9 to + 71.4
Pods/plant	-29.7 to + 55.3	-23.5 to + 73.5
Biological yield	-31.7 to + 45.8	+ 0.7 to +116.9
Seed yield	-25.7 to + 49.5	+ 8.9 to + 50.6
100-seed weight	-28.6 to + 8.8	-10.7 to + 89.3
Harvest index	-31.5 to + 13.9	-40.7 to - 9.3

3.1.11.2. Genetics of resistance to Ascochyta blight

Parents, F_1s, F_2s and backcrosses of several crosses were studied in the greenhouse. The results indicated that (a) genes for resistance were recessive and (b) there were differences in resistance between seedling stage and podding stage and the level of resistance in the seedling was higher than in the adult plant. The results are still being compiled and will be reported in future.

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3.1.11.3. Mutation studies

Genetic variability for certain important traits, such as cytoplasmic-genetic male sterility, determinancy, 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. Other objectives of the project were to create: (a) seed size larger than 26 g/100 seeds in ILC 482, (b) plants taller than those of ILC 3279, and (c) higher level of resistance to Ascochyta blight in ILC 6104, a large-seeded and early maturity line.

The three cultivars, were exposed to 40, 50 and 60 KR of gamma irradiation or treated with 0.1 and 0.2% solution of Ethylemethane sulphonate (EMS) for two hours after one hour presoaking in water during May 1987. EMS treated seeds were washed for 1 hr after treatment. 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.

Appearance of a large number of chlorophyll mutants, Albina, Chlorina, Viridis, and Xantha in all treatments of the three cultivars indicated that mutagenic treatments were effective. A wide range of viable morphological mutants affecting most plant parts, such as leaf, flower, plant height, plant type, pod, maturity, and seed, were observed. Some mutants of economic importance included with 50% larger seed size than ILC 482, and another mutant with 20% more plant height than the tall parent ILC 3279. These mutants will be studied in M_3 generation next season.

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3.1.12. Germplasm evaluation

3.1.12.1. Seed-shattering

Chickpea is traditionally harvested by hand at physiological maturity. Harvest by hand or machine at complete maturity may lead to seed shattering. Therefore, evaluation of 6224 kabuli chickpea germplasm lines for seed shattering was done during 1987/88. The plants were allowed to stand for one month after complete maturity before rating on 1-9 scale, where 1 = no seed shattering and 9 = more than 40% shattering (Table 3.1.12). Of the accessions 120 did not set pods and of remaining 6104 accessions, about 9.9% lines had no shattering. Only 1.2% of the total lines showed more than 20% seed shattering. Hence, the kabuli chickpea accessions appear quite suitable for mechanical harvesting.

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3.1.12.2. Iron deficiency chlorosis

A total of 6224 germplasm accessions grown at Tel Hadya during both winter and spring seasons of 1987-88 were evaluated for iron deficiency chlorosis. A scale of 1 to 5 was used for evaluation of the material, where 1 = highly tolerant, plants with deep green chlorophyll, no deficiency symptoms; 2 = tolerant, light yellow young leaves on a few plants; 3 = intermediate, all plants show some chlorosis of young leaves and stunting; 4 = highly susceptible, plants with severe chlorosis and stunted growth; and 5 = susceptible, plants killed due to severe chlorosis. About 98% of the accessions were highly tolerant, while less than 1% of the accessions were susceptible. None of the lines died due to severe iron deficiency chlorosis. Nine lines showed severe chlorosis and stunted growth during both winter and spring and three additional lines in winter only (Table 3.1.13.). This study suggests that iron deficiency chlorosis is not a serious problem in the calcarious soil of Tel Hadya in northern Syria and the problem can easily be tackled through a negative selection in the segregating populations.

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Table 3.1.12. Evaluation of 6104 chickpea accessions for seed shattering at Tel Hadya, during winter 1987/88[1].

Shattering Score	Shattering (%)	Number of accessions	% of total accessions
1	0	606	9.9
2	<1	1954	32.0
3	1	2375	38.9
4	2-5	695	11.4
5	6-10	284	4.7
6	11-20	117	1.9
7	21-30	50	0.8
8	31-40	9	0.2
9		14	0.2
Total		6104	100.0

Score: 1 = 0% seed shattering; 9 = >40% seed shattering.

3.1.12.3. Evaluation of winter sown germplasm

A total of 6224 germplasm accessions including land races and breeding lines were sown between 27 November and 4 December 1987 and evaluated

Table 3.1.13. Evaluation of chickpea germplasm lines for tolerance to iron deficiency chlorosis at Tel Hadya, 1987/88.

Iron deficiency score	Winter		Spring	
	Number of accessions	% of total	Number of accessions	% of total
1	6146	98.7	6164	99.0
2	6	0.1	27	0.4
3	60	1.0	24	0.4
4	12	0.2	9	0.2
5	0	0.0	0	0.0
Total	6224	100.0	6224	100.0

Score: 1 = Highly tolerant; 3 = Intermediate; 5 = Highly susceptible.

jointly with Genetic Resources Unit for more than 25 descriptors. While the data are still being compiled, work on three most important traits, namely 100-seed weight, plant height and days to 50% flowering, has been completed and is briefly discussed here.

Seed size. Seed size is generally classified into small, medium, and large corresponding to the 100 seed weight of 16-25 g, 26-40 g, and 41-60 g, respectively. We added two more classes, very small and very large with 100 seed weights of $\leq$ 15 g and $\geq$ 61 g, respectively. It was interesting to note that majority of the lines had medium seed size followed by small seed size (Figure 3.1.9). The mean weight of all the accessions was 30 g/100 seeds with a range of 8 to 70 g.

Plant height. The plants were classified into tall, mid-tall, normal, and short corresponding to a height of $\geq$ 71 cm, 70-65cm, 64-46cm and $\leq$ 45 cm. Data revealed that 78% of the lines had normal height (Figure

3.1.9). But there were 71 lines which were classified as tall. The mean height of all lines was 54 cm with a range of 30 to 85 cm. Obviously, the very tall lines would be useful in breeding for tall type.

Seed weight classes

VS=Very small(≤15g)
S=Small (16-25g)
M=Medium (26-40g)
L=Large (41-60g)
VL=Very large (>61g)

Plant height classes

T=Tall (≥71cm)
MT=Medium tall (65-70 cm)
N=Normal (46-64 cm)
S=Short (≤45 cm)

Days to flower classes

VE=Very early (≤120 days)
E=Early (121-130 days)
M=Medium (131-140 days)
L=Late (141-150 days)
VL=Very late (≥ 151 days)

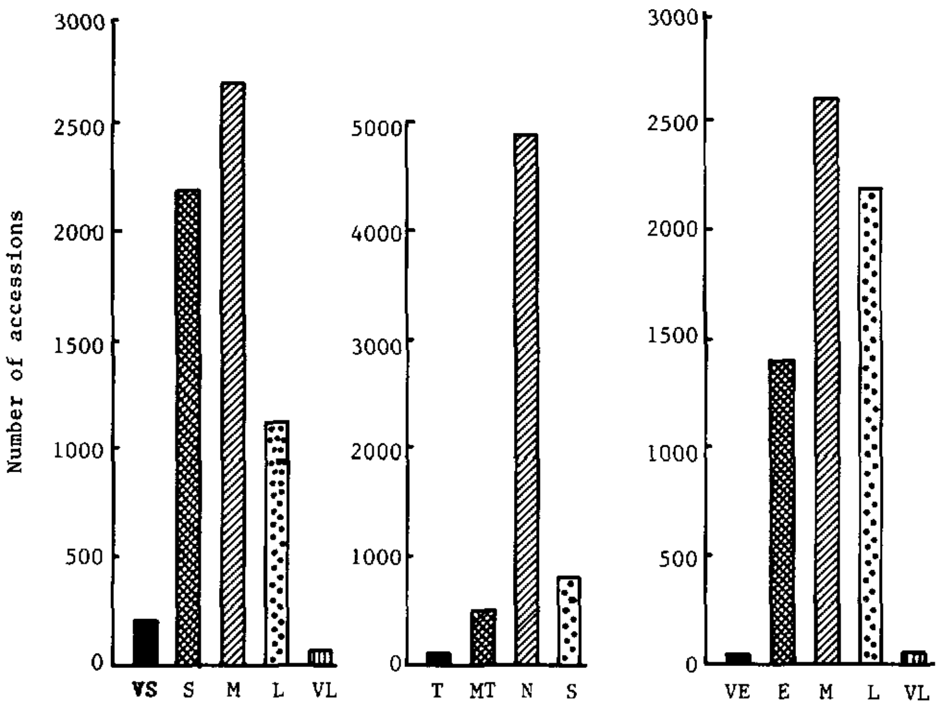

Figure 3.1.9. Frequency distribution for seed-weight, plant height and days to flowering classes in 6224 germplasm accessions sown in winter, 1978/88, Tel Hadya.

Days to 50% flowering. Chickpea cultivars are generally classified into three classes, early, medium and late, on the basis of days to 50% flowering. We added two additional classes, very early and very late. Very early kabuli lines are good for East Africa. Early to medium maturity lines are suited to the spring sowing in the Mediterranean region and winter sowing in the Indian subcontinent. Medium to late maturity groups are suited for winter sowing in the Mediterranean region. The very late maturity types are no good for direct commercial cultivation, but might have useful genes that could be transferred to lines in another maturity group. The evaluation of 6221 germplasm lines revealed that 34 lines were very early, 1385 lines early, 2592 lines medium, 2168 lines late and 42 lines very late (Figure 3.1.9). The mean time to 50% flowering of all lines was 137 days with a range of 115 to 155 days.

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3.1.13. Wild *Cicer* species

3.1.13.1. Evaluation of collection

One hundred and thirty-seven collections of eight annual wild *Cicer* species were evaluated for 32 descriptors during 1987/88 and results for 13 traits are summerized in Table 3.1.14. There was little in the wild species in terms of the desirable morphoagronomic traits which could be transferred to cultivated species. However, the number of seeds/pod in *C. bijugum* (1.71), *C. judaicum* (1.59) and *C. yamashitae* (1.59) was higher than *C. arietinum* (0.93 in ILC 482). The 100-seed weight in these species was very low and ranged between 1.32 to 14.68

g. It is thought that higher number of seeds/pod in wild species could be partly due to small seed size and not entirely due to genetic make up of the plant. The number of primary and secondary branches present in some wild species is higher than in the cultigens and this could be of use in breeding.

Table 3.1.14. Mean and range (in parenthesis) of nine Cicer species for 13 characters evaluated at Tel Hadya, 1987/88.

	Days to flowering (no.)	Uniformity in maturity	Plant height (cm)	Plant width (cm)	Leaflets (no.)	Primary branches (no.)	Secondary branches (no.)
C. bijugum	192 (188–199)	u	16.8 (11–23)	60.25 (48–69)	5 (5–7)	11.3 (9–15)	38.2 (23–49)
C. chorassanicum	208 (201–220)	uu	3.8 (3–4)	10.63 (9–13)	3	2.67 (1–4)	0
C. cuneatum	NA	NA	NA	NA	NA	NA	NA
C. echinospermum	173 (173–174)	u	28.4 (21–34)	63.65 (59–68)	11	13.5 (12–16)	14.7 (12–17)
C. judaicum	165 (159–177)	uu	14.4 (8–22)	30.05 (12.3–48)	9.6 (6–11)	7.9 (2–13)	3.1 (1–6)
C. pinnatifidum	173 (166–180)	uu	15.5 (8.6–20)	21.4 (12–28)	7 (6–8)	8.3 (3–12)	2.3 (0–8)
C. reticulatum	171 (169–175)	u	26.6 (23–32)	90.1 (36.6–96)	9.7 (9–10)	20.9 (16–25)	36.5 (27–44)
C. yamashitae	168	uu	12.6	33.1	7	6	3
C. arietinum	164	u	57	25.8	12	7	19

	Tertiary branches (no.)	Pods/pl (no.)	Seeds/pl (no.)	BYD (kg/ha)	SYD (kg/ha)	100-seed weight (g)
C. bijugum	3.13 (0–5)	52.0 (15–97)	0.89 (0.56–1.71)	2463 (1004–4920)	718.9 (179–1680)	7.8 (3.08–14.68)
C. chorassanicum	0	5 (3–6)	0.64 (0.53–0.75)	57.1 (41–72)	11.75 (9–14)	1.71 (1.31–2.5)
C. cuneatum	NA	NA	NA	NA	NA	
C. echinospermum	0	83.7 (50–109)	0.92 (0.92–0.95)	6134 (3897–8671)	2115.8 (1177.11–3023.11)	12.14 (11.49–13.16)
C. judaicum	1.5 (0–2)	23.67 (4–4.5)	1.15 (0.66–1.59)	510.4 (111.55–1281)	106.55 (24–333)	1.67 (.32–3.13)
C. pinnatifidum	0 (3–64)	39.3 (0.59–1.32)	1.00 (135–22)	743.4 (13–459)	223.8 (2.08–3.44)	2.51
C. reticulatum	0.96 (0–5)	77 (36–133)	0.98 (0.92–1.22)	5521.9 (3076–9294)	2281.7 (1179–3874)	13.12 (8.11–16.22)
C. yamashitae	0	10	1.59	312.4	147.5	1.38
C. arietinum	4	101	0.93	11527.11	5738.6	26.84

u = Uniform; uu = Ununiform; NA = Not available; BYD = Biological yield; SYD = Seed yield

3.1.13.2. Cytogenetic investigation

The cytogenetic analysis of eight wild Cicer species revealed that all of them posses 2n = 16 chromosomes, the same as that of cultivated species. Therefore, crossability barrier in wild and cultivated species is not due to differing number of chromosomes.

3.1.13.3. Interspecific crosses

We attempted a 9 x 9 diallel cross including eight wild and one cultivated species during 1987/88. Seventy-two crosses including reciprocals were attempted. Surprisingly "hybrid" seeds from many cross combinations have been produced. C. chorassanicum seems to be a poor combiner and when it was used as a female parent no seed was produced. Possibility of selfed seeds are not ruled out.

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3.2. Economic Feasibility of Winter Sowing

A survey of 22 farmers in Syria who had planted chickpea during winter and spring on more than one hectare plot was conducted. Winter sown Ghab 1 and Ghab 2 were present at 20 and 5 sites, respectively and spring sown local at 14 sites. The economic return for 1987/88 based on the information collected during the survey is shown in Table 3.2.1. The gross returns from winter-sown Ghab 1 and Ghab 2 far exceeded those from spring-sown Local. The cost of production of winter-sown crop was higher because of expenditure on weed control (S.L. 1396/ha) and slightly higher cost of fertilizer and harvesting compared to spring crop. After deducting the cost, the net returns fromspring-sown local.

Table 3.2.1. 1987/88 chickpea budgets based on yield data from farmer-managed on-farm trials with large (>1 ha) plots and economic survey of 22 farmers producing both spring and improved winter crops in Syria.

	Spring sown local	Winter sown Ghab 1	Winter sown Ghab 2
Sales value			
Seed yield (Kg/ha)	1,328	1,912	2,087
Sale price (SL/ha)	8.5	8.5	8.5
Total sale value (SL/ha)	11,288	16,252	17,739
Costs (SL/ha)			
Tillage	891	662	662
Seed and seeding	1,850	1,850	1,850
Costs (SL/ha)			
Fertilizer	446	791	791
Weed control	0	1,396	1,396
Harvest operations	2,630	2,920	2,920
Total variable costs	5,817	7,619	7,619
	5,471	8,633	10,120
Profit (SL/ha)			
Profit/cost ratio 1987/88	0.94	1.13	1.33

During 1986/87, winter-sown Ghab 1 and Ghab 2 cultivars were 59 and 67% more profitable than spring-sown local cultivar. Both years winter-sown chickpea produced 600 kg/ha more than the spring-sown chickpea. During the survey, non-availability of seed of Ghab 1 and Ghab 2 was mentioned as a major limitation in the spread of winter chickpea. Weed control was reported to be a major constraint in winter chickpea production.

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3.3. Chickpea Pathology

Chickpea suffers from several diseases. In 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 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 hybridization program. Fusarium wilt is wide-spread in North Africa. Screening for wilt-resistance is carried out in cooperation with national program in Tunisia. Stunt (bean leaf roll) virus is present throughout the region and can become serious occasionally. Therefore, care is taken to eliminate the susceptible lines through field observations.

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 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 of chickpea.
6. Collect information on other chickpea diseases in WANA region through field surveys and develop cooperative work with national programs to identify multiple disease resistant sources in chickpea.

3.3.1. Chickpea disease surveys

Disease surveys were conducted in Algeria, Morocco, Tunisia and Syria. Along with Ascochyta blight, Sclerotinia stem rot was commonly observed in winter planted chickpea in Morocco and Algeria. Fusarium wilt and stunt were present in farmers' fields and experimental plots. In Tunisia, cultivation of chickpea was restricted due to extremely dry weather conditions. Depending on the season, Ascochyta blight, wilt and stunt can pose serious threat to chickpea in Tunisia. At Terbol station in Lebanon, Fusarium wilt and stunt were in severe form in some of the chickpea plots. In Syria, early infection of Ascochyta blight was observed in winter planted chickpea at several locations. However the disease was severe at Jellin and Izra'a, only.

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3.3.2. Screening for Ascochyta blight resistance

3.3.2.1. Field screening

An area of 8.6 ha at Tel Hadya farm was planted in mid November with chickpea breeding material, germplasm, entries from chickpea international nurseries and preliminary yield trials to identify the sources of resistance to Ascochyta blight (Table 3.3.1). The susceptible check ILC 263 was planted after every 10 test rows throughout the field and as a strip all round the field. The nursery was inoculated with a mixture of 4 races (1,2,3,4) multiplied from the laboratory cultures in mid-February, March and April. The mist irrigation system was used to create the humidity in the field for the development of the disease.

Table 3.3.1. Chickpea material screened in Ascochyta blight Nursery during 1987/88, Tel Hadya.

Field 31	Area: 8.7 ha.
Material Planted	
1. F2	358 population
2. F3	292 Progenies
3. F4	5878 Progenies
4. F5(W)	2452 Progenies
5. F6(W)	536 Progenies
6. F5(T)	85 Progenies
7. F6(T)	251 Progenies
8. F5(L)	1733 Progenies
9. F6(L)	77 Progenies
10. F4 Desi	544 Progenies
11. F5 Desi	107 Progenies
12. F6 Desi	129 Progenies
13. Germplasm	1340 Lines
14. CIABN	60 Lines
15. CAN	18 Lines
16. PYT entries	672 Lines

Of the 1340 germplasm lines screened in Ascochyta blight nursery 141 lines, which included 114 FLIP lines were found resistant (Table 3.3.2) with 3 rating on 1-9 scale. Of the 60 lines included in Chickpea International Ascochyta Blight Nursery (CIABN-88), 15 were found resistant. Of the 18 lines included in Chickpea Ascochyta Blight Nursery (CAN-88) 17 were found resistant to blight. Several entries from Chickpea International Yield Trials, and Preliminary Yield Trials were also found promising (Table 3.3.3).

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Table 3.3.2. Field reaction of chickpea germplasm lines to Ascochyta blight at Tel Hadya, 1987/88.

Particulars	No. of lines screened	Disease reaction on 1 - 9 scale								
		1	2	3	4	5	6	7	8	9
New germplasm	619	0	0	8	12	15	49	150	197	188
Old germplasm	240	0	0	19	6	16	10	39	65	85
FLIP lines	481	0	0	114	90	174	77	18	5	3
Total	1340	0	0	141	108	205	136	207	267	276

Table 3.3.3. Disease reaction of chickpea lines from different trials (1988) in Ascochyta blight nursery.

Particulars	No. of entries	No. of lines with a disease rating* of				
		1	2	3	4	5
CIABN	60	0	0	15	17	19
CIYT-L	19	0	0	0	0	3
CIYT-T	21	0	0	0	2	4
CIYT-MR	21	0	0	7	3	6
CIYT-STR	21	0	0	7	3	7
CIYT-SPR	21	0	0	1	4	2
CIYT-DS	23	0	0	2	2	7
CIYT-E	1	0	0	0	0	0
CISN-W	60	0	0	0	2	12
CISN-SPR	48	0	0	3	2	17
PYT-L	73	0	0	0	0	8
PYT-T	36	0	0	1	4	14
PYT-S	236	0	0	52	44	71
PYT-DS	92	0	0	39	13	26

* Disease reaction on 1-9 scale.

3.3.2.2. Plastichouse screening

A total of 740 advanced chickpea lines were screened in the plastic house against 6 races of <u>Ascochyta</u> <u>rabiei</u> at seedling stage in unreplicated trial.

Promising lines were also screened in vegetative and reproductive stage in a replicated trial. The seedlings were raised in plastic pots and inoculated with the spore suspension (20,0000/ml). Lines found resistant in the vegetative stage were then inoculated in the reproductive stage. Reduced resistance was observed in the reproductive stage. No line was rated 3 on 1-9 scale against all the 5 races. There were only 6 lines found promising against race 6. These were FLIP 85-122, FLIP 84-37, FLIP 85-84, FLIP 85-93, FLIP 85-123 and FLIP 85-131 (Table 3.3.4).

Table 3.3.4. Reaction of promising chickpea lines in vegetative and reproductive stage to six races of <u>Ascochyta</u> <u>rabiei</u> in plastichouse screening.

Race	No.of lines screened	No.of lines with a disease rating* of									
		1	2	3	4	5	1	2	3	4	5
		Vegetative stage					Reproductive stage				
1	131	0	2	12	35	29	0	0	0	3	9
2	133	0	19	24	32	23	0	0	0	13	30
3	185	0	5	38	47	38	0	0	0	12	32
4	119	0	2	7	17	21	0	0	0	0	10
5	465	0	0	28	50	120	-	-	-	-	-
6	24	0	1	4	5	7	0	0	0	1	5

* Disease reaction on 1-9 scale.

3.3.2.3. <u>Growth chamber screening</u>

Seventy five chickpea lines reported resistant were screened under controlled environmental conditions against races 3 and 6 and isolate

'F'. While several lines were found resistant against race 3 (3 to 5 rating) all were susceptible to race 6 and isolate 'F'. These two isolates were aggressive and similar in their reaction.

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3.3.3. Host plant resistance

The environmental conditions necessary for the development of Ascochyta blight of chickpea have been described in the literature. Long periods of cool moist conditions during the growing season favour the disease. Multilocation trials conducted by ICARDA indicated the wide variation in the disease reaction from year to year and place to place. While a certain amount of variability exists in the fungus which can be a serious problem in resistance breeding, there is a wide variation in the amount of humidity influenced by amount and period of rainfall in WANA region during winter. Temperatures from January to April are generally favourable for disease development.

Three chickpea lines of known disease reaction to Ascochyta blight (ILC-1929, -482 and -3279) were studied in plant growth chamber (20^{o}C) for the disease reaction as influenced by different period of 100% relative humidity following inoculation. Chickpea seedlings were raised in plastic trays (15 x 12 x 8 cm) each containing 5 lines. There were five seedlings for each line. Seven-day old seedlings were inoculated with a spore suspension containing 20,0000 spores per ml. The trays were covered with transparent plastic lids and incubated in plant growth chamber (Conviron) at 20^{o}C with 12 hrs light. The plastic lids were removed 1 to 7 days after inoculation. The disease rating was taken 10 days after inoculation.

The studies indicated that the disease reaction of a particular line could change with environment (duration of humidity) within the same isolate-genotype combination. The aggressiveness of the two isolates (3 and 6) was also influenced by RH. Longer incubation period with nearly 100% RH resulted in higher disease severity in moderately susceptible and resistant cultivars (Table 3.3.5).

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Table 3.3.5. Reaction of plants of ILC 1929, 482 and 3279 to two races of Ascochyta rabiei as affected by incubation period.

Incubation period (days)	Disease reaction (1-9 Scale)[1]					
	Race 3			Race 6		
	ILC 1929	482	3279	ILC 1929	482	3279
1	5.0	2.2	2.0	7.0	3.0	2.2
2	7.0	3.0	2.7	7.7	6.5	3.0
3	8.7	4.2	3.0	9.0	7.0	4.2
4	9.0	4.2	3.0	9.0	6.7	5.0
5	9.0	5.0	4.5	9.0	7.7	5.0
6	9.0	7.0	5.0	9.0	8.7	7.0
7	9.0	7.7	6.2	9.0	9.0	7.0

1 Disease rating taken 10 days after inoculation.

3.3.4. Pathogenic variability in Ascochyta rabiei

The studies to understand the nature of pathogenic variability in A. rabiei were continued in controlled environment at 20°C and 12 hrs light. Seven day old seedlings raised in plastic trays were inoculated with a spore suspension (20,0000 spores/ml) and held at 100% RH for 5 days. Observations on disease (1-9 scale) were recorded 10 and 15 days after inoculation.

Several isolates of A. rabiei were collected from Tel Hadya farm and from other parts of Syria. Isolates from Tel Hadya were grouped into 6 classes, on the basis of their morphological characters. These were then studied for their reactions on 25 chickpea lines, and could be differentiated into two distinct groups (mild and aggressive) on the basis of their capacity to infect the plant. The differences in disease reactions were not clear enough to classify them into races.

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3.3.5. Epidemiology of Ascochyta blight

In early January 1988, chickpea plants of highly susceptible ILC 1929 raised in plastic house in the pots were kept at 17 locations on Tel Hadya farm and 3 locations outside the farm, and watched regularly for blight infection. The occurrence of blight infection during the month of January at most of the locations (11 locations at Tel Hadya and 2 outside Tel Hadya) supported the hypothesis that the inoculum could be disseminated by wind.

Rain water collected regularly from 5 locations on Tel Hadya farm during winter (January to April 88) was examined for fungal spores. One-celled spores (occasionally two-celled) closely resembling pycnidio spores of Ascochyta and urediospores of yellow rust of wheat were detected in rain water samples during February-March.

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3.3.6. Studies on biological resistance mechanisms in chickpea to Ascochyta rabiei.

The incorporation of strong and durable resistance to A. rabiei is a prerequisite for winter sowing of chickpea in the mediterranean area. The conventional screening and crossing of promising chickpea germplasm revealed a few lines with some resistance which, however, proved not to be stable to different isolates of A. rabiei and adverse weather conditions. Innovative resistance screening techniques were initiated to identify stronger sources of resistance to A. rabiei. The identification of effective biochemical, dynamic and constitutive resistance mechanisms in different chickpea genotypes and wild species will provide the breeder with criteria for quick and miniaturized screening. Traits to resistance found in different sources have to be combined in one cultivar which might be accomplished by wide crossing using an ovule-embryo-rescue technique. Collected data on effective working resistance mechanism will also provide fundamental information which can be used to identify resistance genes (DNA-sequence and their regulation) for chickpea improvement by genetic engineering.

Since reproducible, miniaturized inoculation techniques are required for a reliable germplasm screening as well as for any investigations on biochemical resistance mechanisms, an improved inoculation procedure was developed in the growth chamber (Conviron). A short outline of the procedure is given below. Chickpea seeds were sown in trays of germination boxes, under controlled temperature, nutrient and water supply. Regular and uniform water supply was guaranteed by a polyamid wick technique. After about 7 days when the seedlings unfolded their 3rd leaf the seedlings were inoculated with a spore suspension (1,6 X 10^5 spores/ml). After inoculation the trays of the germination boxes were covered airtight with a transparent plastic cover and leaf wetness was maintained precisely for the respective period of time. Disease severity was recorded from the 3rd until the 14th day after inoculation.

3.3.6.1. Reaction of isolates of differing aggressiveness

To demonstrate the applicability and possible use of the improved inoculation technique 10 chickpea varieties (7 Kabuli-, 3 Desi types) were tested for their reaction to two *A. rabiei* isolates with different aggressiveness (Isolate 3 = less aggressive, isolate 6 = more aggressive). The results revealed 3 distinct patterns of disease development. In all interactions the first disease symptoms could be observed on the 3rd day after inoculation. The speed of disease development differed according to the aggressiveness of the isolate and the level of resistance in the host. In all interactions a steady level of disease severity was reached 14 days after inoculation. ILC 1929 had the highest level of susceptibility to both *A. rabiei* isolates and nearly all plants were killed (Fig. 3.3.1.). ILC 3279,-202,-72, and ICC 3996 showed resistant reaction to the less aggressive isolate 3 and a weak tolerance to the more aggressive isolate 6 (Fig. 3.3.1). The genotypes ILC 482,-215,-249 and ICC 4935 and 4107 revealed resistant reactions to the less aggressive isolate 3, but a highly susceptible reaction to the more aggressive isolate 6 with almost 100% of plants dead 14 days after inoculation (Fig. 3.3.2). Susceptible and resistant interactions could also be recognized by the more pronounced hypersensitive reaction in the resistant interaction, where the first disease symptoms, (uncoloured tissue depressions) soon turned dark brown, whereas in the susceptible interaction the depressions remained uncoloured for several days and produced many pycnidia during the observation period. In all resistant interactions also pycnidia were

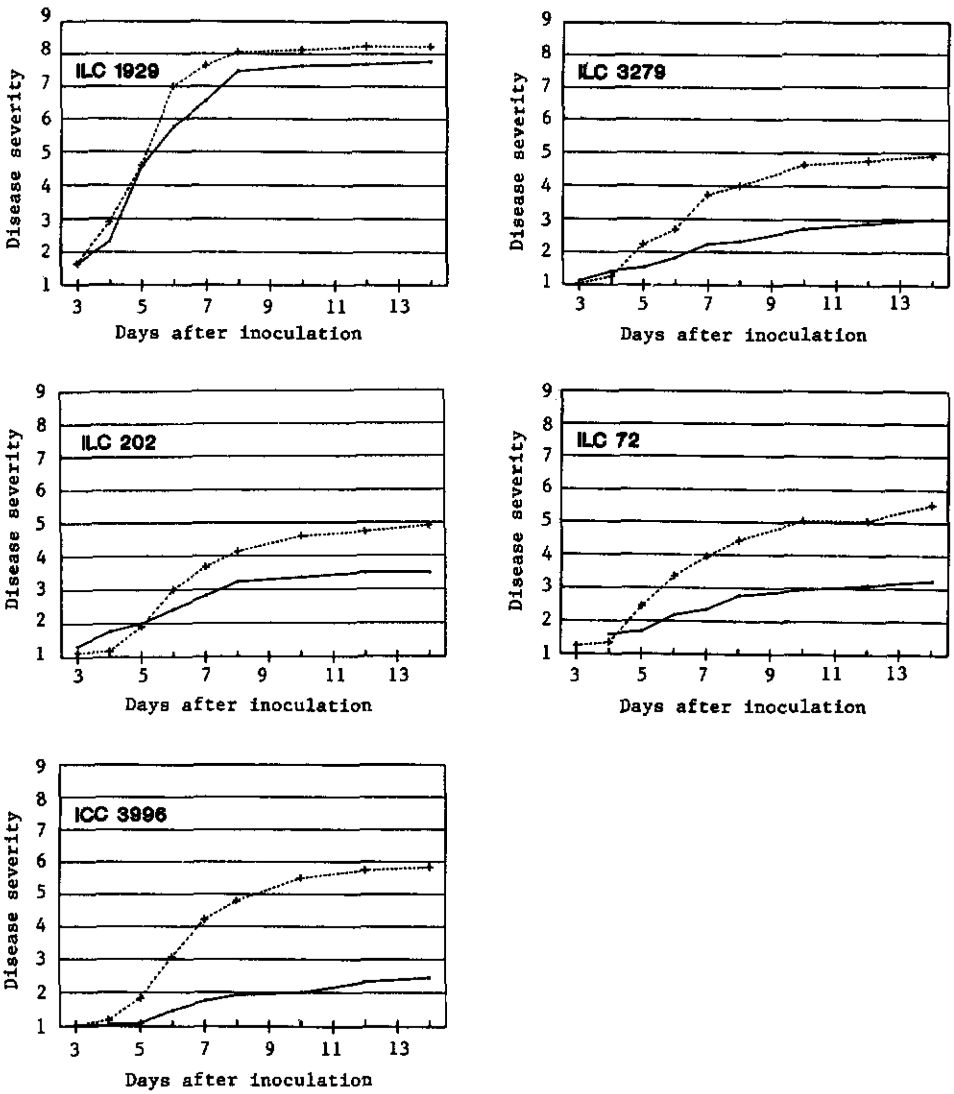

Figure 3.3.1. Disease development in ILCs 1929, 3279, 202, 72 and ICC 3996 after inoculation with Ascochyta rabiei isolate 3 (less aggressive) and isolate 6 (more aggressive) under controlled environmental conditions.

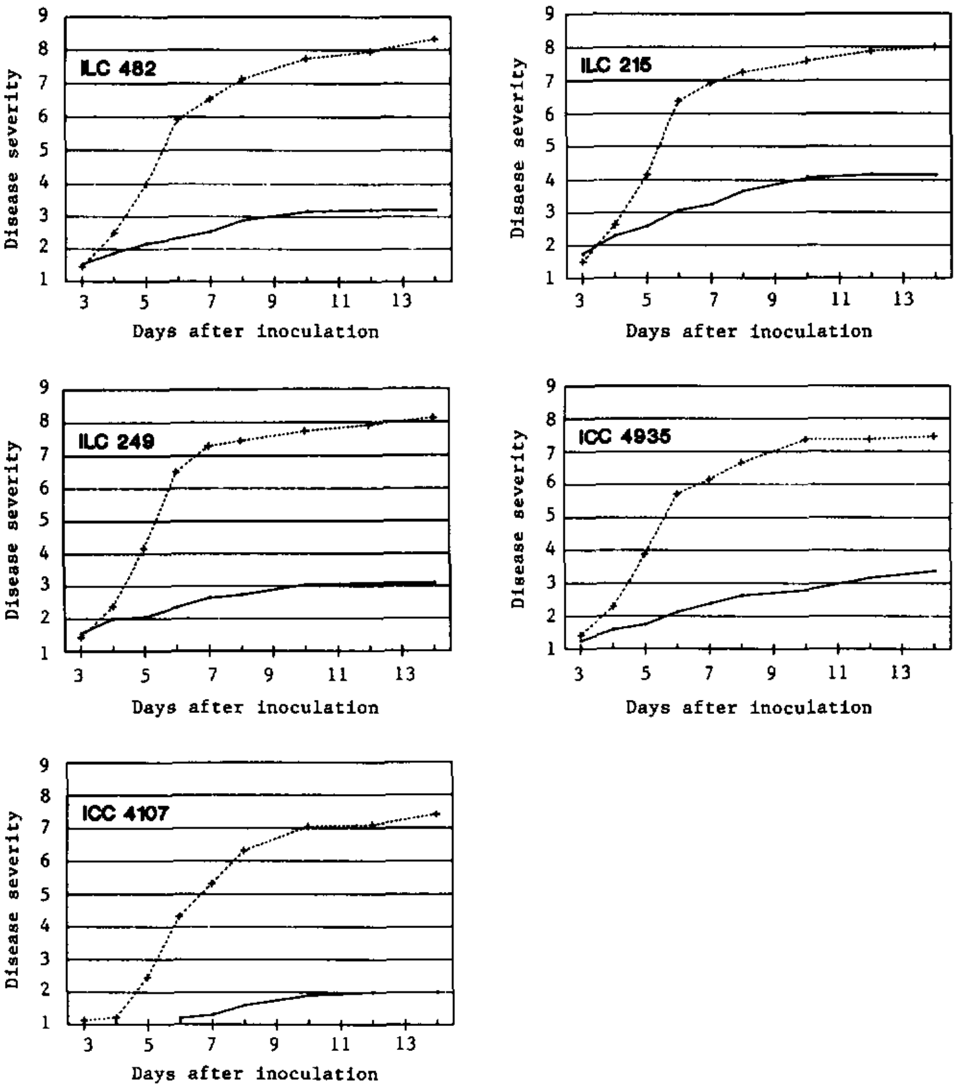

Figure 3.3.2. Disease development in ILCs 482, 215, 249, ICCs 4935 and 4107 after inoculation with <u>Ascochyta rabiei</u> isolate 3 (less aggressive) and isolate 6 (more aggressive) under controlled environmental conditions.

produced, but to a much lesser extent. The observed production of pycnidia in all interactions indicates the risk of further disease outbreaks in case of an appropriate leaf wetness period.

3.3.6.2. Reaction of wild Cicer spp.to Ascochyta rabiei

One accession each of Cicer judaicum, C. pinnatifidum, C. cuneatum, C. reticulatum and C. yamashitae were studied for their reaction to the aggressive isolate 6, using the technique described earlier. ILC 1929,-482, and -3279 were used as check. Seeds of all wild species were scarified, still germination in C. bijugum and C. chorassanicum was less that 25% and thus these species could not be tested. Single plant observations (8-9 plants per treatment) were taken from the 3rd to 15th day after inoculation.

Only C. judaicum, showed a resistant reaction, which was similar to ILC 3279 (Fig. 3.3.3). All other wild accessions showed susceptible to even highly susceptible reactions. The reason for the relatively mild disease development in the check varieties was a technical failure in the growth chamber, in which an extended light period increased the temperature inside the inoculation trays and reduced the period of leaf wetness thereby reducing the disease development.

To improve the comparability between the chickpea species, a more uniform plant growth is desirable, which could be achieved by planting the species gradually as they take different time to germinate. The following planting scheme is recommended:

1. C. echinospermum - Planting on Day 1
2. C. reticulatum - " Day 5

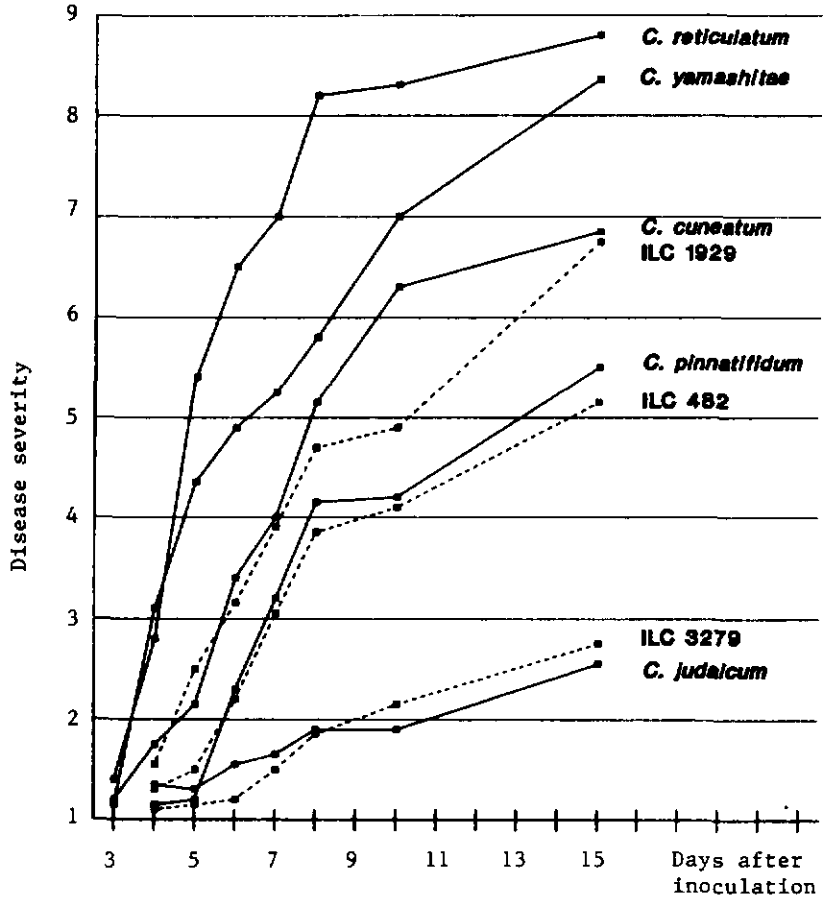

Figure 3.3.3. Disease development in 5 wild chickpea species after inoculation with the more aggressive Ascochyta rabiei isolate 6 under controlled environmental conditions. IIC's 1929, 482, 3279 were used as check.

3. C. cuneatum - " Day 7
4. C. judaicum - " Day 10
5. C. yamashitae - " Day 11
6. C. pinnatifidum - " Day 12
7. C. arietinum - " Day 12

3.3.6.3. Lignification as an active resistance mechanism

The purpose of the experiment was to detect and analyze any changes in the lignin content of chickpea plantlets during infection with A. rabiei and thus provide information on the role of pathogen induced lignification as a resistance mechanism in chickpea. ILC 3279, 1929 and 482 were inoculated with two isolates of A. rabiei of differing aggressiveness. No changes in the relative lignin content in any of the variety-isolate combinations occurred within 2 days after inoculation. However, 4 days after inoculation pathogen induced differences in lignin content were detected. In the susceptible interactions (ILC 1929 inoculated with isolate 3 and 6, ILC 482 inoculated with isolate 6) the lignin content decreased below the control level, indicating either a reduced natural lignin synthesis in the plant or an active lignin destruction by the pathogen (Fig. 3.3.4). In the resistant interactions (ILC 3279 and ILC 482 inoculated with isolate 3) an increase in lignin content as compared to the control was observed. An additional lignin production in the plants might serve as an active defense mechanism in the form of a mechanical barrier to prevent further spread of the pathogen in the host tissue. In the tolerant interaction (ILC 3279 inoculated with isolate 6) the lignin content did not differ from the control, so that apparently the pathogen induced lignin synthesis and decomposition were balanced. This experiment should be repeated on a single plant basis. At the same time the plants should be analyzed for phytoalexin accumulation and the interaction of both resistance mechanisms elucidated.

Dr. F. Weigand

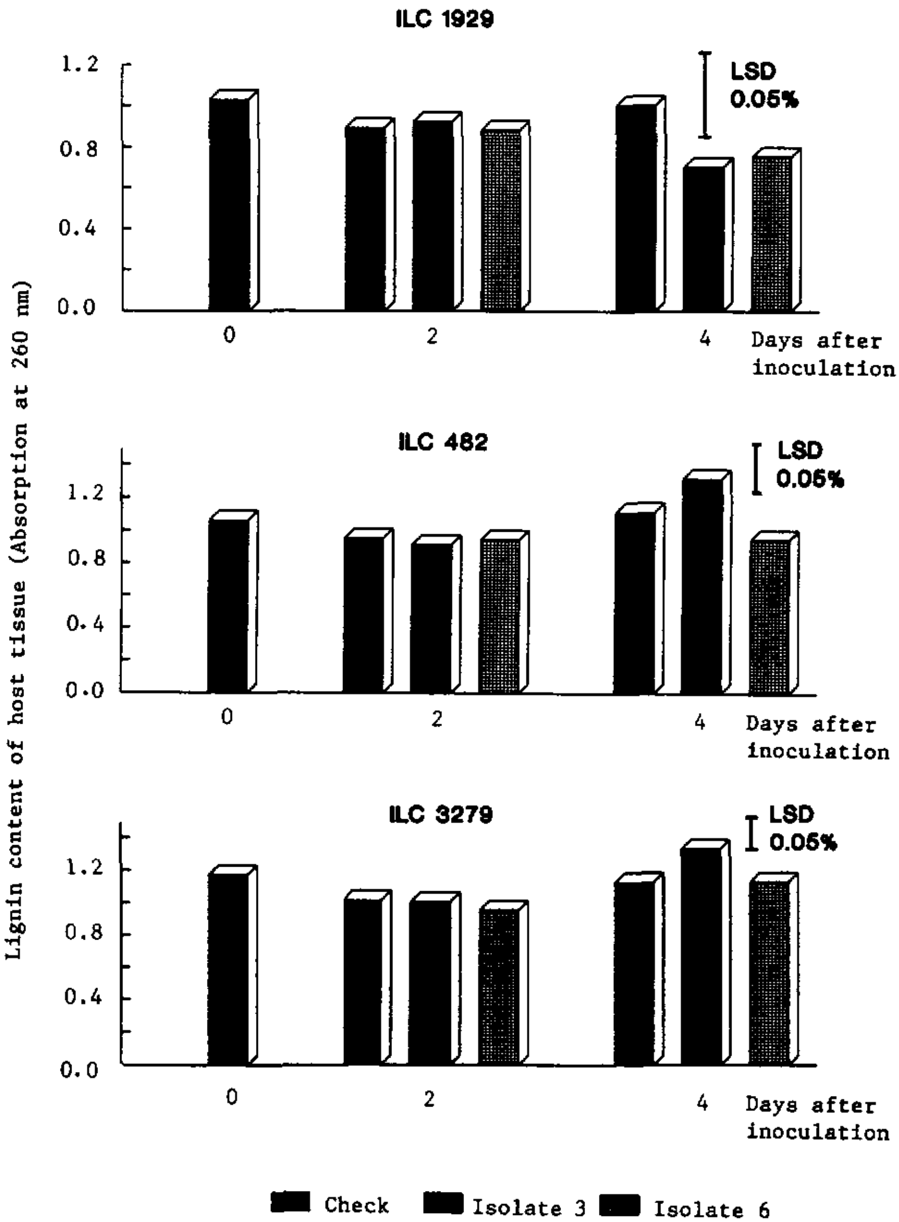

Figure 3.3.4. Lignin content in 3 chickpea lines after inoculation with *Ascochyta rabiei* isolate 3 (less aggressive) and isolate 6 (more aggressive).

3.4. Chickpea Entomology

While the occurrence of insect pests was continuously monitored to have an early detection of change in pest status, studies in 1987/88 mainly concentrated on the chickpea leafminer, Liriomyza cicerina and the storage pests.

Unfortunately, because of accidental faulty seed treatment, all winter and spring chickpea trials were lost. The spring trials were however replanted, but late and therefore the yield data were not reliable. Thus, only results on sampling methods and resistance screening for leafminer and storage insect pests are presented here.

3.4.1. Sampling methods for leafminer

In the resistance screening and the development of control recommendations practical sampling methods for the assessment of insect populations and damage levels are needed. Sampling of adult leafminer populations with the D-Vac revealed 2 peaks, the first in the beginning of May, a second in the early June (Fig. 3.4.1). As the adult population decreased, larval populations increased, as revealed by sampling using water filled trays placed between the rows to collect the full-grown larvae dropping from the leaves to the soil for pupation. The increase of the larvae population was paralleled by an increase in the percent mining of the chickpea plants and thus it could also be used as a selection criteria while screening of large number of genotypes for their resistance to leafminer.

Dr. S. Weigand

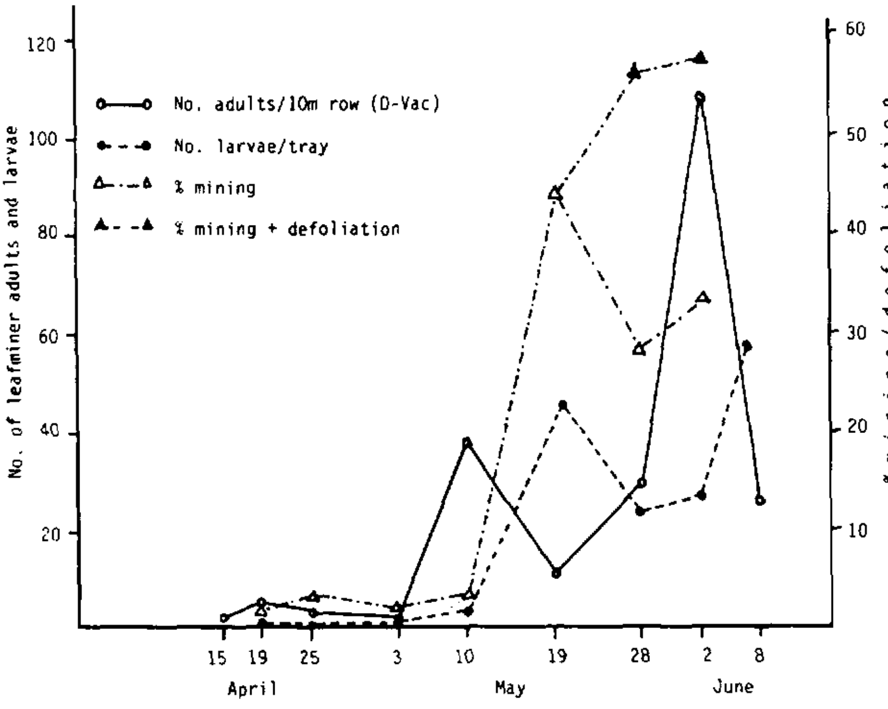

Fig. 3.4.1. Chickpea leafminer adult and larvae population development and percentage leaflets mined, Tel Hadya 1987/88.

3.4.2. Host plant resistance to leafminer

As in the previous years a number of chickpea germplasm lines were evaluated in a mass screening in the field under natural leafminer infestation using a visual damage score (VDS).

The score measured on 1 to 9 scale is based on the intensity and extent of damage including the percent mining and defoliation of the plant. Leafminer only causes indirect damage and a complex of factors influence the relation between leaf injury and reduction in yield. In order to improve the correlation of the visual damage score with the yield loss the scale has been revised this year and is as following:

Vegetative stage

1 = no mining

3 = a few mines in less that 20% of the leaflets

5 = mines common in approximately 30-40% of the leaflets

7 = many mines in 50-70% of the leaflets

9 = many mines in almost all (90%) the leaflets

Reproductive stage

1 = no mining, no defoliation

3 = a few leaflets mined, no defoliation

5 = defoliation in lower half of the plant and starting (0 - 10%) in the upper part of the plant

7 = extensive defoliation (30 - 50%) in the upper part of the plant

9 = almost complete defoliation.

Rating should be conducted twice in the season, once when the plants are in the vegetative stage and second time when they are in the reproductive stage. The first rating measures the percent mining of the plant and has proved to be highly correlated ($r = 0.8$) with the percent leaflets mined, when counted. The second rating measures the defoliation in the plant, indicating whether the plant could tolerate the mining and/or had effective defense reactions to the initial mining. The second rating is specially important, since the defoliation has higher impact on yield loss than the mining alone. Frequently plants were observed with a considerable percentage of mining in the beginning but with little defoliation later. The ratings measuring the mining in such cases could indicate different resistance mechanisms.

In this season's screening of a total of 647 chickpea lines which included promising lines for reconfirmation, new germplasm and wild species, 10 lines received a rating of 4 and one line (ILC 5901) 3 (Table 3.4.1). These lines need to be studied more closely for resistance factors. Most of the chickpea lines found so-far with some resistance to leafminer tend to have smaller leaflets and particularly small seeds. The effect of such factors on the insect biology, i.e. development, mortality, fecundity etc. needs to be studied. Factors like plant height, days to flowering and maturity apparently were not correlated with resistance to leafminer.

Drs. S. Weigand and K.B. Singh

Table 3.4.1. Leafminer resistance ratings and plant characteristics of some selected chickpea lines, Tel Hadya, 1987/88.

ILC No.	VDS*	Leaf area (cm^2)	100-seed weight	Plant height	Days to flowering	Days to maturity
316	4	4.6	20.5	52	155	187
394	4	5.3	20.3	59	151	185
655	4	4.5	23.0	57	153	185
822	5	3.2	20.9	55	146	181
992	4	3.9	23.8	49	149	185
1003	4	4.5	23.1	49	151	185
1009	4	4.4	21.9	47	149	185
1048	4	4.5	19.1	47	155	185
1216	4	4.0	22.4	54	151	185
3828	4	4.9	25.6	50	149	199
5655	4	3.0	20.6	41	134	180
5667	5	3.7	19.0	40	134	180
5901	3	4.8	23.8	50	146	182
3397	9	4.2	59.4	58	122	182

* VDS = Visual damage score at reproductive stage.

Table 3.4.2. Susceptibility of 137 accessions of 8 wild annual Cicer species to Callosobruchus chinensis measured by number of progeny produced per female, laboratory study, 1988.

Cicer species	No. of lines	100-seed wt. (g)	Progeny/female Mean ± S.E.	Range
C. judaicum	49	1.67	7.7 ± 0.7	0.0 - 14.0
C. pinnatifidum	29	2.51	12.5 ± 0.9	0.5 - 24.0
C. bijugum	23	7.88	1.2 ± 0.4	0.0 - 7.0
C. reticulatum	23	13.12	10.8 ± 2.0	0.0 - 30.0
C. chorassanicum	4	1.71	7.6 ± 2.0	2.5 - 12.0
C. echinospermum	3	12.14	0.0 ± 0.0	0.0 - 0.0
C. cuneatum	3	-	2.5 ± 1.6	0.0 - 5.5
C. yamashitae	3	1.38	16.0 ± 0.4	11.0 - 16.5
Check (ILC 482)	3 reps	29.40	50.5 ± 3.8	43.0 - 55.5

3.4.3. Storage insect pests

3.4.3.1. Host plant resistance

Resistance screening to Callosobruchus chinensis was continued in the laboratory with 900 lines in 1988, whereby the percent infested seeds and number of progeny per female were recorded. Seed infestation reached up to 100% and a maximum progeny of 65 per female was found. Screening of 4000 ILC accessions so far did not reveal any resistant lines. However, in the screening of 137 accessions of 8 chickpea wild species some accessions with very low seed infestation and progeny per female were found (Table 3.4.2). These wild species will be rescreened and more closely studied for possible resistance factors next season.

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3.4.3.2. Methods of protection

As an alternative to host-plant resistance different methods of protection of chickpea seeds in the store against C. chinensis infestation were studied. The same treatments that were used in lentil (see 2.4.2.4) were applied to 2 chickpea cultivars, ILC 482 and Syrian Local. All insecticides and oils showed a very high effectiveness (100%) in controlling the infestation immediately after the seed treatment. Even 8 months after the treatment the insecticides had a 100% efficacy. The effectiveness of cotton seed- sunflower- and corn oil, however, was not that long-lasting and decreased to about 40% only after 2 months. Olive oil with and without salt however showed 90% effectiveness after 2 months but this decreased to about 40% after 8 months. Studies on the effectiveness of oils and other substances in seed protection and their effect on seed quality will be continued to develop an economical, practicable and safe method to protect chickpea grain stored for human consumption.

Drs. O. Tahhan and S. Weigand.

3.5. Chickpea Microbiology

3.5.1. Biological nitrogen fixation studies

Defining the necessity for inoculation is an important consideration in nitrogen fixation research for national programs, for it allows national scientists to concentrate efforts in inoculation response demonstration only where potential for response exists. This need for inoculation may exist because of a low native rhizobial population, or a population which is not efficient in nitrogen fixation with introduced, improved cultivars.

The methodology which has been used to define need to inoculate involves yield comparison of symbiotic plants mainly dependent on fixed nitrogen with native rhizobia, and plants fully supplied with nitrogen fertilizer, adequate to produce a high yield (120 kg N/ha, supplied in split application). Over the last two seasons, inoculation treatments have been included in need to inoculate field trials, using best strains selected at ICARDA, to verify the use of N fertilizer response to predict response to inoculation.

Figure 3.5.1 shows the relationship between seed yield increase over unfertilized uninoculated control due to nitrogen fertilization and response from inoculation with selected strains over control. The linear regression coefficient ($r = 0.73$) indicates a strong positive relationship between response to nitrogen fertilization and inoculation in 15 elite chickpea lines at three sites in northern Syria. These results suggest information gained from response of a crop to simple N fertilization, when compared to an unfertilized N-fixing crop, can be utilized to focus research efforts where inoculation with selected strains has a high probability of success.

Strain selection research in chickpea microbiology has yielded a set of 12 highly effective, competitive strains for use in regional inoculation response trials. Production of antisera for these strains, to enable identification in soils and in nodules, is nearly completed. Three of the strains were included in 20 inoculation response trials sent to cooperators throughout the region in 1987/88 season. In addition, the trial was conducted at Tel Hadya and Jinderiss stations with two Syrian-released cultivars, Ghab 1 and Ghab 2.

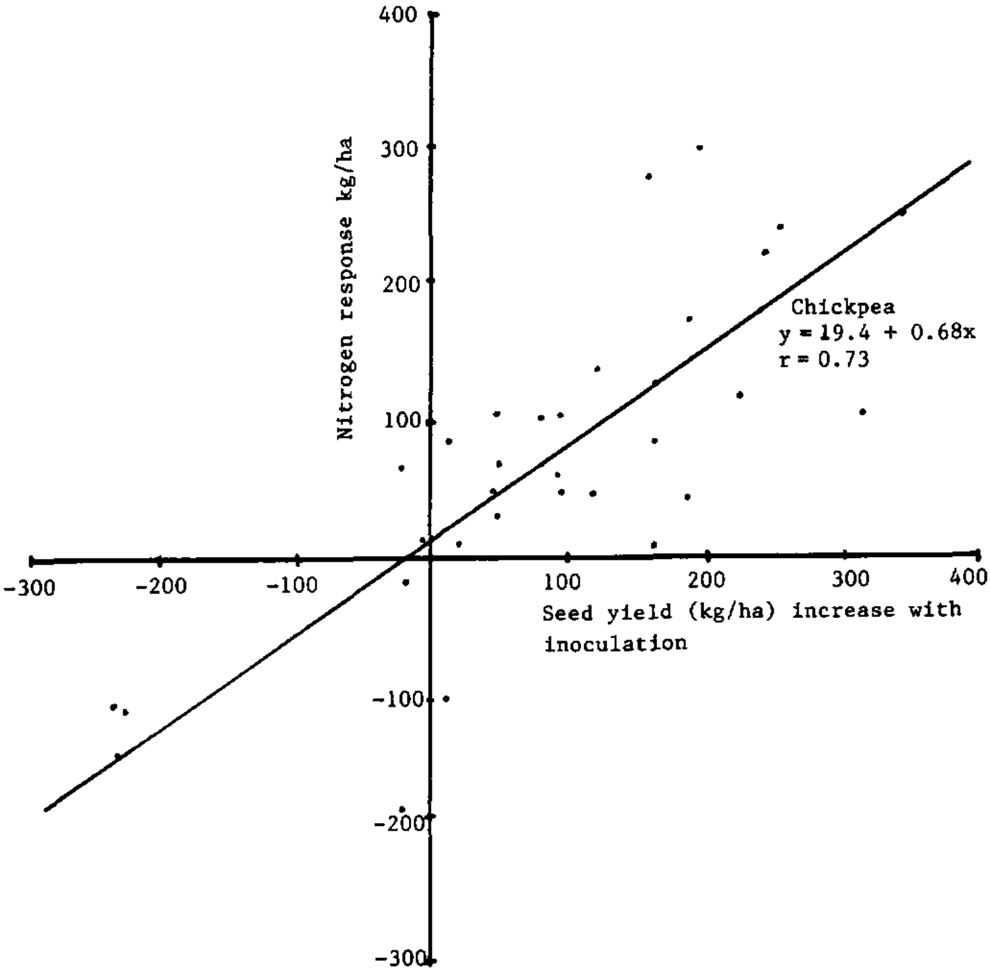

Figure 3.5.1. Relationship between chickpea response to 120 kg N/ha and to inoculation with best strains, for 15 cultivars over 3 locations in N. Syria. Axes represent seed yield kg/ha increase over uninoculated unfertilized control.

One of the strains tested, CP31 gave no significant yield response on the cultivars in either location in 1986/87 season (Table 3.5.1). However, during 1987/88, inoculation with CP31 significantly increased grain yield in Ghab 1 by 37 and 97 percent at Tel Hadya and Jinderiss, respectively, and in Ghab 2 by 15 and 39 percent. Inoculation with another strain, CP39, gave grain yield increases of 47 and 116 percent in Ghab 1 at Tel Hadya and Jinderiss, respectively and increases of 15 and 21 percent in Ghab 2 at the two locations. These two strains proved to be highly competitive with the native rhizobial population, which numbered > 10^3/g soil, with yield increases indicating superior effectiveness in nitrogen fixation. No results have yet been received from regional cooperators for 1987/88 season.

Table 3.5.1. Seed and biological yields of two chickpea cultivars at two locations, with and without inoculation by selected _Rhizobium_ strains, during two seasons. Figures followed by asterisk are significantly ($P = 0.05$) higher than those under uninoculated treatment.

Cultivar	Location	Season	Grain yield (kg/ha) Uninoculated	Strain 31	Strain 39	Biological yield (kg/ha) Uninoculated	Strain 31	Strain 39
Ghab 1	Tel Hadya	86/87	1840	1968	-	5514	6083	-
		87/88	1949	2668*	2858*	4683	5843*	6550*
	Jinderisss		86/87	2045	2035	-	4700	4469 -
		87/88	1070	2108*	2313*	2784	5277*	5327*
Ghab 2	Tel Hadya	86/87	998	1216	-	4380	5216*	-
		87/88	1700	1959*	1948*	4964	5635*	5654*
	Jinderiss	86/87	2185	2081	-	6176	6535	-
		87/88	1433	1988*	1728	4639	5937*	5208

In order to evaluate inoculation response of a wide range of plant germplasm, 12 cultivars were inoculated with 3 single-strain inoculants in a winter-planted field experiment at Tel Hadya, which incorporated ^{15}N microplots for quantification of nitrogen fixed. In this trial, grain yield differences due to cultivar were largest, as might be expected when dealing with a wide range of plant types. However, differences due to strains and the interaction between strains and cultivars were also significant. The soil contained a mixed population of native chickpea rhizobia at approximate 10^3/g soil.

The effect of inoculation with the best strain, CP39, on seed yields can be seen in Figure 3.5.2, where differences between uninoculated and inoculated treatments are indicated. The average grain yield increase across cultivars due to inoculation was 248 kg per ha or 13 percent. Total nitrogen yield per hectare was also increased by 15 percent average over cultivars with inoculation. Maximum grain yield increase (47 percent) occurred with inoculation of ILC 482, while inoculation depressed yield (14 percent) in ILC 72, indicating the extent of cultivar-strain interaction.

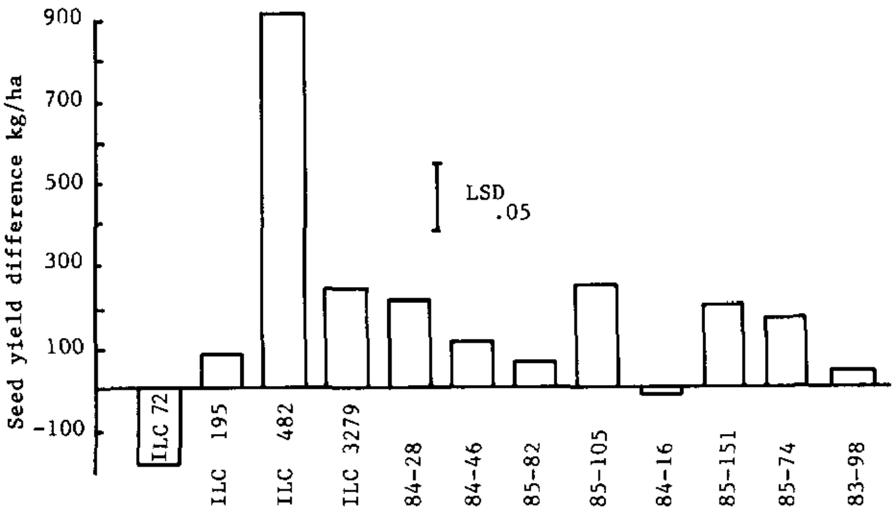

Fig. 3.5.2. Seed yield response to inocualtion of 12 chickpea cultivars (10^3 native rhizobia/g soil) by ICARDA strain CP39. Tel Hadya, 1987/88.

In a spring-planted experiment at Tel Hadya, cultivars ILC 482 , ILC 3279 and ILC 195 were inoculated with best strains, and again strain CP39 gave the highest response. Over the 3 cultivars, grain yield increase due to inoculation was 99 kg/ha (significant at P=0.05) or 15 percent. Cultivar ILC 195 gave the highest response to inoculation, with a 30 percent increase in seed yield over the uninoculated treatment.

These results indicate a potential role for inoculation of chickpea, even in traditional production areas where high native rhizobial populations exist. Where no native rhizobia are present, much greater yield increases from inoculation would be expected. Forthcoming ^{15}N results from the 1987/88 cultivar evaluation trial will show more clearly the N fixing ability of chickpea, and indicate which cultivars are able to obtain a greater proportion of total plant N from the atmosphere via symbiotic fixation.

Nitrogen balance trials conducted in 1986/87 and 1987/88 at Tel Hadya, and collaboratively at INRA, Montpellier, France in 1986/87, indicate that chickpea can fix between 42 and 70 percent of its nitrogen requirement, depending on time of planting and environmental conditions (Table 3.5.2). Because of favourable soil moisture and temperature during vegetative growth, a greater proportion of crop N is derived from fixation in the winter-planted crop. The quantities of total crop nitrogen and N fixed in the spring-sown crop may be quite low. The differences in climates at Montpellier and Tel Hadya account for the large differences in crop nitrogen yields in winter- and spring-sown crops; a very cold winter and wet spring in Montpellier nearly equalized winter- and spring-sown crops.

Table 3.5.2. Nitrogen balance of four legume crops for two cropping seasons at Tel Hadya, Syria and one season in Montpellier, France. Orobanche severely affected lentil, faba bean and peas in 1986/87 season at Tel Hadya. Cold winter in Montpellier equalized winter and spring planting in chickpea.

		Biological yield (kg/ha)	Grain yield (kg/ha)	Total crop N (kg/ha)	% N from fixation	kg N/ha from fixation	kg N/ha from soil
Winter chickpea	1986/87	5988	2407	181	70%	127	54
	1987/88	6079	2441	112		78*	33*
Montpellier	1986/87	4974	3327	130	60%	78	52
Spring chickpea	1986/87	1226	545	21	42%	9	12
	1987/88	2251	960	36		18*	18*
Montpellier	1986/87	4526	3102	120	47%	57	52
Lentil	1986/87	6020	1126	130	68%	88	42
	1987/88	7009	2354	132		90*	42*
Montpellier	1986/87	7926	3515	215	79%	169	46
Faba bean	1986/87	4562	1742	118	76%	89	29
	1987/88	7518	3289	177		135*	42*
Montpellier	1986/87	5873	3614	195	94%	183	12
Pea	1986/87	1458	751	44	72%	32	12
	1987/88	4018	1814	86		62*	24*
Montpellier	1986/87	7289	3427	171	82%	141	30

* Estimated using the 1986/87 values for % N from fixation.

From estimations of proportion of total crop N derived from the soil it can be seen that considerable quantities of nitrogen may be removed by the crop from soil, but the amount exported will depend on many factors. These factors will be investigated in future rotational experiments.

Dr. D. Beck

3.5.2. VA-mycorrhiza studies

Work on vesicular-arbuscular mycorrhiza (VAM) in food legumes was continued, concentrating on chickpea. Environmental limitations for a chickpea crop affect both the plant and its fungal symbiont, as the fungus is dependent on assimilates from the host.

In north-western Syria chickpea development is strongly affected by low temperatures at early and soil water deficit at late stages of development, and a lack of available P in the soils. The influence of these factors, singly and in combination, on the efficiency of the VAM was tested in several pot trials. It appeared that the striking dependence of chickpea on VAM shown in FLIP Annual Report 1987 cannot be generalized. This season's studies indicate that the efficiency of VAM not only depends on P supply but also on soil water status and temperature.

Figure 3.5.3 shows strong influence of temperature on the efficiency of VAM in chickpea supplied with different levels of P in a soil deficient in available P. At low temperature and medium levels of P-supply the mycorrhizal chickpeas were significantly ($P = 0.05$) more efficient in dry matter production than non-mycorrhizal ones - most probably due to higher nutrient uptake activity - while at high temperature mycorrhiza did not affect the crop.

In a pot trial examining the effects of P-supply and water stress on the efficiency of the symbiosis, the crop benefitted most from mycorrhiza when grown in a low-P soil at medium water stress level.

Studies on the VAM in field grown chickpea have been started to

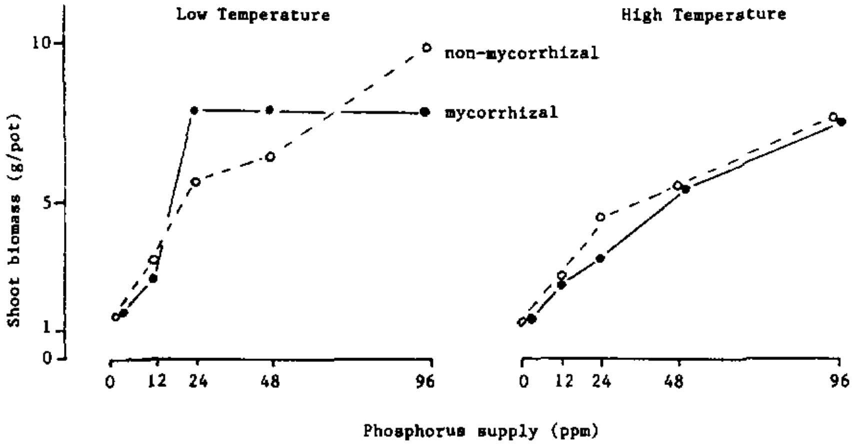

Fig. 3.5.3. Shoot biomass of chickpea at flowering stage as influenced by inoculation with VA-mycorrhiza (M), P - supply and temeprature regime - Pot experiment 1987/88.

verify whether an extrapolation of the findings in the pot experiments to the field crop is possible. Further work is necessary to prove that VA-mycorrhiza actually has a prominent influence on growth and yield of chickpea in north-western Syria.

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3.6. Chickpea Physiology and Agronomy

3.6.1. Evaluation of spring sown chickpea for drought tolerance and response to increasing moisture supply

In West Asia and North Africa, chickpea is normally sown in spring and the crop depends mainly on the conserved soil moisture which is progressively depleted with growth of the crop. The crop faces drought in late vegetative and reproductive growth because of increasing evaporative demand and decreasing soil moisture. A study was, therefore, initiated during the 1985/86 cropping season to identify drought tolerance in spring sown chickpea genotypes under field conditions. The characters identified should permit chickpea genotypes to respond positively (phenological plasticity) if moisture supply is improved. A line-source sprinkler system was used to develop a soil moisture gradient which would permit evaluation of the genotypic response to variable moisture supply. Using this technique studies were continued in 1986/87 and 1987/88. During the 1987/88 season, diverse genotypes differing in phenology, seed size, height and yield potential were used. This included 12 kabuli chickpea lines from ICARDA and 5 lines which were selected at ICRISAT for drought tolerance. The season was however wetter than normal and therefore the rainfed crop did not experience the magnitude of drought that would be common in the normal years.

The number of days from sowing to flowering and maturity varied among genotypes. As in the 1986/87 season, ICCL 82001 flowered earliest, followed by ICC 4958, ILC 1930, ILC 464, FLIP 84-78C and Annigeri (Table 3.6.1). FLIP 84-74C, FLIP 85-4C and FLIP 85-49C were last to flower. In the rainfed treatment, ICCL 82001 matured earliest, followed by ILC 1930, ICC 4958 and ILC 1919. Irrigation delayed maturity (Table 3.6.1).

Seed yield was significantly influenced by moisture supply. Under rainfed conditions, there were significant differences among genotypes, with ILC 1930 and ICC 4958 giving the highest yields and ICC 10448, ICC 10991, FLIP 85-4C and FLIP 85-49 giving low yields (Table 3.6.2).

Table 3.6.1. Number of days from sowing to different stages of development of chickpea sown on 13 March, 1988, Tel Hadya.

Genotypes	Days from sowing to			
	Emergence	Flower	Maturity	
			Rainfed	Irrigated
ILC 464	14	51	86	93
ILC 629	14	53	86	93
ILC 1919	14	53	84	86
ILC 1930	12	50	82	86
ICC 4958*	14	49	82	86
ICC 10448*	14	53	86	93
ICC 10991*	12	52	86	93
ICCL 82001*	12	45	75	78
FLIP 82-73C	14	53	89	93
FLIP 83-2C	14	56	89	93
FLIP 84-12C	14	56	92	96
FLIP 84-74C	12	59	86	93
FLIP 84-78C	12	51	89	93
FLIP 84-80C	14	53	92	96
FLIP 85-4C	14	59	96	98
FLIP 85-49C	14	59	96	98
ANNIGERI*	14	51	89	93

* Lines obtained from ICRISAT.

Correlations of seed yield with days to flower, days to physiological maturity, straw yield and total biological yield were determined using data for all genotypes, as well as for ICARDA kabuli chickpeas alone and the results are presented in Table 3.6.3. Under rainfed conditions, early flowering and early maturity appeared to be the most important attributes for high seed yield in ICARDA lines.

The line-source sprinkler permitted screening of genotypes for response to increasing moisture supply (Table 3.6.2). As in 1986/87, FLIP 85-4C which gave low yield under rainfed condition, was most

Table 3.6.2. Seed yield (kg/ha) of spring sown chickpea genotypes as affected by moisture supply, Tel Hadya, 1987/88.

Genotype	Irrigation applied (mm) above 504 mm of rainfall								Mean
	0	10	30	50	70	90	110	130	
ILC 464	1255	1344	1551	1442	1588	1772	1850	1908	1589
ILC 629	1068	1044	1242	1143	1350	1412	1824	1898	1372
ILC 1919	1228	1340	1367	1418	1446	1456	1480	1588	1415
ILC 1930	1364	1425	1486	1500	1670	1772	1888	2027	1642
ICC 4958	1361	1534	1432	1486	1599	1680	1803	1718	1577
ICC 10448	861	895	1000	850	1041	990	1204	1139	997
ICC 10991	847	850	929	973	1037	1122	1310	1364	1054
ICCL 82001	935	1010	1034	1061	1170	1282	1323	1163	1122
FLIP 82-73C	1160	1092	1194	1276	1456	1578	1786	1633	1397
FLIP 83-2C	1187	1180	1228	1337	1388	1459	1582	1575	1367
FLIP 84-12C	1017	1075	1238	1245	1500	1653	1871	1850	1431
FLIP 84-74C	997	1105	1109	1184	1395	1510	1700	1690	1336
FLIP 84-78C	1269	1293	1384	1463	1616	1677	1867	1929	1562
FLIP 84-80C	1061	1218	1262	1286	1534	1738	1922	1895	1489
FLIP 85-4C	803	895	888	1102	1337	1548	1796	1721	1261
FLIP 85-49C	833	956	983	1095	1252	1333	1514	1609	1197
Annigeri	1180	1262	1344	1378	1469	1541	1633	1626	1429
MEAN	1084	1148	1216	1249	1403	1501	1668	1667	

	MOISTURE (M)	GENOTYPE (G)	M X G
LSD (5%)	49.9	287.6	346.1
SE	18.0	101.2	122.7
CV (%)	10.9	41.9	

Table 3.6.3. Correlations between seed yield and some traits in spring sown chickpea, Tel Hadya, 1987/88.

Traits	Seed yield for	
	All genotypes	ICARDA lines
Days to flower	-0.450	-0.870
Days to maturity	-0.347	-0.804
Straw yield	0.062	-0.346
Biological yield	0.561	0.327

responsive to increase in moisture supply; whereas FLIP 84-74C was moderately responsive (Figure 3.6.1a). ILC 1930, although giving high seed yield under rainfed condition, maintained, as in 1986/87, high seed yield under increased moisture supply also (Figure 3.6.1a). The advantage of ILC 1930 compared to other genotypes lies in its ability to invest in seed yield rather than straw when moisture supply is increased (Figure 3.6.1).

Table 3.6.4 gives evapotranspiration, biological yield, seed yield and water use efficiency of seven selected genotypes in the rainfed and highest irrigation treatments. Amongst the ICARDA selections, water use efficiency was higher in the irrigated than in the rainfed treatment whereas the ICRISAT lines had higher water use efficiency in the rainfed than irrigated treatment. In the ICARDA lines, ILC 1930 had the highest water use efficiency. In the ICRISAT lines, ICC 4958, had the highest water use efficiency.

The 1987/88 results of yield under rainfed condition and the response to increasing moisture supply confirmed the results of the 1986/87 season, as it was shown again that ILC 1930 did well under rainfed condition and gave superior yields when irrigated. The correlations showed that early flowering and maturity are important attributes in ICARDA lines. In the ICRISAT lines, except for ICC 4958 which had a similar response as ILC 1930, most of the lines appear to have mechanism of drought escape. In the future emphasis will be devoted to understand the mechanism of drought tolerance and development of improved screening techniques.

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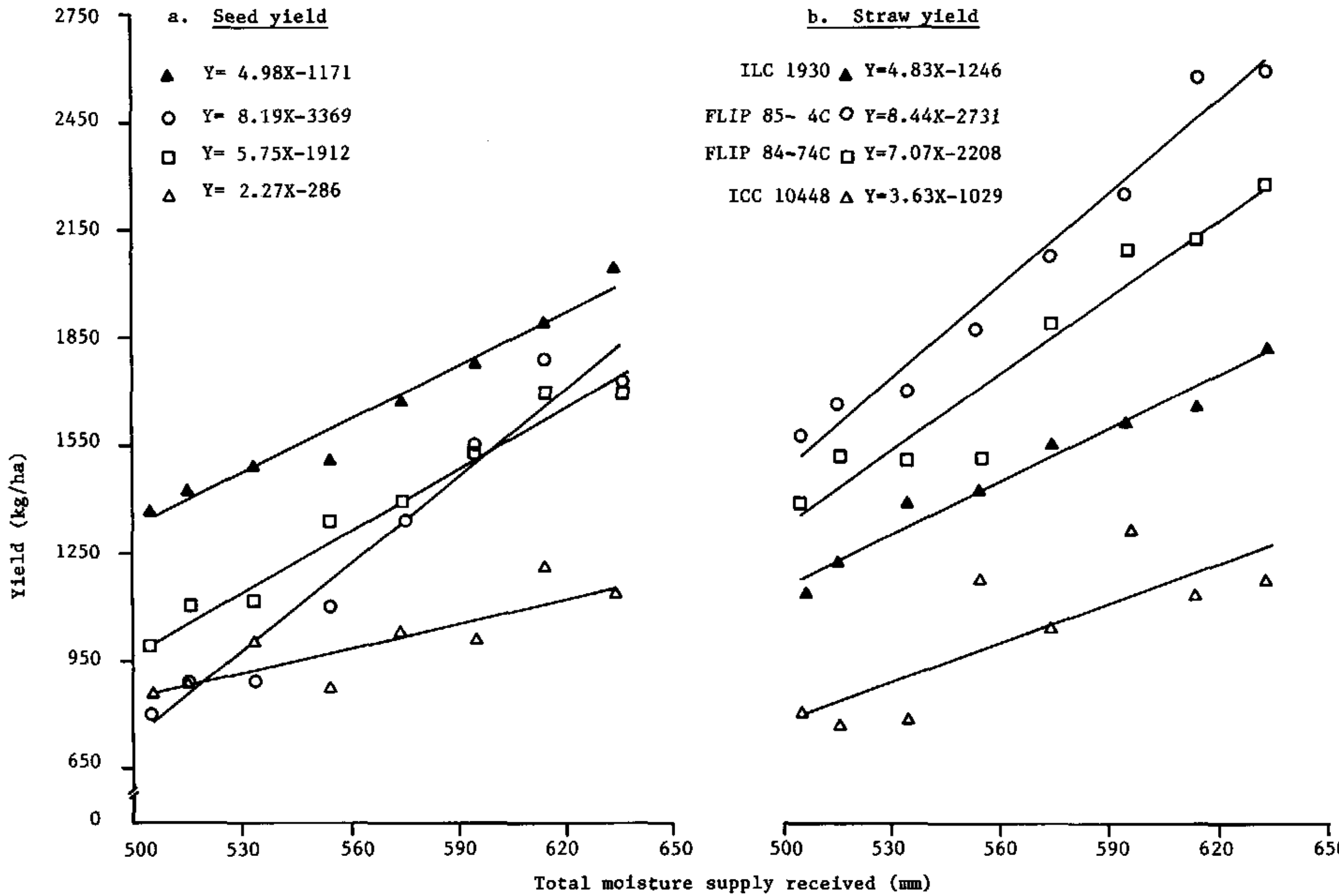

Fig. 3.6.1. Relationship between moisture supply and seed and straw yields of four selected genotypes, Tel Hadya, 1987/88.

Table 3.6.4. Total evapotranspiration (E_t) and water use efficiency (WUE kg/ha/mm) for total biological yield (BY) and seed yield (SY) under rainfed (R) and irrigated (I) conditions of some genotypes of chickpea sown in spring under moisture gradient. Tel Hadya, 1987/88.

Genotype	E_t (mm)	Yield (kg/ha)		WUE (kg/ha/mm)	
		BY	SY	BY	SY
ILC 629 (R)	256.3	2280	1068	8.60	4.17
ILC 629 (I)	369.2	3788	1898	10.26	5.14
ILC 1919 (R)	241.8	2207	1228	9.13	5.08
ILC 1919 (I)	298.7	2902	1588	9.72	5.32
ILC 1930 (R)	253.6	2502	1364	9.87	5.38
ILC 1930 (I)	320.6	3857	2027	12.04	6.33
*ICC 4958 (R)	228.6	2352	1361	10.29	5.95
*ICC 4958 (I)	336.5	3076	1718	9.14	5.11
*ICC 10448 (R)	229.2	1664	861	7.26	3.76
*ICC 10448 (I)	331.8	2316	1139	6.98	3.43
*ICCL 82001 (R)	194.1	1872	935	9.64	4.82
*ICCL 82001 (I)	280.9	2301	1163	8.19	4.14
FLIP 85-4 (R)	249.8	2378	803	9.52	3.21
FLIP 85-4 (I)	406.4	4319	1721	10.63	4.23

* Lines selected at ICRISAT for low rainfall areas.

3.6.2. Chemical weed control

The experiment was conducted at Tel Hadya and Jindiress where the annual precipitation was 504 and 715 mm, respectively. The aim was to evaluate the effectiveness of some new herbicides and to compare them with those already recommended.

The level of weed infestation was low in Tel Hadya and high in Jindiress. Broadleafed weeds were dominant in both locations but Jindiress had more grasses than Tel Hadya. Sinapis arvensis, Vaccaria phyamidata, Carthamus syriacus, Gaiium tricorne and Athemis sp. were the main broadleafed weeds. Phalaris brachyrtachys, Avena sterillis and volunteer cereals were the main grasses in the trial area. Yield losses due to weeds were 10% in Tel Hadya and 50% in Jindiress, respectively.

Table 3.6.5. Effect of chemical weed control on seed yield of winter chickpea and dry matter of weeds (TDW), Tel Hadya and Jindiress, 1987/88.

Treatment	Rate of application (Kg a.i./ha)	Tel Hadya Seed yield (Kg/ha)	Tel Hadya TDW (Kg/ha)	Jindiress Seed yield (Kg/ha)	Jindiress TDW (Kg/ha)
Weedy check	-	577	543	724	2087
Weed free	-	640	113	1517	506
Cyanazine + Pronamide, pre-emergence	0.75+0.5	669	475	1243	967
Terbutryne + Pronamide, pre-emergence	2.0+0.5	666	417	1118	728
Codal, pre-emergence	2.0	510	464	1317	924
Carbetamide, pre-emergence	1.5	430	763	639	1735
Carbetamide, post-emergence	1.5	603	457	740	2451
Dinoseb acetate + Fenoxaprop ethyl, post-emergence	1.0+0.15	687	811	998	1997
Dinoseb acetate + Fluozifop butyl, post-emergence	1.0+0.25	514	450	781	1416
Aresin Combi, post-emergence	1.0	415	682	643	2219
LSD (5%)		180.9	391.3	197.1	521.4
C.V. (%)		21.8	52.1	21.1	23.9

In Tel Hadya, weed control treatments did not result in improved yield over weedy check due to the relative low weed infestation. Of the new chemicals tested, pre-emergence application of Codal gave good weed control and resulted in significantly higher seed yield than the weedy check in Jindiress (Table 3.6.5). Post-emergence application of Dinoseb acetate mixed either with Fenoxaprop ethyl or Fluazifop methyl did not give good results in Jindiress due to delayed application.

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4. 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 the Ministry for Economic Cooperation, Federal Republic of 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 of dry pea varieties adapted to the farming systems of WANA. The work on pea improvement is therefore concentrated in the following area:

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

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

4.1. Germplasm Collection and Evaluation

Germplasm and released varieties were collected from institutions in developed and some developing countries. Three hundred and nine entries were yield tested at Tel Hadya in an augmented block design with three repeated checks. The checks were the widely grown line in Syria (accession 223) and two widely grown cultivars around the Mediterranean region (accessions 224 and 225). Seasonal precipitation was 504 mm, as compared to the long term average of 331 mm. Seed yield ranged from 0 kg/ha (for accessions 45, 192, 194, 204, 238 and 265) to 4575 kg/ha (for accession 216); the range in biological yield was from 0 kg/ha (for accessions 45, 204, 238 and 265) to 10991 kg/ha (for accession 125). Pea accession numbers 216 and 267 produced significantly more seed yield than the best check (accession 225) and 105 accessions outyielded ($P \leq 0.05$) the widely grown local check (accession 223).

4.2. Preliminary Yield Trial

Superior entries selected from genetic evaluation were tested in a preliminary yield trial at Tel Hadya and Terbol. The experiment was conducted as 7x7 triple lattice. At Tel Hadya the number of days to flower ranged from 101 (for accessions 23, 25 and 34) to 127 (for accession 218). Seed yield varied from 1634 kg/ha (accession 36) to 4342 kg/ha (for accession 7) and the 10 highest yielding accessions are given in Table 4.2.1. At Terbol, plant stand was variable. Number of days from sowing to flower ranged from 118 (accession 25 and 23) to 143 (accession 8). Seed yield varied from 1517 kg/ha (accession 6) to 4677 kg/ha (accession 42) and the top 10 entries are given in Table 4.2.1. Entries 7, 24 and 167 appeared in the top ten entries at both locations. At Tel Hadya 19 entries significantly ($P \leq 0.5$) exceeded the local check but at Terbol only one (Table 4.2.1).

Table 4.2.1. Seed yield (kg/ha) of 10 highest yielding entries in Pea Preliminary Yield Trial, 1987/88.

Tel Hadya		Terbol	
Accession No.	Seed yield (kg/ha)	Accession No.	Seed yield (kg/ha)
7	4342	42	4677
24	3974	21	3551
167	3791	24	2931
62	3627	7	2911
63	3537	109	2831
33	3479	36	2801
22	3460	219	2756
4	3383	173	2728
25	3130	30	2649
10	3112	167	2639
(Syr. Local 8 Check 1)	2096	L8	2623
(The Lincoln 59 Check 2)	2825	L59	2176
LSD (5%)		756	1433
CV (%)		16.8	38.2

4.3. Comparative Performance of Pea Cultivars at Different Sowing Dates

A study initiated during the 1986/87 cropping season to test the performance of 20 dry pea cultivars of diverse origin when sown in early winter, mid-winter and spring was repeated. During the 1986/87 season, total moisture supply received was 359 mm and sowing dates were 11 December 1986, 1 February 1987 and 3 March 1987 and the respective seed yields were 2121 kg/ha, 1544 kg/ha and 956 kg/ha. In 1987/88, seasonal moisture supply was 504 mm. Planting was carried out on 24 November 1987, 3 January 1988 and 21 February 1988, representing respectively, early winter, mid-winter and spring sowings. Germination and plant stand were generally variable and poor during the 1987/88 season and *Orobanche* infestation level was high. As shown in Table 4.3.1. seed yield did not vary significantly with the dates of sowing, due to high coefficient of variability. However, the yield of mid-winter sowing tended to be higher than the other sowing dates. There were significant variations in yield among genotypes with Small Sieve Freezer giving the highest mean seed yield of 2670 kg/ha, followed by Kelvedon Wonder with 2555 kg/ha. Low mean seed yields of 1581, 1568 and 1549 kg/ha were obtained respectively from Onward, Progretta and Baf. Date of sowing x genotype interaction was non-significant.

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Table 4.3.1. Seed yield (kg/ha) and rank (R) of pea varieties as influenced by date of sowing, Tel Hadya, 1987/88.

Variety	Sowing date						Mean	
	24.11.1987		3.1.1988		21.2.1988			
	Y	R	Y	R	Y	R	Y	R
Small Sieve Freezer	3295	1	2925	2	1790	4	2670	1
Kelvedon Wonder	3609	4	3034	1	2023	1	2555	2
Kodiak	2663	2	2600	7	1535		2266	3
Petit Provincale	2266	7	2821	4	1681	9	2256	4
Upton	2046		2914	3	1718	5	2226	5
The Lincoln	1951		2817	5	1901	2	2223	6
Dark Skin Perfection	2570	5	2356		1688	8	2205	7
Alaska	2650	3	2210		1689	7	2183	8
Early Onward	2270	6	2473	9	1794	3	2179	9
Syrian Local	2218	8	2471	10	1698	6	2129	10
Despe	1740		2736	6	1680	10	2052	11
Scout	2118		2333		1526		1992	12
Facima	2157	10	2453		1245		1952	13
Sprite	1965		2138		1500		1868	14
Maro	1341		2493		1561		1798	15
Filby	1764		2315		1287		1789	16
Frisson	2159	9	2043		1115		1772	17
Onward	1767		1885		1091		1581	18
Progretta	1747		1916		1040		1568	19
Baf	1772		1908		968		1549	20
Mean	2153		2442		1527			

	Date	Variety	Interaction
LSD (5%)	NS	395	NS
CV (%)	143.5	24.2	

Y = seed yield (kg/ha), R = rank.

4.4. Weed Control

Peas are grown in rotation with cereals. They have slow initial growth and hence suffer from weed competition. Most varieties lodge at an early stage and weeds grow through the canopy. Weeds reduce seed yield, may increase disease infestation and may impair harvesting. Efficient weed control is therefore vital. A study was conducted at Tel Hadya to quantify yield losses due to weeds, identify promising herbicides for weed control and determine the effect of weed competition on peas of different growth habits.

Besides volunteer barley, the other major grassy weed was Phalaris brachystachys and major broad-leafed weeds were Sinapsis arvensis, Coronilla scorpioides, Carthamus lanatus, Scorpiurus muricatus, Vaccaria pyramidata, Geranium tuberosum, Galium tricornutum, Cirsium syriacum, Amaranthus blitoides, Ranunculus arvensis and Euphorbia sp. Pea cultivar Syrian Local produced better total dry matter and suppressed weeds more than Facima (Table 4.4.1). Among weed control treatments, all handweeding treatments suppressed weeds and among the herbicides, a pre-emergence application of a combination of Propyzamid (0.5 kg a.i./ha) and Methabenzthiazuron (2.5 kg a.i./ha), a post-emergence application of a combination of Fluazifop-butyl (0.5 kg a.i./ha) and Bentazon (1.5 kg a.i./ha); and a pre-emergence of application of Propyzamid (0.5 kg a.i./ha) plus Cyanazine (0.75 kg a.i./ha) were effective in controlling weeds (Table 4.4.1). The effect of weed control treatments was, however, not reflected in seed yield (Table 4.4.2) because of the high and variable level of Orobanche spp. infestation (Table 4.4.1).

Table 4.-.1. Yield of weeds and Orobanche shoots (kg/ha) at harvest stage of two pea cultivars as affected by weed control treatments, Tel Hadya, 1987/88.

Treatment	Cultivars				Mean	
	'Syrian Local'		'Facima'			
	Weeds	Orobanche	Weeds	Orobanche	Weeds	Orobanche
Weedy check	412	202	2882	522	1647	362
Hand weeding 10 weeks ae*	6	145	108	728	93	437
Hand weeding 14 weeks ae	74	195	175	776	124	486
Hand weeding 10+14 weeks ae	53	255	150	608	102	431
Hand weeding 14+16 weeks ae	94	312	103	773	99	543
Propyzamid + Methabenzthiazuron, pre-emergence	13	83	39	241	26	162
Propyzamid + Cyanazine, pre-emergence	126	73	719	234	423	154
Dinoseb-acetate + Monolinuron, pre-emergence	721	328	1748	426	1235	377
Fluazifop-butyl, post-emergence	145	213	2708	728	1426	471
Cycloxyadin, post-emergence	69	372	1415	610	742	491
Fluazifop-butyl + Bentazon, post-emergence	16	264	510	593	263	428
Mean	157	222	966	567	562	395

* ae = after emergence

Table 4.4.2. Pea seed yield (SY), straw yield (STRY) and total biological yield (TBY) in kg/ha as affected by weed control treatments in two dry pea cultivars. Tel Hadya, 1987/88.

Treatment	Cultivars						Mean		
	'Syrian Local'			'Facima'					
	SY	STRY	TBY	SY	STRY	TBY	SY	STRY	TBY
Weedy check	1291	4840	6131	1635	3108	4743	1463	3974	5437
Hand weeding 10 weeks ae*	1070	4855	5924	2151	3294	5446	1610	4075	5685
Hand weeding 14 weeks ae	1273	4934	6206	1849	2984	4833	1561	3959	5520
Hand weeding 10+14 weeks ae	818	4898	5716	1945	2799	4744	1382	3849	5230
Hand weeding 14+16 weeks ae	1162	4245	5407	1920	2999	4919	1541	3622	5163
Propyzamid + Methabenzthiazuron	1524	3635	5159	2048	2434	4482	1786	3034	4821
Propyzamid + Cyanazine	1290	3691	4981	1930	2265	4195	1610	2978	4588
Dinoseb-acetate + Monolinuron	1037	3239	4329	1673	1976	3649	1355	2634	3989
Fluazifop-butyl	1231	5679	6911	1438	2687	4125	1335	4183	5518
Cycloxydim	912	4670	5581	1906	2894	4780	1409	3782	5191
Fluazifop-butyl + Bentazon	1261	4615	5876	2178	2844	5022	1720	3729	5449
Mean	1170	4487	5657	1879	2753	4632	1525	3620	5145

* ae = after emergence

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5. 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, weed control, planting time, plant population, etc. (Table 5.1.1). Nurseries are only sent on request and often include specific germplasm developed for a particular region or a national program. Increasing diversification of nurseries to meet the changing needs of the NARS is evident from Fig. 5.1.1. Whereas in 1977/78 only Yield Trials and Screening Nurseries were dispatched, during 1988/89 the trials dispatched included in addition Stress Tolerance Nurseries, Segregating Populations and Agronomy Trials.

These tests identify genotypes with specific and wide adaptation and the performance data permit assessment of genotype 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

Table 5.1.1. Food Legume International Nurseries supplied for the 1988/89 season.

International Trial/Nursery	No. of sets
Faba Bean	
Yield Trial, Large-Seed (FBIYT-L-89)	25
Yield Trial, Small-Seed (FBIYT-S-89)	25
Yield Trial, Determinate (FBIYT-D-89)	25
Screening Nursery, Large-Seed (FBISN-L-89)	30
Screening Nursery, Small-Seed (FBISN-S-89)	30
Screening Nursery, Determinate (FBISN-D-89)	30
* F_4 Nursery - A (with Ascochyta Blight Resistance) ($FBIF_4NA$-89)	5
* F_4 Nursery - B (with Chocolate Spot Resistance) ($FBIF_4NB$-89)	10
* F_4 Nursery - D (with Determinate Type) ($FBIF_4N$-D-89)	12
Ascochyta Blight Nursery (FBIABN-89)	8
Chocolate Spot Nursery (FBICSN-89)	8
Rust Nursery (FBIRN-89)	8
Fertility-Rhizobium Evaluation Trial (FBFRT-89)	15
Inoculation Response Trial (FBIRT-89)	10
Weed Control Trial (FBWCT-89)	15
Orobanche Chemical Control Trial (FBOCCT-89)	5
Sub total	261
Lentil	
Yield Trial, Large-Seed (LIYT-L-89)	60
Yield Trial, Small-Seed (LIYT-S-89)	35
* Yield Trial, Early (LIYT-E-89)	35
Screening Nursery, Large-Seed (LISN-L-89)	52
Screening Nursery, Small-Seed (LISN-S-89)	30
Screening Nursery, Early (LISN-E-89)	59
Screening Nursery, Tall (LISN-T-89)	52
F_3 Nursery (LIF_3N-89)	13
F_3 Nursery, Early (LIF_3N-E-89)	26
* Cold Tolerance Nursery (LICTN-89)	17
* Ascochyta Blight Nursery (LIABN-89)	20
Fertility-Rhizobium Evaluation Trial (LFRT-89)	16
Inoculation Response Trial (LIRT-89)	17
Weed Control Trial (LWCT-89)	21
Sub total	453
Chickpea	
Yield Trial Spring (CIYT-Sp-89)	42
Yield Trial Winter, Mediterranean Region (CIYT-W-MR-89)	50
Yield Trial Winter, Sub-Tropical Region (CIYT-W-STR-89)	30
Yield Trial Large Seed (CIYT-L-89)	74
Yield Trial Tall (CIYT-T-89)	59
Screening Nursery Winter (CISN-W-89)	55
Screening Nursery Spring (CISN-Sp-89)	46
F_4 Nursery (CIF_4N-89)	18
Ascochyta Blight Nursery: Kabuli (CIABN-A-89)	26
Ascochyta Blight Nursery: Kabuli + Desi (CIABN-B-89)	20
Leaf-miner Nursery (CILN-89)	8
Cold Tolerance Nursery (CICTN-89)	28
Fertility-Rhizobium Evaluation Trial (CFRT-89)	16
Inoculation Response Trial (CIRT-89)	20
Weed Control Trial (CWCT-89)	17
Sub total	509
TOTAL	**1223**

* New Nurseries added for 1988/89.

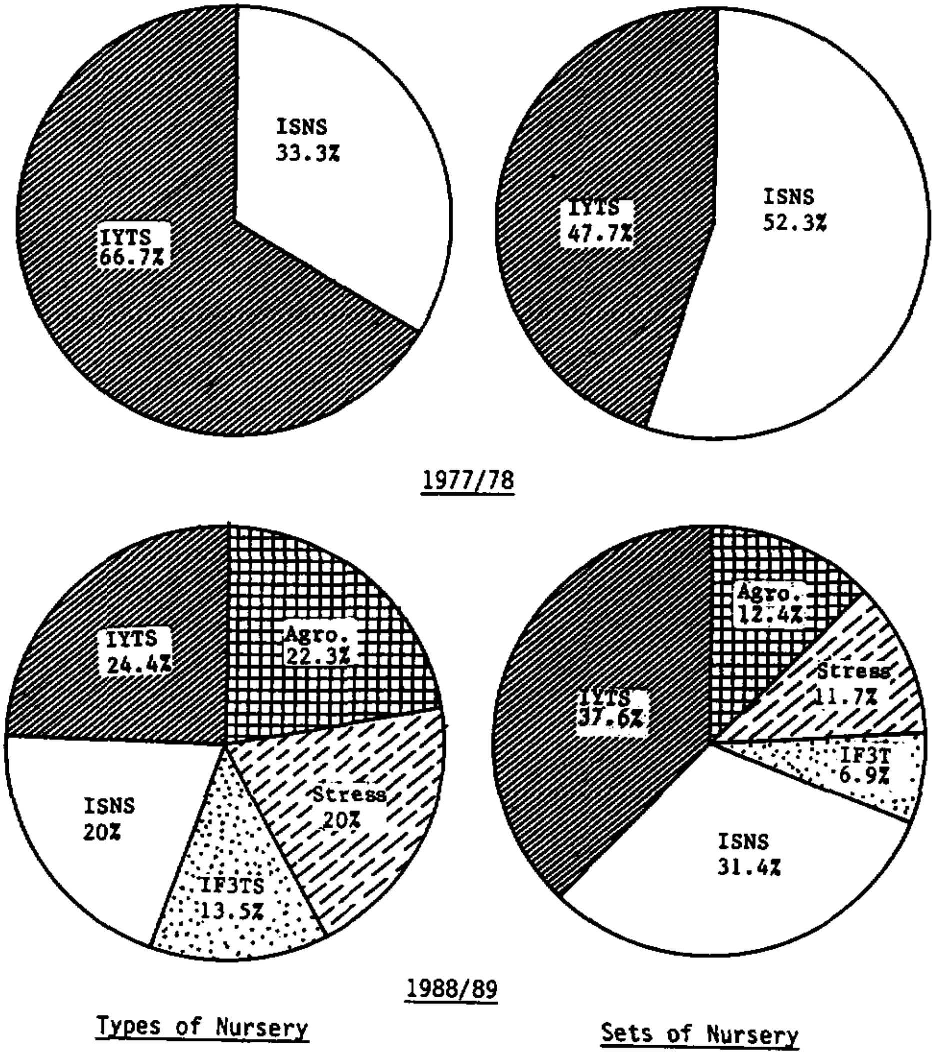

Fig. 5.1.1. Diversification and distribution of nurseries during 1977/89, as reflected by the types of nurseries available and numbers of sets of these supplied to the cooperators, IYTS = International Yield Trial; ISVS = Screening Nurseries; IF_3T = International F_3 Trials.

potential of their cultivars.

The results for 1986/87 season have been analyzed and the report is in preparation. The salient features of 1986/87 international nursery report are presented here. Increased follow-up has hastened the return of data from cooperators in recent past and for the 1986/87 season the return was 61 per cent. We hope to improve this further in future. A number of cooperators requested large quantitites of seed of some elite lines identified by them from the international nurseries/trials and we have attempted to meet their requests. Some of the salient features of the international nurseries are presented below cropwise:

5.1. Faba Bean

Results of the Faba Bean International Yield Trial-Large Seed (FBIYT-L) indicated that out of 31 trials analysed for seed yield only at six locations namely, Beja and El-Kef in Tunisia, Homs in Syria, Athallassa in Cyprus, Perico in Argentina, and Islamabad in Pakistan, some of the lines outyielded the local check by a significant ($P \leq 0.05$) margin. The five best yielding entries included, ILB 1270, FLIP 82-54FB, FLIP 83-5FB, FLIP 82-45FB and ILB 398. The ANOVA for stability revealed that the mean squares due to both linear (predictable) and non-linear (unpredictable) portions of genotype x environment interaction were significant (Table 5.1.2). The perusal of these estimates for individual entries revealed that the performance of 19 entries out of 23 was predictable. Twelve entries namely, FLIP 83-5FB, 74TA 22, FLIP 82-28FB, 79S 4, 76TA 56246, FLIP 82-45FB, 80S 80135, FLIP 83-6FB, FLIP

82-53FB, Turkish local, FLIP 82- 27FB, and FLIP 82- 30FB in descending order of superiority were with average stability and predictable behaviour. Another entry, namely 79S 653 with above average performance, however, showed specific adaptation to high yielding environments.

Table 5.1.2. Analysis of variance for stability for seed yield for the entries in FBIYT-L-87.

Source	Degree of freedom	Mean squares
Entry	22	2202110*
Entry x location + Location	667	2462610*
Location (linear)	1	1532680000*
Entry x location (linear)	22	501918*
Pooled deviation	644	153486*
Replication within location	60	71865008
Pooled error	1320	126625

* Significant at P = 0.05.

The Faba Bean International Yield Trial-Small Seed (FBIYT-S) analysed for 18 locations revealed that at Catania in Italy and Islamabad in Pakistan, yield of some entries exceeded the respective local checks by significant margins. Across locations, the five hightest yielding lines were: FLIP 82- 35FB, FLIP 83- 96FB, FLIP 83-95FB, FLIP 83-100FB and 80S 46121.

In the Faba Bean International Screening Nursery-Large Seed (FBISN-L) the results were analysed for 28 locations, and at six locations (Temuco and Hidango in Chile, Sakha in Egypt, Islamabad in Pakistan, El-Kef in Tunisia and Ankara in Turkey) a large number of test entries exceeded the respective local checks by significant margins (at P $\leq$ 0.05). The five best entries across locations included FLIP 84-138FB, ILB 1269, FLIP 84-109FB, FLIP 84-114FB and FLIP 84-151FB.

In the Faba Bean International Screening Nursery-Small Seed (FBISN-S) at five locations, namely Tarquinia in Italy, Marrow in Jordan, Cordoba in Spain, Terbol in Lebanon and Ankara in Turkey, some of the test entries significantly exceeded the respective local checks in seed yield. The five best yielders included FLIP 84-165FB, FLIP 84-168FB, FLIP 83- 3FB, FLIP 84-216FB and FLIP 84- 57FB.

The results of F_4-Nursery (FBIF$_4$N) were reported from 9 locations and the ANOVA for seed yield revealed that at 8 locations a large number of the segregating populations were statistically (P = 0.05) similar or superior to the respective local checks in seed yield. This exhibited that the selection of superior plants was feasible at all these locations. The five best yielding populations across locations included, Cross Nos. S84144, S84154, S84099, S84098 and S84093.

The results on Faba Bean International Ascochyta Blight Nursery (FBIABN) were reported from 8 locations. Across locations, out of 16 entries only three namely L85-Lat 77-A x A (L83150), Sel. 80 Lat 14422-3 (BPL 460) and Sel 80 Lat. 15035-1 (BPL 818) were rated between 1-5 and tolerant.

The results of Faba Bean International Chocolate Spot Nursery (FBICSN) were reported from ten locations. Only at four locations, namely Holletta in Ethiopia, Giza in Egypt, Idleb in Syria and Sidi Bel Abbes in Algeria, the susceptible check had the rating between 7 and 9.

Although a few entries were resistant/tolerant at individual locations but across locations none of the entries was tolerant or resistant. In general, three entries, namely selections 81L Lat. 24694 (BPL 261), 81 Lat. 25114 (BPL 1821) and Sel 81 Lat. 24948-1 (BPL 1179) were tolerant/resistant at most of the locations.

The Faba Bean Weed Control Trial (FBWCT) results were analysed for 3 locations for seed yield and the treatment effects were significant for all the locations. Only at two locations, namely Tarquinia in Italy and Dhamar in Yemen Arab Republic some of the weedicide treatments were significantly superior to the respective weedy check. The most effective treatment included pre-emergence application of Bladex at 0.5 kg a.i./ha + Kerb at 0.5 kg a.i./ha.

The Faba Bean Fertility-Evaluation Trial (FBFIT) was analysed for three locations but the ANOVA for seed yield was significant for only two locations. The treatment with application of 60 kg P_2O_5/ha + 60 kg K_2O/ha was significantly superior to the unfertilized uninoculated check but the application of nitrogen alone at 100 kg/ha did not exhibit significant increase. This revealed that the nitrogen requirement was fulfilled either by native rhizobia or by available nitrogen in the soil.

5.2. Lentil

Data from 34 locations were analysed for seed yield for Lentil International Yield Trial-Large Seed (LIYT-L). At nine locations, namely Horsham and Mallee in Australia, Valdivia and Graneros in Chile, Catania in Italy, Quetta in Pakistan, Terbol in Lebanon, and Erzurum and Haymana in Turkey, some of the entries exceeded the respective local check in seed yield by a significant (P = 0.05) margin. The five heaviest yielding lines across locations were ILL 5582, FLIP 84- 27L, FLIP 84-152L, FLIP 85- 35L, and ILL 5671. Stability analysis based on Eberhart and Russel (1966) model for seed yield of LIYT-L entries, revealed that both linear and non-linear portions of interaction mean squares were non-significant (Table 5.2.1). This exhibited that the behaviour of entries in the trial with respect to seed yield was predictable and the response of entries to varying environments was not significantly different. Nine entries, namely, ILL 4400, 74TA 19, 78S 26002, FLIP 84-27L, FLIP 84-84L, FLIP 84-92L, FLIP 84-152L, FLIP 85-2L and FLIP 85-4L with average stability, non-significant deviations from regression, and above average mean, had general adaptation. However, two entries namely FLIP 85- 3L and FLIP 85- 35L with regression more than one, and one entry FLIP 84-100L with regression less than one were specifically adapted to high yielding and low yielding environments, respectively.

Table 5.2.1. Analysis of variance for stability for seed yield for the entries in LIYT-L-87.

Source	Degree of freedom	Mean squares
Entry	22	180516*
Entry x location + Location	644	818566*
Location (linear)	1	478097000*
Entry x location (linear)	22	120574
Pooled deviation	621	74729
Replication within location	58	339819*
Pooled error	1276	79809

* Significant at P = 0.05.

The results of Lentil International Yield Trial-Small Seed (LIYT-S) revealed that at 12 out of 22 locations analysed, (Darul-aman in Afghanistan, Horsham and Walpeup in Australia, Catania in Italy, Terbol in Lebanon, Quetta and Islamabad in Pakistan, Deir-Ezzor and Tel Hadya in Syria; Beja, El-Kef, and Oued Melize in Tunisia) 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 85- 16L, FLIP 84- 43L, FLIP 84- 26L, FLIP 84- 44L and ILL 5562.

The analyses of results for seed yield for Lentil International Screening Nursery (LISN) Large (L), Small (S), Tall (T) and Early (E) for 36, 25, 37 and 26 locations, respectively, revealed that at 13, 11, 11 and 3 locations some of the test entries exceeded the respective local check by a significant (P = 0.05) margin. The five heaviest yielders across the locations for these nurseries are given in Table 5.2.2. The best yielding lines in LISN-E, were not among the earliest maturing lines but were among the medium-early ones.

Table 5.2.2. The best five lines across locations in lentil screening nurseries, 1986/87.

Rank	Name of nursery			
	LISN-L	LISN-S	LISN-T	LISN-E
1	FLIP 86-5L	FLIP 87-53L	ILL 5582	FLIP 84-112L
2	FLIP 87-17L	FLIP 84-51L	FLIP 84-51L	FLIP 84-78L
3	FLIP 87-1L	FLIP 87-43L	FLIP 86-3L	FLIP 86-53L
4	FLIP 87-20L	FLIP 87-48L	FLIP 84-59L	FLIP 86-41L
5	FLIP 87-5L	FLIP 87-57L	FLIP 87-45L	ILL 358

The results from Lentil International F_3-Trial (LIF_3T) and F_3-Trial-Early (LIF_3T-E) reported from 12 and 10 locations, respectively, were analysed. One cross at Shandweel in Egypt and 8 crosses at Islamabad in Pakistan in LIF_3T; and two crosses at Denbi in Ethiopia and four crosses at Tel Hadya in Syria in LIF_3T-E, gave significantly higher yield than the respective local checks. Out of these, at 9 and 10 locations, respectively, at least a few crosses were equal or superior to the respective local checks in LIF_3T and LIF_3T-E. The five best yielding crosses included ILL 1939 X FLIP 84- 56L (cross No. 177), FLIP 85- 41L X FLIP 84- 51L (cross No. 221), ILL 5588 X ILL 5604 (cross No. 154), ILL 5572 X ILL 5604 (cross No. 139), and FLIP 84-73L X ILL 5588 (cross No. 108) in LIF_3T; and ILL 2578 X ILL 2581 (cross No. 4), ILL 2578 X ILL 4403 (cross No. 279), ILL 3527 X ILL 2581 (cross No. 283), ILL 3527 X ILL 2582 (cross No. 284), ILL 4407 X ILL 4403 (cross No. 297). It is worth mentioning that all these crosses included parents either from India or Pakistan and all the populations in LIF_3T-E were earlier in flowering than the respective check.

Out of eight locations for which results of Lentil Weed Control Trial (LWCT) were analysed, only four locations had significant treatment effects. A combination of Gesagard (@1.5 kg a.i./ha) and Kerb (@ 0.5 kg a.i./ha) as pre-emergence application was best at most of the locations.

The results of Lentil International Fertility-Evaluation Trial (LFIT) were reported from 3 locations. The ANOVA was significant at Mymensing (Bangladesh) and Dhmar (Yemen Arab Republic). The treatment with P_2O_5 at 80 kg/ha + K_2O at 60 kg/ha gave significantly higher yield than the unfertilized control at both the locations.

5.3. Chickpea

The seed yield data were analysed for 26 locations for Chickpea International Yield Trial-Spring (CIYT-S). A large number of entries exceeded the respective local checks by a significant (P = 0.05) margin at nine locations namely Dohuk in Iraq, Beja , Oued Meliz, El-Kef and Ras Rajel in Tunisia, Adana and Ankara in Turkey, Tel Hadya in Syria and El-Khroub in Algeria. The five best entries across the locations were FLIP 84-60C, FLIP 84-149C, FLIP 84-155C, FLIP 84-164C and ILC 482.

The seed yield data for Chickpea International Yield Trial-Winter-Mediterranean Region (CIYT-W-MR) revealed that out of 39 locations for which data were analysed, at 23 locations (Setif, El-Guadah, Sidi Bel Abbes and Guelma in Algeria; Laxia in Cyprus, Tarquinia in Italy; Marrow and Irbid in Jordan; Satsaf in Libya; Terbol in Lebanon; Elvas in Portugal; Granada and Madrid in Spain; Beja, Oued Meliz and El-Kef in Tunisia; Izraa, Idleb, Hama, Heimo, Gelline and Homs in Syria and Adana in Turkey) some entries exceeded the respective local checks by a significant (P = 0.05) margin. The five best entries across locations included FLIP 83- 48C, FLIP 84- 92C, FLIP 84- 93C, FLIP 84-144C and FLIP 84-145C. The ANOVA for stability for seed yield in CIYT-MR indicated that mean squares due to pooled deviations (non-linear portion) were not significant and entry x location (linear portion) were significant (Table 5.3.1). This exhibited that the major portion of entry x location interaction was predictable across locations and the performance of entries across locations could be predicted. Further some of the entries, namely FLIP 84-145C, ILC 482, FLIP 83-71C, FLIP 84-102C, FLIP 84-109C and FLIP 83- 98C had regression coefficient equal to one, deviations from regression as zero and the average seed yield more than the general mean and were thus widely adaptable.

Table 5.3.1. Analysis of variance for stability of seed yield for the entries in CIYT-W-MR-87.

Source	Degree of freedom	Mean squares
Entry	22	364290*
Entry x location + Location	874	804291*
Location (linear)	1	651821000*
Entry x location (linear)	22	153465*
Pooled deviation	851	56115
Replication within location	117	39120
Pooled error	2574	39119

* Significant at P = 0.05.

In the *Chickpea International Yield Trial-Sub-Tropical Region* (CIYT-STR), a few entries exceeded the respective local check by a singificant margin at 5 out of 17 locations analysed for seed yield. These locations included Faisalabad and Chakwal in Pakistan, and Beja, El-Kef and Oued Meliz in Tunisia. The five heaviest yielders across locations were FLIP 81-293C, FLIP 82-127C, FLIP 83- 73C, FLIP 84-185C and ILC 482.

The analysis of results of Chickpea International Yield Trial-Large-Seed (CIYT-L) for 38 locations revealed that at 21 locations (Setif and Guelma in Algeria; Saskatoon in Canada; Larissa in Greece; Tarquinia and Papiano in Italy; Jubeiha in Jordan; Culiacan in Mexico; Elvas in Portugal; Badajoz and Sevilla in Spain; Heimo, Jinderiss and Tel Hadya I & II in Syria; Beja, El-Kef and Oued Meliz in Tunisia; Ankara and Amasya in Turkey; and Terbol in Lebanon) some of the test entries exceeded the respective local check by a significant margin. This was the first year when the test entries in CIYT-L had resistance to Ascochyta blight. The five heaviest yielders across the locations were FLIP 83- 77C, FLIP 84- 15C, FLIP 84- 19C, FLIP 85- 5C, and FLIP 85- 61C.

The Chickpea International Yield Trial Tall Type (CIYT-T) was conducted for the first time during 1986/87. The results were reported from 34 locations and ANOVA for seed yield revealed that at Mosul in Iraq; Tarquinia in Italy; Marrow in Jordan; Oeiras and Elvas in Portugal; Badajoz and Sevilla in Spain; Tel Hadya and Al-Ghab in Syria; Beja, Oued Meliz and Ras Rajel in Tunisia; Adana and Menemen in Turkey; Terbol in Lebanon; Al-Tamia in Iraq; and El-Kharoub in Algeria, some of the test entries exceeded the respective local checks in seed yield by significant (P = 0.05) margin. The five heaviest yielders across the locations included FLIP 84- 20C, FLIP 84- 32C, FLIP 84-182C, FLIP 85-14C, and FLIP 85- 19C.

The adjusted seed yields in Chickpea International Screening Nursery Winter (CISN-W) revealed that at 15 locations out of 36, some of the entries exceeded the respective local check by a significant (P = 0.05) margin. The five heaviest yielders across the locations included FLIP 82-293C, FLIP 85- 94C, FLIP 85- 95C, FLIP 85- 97C and FLIP 85-168C.

The results of Chickpea International Screening Nursery Spring (CISN-S) were reported from 24 locations. At 5 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 84- 72C, FLIP 85- 10C, FLIP 85- 82C, FLIP 85- 96C and FLIP 85-107C.

The results of Chickpea International F_4-Trial reported from 34 locations showed that at eight 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 X84TH 2 (FLIP 81- 3C X ILC 3682), X84TH 6 (FLIP 81- 41C X ILC 2399), X84TH 58 (ILC 200 X ILC 3682), X84TH 23 (FLIP 82-232C X ILC 116) and X84TH 7 (FLIP 81- 41C X ILC 3841).

The *Chickpea International Ascochyta Blight Nursery* (CIABN) results from 5 Pakistan locations namely Chakwal, Faisalabad (AARI & NIAB), Islamabad and Peshawar, and one other location, namely Marrow in Jordan, revealed that none of the entries was tolerant to Ascochyta blight infestation across locations. Considering only those results obtained from other 12 locations, however, it was clear that two entries, namely FLIP 84- 85C and FLIP 84-182C had rating ranging from 1 and 3; and 12 entries, namely ILC 202, ILC 2506, ILC 3868, ILC 4421, FLIP 83- 46C, FLIP 83- 72C, FLIP 83- 97C, FLIP 84- 48C, FLIP 84- 81C, FLIP 84- 83C, FLIP 84- 87C and FLIP 84- 92C exhibited a rating ranging from 1 and 4. These entries were thus rated as resistant to Ascochyta blight across these loations.

The results of Chickpea International Leaf Miner Nursery (CILMN) were received from nine locations but the leafminer score was reported from Montpellier (France) only. At Montpellier the susceptible repeated check took the rating of 9 (on 1 to 9 scale) and all other entries rated between 2 to 5. The entries with rating 2 included ILC

394, ILC 663, ILC 822, ILC 2250 and ILC 3800 and were comparatively better in resistance to leafminer attack as compared to others. All these resistant sources originated in Iran except ILC 3800 which originated in Mexico.

The data on Chickpea Weed Control Trial (CWCT) reported from ten locations revealed that weeds in chickpea caused a heavy yield loss at almost all the locations. The pre-emergence application of Igran @ 3.0 kg a.i./ha, and Igran @ 3.0 kg a.i./ha + Kerb @ 0.5 kg a.i./ha were effective across locations.

The results of Chickpea Fertility-Evaluation Trial were reported from three locations but only at Kabul (Afghanistan) were the treatment effects significant.

5.4. Identification of Superior Genotypes by the NARS

From the genetic material supplied in the international testing program the national programs released 8 varieties of chickpea, Kyrenia (ILC 464) in Cyprus, Califfo (ILC 72) and Sultano (ILC 3279) in Italy, ILC 195 and ILC 482 in Morocco, Shendi in Sudan, ILC 482 and ILC 3279 in Algeria; and three varieties of lentil, INIAP 406 (FLIP 84- 94L) in Ecuador, Idleb 1 (78S 26002) in Syria, and Firat 87 (75 Kf 36062) in Turkey, for general cultivation during 1987/88. In addition a large number of lines were identified for multilocation testing, on-farm trials or pre-release multiplication.

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6. OROBANCHE STUDIES

Orobanche spp. are important angiospermic parasites affecting the productivity of seed legume crops in several areas in the West Asia and North Africa Region. The incidence of this weed is particularly high in faba bean, lentil, peas, and some forage legumes. Hence studies are conducted towards the development of integrated control of the parasite. The work is carried out in close collaboration with the University of Hohenheim (Prof. Dr. Koch, Dr. Sauerborn) with special funding from GTZ, Federal Republic of Germany.

6.1. Soil Solarization

6.1.1. Effect on Orobanche control and crop yield

For further confirmation of the last two years results and additional detailed information two solarization trials were conducted during 1987/88, one planted with faba bean and the other with lentil. Periods of solarization were 0, 20, 30, 40, and 50 days of covering the soil with polyethylene. Besides crop and parasite development the general weed infestation and the effects on Orobanche seed viability were studied.

The mean daily soil temperatures of the 40 days treatment over 4 years are given in Table 6.1.1 showing that temperature changed from year to year.

The infestation level with Orobanche seed in the experimental plots in 1987/88 in general was extremely high, resulting in an Orobanche dry weight production of nearly 1.5 t/ha in the faba bean

Table 6.1.1. Mean daily maximum temperature of solarized (Polyethylene - covered for 40 days) and uncovered (control) soil at several depths.

Year	Solarization Soil depth (cm)			Control Soil depth (cm)		
	5	10	15	5	10	15
1985	50.8	46.0	40.0	36.5	31.0	29.7
1986	44.6	41.1	41.6	35.7	35.1	30.5
1987	50.3	45.7	41.3	43.4	37.2	33.2
1988	52.5	46.9	44.2	40.2	31.9	28.6

control plots. This provided the opportunity to test the effectivity of solarization, although the high infestation with seed in the alley might have led to some contamination of solarized plots. Number of Orobanche shoots was reduced, in comparision to untreated control, by 87% in faba bean and 94% in lentils with the 50 days treatment, whereas crop seed yield increased from 54 kg to 1610 kg in faba bean and from 45 kg to 1070 kg in lentils (Fig. 6.1.1 to 6.1.4). The higher dry weight production of Orobanche on faba bean can be attributed to the more vigorous growth on this host plant as compared with lentil. No complete control of the parasite was achieved due to high Orobanche seed bank of up to 200 000 Orobanche seeds per m^2. Even with a 95% control of Orobanche seeds in soil in this situation up to 10 000 seeds/m^2 might be present which are sufficient to affect the crop. Another study showed that with more than 45 000 seeds/m^2 no susceptible crops should be planted (see: Orobanche Seed Bank Studies).

Nevertheless, the effect of solarization in reducing the Orobanche seed population should be stressed. This was further confirmed by assessment of the viability of Orobanche seeds burried in the solarized

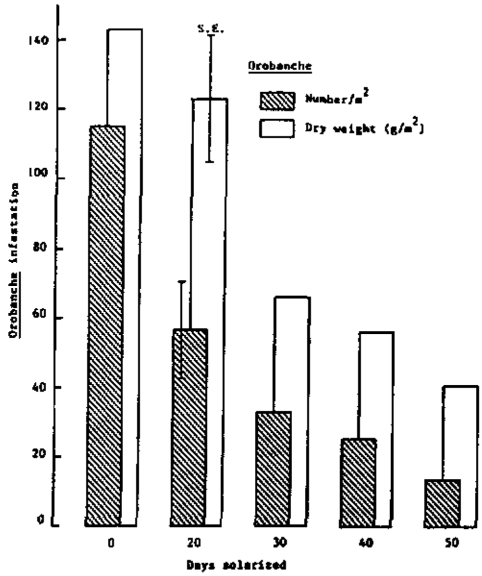

Fig. 6.1.1. Effect of solarization on *Orobanche* infestation in faba bean, Tel Hadya, 1987/88.

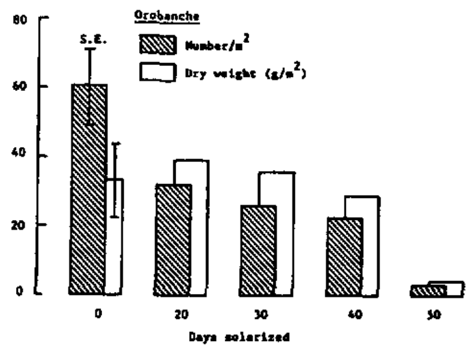

Fig. 6.1.2. Effect of solarization on *Orobanche* infestation in lentil, Tel Hadya, 1987/88.

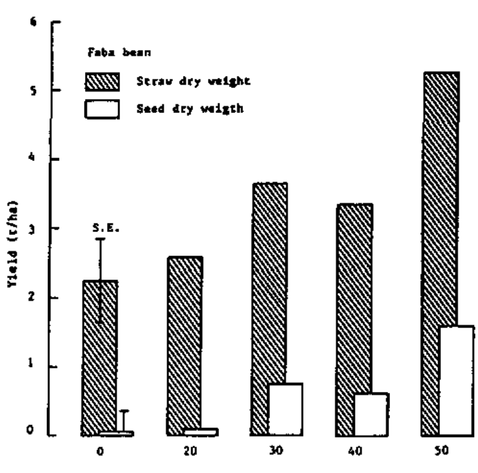

Fig. 6.1.3. Effect of solarization on yield of faba bean (ILB 1814), Tel Hadya, 1987/88.

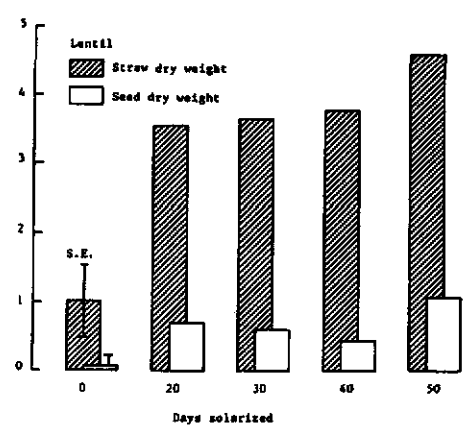

Fig. 6.1.4. Effect of solarization on yield of lentil (ILL 4400), Tel Hadya, 1987/88.

and control plots at different depths (Fig. 6.1.5). Viability was reduced up to 100% in the 5cm top layer of solarized soil whereas seeds burried in deeper soil layers (15cm) still maintained a viability of 10% after 20 days and 1% after 50 days of solarization. However, these seeds had been removed from the soil after the treatments, whereas the seeds naturally remaining in soil might be weakened and affected by microorganisms during the growing season.

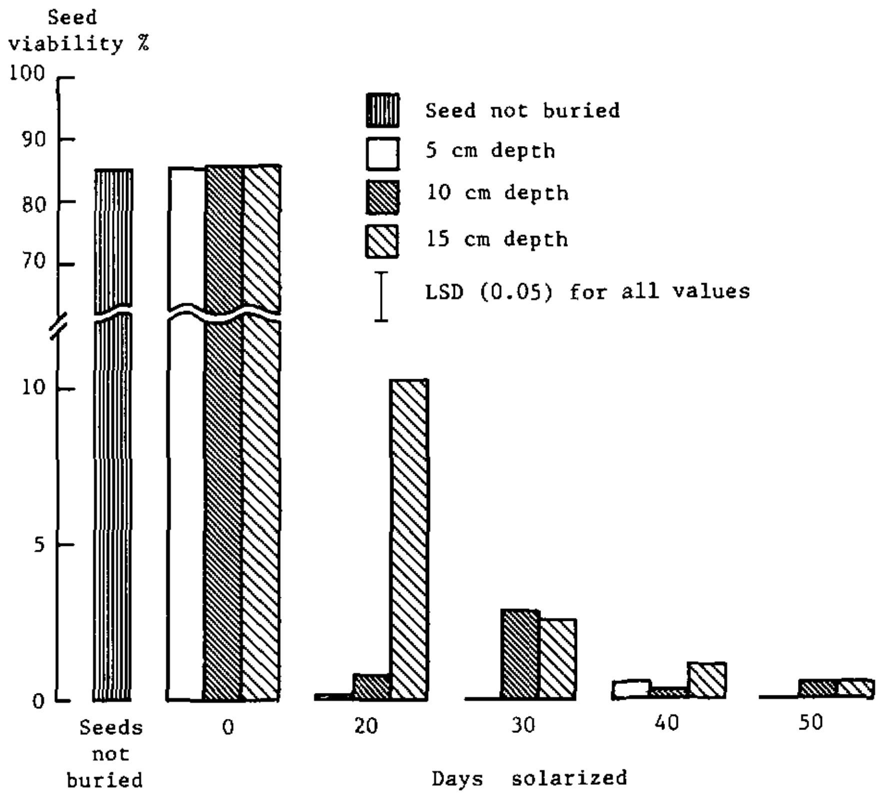

Fig. 6.1.5. Viability of Orobanche crenata seed after various periods of solarization (seeds had been buried at 5, 10, and 15 cm soil depth); mean of 4 x 100 seeds, replicated twice.

6.1.2. Effect of solarization on weeds

Most of the weeds were controlled by solarization. With some species, however, the effect was low or in the case of Muscari racemosum (Liliaceae) even a stimulating effect was observed. No damaging effect of solarization on the bulbs was noticed as bulbs bearing leaves could be found in 25cm as well as in 5cm soil depths. Similar results had been obtained in previous studies on the leguminuous weeds Coronilla scorpioides and Scorpiurus muricatus (ICARDA, Annual Report, 1986). Thus, solarization, has a stimulating effect in some weeds. The dormancy breaking effect of temperature might accrue directly by damaging the hard seed coat in some Fabacea species or indirectly by chemical processes in the bulbs of some Liliacea species.

6.1.3. Residual effect of solarization

Studies on the long term effects of this control measure are necessary to get information on the economics whether the high costs of the method can be compensated by lasting positive results.

Data are now available for residual effect for up to three years of solarizing once (Table 6.1.5). Every year the legume crop was grown in this experiment. The main result is that reduction in Orobanche number and dry weight following 40 days solarization was the same even after 3 years as in the first year. Reduction in the third year due to 40 days solarization amounted to 85% in Orobanche dry weight compared to the control. Differences in Orobanche number and dry weight from year to year and between the fields arise from different sowing dates, climatic factors, and Orobanche seed banks in soil. In the 3rd year,

Table 6.1.5. Residual effect of solarization after the first, second, and third year.

Years after solarization	Crop	Days of solarization in the 1st year	Crop yield t/ha	Total DW of weeds t/ha	Orobanche DW kg/ha	Orobanche no./m2	Coronilla no./m2	Scorpiurus no./m2	Phalaris no./m2
1	lentil	0	0.4	1.2	572	94	5	3	4
		10	0.4	1.0	690	140	16	2	35
		20	1.1	0.2	347	26	31	10	0
		40	1.6	0.1	22	1	19	5	0
S.E. of Mean			0.2	0.1	290	25	4	4	10
2	faba bean	0	1.7	1.5	778	43	41	3	17
		10	1.9	0.9	1088	40	34	4	3
		20	2.6	0.3	344	16	26	3	0
		40	2.9	0.3	90	3	25	2	0
S.E. of Mean			0.2	0.2	159	9	8	2	4
3	lentil	0	1.1	4.3	128	13	76	7	15
		10	1.1	4.5	106	10	69	21	23
		20	1.4	3.7	59	5	76	7	1
		40	1.8	2.9	19	1	59	7	2
S.E. of Mean			0.2	0.5	21	2	14	10	7

crop yield still was significantly higher in solarized plots (40 days) as compared to the control. Furthermore, total dry weight of weeds was also markedly reduced. However, broadleaved weeds (e.g. Carthamus flavescens) reestablished fast and grew abundantly, especially as there was no control by tillage, since cultivation of the plots had been avoided. On the other hand, under continuous cropping of legumes monocotyledonous weeds (Phalaris brachystachys, Sorghum halepense) remained still suppressed three years after solarization.

The population of Rhizobium leguminosarum was not reduced to a critical level affecting its efficacy in nitrogen fixation and had reestablished at the normal level by mid January.

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6.2. Chemical Control of Orobanche spp.

6.2.1. Evaluation of herbicides in legume crops

Two systemic herbicides, glyphosate (Round up) and imazaquin (Scepter), were applied in this study. Glyphosate is a standard herbicide for Orobanche control in faba bean for which it was used as check while in lentil and chickpea it was tested at different rates. Imazaquin was found to be effective on Orobanche during the past two seasons and therefore testing was continued with different rates and timing of application. Compared with glyphosate it was sprayed at a low dosage. Both chemicals were applied once, twice or thrice at different rates with a knapsack sprayer at a volume of 400 l/ha. Each crop received 14 treatments as presented in Fig. 6.2.1.-6.2.4.

Rates of the herbicides were calculated on the basis of the previous years experiments in which the level of infestation of Orobanche seeds in the soil was medium. This season however, a heavy infested field was used resulting in an overall high infestation with Orobanche.

6.2.1.1. Faba bean

Number of above ground Orobanche spikes per ha amounted to 1.58 million/ha in the control. Moreover, infestation with Orobanche was so heavy that only in the glyphosate treated plots faba bean seeds (0.34 t/ha) were harvested (Fig. 6.2.1). Two applications of 80g a.i./ha glyphosate significantly reduced number and dry weight of Orobanche by 92.8 and 87.7%. Split treatments with imazaquin at a total rate of 20g a.i./ha only resulted in a Orobanche reduction of 20 and 41% with best

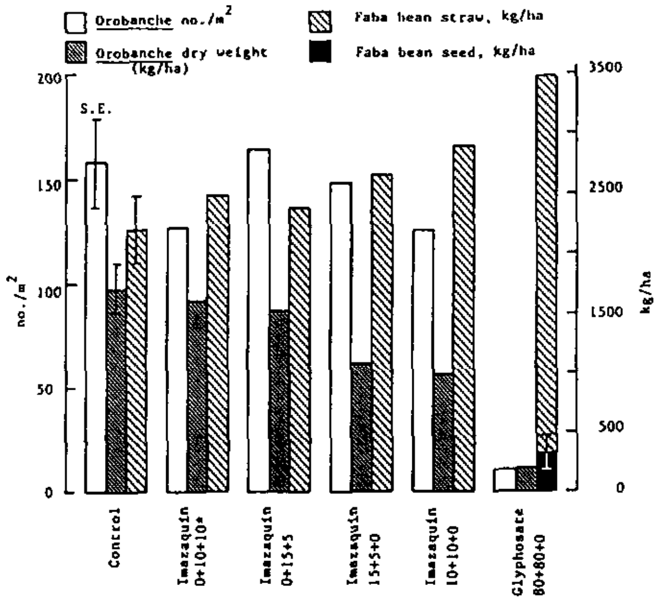

Fig. 6.2.1. Effect of herbicide treatments on Orobanche and faba bean; * 1st spraying at Orobanche tubercle stage, 2nd at bud stage, 3rd 15 days later; dosage in g a.i./ha.

effects occurring when chemical was applied early (at tubercle and bud stage of the parasite). This low effectivity might be due to the high infestation as previous trials with imazaquin on low infested soil had provided up to 100% control of Orobanche. It appears, therefore, that the seed reservoir in soil has to be considered and herbicide rates have to be adjusted to it. These results indicate that at lower infestation levels glyphosate, to avoid phytotoxicity problems can be replaced by imazaquin. At increasing infestation levels however imazaquin becomes less effective than glyphosate. Higher rates of imazaquin still need to be tested under such conditions, especially as no phytotoxicity had been observed from the tested rates.

6.2.1.2. Chickpea

The number of Orobanche spikes per ha in chickpea (0.2 million/ha) was less than in faba bean (1.5 million/ha) or lentil (1.1 and 0.2 million/ha with early and late sown lentil, respectively) and therefore seed yield was not much affected (Fig. 6.2.2.). Due to the low dosages of herbicides differences between treatments were not significant at P=0.05. Nevertheless, reduction in Orobanche number and dry weight with 12.5g a.i. imazaquin/ha was 39 and 43% and with 2 x 30g a.i. glyphosate/ha, 77 and 88% respectively. Yield increase was highest (20%) in the 3 x 10g a.i. glyphosate/ha treatment. With the tested rates of glyphosate no phytotoxicity was found even at the highest rate, while, imazaquin at 12g a.i./ha caused a light chlorosis in chickpea leaves which was detected after the first spray of 7.5g a.i./ha.

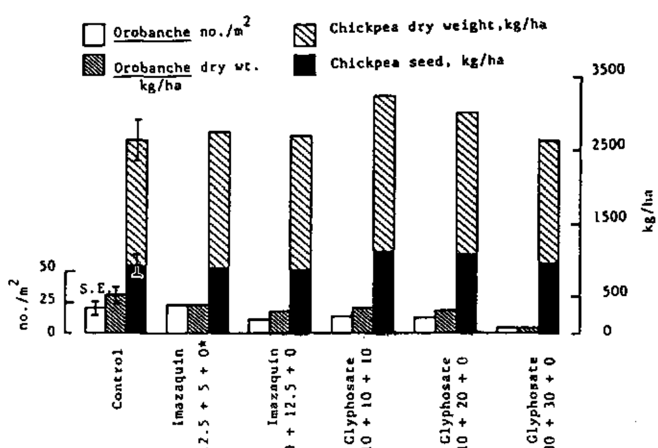

Fig. 6.2.2. Effect of herbicide treatments on Orobanche and chickpea; * 1st spraying at Orobanche tubercle stage, 2nd at bud stage and 3rd 15 days later; dosage in g a.i./ha.

6.2.1.3. Lentil

The herbicides were applied on ILL 4400, planted on Nov. 19, and on ILL 5582 (a cultivar suitable for late planting) sown on Jan. 5. Results showed that both, imazaquin and glyphosate, did not provide effective Orobanche control (Figs. 6.2.3 and 6.2.4). No increase in seed yield and a non-significant increase in straw yield of 13% in early sown lentils with 12.5 + 5g imazaquin/ha only were found. Most of the treatments tended to decrease seed yield. The number of Orobanche however, was reduced significantly by some of the imazaquin rates but only in ILL 4400 planted early. As differences arising from the herbicides were expected to be higher in the later planted genotype and the opposite was the case in this experiment further studies will be necessary to assess the effectivity of herbicides in early planted lentil. Climatic influences might play a role as might time of application. No phytotoxicity was observed in the treatments.

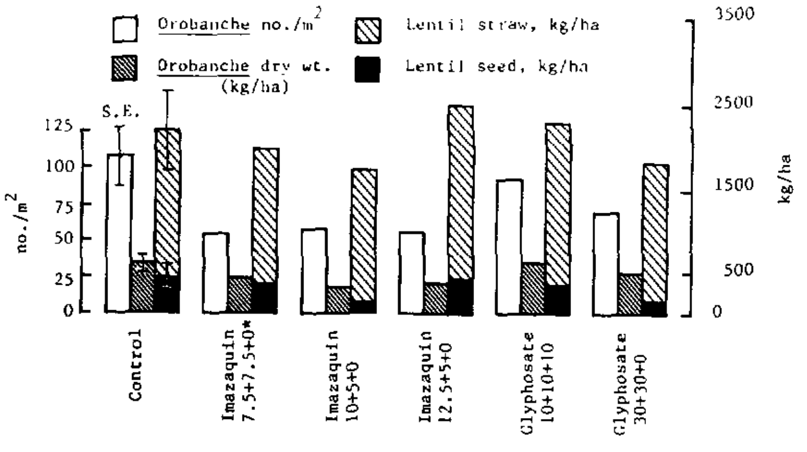

Fig. 6.2.3. Effect of herbicide treatments on Orobanche and lentil (ILL 4400, planted on Nov. 19); * 1st spraying at Orobanche tubercle stage, 2nd at but stage, 3rd 15 days later, dosage in g a.i./ha.

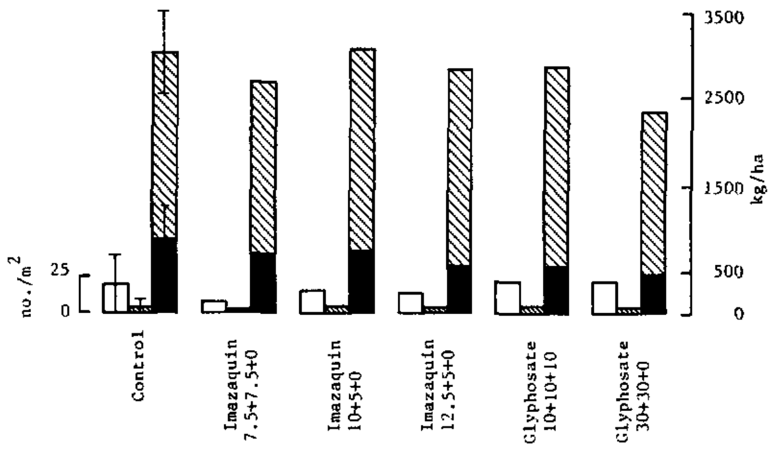

Fig. 6.2.4. Effect of herbicide treatments on Orobanche and lentil (ILL 5582, planted on Jan. 5) (see legend with Fig. 2.3.).

6.2.2. New herbicides for Orobanche control

Additional herbicide formulations of the imidazolinone family were tested in an experiment in lentil and faba bean. Imazaquin without surfactant was tested at two rates (2 x 7.5 and 2 x 10g a.i./ha) as well as imazethapyr with and without surfactant. Dosage in lentil was 70% lower than in faba bean.

No phytotoxicity occured on lentil while in faba bean imazethapyr caused a slight leaf rolling, weak chlorosis and some reddish tips of the youngest leaves. Because of 2 weeks delayed planting of faba bean Orobanche attack was less (Fig. 6.2.5.). Imazaquin without surfactant resulted in high Orobanche control and yield increase. In lentil the effect was less but imazaquin without surfactant as well as imazethapyr were promising and will be studied further.

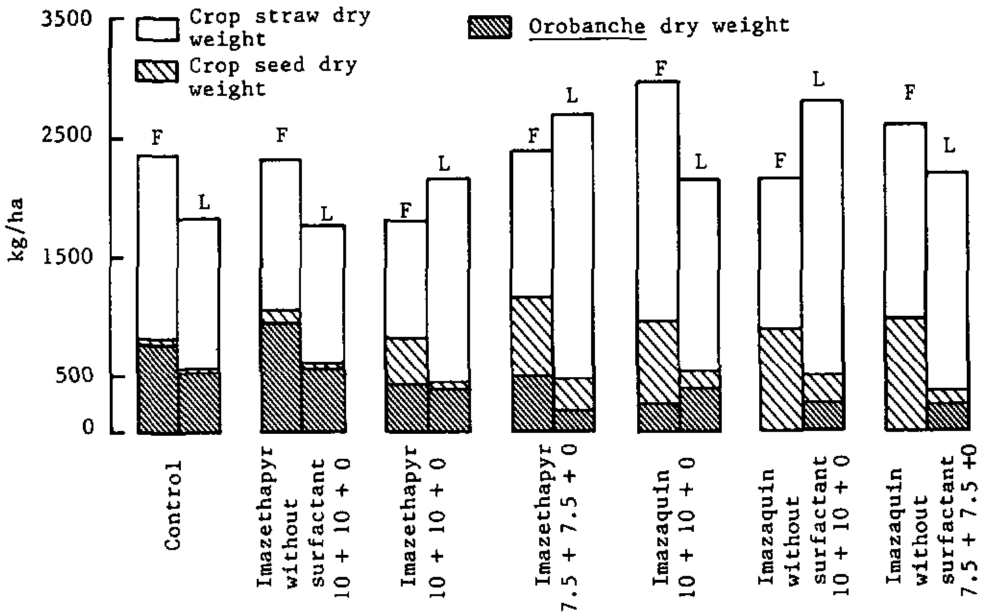

Fig. 6.2.5. Effect of several herbicide formulations on Orobanche in faba bean (F) or lentil (L).

6.2.3. Morphological changes in Orobanche through herbicide applications

In plots treated with imidazolinone compounds the Orobanche spikes differed from normal, as they were elongated and bearing a lower number of flowers and fruit capsules. Capsules, if developed, were reduced in size and the corolla was not or poorly developed. This was found in all trials treated with this compound. The number of abnormal spikes varied with the dosage applied. With solarization, two times application of 10g a.i. imazaquin early compared to late spray increased the proportion of such deformed spikes from 5 to 25% while without solarization percentage increased from 9.3 to 70. Thus, these chemicals do affect Orobanche seed production, even if dry matter production is not much affected.

6.2.4. Tolerance to glyphosate in faba bean, lentil and pea

Tolerance of faba bean, lentil and pea to various rates of glyphosate in the absence of parasite was studied at Terbol to develop better understanding of the threshold values for use when controlling Orobanche. Glyphosate was sprayed at 6 different rates ranging from 0 to 600g a.i./ha and the applications were made once only at one of the 5 different developmental stages of the crops, ranging from vegetative to late podding stage. All the three crops showed higer tolerance to the herbicide than expected (Fig. 6.2.6.). Even 360 and 600g a.i./ha applied in faba bean reduced yield only by 8 and 33%, respectively. Compared with faba bean, peas were more susceptible with 0 and 17% yield reduction at 240 and 360g a.i./ha, respectively. The most susceptible crop was lentil with 11 and 27% reduction in yield at these dosages. It has to be remembered that Terbol has a cooler climate than the low altitude sites and this may reduce the efficacy of the herbicide.

With regard to the different crop stages plants during the early developmental stages were more sensitive to the herbicide (Fig. 6.2.6.). Peas were more sensitive at the vegetative stage, faba bean at flowering, whereas in lentil, no most sensitive stage was identified. Susceptibility to glyphosate therefore is not mainly related to the flower drop as postulated sometimes, but the biomass

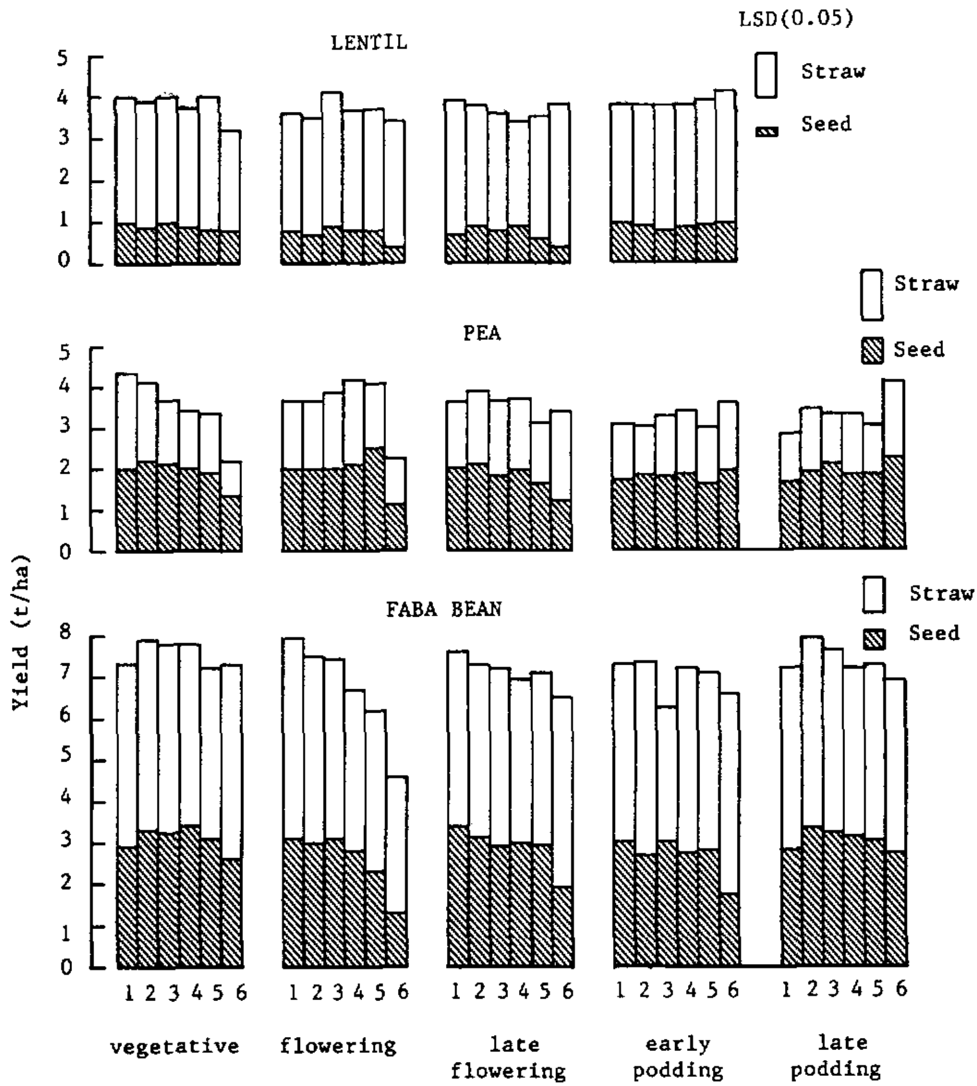

Fig. 6.2.6. Effect of 6 glyphosate treatments at 5 crop stages on yield of lentil, pea and faba bean; 1,2,3,4,5, and 6 refer to 0, 30, 60, 120, 240 and 360g a.i./ha in lentil and peas, but to 0, 60, 120, 240, 360, and 600g a.i./ha in faba bean.

itself is affected by high dosages when applied at critical times. These results will be a basis for the further screening for glyphosate tolerance in the germplasm collection.

6.2.5. Infestation of Orobanche in peas and its control

In previous years at Tel Hadya, peas (Pisum sativum) were heavily infested with Orobanche. Therfore the development of Orobanche in peas was studied and two herbicides tested for its control, glyphosate, which is already reported to be effective in peas although somewhat phytotoxic, and imazaquin. The rates used were 0, 20, 40 and 60 g a.i./ha of glyphosate or 0, 7.5, 10 and 20 g a.i. of imazaquin applied at the tubercle stage of Orobanche development.

Orobanche numbers and dry weight were so high, that no seed yield was obtained, showing the threat of this parasitic weed in pea production. All the tested dosage of herbicide had the same effect but were perhaps still too low to provide effective control of Orobanche under such heavy infestation (Fig. 6.2.7). Glyphosate increased dry weight of peas by 37% and decreased number and dry weight of Orobanche by 26% and 47%, respectively compared to control. Imazaquin increased dry weight of peas by 67% but also increased the number of Orobanche by 29%, while decreasing the Orobanche dry weight by 12%. The results demonstrated that under such high infestation levels higher rates of herbicides should be applied, especially as no phytotoxicity, even with the highest rate, was noticed.

The development of Orobanche seems to be closely related to soil temperature (Fig. 6.2.8.). Weakly mean temperatures below 9°C

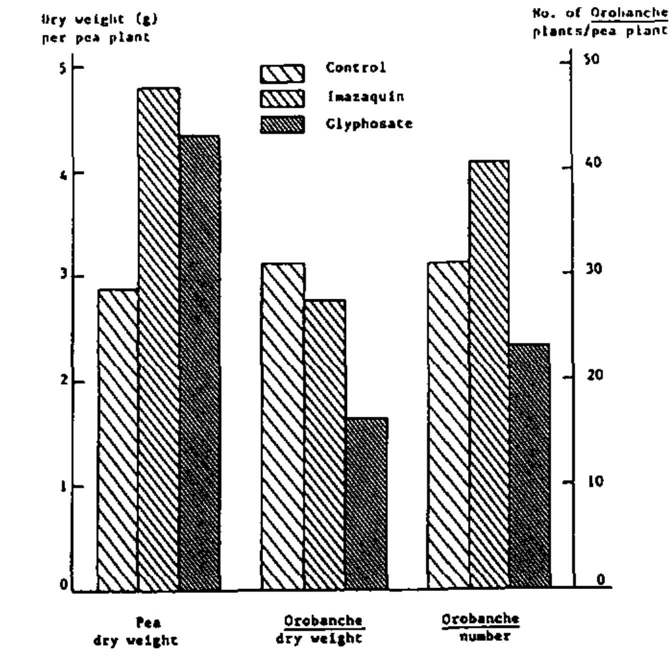

Fig. 6.2.7. Effect of glyphosate and imazaquine on dry weight production of pea (host) and Orobanche (parasite). Data taken at 12.3.1988.

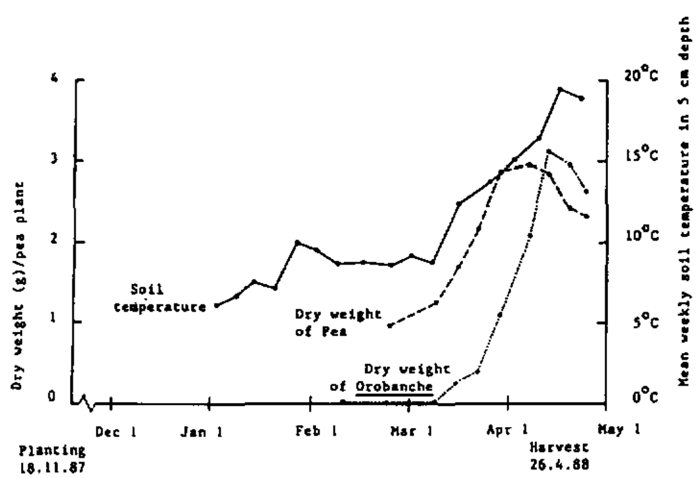

Fig. 6.2.8. Dry matter development of pea and orobanche in relation to soil temperature.

suppressed development of the parasite. With temperatures above 9°C, however, dry weight production of Orobanche started. A similar threshold (8°C) is reported in literature from laboratory experiments on the germination of Orobanche seeds. The host on the other hand is more tolerant to low temperatures with dry matter production starting at temperatures lower than the threshold for Orobanche.

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6.3. Integrated Control of Orobanche

6.3.1. Faba bean - solarization x sowing date x herbicide

At present, the only way to achieve sufficient Orobanche control is by combining several control measures. Solarization for 40 days, delayed sowing by 3 weeks and treatments with imazaquin and glyphosate had already been tested separately in the past at Tel Hadya. They were now combined in one experiment. Glyphosate or imazaquin were sprayed twice (at tubercle stage and bud stage of Orobanche) at rates of 80 + 80 and 10 + 10g a.i./ha, respectively. The field used in this study had heavy Orobanche infestation.

Seed yield without control measures was nearly zero, while Orobanche number and dry weight amounted respectively to 1.79 million/ha and 1796 kg/ha (Fig. 6.3.1.) with a negative correlation between Orobanche and faba bean seed yield. Among the single treatments, solarization was most effective in increasing crop seed yield, which was negligible in the other single measures. Orobanche

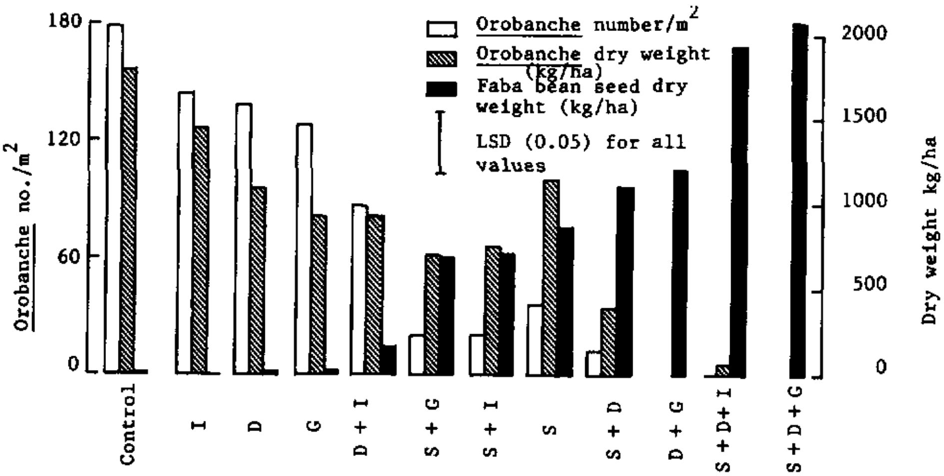

Fig. 6.3.1. Effect of different treatments and their combinations on Orobanche and faba bean. S = solarization, D = delayed sowing, I = imazaquin, G = glyphosate.

was decreased by all the treatments. The combination of solarization plus delayed sowing plus glyphosate resulted in the highest crop yield (2.1 t/ha) and a 100% control of Orobanche. The combination of delayed sowing plus glyphosate was effective in controlling the Orobanche whereas delayed sowing plus imazaquin was poor. Only in combination with solarization plus delayed sowing did imazaquin increase yield significantly, and reached at par with glyphosate.

An economic evaluation of this experiment revealed that the combination of delayed sowing plus glyphosate was most economical. But solarization as a third component increased yield by 0.85 t/ha and a residual effect on yield increase of about 40% and 30% in the second and third year is to be expected. Nevertheless, with price for the plastic being above US$ 500/ha the application of solarization in faba bean will not be an economical preposition for commercial use.

6.3.2. Lentil - genotype x date of sowing

The use of delayed planting as a means to avoid heavy Orobanche attack has been demonstrated earlier and is known to farmers. Greatly delayed planting *per se*, however, reduces seed yield. In order to avoid this yield decrease and to test different herbicides an experiment was conducted using two lentil genotypes, Syrian Local (ILL 4400), planted at the normal time and an early maturing genotype, Idleb 1 (adapted to late sowing) planted at Jan. 5, and herbicide treatments (14) in a split-plot design.

Under the high Orobanche infestation highly significant differences between the two genotypes/dates were found with a 3.6 fold higher dry weight of Orobanche and a 2.7 fold lower lentil seed yield in ILL 4400/normal date than in Idleb 1/late date (Fig. 6.3.2.). The use of Idleb 1 therefore has to be recommended in combination with late sowing as an effective control measure for Orobanche under heavy infestation. Differences between herbicide treatments were low and none of them increased seed yield of lentil significantly above the control. For further details on herbicide treatments see section 6.2.1.

6.3.3. Lentil - combination of sowing date and solarization for cultivar ILL 4400

Both methods, delayed sowing and solarization, reduced the number and dry weight of Orobanche significantly. However, with solarization the effect was more dramatic. Delayed sowing alone reduced the number of Orobanche per area by 81%, solarization alone by 91% (Fig. 6.3.3.). The combination resulted in a 99.4% decrease in number of Orobanche and

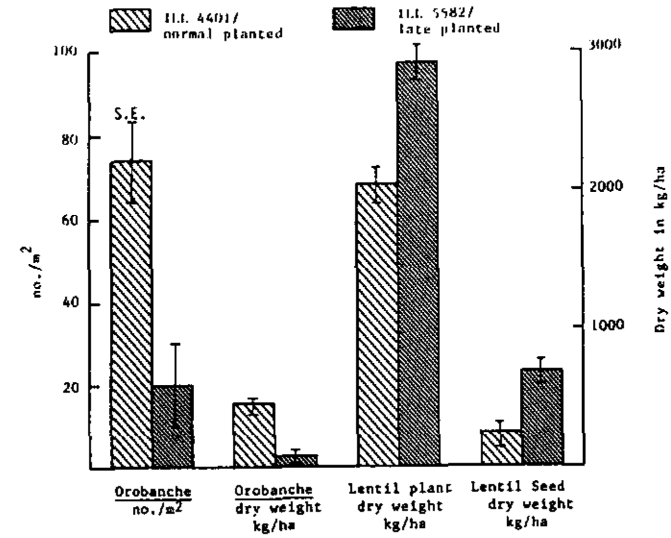

Fig. 6.3.2. Effect of genotype/sowing date on <u>Orobanche</u> and lentil.

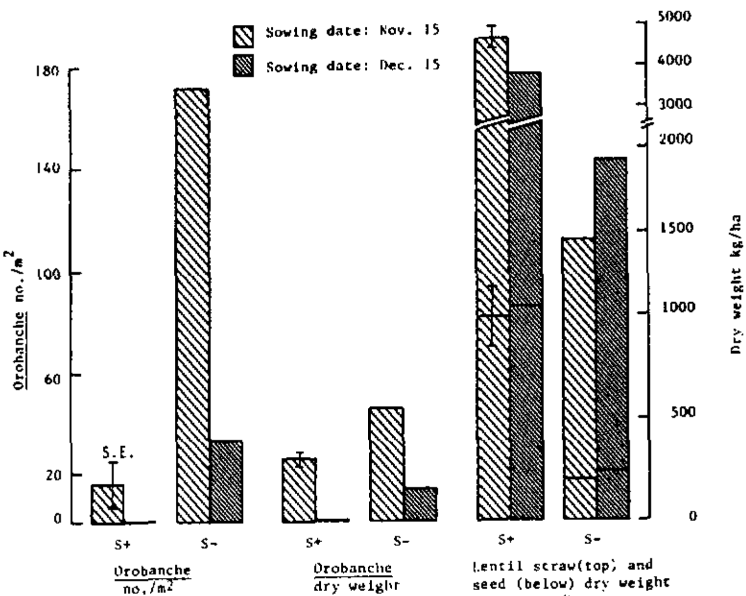

Fig. 6.3.3. Effect of sowing date and solarization on Orobanche and lentil (S+ = solarization for 40 days, S- = without solarization).

in 95.8% of Orobanche dry weight. Lentil seed yield increased with delayed sowing by 19%, with solarization by 376%, and through combination of both methods by 403%.

The effect of the late planting was positive but not as pronounced as in Idleb 1 in the other experiment (section 6.3.2.). In combination with solarization however, late planting would not be advantageous since the infestation of Orobanche is already reduced to a minimum. As shown in Fig. 6.3.3 lentil biomass with solarization plus early planting in fact is significantly higher than with the late planting date. Therefore, with solarization an early planting is preferred.

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6.4. Biological Control

Phytomyza orobanchia Kalt. (Agromyzidae) is reported from eastern Europe to be an agent for biological control of Orobanche. This fly is monophagous and its larvae feed in the stem as well as in the fruit capsules of the parasite. As no reports on the occurrence of the insect in Syria were available a survey was started to assess occurrence and, if the insect is present, also its distribution in the country. A preliminary assessment of the fly's effectivity was also done. The survey covered 31 faba bean fields of which 21 were found to be infested with Orobanche crenata (Tab. 6.4.1.). These fields were examined for the insect and in 95% of the fields Phytomyza was present. Infestation of fields ranged from 0 to 96.7% with a mean of 55.5% over all locations. Of all the examined capsules 32.3% were found to be parasitized (range:0 - 70%). With a reduction of seeds per capsule by

90% a total effectivity of 29% destruction of Orobanche seed from Phytomyza under natural conditions was found.

During this survey Phytomyza was found parasitizing on Orobanche aegyptiaca, too. In addition, 5.9% of the capsules of O. crenata were affected by other organisms, mainly fungi. Samples of them were collected for further evaluation, i.e. purification and isolation.

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Table 6.4.1. Infestation (%) with Phytomyza orobanchia at different locations in Syria.

No.	Location	Infestation of Orobanche plants	Infestation of Orobanche capsules	Orobanche attack on faba bean
1	Tel Hadya, ICARDA farm (B7)	46.7	21.1	xxx
2	4 km s-e of AL-Bab	73.3	32.2	xx
3	7 km n-e of Al-Bab	83.3	47.8	x
4	10 km n-w of Al-Bab	96.7	68.9	xxx
5	25 km n of Al-Bab, near Turkey	43.3	23.3	x
6	15 km n-e of Mare	30.0	14.4	xxx
7	2 km e of Mare	23.3	8.9	x
8	5 km w of Mare	46.6	25.5	xx
9	5 km w of Tel Rifaat	0.0	0.0	x
10	10 km s of Tel Hadya	40.0	18.9	x
11	2 km s of Jisr-Al-Shogur	60.0	30.0	xx
12	25 km n-e of Lattakia	93.0	68.9	xx
13	Jableh, ICARDA - Station	78.4	41.7	xxx
14	15 km w of Apamea	63.3	38.9	xx
15	10 km n of Banias	60.0	26.7	xxx
16	10 km n of Tartous	93.3	68.9	xx
17	20 km s-e of Tartous	70.0	36.7	xx
18	10 km w of Homs	90.0	70.0	x
19	5 km s-e of Homs	20.0	8.9	x
20	20 km n of Hama	4.9	1.6	x
21	5 km n of Saraqueb	50.0	25.5	x

s = south; e = east; n = north; w = west
x = Low attack; xxx = High attack

6.5. Studies on *Orobanche* Seed Bank in Soil

6.5.1. Estimation of the *Orobanche* seed

For many studies information on the magnitude of the *Orobanche* seed bank in soil would be helpful, e.g. in the evaluation of control measures as well as in the prediction of a possible attack on a crop. A method for the extraction of *Orobanche* seeds from soil had been developed at ICARDA previously which now was used to determine the number of soil samples necessary for a reliable evaluation.

It was found that the *Orobanche* seed density varies greatly but aggregation is not limited to few spots in the field, (Fig. 6.5.1.). By the evaluation of 3 x 60 single samples, each batch deriving from an area of 64m x 130m, it could be demonstrated that at least 800 single soil samples per ha are necessary for a report with 70% precision. For reliable surveys of the seed bank for field experiments bulked samples of at least 2 samples/m^2 will be necessary.

In addition to this, the vertical distribution of *Orobanche* seeds was studied. Highest percentage of *Orobanche* seeds was present in the top most soil layer and it decreased with increasing depth (Fig. 6.5.2.). The upper 30cm of the soil contained 78% of the total amount of seeds but seeds were found upto 90cm depth. This is of importance with regard to the effect of deep ploughing.

6.5.2. Effect of *Orobanche* seed densities in the soil on crop yield

With information on the *Orobanche* seed density in soil being scanty little is known about the critical level of *Orobanche* infestation in the soil. A pot experiment therefore was conducted for two years.

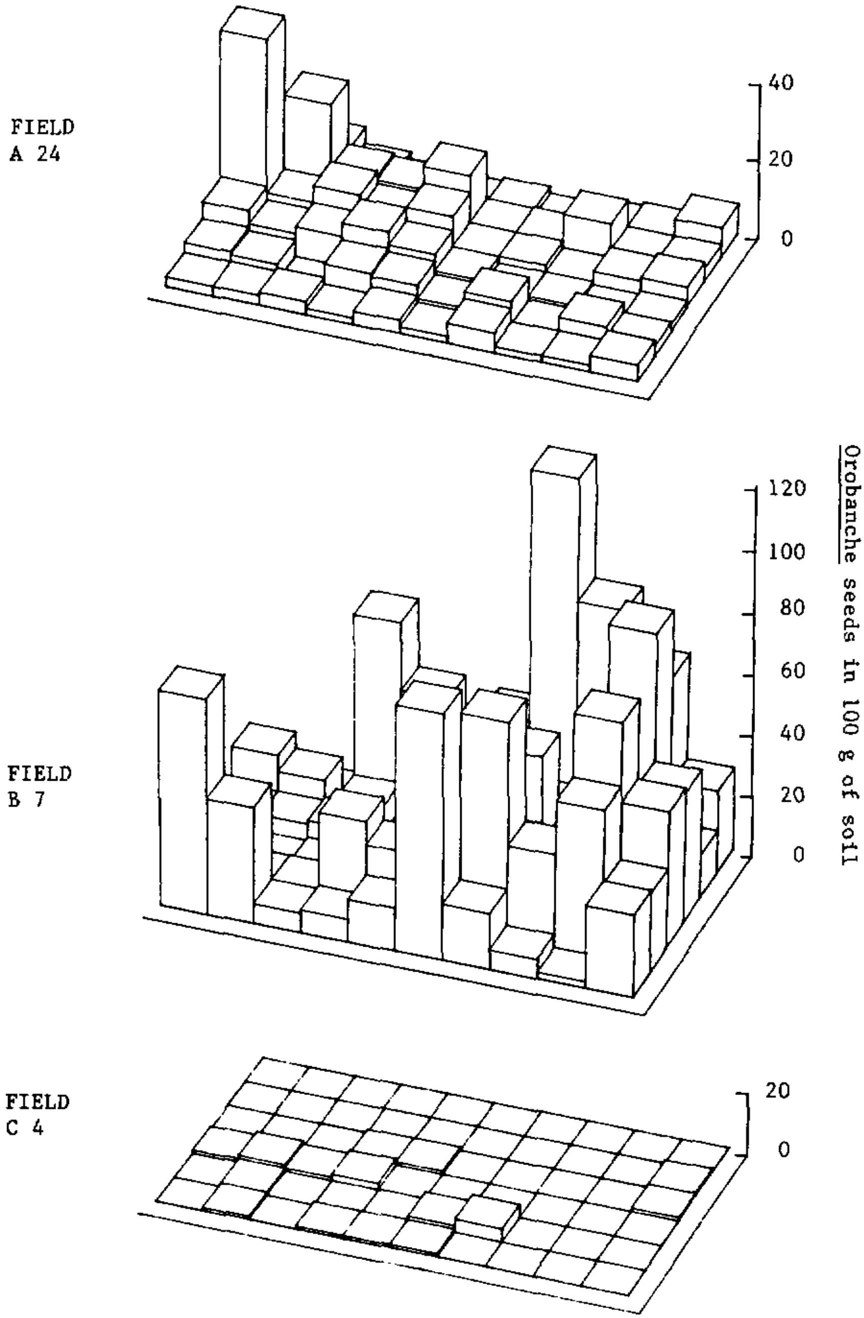

Figure 6.5.1. Distribution of *Orobanche* seed in sections of 3 fields at Tel Hadya. Each section is 54 m x 130 m, representing 60 single samples. Multiplication of *Orobanche* seed numbers by factor 1793 gives the number of seeds/m^2 up to 15 cm soil depth.

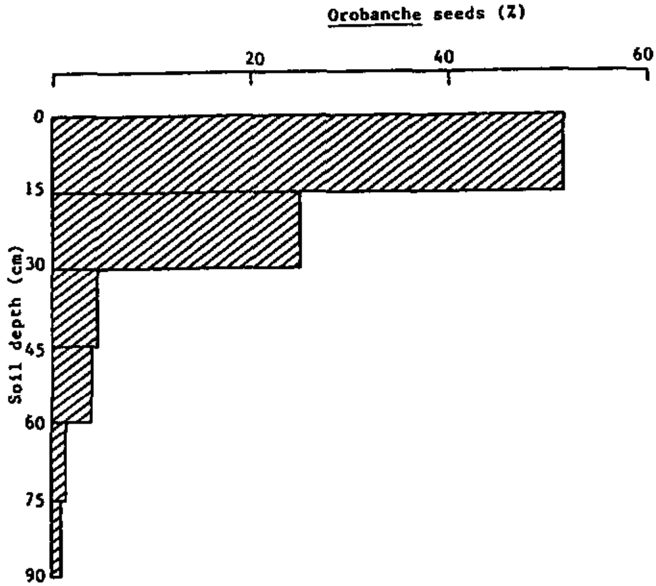

Fig. 6.5.2. Orobanche seeds (%) at various depths of the soil - Tel Hadya, 1986/87.

Pots with different Orobanche seed loads mixed in 8 kg of soil were embedded in the field and planted with faba bean in 10 replications for each seed rate.

Although the crop yield in the second year was lower due to a slightly later planting the behaviour of crop and parasite parameters followed the same pattern as in the first year (Fig. 6.5.3.). As a mean over both experiments with less than 30,000 Orobanche seeds/m^2 no reduction in faba bean yield occurs. With about 100,000 seeds/m^2 however, seed yield dropped to 50%. Therefore, 30,000 seeds/m^2 can be taken as a threshold above which the crop yield is affected. However, the date of sowing could be a factor that may affect this threshold.

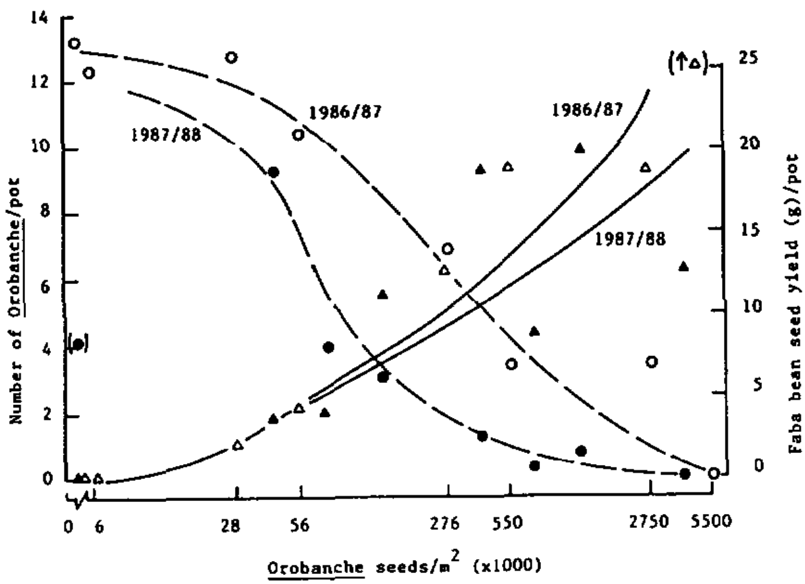

Fig. 6.5.3. Effect of Orobanche seed density in soil on Orobanche infestation and seed yield of faba bean; results from two years (●, O seed yield; ▲,△ Orobanche shoots).

6.5.3. Effect of different crops on the Orobanche seed bank

The effect of 10 different crops and fallow on the build up of Orobanche seeds in soil was evaluated. Soil samples were taken before sowing of the crops and before maturity of newly produced Orobanche seed in spring. None of the crops was found to reduce the Orobanche seed bank significantly (Tab. 6.5.1.). On average, seed reduction after the six month-cropping season amounted to 6.5%, only. With the production of newly produced Orobanche seeds however, there was an enormous increase of the seed bank in plots sown with susceptible crops. For example, with Vicia narbonensis, highly affected by the parasite, Orobanche shoots produced about 17 millions of new seed per m^2.

Table 6.5.1. Effect of different crops on the Orobanche seed bank in the field: Calculated no. of Orobanche seeds/m^2.

Crop	Before planting	Before Orobanche maturity	After Orobanche maturity
Barley	98400	54000	58841*
Fallow with weeding	87600	61800	61800
Vicia dasycarpa	114000	64800	96478
Coriander	96600	114000	114000
Flax	118800	121800	121800
Cumin	125400	78000	129142
Chickpea	60000	63000	1783507
Pea	91200	113400	7317173
Vicia narbonensis	111600	110400	17602832
Lentil	168000	160200	31785531
Faba bean	148800	200400	32528599**
Total	1220400	1141800	91541000
Mean	110945	103800	8317927
%	100	93.5	7497

* Orobanche on weeds
** Late planted faba bean

Results in Table 6.5.1. indicate that in just one season the effect of a crop on seed bank reduction by stimulating seed germination seems to be low. But the effect of different crops on the increase of the seed bank by sustaining Orobanche shoots is tremendous. It becomes clear that more care should be given to avoid Orobanche seed production in fields. Thus, it is of practical importance to use one of the low Orobanche seed producing crops and to avoid those that are highly susceptible.

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6.6. Study on Genetic Diversity in Orobanche

A high degree of genetic variability within a species, expressed as different genotypes, races, strains or pathotypes, would present further constraints in screening for Orobanche resistant crop genotypes. Therefore, it is important to know the extent of variability naturally present in the parasite. The natural occurrence of different phenotypes of O. crenata in one field supports the hypothesis that there should be large variability present.

The differences in protein pattern as detected by electrophoresis can be used to distinguish between species, which sometimes are difficult to be differentiated based on morphological traits (e.g. in the case of O. aegyptiaca and O. ramosa). In the present study selected Orobanche spikes representing different phenotypes of one species were investigated. Fig. 6.6.1 shows that most of the O. crenata plants share the same SDS-protein pattern. Similarly no differences could be noticed among the O. aegyptiaca plants even when they were derived from different hosts. However, clear difference was present between the two species of Orobanche.

Further tests will be necessary to assess differences within the O. crenata population on a larger number of samples from different origins. Analysis of seeds should be included as more consistent results can be expected from them as compared to fresh plant material.

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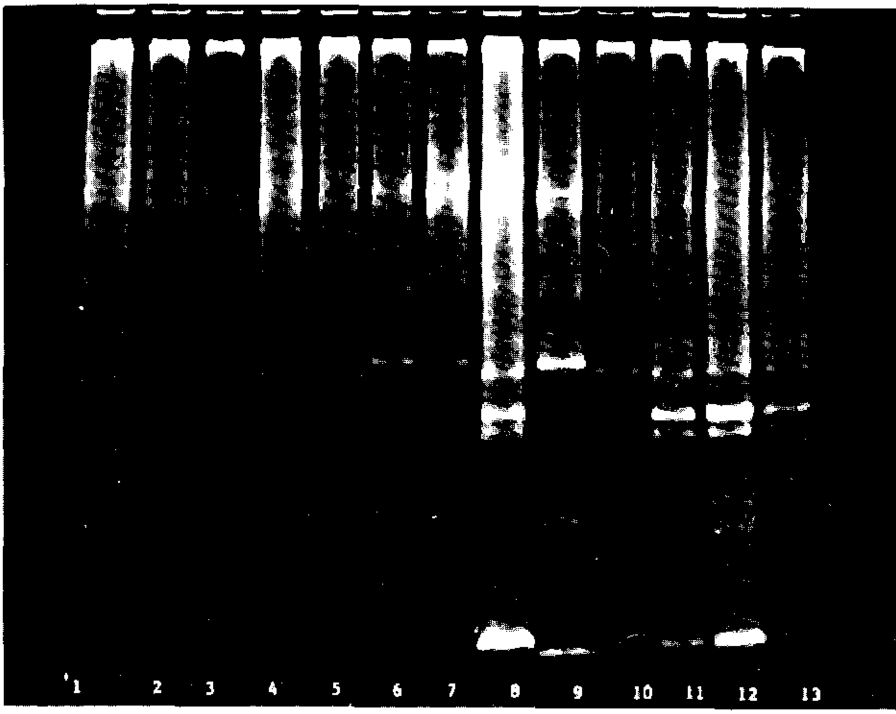

Fig. 6.6.1. Protein band pattern following SDS-electrophoresis on 13 *Orobanche* plants: Nos 1-7 and 9 represent *O. crenata*, nos 8 and 10-13 are from *O. aegyptiaca*.

7. COLLABORATIVE PROJECTS

7.1. Nile Valley Project

The 1987/88 season was the third and last year of the third phase of this special project on faba bean which covered Egypt, Sudan and Ethiopia. This year, research work had, as usual, a heavy "on-farm" emphasis with a porportion of resources and efforts devoted to the back-up research. In Ethiopia, a pilot production/demonstration program was conducted for the second year. In the three Nile Valley countries, the project was marked by increased interaction between project scientists and extension workers in providing support to production programs. On-farm and back-up research results for the 1987-1988 crop season from Egypt, Sudan and Ethiopia were presented and discussed in 10 sessions at the IX NVP Annual Coordination Meeting held in Cairo, Egypt, from 19 to 22 September, 1988. The major project highlights of research are described here.

7.1.1. Program in Egypt

7.1.1.1. Pilot Demonstration Plots in El-Minia and Fayoum

As last year, the extension specialists and village agents of the Agricultural Development Project in the two governorates were trained by subject matter specialists of the NVP in the conduct of the pilot demonstration program.

The recommended production package included four main factors, i.e. use of Orobanche tolerant faba bean cultivar Giza 402, recommended seed rate (184.5 kg seed/ha), N and P fertilizer application (35.7 kg N

+ 71.4 kg P_2O_5/ha) and weed control (hand weeding or pre-emergence application of 'Topogard' at 3.57 kg/ha). Other practices recommended included sowing in early November, Orobanche control with Glyphosate, aphid control with Pirimor and frequent irrigation during flowering. Demonstration farmers in the two governorates were provided certified seed of Giza 402, N and P fertilizers and Pirimor aphidicide on credit through village cooperatives.

In El-Minia the demonstration plots (45), selected by the extension agents, occupied 276.6 ha involving 87 farmers. The demonstration plot area ranged from 2.1 to 2.9 ha belonging to 1-6 farmers (Table 7.1.1). A sample of 45 demonstration farmers along with an equal number of outside demonstration farmers were surveyed for comparative faba bean production, cost and benefit. At harvest, five random plots of 20-25 m^2 each were harvested for yield estimates in each of the 90 demonstration and outside demonstration fields. Yield estimates of demonstration farmers fields as compared to those outside the demonstation showed an average increase of 600 kg/ha (21.3%) in seed yield and 730 kg/ha (11.7%) in straw yield. The average profitability (net benefit as a % of total cost) was 325 and 220% respectively, for the 'demonstration' and 'outside demonstration' farmers in the nine districts (Table 7.1.2). In Fayoum nine villages in four districts were chosen to demonstrate the improved production package to farmers. Eighteen demonstration plots (plot size ranged from 0.5 to 2 ha) along with an equal number of outside demonstration fields were selected by the extension agents. As an average over all demonstration plots in Fayuom Governorate, the test package increased seed yield by 550 kg/ha (21.2%) and straw by 540 kg/ha (9.4%). The profitability of the recommended package was 126% as against 85% for the traditional practices (Table 7.1.3).

Table 7.1.1. Number and area of demonstration plots in El-Minia Governorate, Egypt, 1988.

District	Number of* demonstrations	Number of farmers	Area (ha)
Edwa	5	7	22.7
Maghagha	5	19	34.5
Bani-Mazar	5	6	37.8
Matay	5	9	27.8
Samallot	5	5	23.2
Minia	5	5	32.8
Abo-Korkas	5	5	36.1
Mallawy	5	12	31.9
Dir-Mawas	5	19	29.8
Total	45	87	276.6

One demonstration plot per village.

Table 7.1.2. Average seed and straw yields (t/ha) and economic evaluation of in- and out-of-demonstration farmers in El-Minia Governorate, Egypt, 1988.

	In demonst.		Out demonst.		Difference	
	Mean	S.D.	Mean	S.D.	Mean	%
Yield (t/ha)[1]:						
Seed	3.42	0.88	2.82	0.93	0.60	21.3
Straw	6.95	1.64	6.22	1.72	0.73	11.7
Economic Evaluation:						
Total variable costs (LE/ha)[2]	523		582		-59	
Net benefit (LE/ha)	1698		1280		418	
Profitability (%)	325		220		105	

1 = Seed price (LE/t) 483.9
Straw price (LE/t) 80.0
2 = Do not include land rent.

Table 7.1.3. Average seed and straw yields (t/ha) and economic evaluation of in- and out-of-demonstration farmers in Fayoum Governorate, Egypt, 1988.

	In demonst.		Out demonst.		Difference	
	Mean	S.D.	Mean	S.D.	Mean	%
Yield (t/ha)*:						
Seed	3.14	0.65	2.59	0.53	0.55	21.2
Straw	6.27	0.95	5.73	0.64	0.54	9.4
Economic Evaluation:						
Total variable costs (LE/ha)**	895		908		-13	
Net benefit (LE/ha)	1131		773		358	
Profitability (%)	126		85		41	

* Seed price (LE/t) 516.9
Straw price (LE/t) 60.0
** Include land rent.

7.1.1.2. Pilot Demonstration Plots in Behaira Governorate

Based on the results of the improved package tested in the adjacent Kafr El-Sheikh governorate in the first and second phases of the NVP, and also on the results of the on-farm research carried out in 1986/87 season in Behaira governorate, a research-extension program for faba bean improvement was initiated and conducted in Behaira in 1987/88 season. As in Minia and Fayoum governorates, the extension specialists and village agents in Behaira were trained by subject matter specialists of the NVP.

The recommended package included five main factors, i.e. use of faba bean cultivar Giza 3, recommended seed rate (184.5 kg seed/ha), N and P fertilizer application (35.7 kg N + 71.4 kg P_2O_5/ha), weed control (either by pre-emergence application of 'Topogard' at 2.95 kg a.i./ha or by hand weeding) and disease control with Diathane M45.

Other practices recommended included sowing around mid November and frequent irrigation during flowering and pod setting.

Ten demonstration plots of approximately 1.5 ha each along with the same number of outside demonstration fields were selected by the extension agents in four villages in two districts, Itai El-Barood and El-Delingat. However, data were recorded only on seven plots, while the other three plots were discarded due to high infestation with Orobanche. Three random samples 25 m^2 each were taken to estimate seed and straw yields in each of the 14 in and out of demonstration plots by the NVP specialists and extension staff. In general, the mean seed yields of faba bean this season was lower than usual because of the severe attack with foliage diseases especially chocolate spot. Yield estimates of demonstration fields showed an average increase of 1070 kg/ha (98.3%) in seed yield and 270 kg/ha (27.8%) in straw yield with improved package (Table 7.1.4). The profitability of the recommended package was 76% as against 10% for the traditional practices.

Table 7.1.4. Average seed and straw yields (t/ha) and economic evaluation of in- and out-of-demonstration farmers in Behaira Governorate, Egypt, 1988.

	In demonst.		Out demonst.		Difference	
	Mean	S.D.	Mean	S.D.	Mean	%
Yield (t/ha)*:						
Seed	2.39	0.54	1.32	0.62	1.07	98.3
Straw	3.08	0.62	2.81	1.15	0.27	27.8
Economic Evaluation:						
Total variable costs (LE/ha)	700		640		60	
Net benefit (LE/ha)	534		59		475	
Profitability (%)	76		10		66	

* Seed price (LE/t) 484.0
Straw price (LE/t) 25.0

7.1.1.3. Impact of the NVP research-extension program on faba bean improvement in El-Minia, Fayoum and Behaira governorates

In an attempt to study the adoption rate of the recommended package among farmers in- and out- of demonstration fields, before and after the operation of the NVP research and extension program, a sample of 45, 36 and 14 demonstration farmers along with an equal number of outside demonstration farmers were surveyed in El-Minia, Fayoum and Behaira Governorates, respectively. Investigation was conducted through personal interviews using a pretested questionnaire covering social aspects, role of extension, size of holding, cultural practices, costs and farmers problems and constraints. Result of this survey in El-Minia governorate is presented in Table 7.1.5. It is clear that there was improvement in the adoption of components of the production package by the farmers both in and out of demonstration program following advice from the agents.

Table 7.1.5. Adoption rates of recommended and practices among farmers in- and out-of-demonstration plots before and after the research extension program on faba bean in El-Minia Governorate, Egypt.

	In demonstration								Out demonstration			
	1986/87				1987/88				1987/88			
	Traditional		Advised		Traditional		Advised		Traditional		Advised	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1. Variety	35	39	55	61	6	7	84	93	19	12	71	79
2. Seed rate	61	68	29	32	21	23	69	77	31	34	59	66
3. Land preparation	72	80	18	20	62	69	28	31	65	72	25	28
4. Sowing method	42	47	48	53	27	30	63	70	32	36	58	64
5. Plant density	79	88	11	12	33	37	57	63	51	57	39	43
6. Fertilizer	79	88	11	12	43	48	47	52	55	61	35	39
7. Weed control	80	89	10	11	42	47	48	53	61	68	29	32
8. Insect control	81	90	9	10	39	43	51	57	42	47	48	53

7.1.1.4. Pilot demonstration of *Orobanche* control in El-Minia governorate

In 1987/88 season, 8 demonstration plots of 1.25 to 2.0 ha each in five districts in El- Minia were conducted by NVP scientists in fields naturally infested with *Orobanche*. The recommended package for parasite control included use of the parasite tolerant cultivar Giza 402 and application of glyphosate (Lancer at 179 cm^3 in 500 l water per hectar) at flower initiation and repeated 15 days later. Optimum levels of N and P fertilizers (37.5 kg N + 71.4 kg P_2O_5/ha) and seed rate (184.5 kg seed/ha) were used. The demonstration farmers were provided the seed of the cultivar Giza 402 and fertilizers through the village cooperatives. They were also provided the glyphosate and Knap-sack sprayers by the extension agents in the villages and farmers sprayed the herbicides in the presence of NVP scientists and extension agents. For comparison, a naturally infested field in the immediate neighbourhood was selected as outside demonstration farm. The control package gave positive and consistent seed yield increases ranging from 0.48 t/ha (23.8%) to 2.54 t/ha (184.1%) with an average of 1.56 t/ha (98.7%), over the farmers practices. The average increase in straw yield was 59.7% (Table 7.1.6). The recommended package reduced the number and dry weight of *Orobanche* by 67.6% and 70.2%, respectively. The profitability of this package was 307% against 142% for traditional practice.

On the average of the three seasons, 1986, 1987, 1988, results from 21 demonstration fields in El-Minia governorate indicated high efficiency of the package in reducing *Orobanche* infestation (Fig. 7.1.1) and increasing faba bean production and farmers profitability (Fig 7.1.2).

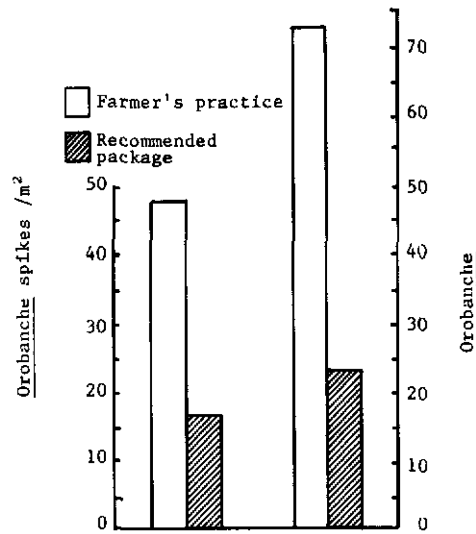

Figure 7.1.1. Effect of Orobanche control package on number and weight of Orobanche spikes; mean data from pilot production plots at 21 sites in El-Minia, Egypt, 1986, 1987, 1988.

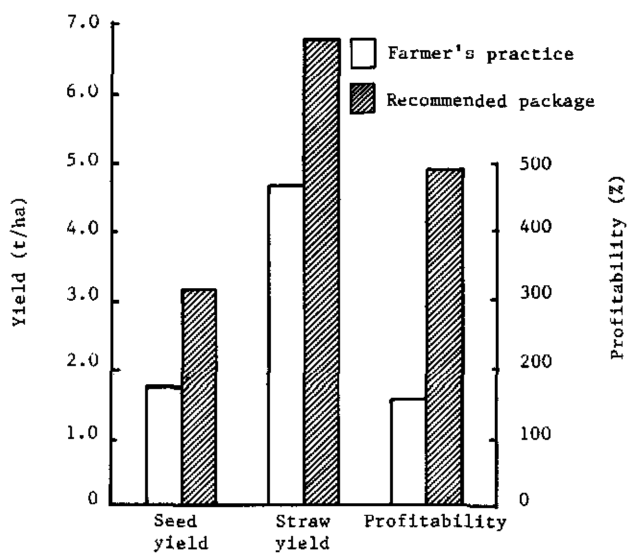

Figure 7.1.2. Effect of Orobanche control package on seed and straw yield and profitability of faba bean production; mean data from 21 pilot production plot sites in El-Minia, Egypt, 1986, 1987, 1988.

Table 7.1.6. Average seed and straw yields (t/ha) and economic evaluation of in- and out-of-demonstration plots for Orobanche control package in El-Minia Governorate, Egypt, 1988.

	In demonst.		Out demonst.		Difference	
	Mean	S.D.	Mean	S.D.	Mean	%
Yield (t/ha):						
Seed	3.15	0.68	1.59	0.33	1.56	98.7
Straw	8.29	1.75	5.19	1.09	3.10	59.7
Orobanche:						
No. of spikes/m^2	27.4	10.6	84.5	25.6	-75.1	67.6
Dry weight (g/m^2)	24.6	13.4	82.6	37.1	-58.0	70.2
Economic Evaluation:						
Total variable costs (LE/ha)	538		490		48	
Net benefit (LE/ha)	1650		695		955	
Profitability (%)	307		142		165	

7.1.1.5. Pilot Demonstration of Orobanche Control in Fayoum governorate

Three demonstration trials of 1.5 ha each in two districts in Fayoum governorate were conducted by NVP researchers in fields naturally infested with Orobanche. The factors of the recommended package were the same as in El-Minia. For comparison a naturally infested neighbouring field was selected as outside demonstration farm at each site. The control package gave positive and consistent seed yield increases ranging from 1.33 t/ha (153.6%) to 1.8 t/ha (245.3%) with an average of 1.55 t/ha (194.0%). The average increase in straw yield was 41% over the farmers traditional practice. The recommended package reduced dry weight of Orobanche by 82.2%. The profitability of the recommended package was 130% as against 13% for the traditional practices. (Table 7.1.7).

Table 7.1.7. Average seed and straw yields (t/ha) and economic evaluation of in- and out-of-demonstration plots for *Orobanche* control package in Fayoum Governorate, Egypt, 1988.

	In demonst.	Out demonst.	Difference
Yield (t/ha):			
Seed	2.35	0.80	1.55
Straw	3.15	2.23	0.92
Orobanche:			
Dry weight (g/m^2)	19.5	109.7	90.2
Economic Evaluation:			
Total variable costs (LE/ha)	611	632	21
Net benefit (LE/ha)	792	81	711
Profitability (%)	130	13	117

7.1.1.6. Researcher-managed on-farm trials on land preparation and methods of sowing under different tillage systems in El-Minia governorate

In 1987/88 season, nine researcher-managed on-farm trials in three districts in El-Minia were conducted to test different land preparation and sowing methods in farmers's fields with the objective of reducing cost and maximising profits. The following treatments were tested:

1. Chisel ploughing twice + seed broadcast + ridging by chisel plough to cover the seed (common farmers method).

2. Chisel ploughing three times + ridging + planting three rows per ridge (common farmers method).

3. Rotavator hoeing to 5 cm depth + seed broadcast + rotavator hoeing to 3 cm to cover the seed (test method).

4. Planting on the old ridges of the preceding summer crop in single-seeded hills, 15 cm apart on three-row ridges (recommended method for zero tillage).

Over all sites, the broadcast hoeing method (3) and hill sowing on old ridges method (4) resulted in better emergence. Heavy seed cover in broadcast/two ploughing method (1) and poor physical condition of land in three ploughings method (2) led to poor emergence. Average seed and straw yields and profitability of the two sowing methods, hill sowing on old ridges (4) and broadcast sowing with two hoeings(3), were higher compared with the traditional methods (Table 7.1.8).

Table 7.1.8. Average seed and straw yields (t/ha), net benefit (LE/ha) and profitability (%) of different sowing methods in El-Minia, Egypt, 1988.

	Sowing method			
	Broadcast/ 2 ploughings	Hills on ridges/ 3 ploughings	Broadcast/ 2 hoeings	Hills/ old ridges
Yield (t/ha)*:				
Seed	3.05	3.87	4.61	4.76
Straw	6.91	7.34	7.72	8.36
Economic Evaluation:				
Total variable costs (LE/ha)	666	728	660	687
Net benefit (LE/ha)	1323	1709	2183	2272
Profitability (%)	199	235	331	331

* Seed price (LE/t) 516.12
Straw price (LE/t) 60.00

On the average of the three seasons 1986, 1987 and 1988, results from 16 researcher-managed on-farm trials in three districts in El-Minia Governorate showed that the sowing method 'hills/old ridges' followed by 'broadcast/two hoeings method' gave higher seed and straw yields and profitability compared with the traditional sowing methods (Fig. 7.1.3).

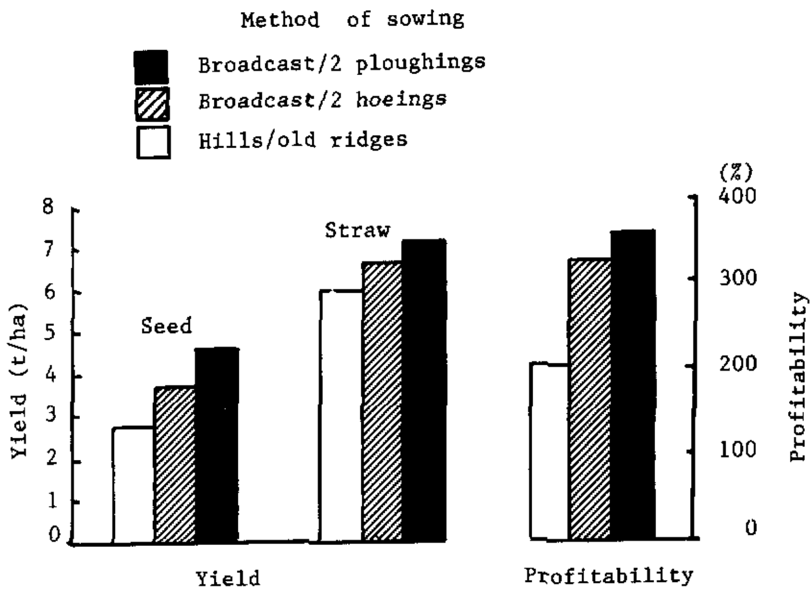

Figure 7.1.3. Effect of different sowing methods on seed and straw yield and profitability; mean of 16 sites of researcher managed on-farm trials in El-Minia, Egypt during 1986, 1987 and 1988.

7.1.1.7. Researcher-managed on-farm trials on sowing methods under zero, minimum and full tillage systems after rice in Behaira governorate

Three on-farm trials were conducted in two districts in Behaira Governorate to test the following sowing methods:

1. Broadcasting seed on flat untilled soil + rotavator hoeing to cover the seed (test method).

2. Chisel ploughing twice + seed broadcast + ploughing again and leveling to cover the seed (farmers' method).
3. Planting in hills-using small manual hoe on dry flat untilled soil (farmers' method).

Broadcast/hoeing method (1) resulted in better emergence and higher plant population and out-yielded the chisel ploughing/broadcast method. Although the no-till hill planting method (3) ranked first in seed yield, the broadcast/rotavator method had the highest profitability compared with farmers methods (Table 7.1.9).

Table 7.1.9. Average seed and straw yields (t/ha), net benefit (LE/ha) and profitability (%) of different sowing methods in Behaira, Egypt, 1988.

	Sowing method		
	Broadcast/ rotavator	Chisel ploughing/ broadcast	No till/planting in hills
Yield (t/ha):			
Seed	2.44	2.12	2.81
Straw	2.80	2.00	2.00
Economic Evaluation:			
Total variable costs (LE/ha)	699	717	801
Net benefit (LE/ha)	552	359	609
Profitability (%)	79	50	76

7.1.1.8. Researcher-managed on-farm trials on sowing dates of faba bean in Fayoum governorate

Two on-farm trials were conducted in two districts in Fayoum Governorate to study the effect of sowing date on faba bean production. The sowing dates tested at both sites were: 1st October, 15th Oct., 1st

Nov. and 15th Nov. At both sites a significant reduction of a mean of 1.21 t/ha in seed and 1.65 t/ha in straw yield was observed when the crop was sown late in mid-November as compared with mid-October (Table 7.1.10). Thus, the optimum sowing date of the faba bean cultivar Giza 402 in Fayoum governorate would be the first half of October.

Table 7.1.10. Effect of sowing dates on seed and straw yields (t/ha) in Fayoum, 1988.

Sowing date	Itsa		Sannoris		Mean	
	Seed	Straw	Seed	Straw	Seed	Straw
1st Oct.	2.21	4.91	3.22	6.88	2.72	5.59
15th Oct.	2.59	5.12	2.82	6.42	2.71	5.77
1st Nov.	2.45	4.43	2.68	4.84	2.57	4.67
15th Nov.	1.53	3.42	1.51	4.83	1.50	4.12
L.S.D. (P= 0.05)						
Sowing dates	0.26	0.82	0.64	2.03	0.31	0.98
C.V. (%)	12.6	17.7	6.0	9.2	10.4	15.2

7.1.1.9. Back-up research

Research was conducted on crop agronomy, genetic improvement, pathology, entomology, microbiology, Orobanche and weed control, soil fertility and plant nutrition, mechanization and nutritional quality. Results are reported in the Proceedings of the IX Annual Coordination Meeting held in Cairo, 19-22 Sept., 1988. Only a few major findings are presented here.

The breeding program in Egypt was carried out at four main research stations, Giza, Sakha, Nubaria and Sids, in addition to two sub-stations, Gimmeza and Shandaweel. These stations covered all the three agro-ecological regions: North Delta, and Middle and Upper Egypt. Results from the last three years (1985-1987) indicated that three lines derived from a cross between ILB 938 and Giza 3 were significantly less infected with chocolate spot, rust and Alternaria leaf spots than Giza 3. On the average over the three years, these three lines 461/845/83, 461/847B/83 and 461/841/83 in addition to line 461/837/83 gave 21.4%, 16.9%, 12.0% and 1.7% higher seed yield than the commercial cultivar Giza 3. To maintain their genetic purity and start a program for seed multiplication single plant progeny rows were grown at Sakha Research Station in 1987/1988 season. Selection was practiced between progenies. Single plant selection was also practiced within each selected progeny and remaining plants were harvested and bulked. In 1992 these lines could be grown on 60 to 100 ha each for seed multiplication and for wider testing before release. In other studies promising lines resistant to chocolate spot, rust, aphids and Orobanche, and lines with high yield potential were identified through evaluation of different local and exotic breeding material.

In an Orobanche chemical control study at Giza in a soil naturally infested with Orobanche seeds, Imazaquin (Scepter = AC252, 214, 18%, liquid), as foliar post-emergence application of two sequential sprays (at 22.5 g/ha a.i. in 500 l water/ha) proved better control than glyphosate.

National scientists in the Agricultural Research Center, Giza, Egypt in collaboration with staff of extension department and production projects in El-Minia and Fayoum.

7.1.2. Program in Sudan

7.1.2.1. Pilot production/demonstration program in Saiyal Agricultural Scheme, Northern Region

On-farm research conducted through the Nile Valley Project since 1979 showed that the productivity of faba bean in the northern region of the Sudan (traditional faba bean growing area) could be raised greatly by the adoption of a simple improved production package. In the 1987-88 cropping season, the Government of UK gave financial support to a pilot production/demonstration program in Saiyal Agricultural Scheme to extend research findings to farmers on a large scale. An improved package of management consisting of early planting, frequent irrigation and pest control was applied in the whole faba bean area in Saiyal scheme and compared with farmers' practices in the neighbouring scheme of Kali. The demonstration plots occupied 421.5 ha involving 552 participating farmers in three sections of the scheme. A total of 100 farmers in Kali scheme with faba bean acreage of 80.9 ha were taken for comparison (Table 7.1.11). Yield estimates of demonstration plots in Saiyal scheme as compared to those in Kali scheme showed an average increase in seed yield of 1411 kg/ha (178.9%).

7.1.2.2. Pilot production/demonstration program in El-Basabeir-Hagar El-Asal area

A pilot production/demonstration program was run in El-Basabeir-Hajar El-Asal area in the southern part of the Nile Province of Sudan to compare an improved production package consisting of early planting, frequent irrigation, and pest control with farmers' practices. Eleven production plots were chosen to represent the different pump-schemes lying between El-Basabeir and Hagar El-Asal. The size of the individual plots ranged from 2.1 to 8.6 ha with a total of 41.9 ha. Neighbouring farms were used for comparison. Demonstration plots were sown in the end of October to early November, given a mean number of 8.4 irrigations and two pesticide sprays. The neighbouring plots were sown mostly in 2nd or 3rd week of November, given 5.6 irrigations and nearly no insecticide was used.

Table 7.1.11. Input of variable factors and average grain yield (t/ha) of the pilot production/demonstration plots in Saiyal scheme and neighbouring fields in Kali scheme, Sudan, 1988.

	No.of farmers	Total area (ha)	Range of sowing dates	Pest control	Av. no. of irrigations	Seed yield (t/ha)
Saiyal scheme, in demonst.	522	421.5	25 Oct.- 15 Nov.	+	6.2	2.200
Kali scheme, out demonst.	100	80.9	15 Nov.- 30 Nov.	-	4.5	0.789
Difference						1.411
% difference						179

The effect of the package on grain yield was highly significant (Table 7.1.12), recording yield increase over the neighbouring fields ranging from 0.4 to 1.7 t/ha with an average of 0.7 t/ha (49% increase). Economic evaluation indicated that use of the package was profitable with an average increase in net benefits of LS 1975/ha over farmers practices.

Table 7.1.12. Average grain yield (t/ha) and economics of pilot production/demonstration plots and neighbouring farms in *El-Basabeir-Hajar El-Asal area, Sudan, 1988.*

Plot No.	Production/ demonstration plots		Neighbouring farms		Yield increase over neighbouring farms	
	Total area (ha)	Average yield (t/ha)	Total area (ha)	Average yield (t/ha)	(t/ha)	(%)
1	2.1	2.5	1.9	1.1	1.4	125
2	8.6	2.1	4.9	1.4	0.6	44
3	3.9	2.0	1.7	1.4	0.6	45
4	2.1	2.1	1.3	2.0	0.1	6
5	2.5	2.1	3.1	1.5	0.6	41
6	3.1	2.8	2.3	1.0	1.7	167
7	3.3	2.8	2.5	1.6	1.1	69
8	3.6	1.9	3.0	1.5	0.4	28
9	3.8	1.9	0.6	1.5	0.4	26
10	4.4	1.8	3.0	1.5	0.4	24
11	4.4	1.8	3.4	1.4	0.4	34
	41.8		27.7			
Mean	3.8	2.2	2.5	1.4	0.7	49
Gross benefit(LS/ha)	5950		3975			
Variable cost(LS/ha)	2041		2041			
Net benefit(LS/ha)	3909		1934			
Profitability (%)	192		96			

7.1.2.3. Pilot production/demonstration plots in the new areas in Sudan.

A high potential of faba bean cultivation in the new areas had been well demonstrated over a 5-year period in the yield maximization trials and pilot production/demonstration plots conducted at Gezira, Rahad and New Halfa schemes. In continuation of these efforts to extend faba bean cultivation to the new areas 84 farmers in Gezira, 10 in Rahad and 12 in New Halfa were assisted to grow the crop each in an area of about one feddan (0.42 ha) following the production package developed in the NVP at the Gezira Research Station, Wad Medani. The average yield for 84 plots in the Gezira scheme was 1.9 t/ha with an average net return of Sudanese Pound 3117/ha (Table 7.1.13). In New Halfa the net returns were smaller because of lower yields than in the Gezira scheme. At Rahad, where 10 farmers participated, average yield was only 967 kg/ha (range 394 to 1870 kg/ha) because six of the farmers had poor crop management and got an average yield of 622 kg/ha only, while the other four farmers who could follow the recommendations fully got an average yield of 1484 kg/ha.

Table 7.1.13. Average seed yield (kg/ha), gross and net returns (LS/ha) and profitability (%) of pilot production/demonstration plots in the Gezira and New Halfa schemes in Sudan, 1988.

	Gezira scheme				New
	Southern group	Central group	Northern group	Average	Halfa
Number of plots	10	38	36		12
Average yield (kg/ha)	2300	1900	1533	1911	1100
Gross returns (LS/ha)	6280	5489	3830	5200	3148
Total variable costs (LS/ha)	2196	2231	1822	2083	2138
Net return (LS/ha)	4084	3258	2008	3117	1010
Profitability (%)	186	146	110	147	47

7.2.1.4. Economics of faba bean production in the new areas in Sudan

To predict the impacts of widespread introduction of faba bean cropping among the small tenancies in Gezira scheme, and to provide both quantitative and qualitative information which will be of use to crop researchers, policy makers and extension leaders in optimizing the speed, direction and balance of their efforts towards improving the Gezira rotation, and increasing income of farmers with the introduction of faba bean in the cropping system this study was undertaken in 1988. The farming and household in Gezira scheme were analysed and sampled faba bean retailers and consumers in some towns of Gezira and Khartoum provinces were interviewed. Investigation of farmers' business was conducted through a personal interview using a pretested questionnaire. A total of 120 farmers were interviewed, 80 of them were farmers not growing faba beans, while the rest were from those who participated in the pilot production/demonstration plots during the 1987/88 season.

The preliminary results indicated the profitability of faba bean over all crops grown by tenants in Gezira scheme (cotton, sorghum, wheat, and groundnuts). All farmers interviewed, expressed their willingness to grow faba beans and assessed most of the cultural practices to be easy to carry out and/or to be same as for other crops currently grown. Insects and diseases of faba bean were common problems faced by farmers in Gezira scheme. The majority of farmers did not face problems in marketing their produce, however, few faced this problem due to the inferior grain quality. The small size faba bean has the highest demand compared to the medium and large seed types. Before buying the produce, the retailers test the crop by cooking it at home. All retailers sold the Gezira produced faba bean (BF 2/2) at the same price as the small size grain varieties (Agabat) produced in the traditional areas. Due to the fact that Gezira produced faba bean is harvested 10-15 days before that of the traditional areas, and need shorter time and less efforts to be transported to local markets in central Sudan, it could always be marketed during the period of high demand thus giving additional economic advantage to the farmers.

7.1.2.5. Back-up research

Back-up research covering different disciplines was carried out with particular emphasis on faba bean improvement for new areas (south of Khartoum). Progress was made in identifying superior genotypes, irrigation practices, insect-control, weed control, biological nitrogen fixation and seed quality. Virus problems were also investigated.

Seeds of five newly developed genotypes namely 00104, 00482, 00634, 00648 and 00654 were purified under bee-proof cages for further multiplication and eventual release to the farmers. A reasonable amount of seeds is now available for multiplication in isolation plots next season. These genotypes were tested for four years (1983-1986) in different yield trials and proved their superiority over the local cultivars Hudeiba 72 and BF2/2.

7.1.3. Program in Ethiopia

7.1.3.1. Pilot production/demonstration plots in the central and north-west zones

Pilot production/demonstration program on the recommended package of faba bean was conducted in the red and black soil areas of the central and northwest zones of Ethiopia. The sites were selected by the extension agents. A training program on the improved package was arranged for the extension agents at Holetta Agricultural Research Center. Later, at their respective sites, they provided training to

Table 7.1.14. Grain yield (kg/ha) of faba bean grown with improved and farmers' methods in red and black soils, Ethiopia, 1987.

Demonstration site	Altitudes (m)	No.of farmers	Total area (ha)	Grain yield (kg/ha)			
				Improved package	Farmers' practice	Difference (Kg/ha)	(%)
Red soils:							
Central zone:							
Wolmera-Goro	2400	1	1.0	2110	1220	890	73
Wolmera-Chocke	2400	1	1.0	2190	1390	800	58
Sademo	2400	7	3.5	2460	1170	1290	110
Telecho	2500	5	2.5	1360	770	590	77
Wajetu	2350	1	1.0	2670	800	1870	234
Meta-Robi	2600	2	2.0	1900	900	1000	111
Hamus Gebeya	2250	1	1.0	1230	370	860	232
Ambo	1900	1	1.0	1800	1000	800	80
Northwest zone:							
Debre Tabor	2680	2	2.0	1650	1000	650	65
Mota	2450	3	3.0	940	730	210	29
Debat	2600	2	2.0	1810	950	860	91
Hossana	2580	4	2.0	1950	1200	750	63
Degem	2800	2	1.0	1450	900	550	61
Mean				1810	950	860	99
LSD (P=0.05)				246			
CV (%)				20			
Black soils:							
Goha-Tsion	2500	2	2.0	850	650	200	31
Deneba	2680	2	2.0	600	400	200	50
Inewari	2650	2	2.0	850	500	350	70
Denbi	2210	1	1.0	490	430	60	14
Bichena	2450	2	2.0	420	350	70	20
Mean				640	460	180	37
LSD (P=0.05)				147			
CV (%)				15			

farmers on the objectives of the demonstration fields. The altitudes of the demonstration sites ranged from 1900 to 2680 m and rainfall from 900 to 1200 mm. The recommended package of management consisted of use of the improved varieties (CS 20 DK in high elevation sites and NC 58 at intermediate elevation sites), higher seed rate (200 kg/ha),

Table 7.1.15. Grain yields (kg/ha) of faba bean grown with improved and farmers' methods at 10 sites of the intermediate altitudes of the Central zone of Ethiopia, 1987.

Demonstration site	Altitudes (m)	No.of farmers	Total area (ha)	Grain yield (kg/ha)			
				Improved package	Farmers' practice	Difference (Kg/ha)	Difference (%)
Godino	2200	1	0.5	1070	170	900	529
Ketaba	2200	1	0.5	1000	680	320	47
Chalo	1800	1	0.5	2400	1200	1200	100
Ejere 1	2050	1	0.5	860	640	220	34
Ejere 2	2050	1	0.5	900	820	80	10
Lemmi	2200	1	0.5	300	200	100	50
Dukem	2000	1	0.5	320	220	100	46
Dukem (Wajetu)	2000	1	0.5	200	100	100	100
Ensellale 1	1760	1	0.5	1270	1040	230	22
Ensellale 2	1760	1	0.5	1350	900	450	50
Mean				970	600	370	99
LSD (P=0.05)				274			
CV (%)				35			

Table 7.1.16. Partial budget analysis of the effect of the recommended package of faba bean production in red soil areas, Ethiopia, 1987.

	Improved package	Farmers' practice	Difference
Average grain yield (kg/ha)	1810	950	860
Gross return			
AMC price (Birr/ha)	579	305	274
LM price (Birr/ha)	1176	620	556
Total variable costs (Birr/ha)	340	130	210
Net benefits			
AMC price (Birr/ha)	239	175	64
LM price (Birr/ha)	836	490	346

fertilizer application (100 kg DAP/ha) and weeding twice. At all the sites, the recommended package gave significantly higher yields than the farmers' practice. Grain yield advantages from the application of the improved package were 860, 180 and 370 kg/ha in the red, black soils (Table 7.1.14) and intermediate altitudes (Table 7.1.15), respectively. Grain yields in vertisols and intermediate altitudes were lower compared with those in red soils due to waterlogging and severe black root-rot in the black soils and low rainfall in the intermediate altitudes.

Economic evaluation of the demonstration plots in the red soils showed that the improved package was very profitable and resulted in an average increase in net benefits of 64 and 346 Ethiopian Birr/ha over the farmers practices with the Agricultural Marketing Corporation (AMC) and local market (LM) prices, respectively (Table 7.1.16). However, in the black soil and intermediate altitudes the grain yields obtained were not economical. Therefore, faba bean research should focus on developing varieties and management practices suitable for vertisols.

7.1.3.2. *Rate of adoption of the recommended package by farmers*

Observations on the adoption rate of the improved package of faba bean production by farmers were made in 1987 in some demonstration areas of 1986. It was found that in the red soil areas farmers quickly adopted improved variety CS 20DK for cultivation with recommended seed rate (200 kg/ha) and half the recommended rate of fertilizer (50 kg DAP/ha). However, none of them were found to weed the crop at the critical stage of weed competition. They only weeded once late in the season to remove the main weeds, which were generally fed to cattle. This is partly due to the fact that farmers during this time are busy in seeding tef and other crops, and also partly because they feel weeds cause little damage to crop yields.

7.1.3.3. Diagnostic survey in three major faba bean producing districts in the northern Shewa Administrative Region

A diagnostic survey was conducted in three major faba bean growing districts of northern Shewa to identify major faba bean production constraints. Shewa has the largest area under faba bean. The three districts (two in Menagesha and one in Tequlet-Bulga zone) were selected since faba bean is one of the major crops and they have special production problems because of soil conditions and rainfall.

The altitude of the survey area ranged from 2550 to 2650 m with mostly flat topography. Soils in the area were mostly vertisols or vertic in nature. The rainy season extends from April to September and the mean annual rainfall ranges from 800-1000 mm.

A total of 23 farmers were interviewed using a non-formal questionnaire (to put the farmers at ease). In addition, heads of the extension agents for each districts were interviewed to confirm the reliability of the data. Data collected from the survey showed that faba bean is the second most important crop following wheat in Inewari area and third in Sendafa and Aleltu area preceded by wheat and tef. With respect to management, frequent land ploughing (2-3 times) and weeding is common. Farmers also expressed their desires to apply fertilizer if available in enough quantities. The demand for the seeds of improved varieties is high although they are not available. The production pattern in the study areas is changing, mainly due to pests and diseases in faba bean. Major problems of faba bean production are pod borer, black root-rot and aphids. Aphid damage on faba bean depends on the amount of rainfall during the growing season. Some farmers in Sendafa and Aleltu areas stopped growing faba bean for four years due to pod borer and root-rot problems. Some farmers in Inewari area also reported complete failure of faba bean crop due to pod borer and aphids last season. As a result chickpea, lentil and roughpea (Lathyrus sativus) are substituting faba bean in the rotation. Therefore, the faba bean improvement team of IAR needs to investigate the disease and pest problems of faba bean to alleviate these problems in near future.

7.1.3.4. Evaluation of faba bean production package on farmers' fields in the central and south-eastern highlands of Ethiopia

In the past, the Highlands Pulses Improvement Project identified several superior varieties of faba bean and some improved cultural practices for these varieties. However, this technology generated by the researcher was not tested for its validity on farmers' fields. Thus, a program to test a package of production of faba bean on farmers' fields was initiated in 1985 crop season to study the role of the components or the complete package in increasing the productivity of faba bean. From the results of 1985 and 1986 crop seasons it was found that the use of improved variety, fertilizer, hand weeding, and early sowing are the most important factors for increasing the productivity. The objective of the 1987 season trials was to further evaluate these production factors on farmers' fields.

The on-farm trials were conducted at five sites each in Menagesha (Holetta) and Selale zones, and seven sites in Yerer-Kereyu (Ada) zone of the Shewa administrative region. These were also for the first time conducted at three sites in Chilalo zone of the Arsi administrative region. In Yerer-Kereyu and Menagesha zones the cultivars NC 58 and CS 20DK were used, respectively, with three test factors namely, time of sowing, weeding and fertilizer. In Chilalo zone variety was added as the fourth test factor. In Selale zone the test factors were date of sowing, variety and weed control with a blanket application of 100 kg diammonium phosphate per ha except at one site, Sefani, where fertilizer was used as a test factor instead of sowing date. Of the four zones where faba bean on-farm trials were carried out, highest mean grain yield of 1398 kg/ha was obtained from Chilalo (Arsi) followed by 1217 kg/ha from Menagesha (Holetta) (Table 7.1.17). The overall mean grain yield was low in Yerer-Kereyu because of moisture stress due to below normal rainfall during the season, and also was low in Selale because of drainage problems at most locations leading to a higher incidence of black root rot. Considering the mean grain yield advantage of both 1986 and 1987 cropping seasons fertilizer application and early sowing were the most important factors in Yerer-Keryu and Menagesha zones. In Selale zone, early sowing resulted in the highest mean advantage while the use of the improved variety and weeding had little effect. Therefore, the development of improved variety adapted for the waterlogged and root-rot endemic areas in vertisols and the improved drainage system may help in alleviating this problem in Selale zone.

7.1.3.5. Back-up research

Research in Ethiopia was conducted in the fields of germplasm evaluation and genetic improvement, disease, insect, and weed control, microbiology and nutritional quality. Details are given in the

Table 7.1.17. Average grain yield (Kg/ha) obtained from individual factor and/or combination of factors in the faba bean on farm trials in Ethiopia, 1987.

Treatment*		Zone			
		Yerer-Kereyu	Menagesha	Selale	Chilalo
T 1	S1 V1 F1 W1	429	1615	440	2344
T 2	S1 V1 F2 W1	356	1630	-	1864
T 3	S1 V2 F1 W2	-	-	563	1089
T 4	S1 V2 F2 W2	-	-	-	786
T 5	S2 V1 F1 W2	480	982	558	1308
T 6	S2 V1 F2 W2	393	892	569	1181
T 7	S2 V2 F1 W1	-	-	734	1364
T 8	S2 V2 F2 W1	-	-	-	1225
T 9	S2 V2 F2 W2	270	880	412	858
T10	S1 V2 F2 W1	380	1309	-	1503
T11	S1 V1 F1 W2	547	1558	-	1431
T12	S1 V1 F2 W2	337	1515	-	1142
T13	S2 V1 F1 W1	493	910	-	1950
T14	S2 V1 F2 W1	451	875	-	1583
T15	S1 V2 F1 W1	-	-	710	1722
T16	S1 V1 F1 W2	-	-	431	-
T17	S2 V2 F1 W2	-	-	783	1016
T18	S2 V1 F1 W1	-	-	588	-
Mean		414	1217	579	1398

* Letters S, V, F, nd W denote date of sowing, variety, fertilizer and weed control, respectively. The subscripts 1 and 2 denote the recommended and farmers' practice, respectively.

proceedings of the IX coordination meeting of the NVP, and therefore only a few major findings are presented here.

Promising faba bean varieties were evaluated for their performance for grain yields and other agronomic characters in two types of trials, namely, national variety trial and verification trial. Two sets of entries (A & B) were tested in the national variety trial: 14 test entries in A set for the high-altitude areas and 12 entries in B set for the mid-altitude areas. In the A-set the mean grain yields across locations ranged from 610 kg/ha at Adet to 3450 kg/ha at Sinana with four test entries outyielding the long term standard check CS 20 DK. In the B-set, the mean grain yields across location ranged from 1030 kg/ha at Kulumsa to 3940 kg/ha at Sinana. Five test entries, NEB 207 X 74TA 74-6D, MKT (8) Bedele, NEB 207 X 74TA 207, MKT Illubabor and DZ MKT 74B outyielded the long term standard cultivar by 400 kg/ha or more. Of the three varieties tested in the verification trial, the highest mean grain yield was obtained from the long term standard check CS 20 DK (2026 kg/ha) followed by Coll 2/77 (1937 kg/ha).

A total of one hundred and ninety-four faba bean accessions from Ethiopia (from PGRC/E) and five international nurseries and trials were evaluated and single plant selections were made.

Twenty-five large-seeded and 250 small-seeded determinate and 72 IVS faba bean lines were recceived from ICARDA and evaluated at Holletta and Debre Zeit. Most of these lines were found susceptible to chocolate spot and rust and were poorly adapted. Nevertheless, a total of 49 single plant selections from determinate and 30 from IVS were selected at both the locations for better podding, disease tolerance, earliness and short plant height.

A plant population study using row and broadcast methods of sowing was conducted at Holetta (2390 m altitude) and Debre Zeit (1900 m altitude). At Holetta, 50 plants/m^2 gave the highest grain and biological yields whereas the plant population did not affect faba bean production at Debre Zeit. Although the sowing method did not affect grain yield at Holetta, row sowing provided significant grain yield advantage at Debre Zeit.

Results of surveys made during the 1986 and 1987 crop seasons to assess the disease situation in faba bean in the central highlands of Ethiopia revealed that chocolate spot (Botrytis fabae) was the most important disease of faba bean followed by rust (Uromyces vicia-fabae) and black root-rot (Fusarium solani). The chocolate spot was widely prevalent in all the faba bean growing areas, in severe form in mid-altitude area (1900-2200 m altitude). Rust was widely prevalent in severe forms in mid-altitude areas (1900-2200m altitudes) and in slight form in high altitudes. Black root rot was widely prevalent but only in vertisols where waterlogging occurred. The potentially important diseases included Ascochyta blight, and leaf roll virus. The eight other diseases observed were of minor significance.

Work on the identification of physiological races of Botrytis fabae in Ethiopia was initiated. Thirty isolates were collected from which eight isolates are being maintained in the laboratory. These isolates will be tested on 27 different faba bean lines during the 1988 crop season.

A survey of faba bean storage pests conducted showed that the bean bruchid (Callosobruchus chinensis) is the major insect pest of faba beans, particularly in the medium altitudes of the central zone, especially the warmer areas of the Yere-Kereyu awaraja. Thus, due attention must be given to the application of already available control methods, and the development of suitable and economical storage pest management strategies that would minimize the losses in quality and quantity.

7.2. NORTH AFRICA/ICARDA FOOD LEGUME COLLABORATIVE PROGRAM

Cooperation continued between ICARDA and national food legume improvement programs in Morocco, Algeria 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 is being emphasized to strengthen research through multidisciplinary and specialized team efforts. ICARDA regional food legume scientist posted in Morocco continued to work closely with national scientists in addition to coordinating national and regional research activities. The back stopping support from ICARDA base in Aleppo provided national programs with needed technical input. For this purpose, nine ICARDA-FLIP scientists visited the region during the season. Short and long term non-degree training continued to develop national program capabilities.

7.2.1. Tunisia/ICARDA Cooperative Project

In the Food Legume Cooperative Project between ICARDA and INRAT (L'Institut National de la Recherche Agronomique de la Tunisie), Tunisian and ICARDA scientists continued their jiont efforts in the improvement of all three food legumes. The Institut National d'Agronomy (INAT) was involved in disease work while the Office des Cereals verified and demonstrated important research findings in farmers fields.

The 1986/87 season was characterized by a serious drought, the most serious since the last 30 years, to the point that the crop in El-Kef Research Station in the South was plowed under and research activities were conducted only at Beja and Oued Meliz Research Stations where effective rainfall was 362 and 328 mm, respectively, representing 63% and 65% of their respective mean annual rainfall. To rescue the crop at Oued Meliz, all three crops were given one supplemental irrigation (20-30 mm). Because of the drought, yields were reduced by 40 to 49%.

7.2.1.1. Faba bean breeding

In both large and small seeded faba bean breeding programs, main emphasis was on higher yield with durable resistance to Botrytis, Ascochyta, stem nematode and Orobanche, utilizing local populations in hybridization and selection. In spite of the drought several large and small seeded lines outyielded the local check (Tables 7.2.1 and 7.2.2).

In the large seeded yield trials, out of 115 advanced breeding lines tested in advanced (FBAYT-L1 & L2), preliminary (FBPYT-L1 & 12 & 13), regional (FBRYT) and international (FBIYT-L) trials; 45 and 36 lines outyielded the local check at Beja and O. Meliz, respectively, by upto 49%. However, of the superior lines only nine exceeded the local check mean significantly. In different advanced trials ILB 1821 outyielded the local check significantly by 29 and 18% at Beja and O.

Table 7.2.1. Grain yield of large-seeded faba bean lines with wide adaptation in national and international yield trails in different locations in Tunisia, 1987/88.

Trial and pedigree	Beja		O. Meliz		Mean	
	Yield (kg/ha)	% of local	Yield (kg/ha)	% of local	Yield (kg/ha)	% of local
FBAYT-L1 (Advanced)						
78S 48426 (ILB268)	3033	120	3050	100	3041	109
S82 113-8	2958	117	3355	100	3156	113
80S 80028	2953	117	3032	99	3007	108
ILB 1821	3250	129	2282	74	2766	99
Reina Blanca	2883	114	3200	105	3041	109
Local mean	2521	100	3049	100	2785	100
LSD (5%)	567		649			
C.V. (%)	16.5	20.0				
FBAYT-L2 (Advanced)						
ILB 1821	2408	84	3290	118	2849	109
Reina Blanca	3150	110	2890	104	3020	115
Local mean	2852	100	2779	100	2617	100
LSD (5%)	655		346			
C.V. (%)	18.4		18.0			
FBPYT-L2						
S84097	2262	86	3487	149	2874	115
S84099	2487	94	3312	141	2899	116
S84103	2662	101	3212	137	2937	118
S84148	3037	115	3350	143	3193	128
S84156	2275	86	3100	132	2562	103
Reina Blanca	2137	81	2675	114	2406	97
Local Mean	2638	100	2345	100	2491	100
LSD (5%)	601		639			
C.V. (%)	17.1		14.0			
FBIYT-L						
FLIP 83-6FB	2300	103	3387	119	2843	112
80S 80135	2550	114	3012	106	2781	112
ILB 1815	2087	93	3162	111	2624	103
Gemini	1912	85	3987	140	2949	116
Pam 1.	337	104	3300	116	2818	111
New Mammoth	2412	108	3375	119	2893	114
Reina Blanca	2325	104	3787	133	3056	120
Local mean	2238	100	2844	100	2541	100
LSD (5%)			942			
C.V. (%)	31.0		19.9			

Values underlined are significantly higher than the yield of local check mean at 5% probability level.

Table 7.2.2. Grain yield of small-seeded faba bean lines with wide adaptatioon in national and international trials in different locations in Tunisia, 1987/88.

Trial and pedigree (kg/ha)	Beja		O. Maliz		Mean	
	Yield local	% of (kg/ha)	Yield local	% of (kg/ha)	Yield local	% of
FBAYT-S1						
FLIP 83-106FB	2500	117	4082	110	3291	113
80 S 43238	2450	114	4032	109	3241	111
80S 43859	2658	124	3686	99	3172	108
Brocal (77TA48)	2733	127	3700	100	3216	110
Paleolo	2125	99	4725	128	3425	117
FLIP83098FB	2108	89	4225	114	3166	108
Local mean	2144	100	3705	100	2924	100
LSD (5%)	N.S.		532			
C.V. (%)	22.6		13.0			
FBIYT-S						
FLIP 83-106FB	2287	97	4700	129	3493	116
FLIP 84-45FB	2175	92	3875	106	3025	101
76TA 56267	2287	79	3912	107	3099	103
Local mean	2356	100	3644	100	3000	100
LSD (5%)	N.S.		936			
C.V. (%)	21.2		16.7			

Values underlined are significantly higher than the yield of the local check mean at 5% probability level.

Table 7.2.3. Performance of two large-seeded faba bean lines expressed as percentage of local check yield over years and locations in Tunisia.

Season	74 TA 22 (ILB 9)			Reina Blanca (ILB 1217)		
	Beja	Kef	Other locations*	Beja	Kef	Other locations*
1982/83	-	111	108	152	135	112
1983/84	55	90	98	150	102	114
1984/85	146	192	127	104	120	-
1985/86	89	113	101	117	110	103
1986/87	126	134	129	132	118	139
1987/88	93	-	85	101	-	115

* Mateur 1982/83 and 1983/84; and Oued Meliz 1985/86, 1986/87 and 1987/88. Local check: Aquadulce population.

Meliz, respectively. Inspite of drought, ILB 1821 yielded 3.3 t/ha at Beja while Gemini yielded 4.0 t/ha with one supplementary irrigation at O. Meliz. Comparing superior lines over years and locations, Reina Blanca (ILB 1217) was less affected by drought compared to 74TA 22 (Table 7.2.3).

In the small seeded trials, 84 advancead breeding lines were yield tested in advanced (FBYT-S1 + S2), preliminary (FBYT-S) and international (FBIYT-S) trials. Number of lines outyielding the local check were 20 and 19 at Beja and O. Meliz, respectively, but only two lines, FLIP 83-106FB and Paleolo, did so significantly. Both yielded up to 4.7 t/ha with one supplementary irrigation at O. Meliz (Table 7.2.). Small seeded selections 75TA 10 (80S 43238), 77TA 48 (80S 43859) and FLIP 83-89FB continued to perform well inspite of drought (Table 7.2.4).

Table 7.2.4. Performance of superior small-seeded faba bean lines, over years and locations in Tunisia, 1987/88.

pedigree	1986/87 season (wet)				1987/88 season (dry)			
	Beja		Kef		Beja		O. Meliz	
	Yield (kg/ha)	% of local	Yield (kg/ha)	% of local	Yield (kg/ha)	% of local	Yield (kg/ha)	% of local
77TA48	3992	101	4441	114	2658	124	3686	99
75TA10	4925	125	4525	116	2450	114	4032	109
FLIP 83-89FB	5050	128	4891	126	2108	89	4225	114
Local mean	3837	100	3894	100	2144	100	3705	100
SE+	546		470				532	
C.V. (%)	14.2		11.8		22.6		13.0	

Values underlined are significantly higher than the yield of the local check mean at 5% probability level.

Following the pedigree selection method, more than 300 single plant selections were made from F4 segregating populations. These populations originated from crosses made at ICARDA for Tunisian conditions by making use of local populations in hybridization. Many selections from local populations performed well despite the adverse drought conditions.

The determinate faba bean lines failed completely this season and produced low biomass under the excessive drought. The highest yielder was FLIP 86-118FB which produced 1.3 t/ha, only 77% of the local check yield.

In the regional trial, the Moroccan lines F.S. 1047 and F.S. 1049 yielded similar to Aquadulce (1.86 t/ha) under Beja conditions. In the screening nurseries, 327 lines comprising exotic and local selections, determinate types and F4 progenies were evaluated and 45 and 7 lines were superior to the local check at Beja and O. Meliz, respectively.

7.2.1.2. Chickpea breeding

Compared to last season and due to drought, 40% yield reduction was observed in chickpea at Beja and 14% at O. Meliz where 30 mm supplementary irrigation was given in April. More lines outyielded the local checks at O. Meliz compared to Beja. This indicates the better responsiveness of exotic advanced breeding lines to more favorable conditions compared to local cultivars.

In winter chickpea, 139 advanced breeding lines were yield tested in two advanced national trials (CAYT-W1 & W2) and five international trials (CIYT-MR, -MRT, -L, -DS, -SP) at the two locations except for the dual season trial (23 entries) which was only evaluated at Beja. Of the lines evaluated at both locations, 38 and 108 lines exceeded the local checks at Beja and O. Meliz, respectively. However, only three lines (FLIP 84-146C, ILC 482, FLIP 82-293C) outyielded the local check significantly (by 55 to 82%) at O. Meliz. Inspite of drought, FLIP 84-146C yielded 4.2 t/ha (Table 7.2.5). In the advanced yield trial, several lines showed wide adaptation and were superior in yield compared to the local check at least in one location (Table 7.2.6). All these lines have a good level of resistance to Ascochyta blight. FLIP 82-239C which showed consistently good yield performance over years and locations yielded 3.1 t/ha at Beja inspite of drought.

In spring chickpea, out of 139 advanced breeding lines yield tested at Beja, 109 lines exceeded the local check. However, only three lines (FLIP 84-106C, FLIP 84-81C, FLIP 85-48C) did so significantly. FLIP 84-106C yielded 1.15 t/ha, 43% greater than the best local check (C.V. 16.3%).

In national, regional and international observation nurseries, 221 lines were evaluated for winter sowing in 1 to 2 locations and 47 and 49 lines were selected at Beja and O. Meliz, respectively. Out of 74 lines evaluated for spring sowing, 46 lines were selected at Beja.

Screening for wilt resistance at Beja wilt sick plot (BWSP) revealed several resistant lines. After two screening cycles 304 lines out of 2932 lines showed 10% or less wilt incidence and thus were considered wilt resistant. Out of 1000 accessions from ICARDA germplasm collection, 29 lines were resistant. ICRISAT 64-line screening nursery for wilt resistance had 39 resistant lines in BWSP.

Table 7.2.5. Grain yield of superior chickpea lines in international trails in one or two locations in Tunisia, 1987/88.

Trial and pedigree	Beja Yield (kg/ha)	Beja % of local	O. Meliz Yield (kg/ha)	O. Meliz % of local	Mean Yield (kg/ha)	Mean % of local
CIYT-W-MR-I						
FLIP 84-28C	1950	84	2768	392	2359	156
FLIP 84-81c	2106	91	2081	295	2094	137
FLIP 85-146c	2057	89	2006	284	2032	135
Local amdoun	2313	100	706	100	1510	10
SE ±	354		571			
C.V. (%)	21.0		32.0			
CIYT-L						
FLIP 85-1C	1469	130	1231	150	1350	138
FLIP 85-5C	1769	156	1143	140	1456	149
FLIP 85-14C	1363	121	1400	171	1382	142
FLIP 85-15C	1775	157	943	103	1309	134
FLIP 85-17C	1744	154	1218	149	1481	152
FLIP 8556C	1163	103	1381	169	1272	130
FLIP 85-60C	1894	167	875	107	1385	142
FLIP 85-135C	1475	130	1475	180	1475	151
Local Amdoun	1131	100	818	100	975	100
LSD (5%)	N.S.	N.S.				
C.V. (%)	34.4		22.2			
CIYT-SP						
ILC 482	1650	100	3587	182	2619	145
FLIP 81-293C	1694	103	3268	165	2481	137
FLIP 84-12C	-	-	3062	155	-	-
FLIP 84-81C	-	-	2987	151	-	-
FLIP 84-146C	-	-	4200	213	-	-
FLIP 84-155C	1763	107	-	-	-	-
FLIP 84-164C	2206	134	2575	130	2391	132
FLIP N84-182C	-	-	3018	153	-	-
FLIP 85-59C	-	-	3069	155	-	-
FLIP 85-68C	2163	132	-	-	-	-
FLIP 85-88C	1794	109	2193	111	1999	110
Local Amdoun	1644	100	1975	100	1810	100
LSD (5%)	N.S.		1098			
C.V. (%)	25.5		16.0			

In F3 populations originating from crosses made at ICARDA for Tunisia, 233 single plant selections were resistant to wilt.

Table 7.2.6. Grain yield of superior lines in advanced national trials in one or two locations in Tunisia, 1987/88.

Trial and pedigree	Beja		O. Meliz		Mean	
	Yield (kg/ha)	% of local	Yield (kg/ha)	% of local	Yield (kg/ha)	% of local
CAYT-W1						
FLIP 82-87C	3120	138	-	-	-	-
FLIP 82-150C	2726	121	-	-	-	-
FLIP 83-47C	2428	107	2432	122	2430	114
FLIP 84-81C	2593	115	2050	103	2322	109
FLIP 84-102C	-	-	3125	156	-	-
FLIP 84-146C	-	-	3031	152	-	-
FLIP 84-148C	2412	107	2931	147	2672	125
FLIP 84-164C	2575	114	2306	115	2441	115
FLIP 84-168C	2445	108	2432	122	2439	127
FLIP 84-197C	2338	103	3087	154	2731	127
Local mean	2260	100	2000	100	2130	100
LSD (5%)	877		N.S.			
C.V. (%)	21.5		21.0			
CAYT-W2						
FLIP 81-293C	2435	112	2512	171	2474	136
FLIP 82-239C	3125	144	-	-	-	-
FLIP 83-79C	2212	102	3131	213	2672	147
FLIP 84-91C	2176	101	2195	149	2186	120
FLIP 84-185C	2563	118	2307	157	2435	134
FLIP 85-13C	2163	100	2075	141	2119	117
FLIP 85-60C	2162	100	1471	100	1817	100
LSD (5%0	651		N.S.			
C.V. (%)	20.9		20.0			

Screening for resistance to Ascochyta blight was made in F2 to F6 populations following the artificial inoculation under field conditions. To combine resistance to both Ascochyta and wilt diseases, 40 F3, 144 F4 and 23 F5 single plants were selected based on their resistance to both diseases. A total of 23 F6 bulks having resistance to both Ascochyta and wilt were selected for yield testing. However, the seed size of these bulks needs to be increased.

7.2.1.3. Lentil breeding

In lentil, 150 advanced breeding lines were yield tested in advanced (LAYT-L1 & L2), preliminary (LPYT-L), regional (LRYT) and international (LIYT-L & S, LIF3T) trials at Beja since the crop at El-Kef was plowed under due to excessive drought. Only one advanced large-seeded trial was also evaluated at O. Meliz. At Beja, 77% of the lines exceeded the local check Ouestalia in yield while at O. Meliz 18 lines out of 19 outyielded the check. However, 22 lines did so significantly at Beja but none at O. Meliz. Compared to tested entries, the local showed greater response to supplementary irrigation at O. Meliz (Table 7.2.7). In the advanced national yield trial, yield increases upto 120% and 36% were achieved compared to the local check at Beja and O. Meliz, respectively (Table 7.2.7). Most of these lines and others showed wide adaptability over locations and seasons with mean yield increases of 23 to 44% over the local cultivars (Table 7.2.8). In the preliminary yield trial, seven lines (81S 15, FLIP 84-39L, FLIP 86-5L, FLIP 87-28L, FLIP 87-30L, FLIP 87-33L, FLIP 87-36L) exceeded the local check significantly by 50% to 78%. In international trials, 86S 52, 86S 215 and FLIP 86-29C did so with yield increases of 93%, 68% and 38%, respectively.

Four international screening nurseries (small, large-seeded types, early maturity and tall types) comprising 179 advanced breeding lines were evaluated at Beja and 98 lines were selected. In the large-seeded and tall type nurseries evaluated at O. Meliz, only 15 lines were selected for replicated yield testing next season.

The two lentil lines released for farmers in 1986 continued to

Table 7.2.7. Grain yield of lentil lines exceeding the local check and showing wide adaptation in advanced national yield trial evaluated at two locations in Tunisia, 1987/88.

Trial and pedigree	Beja		O. Meliz		Mean	
	Yield (kg/ha)	% of local	Yield (kg/ha)	% of local	Yield (kg/ha)	% of local
ILL 20	1400	159	1757	104	1579	123
ILL 4606	1429	162	1995	118	1712	133
76TA66005	1633	186	1882	111	1758	137
82S55	1291	147	2307	136	1800	140
FLIP 84-50L	1420	161	-	-	-	-
FLIP 84-51L	1358	154	1712	101	1537	120
FLIP 84-61L	1383	157	1487	88	1435	112
FLIP 84-62L	1372	156	2188	129	1780	138
FLIP 84-103L	1933	220	-	-	-	-
FLIP 84-106L	1520	173	2207	131	1864	145
FLIP 86-136L	1362	155	1787	106	1575	122
FLIP 86-3L	1679	191	1378	81	1529	119
Local questalia	880	100	1691	100	1286	100
LSD (5%0	435		1247			
C.V. (%)	23.2		27.1			

Values underlined are significantly higher than the yield of the local check mean at 5% probability level.

Table 7.2.8. Performance of widely adapted lentil lines expressed as percentage of local check yields over locations and seasons in Tunisia.

Pedigree	Beja		O. Meliz		El-Kef	Mean
	1986/87	1987/88	1986/87	1987/88	1986/87	
ILL 1939	124	119	130	136	106	123
ILL 4606[a]	99	162	122	118	141	128
76TA66005	159	186	132	111	131	144
FLIP 84-50L	78	161	137	-	132	127
FLIP 84-61L	132	157	132	88	136	129
FLIP 84-62L	140	156	116	129	104	129
FLIP 84-125L	112	147	128	121	118	125
FLIP 84-159L	158	128	137	129	122	135
FLIP 85-16L	164	131	123	-	104	131
Local (Ouestalia)	100	100	100	100	100	100

a. Released in 1986.

perform well. On the average, Nesir (ILL 4400) and Nefza (ILL 4606) yielded 21% and 25%, respectively, more than the local check (Table 7.2.9).

Table 7.2.9. Performance of newly released lentil cultivars at two locations in Tunisia, 1987/88.

Cultivar	Beja		O. Meliz		Mean	
	Yield (kg/ha)	% of local	Yield (kg/ha)	% of local	Yield (kg/ha)	% of local
Nesir (ILL 4400)	1184	127	1982	117	1583	121
Nefaz (ILL 4606)	1282	138	1995	118	1639	125
Local	932	100	1691	100	1312	

7.2.1.4. Agronomy

Agronomy studies were resumed this season to identify appropriate cultural practices for newly released cultivars. In winter chickpea, narrow inter-row spacing was more important in increasing yields than high population density for both newly released cultivars 'Chitoui' (ILC 3279) and 'Kassab' (FLIP 83-46C) although the magnitude of response of the two cultivars was different (Table 7.2.10). 'Chitoui' being late was affected more by drought and its yield was reduced by more than 50% as inter-row spacing was increased from 30 cm to 80 cm averaged over all levels of seeding density. With wider row spacing, yields of 'Chitoui' were reduced drastically. With high plant density, there was excessive competition for moisture at early growth stages and thus moisture was already depleted at the reproductive stage. For both cultivars and the local, a row spacing of 30 cm and a population of

30-40 plants/m^2 is appropriate for high yield under the conditions of the experiment for this season.

Table 7.2.10. Grain yield (kg/ha) of two newly released winter chickpea cultivars, Chitoui (ILC 3279) and Kassab (FLIP 83-46C), as affected by inter-row spacing and population density at Beja, Tunisia, 1987/88.

Population cultivar	Inter-Row Spacing 30 cm	40 cm	60 cm	80 cm	Mean
P1 (30 plts/m^2)	kg/ha				
- Local	2790	2607	2048	2202	2412
- Chitoui	2349	2073	1895	1337	1913
- Kassab	2781	2330	1761	1837	2177
Mean	2460	2337	1901	1792	2167
P2 (40 plts/m^2)					
- Local	2975	2288	2483	1997	2435
- Chitoui	2196	1724	1724	973	1678
- Kassab	2711	2337	1839	1771	2165
Mean	2672	2150	2015	1580	2093
P3 (50 plts/m^2)					
- Local	2780	2115	2219	1980	2273
- Chitoui	2057	2004	1084	712	1464
- Kassab	2641	2406	2206	2053	2326
Mean	2484	2176	1836	1582	2021
Mean					
- Local	2850	2337	2250	2060	2374
- Chitoui	2201	1967	1568	1007	1686
- Kassab	2711	2358	1935	1887	2223
Over all Mean	2587	2221	1918	1651	2094

Weeds reduced yields by 57% in faba bean, 90% in winter chickpea, 83% in lentil and 76% in dry pea. Effective herbicide were identified as follow:

Faba bean: Igran 3.0 kg a.i./ha + Kerb 0.5 kg a.i./ha

Chickpea: Igran 4.0 kg a.i./ha + Kerb 0.5 kg a.i./ha

Lentil: Maloran 2.0 kg a.i./ha + Kerb 0.5 kg a.i./ha

Pea: Tribunil 2.0 kg a.i./ha + Kerb 0.5 kg a.i./ha

Results on date of sowing confirmed the advantage of early sowing (November) in various cultivars.

7.2.1.5. Pathology and biotechnology

Apart from the wilt diseases which continued to cause considerable damage to chickpea specially in the area of Mateur, the dry season was not favorable for the development of other diseases. Sporadic Ascochyta blight occurred, however, at O. Meliz station.

In chickpea, the main objective of the national program is to combine resistance to both diseases in one desirable genotype. Screening for resistance to Ascochyta blight and wilts continued under artificial conditions at Beja as already mentioned in the section on breeding. Ascochyta blight rating scale is being modified using 600 infected plants to reduce chances of mis-classification from 30% to 5% using a linear infection index based on the size of necrotic lesions. In screening for wilts, several lines were confirmed for their resistance to wilt (showing 10% wilt incidence or less) and these lines will be included in ICARDA-regional wilt resistance screening nursery for 1988/89. The pot technique to screen for reaction to Fusarium and Verticillium wilt separately was improved. Studies were conducted on the variability of fungal populations of both wilt species as part of a Ph.D. thesis.

In faba bean, the problem encountered in creating artificial epiphytotics of Botrytis fabae was identified. The inoculum used in the past was not isolated from the "aggressive stage" culture.

In applied biotechnology, inoculation of the roots of faba bean seedlings with Agrobacterium rhizogenens increased root growth and doubled the number of nodules but nodule size was reduced. The practical implication of this response on amount of N fixed and yield needs to be investigated.

7.2.1.6. On-farm trials

On-farm activities were seriously affected by drought. Out of four regions, results were obtained from two: Beja and M. Bourghiba where rainfall was 289 and 358 mm, respectively and poorly distributed. The positive effect of chemical weed control was apparent in all food legume crops with yield increments of 38% to 58% over farmers practice. The advantage of early date of planting was apparent in chickpea and lentil. In chickpea, farmers practice of spring planting gave no yield while winter sowing gave 354 kg/ha. Lentil planted early gave 37% more yield than the farmer's practice. High population density increased yield in chickpea and small seeded faba bean by 48% and 22% over farmer's practice.

The three chickpea lines released to farmers performed well except for 'Chitoui' (ILC 3279) which, being late, suffered considerably from the drought at Beja but responded well to supplementary irrigation of 30 mm at O. Meliz (Table 7.2.11.). It yielded 1106 kg/ha at Beja compared to 2229 kg/ha at O. Meliz. Although susceptible to Ascochyta blight, the local cultivar did well in winter sowing since the disease did not develop this season.

Tunisian National Program Scientists and Dr. M. Solh.

Table 7.2.11. Performance of the three released chickpea varieties as winter and spring sown crops in comparison to a local cultivar in Tunisia, 1987/88.

Cultivar[1]	Winter		Spring
	Beja	O. Meliz	Beja
Kassab	2096	2719	956
Chtoui	1106	2229	816
Amdoun	-	-	1050
Local cultivar	2211	1735	762

1. Kassab and Chitoui are released as winter cultivars, Amdoun 1 as a spring cultivar.

7.2.2. Morocco/ICARDA Cooperative Project

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 the three food legume crops. Other national institutions such as MARA/D.P.V., ENA-Meknes and I.A.V. Hassan II contributed also to the national food legume improvement program. A multidisciplinary national research team had already been formed to work on various components of improved production package to be transferred to farmers. A pathology and breeding for disease resistance network was established to strengthen and coordinate research activities.

Research on food legumes was conducted this season on nine research stations: Jama'a Shim, Khemis Zememra, Ain Nizagh, Sidi Laidi, Dar Bouazzeh, Guich, Merchouch, Allal Tazi and Douyet. The first four stations are in arid to semi-arid areas with mean annual rainfall of 255 to 402 mm. The last five stations, in the north-central regions, are also in semi-arid areas but with more favorable growing conditions, with mean annual rainfall between 358 to 454 mm. 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, Allal Tazi); while work on chickpea and lentil was mainly in relatively less favorable conditions besides Merchouch. Dar Bouazzeh station was developed this season as a coastal site for disease work in both faba bean and chickpea. The off-season site Annaceur was used for the first time to increase chickpea seed and to continue experimentation on faba bean and lentil.

Climatically, contrary to last season, the 1987/88 season was characterized by heavy rainfall and good moisture distribution particularly in the less favorable areas. In these areas, the 1987/88 rainfall exceeded the annual average precipitation by 45 to 95%. Biotically it was the year of foliar diseases and the comprehensive disease survey done is discussed later.

7.2.2.1. Faba bean breeding

The faba bean breeding program focuses on high and stable yield with large seed, early maturity, and resistance to major diseases and Orobanche spp. The program this season included maintainance of national germplasm collections (314 accessions), yield testing and observation nurseries of advanced breeding lines, F4 and F7 progeny rows, bulks and single plant selections in F2, F3, F4 and F7 segregating populations, and screening for resistance to Botrytis fabae, Uromyces fabae, Ascochyta fabae and Orobanche.

Table 7.2.12. Performance of widely adapted faba bean lines in consecutive seasons, 1986/87 and 1987/88, at Douyet Morocco.

Pedigree	1986/87(FBIYT-L)		1987/88(FBIYT-L)		Mean	
	Yield (kg/ha)	% of local	Yield (kg/ha)	% of local	Yield (kg/ha)	% of local
ILB 1821	1226	124	920	110	1073	117
74TA22	1210	132	878	105	1094	120
80S44027	1329	134	985	117	1157	126
FLIP 82-28FB	1274	128	900	107	1087	119
FLIP 82-29FB	1300	131	935	111	1100	120
FLIP 82-30FB	1400	141	908	108	1154	126
FLIP 83-6FB	1300	131	942	112	1121	123
Reina Blanca	1199	121	1137	135	1168	128
Aguaducle (local check)	992	100	840		915	
LSD (5%)	392		N.S.			
C.V. (%)	22.2		12.9			

In the replicated yield trials, 78 advancead breeding lines and/or populations were yield tested in one advanced and three preliminary (one national, two international) trials in 1 to 2 locations. At Douyet, 49 entries outyielded the local check but only seven did so significantly; while 2 and 19 entries exceeded the local cultivar at Allal Tazi and Jama'a Shim where only 2 lines did so significantly. Inspite of the generally low yield, several lines in the advanced yield trial showed wide adaptation over seasons at Douyet (Table 7.2.12.). FLIP 82-28FB and Reina Blanca showed also fairly wide adaptation over locations with yield increases of 17 and 33%, respectively, over the improved Aquadulce at Allal Tazi (Table 7.2.13.). Pam 1 outyielded Aquadulce by 53% at Allal Tazi but gave similar yield at Douyet. In the preliminary yield trial all 19 tested lines outyielded Aquadulce but only three lines (FLIP 84-128FB, FLIP 84-147FB, FLIP 84-104FB) did so significantly with 35 to 46% more yield. Contrary to visual observations, several determinate lines were superior or as good yielders as the indeterminate local check Aquadulce (Table 7.2.14.), only FLIP 86-146FB (2.9 t/ha) outyielded the indeterminate line ILB 1418 (2.8 t/ha) at Douyet. Data at Jama'a Shim are inconclusive because of high C.V. value. Nevertheless, the superior determinate lines cannot be advanced without purification and re-selection since they are highly heterogenous and susceptible to various foliar diseases besides their undesirable medium to small seed size.

The faba bean breeding program is putting more emphasis on the utilization of local populations in hybridization and selection since exotic advanced breeding lines showed limited adaptation to Moroccan conditions. For this reason, single plant selections were made in early and late segregating generations originating from crosses made at ICARDA and targetted to Moroccan conditions using local populations. Out of 415 F4 progeny rows, 83 progenies were selected as bulks and 417 single plant selections were made. In 347 F7 progeny rows, 98 progenies were selected as bulks and 375 single plant selections were made. Progenies selected as bulks will be included in preliminary yield trials or observation nurseries with four row plots. Seven F2 and 12 F5 bulk populations were selected out of 49 and 38 segregating populations, respectively.

Screening for Orobanche resistance was done in an infested field on 200 BPL accessions, the national germplasm collections and a collection of lines selected for horizontal resistance to Orobanche.

Table 7.2.13. Performance of best faba bean tested lines in the international yield trial (FBIYT-L) at two locations in Morocco, 1987/88.

Pedigree	Douyet Yield (kg/ha)	Douyet % of local	Alal Tazi Yield (kg/ha)	Alal Tazi % of local	Mean Yield (kg/ha)	Mean % of local
FLIP 82-28FB	3500	94	2426	117	2963	102
Reina Blanca	3611	97	2761	133	3187	110
Gemini	3222	87	2724	131	2973	102
Pam 1	3611	97	3191	153	3401	117
Aquaducle (local check)	3722	100	2080	100	2901	
SE+	254					
C.V. (%)	142		18.0			

Values underlined are significantly higher than yield of local check at 5% probability level.

Table 7.2.14. Grain yield of selected determinate faba bean lines (FBIYT-D-88) at two locations in Morocco, 1987/88.

Pedigree	Douyet Yield (kg/ha)	Douyet % of local	Jama'a Shim Yield (kg/ha)	Jama'a Shim % of local	Mean Yield (kg/ha)	Mean % of local
FLIP 84-230FB	2533	106	1558	141	2046	117
FLIP 84-243FB	2533	106	2063	187	2298	131
FLIP 84-244FB	2477	103	2375	215	2426	138
FLIP 86-107FB	3067	128	1795	163	2431	139
FLIP 86-118FB	2744	114	1858	168	2301	131
FLIP 86-146FB	2944	123	1537	139	2241	128
ILB 1418*	800	117	2833	257	2817	161
Aquaducle*	2400	100	1104	100	1752	100
SE+	260		416			
LSD (5%)	756		1209			
C.V. (%)	17.5		43.0			

* Indeterminate types.

Four BPL accessions (BPL 3325, BPL 3326, BPL 3327 and BPL 3330) showed some tolerance to Orobanche. Due to poor distribution of Orobanche infestation in the field, susceptible lines were discarded from the collection and the remaining will be screened further.

7.2.2.2. Chickpea breeding

The chickpea breeding focuses on the development of high yielding cultivars adapted to winter and spring sowing 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 wilts and leafminer resistance which are important in both seasons but more so in spring.

Two winter cultivars (ILC 195 and ILC 482) were officially released to farmers in October, 1987. Three winter lines (FLIP 81-293C, FLIP 82-128C, FLIP 82-161C) are in pre-release catalogue trials. This season the program recommended three additional winter lines (FLIP 83-71C, FLIP 82-150C, FLIP 82-152C) resistant to Ascochyta blight and having relatively larger seed.

In the winter chickpea program, 154 advanced breeding lines were yield tested in four international (CIYT-W-MR, CIYT-W-MR-T, CIYT-L, CIYT-E), one regional (CIYT-DS), three advanced (CAYT-L, CAYT-I & II) and one national (CNYT) trials in 1 to 4 locations. Yield levels were high because of good rainfall and most yields were around 3 t/ha but several lines yielded more than 4 and 5 t/ha at Jema'a Shim and Douyet, respectively. Considering the various locations, number of lines outyielding the local check ranged between 23 to 79, many of which did so significantly (Tables 7.2.15 and 7.2.16). The local check was killed by Ascochyta blight in some trials in Merchouch and Douyet under natural infestation.

In the national trial, FLIP 83-47C, FLIP 83-48C and FLIP 83-71C outyielded the local check by 90, 83 and 72%, respectively; and ILC 482 by 40, 33 and 22%. In the advanced large-seeded trial (CAYT-L) the yield advantage of selected lines over the local was only 2 to 18%, but these lines have large seed besides being more tolerant to Ascochyta blight than the local check. Several lines in advanced yield trials (CAYT-I & II) showed wide adaptation in addition to being superior in yield to the local check by 10 to 28% over three locations representing different agroclimatic zones (Table 7.2.15).

In the international trials several lines expressed high yield and wide adaptation and several lines exceeded the newly released ILC 482 (Table 7.2.16). In CIYT-W-MR yield advantage over the local ranged between 18 to 35% over locations; while in CIYT-L, where Ascochyta affected the local check in some locations, yield advantages were more than 200% across locations (Table 7.2.16). In the winter tall chickpea (CIYT-WMT-T), all tested entries exceeded the local at Merchouch and yield increases up to 183% were achieved. Lines which yielded more than 150% were ILC 195, ILC 3279, FLIP 85-12C, FLIP 85-57C and FLIP 85-151C. In international screening nursery (CISN-W) all 62 tested entries exceeded the local check.

Development of dual season chickpea, a regional activity, received particular emphasis in Morocco. Out of 34 lines tested, 7 were promising over 3 locations since their yield was doubled in winter while yielding as much or slightly more than the best local cultivars

Table 7.2.15. Multilocation performance of high yielding and widely adapted winter chickpea lines in national and advanced trials in Morocco, 1987/88.

Trial and pedigree	Jama'a Shim		Ain Nizagh		Merchouch		Mean	
	Yield (kg/ha)	% of local	Yield (kg/ha)	% of local	Yield (kg/ha)	% of local	Yield (kg/ha)	% of local
CNYT								
FLIP 81-293L	2687	139	1625	115	2343	205	2218	148
FLIP 83-47C	3540	138	1718	121	3307	289	2855	190
FLIP 83-48C	3702	191	1562	110	2968	259	2744	183
FLIP 83-71C	3062	158	1531	108	3177	277	2590	172
ILC 482	2783	144	2156	152	1796	157	2245	150
PCH 46(Local)	1937	100	1416	100	1145	100	1499	100
LSD (5%)	1193		N.S.		965			
C.V. (%)	20.1		29.5		25.6			
CAYT-L (large seeded)								
FLIP 83-77C	4217	117	1812	118	2734	125	2888	118
FLIP 84-12C	3280	91	1906	124	2812	129	2666	109
FLIP 84-19C	3342	93	1625	106	2499	114	2489	102
FLIP 85-54C	3687	103	1406	92	2369	108	2487	102
PCH 46(local)	3592	100	1531	100	2187	100	437	100
LSD (5%)	733		661		772			
C.V. (%)	10.2		20.8		23.7			
CAYT-1								
FLIP 82-47C	4000	116	2291	147	3072	115	3121	122
FLIP 83-71C	3740	109	1812	116	3229	120	2927	114
FLIP 83-98C	4062	118	1812	116	3072	115	2982	116
FLIP 84-80C	3850	112	2062	132	3307	123	3073	120
FLIP 84-92C	4312	125	2250	144	3281	122	3281	128
FLIP 84-93C	4062	118	2031	130	3411	127	3168	124
FLIP 84-109C	3842	112	1718	110	3151	117	2904	113
FLIP 84-144C	3092	90	2500	160	3098	116	2897	113
FLIP 84-145C	3912	114	2500	160	2734	102	3049	119
ILC 482	4325	126	2281	146	2838	106	3148	123
PCH46(local)	3427	100	1562	100	2682	100	2560	100
LSD (5%)	641		N.S.		415			
C.V. (%)	8.1		32.2		10.1			
CAYT-2								
S85-017	3500	106	2093	122	2942	107	2845	110
S85-059	3625	110	2156	125	2916	106	2899	112
S85-085	3342	101	1656	96	3619	131	2872	111
S85-087	3967	120	1843	107	3117	113	2976	115
PCH46(local)	3310	100	1718	100	2760	100	2596	100
LSD (5%)	705		N.S.	964				
C.V. (%)	9.6	38.8	25.6					

Values underlined are significantly higher than the yield of the local

Table 7.2.16. Multilocation performance of high yielding and widely adapted winter chickpea lines in international trials in Morocco, 1987/88.

Trial and	K. Zememra		Ain Nizagh		Merchouch*		Douyet		Mean**	
pedigree	Yield (kg/ha)	% of local	Yield (kg/ha)	% of local	Yield (kg/ha)	% of local	Yield (kg/ha)	% of local	Yield (kg/ha)	% of local
CIYT-W-MR										
FLIP 81-293C	2422	107	3053	124	1979	127	3266	146	2655	126
FLIP 83-47C	2171	96	3191	130	1771	113	3666	169	2699	128
FLIP 83-48C	2508	111	3125	127	1770	113	3223	149	2657	126
FLIP 83-71C	2857	126	2558	104	1354	87	3443	159	2553	121
FLIP 83-97C	2614	116	2358	96	1979	127	3166	146	2529	120
FLIP 83-98C	2300	102	2140	87	1458	93	5000	231	2725	129
FLIP 84-80C	2674	118	2937	119	1667	107	3166	146	2611	124
FLIP 84-92C	3131	139	2483	101	1458	93	4276	197	2837	134
FLIP 84-93C	2302	102	3000	122	1354	87	3666	169	2581	122
FLIP 85-43C	3328	147	2790	144	1458	93	2666	123	2561	121
FLIP 85-48C	2502	111	2884	117	1667	107	3776	174	2561	121
FLIP 85-78C	2625	116	3108	126	1771	113	3890	180	2849	135
FLIP 85-93C	2822	125	2658	108	1354	87	3776	174	2654	126
ILL 482	2342	104	2766	112	1563	100	3333	154	2501	118
PCH46(local)	2260	100	2458	100	1563	100	2166	100	2112	100
S.E. ±	328		-		282		393			
LSD (5%)	934				674		118			
C.V. (%)	23.6		27.8		25.1		20.7			
CIYT-L***										
FLIP 84-19C	2934	165	1437	192	2916		3276	147	2641	222
FLIP 85-4C	2542	142	1666	222	2152		2723	122	2271	191
FLIP 85-5C	2891	162	1791	139	2222		3390	152	2574	216
FLIP 85-17C	2971	167	2750	366	2430		3276	147	2857	239
FLIP 85-60C	3354	188	916	122	3055		4000	180	2831	239
PCH37(local)	1782	100	750	100	0		2223	100	1189	100
S.E. ±	335		-		231		416			
LSD (5%)	968		828		668		1200			
C.V. (%)	22.0		32.9		16.3		24.4			

Values underlined are significanlty higher than the yield of the local at 5% probability level.

* At Merchouch CIYT-W-MR was planted as spring.

** Including CIYT-L at Merchouch where local was completely killed by Ascochyta blight.

*** Ascochyta blight affected the local check at Ain Nizagh, Merchouch and Douyet.

when spring sown (Table 7.2.17). FLIP 84-92C yielded 139 and 10% more than the winter and spring local checks, respectively. These results reflect the good adaptation of the local cultivars to spring sowing but not to winter sowing.

Table 7.2.17. Grain yield of promising dual season (winter and spring) chickpea lines in three locations in Morocco, 1987/88.

Pedigree	Jama'a Shim		Merchouch		Douyet		Mean		% of best local	
	winter (kg/ha)	Spring (kg/ha)	Winter (kg/ha)	Spring (kg/ha)	Winter (kg/ha)	Spring (kg/ha)	Winter (kg/ha)	Spring (kg/ha)	Winter	Spring
FLIP 81-293C	3500	1820	3229	1631	4440	3235	3723	2228	210	100
FLIP 82-121C	3550	1760	3055	2013	3833	3479	3491	2291	196	103
FLIP 82-150C	3480	1420	3229	1874	5166	2727	3958	2007	223	90
FLIP 83-47C	4330	2070	3506	2013	5066	2822	4301	2302	242	104
FLIP 84-8C	4400	1390	3298	1874	4833	3044	4177	2103	236	95
FLIP 84-92C	4040	2570	3576	2013	5056	2727	4224	2437	239	110
FLIP 84-108C	3250	1850	2951	1874	4000	3033	3400	2252	192	101
FLIP 84-109c	3830	2050	2673	1805	4166	2833	3556	2229	201	100
FLIP 84-145C	3970	1860	3229	1736	4943	2500	4047	2032	229	92
FLIP 84-163C	3630	1410	2910	2013	5276	3144	3941	2189	223	99
ILC 195*	3725	1730	3402	1874	4833	2822	3987	2142	225	96
ILC 482*	4000	1140	3576	1874	5110	3050	4429	2021	250	91
PCH37** (local)	2750	1450	0	2013	0	2777	915	2220	52	100
PCH 46	3125	1870	1354	1736	833	1188	1771	1458	100	66
LSD (5%)	N.S.	N.S.	1075		518	2106	N.S.			
c.v. (%)	15.4	33.3	14.4	11.0	200	23.9				

Values underlined are significantly higher than the yield of the best check at 5% probability level.

* Released officially in October 1987.

** PCH 37 was killed by Ascochyta blight at Merchouch and Douyet.

In the spring chickpea program, 57 advanced breeding lines were tested in an international (CIYT-sp) and a regional dual season (CIYT-DS) trial at 1 to 3 locations. Additional local adapted lines were added to the second trial. Only a few lines exceeded the local check which is well adapted to spring sowing. Number of lines exceeding the local check were 3, 9 and 18 at Jama'a Shim, Merchouch and Douyet, respectively. Yield increases did not exceed 16% at any location. FLIP 82-92C, FLIP 82-121C and FLIP 83-47C were the best yielders across locations with yield advantage of 3 to 10%.

7.2.2.3. 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 types with good pod retention).

This season two serious problems affected lentil research results at the two main research stations, Merchouch and Sidi Laidi. Heavy Orobanche infestation affected most trials at Merchouch, while a rust epidemic broke on lentil across the country but more seriously in Chaouia-Abda area where Sidi Laidi is located. Apparently, this is the first year that rust epidemic broke out in Morocco. The wet season, particularly in the south central areas contributed to the rapid disease development and spread. Use was made of rust epidemic to eliminate susceptible material. In future, breeding for combined resistance to rust and Orobanche should be initiated.

In the breeding program, 208 advanced breeding lines were yield tested in four international (LIYT-L+S, LIF3T, LIF3T-E), one regional (LRYT), four preliminary (LPYT-S1+S2, LPYT-L1+L2) and two advanced (LAYT-L+S) trials at 1 to 3 locations. The local check was outyielded by 81,53, 11 lines at Merchouch, Sidi Laidi and Jema'a Shim, respectively. Yield differences were significant in 21, 29 and 5 lines in the same order. However, C.V. values were high in 3 trials (LIYT-L & S, LRYT) because of the serious Orobanche and rust infestation and results in these trials were inconclusive. It was apparent from the results that early maturing lines such ILL 4605 and FLIP 86-16L did exceptionally good under heavy rust and Orobanche infestation. FLIP 86-16L yielded 915 and 1511 kg/ha compared to 240 and 70 kg/ha of the local check, respectively, at Sidi Laidi (rust epidemic) and Merchouch (Orobanche infestation). Several lines in advanced yield trials showed wide adaptation in-spite of the damage from pests (Table 7.2.18).

Table 7.2.18. Grain yield of large and small-seeded lentil with wide adaptation in Morocco, 1987/88.

Trial and pedigree	Jema'a Shim		Sidi Laidi*		Merchouch**		Mean***	
	Yield (kg/ha)	% of local	Yield (kg/ha)	% of local	Yield (kg/ha)	% of local	Yield (kg/ha)	% of local
LAYT-L (large-seeded)								
ILL 4605	1881	119	810	281	1994	113	1938	116
ILL 5746	1669	106	143	50	2217	125	1934	116
L56 (LOCAL)	1581	100	288	100	1770	100	1676	100
LSD (5%)	533		N.A.		570			
C.V. (%)	22.7				21.88			
LAYT-S (small-seeded)								
76TA66005	1425	137	315	828	1248	134	1337	136
FLIP 84-26L	1350	130	320	842	1024	110	1187	120
FLIP 84-29L	1406	136	325	855	1068	114	1237	125
FLIP 84-75L	1550	149	308	811	1064	114	1307	133
FLIP 84-88L	1263	122	216	568	1098	118	1181	120
L24(local)	1037	100	38	100	934	100	986	986
LSD (5%)	383		N.A.		425			
C.V. (%)	22.7				27.1			

* Heavy rust epidemic affected all trials.
** Heavy Orobanche infestation.
*** Data of Sid Laidi not included.

Yield levels were generally low at Merchouch and Jama'a Shim and yield advantages over both locations ranged between 16-36% over the local cultivars. Yields at Sidi Laidi were almost nil because of rust and thus were not considered.

Better yields were obtained in preliminary yield trials and the small-seeded FLIP 84-51L, FLIP 86-62L, and FLIP 87-52L yielded 2.42, 1.94 and 1.89 t/ha, respectively, which is more than double the local cultivar yield of 0.94 t/ha (Table 7.2.19). Large seeded lines yielded 24 to 59% more than the local (Table 7.2.19).

Selected F3 populations from LIF3T and LIF3T-E were advanced to F4 for single plant selections. Selections were made in early and tall

Table 7.2.19. Grain yield of promising lentil lines in preliminary yield trials at Merchouch, 1987/88.

Large-seede (LPYT-L1)			Small-seeded (LPYT-S1)		
Pedigree	Yield (kg/ha)	% of local	Pedigree	Yield (kg/ha)	% of local
FLIP 86-10L	2059	124	FLIP 84-51L	2424	259
FLIP 86-12L	2081	126	FLIP 86-28L	1648	176
FLIP 86-16L	2159	130	FLIP 86-32L	1709	183
FLIP 86-19L	2057	124	FLIP 86-62L	1939	207
FLIP 86-19L	2057	124	FLIP 86-62L	1939	207
FLIP 86-21L	2461	148	FLIP 86-63L	1781	190
FLIP 87-19L	2474	149	FLIP 87-30L	1672	179
FLIP 87-21L	2630	159	FLIP 87-47L	1739	186
ILL 4605	2109	127	FLIP 87-52L	1887	202
L56 (local)	1658	100	L24 (local)	936	100
LSD (5%)	626			608	
C.V. (%)	22.1			24.7	

Values underlined are significantly higher than the yield of the local check at 5% probability level.

screening nurseries, LISN-T and LISN-E, where the local check ranked the 30th and 34th, respectively.

Based on their good performance, ten lines will be included in multilocation national and verification trials next season. These are ILL 4605, ILL 5582, ILL 5698, ILL 5700, ILL 5720, ILL 5745, ILL 5752, ILL 5991, ILL 60001 and ILL 6209. ILL 6002 will be given special attention being high yielding under both biotic and abiotic stresses.

7.2.2.4. Agronomy and microbiology

The agronomy program emphasized verification of new technologies on farmers fields and identification of appropriate cultural practices through experimentation on the station and on farmers fields.

Diagnostic studies showed that weed control was the most critical factor to achieve high yield in winter chickpea. Phosphorus fertilization was the second most important factor and yield response was apparent even at a rate as low as 20 kg P_2O_5/ha. The importance of early planting (November) and narrow row spacing (30 cm) was also apparent.

Studies on date of planting and population density were concluded this season with the following recommendations:

- Faba bean: early November, 30 plants/m^2, 50 cm row spacing.
- Winter chickpea: November, 30 plants/m^2, 30 cm row spacing.
- Lentil: November, 200 plants/m^2, 30 cm row spacing.

Yield losses due to weeds were up to 100% in winter chickpea, 45% in faba bean and 55% in lentil. Studies on weed control for several years indicated that Igran (3.0 kg a.i./ha) can be recommended as pre-emergence herbicide in winter chickpea under the conditions of Chaouia-Abda region. In the same area, Igran (3.0 a.i./ha) plus Kerb (0.5 kg a.i./ha) was effective in winter chickpea in addition to faba bean. Topogard (0.75 kg a.i./ha) was as effective as manual weeding in faba bean. In the north (Douyet), Igran and Maloran (1.5 kg a.i./ha) plus Kerb (0.5 kg a.i./ha) were partially effective as in winter chickpea. Maloran plus Kerb were as effective hand weeding in faba bean and lentil. Topogard or Tribunil (2 kg a.i./ha) plus Kerb (0.5 kg a.i/ha) gave similar results on faba bean while Igran was also effective in lentil.

Results on lentil mechanization showed that the standard cereal grain drill and the double knife cutter bar provided the best combination of planting and harvesting methods, respectively (Table

7.2.20a). Yields were generally low because of the rust epidemic. Grain losses with the double knife cutter bar were slightly less than with the labor-intensive hand harvesting (Table 7.2.20b). The heavy rain while the crop was still in the field increased grain losses even in hand harvesting as apparent by comparing the losses in 1986/87 and 1987/88 (Table 7.2.20b). Before recommendation to farmers, a piling or pick-up device will be attached to the cutter bar to collect the harvested crop.

Table 7.2.20. Effect of planting and harvesting methods on yield (kg/ha), grain and straw losses in lentil at Sidi Laidi, Morocco, 1987/88.

a. Grain yield:

Harvesting Method	Planting method			
	DT	DA	C1	C2
HH	910.5	466.0	429.5	387.5
DK	708.5	786.0	628.5	490.5
CH	626.0	569.5	846.5	751.0

b. Grain and straw losses (%) as affected by method of harvest

Method	1986-87		Method	1987-88	
	Grain	Straw		Grain	Straw
HH	4.1	3.1	HH	20.6	29.8
SM	17.8	36.8	DK	18.6	40.6
CH	15.9	57.0	CH	29.5	66.6
Mean	12.6	32.2		22.9	45.6

HH: Hand harvesting
DK: Double knife cutter bar
SM: Side mower
CH: Combine harvest

DT: Drill tractor driven
DA: Drill animal-driven
CI: Broad-cast seeding
C2: Local plow planting.

Studies on the need for inoculation with rhizobia indicated no response to inoculum in the traditional production areas in all the three food legume crops. Future studies will be restricted to non-traditional production areas with emphasis on winter chickpea. The three efficient rhizobium strains (PC 31, PC 36, PC 39) introduced from ICARDA were not more effective on winter chickpea compared to native strains at Sidi Laidi. PC 39 strain is Moroccan by origin.

7.2.2.5. Pathology

7.2.2.5.1. Screening for disease resistance:

Pathology work was strengthened this season by the development of expertise and facilities at Dar Bouazzeh Research Station as a coastal disease screening site. Screening for resistance was done against Ascochyta rabiei in chickpea and Bortyris fabae, Ascochyta fabae and rusts in faba bean.

In chickpea, 21 lines were rated as resistant to Ascochyta blight (3 rating on 1 to 9 scale) and 14 as moderately resistant with 5 rating:

Resistant: ILC 195, ILC 482; FLIP 81-91C, -293C; FLIP 82-72C, -91C, -127C, -128C, -150; FLIP 83-47C, FLIP 84-19C, -93C, -145C; FLIP 85-1C, -5C, -14C, -56C, -60C, -73C, -133C, -135C.

Moderately Resistant: FLIP 83-47C, -71C, FLIP 84-80C, -92C, -99C, -102C, -158C; FLIP -85-4C, -45C, -48C, -55C, -71C, -73C, -208C.

In screening for resistance to wilts in chickpea, symptoms were apparent at early stages of plant growth in ICARDA regional wilt screening nursery in the wilt sick plot at Khemis Zememra. However, plants recovered because of high rainfall and possibly due to low inoculum density in the soil. Conditions were not favorable this season for wilt disease development.

In faba bean, lines showing moderate resistance to Botrytis included ILB 3025 (FLIP 87-127FB), R 40, L 83108 and BPL 2139. Those with moderate resistance to rusts were L 82014, BPL 552, BPL 1179. Artificial inoculation of Ascochyta fabae did not work because of low spore count in the inoculum (2500 instead of 40000 spores/ml).

7.2.2.5.2. Disease survey and network formation

A disease survey was conducted in cooperation with INRA, ENA-Meknes, Bari-Italy and ICARDA. The survey was conducted for 16 days (7 days in late March and 9 days in late April). It was timely since the wet weather favored disease development. A detailed report on the survey is available separately. Prevailing diseases this season were:

- Faba bean: 99% of the visited fields had Botrytis and disease severity was rated 7 (equivalent to 80% yield damage). Orobanche crenata was also serious mostly in the north. Other diseases of importance were stem nematodes (*Ditylenchus dipsaci*) *Alternaria* and viruses.

- Chickpea: Wilt/root rot complex (Fusarium sp. and Rhizoctonia sp.) was the most important disease. Depending on the region, the frequency of infested fields ranged between 8 to 30% and the disease incidence ranged from 5.2 to 28%. Nematodes were also identified on chickpea and a comprehensive report by Bari-Italy covers details.

- Lentil: Orobanche, rust (Uromyces sp.) and wilt/root rot complex (Fusarium sp., Selerotinia sp., Pythium sp. and Rhizoctonia sp.) were the most important. Wilt/root rot complex existed in 50-88% of fields visited in Zaea plateau. Rust epidemic broke out in the Chaouia region where farmers had to plow under their crop. According to available information, it is the first rust epidemic in Morocco.

A national network was established on food legume pathology and breeding for disease resistance. Nine national scientists from various national institutions attended the first meeting with four ICARDA scientists. A one-day seminar was held to present research work already done as well as discussing future research emphasis. For coordination of research activities a follow-up committee was formed. The Moroccan Pathology Network will be the nucleus for a regional network.

7.2.2.6. Entomology

Studies on Sitona sp. indicated that although carbofuran reduced nodule damage considerably at seedling stage in faba bean, it did not result in positive yield response possibly because the insecticide was not effective at later growth stages.

In screening chickpea germplasm for resistance to leafminer (Liriomyza cicerina), two lines, ILC 5901 and FLIP 84-92C, were highly resistant (1-3 score) and six lines, ILC 5351, ILC 5594, ILC 5641, ILC 5646, ILC 5682 and ILC 5655, moderately resistant (3-5 score).

Bruchus rufimanns was identified as the major species of seed beetle causing damage in faba bean.

7.2.2.7. On-farm demostration

The winter chickpea package was demonstrated at 22 and 30 on-farm sites for the two newly released cultivars ILC 195 and ILC 482, respectively. Farmers were satisfied with the performance of the winter chickpea and their yields were 1.5 t/ha or more. In the Chaouia-Abda region yields up to 3.6 and 4.6 t/ha were obtained with and without phosphorus (Table 7.2.21). These values were 110 and 145% more than the local farmers' practice, respectively. Over 8 sites, ILC 482 with phosphorus yielded more than 63% over the average farmers' practice. Due to favorable conditions, Ascochyta blight killed the local cultivar completely at one site while ILC 482 was slightly affected (Table 7.2.21). Over locations, yield gains from phosphorus were 29% for ILC 482 and 33% for the local cultivar.

Table 7.2.21. Grain yield (kg/ha) of chickpea of eight on-farm demonstration plots in the Chaouia-Abda region, Morocco, 1988.

Plot	Winter sowing				Mean	Farmer's practice
	ILC 482		Local			
	P_2O_5 (kg/ha)		P_2O_5 (kg/ha)			
	0	60	0	60		
1	2120	2320	1640	2200	2070	1475
2	1280	1560	960	1240	1260	1250
3	960	1840	480	1080	1090	1244
4	720	1320	0	0	510	1195
5	480	960	440	440	580	1198
6	3600	4200	2600	3600	3500	1710
7	3400	3800	3000	3400	3400	1886
8	1000	1500	400	700	900	810
Mean	1695	2188	1190	1583	1664	1346

Moroccan National Scientists and Dr. M. Solh.

7.2.3. Algeria/ICARDA Cooperative Project

The cooperation between Algeria-ITGC (Institut Technique Des Grandes Cultures) and ICARDA continued during the 1987/88 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 on-farm verification; and level III demonstration of important research findings. Work on back-up research which included both agronomy and breeding was also conducted at other research stations, Tiaret, Setif, Khroub and Geulma.

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 1987/88, serious drought characterized the season in Algeria particularly in SBA and Setif where rainfall was poorly distributed. Annual rainfall for 1987/88 season was 218.5, 226.4, 336.4 and 323.3 at SBA, Setif, Khroub and Guelma, representing 55, 48, 75 and 50% of the respective mean annual precipitation. The distribution of rainfall at Khroub and Tiaret was fairly good and thus better results were obtained. Because of drought, results at SBA, Setif and Geulma were inconclusive as reflected by the high C.V. and missing data. At Guelma most trials of winter crops were plowed under while at Setif and Sidi-Bel-Abbes, plant growth was stunted and weak. Biotic stresses were not favoured this season due to drought. However, stem nematodes and Sitona weevil were serious on faba bean at SBA while on chickpea, stem rot was serious at SBA and Tiaret, wilt/root rot complex at SBA and Guelma and Ascochyta blight at Khroub. Results presented reflect both abiotic and biotic stresses of the season.

7.2.3.1. Back-up research

Back-up research in faba bean, chickpea and lentil included breeding for higher and stable yield through the evaluation of ICARDA germplasm and advanced breeding lines. In the breeding program, there is an urgent need to develop screening for diseases of economic importance through artificial inoculation since natural disease infestation is not dependable and not uniform. Agronomy studies aim at identifying appropriate cultural practices which are important to increase food legume national production.

7.2.3.1.1. <u>Faba bean breeding</u>

Breeding work on faba bean focuses on high and stable yield with disease resistance and large seed. However, inspite of being the largest food legume crop, breeding work is limited to the evaluation of exotic advanced breeding lines for yield and adaptation. With the new faba bean/pea breeder joining ITGC, the breeding program will be strengthened. During this season, 57 advanced breeding lines (large and small-seeded) were yield tested in international (FBIYT-L & S) and regional (FBRYT) trials at 1 to 2 locations. The effect of drought was more critical at SBA compared to Khroub (Table 7.2.22). The best yielding line at Sidi-Bel-Abbes, (FLIP 83-50FB) and at Khroub (FLIP 83-105FB) produced 0.58 t/ha and 2.24 t/ha, respectively. None of the tested entries outyielded the local check significantly due to high C.V. values. However, several lines produced more than double the yield of the local check and a total of 51 lines were selected for next season. The large seeded lines New Mammoth, FLIP 82-28FB, Turkish local and the small seeded ILB 1821, FLIP 82-12FB, FLIP 83-50FB, ILB

3188 were among the better yielding lines. In the regional trial, the Moroccan line F1047 yield 15% more than the improved Aguadulce. Lines selected for verification trials at SBA based on good performance in past years were New Mammoth, Reina Blanca, Violetta di Policorro and Seville Giant. At Khroub yields were high considering the local rainfall. The large seeded 74TA 22, Pam 1 and FLIP 82-30C produced 32, 23 and 16% more than the improved local check Seville Giant.

Table 7.2.22. Grain yield of widely adapted large and small-seeded faba bean lines in the international trials at two locations in Algeria, 1987/88.

Trial and pedigree	Sidi-Bel-Abbes		Khroub	
	Yield (kg/ha)	% of check	Yield (kg/ha)	% of check
FBIYT-L (large-seeded)				
74TA 22	-	-	1585	132
FLIP 82-28FB	465	120	1218	101
FLIP 82-30FB	423	190	1395	116
Pam 1	379	97	1478	123
New Mammoth	480	124	1270	105
Sidi Moussa (check)	389	100	-	-
Seville (check)	-	-	1205	100
LSD (5%)	N.S.		720	
C.V. (%)	50.9		37.2	
FBIYT-S (small-seeded)				
74TA 91	-	-	2223	112
FLIP 82-35FB	357	240	1856	94
FLIP 83-3FB	252	169	1981	100
FLIP 83-48FB	363	244	2135	108
FLIP 83-50FB	579	389	1804	91
FLIP 83-88FB	337	226	2057	104
FLIP 83-105FB	377	253	2236	113
Quarantine (check)	149	100	-	-
Seville (check)	-		1981	100
LSD (5%)	N.S.		57.1	
C.V. (%)	41.2		36.7	

Eight selections were made in international screening nurseries (FBISN-L, FBICSN and FBIABN) based on pod set and tolerance to stem nematodes. Both Botrytis fabae and Ascochyta fabae did not develop this season because of drought. Stem nematodes were serious on SBA station and farmers fields.

SBA station with 390 mm mean annual rainfall and poor soil is not suitable for faba bean research. It is suggested that Tassela Pilot farm in Zone I (15 km from SBA) where the genetic potential of faba bean genotypes can be expressed fully should be used in future.

7.2.3.1.2. Chickpea breeding

Breeding work on chickpea focuses on high yield with resistance to Ascochyta rabiei, large seed and adaptation to winter and spring planting. More emphasis is put on winter chickpea. This season, the spring crop failed completely due to drought.

The national program released this seaosn three new chickpea cultivars after several years of evaluation. The first winter chickpea cultivars released in Algeria are ILC 482 and ILC 3279. The third new cultivar is Sebdou which is recommended for planting in early February.

In winter chickpea, 182 advanced breeding lines were tested in international (CIYT-W-MR, CIYT-W-MR-T, CIYT-L, CIYT-DS, CIYT-SP, CIF4T), preliminary (CPYT-A & B & C) and multilocation (CMYT-I & II) trials in 1 to 5 locations. A number of lines exceeded the local check and 67, 61, 17, 14, and 13 lines were selected from replicated yield trials at SBA, Khroub, Tiaret, Setif and Geulma, respectively for further evaluation next season. Several of these lines were significantly better yielding than the local check (Table 7.2.23 and 7.2.24), particularly at Khroub where Rabat 9, the local cultivar, was seriously affected by Ascochyta blight.

In the international trials (CIYT-W-MR & T) several lines showed wide adaptation across locations inspite of the differences in agroclimatic conditions (Table 7.2.23). Yields of tested lines were more than four times the local checks mainly due to susceptibility of the local cultivars to *Ascochyta* blight and wilt as well as late maturity in case of Rabat 9. Several lines (FLIP 83-98C; FLIP 85-13C, -18C, -19C, -49C, -93C) outyielded the newly released cultivars (ILC 482 and ILC 3279), at least in one location, by up to 28%. At Tiaret, FLIP 83-98C and FLIP 85-93C yielded almost 3.0 t/ha while Rabat 9 and ILC 482 yielded 1.1 and 2.6 t/ha, respectively. In CIYT-L, the large seeded line FLIP 85-17C yielded 1.7 t/ha which is significantly greater by 42% than the local check yield at Tiaret. In Khroub, the large seeded lines FLIP 85-4C, FLIP 85-5C and FLIP 85-15C yielded 3.0 to 3.5 t/ha, 53 to 78% greater than the local Rabat 9 (2.0 t/ha).

In preliminary and multilocation trials, several lines were superior not only to the local but also to the newly released cultivars (Table 7.2.24). Yield advantages of superior lines exceeded Rabat 9 by 114 to 168% and ILC 482 by 7 to 34%, at Tiaret and by 234 to 509% and 32 to 82% at Khroub, respectively. In the multilocation trial at SBA, yields were low and C.V. values were high due to drought and wilts. Across three locations, yield ranged between 0.42 to 0.72 t/ha and C.V. values were 27 to 36%. Twelve lines were selected with yields 23 to 65% greater than the local check. FLIP 84-145C, FLIP 84-144C, ILC 482, ILC 190 and X 80TH 177/ILC 195 X 80TH 177/ILC 195XILC 482 were exceptionally good lines.

Based on over-all performance over years and locations the following lines will be included in multilocation trial for winter chickpea: FLIP 81-293C; FLIP 83-49C, -97C, -98C, FLIP 84-19C, -32C, -53C, -109C, -144C, -145C; FLIP 85-15C, -16C, -18C, -55C. For spring chickpea FLIP 81-293C; FLIP 84-82C, FLIP 84-167C, and FLIP 84-181C will be tested in multilocation trial.

Table 7.2.23. Multilocation performance of high yielding and widely adapted winter chickpea lines in Algeria, 1987/88.

Trial and pedigree	Sidi-Bel-Abbas		Tiaret		Khroub		Mean**	
	Yield (kg/ha)	% of check	Yield (kg/ha)	% of check	Yield (kg/ha)	% of check	Yield (kg/ha)	% of check
CIYT-W-MR								
FLIP 83-47C	-	-	1920	173	1783	256	1852	205
FLIP 83-71C	390	105	2430	219	1702	244	1507	208
FLIP 83-98C	420	121	2880	259	1926	276	1742	240
FLIP 84-79C	-	-	2680	241	1416	203	2048	227
FLIP 84-102C	410	118	2010	181	1708	245	1376	190
FLIP 85-93C	-	-	2960	267	1257	180	2110	233
ILC 482	-	-	2580	232	1556	223	2068	229
Local check*	370	100	1110	100	697	100	726	100
LSD (5%)	136		739		246			
C.V. (%)	34.0		14.9		19.1			
CIYT-W-MR-T								
FLIP 85-12C	184	153	2030	431	1408	140	1207	378
FLIP 85-13C	230	191	2070	440	1932	192	1411	442
FLIP 85-18C	230	191	1590	338	1890	188	1237	388
FLIP 85-19C	150	125	2340	498	1650	164	1380	433
FLIP 85-49C	200	166	1650	248	1971	196	1274	399
FLIP 85-57C	170	141	1690	360	1814	180	1225	384
FLIP 85-62C	170	141	1970	419	1585	157	1242	389
FLIP 85-112C	320	267	1970	419	1421	141	1237	388
ILC 195	330	275	1920	408	1530	152	1260	395
ILC 3279	260	233	1830	389	1749	174	1280	401
Local check*	120	100	470	100	1007	100	319	100
LSD (%)	N.A.		738		308			
C.V. (%)	N.A.		17.5		21.1			

Values underlined are significantly higher than the yield of the local check at 5% probability level.

* The local check is Sebdou at Sidi-Bel-Abbes and Rabat 9 at Tiaret and Khroub.

** Means were based on 2 or 3 values depending on data from Sidi-Bel-Abbes.

Table 7.2.24. Grain yield of superior winter chickpea lines in comparison with the local Rabat 9 and the newly released cultivar ILC 482 at Tiaret and Khroub in Algeria, 1987/88.

Tiaret (CPYT)				Khroub (CMYT)			
Pedigree	Yield (kg/ha)	% of local	% ILC482	Pedigree	Yield (kg/ha)	% of local	% ILC482
FLIP 83-7C	2140	228	114	X 83TH 21	1382	479	144
FLIP 84-12C	2010	214	107	X 83TH 45	1273	442	132
FLIP 84-79C	2050	218	109	X 83TH 111	1416	491	147
FLIP 84-80C	2050	218	109	FLIP 82-128C	1458	506	151
FLIP 84-92C	2520	268	134	FLIP 82-172	1754	609	182
FLIP 84-93C	2060	219	110	FLIP 83-42C	1359	472	141
FLIP 84-144C	2270	241	121	FLIP 83-47C	1369	475	142
ILC 3279	2060	219	110	FLIP 83-69C	1630	566	169
ILC 482	1880	200	100	ILC 482	963	334	100
Rabat 9	940	100	50	Rabat 9	288	1001	30
LSD (5%)	547			LSD (5%)	640		
C.V. (%)	14.3			C.V. (%)	33.9		

Values underlined are significantly higher than the yield of the local Rabat 9.

In non-replicated observation nurseries, the adaptation of 275 chickpea lines were tested and 21 lines were selected at SBA from the regional chickpea nursery for North Africa (RCSN-NA). At Tiaret, 21 lines were selected from CIABN-A.

After being trained in crossing techniques, the national program started breeding through hybridization. Because of better conditions at Khroub, the program is advancing F1 crosses, 15 F1 progenies and 18 F3 progenies. In addition, nine F4 populations were selected as bulks from ICARDA CIF4T to be advanced for single plant selections under local conditions.

7.2.3.1.3. Lentil breeding

Lentil breeding emphasized high yield, early maturity, acceptable seed quality and mechanical harvesting traits.

Based on their performance on farmers fields, two large seeded cultivars, Balkan 755 and ILL 4400 were recommended for release to farmers. The small-seeded Syrie 229 was already released last season.

In both large and small seeded lentil, 133 advanced breeding lines were yield tested in nine replicated trials in 1 to 4 locations: three international (LIYT-L & S, LIF3T), one regional (LRYT) and six national (LPYT-A & B -SBA, LPYT-Tiaret, LPYT-Khroub, 3 multilocation). National trials comprise mostly ICARDA enhanced material selected under local conditions and some selections from local populations. Number of lines which exceeded the local check were 57, 21 and 8 in SBA, Tiaret and Khroub, respectively. They were promoted for further testing next season.

At SBA, lentil yields were mostly below 0.4 t/ha due to drought. Contrary to expectations under moisture stress in semi-arid conditions, early maturing lines performed poorly compared to lines with medium maturity. Apparently, the moisture stress in February and early March affected early-maturing lines while medium-maturity lines were benefited by the late rains in April. The improved early cultivar Syrie 229 produced exceptionally low yields at SBA station, contrary to other locations (Table 7.2.25). Inspite of generally poor performance, several tested lines outyielded Syrie 229 by 2 to 5 times.

In the international trials LIYT-S and LIYT-L, the best lines yielded 254 and 299 kg/ha, respectively, while the improved check Syrie 229 yielded only 86 and 193 kg/ha in the same order. The best small-seeded lines were FLIP 84-159L, FLIP 84-161L and FLIP 85-25L while the best large seeded lines were FLIP 86-8L and 81S 38226. In the regional North-African trial, 14 lines were selected and the best line 54749 (x 81S 116) yielded 239 kg/ha, five times the yield of Syrie 229 (45 kg/ha). In LIF3T, cross N^{o} 44 yielded 1128 kg/ha while Syrie 229 yielded 495 kg/ha. In preliminary yield trials, yields were also low but several lines outyielded Syrie 229 by 60 to 288% with a maximum yield of 470 kg/ha (Table 7.2.25). In the multilocation trial, ten lines were selected based on wide adaptation. Selected lines yielded 1 to 30% more than the improved Syrie 229 (730 kg/ha). The best three lines were NEL 2889, 310C x ESTON 1 and 76S 28004.

At Tiaret, lentil yields were relatively higher than SBA because of better rainfall. In the international trial LIYT-L, 7 lines were selected with 16 to 99% more yield than the check Metropole (660 kg/ha). Best lines were ILL 4400, FLIP 85-2L, FLIP 84-81L, FLIP 84-84L and FLIP 84-92L. In preliminary yield trials, 9 lines outyielded the check L.B. Chili by 71 to 217% and the best four were significantly better yielders (Table 7.2.25).

At Khroub, Syrie 229 the improved check ranked the first in yield in LIYT-L and LIF3T with yields of 1620 and 1693 kg/ha, respectively. The old time local cultivar L.B. Chili ranked the last in LPYT while Syrie 229 ranked 4th in the same trial. The best line was FLIP 87-20L which produced significanlty greater yield (2796 kg/ha) than Syrie 229 (2197 kg/ha) by 27%. Other good lines, FLIP 87-17L AND P-B Dahra, yielded 16% more than Syrie 229.

Table 7.2.25. Grain yield of superior lentil lines in preliminary yield trials at Sidi-Bel-Abbas and Tiaret, 1987/88.

SBA (LPYT-A)			Tiaret (LPYT)		
Pedigree	Yield (kg/ha)	% of local	Pedigree	Yield (kg/ha)	% of local
Balkan 755	470	388	Syrie 229	1690	217
NEL 1889	434	359	Rediaz	1560	200
NEL 468	387	328	Kreta	1500	192
FLIP 84-159L	389	321	Setif	1490	191
FLIP 84-62L	378	312	FLIP 84-100	1430	183
81S38342	376	311	NEL 30	1390	178
ILL 4400	339	280	FLIP 84-49L	1350	173
74TA19	318	263	NEL 468	1340	172
FLIP 84-100L	294	243	FLIP 85-2L	1330	171
78S26002	193	160	Metropole	1080	138
Syrie 9(check)	121	100	L.B. Chili (check)	780	100
LSD (5%)	128			666	
C.V. (%)	29.3				29.4

Values underlined are significantly higher than the yield of the local check.

In non-replicated international nurseries (LISN-L, LISN-T, LIABN), 20 and 22 lines were selected at SBA and Tiaret, respectively. Selected lines had good pod set, early maturity, tall and erect canopies.

7.2.3.1.4. Agronomy and microbiology

Agronomic studies included date of sowing, seeding rate, fertilization, *Rhizobium* inoculation, weed control and mechanical harvesting of lentil and chickpea. Some of these studies were conducted in on-farm verification trials while others were part of the back-up research. Recommendations are already available to farmers in Wilayet SBA on date of sowing, seeding density and herbicides for chickpea and lentil.

Recommended dates for planting are: early November for faba bean; mid December for winter chickpea; mid November to mid December for lentil. Seeding density recommendations are for chickpea 40 plants/m^2 (120-150 kg/ha) and for lentil 200 plants/m^2 (100-110 kg/ha). For chemical weed control, the following herbicides are effective in pre-emergence applications:

- chickpea: Igran (3.0 kg a.i./ha) + Kerb (0.5 kg a.i./ha)
- lentil : Maloran (1.5 kg a.i./ha) + Kerb (0.5 kg a.i./ha)
  or Tribunil (2.0 kg a.i./ha) + Kerb (0.5 kg a.i./ha)

In CWCT-88 in winter chickpea, the post-emergence herbicide treatment with Pyridate yielded 34% more than the weedy check and as much as the hand weeded control (1180 kg/ha). Cyanazine (0.5 kg a.i./ha) as pre-emergence yielded 30% more than the weedy check and 98% of weed-free control. Igran (3.0 kg a.i./ha) was also effective in controlling weeds in winter chickpea at Khroub. In LWCT-88 in lentil at SBA, Prometryne (Gesagard) at 1.5 kg a.i./ha with or without Kerb (0.5 kg a.i./ha) gave 87% of the yield of weed free check and was similar to Maloran.

In both fertilization and inoculation trials (IFRT-88 and IRT-88), no significant response to fertilization with phosphorus and potassium was observed in lentil. Lentil gave 27% increase in yield due to fertilization with 100 kg N/ha while chickpea showed no response. In inoculation trials, the chickpea Rhizobium strains 39 and 44 introduced from ICARDA increased yield of winter chickpea by 17% while strain 31 did so by 13%. The introduced lentil strains had no effect on yield. Weather conditions this season would necessitate application of caution on these results.

7.2.3.1.5. Pathology and entomology

Activities in pathology included screening for disease resistance, assessment of the disease situation and studies on pathogenic variability of Ascochyta rabiei. Work on diseases is done in collaboration with ITGC, INA and ICARDA. In entomology, survey of the insect pest situation was made in Wilayet SBA.

For Ascochyta blight, artificial inoculation of CIABN nursery at SBA started the disease symptoms early in the season. However, due to the dry weather and the inability to irrigate, disease spread was not uniform and disease development stopped. In one hot spot, lines FLIP 83-72C and FLIP 84-93C scored 2 on the 1-9 rating scale while the spreader line ILC 263 scored up to 7.

For wilts, naturally infested sick plots were used at SBA and Guelma to screen two wilt-resistance screening nurseries: ICARDA regional nursery (INARFWN-88) and ICRISAT international nursery (ICRRWN). At SBA, the following 14 lines were found resistant (with less that 10% wilt incidence)

- INARFWN-88: FLIP 84-32C, -88C, -97C; FLIP 85-1C, -20C, -33C, -35C.
- ICRRWN-88: ICC 4973, ICC 12263, ICCL 82108, ICCL 84327, ICCL 85308, ICCV 10, ICCV 11.

At Guelma the following lines were resistant to tolerant to both wilt and drought:

- ICRRWN-88: ICC N° 2862, 4951, 11322, 11322, 12263; ICCL N° 82108, 84303, 84327, 85225.
- CIYT-W-MR: FLIP 85-13, -19C, -57C, -146C, -151C.

- CIYT-L: FLIP 85-14C, -15C, -16C, -17C, -55C, -56C, -60C.
- CPYT: ILC 72.

Assessment of the disease situation was done in Algeria by a team of national and ICARDA scientists. In Wilayet SBA, stem nematodes were serious on faba bean. Infestation up to 100% was observed in one field. In chickpea, *Fusarium* sp. and *Ascochyta pinodella* (*Phoma medicaginis*) were serious in Zeindan farm. In Tiaret, *Ascochyta lentis* was found on lentil but was not serious. In Geulma, Fusarium wilt was serious on chickpea and a whole field was infested on the station. In Khroub, *Ascochyta fabae* was serious on the local cultivar of faba bean.

In the study on variability of *Ascochyta rabiei*, several local isolates were identified with different levels of virulence.

With respect to the insect pests, three major problems were identified: (a) bruchids damage on stored seeds particularly on lentil, (b) leafminer on chickpea and (c) *Sitona* larvae damage on nodules of faba bean.

7.2.3.2. On-farm verification trials

Verification trials were conducted on farmers' fields on varietal performance, chemical weed control and mechanical harvesting in the three agroclimatic Zones I, II and III in Wilayet Sidi-Bel-Abbes (SBA).

7.2.3.2.1. Varietal performance

Variety verification trials were carried out in chickpea and lentil at three sites representing the different agroclimatic conditions.

In chickpea, location mean yields of the 12 tested cultivars were 380, 460 and 600 kg/ha at SBA station and Zeidan and Tassala farms, respectively. Yields were low due to drought and wilt. Both the local cultivar Ain Temochent and the improved spring cultivar Sebdou gave similar yields and were used as checks. The four lines ILC 190, ILC 482, NEC 105 and NEC 2380 were superior over locations and yielded 4 to 18% more than AIN Temochent and 6 to 20% more than Sebdou. However, none were significantly higher than the check at any of the locations. The late maturing ILC 3279 did poorly because of early drought. Based on results of this year and those of previous seasons, ILC 190 will be demonstrated to farmers on large scale for winter sowing while NEC 105 and NEC 2380, being susceptible to Ascochyta, will be demonstrated for spring sowing.

In lentil, the verification trial included 11 lines. Yields were low due to drought particularly at SBA station where yields of most lines were practically nil. Location mean yields were 104, 513 and 877 kg/ha at SBA, Zeidan and Tessala. The improved cultivar Syrie 229 was used as a check. All the lines, except the old time local L.B. du Chili, outyielded Syrie 229 by 2 to 34%. The lines NEL 45 R, NEL 1889, Setif 618 and Balkan 755 were exceptionally good yielders and gave significantly higher yields than Syrie 229 at Tassala Pilot Farm. At Seidan farm they yielded 795 to 1016 kg/ha. These lines will be demonstrated to farmers next season on large scale if enough seed is available.

7.2.3.2.2. Weed control

The effectivity of four and three herbicidal treatments were verified on farmers fields in chickpea and lentil, respectively. In chickpea, the pre-emergence treatment Igran (3 kg a.i./ha) plus Kerb (0.5 kg a.i./ha) proved its effectivity in controlling weeds as it yielded 65% more than the unweeded treatment (Table 7.2.26). Patoran was effective but it caused phytotoxicity and residual effect in the soil. On lentil, Tribunil (2 kg a.i./ha) plus Kerb (0.5 kg a.i./ha) yielded as much as the hand weeded check and four times the unweeded treatment (Table 7.2.16). However, both wild oats and Bromus spp. were not controlled well by Tribunil. Igran (3 kg a.i./ha) plus Kerb (0.5 kg a.i./ha) and Gesagard (1.5 kg a.i./ha) plus Kerb were also effective. Gesagard showed phytotoxicity on lentil. Maloran which is effective on lentil was not used because the chemical was not available.

Table 7.2.26. On-farm verification trials of herbicidal treatments on chickpea and lentil in Sidi-Bel-Abbes, Algeria, 1987/88.

Chickpea			Lentil		
Treatment	Yield (kg/ha)	% of hand weeded	Treatment	Yield (kg/ha)	% of hand weeded
Igran+Kerb	1189	87	Igran+Kerb	3345	83
Kerb	965	71	Tribunil+Kerb	425	102
Igran	1078	79	Gesagard+Kerb	342	82
Aretit	765	56	Patorab	322	77
Potoran	1060	77	Unweeded (check)	106	25
Unweeded (check)	718	52	Hand weeded (check)	417	100
Hand weeding	1368	100			
LSD (5%)	66		LSD (5%)	67	
C.V. (%)	307		C.V. (%)	11.1	

Underlined values are significantly higher than the unweeded check.

7.2.3.2.3. Mechanical harvesting

Verification of combine harvesting of chickpea and lentil was done on farmers fields using 3 m header combine. Results of economic analysis were different for lentil and chickpea whereby combine harvesting was economical in lentil contrary to chickpea. However, results in chickpea are inconclusive because of high level of grain loss due to seed shattering because of delay in harvesting and problems in combine adjustments.

In lentil, grain losses were 44 and 29% in manual and combine harvesting, respectively. Economic analysis showed that cost of production can be reduced by 27% by substituting hand labor by the combine. Reducing grain loss increased income by 24%. Therefore, the cost benefit ratio was improved considerably although lentil yields this season were not economical due to the serious drought. Combine harvesting of lentil will be demonstrated to farmers on large scale in the coming year.

7.2.3.3. On-farm demonstrations

Demonstration plots were set on farmers fields in various agroclimatic zones in Wilayet Sid-Bel-Abbes to transfer to farmers improved production packages in both chickpea and lentil.

7.2.3.3.1. Winter chickpea production package

The winter chickpea package included new varieties (ILC 482, ILC 3279 and Sebdou), date of planting (winter vs spring) and chemical weed control (Igran 3 kg a.i./ha plus Kerb 0.5 kg a.i./ha). Large demonstration plots were managed by ITGC at three sites while additional seeds of improved cultivars were given to progressive farmers to manage production on their own. Of the three sites, one failed due to excessive drought, serious stem rot at seedling stage and dense population of wild vetch which was not controlled by the herbicides. Inspite of the drought, the winter chickpea package gave economic yields and farmers were satisfied with the crop particularly when many lost their spring chickpea or had low yield (average 220 kg/ha in SBA). Winter sowing of ILC 482 yielded 1060 to 1400 kg/ha compared to the 100 to 630 kg/ha of the spring sown local check (Turkish) planted locally (Table 7.2.27). Across locations, ILC 482 yielded more than four times the local check planted in spring and even 26% more than Sebdou. ILC 3279 did not perform well because it is late. Nevertheless, it yielded 694 to 950 kg/ha. Sebdou yielded 700 to 1250 kg/ha. Ascochyta blight did not develop this season due to drought and thus both tolerant lines *ILC 482* and *ILC 3279* had no advantage over the susceptible local lines.

Table 7.2.27. On-farm demonstration plots of winter chickpea at two locations in Wilayet Sidi-Bel Abbes in Algeria, 1987/88.

Season and line	Tassalah Pilot farm		Bengamra		Mean	
	Estimated* (kg/ha)	actual (kg/ha)	Estimated* (kg/ha)	actual (kg/ha)	Estimated* (kg/ha)	actual (kg/ha)
Winter						
ILC 482	1420	1400	980	1060	1200	1230
ILC 3279	*1060*	*950*	*790*	*694*	925	822
Sebdou	1530	1250	990	700	1260	975
Spring						
Sebdou	850	720	-	100	-	410
Turkish type (check)	770	630	-	100	-	365

* Estimates are based on yield of 8 one-meter square quadrats harvested at random.

7.2.3.3.2. Lentil production package.

In lentil, the improved production package included three improved cultivars (Syrie 229, Balkan 755, ILL 4400), early planting, chemical weed control (Patoran 2 kg a.i./ha since Maloran was not available) and combine harvest. It was demonstrated in three sites having different agroclimatic conditions. Yields were low but double of those of L.B. du Chili used locally (Table 7.2.28). ILL 4400 was the best yielder across locations, giving almost twice as much yield as the local L.B. du Chili and 26% more than the newly released Syrie 229.

Algerian National Scientists and Dr. M. Solh.

7.2.4. Other activities

Several activities were undertaken in the region during the 1987/88 season to contribute to the technical research, transfer of technology, development of national programs through training and exchange of visits, coordination of research activities at national and regional levels, development of project proposals for financing national and regional research work, and the assessment of investment in research.

Coordination meetings were held in September, 1987, in Morocco, Algeria and Tunisia to discuss previous years results and develop working plan for 1987/88 season. These meeting were attended by national scientists from various national institutions and 3 to 4 ICARDA-FLIP scientists.

Training was an important component of the 1987/88 activities. Beside residential and individual training courses at Aleppo, two in-country training courses were conducted. The first was a regional

Table 2.7.28. Performance of promising lentil lines in on-farm demonstration plots in Wilayet Sidi-Bel-Abbes in Algeria, 1987/88.

Line	Saadeh Farm		Bengmra		Zeidan		Mean1	
	Estimated2 (kg/ha)	actual (kg/ha)	Estimated2 (kg/ha)	actual (kg/ha)	Estimated2 (kg/ha)	actual (kg/ha)	Estimated2 (kg/ha)	actual (kg/ha)
Syrie 2293	398	360	600	-	460	300	486	420
Balkan 755	260	140	800	-	495	330	518	420
ILL 4400	410	300	719	-	580	578	570	530
L.B.du Chili	110	300	410	-	100	100	207	270

1. Yield estimates at Bengmra were considered in calculating the mean.
2. Estimates are based on 8 one m/sq. quadrats harvested at random.
3. Syrie 229 is already released as an improved cultivar.

training course on experimentation in Meknes-Morocco. Participants were mainly from Morocco (15 from INRA-Morocco and 23 from DVRA-MARA). The course combined researchers and extension agents for the first time in the region. The second course was on crossing techniques in Tunisia. The course was attended by 11 Tunisian participants and one Moroccan.

National scientists were sponsored to visit ICARDA-Aleppo and attend workshops to encourage interaction and regional cooperation. The coordinators of the two food legume programs in Morocco and Algeria and the ICARDA regional scientist visited Aleppo in late May for selection of breeding material and discussions on research methods. One national scientist was supported for the Mediterranean regional meeting on chickpea in Spain.

To assess investment in the development of research work in food legumes in north Africa particularly in Tunisia, the IDRC team visited Tunisia with the regional food legume scientist and later the home-base program for future discussions.

NARSs in North Africa, Dr. M. Solh and other FLIP Scientists.

8. BIOTECHNOLOGY

8.1. Increase of Genetic Variability in Lentil and Chickpea

Often situations are found where the genes available within the cultigens are not sufficient for a substantial further plant improvement. Here biotechnology offers innovative approaches to increase the genetic variability. In November 1987 FLIP started research projects in this area at ICARDA.

8.1.1. Wide-crossing in lentil

Wide-crossing is one possible approach to increase the genetic variability in lentil. In this case an ovule-embryo rescue technique is being used to overcome the crossability barrier between Lens culinaris ssp. culinaris and L. nigricans ssp. nigricans and L. nigricans ssp. ervoides. To develop the procedure and to select the most promising accessions for wide-crossing imbibed seeds were deprived of the integument and cotyledons to simulate the wide-cross situation of disturbed cotyledon development. Ten accessions of L. nigricans ssp. nigricans and L. nigricans ssp. ervoides each were screened for their ability to develop into plantlets. Great differences were observed in the survival rate not only between the 2 wild species but also between accessions of the same species (Fig. 8.1.1 A,B). Losses which occur during the first 10 days of in vitro culturing (1st observation) may be due to the lack of initial growth in response to the hormone composition of the media. It is also likely that the losses are due to mechanical damage caused to the embryo during ovule deprivation of the integuments and cotyledons. To avoid the damage the deprivation of the

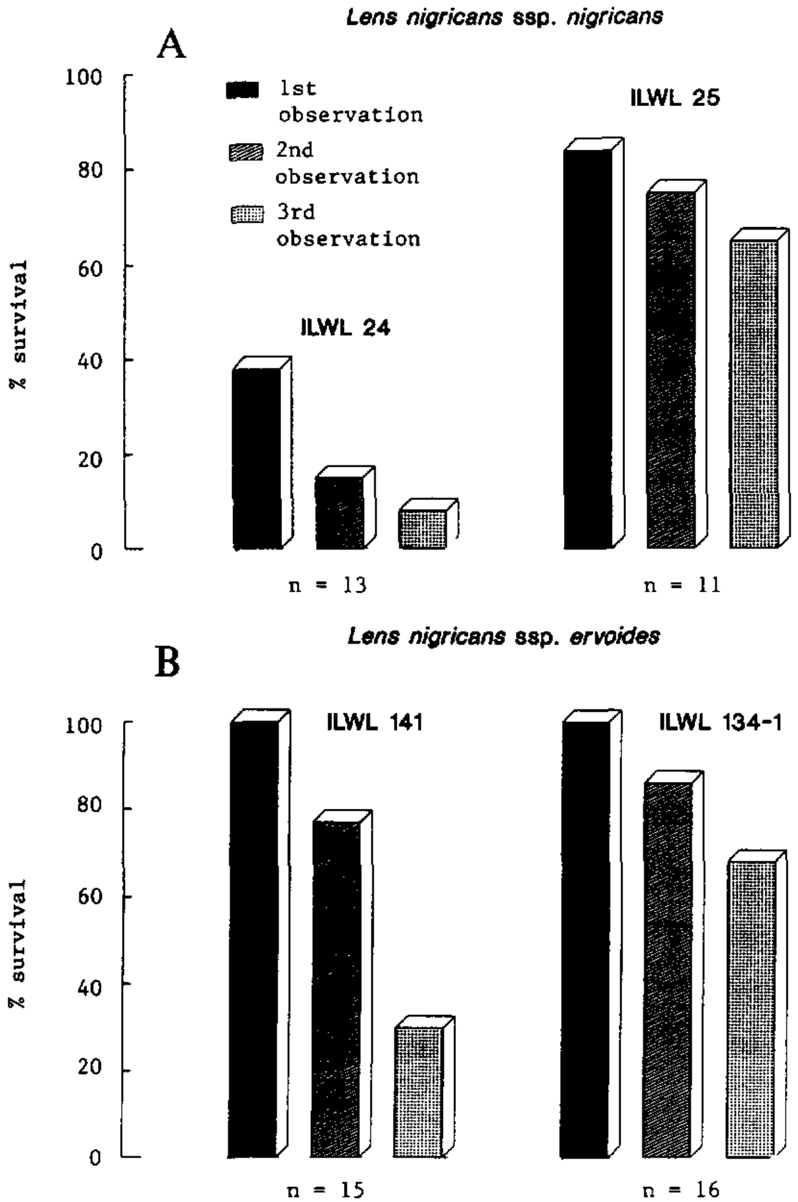

Figure 8.1.1. Survival of embryos deprived of integument and cotyledon in two accessions of L. nigricans ssp. nigricans (A) and L. nigricans ssp. ervoides (B) showing the range in survival rates over the ten accessions. Observations were taken 10 days after the removal of the integument and cotyledon, 3 weeks later, and 2 weeks after transfer to soil.

ovules from the integuments should be conducted using a micromanipulator attached to a stereo-microscope.

The second observation was taken 3 weeks after the first observation and clear differences were found in the development of the plantlets. While in some accessions development was sufficient, in several accessions shoot and root development was poor and some plantlets ceased further development and died. To improve shoot and root development 6 different hormone compositions were used but no effects on development of the plantlets were found.

The third observation showed the survival rate of successfully transferred plantlets to soil, 2 weeks after transfer. Weak plants with poorly developed shoots and/or roots died in spite of all efforts to harden the plantlets gradually. In general L. nigricans ssp. ervoides accessions were less susceptible and had a higher survival rate.

This experiment allowed to identify wild species accessions with a 60-65% survival rate. Most promising accessions, which have a better chance to survive the ovule-embryo rescue technique, are currently used in a wide-crossing scheme with a cultivated lentil variety (Idlib-1). The first successfully pollinated ovules of crosses between the cultigen and accessions of both wild subspecies are in vitro culture at the moment. The ovules are extremely small and when the integument has to be removed without damaging the embryo, a micromanipulator is needed. Some hybrid-embryos are now regenerating into plantlets. The hybrid character of these progenies needs further confirmation. This project should be continued with highest priority.

8.1.2. Somaclonal variation to improve drought tolerance in lentil

The objective of this project is to improve drought tolerance in lentil by mutation. The plants which are cultivated at the cell or callus level have an increased spontaneous mutation rate. Although this increased rate of mutation is a handicap to plant improvement by tissue culture techniques when genetic stablity is required, e.g. in haploid breeding, it might be useful if increased genetic variability is needed. A special advantage as compared with other mutation breeding techniques is the theoretical possibility to select for positive mutations at the same time. A prerequisite for the use of somaclonal variation in combination with in vitro selection is a technical protocol for the following:

1. Callus induction
2. Callus maintenance
3. Selection for useful somaclones
4. Plant regeneration from callus
5. Demonstration that plants aquired improved drought tolerance and that this new characteristic is genetically stable and heritable.

A technical protocol for callus induction and maintenance has been developed. To select tissue with improved water uptake different concentrations of polyethylene glycol (PEG) were added to the basic media using also different periods of application. It was tried to make selections from callus grown on semi-solid media or as suspension culture. Up to now the results, however, are inconsistant and also the ability for regeneration was lost. During regeneration of untreated cells it was possible to produce strong shoots but subsequent root successful.

8.1.3. Callus induction in chickpea

Best callus induction was achieved when shoot apex were used as explant and cultivated on media suplemented with 0.1 mg Kinetin, 0.2 mg 2,4-D and 0.2 mg NAA. This activity was discontinued.

8.1.4. Agrobacterium tumefaciens- a potential gene vector for chickpea

This project is conducted in cooperation with the Department of Botany, University of Frankfurt, FRG. The objective of this project is to identify appropriate strains of Agrobacterium tumefaciens which could be used for application of genetic engineering in chickpea improvement. Four wild strains of A. tumefaciens (WT C58, T37, B6S3 and Ach 5) are presently being tested at ICARDA. Wounded chickpea cotyledons (ILC 482) were inoculated with the bacterium suspension. Three of them (WT C58, B6S3 and Ach 5) induced intensive tumor growth and seem to represent potential gene vectors for chickpea. The biochemical proof of the successful gene transfer, integration in the host genome and the gene expression will be obtained by Southern blotting and the nopaline synthetase test, respectively. Southern blotting represents a DNA-hybridization test which is used to prove the integration of T-DNA (transferred DNA) into the target genome. The nopaline synthetase test shows if the successfully integrated T-DNA is actively expressed in the host genome. These tests will be done at the University of Frankfurt. To improve the non-tissue-culture approach of plant transformation germinating embryos instead of wounded cotyledons will be used in future experiments to reduce the probability of undesirable somaclonal variation during plant regeneration.

8.1.5. Restriction Fragment Length Polymorphism (RFLP)

This project is conducted in cooperation with the Department of Botany, University of Frankfurt, FRG. RFLP is a molecular technique to prepare "fingerprints" from the whole genome of a plant which is unique to the respective genotype. These "fingerprints" can be correlated with traits of agronomical value by a computerized linkage-analysis. Data can be used to map qualitative and quantitative traits on the crop genome and could expedite the recovery of phenotypical undetectable genetic traits of desirable, recurrent parent alleles (in F 2 generation) and thus reduce the length of breeding programs and make them more efficient. Plant material of 15 selected genotypes each of lentil, chickpea and barley are planted and will be analyzed at the University of Frankfurt, FRG by a newly developed set of DNA marker probes.

Dr. F. Weigand.

9. TRAINING AND NETWORKING

Training and networking activities aim at strengthening National Agricultural Research Systems (NARS). The objective is to enhance the technical capability in food legume research in the NARS and strengthen networking. Table 9.1.1. summarises the training activities during 1988. A total of 170 participants received training on various aspects of improvement of lentil, faba bean, and kabuli chickpea.

Table 9.1.1. Summary of training courses in 1988.

Type of training and topics	No. of participants	No. of countries represented
Training courses at Aleppo		
1. Group courses	41	14
1.1. Residential		
1.2. Insect control		
1.3. Disease methodologies		
1.4. Lentil harvest mechanization		
2. Individual non-degree	21	7
2.1. Microbiology		
2.2. Agronomy		
2.3. Entomology		
2.4. Pathology		
2.5. Data processing		
2.6. Mechanization		
3. Individual degree	7	4
3.1. Orobanche control		
3.2. Quality		
3.3. Breeding		
3.4. Agroonmy		
3.5. Physiology		
In-country training courses	101	6
1. Crossing techniques (Tunisia)		
2. Hybridization techniques (Turkey)		
3. Legume Improvement (PROCIANDINO, Ecuador and Colombia)		
4. Field experimentation (Morocco)		
5. On-farm trials (Ethiopia)		

9.1. Group Training

9.1.1. Food legume residential course

The annual food legume improvement course, which covers main part of the cropping season, was attended by 14 participants from 9 countries (Table 9.1.2). The course focused on imparting research skills for field and laboratory work in crop improvement. The participants worked with a multidisciplinary team of legume scientists. They were also exposed to the systems approach in crop improvement research. Complementary topics such as analysis of data, interpretation, and report writing were covered.

Evaluation of the trainees and the course was consolidated during 1988 to include the testing before and after the course as also the continuous evaluation of various activities during the course. The outcome was highly encouraging showing a clear gain in the knowledge base of trainees.

9.1.2. Lentil harvest mechanization

The third Lentil Harvest Mechanization course was held at ICARDA, Aleppo, from 4-12 May, 1988 with funding from the International Development Research Center (IDRC) and co-sponsorship with the Faculty of Agriculture, University of Jordan. Eight trainees (B.Sc. level) from five countries attended the course. The program covered both the theory and practice of lentil harvest mechanization from the standpoints of plant breeding, agronomy, economics, and farm machinery. The course thus tackled the problem in an integrated manner. We intend to do a follow-up so that the trainees upon return will undertake their

Table 9.1.2. Participation in group training in the Food Legume Improvement Program 1988.

Type of Training	Duration	Name of the participating countries	No.of participants
A. Residential			
Food legume improvement	3.5 months	Algeria, Bangladesh, China, Egypt, Sudan, Syria, Turkey, Mexico, Colombia	14
B. Short courses			
Disease methodologies	20.3.-7.4.88	Morocco, Mexico, Syria, Tunisia, Turkey	8
Insect control	24.4.-30.4.88	Algeria, China, Ethiopia, Morocco, Sudan, Syria, Tunisia, Turkey, Pakistan	11
Lentil harvest mechanization	3.5.-12.5.88	Jordan, Morocco, Syria, Tunisia, Turkey	8
C. In-Country Training Courses			
Hybridization techniques	4-17.4.88	Tunisia	13
Hybridization techniques	10-14.5.88	Turkey	11
The First International Course for the Production of Faba Beans, Lentils Sweet Peas and Chickpeas in the Andean region	9-20.5.88	Colombia, Ecuador	11
Field experimentation	6-12.3.88	Morocco, Tunisia	44
Food legume on-farm trials methods	5-14.9.88 3-7.10.88	Ethiopia	22
Total			142

own trials on mechanization in an effort to move the technology to the fields of their farmers.

9.1.3. Insect control

Food legume crops in West Asia and North Africa are attacked by many insect pests which may affect the productivity and stability of the crops. To strengthen the research capabilities of national research programs in this area we conducted a training course on "Insect Control in Food Legumes" during April 24-30, 1988 at Aleppo. The course was attended by 11 participants from 9 countries having B.Sc. and M.Sc. level background. Assessment of insect infestation and damage, sampling and monitoring of insect populations, screening for host plant resistance, use of pesticides, collection of insects, and application of biological control were the topics covered in a series of class-room and field lectures. This course, which is the first in a series, will be followed by others including also topics such as planning of experiments, data collection, evaluation and reporting.

9.1.4. Disease methodologies

Disease problems in food legume crops result in high yield losses in WANA region. To strengthen the research capabilities of NARS scientists in methods of integrated control of diseases a course was conducted during March 20 - April 7, 1988. The course was attended by 14 participants (B.Sc. and M.Sc.) from 9 countries. The participants were trained in identification of major diseases of faba bean, lentil, and kabuli chickpea; propagation of pathogens for artificial inoculation; inoculation in fields; use of disease scales; and use of integrated control methods. Common rating scales and monitoring proceedings are a pre-requisite for effective networking. The training would assist in strengthening the recently developed disease network.

9.1.5. Hybridization techniques in-country courses in Turkey and Tunisia

National programs are now becoming increasingly interested in initiating their own varietal improvement program by undertaking crossing at their own station. Courses were therefore held at Diyarbakir, Turkey, and Tunis, Tunisia, during 4-17 April and 10-14 May, 1988, respectively. The course in Turkey was attended by 11 technicians who practiced the skill of successfully crossing lentil and chickpea flowers. In Tunis, 13 technicians participated and were able to attain good success in crossing in each of faba bean, lentil and chickpea. In both countries the national breeders participated along with ICARDA breeders as instructors.

9.1.6. On-farm trials methodologies in-country course - Ethiopia

On-farm evaluation of cultivars and production practices is a pre-requisite for their acceptance by the farmers. Hence FLIP conducts on-farm trial methodologies courses for NARS. During 1988, the course was conducted at Holetta, Ethiopia for the Highland Pulses Team of Ethiopia in collaboration with the Institute of Agricultural Research (IAR).

The course was conducted in two phases (Phase I: September 5-14; Phase II: October 3-7). It was attended by 11 trainees working on legume research at various research stations of IAR, Debre Zeit of Alemaya University, and extension unit of IAR. The participants were instructed by 12 senior scientists from IAR and ICARDA on: rationale for and types of on-farm trials, their planning and implementation, and data collection and analysis. This was complemented with field visits to on-farm trials being conducted as a part of the Nile Valley Project on faba bean.

9.1.7. Field experimentation in-country course - Morocco

The course was conducted in Meknes, Morocco, during 6-12 March, 1988, to improve the capabilities of field staff involved in the conduct of field experimentation. Besides covering the aspects of design, layout, data collection and data analysis of experiments it also covered ways of handling international and regional nurseries.

Forty four technicians from Morocco and Tunisia attended the course. The mix of extension and research staff allowed exchange of ideas on matters related to trials on farmers' fields. This was augmented by visits to farmers' fields, on-farm trials, and Douyat Research Station. Instruction in the course was mainly done by Moroccan scientists from INRA and INA University at Meknes, along with three ICARDA scientists.

9.1.8. International course on production of food legumes in the Andean region - Colombia and Ecuador

FLIP collaborated with the PROCIANDINO (Programa Cooperativo de Investigacion Agricola para la Subregion Andina) in conducting the "First International Training Course for the Production of Faba Beans, Lentils, Sweet Peas, and Chickpeas in the Andean Region" during May 9-20 at Quito, Ecuador, and Pasto, Colombia. In addition to participation in the conduct of the course, FLIP scientists (the training scientist and the international nursery officer) discussed with the teams from the Andean countries their future training needs and the ways in which networking in PROCIANDINO could be supported.

The course covered general aspects of crop improvement research on food legumes in the Andean countries (Colombia, Ecuador, Peru, Bolivia, and Venezuela), and the relevance of research at ICARDA for the Andean region. This was done through lectures and discussion sessions. The eleven course participants and the country coordinators arrived at a formula whereby each country was assigned the responsibility of undertaking research on a specific problem common in the region. This was done on the basis of availability of trained manpower and resources.

9.2. Individual Non-Degree Training

Training opportunities on individual basis were offered to NARS as per the specific needs identified by them. Skills covered and duration of training are listed in Table 9.1.3. The syllabi were tailored to suit the capability and needs of the individuals.

9.3. Degree Training

Under the Graduate Research Training Program (GRTP) and scholarships from specific donors, 7 students joined FLIP during 1988 and conducted thesis research in partial fulfilment of the requirements for Diploma/ M.Sc. (6) and Ph.D. (1) degrees (Table 9.1.4). In addition eight students, who joined the program in 1987, continued with their thesis research during 1988 (Table 9.1.4). Two of these students completed their Ph.D. degree by their universities. In line with ICARDA policy the supervisors of the students visited FLIP to discuss the progress of thesis research.

Table 9.1.3. Participation in the individual non-degree training 1988.

Topic	Names of the participants	Country	Duration
Microbiology	Mohamed Abdalla El-Khadir	Morocco	3.2.88- 1.3.88
	Mufeeda Ismail	Syria	10.4.88-16.6.88
	Getnet Desalegne	Ethiopia	23.3.88-16.6.88
	Mohamed Labidi	Tunisia	3.4.88- 3.5.88
Entomology	Hassan Houbbo	Syria	25.4.88-25.6.88
	Nabile Kaya	Turkey	1.5.88- 4.5.88
	Ulku Haykir	Turkey	1.5.88- 4.5.88
	Omar Zeghouane	Algeria	1.5.88- 6.5.88
	Samir Tchoketch	Algeria	1.5.88- 6.5.88
	Alemu Kebede	Ethiopia	23.3.88-16.6.88
	Abdel Hamid Fattouh	Syria	
	Nuhad Batham	Syria	
	Khalid Mahmoud	syria	
	Hussam El Din Ibrahim	Syria	
	Hala Rida	Syria	
Breeding	Getachew Fisseha Mengistu	Ethiopia	23.3.88-16.6.88
Agronomy	Hajo Souror	Sudan	4.5.88- 4.6.88
Mechanization	Suleiman Atia Al-Ghabiet	Syria	10.1.88-14.1.88
	Yassin Mohammed Al-Najar	syria	10.1.88-14.1.88
	Issa Bashier	Syria	10.1.88-14.1.88
Physiology & Agronomy	Million Eshete	Ethiopia	2.3.88- 3.9.88

9.4. Workshops

9.4.1. West Asian Seminar on food legumes

A West Asian Seminar on food legume was conducted jointly with the Directorate of Scientific Agriculture Research, Ministry of Agriculture, Syria during May 2-5 at Aleppo. The main objective was to encourage interaction between the food legume researchers within West Asia and get feed-back on research and training needs. Scientists from Cyprus, Iraq, Jordan, Lebanon, Syria and Turkey were invited.

Table 9.1.4. Participation in individual degree training 1988.

Name	Degree	Registered in University	Registered in Country	Duration
Registered in 1988:				
Gerold Wyrwal	M.Sc.	Hohenheim	Germany	22.1.88-22.5.88
Petra Engelhard	M.Sc.	Hohenheim	Germany	5.2.88-30.7.88
Christine Vorlander	M.Sc.	Giessen	Germany	5.2.88-30.7.88
Doris Vetterlein	M.Sc.	Hohenheim	Germany	11.2.88-15.7.88
Andreas Gross	Ph.D.	Hohenheim	Germany	2 years
El Nour Abdul Majid	M.Sc.	Khartoum	Sudan	30.10.87-30.10.88
Christopher Hall	M.Sc.	Reading	England	4.5.88-2.6.88
Registration continuing from 1987:				
Ghada Hanti	M.Sc.	Aleppo	Syria	2 Years
Stefan Schlingloff	Ph.D.	Giessen	Germany	2 Years
Thomas Bambach	Ph.D.	Hohenheim	Germany	3 Years
Edwin Weber	Ph.D.	Hohenheim	Germany	3 Years
Theodor Friedrich*	Ph.D.	Gottingen	Germany	3 Years
Ahmed Hamdi*	Ph.D.	Durham	U.K.	3 Years
Nidal Naneesh	M.Sc.	Jordan	Jordan	2 Years
Bashir Ahmed Malik	Ph.D.	Quaid-I-Azam	Pakistan	2 Years
Mohamed El-Bashir	M.Sc.	Khartoum	Sudan	2 Years
Ahsanul Haq	Ph.D.	Punjab	Pakistan	3 Years

* *Degree awarded during 1988.*

Scientists from China, France and Poland visiting the Program also attended the Seminar.

A summary of food legume research efforts was presented by the scientists from the participating countries and ICARDA. In addition, the meeting discussed and formulated strategies for strengthening the future collaborative activities.

9.4.2. Workshop on the Role of Legumes in the Farming Systems of Mediterranean Areas

As planned in the UNDP supported project on 'Transfer of Technologies' being jointly executed with the PFLP, we organized the third and the last Workshop of the project in Tunis, Tunisia, 20-24 June 1988, to review the research on the role of food and forage legumes in the farming systems in dry areas with Mediterranean type of climate. Twenty three scientists from national programs, seven resource scientists from industrialised countries and 11 ICARDA scientists participated in the Workshop. Data generated on the subject were critically reviewed and recommendations for future work were developed. The Proceedings of the Workshop will be published.

NARS, Dr. H. Ibrahim and other FLIP scientists.

10. PUBLICATIONS

10.1. Journal Articles

Di Vito, M., Greco, N., Singh, K.B. Saxena, M.C. 1988. Response of chickpea germplasm lines to Heterodera ciceri attack. Nematol. Medit. 16: 17-18.

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10.2. Conference Papers

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Production and Improvement in the Mediterranean Countries" held at Zaragoza, Spain, July 11-13, 1988.

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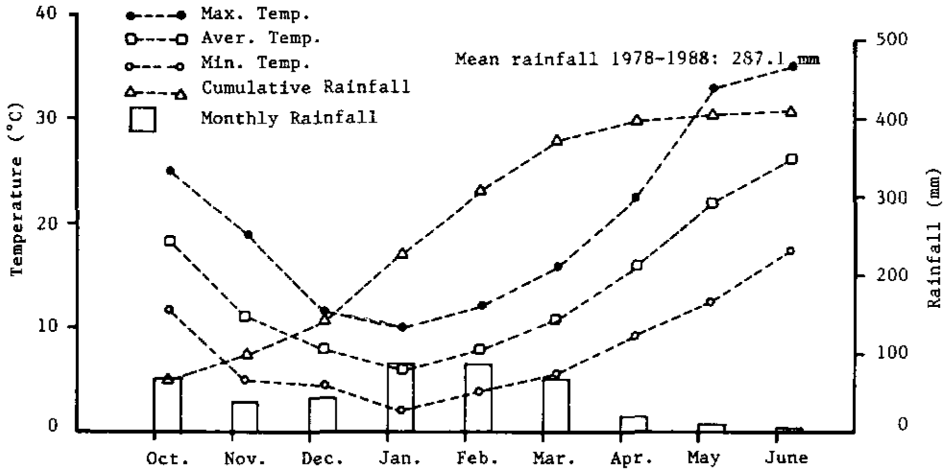

Figure 11.1. Weather data for 1987/88 at Breda.

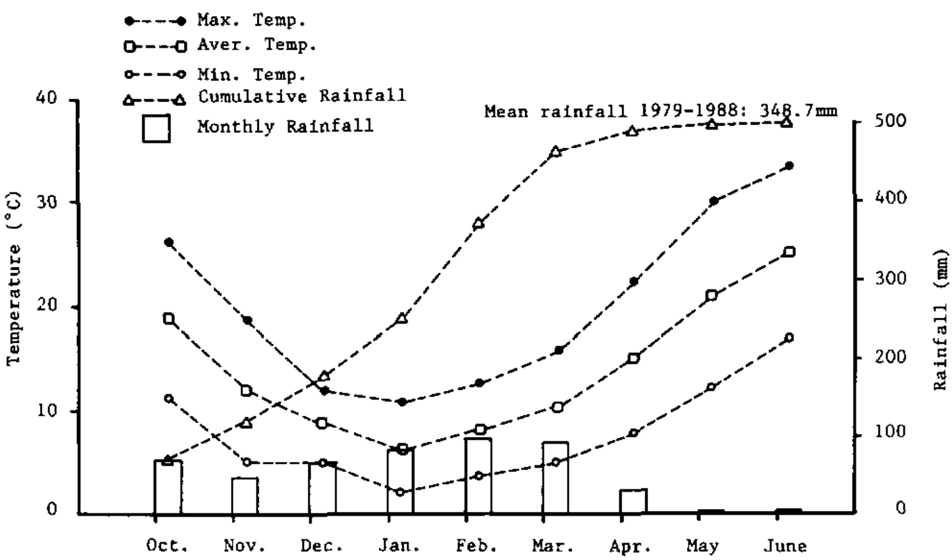

Figure 11.2. Weather data for 1987/88 at Tel Hadya.

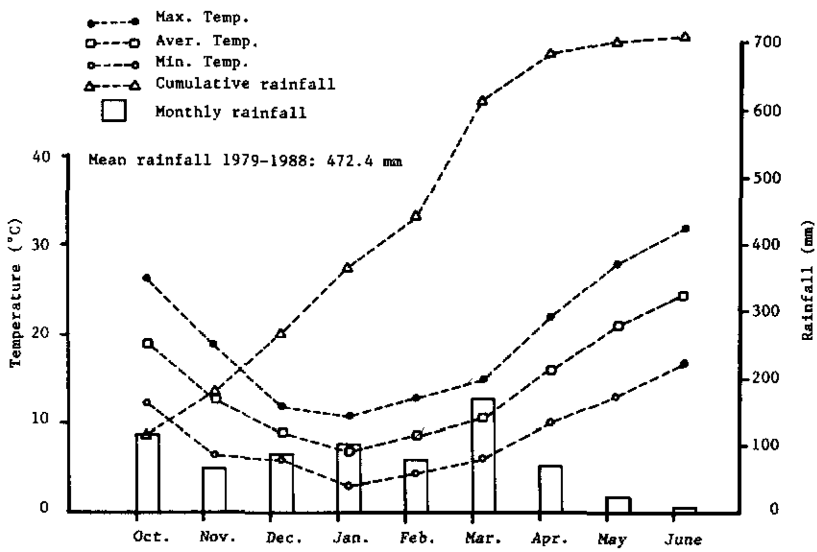

Figure 11.3. Weather data for 1987/88 at Jindiress in 1987/88 season.

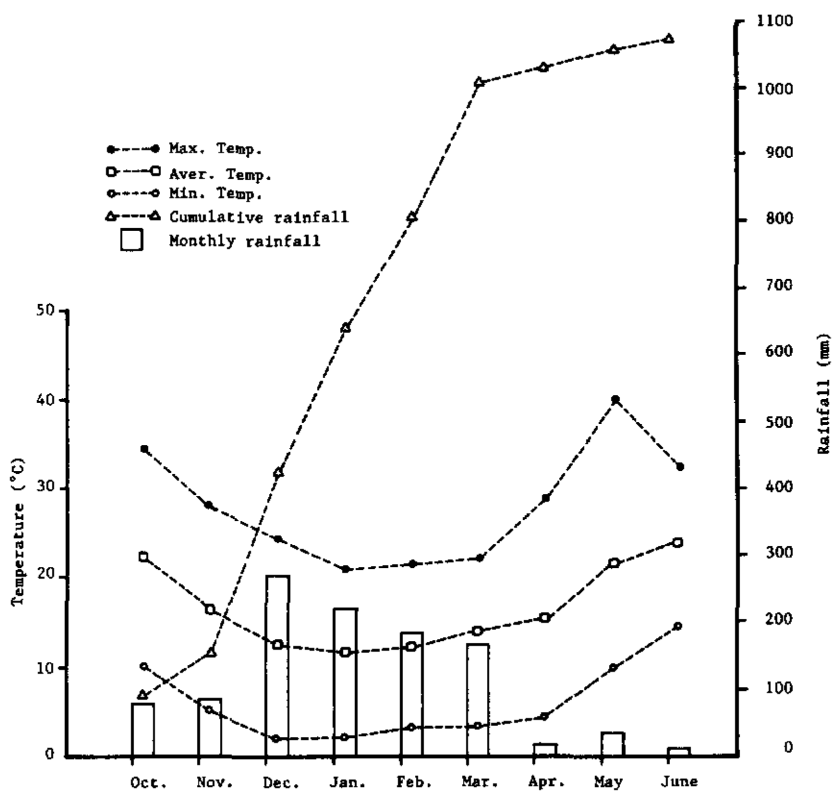

Figure 11.4. Weather data for 1987/88 at Zeera (Lattakia).

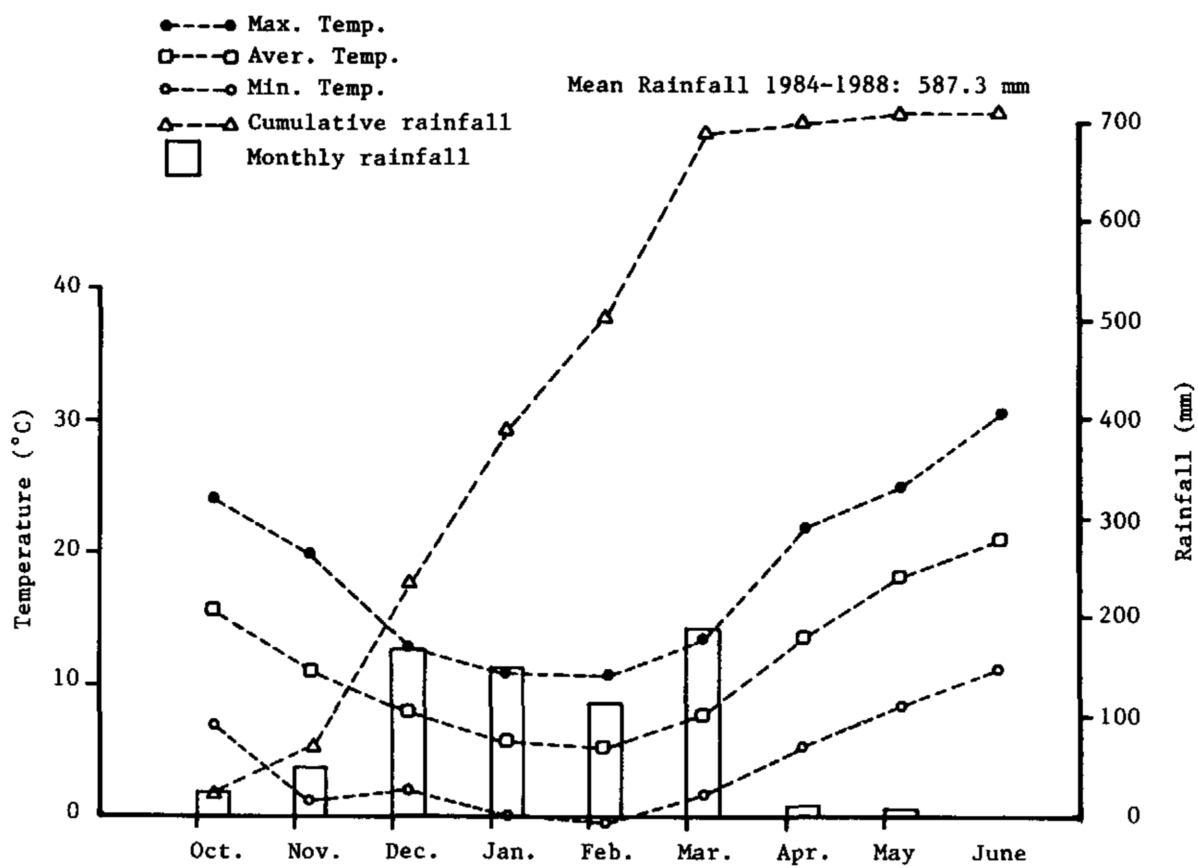

Figure 11.5. Weather data for 1987/88 at Terbol (Lebanon).

Staff list

M.C. Saxena	Program Leader
D. Beck	Microbiologist
S.P.S. Beniwal	Breeder/Pathologist (Ethiopia)
W. Erskine	Lentil Breeder (on sabbatic from Sept.)
S.B. Hanounik	Faba Bean Pathologist (Lattakia)
M.P. Haware	Chickpea Pathologist (ICRISAT)
M. Habib Ibrahim	Senior Training Scientist
L.D. Robertson	Faba Bean Breeder
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
A. Hussain*	Post. Doc. Fellow Lentil Breeding
K-H. Linke	Post. Doc. Fellow Orobanche (GTZ)
M. E. Sherbeeny	Post. Doc. Fellow Faba Bean Breeding (NVP)
S.N. Silim	Post. Doc. Fellow Agronomist/Physiologist
O. Tahhan	Post. Doc. Fellow Entomologist
F. Weigand	Post. Doc. Fellow N. Africa Pathology
Lang Li-juan*	Visiting Scientist
B.A. Malik	Visiting Scientist
M.A. Haq	Assistant Training Scientist
Bruno Ocampo	Research Associate
Stefan Schlingloff	Research Associate
Edwin Weber	Research Associate
Thomas Bambach*	Visiting Research Associate
Andreas Gross	Visiting Research Associate
A. Nabil Ansari	Training Assistant
M.Y. N. Agha	Research Assistant
Fadel Afandi	Research Assistant
Ibrahim Ammouri	Research Assistant
Suhaila Arslan	Research Assistant
Bashar Baker	Research Asssitant
Talal Fadel	Research Assistant (Lattakia)
Samir Hajjar	Research Assistant
Mahmoud Hamzeh	Research Assistant
Hasan Al Hasan	Research Assistant
Abdullah Joubi	Research Assistant
Munzer Kabakabji	Research Assistant
Siham Kabbabe	Research Assistant
Gaby Khalaf	Research Assistant
Lina Khoury*	Research Assistant
Hasan Masri	Research Assistant
Hani Nakkoul	Research Assistant
Nabil Tarabulsi	Research Assistant
Riad Ammaneh	Senior Research Technician
Amir Farra	Senior Research Technician
Fadwa Khanji	Senior Research Technician
Murhaf Kharboutly	Senior Research Technician
Pierre Kiwan	Senior Research Technician (Terbol)
Moaiad Lababidi	Senior Research Technician

Raafat Azzo	Research Technician
Abdel K. Bunian	Research Technician
Aida Djanji	Research Technician
Khaled El Dibl	Research Technician
Mariette Franjieh	Research Technician
Mohamed S. Hayani*	Research Technician
Mohamed Issa	Research Technician
Bernadette Jallouf	Research Technician
M.I. El-Jassem	Research Technician
Elias Kaadeh	Research Technician
Siham Kabalan	Research Technician
Nidal Kadah	Research Technician
Joseph Karaki	Research Technician (Terbol)
Ghazi Khatib	Research Technician (Terbol)
Hisham Kredi*	Research Technician
Omar Labban	Research Technician
Mohamed I. Maarawi	Research Technician
Aida Naimeh	Research Technician (Terbol)
Ahmed Obaji	Research Technician
A. Rahim Osman	Research Technician
Diab Ali Raya	Research Technician
George Rizk	Research Technician (Terbol)
Ahmed Samara	Research Technician (Terbol)
Ziad Sayadi	Research Technician
Elias Zod	Research Technician (Lattakia)
Gulizar Haidar	Program Secretary
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

المركز الدولي للبحوث الزراعية في المناطق الجافة
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1989