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FOOD LEGUME IMPROVEMENT PROGRAM

Annual Report for 1987

ICARDA

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Annual Report for 1987

International Center for Agricultural Research in the Dry Areas

P.O. Box 5466, Aleppo, Syria

CONTENTS

INTRODUCTION

GENERAL

The food legumes, faba bean, lentil and kabuli chickpea, form an important component of the rainfed farming systems of West Asia and North Africa (WANA) because of their ability to fix atmospheric nitrogen, the key to sustainable wheat and barley production in an era of rising fertilizer costs. These crops serve as a 'break' in the cereal based farming systems and thus help in reducing or eliminating the cereal 'yield decline' syndrome observed with continuous cereal cropping. The contrasting adaptations of these food legumes are complementary within the various cropping systems of WANA with faba bean, kabuli chickpea and lentil, in turn, grown under progressively lower rainfall regimes. This order also reflects their respective crop yields, both average and potential.

Faba bean, lentil and kabuli chickpea, as pulses produce good quality protein, complimenting and diversifying the cereal based diet of the WANA region. Faba bean as a green pod and seed is an important vegetable in the WANA region with conservative estimates of 20-30% of the total area used for this purpose, unlisted in production statistics. The green seeds of chickpea are also sometimes used as a vegetable. The straw of these legumes, particularly of lentil, is an important feed within the crop-livestock systems of WANA. Also, by-products from processing factories are used as animal feed.

The three food legumes account for 72% of the total pulse production in WANA, which covers nearly half the world lentil production and a quarter of the world faba bean production. Kabuli type chickpea predominates in the WANA region. Global lentil production has expanded by 40% in the last decade, largely from an increase in area in Turkey due to fallow replacement. In North Africa faba bean is the major food legume, followed by kabuli chickpea and then lentil; the reverse is found in West Asia.

All three legumes suffer low yield due to poor management, susceptibility to environmental stresses (such as heat, cold and drought), susceptibility to pests (such as Orobanche spp., aphids, Sitona, and leafminer) and susceptibility to diseases (such as ascochyta blight, wilt, rust, and chocolate spot). Epiphytotics often are followed by reductions in area because of perceived risks. With lentil the total biomass is low; with faba bean the biomass is high but with a poor balance between vegetative and reproductive growth. Production is constrained in all three crops because of the high cost of hand labor and lack of suitable methods for machine harvest, but especially with lentil.

Unfortunately, faba bean, lentil and chickpea have attracted much less research attention than the major cereals in the past. When ICARDA started, there was a virtual vacuum in food legume research in the WANA region. The ICARDA Food Legume Improvement Program, jointly with ICRISAT for kabuli chickpeas, has, therefore, addressed itself to these problems and is helping NARSs in augmenting their research capabilities to develop improved genetic material and suitable production technology to sustain the cereal based farming systems.

MAJOR ACHIEVEMENTS OF THE PAST TEN YEARS

Faba bean

A collection of 3305 (ILB) open-pollinated accessions has been assembled and 5009 pure line (BPL) accessions have been derived. An evaluation of 840 BPL accessions for 43 descriptors is being published as a catalog. Germplasm is widely distributed to NARSs to expand their genetic variability.

The determinate type has been transferred to a Mediterranean background. As a result determinates with increased seed size and biomass and disease resistance are being disseminated to NARSs. The Independent Vascular Supply trait, which reduces flower drop, has been introduced into an adapted Mediterranean background. The closed flower, which results in self-pollination, is being introduced into an autofertile Mediterranean background.

Sources of resistance have been identified and purified for chocolate spot, ascochyta blight, rust, and stem nematodes. Also, sources of multiple disease resistance have been developed. NARSs have been using these resistant sources in genetic improvement programs.

Many NARSs have made use of newly developed elite lines. Iran has released one cultivar and Chile and Egypt are about to release cultivars. There are lines in on-farm and verification trials in eight countries. More important, however, is the use of ICARDA segregating populations and enhanced germplasm. For example, the Egyptian Program is releasing a disease resistant cultivar. ICARDA has been making between 50-150 crosses per year for national programs upon their request.

Effective herbicides were identified in collaboration with Farm Resource Management Program for control of weeds.

Under low rainfall conditions (300-350 mm) sowing at narrow row spacing and/or at high population was identified as optimal. The amount and contribution of symbiotically fixed nitrogen to total nitrogen with faba bean was determined.

Lentil

Through international agronomic trials, NARSs have identified effective herbicides to control weeds, and conditions under which phosphate fertilization is useful. Herbicide is in use in production in Egypt. The contribution of symbiotic nitrogen fixation to total N yield is more than 80%.

ICARDA has assembled a germplasm collection of 6758 accessions. A lentil germplasm catalog has been published with passport data on 5424 accessions and evaluation data on 19 morphological and stress characters for 4550 accessions. Variability for key traits such as lodging and pod dehiscence has been found, and resistance to cold, rust, ascochyta blight and wilt (with Aleppo University) has been identified. Germplasm has been widely distributed to NARS.

NARSs have released six lentil cultivars in five countries (Ecuador, Ethiopia, Syria, Tunisia, and Turkey) in four of which they are the first lentils resistered. Further cultivar releases are imminent in six countries.

To compliment the breeding, studies have been made on the methodology of selection for lodging, pod dehiscence, phenological adapation (with Reading University), straw quality and quantity, and resistance to Orobanche.

NARSs in Algeria, Jordan, Morocco and Syria are doing collaborative on-farm trials on systems of lentil harvest mechanization involving changed plant type and agronomy.

Kabuli chickpea

A total of 6509 germplasm accessions have been assembled at ICARDA with 3400 accessions evaluated for 29 descriptors and a 'Kabuli Chickpea Germplasm Catalog' published. The germplasm is widely distributed to NARSs throughout the world.

Advancing sowing time from spring to early winter with cultivars resistant to ascochyta blight and tolerant to cold at low to medium elevation in the Mediterranean region almost doubles the yield and increases water use efficiency. The Center has developed ascochyta blight and cold tolerant cultivars for winter sowing. NARSs in seven countries have released 17 cultivars. Winter sowing has already been introduced in these countries at farmers' fields.

A field screening technique for ascochyta blight resistance has been developed. With this technique 17,000 germplasm lines from ICARDA and ICRISAT have been screened and 19 sources of resistance identified, and fifteen NARSs are using them in their genetic improvement. Further, six races of Ascochyta blight have been identified; the perfect stage of Ascochyta rabiei has been found, and the epidemiology of the pathogen studied.

Screening techniques for cold, leaf miner, cyst nematode (with Institute of Nematology, Bari, Italy), Orobanche spp, and wilt (Fusarium oxysporum) in collaboration with Cordoba University, Spain have been developed, and sources of resistance identified for each stress. These resistant sources are being utilized by NARSs in genetic improvement.

Herbicides have been identified with NARSs to control weeds effectively on winter-sown chickpea in collaboration with the FRMP. The winter-sown crop synthesizes approximately double the nitrogen of the spring-sown crop.

International cooperation

FLIP aimed to strengthen the research capabilities of NARSs with the overall objective of increased food legume production. The infrastructure for research on food legumes has been either weak or non-existent in NARSs. A major effort has therefore been made in institution building.

Development of sub-regional networks

A sub-regional network on faba bean has been developed in the Nile Valley covering NARSs of Egypt, Ethiopia and Sudan and ICARDA in multi-facetted linkages. Food legume scientists have been posted to strengthen research in North Africa and Ethiopia.

Joint research

Joint research has been initiated with NARSs on particular problems. An aphid screening laboratory has been set up in Cairo. Screening with NARSs for lentil diseases in Ethiopia and Pakistan and cold tolerance in Turkey is underway, as is wilt screening on chickpea in Tunisia and Spain and cold tolerance screening in Turkey.

A total of 20 institutions in Europe and North America have been involved with some 35 collaborative projects with FLIP in the field of basic research.

Training

FLIP offers training opportunities to NARSs to improve crop improvement research skills. During the last ten years more than 600 scientists and technicians were trained from 15 countries. Specialized short courses in pathology, biological nitrogen fixation, lentil mechanized harvesting, and crossing techniques were given. With the creation of the graduate research training program, more students joined the program linking FLIP with both developing and developed countries. Several training manuals and audio-visual modules were produced for use at ICARDA and in-country training courses.

International Food Legume Testing Program (IFLTP)

The IFLTP developed in response to the needs and requests of NARSs for an efficient distribution system of improved genetic material and production practices. Several NARSs have selected lines from IFLTP for release as cultivars (see 1.2.1.3, 1.2.2.3. and 1.2.3.2) and/or parents as sources of resistance to stress. Agronomic trials have provided the basis for the development of production technologies by different NARSs.

Information dissemination

ICARDA has published newsletters, abstracts, monographs, field guides for constraints, germplasm catalogs, workshop and conference proceedings and bibliographies for use by scientists worldwide working on the three food legumes.

FUTURE STRATEGY

ICARDA in partnership with NARSs aims at a sustainable increase in the production of faba bean, lentil, and kabuli chickpea by farmers, primarily in WANA, through the development and adoption of ecologically sound technologies within the farming systems.

Many constraints are common across rainfed Mediterranean environments, indicating the need for a coordinated research effort to solve the problems.

ICARDA has a major role in the research and development necessary, but this role will vary greatly from country to country depending on the individual capability of NARSs. Our responsibilities, therefore, include 1. basic research, 2. strengthening the capabilities of NARSs, 3. development of collaborative networks, and 4. technology transfer to farmers.

Basic research

To fulfill the stated objectives within the context of our links with NARSs, ICARDA has developed a multi-disciplinary approach to food legume improvement which spans several programs with FLIP playing a central role.

Research will be directed to a) increase yield potential, b) narrow gaps between potential yields and farm production, c) improve stability and sustainability of yields, d) defend against erosion of yields by pests and diseases, and e) sustain cereal and livestock production in the farming systems.

Efforts on germplasm collection, evaluation and maintenance will gradually decrease and will take in future only a small portion of the program resources, in coordination with the Genetic Resources Program. There will be a gradual reduction in the production of cultivars for testing and direct release by NARSs as they assume a greater portion of this responsibility. ICARDA will assume more of a redistribution role of elite lines from NARSs within sub-regions. In the previous five years there was a small decrease in efforts at ICARDA on the production of elite lines with a move towards development of new methodologies to improve the efficiency of crop improvement; in the next years there will be an increasing emphasis on the development of novel breeding methodologies. There will still be a focus on selection for improved plant architecture, disease and pest resistance and tolerance to abiotic stresses (heat, cold and drought), but it will be increasingly directed to the development of parental material and segregating populations with combinations of desired architectural traits and multiple stress resistances.

In faba bean disease resistance (Botrytis and Ascochyta blight) and plant models (determinacy, IVS, autofertility, and self-pollination) are central to improving yield stability. Biomass improvement for food, feed and ease of mechanization will be the major thrust of lentil selection with attention also given to drought, cold and diseases tolerances. In chickpea the key traits are ascochyta blight resistance and cold tolerance for winter sowing, but leaf miner, Fusarium wilt and cyst nematode resistances and increased stature will also be added to parental stocks.

Where necessary, improved screening methodologies will be developed. Improved sources of resistance to current pathogens and sources of resistance to new races will be sought either within the cultigens or their wild relatives, necessitating the use of techniques such as embryo rescue. The inheritance and mechanisms of resistance will be studied, along with the race structure and epidemiology of the major pathogens. Amongst biotic constraints, efforts on Orobanche control will be intensified. In view of ICARDA's increasing emphasis on drier, more marginal environments, research on abiotic stresses (heat, cold and drought) will increase to improve screening methods, identify better sources of tolerance and their associated mechanisms; again, recourse to the wild relatives will be sometimes necessary for better resistance.

With the objective of increased sustainability of the farming systems, the effects on the cereal phase of the rotation and on livestock of new legume technology will be monitored. Consequently, legume crop residues, particularly lentil, will be studied. We will define conditions under which inoculation with Rhizobium is necessary and develop a superior biological nitrogen fixation technology for transfer to NARSs. This will include attention to reduce the destruction of nodules by Sitona weevil. NARSs will be encouraged to undertake location specific agronomic research.

The steady development of ICARDA's research and laboratory facilties will ensure that many of the ICARDA's research goals can be reached with 'in-house' facilities. However, some specific objectives might be efficiently reached by the judicious use of laboratory equipment and expertise not found within ICARDA. Consequently, we will utilize the resources of advanced institutions to solve particular problems linking when appropriate with national programs, to bridge the research gap between advanced institutions and NARSs.

Strengthening the capability of NARSs

ICARDA aims to strengthen the research capabilities of NARSs with an overall objective of increasing the production of food legumes, particularly in WANA. One of our major tasks in the first decade was to assist NARSs in building a sound infrastructure for food legume research. Now an evolution is required in our relationship with NARSs, reflecting their increased research ability and academic maturity. Simultaneous with the development of NARSs, has come the realization of the importance of the geographic/ecological specificity of many of the problems of food legume production. As a result the approach to international collaboration will become more focused on the sub-regional and individual country level in contrast to the earlier global approach. Increasingly the direction of flow of collaboration will change from one-way from FLIP to NARSs to the two-way flow of a mature, true cooperation.

In a major shift of activities, the core faba bean improvement team will move to North Africa, the major area of faba bean production in WANA. This will ensure adaptation of germplasm with disease resistance and alternative plant types to the major area of production, develop linkages on important constraints such as

Orobanche, and most importantly, build the capabilties of key NARSs within WANA.

Many other ways are used to strengthen NARSs such as the international food legume testing program, training, joint research and information dissemination.

The development of sub-regional networks and training for 'impact' are to be given particular priority (1.3.3. and 1.3.4).

International Food Legume Testing Program

The long term objective of the International Food Legume Testing Program (IFLTP) is to distribute improved genetic material among NARSs and to promote testing of production practices to improve productivity. The diversification of trials in IFLTP, which has resulted from the requests of NARS and from increased targetting of material for different specific zones and requirements, will intensify. As NARSs gradually shoulder the responsibility for the development of cultivars, so FLIP will increasingly make available targetted crossing block materials and segregating populations instead of fixed elite lines. In the future we expect that the IFLTP will increasingly be a redistribution activity for some sub-regions with many entries coming from NARSs as well as ICARDA.

Training

A major effort in training will, however, be required for NARSs to undertake the required crop improvement. For example, in 1987 there were no crosses made by NARSs in the ICARDA region in lentil, outside ICARDA.

Training has the technical aim to increase the professional capacity to undertake legume improvement; in addition it forges strong personal links among scientists in NARSs and ICARDA. More emphasis will also be given to increasing the training capabilities of NARSs. A few NARSs have consolidated effective teams, whereas others are still to achieve this. Thus it is necessary to pursue a strategy that will continue on-going training opportunities to offer advanced and diversified training for stronger national research systems.

Joint research

Many of the problems of food legume production are difficult to address efficiently at ICARDA because of ecological specificity. As a result there is joint research with individual NARSs in screening for biotic and abiotic stresses in key locations. Another type of joint research involving the joint planning and conduct of experiments is also underway. In the future joint research with NARSs will be strengthened.

Information dissemination

An important element in building the research capability of NARS is their access to ideas through publications and the promotion of dialogue between scientists at meetings. ICARDA will continue supporting these activities strongly, with increased emphasis on translation of material into appropriate languages, particularly Arabic and French.

Development of sub-regional networks

Neighbouring countries with similar growing environments have many common problems in food legume production and different research capabilities. We are developing sub-regional networks for food legume improvement to build linkages between adjacent NARSs, as well as between ICARDA and NARSs. Using the model of the Nile Valley network on faba bean, we aim to strengthen the Maghreb food legume network, build the W. Asian network and develop a food legume network in Latin America and a lentil network in S. Asia.

Technology transfer to farmers

The responsibility for the transfer of technology to farmers lies with NARSs. However ICARDA will assist NARSs to test and spread newly developed technology through training in on-farm research and in seed production to ensure impact on production at the farm level.

1. FABA BEAN IMPROVEMENT

Faba bean is predominantly grown in medium rainfall environments (450-550 mm). The major effort of improvement work was assigned to development of genotypes and production and plant protection techniques of faba bean for such an environment. Work on faba bean focused on stabilizing yield through resistance to major diseases and pests (ascochyta blight, chocolate spot, rust, orobanche, and aphids) and to improve the 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.

1.1. Development of Cultivars and Genetic Stocks

Faba bean breeding concentrated on resistance to diseases and pests and altering the plant type to control vegetative growth, flower and pod drop, and to change the breeding structure of faba bean. The major objectives of resistance work were to produce lines with uniform resistance to ascochyta blight, chocolate spot, rust, orobanche, and aphids in a useful background, use these in the breeding program, distribute to national programs, and combine into multiple disease/pest resistance sources. Research on determinate and independent vasuclar supply (IVS) types was conducted to increase biomass, seed size, earliness, and to incorporate disease resistance. The closed flower type and autofertile selections from the BPL collection are being used to reduce the dependence of faba bean on bees and make faba bean self pollinated to stabilize yield.

The major avenue of material distribution is by providing sources of resistance and alternate plant types in backgrounds useful to national programs. This is through source of resistance for crossing programs, "pre-selected" segregating populations, early generation lines, and advanced lines through the international testing network.

1.1.1. Use of developed germplasm by national programs

In 1987 Iran released one line (ILB 1269) received from ICARDA as 'Barkat' for green pod production. This line was selected for higher yield, both green pod and dry seed, and because of partial resistance to diseases which allowed high yield even under the presence of ascochyta and botrytis. One line (ILB 1270) is in pre-release increase in Egypt.

In Syria the on-farm trials were started two years ago and one line, ILB 1814 from ICARDA, was tested against the local check. For 1987/88, FLIP 84-239FB, a determinate line has been added to the Syrian on-farm trial. In Lebanon one faba bean line, FLIP 87-26FB is being tested against local checks in an on-farm trial and in Jordan two indeterminate lines (FLIP 87-136FB, FLIP 87-138FB) and one determinate line (FLIP 86-146FB) are being tested in on-farm trials.

Several ICARDA lines are being tested in final multilocational tests prior to on-farm trials next year. These include FLIP 82-30FB, FLIP 84-127B, FLIP 84-128FB, 74T 422, 86S 44027, and ILB 1269 recommended for cataloguing in Morocco and FLIP 83-89FB, 74TA22, 80S 43238 in Tunisia. Additionally, a request for four lines (80S 44150, 76TA 56267, 80S 43977, 80S 43341) has come from a commercial seed firm in Chile for release. Now, many national programs are using ICARDA lines for multi-locational and on-farm trials and a summary of their use in given in Table 1.1.1.

Previous reports have referred to the lack of wide adaptability found for faba bean. One approach to the problem of adaptability is to send segregating populations from crosses of local populations with lines selected for specific traits to provide useful variability for selection at different locations. This will become increasingly important in coming years. Specific traits requested include resistance to rust, ascochyta blight, chocolate spot, stem nematode, virus, and orobanche. Also, crosses of determinate and independent vascular system (IVS) types and also large seeded types

Table 1.1.1. Use of ICARDA lines by National Programs.

Country	Line (s)	Use
Chile	80S 44150, 76TA 56267, 80S 43977, 80S 43341	Commercial seed production
Egypt	ILB 1270	Pre-release multiplication
Iran	ILB 1269	Released as 'Barakat'
Jordan	FLIP 86-146 FB[1], FLIP 87-136 FB[1] FLIP 87-138 FB	On-farm trial
Lebanon	FLIP 87-26 FB	On-farm trial
Morocco	FLIP 82-30 FB, FLIP 84-127 FB, FLIP 84-128 FB, 74TA22, 80S 44027, ILB 1269	Increase for verification trials
Syria	ILB 1814, FLIP 84-139 FB[1]	On-farm trial
Tunisia	FLIP 83-89 FB, 74TA22, 84S 43238	Final national testing

1 Determinate line.

Table 1.1.2. Distribution of F_2 and F_3 bulks and early generation lines to National Programs in 1986 and 1987.

Year	Country	No. of lines/crosses	Type of material
1986	Egypt	1	ILB 1270, 100 kg
1986	Egypt	28	IVS lines
1986	Egypt	183	Small seeded lines
1986	Egypt	457	Determinate lines
1986	Turkey	86	Determinate lines
1986	Turkey	136	large seeded lines
1986	Turkey	10	Lines for increase and yield trials
1986	Algeria	6	Lines for multilocation testing
1986	France	76	Determinate lines
1986	Denmark	70	Determinate lines
1986	Ethiopia	600	F_4 Progenies, 1 large- seeded ILB
1986	Sudan	4	Landraces for mass selection
1986	N. Yemen	16	Multilocational testing of elite lines
1986	N.Yemen	2	FLIP 84-14FB, FLIP 84-41FB for on-farm Trials
1987	Tunisia	195	Lines for PSN-disease resistant
1987	Morocco	200	F_2 populations, and F_3 derived progeneis

1) ILB = ICARDA legume faba bean
2) BPL = faba bean pure line

such as Reina Blanca, Aquadulce and New Mammoth with wider adaptability have been requested.

Additionally, F_3 progenies and lines from preliminary and advanced yield trials have been sent to national programs for selection in different environments. Populations and lines of this type distributed for the last two years are listed in Table 1.1.2.

Dr. L.D. Robertson.

1.1.2. Development of trait specific genetic stocks

The demand for genetic stocks with specific traits such as adaptation to a specific environment, resistance to one or more common pathogens and pests, etc., has continued to grow in the past years. Hence, development and distribution of genetic stocks was given high priority during the 1986/87 season. Work for developing disease resistance included screening and selection within ILB accessions for resistance to *Botrytis fabae* at the disease screening site in Lattakia. However, increasing emphasis is given to using existing resistance sources. This resulted in most work being done on screening F_2 populations and F_3 to F_6 progenies from crosses of resistance sources to different high yielding lines with adaptation to various agro-ecological conditions in the region.

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 is the original germplasm accessions as received, usually heterogenous, heterozygous populations. This collection is the responsibility of the Genetic Resources Program. 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 single plant progenies to produce inbred line sources for use in the breeding program. From this pre-breeding activity 840 BPL's were sufficiently inbred to allow an evaluation trial in the 1985/86

season. These lines were evaluated in a series of 28 experiments with four checks in each. The BPL accessions were evaluated following the IPBGR/ICARDA faba bean germplasm descriptor list. Work is now being completed on a germplasm catalog of this evaluation data in computer form.
Drs. M. El-Sherbeeny and L.D. Robertson.

1.1.2.2. Germplasm for disease resistance

1.1.2.2.1. *Orobanche crenata*

Emphasis in the area of screening for disease resistance over the past ten years was directed towards the detection of new sources of resistance to major fungal and nematode diseases. These efforts resulted in the identification of several useful sources of resistance to chocolate spot, ascochyta blight, rust, and stem nematodes. However, in the 1986-1987 season the program searched for sources of resistance to broomrape (*Orobanche crenata*) which is considered to be among the most important limiting factors in faba bean production throughout North Africa, the Middle East, and Southern Europe.

Therefore, a naturally orobanche-infested field was identified, in collaboration with the Ministry of Agriculture and Agrarian Reforms in Syria, to evaluate ICARDA's germplasm collection for resistance to broomrape. This field was located at the Jable Agricultural Research Station near Lattakia in Syria.

Seeds of 612 germplasm accessions were planted, under insect-proof cages (24x16m), in rows 1 m long and 50 cm apart, with the local susceptible cultivar ILB 1814 repeated every nine test entries.

Of the 612 accessions included in this test, only one (BPL 2830) was rated resistant and nine rated moderately resistant (Table 1.1.3.). Plants of ILB 1814 were repeatedly rated highly susceptible, indicating a uniform disease distribution pattern throughout this test.

In this nursery 14 single plant selections were made. Seeds from these selections will be planted again at the new ICARDA Lattakia site for further evaluation and purification.

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

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, 818, 646, 2485; ILB 752; L83118, L83120, L83124, L83125, L83127, L83129, L83136, L85142, 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
Orobanche crenata[2]	BPL 2756, 2830, 2916, 3190, 3196, 3205, 3243, 3261, 3312, 3336

1. There are several sublines of most sources listed.
2. Based on one year data only.

1.1.2.3. Development of disease-resistant inbred lines

Efforts were continued in the 1986/1987 season, to improve homozygosity for disease reaction in ICARDA's chocolate spot, ascochyta blight, rust, and stem nematode resistant sources. These materials were grown as bulk rows, then inoculated artificially under insect-proof cages to prevent outcrossing. When disease evaluations were made, susceptible plants were uprooted then seeds from resistant sources were harvested and inoculated again. This procedure of inoculation and reselection will continue until a high level of homozygosity for disease reaction is achieved. In the 1986-1987 season 288 chocolate spot, 305 ascochyta blight-, 64 rust-, and 13 stem nematode resistant sources were included from germplasm and crosses from the breeding program.

Although plants within each line seemed fairly uniform, these efforts will continue in the 1987/1988 season to further improve homozygosity for disease reaction within each line. Lines are being used for crosses with high yield and adaption to various environments. These also are distributed as disease resistance sources to cooperators at their request. Table 1.1.3. lists some of the most important sources of resistance to each of these pathogens.

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

1.1.2.4. International disease screening nurseries

Sources of resistance to chocolate spot (FBICSN), ascochyta blight (FBIABN) and rust (FBIRN) were included in the faba bean international disease screening nurseries, which were provided for testing at 51 different locations around the world in 1987. The FBICSN was requested most, followed by the FBIRN and then the FBIABN. Increases in the number of national programs and institutions requesting these nurseries between 1982 and 1987 reflects the increased interest of different collaborators in ICARDA's disease-resistant materials. Results are presented from 1983 to 1986 (Except FBICSN) as those of 1987 have not been received to date.

In the FBICSN one line, BPL 1179 (81 Lat. 24948-1) was rated resistant across all locations including the most virulent isolate, B-29, used in Canada under highly disease-inducive conditions. Additionally, BPL 710 (81 Lat. 24857) and another selection of BPL 1179 (81 Lat. 24948-2) were rated resistant across all locations but rated susceptible to B-29. However, disease reaction of the remaining entries varied considerably among different locations indicating the presence of different races of _B. fabae_. In the FBIABN, BPL 74 (Sel. 80 Lat. 70015), 460 (Sel. 80 Lat. 14422-2), 471 (Sel. 80 Lat. 14434-2), and 646 (Sel. 80 Lat. 14998-2) were resistant at all locations all years, giving evidence of non-specific resistance. However, the other entries showed location-specific resistance. All entries in the FBIRN showed location-specific resistance except BPL 1179 which has a location non-specific resistance to chocolate spot also.

So far, results from the multilocation testing over the period 1980-1986 indicate that the chocolate spot, ascochyta blight, and rust resistant sources of ICARDA remain useful, as evident from their resistance to several pathogenic populations at different locations around the world. Although genes from these sources can still be used effectively to suppress major faba bean diseases, our focus in 1988 will be directed on the multilocation testing of ICARDA's new sources of resistance which have recently been identified, to provide a reserve of new genes for resistance that can be used immediately to suppress any possible new physiological races that could render our present genes for resistance less effective.

Drs. S.B. Hanounik, L.D. Robertson, and R.S. Malhotra.

1.1.2.5. Recombination of disease resistance with local adaptation

At Tel Hadya local germplasm from Egypt, China, Morocco, Tunisia, and Sudan was used for crossing to disease resistant lines. F_2 and F_3 bulks will be supplied in 1988 along with F_2 selections made for disease resistance at ICARDA in the 1987/88 season. Selections will also go into progeny rows with lines fed into preliminary yield trials and F_3 bulks to go into the international F_4 nurseries. Single crosses will be again made with new resistance sources in the 1987/88 season.

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

1.1.3. Development of improved cultivars and genetic stocks for assured moisture environments

Faba bean in most of the ICARDA region is grown where there is adequate rainfall/supplementary irrigation. To obtain high and stable yield, genotypes with high yield potential and resistance to Ascochyta fabae, Botrytis fabae, Uromyces fabae, Orobanche crenata and Ditylenchus dipsaci are needed. Emphasis was therefore placed on developing such genotypes. Sources of resistance for these parasites identified from germplasm evaluation are used in the crossing program with increasing frequency. For the 1986/87 season most of the crosses involved at least one pest resistant parent.

1.1.3.1. Yield potential

The breeding program at ICARDA for faba bean and its linkage with the National Programs is schematically presented in Figure 1.1.1. This scheme makes use of an off-season nursery at Shawbak, Jordan for F_1 and F_4 progeny rows (increase to preliminary screening nursery) stage resulting in a two year time saving. Brassica napus is used to prevent outcrossing for segregating populations, progeny rows, preliminary screening nurseries, and preliminary yield trials. Single plant selections are made within the F_2 populations (at Tel Hadya for yield and at Lattakia for disease resistance) and F_3 progeny rows are grown where selections are made for yield, frost resistance and disease resistance, with these selections going to Lattakia as F_4 progeny rows where selections are made for increase for preliminary screening nurseries (PSN). Lines are then advanced through PSN's and preliminary, advanced and international trials using multilocation testing.

In replicated yield trials the highest yield at Tel Hadya in the 1986/87 season was 5.8 t/ha compared to 5.7 t/ha in the 1985/86 season. Replicated yield trials of 476 lines were conducted at Tel Hadya under irrigated conditions during the 1986/87 season (Table 1.1.4); 169 entries exceeded the best check (or best small seeded

Fig. 1.1.1. **The Faba Bean Breeding Program at ICARDA.**

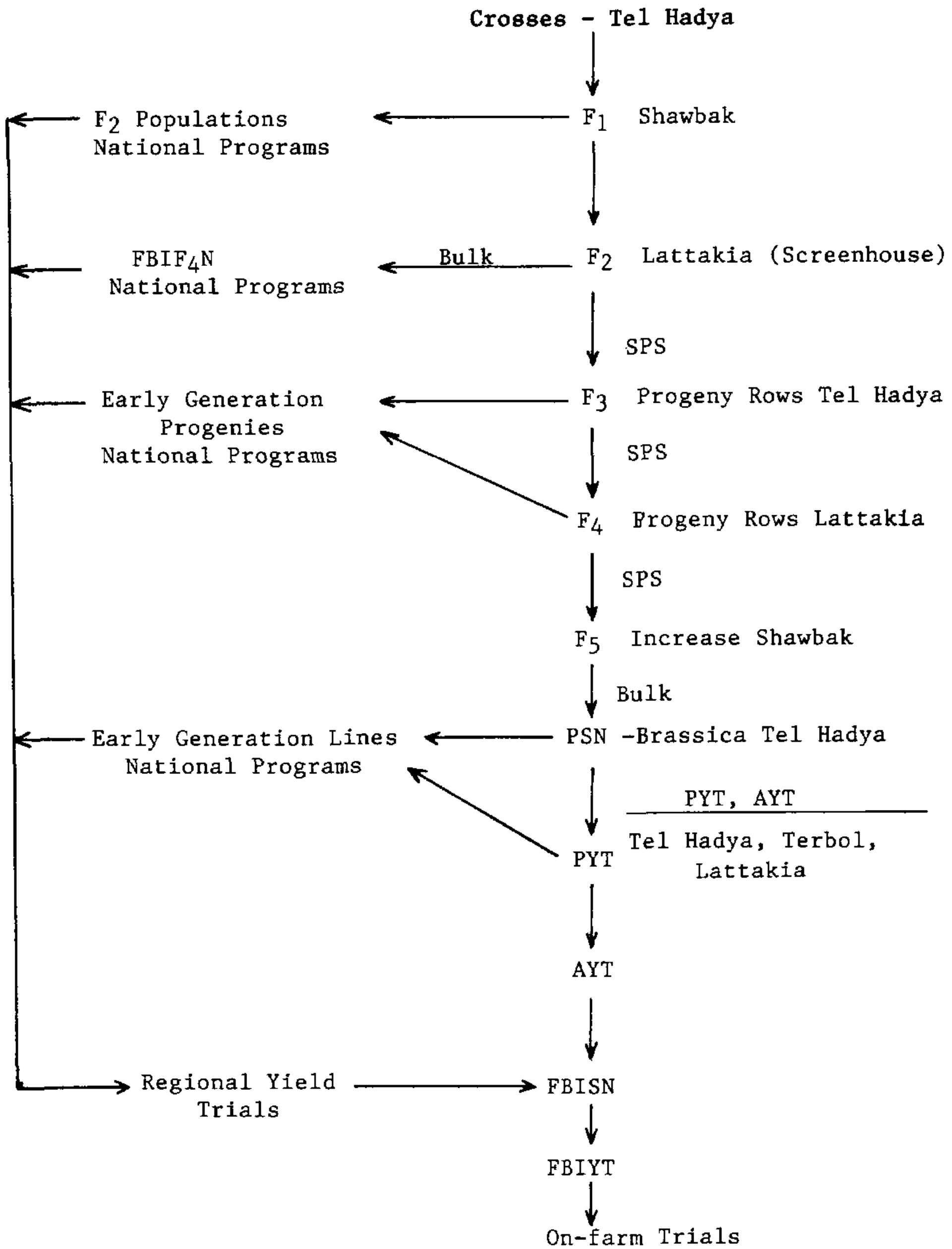

Table 1.1.4. Results of faba bean yield trials grown at Tel Hadya, Syria, 1986/87.

Trial	No. of test entries	No. of lines exceeding best check: Total	No. of lines exceeding best check: Significantly (P=0.05)	Grain yield (Kg/ha x 000): Trial(1) mean	Grain yield (Kg/ha x 000): Best line mean	Grain yield (Kg/ha x 000): Best check mean	Grain yield (Kg/ha x 000): L.S.D. check VS. line (0.05)	C.V. (%)	Checks
FBIYT-L	23	6	0	3.66	4.40	3.89	.712	11.8	ILB 1814
FBIYT-S[1]	23	6	0	3.77	4.36	3.98	.905	14.6	ILB 1814, ILB 1819
FBISN-L[1]	36	0	0	4.01	4.65	5.03	.821	12.6	ILB 1814, ILB 1270
FBISN-S[1]	48	0	0	4.13	4.82	5.03	1.267	16.8	ILB 1814, ILB 1270
AYT-L	96	3	1	4.27	5.82	4.76	.927	13.6	ILB 1814, ILB 1817
AYT-S	45	11(30)[a]	0(6)[a]	3.91	4.81	4.20(3.70)[b]	.752	11.8	ILB 1814, ILB 1816
PYT-L	119	87	28	2.92	3.66	2.76	.425	13.6	ILB 1814, ILB 1817
PYT-S	86	10(37)[a]	0(4)[a]	2.53	3.29	2.86(2.60)[b]	.486	12.0	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, Lebanon, during the 1986/87 season.

Trial	No. of test entries	No. of lines exceeding best check		Grain yield (Kg/ha x 000)				C.V. (%)	Checks
		Total	Significantly (P=0.05)	Trial mean	Best line mean	Best check mean	L.S.D. check VS. line (0.05)		
FBIYT-L	23	5	0	3.04	3.59	3.32	.868	17.4	ILB 1814
FBIYT-S	23	9	0	3.02	3.58	3.23	.919	18.5	ILB 1814, ILB 1819
FBISN-L[1]	36	3	0	2.64	3.21	3.06	.758	17.7	ILB 1814, ILB 1270
FBISN-S[1]	48	1	0	2.41	2.89	2.88	.717	18.3	ILB 1814, ILB 1270
AYT-L	96	43	2	3.16	4.17	3.24	.746	14.7	ILB 1814, ILB 1817
AYT-S	45	8(26)[a]	0	2.76	3.24	3.04(2.73)[b]	.639	14.1	ILB 1814, ILB 1816
PYT-L	119	45	3	2.92	3.49	2.82	.549	16.2	ILB 1814, ILB 1817
PYT-S	86	40	0	2.74	3.44	2.87	1.140	20.9	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.

check in small seeded trials) and 39 of these were significantly better than the check at the 5% probability level.

At Terbol, Lebanon, a total of 476 lines were yield tested in the 1986/87 season with the highest yield 4.17 t/ha (Table 1.1.5); 172 lines outyielded the best check (or best small seeded check in small seeded trials) with 5 lines significantly better at the 5% probability level.

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1.1.3.2. Disease resistance

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

In 1986/87 over 2000 single plant selections were made for resistance in 175 F_2 populations to chocolate spot, ascochyta blight, and rust. Approximately 700 single plant selections were made in F_3 and F_4 progenies, mostly in determinate, IVS and closed flower types. This is a significant achievement; disease resistance was for the first time combined with alternative plant types. Bulks of selected F_2 plants will be increased to provide international F_4 screening nurseries for national programs with "pre-selected" germplasm pools for line development in a disease resistant background.

Considerable evidence is available on the existence of races and pathogenic variabilities in B. fabae, A. fabae, and U. fabae. However, in previous years results have been reported of successful development of lines with durable resistance to chocolate spot and ascochyta blight by combining different mechanisms of resistance. In 1986/87 this work was continued with screening of F_2 populations combining newly discovered sources of resistance to chocolate spot.

Chocolate spot, ascochyta blight, and rust often occur in complex pathological mixtures which can cause serious damage. Several germplasm selection were reselected for multiple disease resistance in the past several years. In 1986/87 several hundred selections were made in F_2 populations for chocolate spot-rust and for ascochyta blight-chocolate spot complexes; selection was done after inoculation with each pathogen. These selections will be retested in the 1987/88 season and used to develop multiple disease resistance sources.

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1.1.4. Development of alternative plant type genetic stocks 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, which is currently excessive under these conditions, and will give a corresponding increase in harvest index.

The 'topless' mutant from N. Europe is poorly adapted to the Mediterranean environment, and efforts are being made to transfer the character into an adapted background. Crosses involving at least one determinate parent numbered 170 this season. These were increased in the off season and F_2 populations will be screened for determinate plants in the 1987/88 season. Emphasis was given to developing disease resistant determinate lines as this was one of the major drawbacks of the original determinate mutant. At Lattakia 298 Botrytis and 260 ascochyta blight resistant/tolerant determinate selections were made. These lines were rated 1-5 versus 9 for the indeterminate susceptible check and the determinate mutant.

Work also was done in selecting for increased seed size and 100 progenies were selected with a seed size greater than 1.5g/seed, whereas the seed size of the original mutant is less than 0.4g/seed.

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

Determinate lines have entered on-farm trials in Syria and Jordan and large scale increases of several determinate lines have started. Much interest was expressed by the Chinese National Program in determinates for use in the inter-cropping system with cotton. Testing will begin in China in 1988/89.

Replicated yield trials were conducted with 25 determinate lines in preliminary yield trials at Tel Hadya and 210 lines at Lattakia and Terbol (Table 1.1.6). In the advanced yield trial at Lattakia 12 determinate lines exceeded the indeterminate check. In the advanced and preliminary yield trials at Tel Hadya some determinate lines yielded not significantly less than the best indeterminate check, ILB 1814. The highest determinate yield was 3.93 t/ha, whereas the yield of the original mutant averaged 0.67 t/ha over three sites.

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1.1.4.2. Independent vascular supply lines (IVS)

These are lines where each flower in a raceme has an independent vascular supply, so that many more flowers in a raceme produce pods and flower shedding is greatly reduced. Major work is being carried out to incorporate earliness, disease resistance and larger seed size in the IVS background. From a preliminary screening nursery twenty two lines were selected for a preliminary yield trial in 1987/88 which are much earlier than the original mutant.

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Table 1.1.6. Results of determinate yield trials grown at Tel Hadya and Lattakia, Syria and Terbol, Lebanon in 1986/87.

Trial	Location	No. of. lines	No. of. lines exceeding check	Trial mean	Best line mean	Best check mean	L.S.D. check vs. line (.05)	C.V. (%)	Checks
AYT-Det-1	Tel Hadya	15	0	2.98	3.93	4.46[1]	.828	16.7	ILB 1814
AYT-Det-2	Tel Hadya	58	0	2.65	3.39	4.04	.661	15.6	ILB 1814, SV0622
PYT-Det	Tel Hadya	252	0	1.83	2.61	3.95	.352	18.6	ILB 1814, ILB 1816, SV0622
AYT-Det-1	Lattakia	15	12	2.76	3.36	2.55	1.108	23.3	ILB 1814
AYT-Det-2	Lattakia	58	5	2.15	3.83	3.26	1.565	36.4	ILB 1814, SV0622
PYT-Det	Lattakia	137	1	1.80	3.84	3.82	.654	27.7	ILB 1814, ILB 1816, SV0622
AYT-Det-1	Terbol	15	0	3.00	3.22	4.50	.642	12.6	ILB 1814
AYT-Det-2	Tebol	58	0	2.39	3.44	3.55	.728	15.1	ILB 1814, SV0622
PYT-Det	Terbol	137	0	2.10	2.97	3.74	.285	17.1	ILB 1814, ILB 1816, SV0622

1) All best check means are for ILB 1814, an indeterminate line.

Table 1.1.7. Correlations among grain yield, biomass, flowering date, plant height, 100-seed weight and seeds/plant for large seeded (df = 136, upper diagonal) and small seeded (df = 91, lower diagonal) faba bean lines grown at Tel Hadya, Syria, 1986/87.

Trait	Grain yield	Biomass	Flowering date	Plant height	100 Seed weight	Seeds/ plant
Grain yield	1.000	0.699**	-0.308**	0.064	0.233**	0.390**
Biomass	0.655**	1.000	-0.247**	0.401**	0.365**	0.065
Flowering date	0.012	0.150	1.000	-0.014	-0.164	0.102
Plant height	0.140	0.339**	-0.174	1.000	0.138	-0.136
100-seed weight	0.231*	-0.029	0.049	-0.159	1.000	-0.667**
Seeds/plant	0.436**	0.267*	-0.281**	0.038	-0.462*	1.000

1.1.4.3. Relationship of yield with phenological and yield component traits

Biomass, 100 seed weight, seeds/pod, flowering date, plant height, and grain yield were studied with 138 large seeded and 93 small seeded lines. The correlations among these traits are given in Table 1.1.7. The largest correlations with grain yield were of biomass for both large seeded (0.699**) and small seeded (0.655**) faba bean lines. Other traits with significant correlations with grain yield were seeds/plant (0.390 and 0.436 for large and small seeded, respectively).

Path coefficient analysis was performed to understand the interrelationships of these traits (Table 1.1.8). The traits with the largest direct effects on grain yield were seeds/plant and 100 seed weight. However, they had large negative indirect effects through compensatory effects with each other. On the other hand, biomass also had a large direct effect on grain yield with both large and small seeded lines (0.449 and 0.493, respectively) and a positive indirect effect (from 100 seed weight with large seeded faba bean lines and from number of seeds with small seeded faba bean lines). Selection for biomass should increase yield through a direct effect and through the correlation of biomass with seed size in large seeded ilnes and the correlation of biomass with seed number in small seeded lines.

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1.1.4.4. Studies on outcrossing

In large-scale breeding programs outcrossing due to insect pollinators is undesirable because this makes it difficult to maintain the genetic identity of individual lines. To prevent outcrossing cumbersome and costly methods of isolation such as distance, insectproof cages, or individual bagging of plants with nylon nets need to be used. In the 1984/85 and 1985/86 seasons different size plots were used to determine the effect of plot size

Table 1.1.8. Direct and indirect effects of biomass, flowering date, plant height, 100-seed weight, and seeds/plant on grain yield with large and small seeded faba bean lines in 1986/87 at Tel Hadya, Syria.

Seed size	Trait	Effect on grain yield		
		Direct	Indirect	Total
Large	Biomass	0.4489	0.2500	0.6989
	Flowering date	-0.1843	-0.1237	-0.3080
	Plant height	-0.0949	0.1585	0.0636
	100-seed weight	0.5352	-0.3023	0.2329
	Seeds/plant	0.7241	-0.3337	0.3904
Small	Biomass	0.4928	0.1624	0.6552
	FLowering date	0.0788	-0.0667	0.0121
	Plant height	0.0459	0.0952	0.1411
	100-seed weight	0.5072	-0.2761	0.2311
	Seeds/plant	0.5595	-0.1230	0.4365

(6x12m, 12x12m and 12x18m with 4m distance between plots) on percent outcrossing. Outcrossing was estimated using a white hilum marker. In the 1985/86 season the effect of border removal on outcrossing rate was also determined.

In both years there was a small difference in outcrossing rate with the different plot sizes; year effect was of the same magnitude as the plot size effect (Table 1.1.9.). With the small plot sizes used for early stage increases of faba bean there was little effect on outcrossing and all were equally effective.

Outcrossing for different sections of borders and centers of the three sizes of plots in 1985/86 is shown in Table 1.1.10. Again, no difference can be seen between borders and centers in outcrossing. It would therefore not be of any use to remove borders when increasing faba bean in small plots.

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Table 1.1.9. Effect of plot size on outcrossing of faba bean with 6x12, 12x12, and 12x18m plots in 1984/85 and 1985/86.

Season	Plot size			Mean	S.E.±
	6x12 m	12x12 m	18x18 m		
1984/85	11.89	10.35	9.34	10.53	4.93
1985/86	8.28	6.90	6.19	7.12	1.54
Mean	10.09	8.63	7.77	8.83	2.34

Table 1.1.10. Effect of border and center harvest on outcrossing of faba bean plots in 1985/86.

Plot size (m)	Section	Outcrossing (%)
6x12	1st meter border	7.8±1.84
	2nd meter border	9.1±1.48
	1st center square meter	8.0±1.49
	2nd center square meter	8.2±2.22
12x12	1st meter border	9.9±0.22
	2nd meter border	9.3±0.22
	3rd meter border	9.2±1.85
	1st center square meter	8.5±1.06
	2nd center square meter	7.3±0.98
12x18	1st meter border	7.1±1.54
	2nd meter border	7.8±1.85
	3rd meter border	6.1±1.92
	1st center square meter	6.3±2.39
	2nd center square meter	6.6±2.20
	3rd center square meter	5.3±1.29

1.2. Faba Bean Diseases

1.2.1. Races in *Ascochyta fabae*

Although different isolates of *A. fabae* may differ appreciably in their virulence and cultural chracteristics only early reports from Canada have been published on physiological specialization of the pathogen. In our multilocation testing of several blight-resistant sources over the past several years certain faba bean lines revealed a location- specific resistance, whereas others showed a location-non- specific resistance. These findings indicated possible physiological specialization in the pathogen. Therefore, our efforts were focused to differentiate lines with genes for a general from those with genes for a specific type of resistance, and also to study the race situation in the pathogen. The two types of resistance were distinguished by the disease reaction of different faba bean lines at different locations, and also by the presence or absence of differential interactions between certain genotypes of the pathogen and those of the host.

Specially designed isolation chambers were used to conduct two pathogenicity tests on host-pathogen interactions in the field. The first test was designed to study the frequency distribution of virulence among 50 isolates of A. fabae collected from major production regions in Syria. Results indicated the presence of considerable pathogenic variability (Fig. 1.2.1. and Table 1.2.1). Based on these results, eight isolates (IA_5, IA_9, IA_{13}, IA_2, IB_3, IB_2, IB_{25} and IB_4) with the widest possible range of virulence were selected. These isolates were used separately to inoculate five faba bean lines selected on the basis of their reactions at different locations (Table 1.2.2).

Table 1.2.1. Occurrence of virulence in inocula IA and IB of Ascochyta fabae on the faba bean lines BPL 471 and ILB 1814 in isolator chambers.

Host-pathogen Combinations	Disease severity (% necrosis)[a]			
	Mean[b]	SD	Range about mean (P = 0.01)	Variance
ILB 1814-IB	47.25K	10.26	44.57 - 49.93	105.24
ILB 1814-IA	29.551	16.68	25.19 - 33.91	278.33
BPL 471-IB	16.00m	5.41	14.58 - 17.41	29.30
BPL 471-IA	11.36n	7.62	9.36 - 13.35	58.09

a. Necrosis on leaves where 0 = no necrosis and 100 = 100% of leaf tissue necrosis.

b. Pairs of means for each line followed by different letters are significantly different at P = 0.01 (t = 9.03 for ILB 1814 and 4.9 for BPL 471).

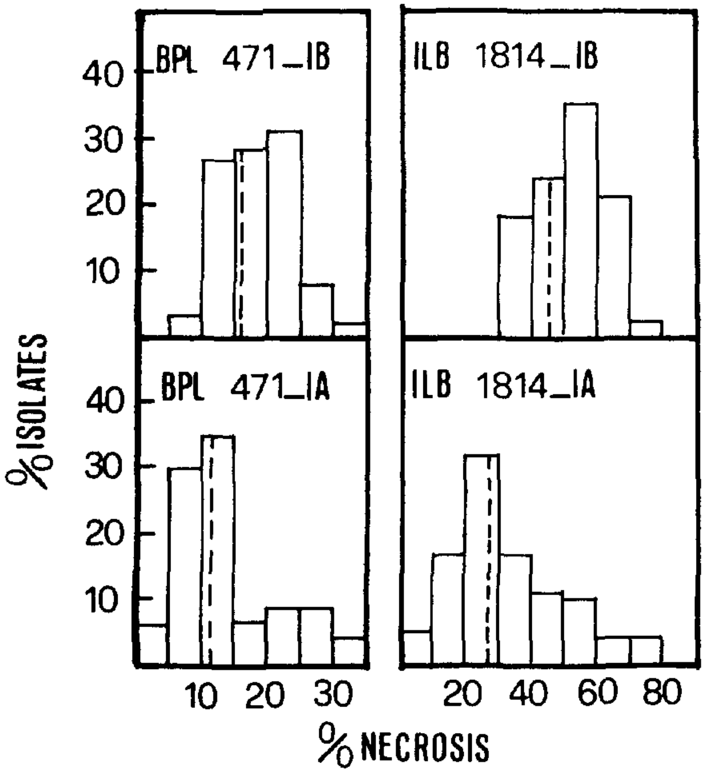

Fig. 1.2.1. Frequency distribution of virulence among isolates of Ascochyta fabae on faba bean lines BPL 471 and ILB 1814. Means are indicated by broken lines. (Means, standard deviations, ranges and variances for above histograms are shown in Table 1.2.1)

In tests repeated twice lines 1 and 5 with resistance at all locations in the FBIABN (1.2.2) were consistently rated resistant to all isolates, whereas lines 7 and 11 with resistance at some but not all locations revealed consistely significant (P=0.01) differential interactions with different isolates (Table 1.2.3). Lines 1 and 5 therefore seemed to have a general type of resistance compared with the specific resistance of lines 7 and 11 to isolates of A. Fabae used in this study.

Based on their reaction on five faba bean lines the eight isolates of the pathogen from Syria were separated into four different groups which apparently represent four physiological races (Table 1.2.3).

Table 1.2.2. Ascochyta blight reaction of entries of <u>Vicia faba</u> at different locations.

Line No. and pedigree	Accession	Origin	Disease reaction[1] Syria							U.K.				Canada[2]			France		Poland		Tunisia
			1980	81	83	84	85	86	87	83	84	85	86	83	84	86	85	86	85	86	86
1 Sel.80 Lat.14434-2	BPL 471	Lebanon	R	R	R	R	R	R	R	R	R	R	R	R	R	NT	R	R	R	R	R
2 Sel.80 Lat.14422-2	BPL 460	Lebanon	R	R	R	R	R	R	R	R	R	R	R	R	R	NT	R	R	R	R	R
3 Sel.80 Lat.14998-2	BPL 646	England	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	NT	R	R	NT[3]
4 Sel.80 Lat.70015	BPL 74	Iraq	R	R	R	R	R	R	R	R	R	NT	R	R	NT	NT	NT	R	NT	NT	R
5 Sel.81 Lat.10026	BPL 2485	Spain	R	R	R	R	R	R	R	R	R	NT	NT	R	R	NT	NT	NT	NT	NT	NT
6 Sel.80 Lat.14435	BPL 472	Lebanon	R	R	R	R	R	R	R	R	R	R	R	R	R	R	S	R	R	R	R
7 Sel.80 Lat.14336	BPL 818	Ethiopia	R	R	R	R	R	R	R	R	R	R	R	R	R	NT	S	NT	R	R	R
8 Sel.80 Lat.14336	BPL 365	Turkey	R	R	R	R	R	R	R	R	R	NT	R	R	R	NT	NT	R	NT	NT	R
9 Sel.80 Lat.14986	BPL 266	Greece	R	R	R	R	R	R	R	NT	NT	R	R	NT	NT	NT	S	NT	R	R	R
10 Sel.80 Lat.14399	BPL 436	Spain	R	R	R	R	R	R	R	NT	NT	NT	R	NT	NT	NT	NT	R	NT	NT	R
11 Syrian local	ILB 1814	Syria	R	S	S	S	S	S	S	NT	NT	R	R	NT	NT	NT	S	R	R	S	R
12 Giza - 4	ILB 1820	Egypt	S	S	S	S	S	S	S	S	S	S	S	S	S	NT	NT	R	NT	NT	NT
13 England local	Hylon	England	NT	NT	NT	NT	NT	NT	NT	S	S	S	S	NT	NT	NT	NT	NT	NT	NT	NT
14 Canada local	Erfodia	Canada	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	S	S	S	NT	NT	NT	NT	NT
15 Polish local	Jasny-II	Poland	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	S	NT	NT
16 French local	48-B	France	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	S	S	NT	NT	NT
17 Tunis local	TS-L	Tunisia	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	S	S

1 = Disease reactions were recorded on ICARDA's 1-9 rating scale.
2 = Reactions in Canada were recorded for isolate A from Manitoba
3 = NT = not tested.

Table 1.2.3. Ascochyta blight reactions of five faba bean lines to eight isolates of *Ascochyta fabae* from Syria (in isolator chambers in the field).

Line	Accession	Disease reaction							
		Group 1 (race 1)			Group 2 (race 2)		Group 3 (race 3)	Group 4 (race 4)	
		IA5	IA9	IA13	IA2	IB2	IB2	IB25	IB4
7	BPL 818	R	R	R	R	R	S	S	S
8	ILB 1814	R	R	R	S	S	R	S	S
1	BPL 471	R	R	R	R	R	R	R	R
5	BPL 2485	R	R	R	R	R	R	R	R
	G-4	S	S	S	S	S	S	S	S

[a] R = resistant (1-25% necrosis, very poor or no sporulation), S = susceptible (26-100% necrosis, moderate to abundant sporulation).

The susceptible reaction of BPL 818 in the FBIABN in France and its resistance at all other locations (Table 1.2.2.) suggested that races 3 and 4 are more common in France compared to other locations. Similarly, the susceptible reaction of ILB 1814 in Syria, France and Tunisia suggests that races 2 and 4 are more common in in these countries compared to other locations. The faba bean lines 1 or 5 and 6, 7 and 11 are usable as a host differential set to check the presence or absence of races 1,2,3, and 4 or to monitor the presence or emergence of new races not mentioned in this work. An in-depth race survey can be conducted employing this host-differential set, to determine which genes for resistance are more effective in different regions.

Our surveys in Syria indicated that races 2 and 4, although present at relatively low frequencies in local populations of *A. fabae*, seem to be more common than races 1 and 3. Therefore, characters for resistance in lines 1,5 and 7 are being exploited in ICARDA's breeding program to develop faba bean blight-resistant cultivars.

Although these efforts identified a number of useful sources with different types of resistance to *A. fabae*, it further demonstrated the presence of considerable pathogenic variability. At the present time, four races have been identified in Syria.

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1.2.2. Mechanisms of resistance to Botrytis fabae

Efforts in the area of host-pathogen interaction continued to focus on passive mechanisms of resistance that suppress the pathogen in the phyllosphere before the invasion of leaf tissue.

Our studies in 1985 and 1986 showed that resistance to chocolate spot in BPL 1179 and 261 can be decreased by washing the leaf surface with tap water, and also by short exposure to a 10% clorox solution. These findings indicated that resistance to chocolate spot in BPL 1179 and 261 is apparently governed by some water soluble compounds and/or biological substances produced by epiphytic bacteria, yeast or filamentous fungi that inhibit the pathogen in the phyllosphere before penetration into leaf tissue. Therefore, four laboratory tests were conducted in 1987, employing in vitro and detached-leaf techniques to study these effects on B. fabae and development of chocolate spot.

a. Spore germination and germtube development of B. fabae, as affected by leaf-washings from different faba bean lines.

   The entire surface of 50 leaflets of resistant, moderately resistant, and susceptible faba bean lines was washed in 100 ml of sterilized distilled water. Washings of leaflets of each line were used separately to prepare a spore suspension containing 500,000 spores of B. fabae per ml of leaf-washing. These suspensions were plated on potato-dextrose-agar medium (PDA), and spore germination and length of germtube were measured after 24 hrs. A spore suspension in distilled sterilized water was plated on PDA as a check.

   Results from this test indicated that washings from leaflets of the resistant BPL 261, 1179 and moderately resistant lines ILB 1814 suppressed significantly (P=0.01) spore germination and germtube development of the pathogen compared to washings from leaves of the susceptible line Rebaya 40 or water (Fig. 1.2.2.).

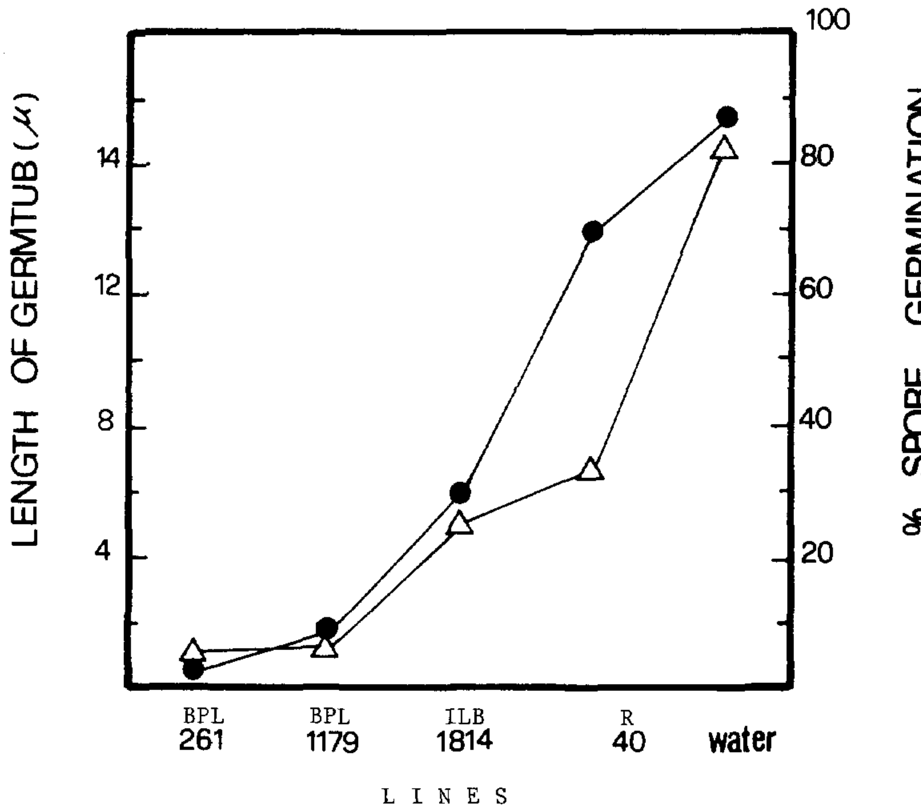


Fig. 1.2.2. Effects of leaf washings from resistant (BPL 261, BPL 1179), moderately resistant (ILB 1814) and susceptible (R 40) faba bean lines on spore germination (O—O) and germ tube length (Δ—) of <u>Botrytis fabae</u> on PDA.

These inhibitory effects should indicate the presence of some water soluble compounds originating from leaf diffusates and/or epiphytic microorganisms. These compounds seem to govern important passive mechanisms of resistance in the phyllosphere of resistant compared to susceptible lines before penetration into leaf tissues.

b. The effects of leaf-washings of certain chocolate spot-resistant lines on disease severity in leaves of the susceptible line Rebaya 40.

Results from this test indicated that spores of *B. fabae* suspended in leaf washings from the resistant lines BPL 261 and 1179, as compared to those in water, failed to induce disease reactions on leaflets of the susceptible line Rebaya 40 (Fig. 1.2.3.). Failure of the pathogen to induce reaction in a susceptible line suggested the presence of inhibitory compounds which seemed to provide effective protection against the pathogen.

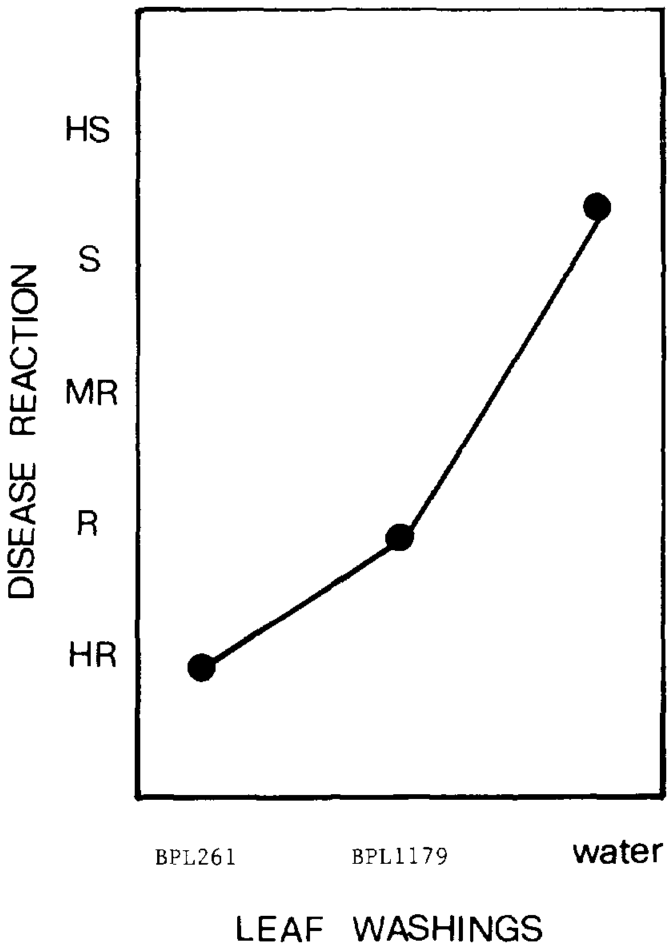


Fig. 1.2.3. Chocolate spot development on the susceptible faba bean lines Rebaya-40 as affected by leaf washings from the resistant lines (BPL 261 and 1179).

c. Effects of artificially-induced-alterations in the phyllosphere by leaf washing on severity of chocolate spot.

Leaflets of resistant and susceptible faba bean lines were collected from the field to study effects of two methods of artificial phyllosphere alteration on severity of chocolate spot. Results from this test indicated that disease severity was significantly affected (P=0.01) by phyllosphere alteration and host resistance (Fig. 1.2.4). Chocolate spot development was least on intact leaflets, follwoed by those which were washed for 5 min. in sterilized distilled water, and then leaflets which were surface-disinfected for 2 min in 10% clorox solution prior to inoculation. Faba bean line BPL 1179 was most resistant, followed by ILB1814, and then Rebaya 40.

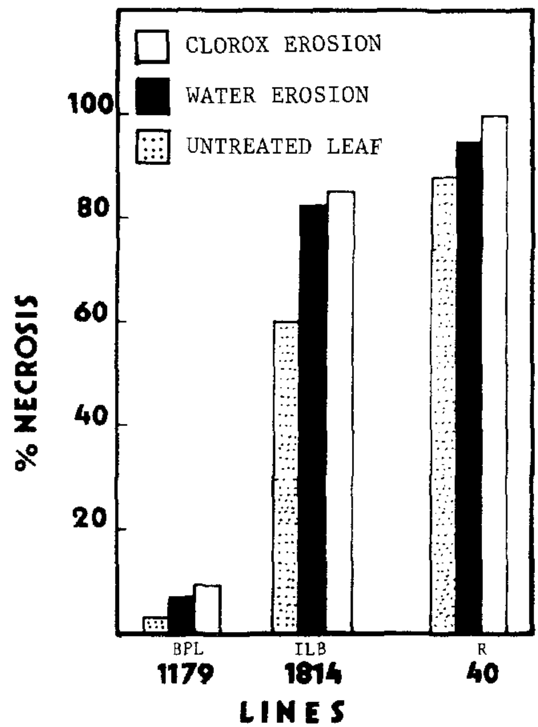


Fig. 1.2.4. The relationship between phyllosphere erosion and severity of chocolate spot on resistant (BPL 1179), moderately resistant (ILB 1814) and susceptible (R-40) faba bean lines.

d. Antagonistic effect of certain epiphytic microorganisms from the phyllosphere of resistant lines on B. fabae.

Of the 300 epiphytic microorganisms isolated from the phyllosphere of resistant lines, there were 5 antagonists that showed different levels of in-vitro inhibition against B.fabae. These antagonists were identified at the International Mycological Institute and found to be in the genera of Penicillium, Fusarium, Alternaria, Cladosporium, and Phoma.

These studies generated new useful information on passive mechanisms of resistance to B. fabae which were lacking in the past. The inhibitory effects of leaflet washings on spores of B. fabae can be used to develop a new in-vitro technique for screening for disease resistance. The presence of certain antagonistic microorganisms in the phyllosphere of resistant lines can be utilized to develop biological control methods against chocolate spot.

Dr. S.B. Hanounik.

1.3. Faba Bean Insects and Their Control

The general objective which applies not only to faba bean, but also to chickpea and lentils, is to develop an integrated pest management system combining all available techniques including host plant resistance, biological control, cultural control and chemical control to manage pest populations so that economic damage is avoided and adverse side effects on the environment are minimized.

This implies the continous monitoring of the occurrence and status of insect pests and natural enemies as well as studies on suitable control methods for the main pest species.

Screening will be continued to identify sources of host plant resistance to aphids, requiring more detailed studies of the extent and nature of resistance mechanisms. An integrated control program may consist of some host plant resistance, the enhancement and/or release of natural predators, and if necessary chemical treatment with a selective insecticide not affecting the beneficial insects.

To further identify the actual and potential bruchid species attacking faba bean, their distribution and economic importance as well as the traditional methods of storage, protection and control, survey will be continued in the ICARDA region. At the same time control recommendations for storage insect pests will be developed both for the field and the store.

1.3.1. Aphid control recommendations

Studies on appropriate control methods for the black bean aphid, Aphis fabae Scop. and Aphis craccivora Koch being the most important insect pests of faba bean, were continued. Since previous studies showed that the aphids might be controlled by just one insecticide application, reliable and practical recommendations for the proper timing of the treatment need to be developed. As in the last season the timing of spraying was based upon the visual damage score (VDS : scale 1-4, 1=no aphids; 4=severe damage) and infestation levels (5%-70% infested stems), but only half of the recommended dosage of Pirimicarb was used. The highest yield was achieved with full protection with no difference between the high and low dosage, followed by spraying once at a VDS of 2 (Fig. 1.3.1). When spraying was timed according to aphid infestation, highest yield was attained when 51 to 70% of the stems were infested at spraying. This can only be explained by the artificially produced aphid infestation, which as in the previous years was necessary because of insufficient natural infestations at Tel Hadya. This year the infestation of March 12 might have been too early, especially as temperatures were low until the end of the month. Because of the artificial infestation the critical levels of percent stems infested were attained very early necessitating spraying well before aphids really damaged the crop. These early sprays did not give protracted protection up to the end of the season.

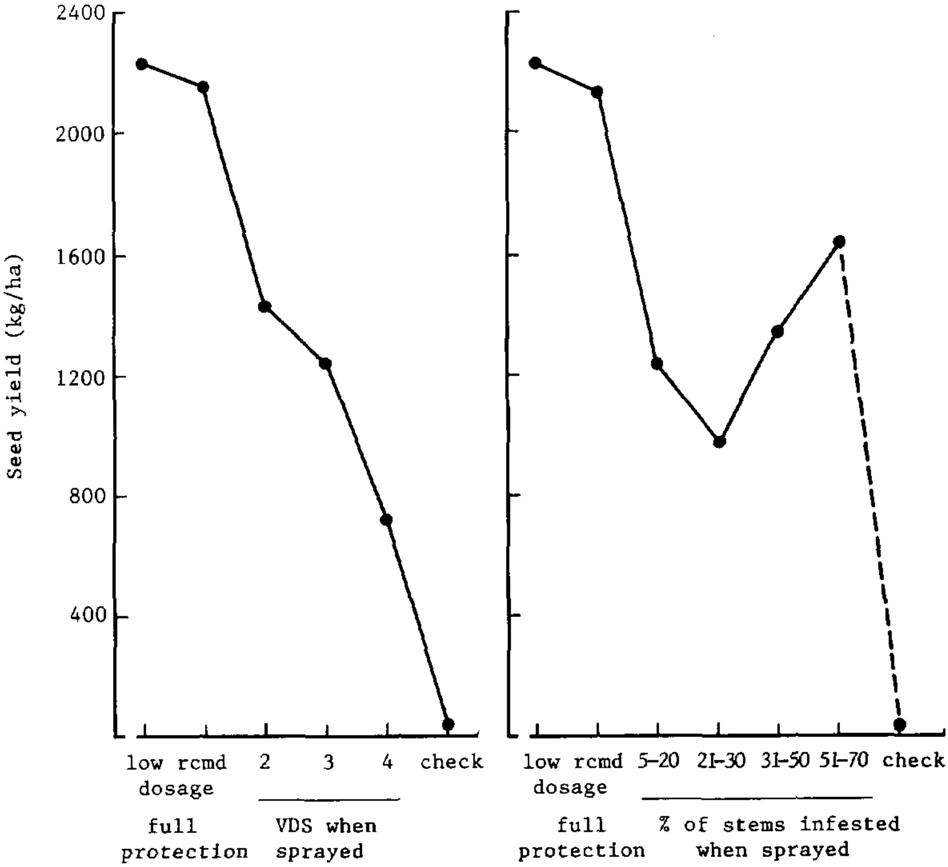


Figure 1.3.1. Effect of timing of insecticide spray (full protection treatment received four sprays of Aphox 50%. Recommended dose was 0.5 g.a.i/liter, low dosage was 0.25 g a.i/liter of spray volume) based on visual damage score (VDS 1-4) or percentage stem infestation by aphids on seed yield of faba bean. Tel Hadya, 1986/87.

These results show that experiments on the development of control recommendations should not rely on artificial infestations, because results can be misleading and not transferable to situations with natural aphid infestations. Therefore next season the threshold studies will be discontinued and only an experiment on aphid resistance screening will be conducted, in which artificial infestations are of minor negative effect.

Drs. S. Weigand and O. Tahhan.

1.3.2. Pollination Studies

The survey of pollinating insects of faba bean was continued in various faba bean growing areas of Syria (Lattakia, Damascus, Hama, Homs, Raqqua, El Ghab valley). About 17 different species of pollinators were collected and sent for identification.

Drs. S. Weigand and O. Tahhan.

1.3.3. Storage Pests

In previous studies Bruchus dentipes Baudi was found to be an important storage pest of faba bean in Syria. Since the infestation occurs in the field, control recommendations have to be developed using different times of application and dosages of insecticides. Because of extremely low B. dentipes infestation this season (5% in the check), no differences between the treatments could be found.

Drs. O. Tahhan and S. Weigand.

1.4. Faba Bean Crop Physiology and Agronomy

The major objectives in faba bean physiology/agronomy are: a) to assess the potential of new plant types developed in the breeding program, identify constraints and as a multiplidisciplinary effort propose a plant ideotype with high yield potential; b) assess genetic variability in response to moisture supply and heat stress; and c) develop production technologies for transfer to national programs for testing and adoption.

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

In favorable environments, yield potential of a crop is largely determined by its efficient utilization of light for dry matter production and a favorable partitioning of the dry matter to the seeds. The traditional varieties of faba bean with indeterminate growth habit attain high total biomass, but give low and unstable yield because upto 98% of the flowers and pods are shed as a result of competition between vegetative and reproductive parts and at each node between flowers. To overcome this problem, the faba bean breeding program has laid strong emphasis on the development of alternative plant types which include determinate growth habit and plants with independent vascular supply to each flower (IVS). Since little is known about these new plant types, a study was initiated during the 1985/86 season to determine whether the major constraints in the traditional indeterminate plants have been removed and whether development of alternative plant types has resulted in new constraints to attainment of high yield. Four faba bean lines were used in the study: ILB 1814 (indeterminate), FLIP 84-230F and FLIP 84-239F (determinate) and IVS 6; these were evaluated at two plant populations (22 and 44 plants/m^2).

Throughout the study, there were no significant interactions between genotypes and populations and results are presented therefore as means of the main effects. The number of primary branches/plant was low at the beginning of the season, increased steadily to a maximum and then stabilized (Fig. 1.4.1). Maximum number of branches/plant in ILB 1814 and IVS 6 was attained in mid March (start of flowering) and towards the end of April in FLIP 84-230F and FLIP 84-239F. Maximum number of branches/plant in IVS 6 was below 3, in ILB 1814 was 3.6, in FLIP 84-239F was 5.6 and in FLIP 84-230F was 6.5. This suggests that the advantage of determinate growth habit in both FLIP 84-230F and FLIP 84-239F may be lost through production of large number of branches/plant, particularly at the reproductive stage. Results show that one way of suppressing the production of large number of branches/plant is planting at high density (Fig. 1.4.1). Photosynthetic area index (PAI), percentage intercepted radiation and dry matter production followed the same pattern; low at the beginning of the season and increasing to a maximum (Fig. 1.4.2, 1.4.3 and 1.4.4). Dry matter

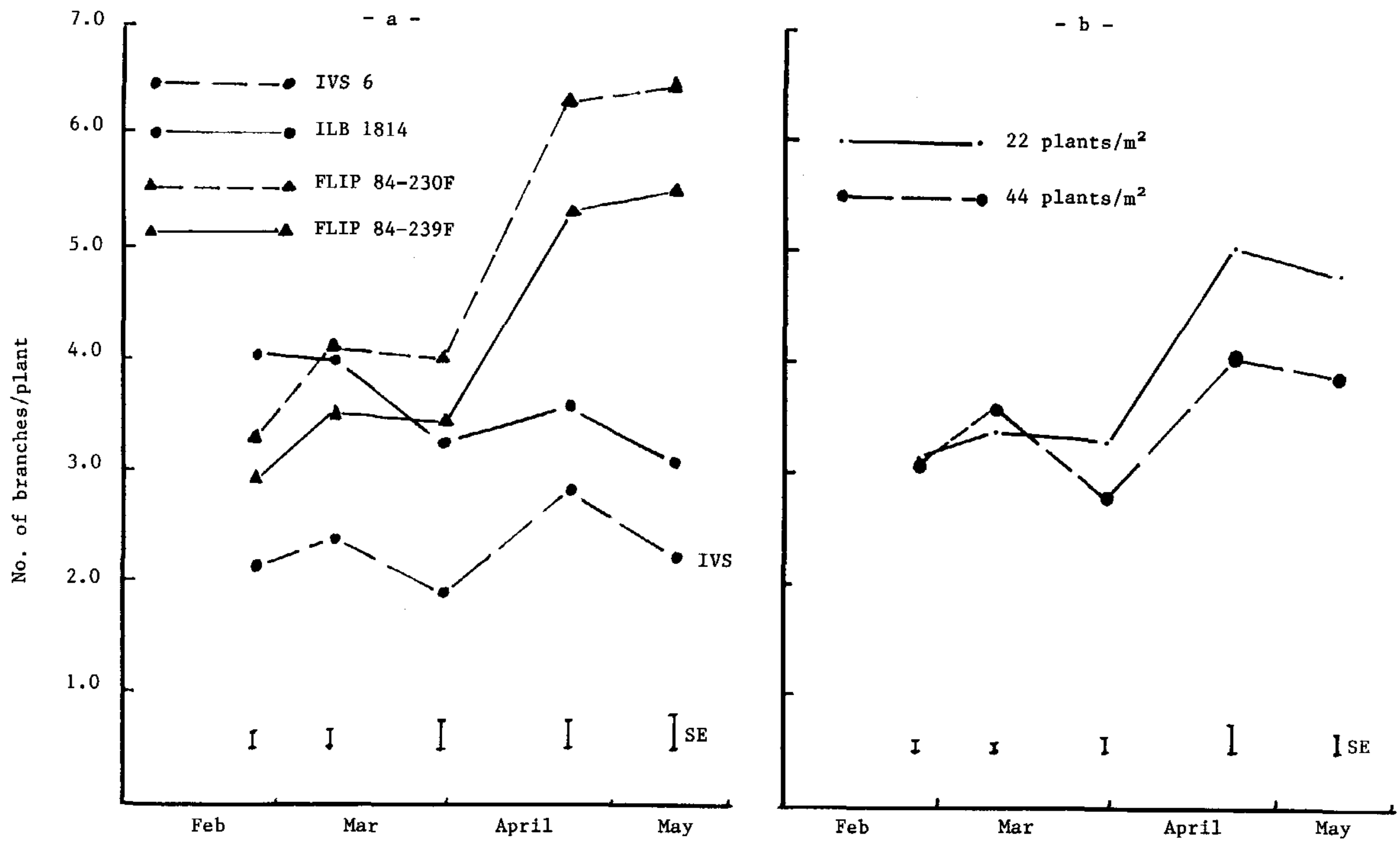


Figure 1.4.1. Number of branches/plant at different growth stages of faba beans of a. different plant types, b. varying population. Tel Hadya, 1986/87.

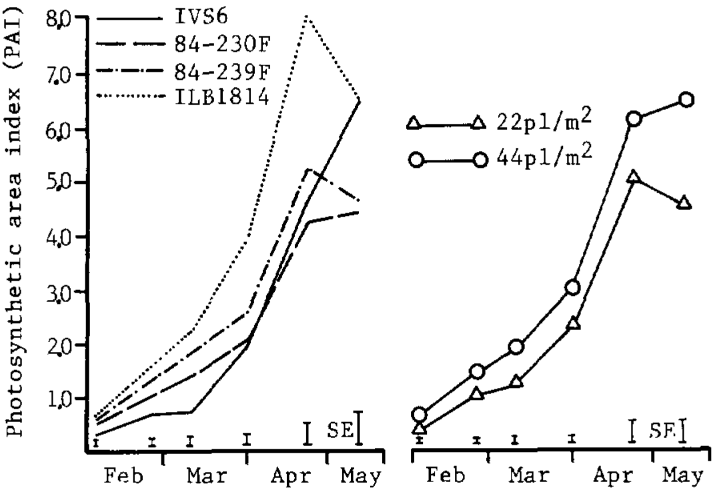


Figure 1.4.2. Build up of photosynthetic area index of faba beans (PAI) as affected by plant types and population. Tel Hadya, 1986-87.

produced was associated with intercepted radiation. As in the 1985/86 season, ILB 1814, which achieved high PAI, intercepted a high percentage of radiation and produced large total dry matter and FLIP 84-230F and IVS 6, with low PAI, intercepted less radiation and produced low amount of dry matter. FLIP 84-239F achieved intermediate PAI, intercepted intermediate level of radiation and produced more total dry matter than FLIP 84-230F and IVS 6 but less than ILB 1814. Percentage dry matter partitioning among genotypes at different growth stages is given in Fig 1.4.5. FLIP 84-230F and FLIP 84-239F partitioned proportionately more assimilates to the reproductive parts and IVS 6, a late genotype, partitioned less. Frost occurred in March and damaged flowers of early flowering FLIP 84-230F most, indicating that in areas prone to frost, lines that flower early are most affected adversely. Seed yield and total biological yield are given in Table 1.4.1. ILB 1814, the indeterminate local genotype, gave the highest yield, followed by FLIP 84-239F and FLIP 84-230F and as in the 1985/86 season the unadapted late maturing IVS 6 gave the lowest yield. Planting at 22 or 44 plants/m^2 did not have significant influence on seed yield.

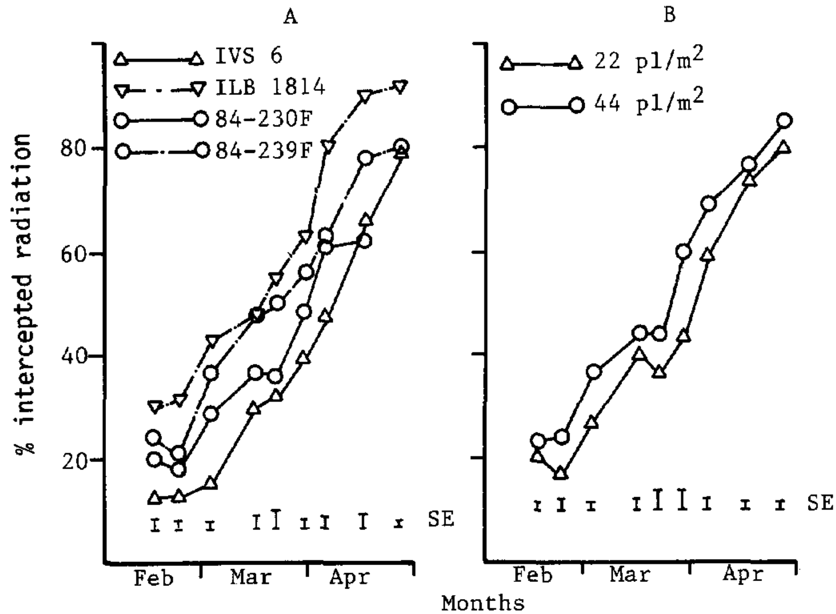


Figure 1.4.3. Percentage intercepted radiation at different growth stages as affected by a. genotype, and b. plant population. Tel Hadya, 1986/87.

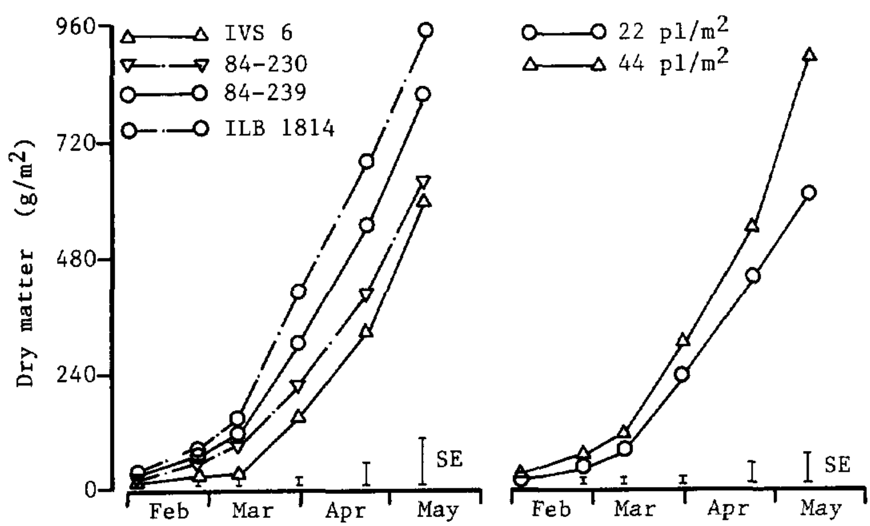


Figure 1.4.4. Total dry matter in g/m^2 at different growth stages for a) four faba bean genotypes and b) two plant populations. Tel Hadya, 1986/87.

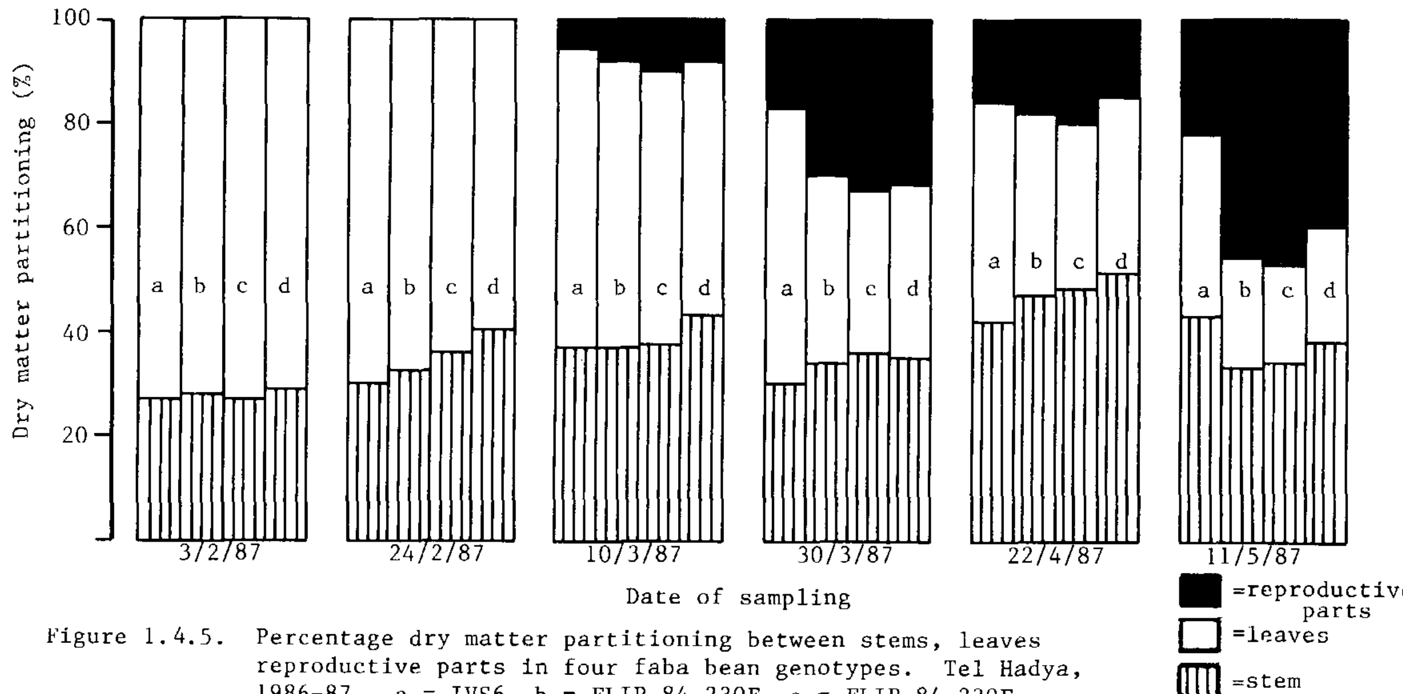


Figure 1.4.5. Percentage dry matter partitioning between stems, leaves reproductive parts in four faba bean genotypes. Tel Hadya, 1986-87. a = IVS6, b = FLIP 84-230F, c = FLIP 84-239F, d = ILB 1814.

However, there were some difference in trends, with FLIP 84-239F having a yield advantage of 13.5% when planted at 44 as compared to 22 plants/m^2 and ILB 1814 having slight reduction of 2% when planted at 44 plants/m^2 as compared to 22 plants/m^2. This shows that as we develop new plant types, production practice for high yield would also vary. The high seed yield obtained was mainly through attainment of high total biological yield (r=0.93) and partitioning a large proportion of the assimilates to the seeds (r=0.47).

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 kg/ha, Plant population/m^2 22	44	mean	Biological yield kg/ha, Plant population/m^2 22	44	mean	Frost damage score*
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) = genotype, (P) = population.
* Frost damage score of flowers taken 10 days after end of frost occurrence. Scale: 1-5, where 1 = no damage; and 5 = complete flower kill.

In conclusion, results indicate that the hypothesis that development of determinate plant type would lead to high seed yield may be right only when the total biomass is increased while at the same time high harvest index is maintained and selection for early cessation of development of newer branches is included in the breeding program.

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

1.4.2. The effect of number of branches on yield and yield components of determinate faba bean.

Studies of growth, dry matter production and partitioning of faba bean plants of different growth habit in both 1985/86 and 1986/87 seasons indicate that determinate plants produce larger number of primary branches/plant than indeterminate conventional varieties. The study also shows that there is continued production of branches even after the start of flowering. The probability is high that production of large numbers of branches, particularly during reproductive growth, could probably result in loss of advantage of terminal inflorescence because of competition between reproductive and vegetative growth. A study was therefore initiated to determine whether (a) production of large number of branches in determinate faba bean line FLIP 84-230F would result in the loss of advantage of terminal inflorescence and (b) the optimum number of branches for high seed yield. In the study ILB 1814 (indeterminate, local genotype) was included to compare the response of indeterminate with determinate lines. The treatments were: two stems/plant (one branch and main stem), three stems/plant, four stems/plant and control (no removal of branches). The required number of stems was maintained in each treatment by removing excess stems on a weekly basis.

Seed and biological yields are given in Table 1.4.2. ILB 1814 outyielded FLIP 84-230F. Debranching had no significant influence on seed and biological yields of ILB 1814. FLIP 84-230F was, however, influenced significantly by the number of branches/plant, each successive increase in number of branches/plant resulted in increase in yield (Table 1.4.2). Frost occurred during second half of March and affected flowers of FLIP 84-230F more adversely than ILB 1814 (frost damage score was 1.9 for ILB1814 and 4.3 for FLIP 89-230F) and since the latter genotype has an indeterminate growth habit, it was able to produce more flowers after frost which was not the case with FLIP 84-230F. The compensation here occured by flowering and podding on later formed branches. Therefore the yield increased in this genotype when the number of branches retained was increased. If the weather at the time of late appearance of branches would have become hot, as is usually the case, this would not have occured.

Table 1.4.2. Seed yield and biological yield in kg/ha as affected by the number of stems/plant. Tel Hadya, 1986/87.

No. of stems/plant	Seed yield (kg/ha) ILB 1814	FLIP 84-230F	Mean	Biological yield kg/ha ILB 1814	FLIP 84-320	Mean
2	4601	2330	3465	6766	3347	5057
3	4476	3035	3765	6816	4285	5550
4	4087	3567	3753	6260	4983	5622
Control	4566	3642	4104	6913	5167	6040
Mean	4432	3140		6689	4445	
	LSD(.05)	SE	CV (%)	LSD(.05)	SE	CV (%)
Genotype	284.9	96.8	10.2	450.9	153.5	11.0
Stem	402.9	137.0		637.6	216.8	
Interaction	569.7	193.7		901.7	306.6	

1.4.3. Evaluation of productivity under rainfed and assured moisture supply of faba bean genotypes selected for low rainfall environment.

For three consecutive seasons, trials under rainfed conditions were conducted to study the effect of row spacing and plant population on yield and water use efficiency of eight faba bean genotypes selected for rainfed environments. The results indicated that a combination of planting at narrow row spacing and high plant population gave the best yields and improved water use efficiency and among the genotypes tested, *80S 43856, 80L 90121 and ILB 1814 gave superior* yields. These three superior genotypes were tested during the 1986/87 season to determine their productivity under assured moisture supply as compared to rainfed condition at 22 and 44 plants/m^2. Precipitation during the season in Tel Hadya was 359 mm. To ensure uniformity in establishment, all treatments received 80 mm of irrigation water; 40 mm at planting and another 40 mm at emergence. The irrigated treatment in addition received two extra 100 mm irrigations in April.

Total biological yield was increased significantly by giving irrigation and planting at higher density (44 plants/m^2 as compared to 22 plants/m^2) and among the genotypes, ILB 1814 gave the highest biomass (Table 1.4.3). Seed yield, however, was increased significantly only by giving irrigation (Table 1.4.4). The lack of response in seed yield to higher population in 1986/87 as compared to the three previous seasons most probably was due to higher moisture supply (439 mm) received by rainfed treatment which permitted production of large biomass; the latter is the major pre-requisite of high seed yield. The results of the four seasons suggest that when moisture supply is limiting as in 1984/85 and 1985/86, high seed yield requires planting at higher density so as to achieve high biomass, but when soil moisture is raised to over 400 mm as in 1986/87, increasing plant population has no additional advantage.

Table 1.4.3. Biological yield (kg/ha) as affected by moisture supply, genotype and plant population. Tel Hadya, 1986/87.

	Rainfed			Assured moisture			
	Population/m^2			Population/m^2			Means for
Genotype	22	44	Mean	22	44	Mean	Genotype
80S 4356	8157	8699	8428	9530	10208	9869	9149
80L 90121	7697	7958	7828	9620	9972	9796	8812
ILB 1814	8648	8597	8623	10572	11065	10818	9720
Mean	8167	8418		9907	10161		
Mean for moisture		8293				10161	

	Populations/m^2	
	22	44
80S 4356	8844	9454
80L 90121	8659	8965
ILB 1814	9610	9831
Mean for population	9037	9417

	(M)	(G)	(P)	MxG	MxP	GxP	MxGxP
LSD (.05)	716.6	464.8	379.5	NS	NS	NS	NS
SE	159.2	161.0	131.4	244.7	185.9	227.6	321.9
CV(%)	8.5	7.0					

(M) = moisture, (G) = genotype, (P) = population

Table 1.4.4. Seed yield in kg/ha as affected by moisture supply, genotype and plant population, Tel Hadya, 1986/87.

Genotype	Rainfed Population/m^2 22	Rainfed Population/m^2 44	Rainfed Mean	Assured moisture Population/m^2 22	Assured moisture Population/m^2 44	Assured moisture Mean	Means for Genotype
80S 4356	4269	4407	4338	4993	5156	5075	4707
80L 90121	4093	3935	4014	5100	5111	5105	4560
ILB 1814	4141	3731	3936	5012	4815	4913	4425
Mean	4167	4025		5035	5028		
Mean for moisture		4096				5031	

	Populations/m^2 22	Populations/m^2 44
80S 4356	4631	4782
80L 90121	4596	4523
ILB 1814	4576	4273
Mean for population	4601	4526

	(M)	(G)	(P)	MxG	MxP	GxP	MxGxP
LSD (.05)	306.4	NS	NS	NS	NS	NS	NS
SE	68.1	77.6	63.3	112.5	93.0	109.7	155.1
CV(%)	7.3		6.8				

(M) = moisture, (G) = genotype, (P) = population

Figure 1.4.6 gives the means of pre-dawn leaf water potential of rainfed and irrigated treatments grown at 22 and 44 plants/m^2. The trend was for leaf water potential to decrease with time. Differences in population on leaf water potential at the same moisture supply were small. Leaf water potential in rainfed treatment was significantly lower than in irrigated treatment (Fig. 1.4.6). Fig. 1.4.7 gives soil water deficits at 30 cm intervals, from 0 to 120 cm within the soil profile. The results show that in all profiles, water deficit was higher at the beginning of the season, afterwhich the deficit was reduced with filling of soil profile during rains, then again in May deficit increased. Like leaf water potential and seed yield, differences between population had no strong influence on water deficit. Differences in water deficit between irrigated and rainfed treatments appeared in April

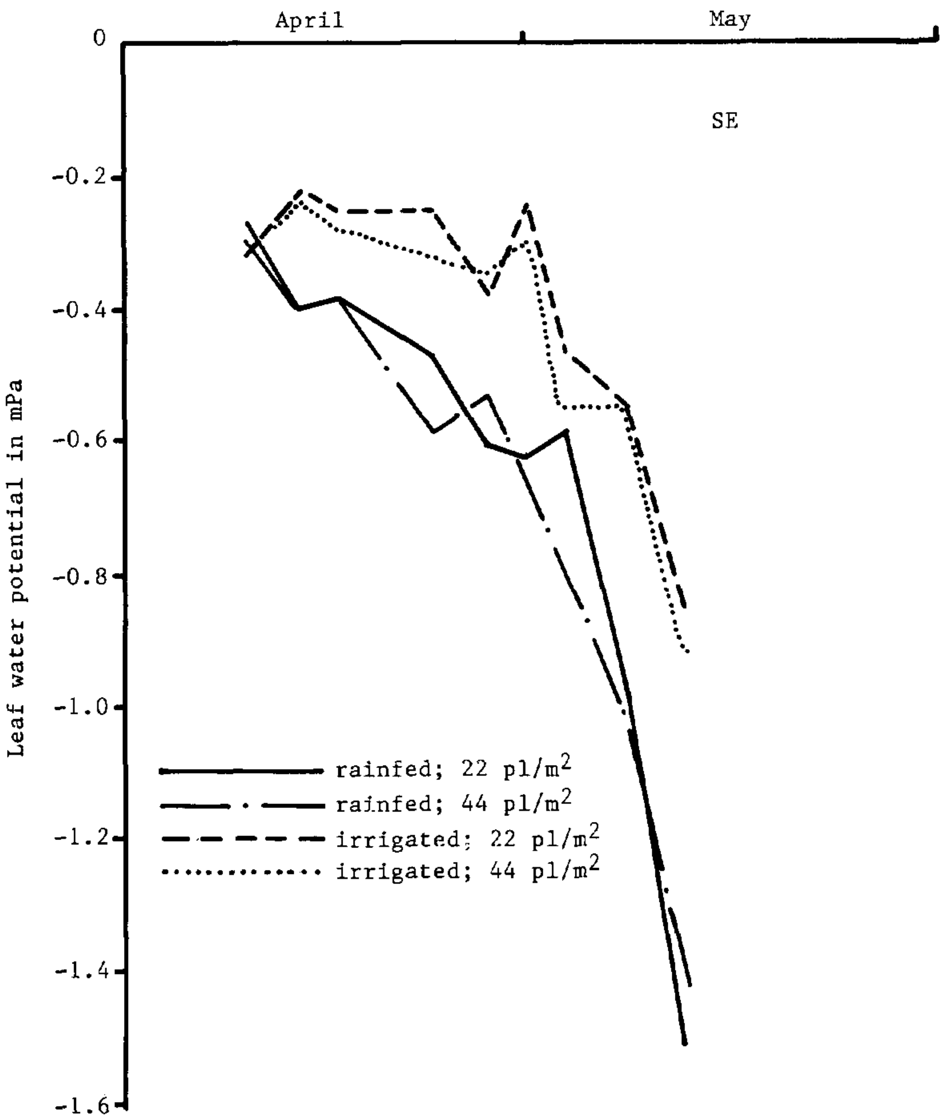


Figure 1.4.6. Leaf water potential (mPa) of rainfed and irrigated faba bean grown at 22 and 44 pl/m^2. Tel Hadya, 1986/87.

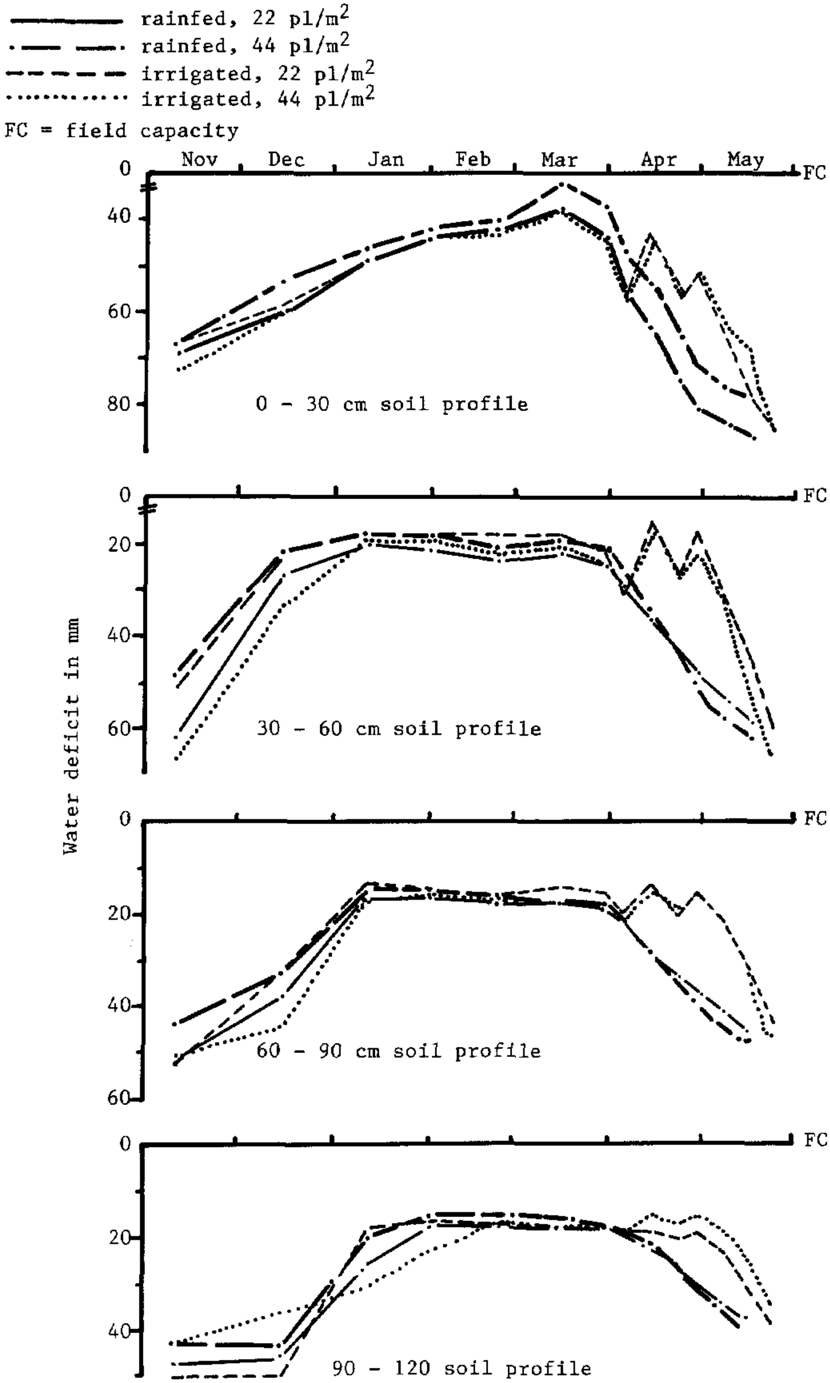


Figure 1.4.7. Cumlative water deficits at selected horizons in ILB 1814. Tel Hadya, 1986/87.

and continued to the end of the growing season, with irrigated crop in all profiles experiencing less water deficit than rainfed treatments. The largest differences in water deficit between irrigated and rainfed treatments were in the 30-90 cm soil profile. The 0-30 cm soil depth had the highest soil water deficit, probably because most of the roots were in this layer.

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

1.4.4. Heat stress

Faba bean is a crop that is sensitive to moisture and temperature stresses. The two stress conditions usually occur together either during the early vegetative stage or during the reproductive period when temperatures would rise progressivey leading to higher rates of evapotranspiration. This study, conducted by an M.Sc. student, aimed at investigating the effect of high temperature during the vegetative and reproductive development of faba bean.

In a replicated trial six faba bean genotypes adapted to subtropical, Mediterranean and temperate environments were used in the study. Supplementary irrigation by surface and sprinkler methods was used to create two regimes and the rainfed crop represented the third regime. It was assumed that the different methods of supplementary irrigation would create temperature differentials.

Average canopy temperature was lower than the temperature of the air above the canopy and varied with the moisture regime. Plants grown under rainfed regime, the most stressful moisture regime, recorded the highest canopy temperature (Fig. 1.4.8). Canopy temperatures of plants grown under sprinkler irrigation were higher than those grown under surface irrigation except on the day of moisture application when the effect was negligible.

The trend in treatment effect on the soil temperature was similar to that of canopy temperature (Fig. 1.4.9). Surface soil temperature was higher than air temperature except on days when irrigation was applied. In the case of rainfed regime, surface soil temperature was always higher than air temperature.

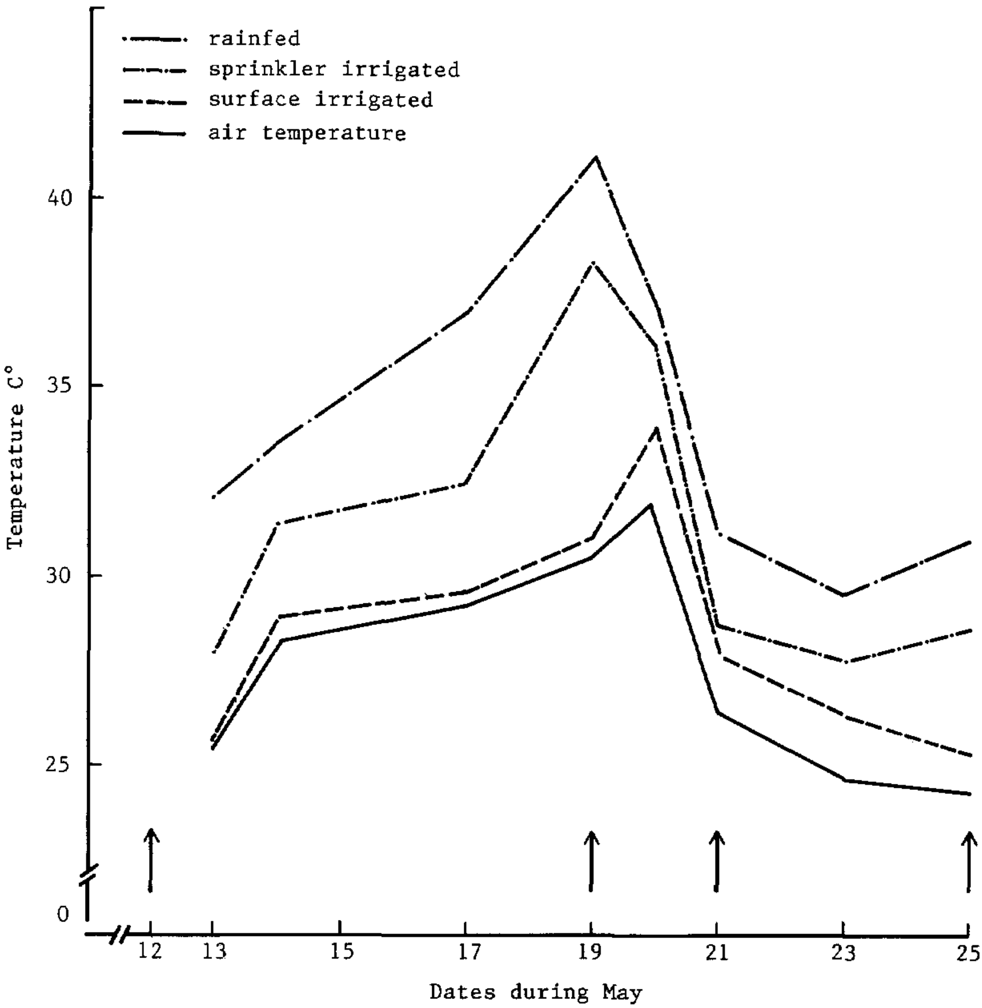


Figure 1.4.8. Mean canopy temperature of six faba bean genotypes as affected by differential soil moisture. Arrows indicate irrigation schedule; temperature recorded at mid-day. Tel Hadya, 1986/87.

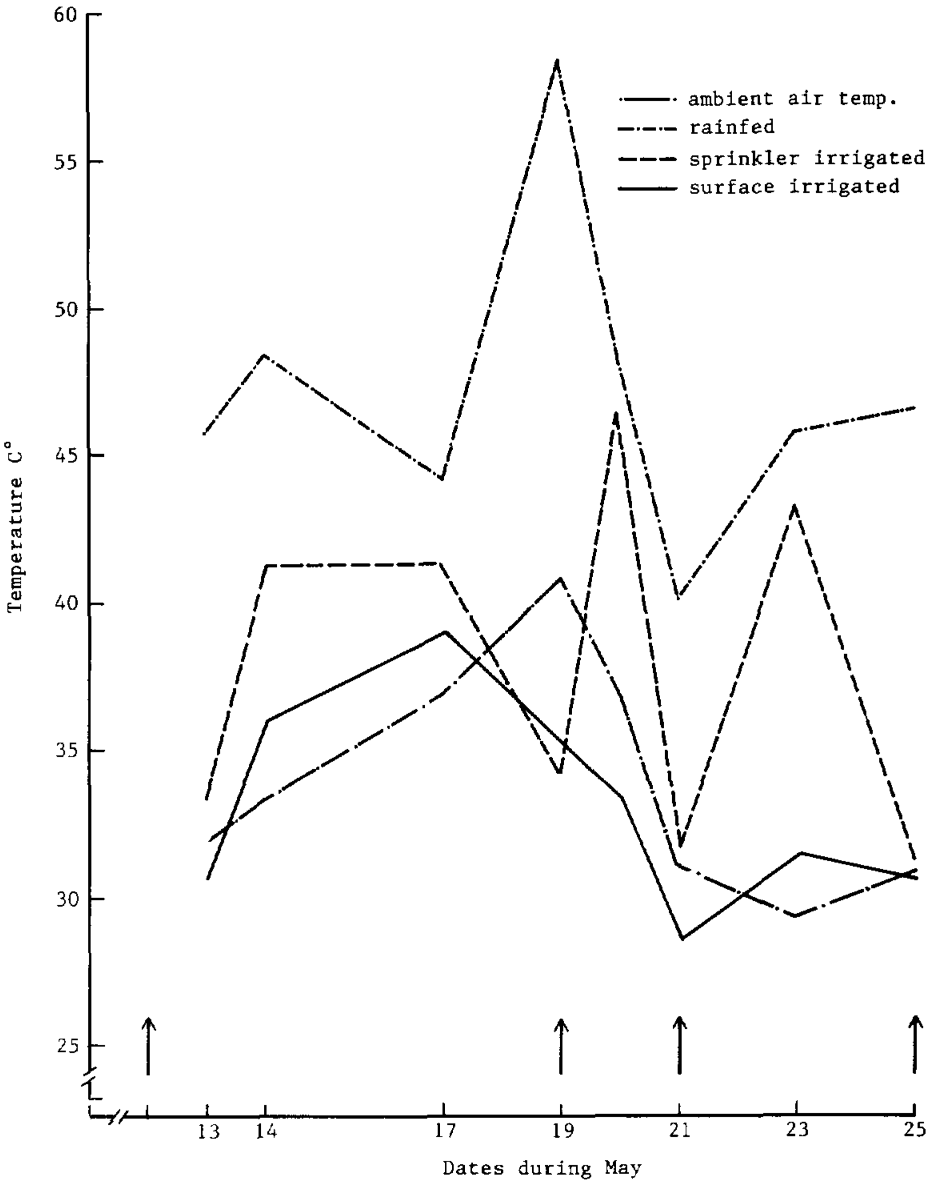


Figure 1.4.9. Mean soil temperature in plots receiving differential irrigation and planted to six faba bean genotypes. Arrows indicate irrigation schedule; temperature recorded at mid-day. Tel Hadya, 1986/87.

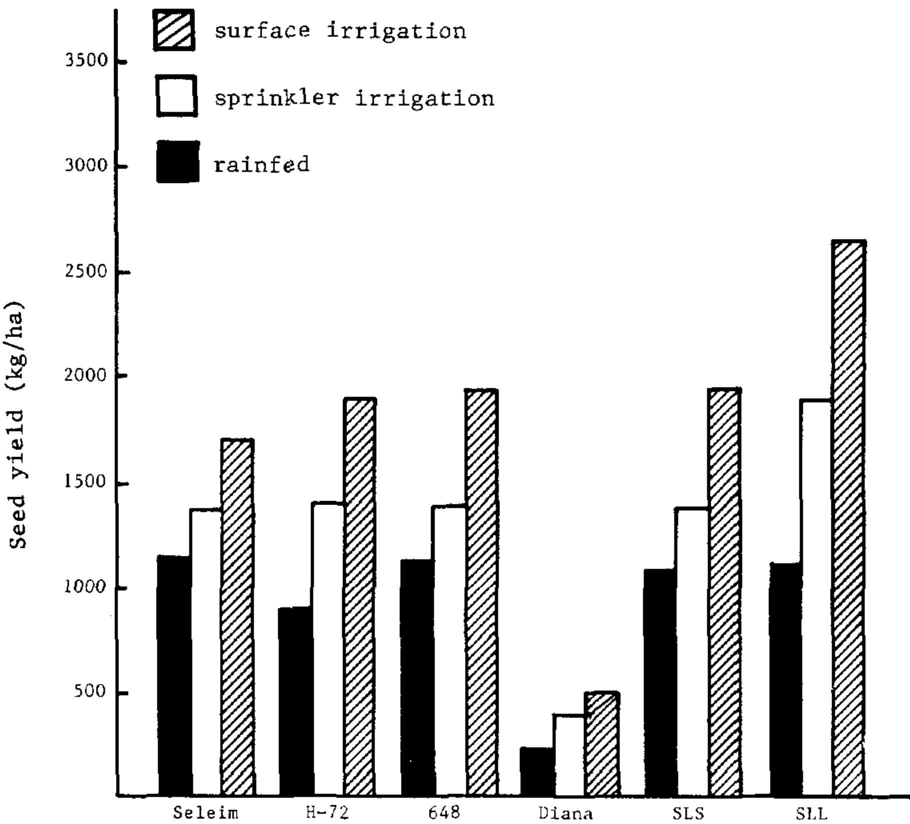


Figure 1.4.10. Mean yield of six faba bean genotypes as affected by moisture and temperature stresses. Tel Hadya, 1986/87. Cultivars Seleim, H-72 and 648 originate from Sudan, cultivars SLS and SLL are from Syria, and cultivar Diana is from U.K.

The effect of treatments on the yield of six genotypes is shown in Fig. 1.4.10. There was no interaction between the genotypes and treatments, but genotype differences were large. The genotype Diana (ILB1044) gave lowest yield while the locally well adapted genotype SLL (ILB1814) gave the highest yield. The moisture stress effects are reflected in canopy temperature differences and both 'moisture' and 'temperature' stresses may operate together. Thus, future drought tolerance studies should look into these factors independently and in combination.

Dr. H. Ibrahim and Mr. Bashir.

1.4.5. Chemical weed control in faba bean

The experiment was conducted at Tel Hadya during 1986/87 growing season under irrigated conditions.

The effect of weeds on crop yield loss and the role of some new selective herbicides in weed control and in effect on crop yield was studied using Syrian local large faba bean cultivar. Some of the herbicides have already been tested in field experiments, some of them are newly developed and being tested for the first year under irrigated conditions in the ICARDA region. The trial was conducted as RCB design with four replications.

Table 1.4.5.1. Effect of weed control on seed yield of faba bean and on weed dry matter, Tel Hadya, 1986/87.

Treatment	Rate of appln. (kg ai/ha)	Time of appln.	Seed yield (kg/ha)	Total weeds (kg/ha)
			*	*
Weedy check	-	-	2597	3675
Weed-free check	-	-	5076	109
Cyanazine + pronamide	1.0 + 0.5	Pre-em	3142	823
Terbutryne + pronamide	3.0 + 0.5	Pre-em	4866	1255
Bentazone + fluazifob butyl	1.0 + 0.5	Post-em	4000	217
Codal	2.0	Pre-em	2749	2142
Secbumetron	0.5	Pre-em	1751	479
Carbetamide + terbutryne	1.5 + 2.5	Pre-em	1994	857
Carbetamide + hand weeding	1.5	Pre-em	4179	127
Imazaquin	0.15	Pre-em	3646	1225
Imazaquin	0.15	Pre-em	3255	296
Imazaquin	0.10	At-em	854	226
Fomesafen + fluazifob butyl	0.2 + 0.5	Post-em	1720	985
Fenoxyprop ethyl + dinoseb acetate	0.15 + 1.0	Post-em	4178	474
Dinoseb acetate + monolinuoron	1.0	Post-em	3001	3592
LSD (0.05)			842	750
CV (%)			19	48

* P<0.05

The level of weed infestation was quite high with Sinapis arvensis as the following dominant species.

In general 98 % of the weeds were broad leaved. Weeds caused about 50 % reduction in seed yield due to very high infestation level (Table 1.4.5.1). A combination of cyanazine with pronamide as pre-emergence spray resulted in the highest seed yield almost equal to plots kept weed-free by hand weeding (Table 1.4.5.1). Post-emergence application of dinoseb acetate + fenoxyprop ethyl and bentazone + fluazifob butyl were the next best combinations. Cyanazine + pronamid combination was also the most effective treatment last year when faba bean was grown under rainfed conditions at Tel Hadya.

Secbumetron and carbetamide + terbutryne as pre-, imazaquin as at-emergence, and fomesafen + fluazifob and imazaquin as post-emergence applications were quite phytotoxic to the crop. These herbicides will be deleted from experiments next year.

Drs. M. Pala, S. Silim and Mr. M. El Ali.

1.5. Faba Bean Microbiology

Faba bean is a traditional crop in the Mediterranean region, and populations of native soil rhizobia bacteria are generally adequate to produce root nodules, the site of nitrogen fixation. However, with introduction of improved cultivars replacing traditional plant types, and particularly with movement into new areas of production, it is possible that significant economical yield increases can be obtained through application of selected specific types of Rhizobium.

The main objective of microbiology research in FLIP is to determine whether legume productivity and hence soil fertility can be increased through manipulation of this plant bacteria partnership. Activities can be divided into: a) determination of the necessity for inoculation under various conditions, accomplished through an international network evaluation of native rhizobial effectiveness; b) inoculant improvement, including selection of strains for effectiveness, competetiveness, and survival ability in soils; c) inoculant technology improvement, to overcome constraints in production and application of inoculants; and d) evaluation of economics of N fixation, through measurement of N fixed under diverse conditions and the fate of fixed N in cropping systems.

Rhizobium strain evaluation and collection

Evaluation of Rhizobium germplasm under controlled conditions is the first step toward providing appropriate inoculation technology where it is needed. Using a greenhouse nitrogen-free aseptic hydroponic gravel culture system, 30 strains newly acquired and in the collection were screened against two cultivars for their capacity to fix nitrogen over a range of plant germplasm. From this evaluation, six strains were chosen as clearly superior, for utilization in further experiments. Additional genetic material collected within the ICARDA region and obtained from international culture collections will be included in this screening activity on a continuing basis.

As a part of its activities supporting work in national programs, Microbiology section provided more than 40 different strains to scientists in 12 countries in the form of cultures or as inoculants. Collection of new strains from the region for evaluation is a cooperative ongoing effort assisted by FLIP and national program scientists.

Necessity for inoculation

Field trials designed to determine the necessity for inoculation were distributed as International Fertility Rhizobium trials throughout the region; twelve trials were conducted in 9 countries. Trials were also conducted at Tel Hadya in Syria. These trials utilize treatments of plus and minus nitrogen, so nitrogen fertilized plants may be compared to symbiotic plants, at two levels of P/K fertility. Where plants given applied nitrogen respond significantly over symbiosis-reliant plants, improvement of N fixation through inoculation may be possible.

No data have yet been received by ICARDA from 1986/87 international trials but cooperators have communicated that in many areas a potential response to inoculation is indicated. At these sites, inoculation response trials will be conducted in 1987/88.

Strain-cultivar field trials

During 1986/87 season, three faba bean cultivars were evaluated at Tel Hadya with three selected rhizobia strains, to determine cultivar specific interactions with rhizobia strains. The strains chosen were 'best guess' in terms of their effectiveness and competetiveness, as greenhouse facilities were previously unavailable for strain selection work.

At Tel Hadya field, where faba bean has a history of cultivation, soil contained more than 10,000 faba bean rhizobia per gram. All cultivars were severely affected by Orobanche infestation, and grain yields averaged only about 2 t/ha. Responses of two local cultivars were quite different from an Egyptian cultivar, Giza 402. Yields of local large (ILB 1814) and Lebanese local small were maximum in the uninoculated treatment indicating that these local cultivars are able to fix adequate nitrogen with native rhizobia strains. Giza 402 responded significantly both to N application and one (Egyptian) rhizobia isolate, indicating a potential for response to selected strains under Syrian conditions.

Dr. D. Beck.

1.6. Faba Bean Quality

Faba bean quality improvement is focussed on increasing both seed yield and its stability, while research on seed quality at ICARDA aims to maintian the nutritional level of seed. This covers the study of both anti-nutritional and nutritional factors in faba bean.

1.6.1. Studies on protein

Fourteen genotypes specially selected for low and high protein content were grown at four locations in two replicates during 1985-86. The average inter-location coefficient of correlation for protein content was 0.78. Using unreplicated data from the 1982-83 and 1984-85 studies which included ten of the genotypes, the standard unit heritability was computed for nine sets of data including three seasons at Tel Hadya and two each at Jinderiss, Lattakia and Terbol. The mean coefficient of correlation was 0.768 indicating a high degree of stability in protein content of these lines. Overall mean results for protein content in the ten genotypes are presented in Table 1.6.1.

Table 1.6.1. Protein content of ten genotypes grown over three seasons at four locations.

BPL	Mean protein (%)	CV (%)	Designation
248	31.1	6.6	High
361	24.7	7.1	Low
369	24.7	9.5	Low
494	30.8	7.1	High
503	29.9	6.5	High
521	30.4	10.7	High
661	28.5	11.3	Medium
774	24.9	4.8	Low
791	25.3	9.1	Low
907	25.0	9.2	Low

1.6.2. Studies on the favogens vicine and convicine

Vicine and convicine are two glycosides which occur in faba bean and cause in susceptible humans a fatal haemolytic anaemia called favism. The disease appears to be most prevalent in some parts of the Mediterranean region where weaning babies are particularly susceptible. ICARDA's food legume quality laboratory has studied the incidence of vicine and convicine in faba bean genotypes, together with the influence of growing location on the content of the favogen. First, 85 genotypes of faba bean were screened for favogens content in 1983 using high performance liquid chromatography. During the next two years seed of selected lines high and low in favogen content was increased for a location study. In 1985-86 25 lines were planted in four locations, Tel Hadya, Jinderiss and Lattakia in Syria, and Terbol in Lebanon.

Combined vicine plus convicine content ranged from about 0.3 to 0.9 percent and there was a strong influence of growing location on the content of both favogens. While some lines retained high favogen content on all locations, none of them retained low amounts. Typical of this is BP 420 which varied from 0.25 to 0.43% in vicine, 0.08 to 0.18% in convicine and 0.33 to 0.61% in vicine + convicine at two growing locations (Hama and Lattakia). Coefficient of variability ranged from 5 to 24% for vicine, 2 to 41% for convicine and 4 to 27% for the two together. Results for vicine and convicine content are summarized in Table 1.6.2.

Using the standard unit heritability technique based on coefficients of correlation between locations, average coefficients of correlation for 25 genotypes over 4 locations were respectively 0.46 for vicine ($r^2 = 0.21$), 0.53 for convicine ($r^2 = 0.28$) and 0.34 for vicine + convicine ($r^2 = 0.21$). These results, together with the high degree of variability between locations, particularly in the case of lines which were low in vicine/convicine at some locations, indicate that heritability of favogens is not sufficiently high to permit selection of genotypes low in favogens. The work is to be repeated in 1986-87 to verify the location effect and to study the effect of growing season.

A near-infrared reflectance (NIR) calibration was developed for the determination of vicine, convicine and vicine + convicine, using

Table 1.6.2. Vicince and convicine content (%) of faba bean, grown in four locations, 1984-85

		Vicine	Convicine	Vicine + Convicine
Tel Hadya	Mean	0.49	0.20	0.69
	CV (%)	15.7	26.5	14.0
	High	0.61	0.35	0.90
	Low	0.30	0.09	0.39
Hama	Mean	0.49	0.17	0.66
	CV (%)	20.5	25.6	17.7
	High	0.66	0.30	0.87
	Low	0.25	0.08	0.33
Lattakia	Mean	0.47	0.20	0.67
	CV (%)	16.0	27.4	14.9
	High	0.62	0.31	0.83
	Low	0.31	0.10	0.46
Terbol	Mean	0.52	0.20	0.72
	CV (%)	16.9	20.9	12.7
	High	0.69	0.30	0.90
	Low	0.34	0.13	0.51
Overall	Mean	0.49	0.19	0.68
	CV (%)	17.6	25.6	15.0
	High	0.69	0.35	0.90
	Low	0.25	0.08	0.33

a Pacific Scientific Research Composition Analyzer, Model 6250. Standard errors of performance (standard deviation of differences between NIR and HPLC data) were respectively 0.01, 0.005 and 0.01. Coefficient of correlation for vicine + convicine (total favogens) was 0.85. The NIR technique would be useful for screening large numbers of samples into high and low categories of favogen content.

Drs. P.C. Williams, and L.D. Robertson.

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 or cropping systems. The importance of the regions in terms of lentil production and the allocation of resources in breeding are summarised below together with breeding aims and the mechanism of production of breeding material.

Region	% of lentil area in developing countries	% of resources	Key characters for recombination	Production of breeding material
Mediterranean low-medium elevation	24	75	Biomass (seed+straw), attributes for mechanical harvest, wilt resistance, drought tolerance	At ICARDA
S. Asia and E. Africa	51	20	Seed yield, early maturity, resistance to rust, ascochyta, and wilt	Cooperation with NARCS
High elevation	14	5	Seed yield, cold tolerance, attributes for mechanization	Cooperation with NARCS

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. 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, 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 resources for national programs in the high altitude and lower latitude regions to undertake 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 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 281mm) and Tel Hadya (328mm) in Syria and Terbol (545 mm) in Lebanon. During the 1986/87 season the rainfall total was above the long-term average at the two wetter locations Terbol (663mm) and Tel Hadya (358mm), whereas at the dry site Breda only 245mm rain was recieved. The low yields at Breda, where the mean seed yields for large and small seeded trials were only 328 and 422 kg/ha, reflected the sparse rain this season (Table 2.1.1). By contrast, the location means for Terbol and Tel Hadya were 1.7 and 1.4 tons seed /ha, respectively.

Table 2.1.1. Results of both large- (L) and small (S) - seeded lentil yield trials at three contrasting rainfed locations; Terbol (Lebanon), Tel Hadya and Breda (Syria) during the 1986/87 season.

Total seasonal rainfall (mm)	663		358		245	
Location	Terbol		Tel Hadya		Breda	
	L	S	L	S	L	S
Number of trials	4	8	4	11	3	10
Number of test entries[A]	92	176	91	294	66	250
% of entries sig. (P<0.05) exceeding check[B]	13	27	3	14	12	18
% of entries ranking above check (excluding above)	36	31	40	40	48	40
Yield of top entry (kg/ha)	2399	2463	1819	2147	550	681
Check mean yield (kg/ha)	1704	1710	1481	1352	318	390
Location mean	1634	1758	1440	1365	328	422
Range in C.V.(%)	8-21	8-14	8-10	10-23	18-26	13-21

A Entries were common across locations.
B Large seeded trial check-ILL 4400; small seeded trial check-ILL 4401.

The mean yield of the check was generally about the same as the location mean indicating that approximately half the entries out yielded the check. More specifically, amongst the small-seeded trials there were 27, 14 and 18% of the test entries that significantly (P<0.05) out yielded the check at Terbol, Tel Hadya and Breda, respectively. A further 31, 40 and 40% of the test entries ranked above the check in yield, but did not exceed the check by a significant margin.

Amongst the large-seeded lines, the percentage of entries yielding significantly more than the check were 13, 3 and 12 at Terbol, Tel Hadya and Breda, respectively. Another 36, 40 and 48% of the large-seeded entries ranked above the check, but exceeded it by a non-significant margin.

Clearly there are many high yielding lines emanating from the breeding program and a substantial number of these lines are performing better than the respective checks over all three locations. In view of the release of Idleb 1 variety in Syria, next season it will be added as an improved check to the trials.

Drs. W. Erskine and A. Hussain.

2.1.1.3. Screening for vascular wilt resistance

Vascular wilt, caused by Fusarium oxysporum f.sp. lentis, is the major disease of lentil in W. Asia. The program aims to reduce damage from wilt by selecting genotypes with reduced susceptibility for national programs.

Four hundred germplasm accessions were sown in the field in Tel Hadya at two sowing dates namely December 19, 1986 and February 2, 1987. Wilt damage, measured as percentage of wilted plants in a plot, was assessed for both sowing dates with a mean of only 0.6% plants wilted from the first date but an average of 9.3% plants wilted from the February sowing. The range in response amongst accessions was also greater in the second date (0-100% plants wilted) than in the first date (0-10% plants wilted). The increased overall level of wilting and increased range in genotypic reaction in the second sowing suggests that delayed sowing may be a useful technique to improve the efficiency of field screening. This will be investigated further next season.

A system of scoring was used whereby data from the delayed sowing only were considered, with the replicate having the highest percentage plants wilted taken as the true wilt score to avoid the problem of uneven fungal distribution. The local check ILL 4400 was considered susceptible giving a maximum of 3% plants wilted; all lines with 3% or more were scored susceptible. Those lines with no wilting were scored resistant, and those lines with > 0 and < 3% plants wilted were scored tolerant. One hundred and fifty accessions were scored resistant out of the 399 screened with a further 77 deemed tolerant.

Amongst the 224 breeding lines screened for wilt reaction, the same check ILL 4400 was used. Seventy five lines were found resistant and 87 lines were tolerant; these will all be rescreened for disease reaction next season. Together resistant and tolerant lines comprised 72% of all the lines screened. The remaining 28% susceptible lines were dropped from the breeding program.

Next season the development of a screening method will be continued, but in the plastic house.

Drs. W. Erskine, A. Hussain and B. Baya'a (Aleppo University).

2.1.1.4. International nurseries

The lentil international nurseries have evolved from the provision of yield trials to a range of targetted crossing blocks/resistant sources, segregating populations and yield trials for the three major agro-ecological regions of production (Table 2.1.2).

Table 2.1.2. Lentil international breeding nursery program showing target regions and type of material distributed.

Type of nursery	Regions		
	Mediterranean low-med.elevation	Lower latitudes	High elevation
Crossing blocks/ Resistant sources	Tall- nursery Large seeded nursery Small seeded nursery	Ascochyta blight nursery* Early nursery	Cold tolerant nursery*
Segregating populations	F_3 trial	Early- F_3 trial	
Yield Trials	Small-seeded trial Large-seeded trial	Early trial*	

* Launched in 1987

During 1987 separate nurseries of Ascochyta blight resistant and cold tolerant sources were initiated. In addition, a yield trial of early flowering lines specific to the lower latitude region was begun, for which the demand by national programs was more than double the available supply.

The use of these genetic stocks by national programs is discussed in sections 2.1.2. to 2.1.4. The analysis of data from these trials allows the recognition of high yielding lines at individual locations and also across locations. For example, in the

Table 2.1.3. Results of the Lentil International Yield Trial - large seeds for the long-term check, local check and an ICARDA line in the West Asia and Mediterranean Region during the 1985-86 season.

Country	Location	ICARDA Long-term check (ILL 4400)	FLIP 84-80L	Local check*	S.E.	CV (%)
Algeria	El-Khroub	2090	2260	1710	269	22
Algeria	Setif	404	775	700	107	31
Cyprus	Orounda	400	818	489	90	27
Egypt	Sakha	778	1111	1689	311	41
Iran	Karaj	968	787	443	73	24
Lebanon	Beqa'a	600	703	467	143	38
Lebanon	Terbol	1282	1356	907	79	10
Libya	Al Kufra	898	3173	1750	243	23
Portugal	Elvas	807	2002	1022	177	23
Spain	Badajoz	1990	2647	1187	421	34
Spain	Madrid	1309	1306	1089	84	11
Syria	Breda	708	913	708	65	13
Tunisia	El Kef	240	427	167	81	55
Tunisia	Oued Meliz	1010	750	1177	217	36
Turkey	Diyarbakir	1699	1296	1486	59	7
Turkey	Erzurum	617	979	758	103	23
Yemen A.R.	Dhmar	1762	1882	1167	194	20
Average yield		1033	1363	(995)		

* Local check differs at each location.

large-seeded international yield trial in 1985/86 season the entry FLIP 84-80L yielded more than the respective local check in 14 out of 17 locations in the West Asia and Mediterranean area (Table 2.1.3). Furthermore its yield advantage over the local check was significant ($P < 0.05$) at nine of these locations, namely Orounda in Cyprus, Karaj in Iran, Terbol in Lebanon, Al Kufra in Libya, Elvas in Portugal, Badajoz in Spain, Breda in Syria, El Kef in Tunisia, and Dhmar in Yemen Arab Republic. FLIP 84-80L is clearly widely adapted to conditions within the region and will be used in the crossing program.

National Agriculture Research Systems and Drs. W. Erskine, R.S. Malhotra and M.C. Saxena.

2.1.1.5. Development of methodology for dihaploid production

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

The project aims to define the conditions for the induction and recovery of haploid plantlets from cultured anthers and microspores. Chromosome doubling can then be undertaken to produce dihapoids.

From the results of several anther culture experiments it has been found that plant growth conditions and pre-treatment of anthers have no effect on amenability to culture. Also the temperature and osmotic extremes which enhance embryogenesis in other species are without effect in Lens. Anther callus seems to occur from the walls and not the microspores. The extraction of microspores from anthers, subsequent brief treatment with high sucrose levels, extreme temperature and various media manipulations were all ineffective in eliciting callus or embryos from microspores. Further media modifications will be explored in the future to stimulate cell division of microspores.

Drs. D. Palmer and W. Tai (Manitoba University) and W. Erskine.

2.1.2. Breeding for the Mediterranean Region

The ICARDA base program provides segregating populations and breeding lines to national programs in North Africa and W. Asia for elevations below 1000m elevation 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.

The Syrian national program has continued the search for high yielding large and small seeded lentils. They have released the country's first lentil variety Idleb 1 (78S26002) on the basis of a yield advantage of 16% in comparison to the local check in three years joint on-farm trials (Table 2.1.4). In addition, this large seeded line has a reduced tendency to lodge, an important attribute in harvest mechanization.

Table 2.1.4. National program releases of lentil lines 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	ILL 4400	1986	Large seeed, high yield
	ILL 4606	1986	Large seed, high yield
Turkey	Firat '87(75Kf 36062)	1987	Small seeds, high yield

Amongst the small-seeded material, 78S26013 has been in on-farm trials in Syria with the local check Hurani 1 since 1982/83 and has shown a 15% yield advantage over a total of 46 locations (Table 2.1.5). The line 78S26013 has additional advantages over Hurani 1 in that it lodges less and is more resistant to both vascular wilt and ascochyta blight.

The entries in Syrian on-farm trials are selected from regional trials (one large seeded and one small seeded) run jointly by the national program at four locations and by ICARDA with two locations. After the 1986-87 season responsibility for these yield trials within Syria has been transferred to the national program. A crossing block of twenty crosses for Syria will form the basis of the training program for crossing in the forthcoming year.

Table 2.1.5. Results of on-farm trials in Syria over the period 1982/83 - 1986/87. (ARC, Douma, Syria/ICARDA program).

Entry	Mean seed yield (kg/ha)	Plant height (cm)	Lodging score (1-5)*	Vascular wilt reaction	Ascochyta blight reaction
78S 26013	1283	31	1.9	Tolerant	Resistant
Hurani 1	1117	31	2.5	Susceptible	Tolerant
S.E.	30.8	0.5	0.1		
No. of locations	46	22	22		

*Score: 1 = 100% plants standing; 5 = 75% plants lodged.

In Lebanon the small-seeded line 78S26013 has been selected for pre-release multiplication by the Agriculture Research Institute, Tel Amara in the 1987/88 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 specifically for Jordan at ICARADA supplied as segregating populations, may provide next-generation cultivars.

Firat' 87 (78Kt36062), a small-seeded lentil with a red cotyledon, was released in S.E. Anatolia, Turkey on the basis of its high yield. Sixty per cent of the Turkish lentil area (750,000 ha in 1986/87) is concentrated in S.E. Anatolia, where cultivation is predominantly of the red, small-seeded type.

Progress in lentil breeding within national programs in N. Africa is discussed under Algeria-8.2.3.1.3., Morocco-8.2.2.3. and Tunisia-8.2.1.3. with emphasis on selection from international nurseries of material generated in W. Asia.

The program in Algeria has released Syria 229, an old introduction, and has ILL 1889 and ILL 4400 in pre-release multiplication. ILL 4400 was also one of the first pair of lentil cultivars released in Tunisia (the other was ILL 4606 in 1986). The Tunisian program is now also recommending FLIP 84-103L for release. In Morocco the first lentil entry into catalogue trials is ILL 4605. In Tunisia a regional training program on crossing in legumes will be conducted in February 1988 to foster hybridization work within national programs in N. Africa.

In Spain two lentil lines are undergoing registration.

National Agriculture Research Systems.

2.1.3. Breeding for lower latitude region

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

Germplasm from the Indian sub-continent is early in flowering, but restricted in genetic diversity despite the large area of lentil grown. Accordingly a total of 400 diverse germplasm accessions were screened for adaptation to South Asia in Islamabad in cooperation with the Pakistan Pulse Program. In addition, response to the important lentil pathogen ascochyta blight was monitored in the field under epiphytotic conditions with the objective of identifying early flowering and disease resistant accessions. Observations for ascochyta were recorded using a 1-9 scale and the mean value over replications was calculated.

The best sources for early flowering material are Egypt, Ethiopia and India, whereas many ascochyta resistant/tolerant sources are available from Chile, Jordan and ICARDA. Table 2.1.6 shows that the best source for both earliness and disease resistance is Ethiopia.

Table 2.1.6. Mean time to flower and ascochyta blight score of germplasm accessions from various countries together with the different sample sizes.

Country of origin	Time to 50% flowering (days)	Average Ascochyta (score 1-9)	Sample size (No. of accesions)
Egypt	106	3.1	26
Ethiopia	109	1.8	26
Pakistan (Loc. check)	109	5	1
India	112	4.6	27
Jordan	120	1.4	31
ICARDA	123	1.4	45
Lebanon	127	1.7	16
Syria	128	1.7	29
USSR	134	1.7	16
Chile	136	1.4	26
Greece	136	1.6	25
Iran	138	2.9	20
Turkey	138	1.9	15
Grand mean (400 accesions)	124.3	2.21	
C.V. (%)	6.3	56.3	
L.S.D. (.05)	7.9	1.26	

The germplasm evaluation for time to flower in Islamabad is part of a larger project to characterise the response of germplasm to photoperiod and temperature in cooperation with Reading University, U.K. (sponsored by the Overseas Development Agency), where the same lines were grown in four environments contrasting in temperature and photoperiod. They were also grown at Tel Hadya at two sowing dates. The results are still being analysed.

In addition to the germplasm tested, 98 early maturing ICARDA breeding lines at the F6 generation stage were also jointly examined with the Pakistan Pulse Program in Islamabad for their disease and phenological characteristics in two yield trials. A higher proportion (85%) of breeding lines were more resistant (score 1 and 2) than germplasm accessions. Twelve per cent of the lines were also earlier to flower than the local check. The disease reaction and flowering time of the best lines in one of the yield trials are

Table 2.1.7. Time to flower (days) and ascochyta blight score of selected entries in a preliminary yield trial in Islamabad, Pakistan.

Entry	Time to 50% flowering (days)	Ascochyta blight (1-9)
Precoz x 74TA9	82	1
Precoz x LL1	90	3
Precoz x 74TA9	91	1
Precoz x 74TA9	93	1
S.L.L. x Precoz	93	1
S.L.L. x Precoz	93	1
Precoz x L-830	94	1
Precoz x L-830	94	1
Precoz x 74TA9	95	1
Precoz x L-830	96	1
78S 26002 x Precoz	97	1
Local check	113	6
L.S.D. (.05)	4.8	1.1

shown in Table 2.1.7. It is clear that early maturing disease resistant lines are now emerging from the program, but confirmation of their disease reaction is still required.

The line ILL 2573 is in on-farm trials in the north of Punjab Province, and ILL 4605 is being considered for release for the Chakwal area of Punjab. The line FLIP 86-38L has demonstrated high yield at Islamabad and resistance to Ascochyta in two seasons and has a good seed type.

In Ethiopia sources of resistance to both rust and Ascochyta blight have been selected from international trials. The Ethiopian lentil breeder made, during his stay at ICARDA in 1987, specific crosses for Ethiopia, which will form the basis of the national breeding program.

In Ecuador the national program has released INIAP-406 (FLIP 84-84L) during 1987 on the basis of its earliness, rust resistance and high yield.

National Agriculture Research Systems.

2.1.4. Breeding for high altitude region

The high altitude region consists of the plateau regions of Iran and Turkey, where lentil is spring sown because of the severe winter. It has been shown however, that winter sowing of cold tolerant lentil results in increased yield. Following the joint screening of 3592 germplasm accessions near Ankara, Turkey over the severe winter of 1980, cold tolerance was found in 238 accessions. Single plant selections were made by the national program amongst the cold tolerant lines, and one line 1066-1 is now a candidate for release for winter sowing. Segregating populations using the most cold tolerant parents are being supplied for selection under severe winter conditions in Iran and Turkey.

National Agriculture Research Systems.

2.2. Lentil Harvest Mechanization

2.2.1. Village trial of lentil harvest by cutter bar

Hand harvest was compared to the double-knife mower on large plots in three villages namely Afes (Idleb Province), Al Kamieh (Aleppo) and Ibta (Dera'a), spread through the main lentil-growing areas of Syria during the 1986/87 season. At each site the local red-cotyledon, small-seeded lentil Hurani 1 was compared to the ICARDA selections 78S26013 and 76TA66088. These village projects were part of a collaborative program between the Syrian Ministry of Agriculture and ICARDA and financed by the International Development Research Centre, Ottawa, Canada.

The mean for seed yield across sites was 1.7 tons/ha with the highest yields being realized at Al Kamieh (2.1 t/ha). The mean yields at Afes and Ibta were 1.61 and 1.38 tons seed/ha, respectively. Mowing with a cutter bar reduced the seed yield, compared to hand harvest, by 12% from 1.81 t/ha to 1.59 tons/ha, and

Table 2.2.1. Partial budget of three genotypes and their average performance in the village trials in 1986/87 season.

Details	ILL 16		ILL 223		Hurani 1		Mean	
	Hand	Machine	Hand	Machine	Hand	Machine	Hand	Machine
Grain yield (kg/ha)	1919	1922	1822	1321	1698	1526	1813	1589
Straw yield (kg/ha)	2328	1864	2217	1326	2554	1974	2366	1721
Grain revenue (SL/ha)	11508	11532	10938	7926	10188	9156	10878	9534
Straw revenue (SL/ha)	4074	3262	3879	2320	4470	3455	4140	3012
Total revenue (SL/ha)	15582	14797	14817	10246	14658	12611	15018	12546
Pulling or cutting cost (SL/ha)	1000	252[a] 132[b]	1000	252[a] 132[b]	1000	252[a] 132[b]	1000	252[a] 132[b]
Net benefit over pulling or cutting cost only (SL/ha)	14582	14542[a] 14662[b]	13817	9994[a] 10114[b]	13658	12359[a] 12479[b]	14018	12294[a] 12414[b]

a) Upper limit of mechanical cutting cost
b) Lower limit of mechanical cutting cost
Lentil prices, Grain = 6.00 SL/kg
Straw = 1.75 SL/kg

also lowered the straw yield by 27% from 2.37 to 1.72 tons/ha. The genotype 78S26013 yielded 1.92 tons seed/ha overall, which was 19% and significantly more than the yield of the local check Hurani 1. A significant genotype x harvest method interaction ($P < 0.1$) showed that the seed yield of 78S26013 was not reduced by harvest mechanization, whereas the yields of Hurani 1 and 76TA66088 were lowered by 10 and 26% respectively (Table 2.2.1).

Drs. W. Erskine, J. Diekmann and ARC, Douma.

2.2.2. Socio-economic analysis of village trials on lentil harvest mechanization

The main objectives of the socio-economic research on lentil mechanization for 1986/87 were to: 1) update cost/benefit data of lentil production, in general, and harvesting cost in particular; 2) observe farmers' perspectives and predict their acceptance of tested technology; and 3) evaluate agronomic results of the village project trials economically. Therefore, a limited farm survey (14 farmer sample) was conducted in the vicinity of on-farm sites in Aleppo and Idleb provinces. Sampled farmers, randomly selected, were interviewed once and a brief, specific questionnaire addressed to them. Survey results, information from secondary sources, observations of farmers' reactions to machine performance during harvesting the trials on farmers' fields, and the economic analysis of these trials indicated the following issues:

1. Considerable changes in the economics of lentil production occurred in one year. Lentil grain and straw prices increased by 60% and 75% respectively; compared to prices two years ago the respective figures are 230% and 100%. Similar trend was also observed in capital input cost, especially seeds and pesticides.

2. While total production costs increased, in two years by 44%, gross revenue increased by 170%, and net profits increased by about 600% (Table 2.2.2). According to survey data, lentil production has become a very attractive enterprise for farmers; with a moderate level of management and capital investment, net profit can be as high as 5640 SL per hectare.

3. Under current conditions of lentil production economics, mechanical harvesting might not be an attractive option economically unless yield losses due to mechanization are reduced to the very minimum. On-farm trials results indicated average yield losses of 12% for grain and 27% for straw (Table 2.2.2). Using yield figures of the survey (1100 kg/ha grain and 1700 kg/ha straw) yield losses are equivalent to 132 kg grain and 460 kg straw, or equivalent to 1600 SL/ha revenue which equals 160% of manual pulling cost. In full support to the conclusion mentioned above, partial budget analysis of pooled data of the three genotypes tested by on-farm trials (Table 2.2.1), showed that hand harvesting produced 1724 SL/ha net benefit (after only harvest cost, i.e., other cost items are not deducted from gross benefit) more than produced by mechanical harvesting.

4. Turning from data averaged over the three lines, it is very interesting to see genotype ILL 16 showing good ability for mechanical harvesting with zero grain losses. Although straw

Table 2.2.2. Comparison of economic profitability of lentil production for farmers between 1985/86 and 1986/87 seasons in Syria.

Items	1986/87	1985/86	% increase
Grain yield (kg/ha)	1100	1100	-
Straw yield (kg/ha)	1700	1700	-
Grain revenue (SL/ha)	6600	2057	220
Straw revenue (SL/ha)	3000	1496	100
Total gross benefit (SL/ha)	9600	3553	170
Total cost of production (SL/ha)	3960	2751	44
Net revenue or profitability (SL/ha)	5640	802	600

Note: This table is prepared to show the effect of the huge increase in output prices on the profitability of lentil production and its implications on harvesting cost. Therefore, we used average yield of normal year as indicated by survey results of two years.

yield was reduced by 20% due to mechanization, these losses were compensated for by lower cost of mechanical harvest compared to hand harvest (Table 2.2.1). This implies a good potential for mechanical harvest.

5. Mechanical harvesting of lentils should not be evaluated solely by its economic consequences; other criteria should be included such as increased area expected due to increased attractiveness of crop economics, and the labour supply bottleneck which occurs during the short, critical period of harvest. Seventy-nine percent of sampled farmers used hired labor for lentil harvesting of which 90% reported difficulties in terms of labor supply and timing.

Farmers attending harvesting of on-farm trials were very positively impressed by the double knife cutter bar although its performance was not perfect. All attending farmers who own tractors expressed their ability and desire to buy the equipment as it becomes available in the market, realizing that it can be used for several other crops.

Mr. A.B. Salkini and Dr. W. Erskine.

2.2.3. Comparison of lentil harvest equipment

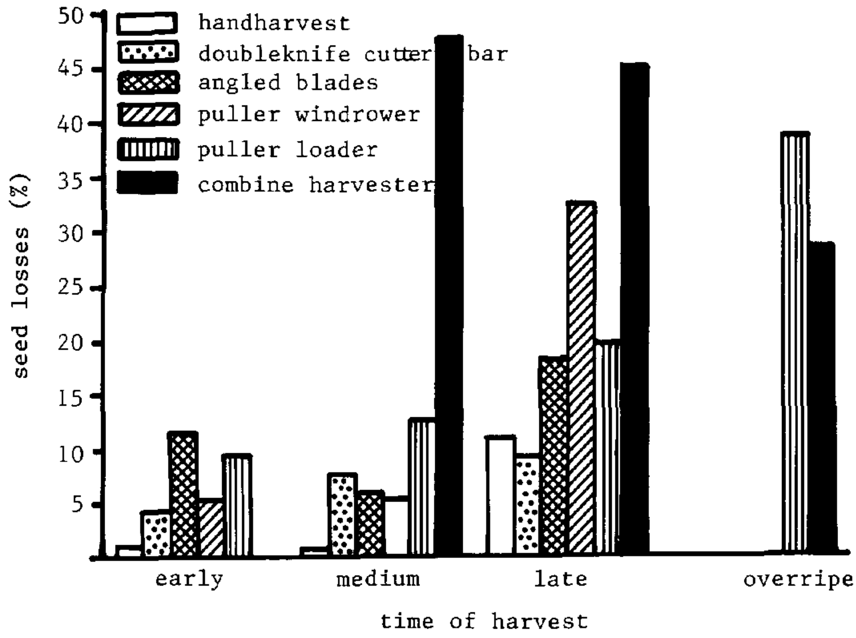
Trials comparing different lentil harvest systems were conducted at ICARDA Tel Hadya in 1987 under the GTZ- financed project with the Institute of Agricultural Engineering of the University of Gottingen. The trials were conducted on two lentil varieties either broadcast onto ridges or drilled with harvest at different crop moisture levels varying from early harvest stage when 20% of the pods were brown through to over-ripeness. The harvest methods were: hand harvest; angled blades (front mounted and without swathing); double-knife cutter bar (rear-mounted); combine harvester modified with a set of air jets instead of the reel to blow lentils into the machine, with a double knife cutting system and with a towed chaff-collector; and two different lentil puller systems, one a puller-windrower with pulling belt and the other a puller loader with pulling roller and conveyor fan for loading the crop onto a trailer.

In the trials at Tel Hadya the harvested yields of seed and straw were measured along with seed and straw losses, soil and stone uptake, seed damage and moisture level as well as working speed. Additional tests were undertaken on the two lentil pullers to optimize construction details and working parameters.

There were no significant differences between varieties or between the sowing methods. All plants were standing and there was no lodging; furthermore, the soil was dry and soft in the top 2 cm so all harvest methods could perform without problems.

There was a clear influence of time of harvest on seed and straw losses pointing out the optimum harvest period for each different method (Fig. 2.2.1.).

Figure 2.2.1 shows the average seed and straw losses from harvesting at early (20% of pods brown), medium (50% of pods brown), late (100% of pods brown), and overripe (two weeks after 100% pods brown) stages for the six harvest methods. Losses are indicated as a percentage of the total potential yield of the plots.



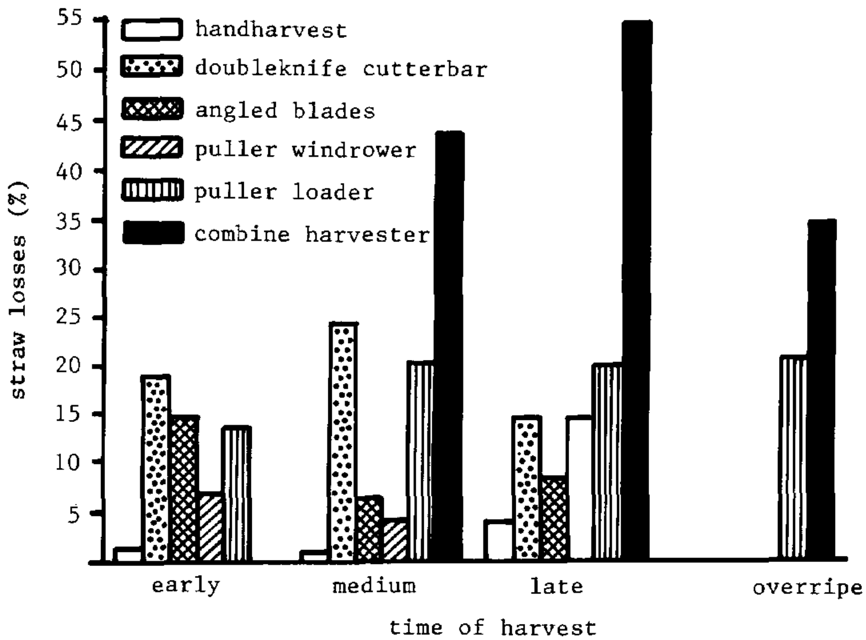


Figure 2.2.1. Seed and straw losses of different lentil harvest methods at different harvest stages.

Hand harvest is best done at the early or medium stage of ripeness because of excessive seed loss from a delayed harvest. Angled blades work with reasonable losses only at medium harvest. The puller windrower showed sharply rising losses at late harvest. The puller loader generally performed poorly because the pulling geometry was not optimal. The combine harvester has its working optimum at overripe harvest, as long as the natural dehiscence and shedding of seeds and pods is not too high. The high level of combine losses is due its integration of all harvest steps within the machine (cutting, threshing, and cleaning), whereas for the other methods only cutting or pulling losses are indicated. Focussing solely on the cutting of the combine, the seed losses at an overripe harvest are reduced to 19% of the total plot yield.

Next year we plan to repeat the comparative trials with a new puller designed in the light of this year's experience.

Mr. T. Friedrich and Prof. F. Wieneke (University of Gottingen); and Drs. J. Diekmann, P. Jegatheeswaran and W. Erskine.

2.2.4. Evaluation of the residual effect of different lentil harvest treatments in 1985/86 season on a subsequent wheat crop

As part of a major effort at ICARDA to mechanize lentil harvest, a trial was conducted during 1985/86 season on the effect of height of cut (ground level and cutting at 5 and 10 cm above ground) as compared to hand pulling on loss of seed and straw yields of lentil genotypes. The straw losses of lentil were 697, 1494 and 1618 kg/ha, respectively for cutting at ground level, and at 5 and 10 cm above ground, representing 5.0, 12.0 and 12.4 kg N/ha left in the stubble. In 1986/87, therefore, a study was conducted to measure the residual effect of the different lentil harvest treatments on a subsequent wheat crop. Each subplot was divided into two equal parts; one half received no N fertilizer and the other half received 60 kg N/ha as a split dosage; 20 kg N/ha at planting and 40 kg N/ha in February 1987.

Table 2.2.3. Effect of 1985/86 method of harvest of lentil on total biological yield (TBY), seed yield (SY) and harvest index of wheat grown in 1986/87 at 0 kg and 60 kg N ha^{-1}. Tel Hadya, 1986/87

	1985/86 cropping treatment (method of harvest of lentil in 1985/86)				Mean for applied N
	Hand pulled	Cut 0 cm	Cut 5 cm	Cut 10 cm	
TBY kg ha^{-1}					
0 kg N ha^{-1}	5600	5689	6386	5780	5864
60 kg N ha^{-1}	5819	6230	6234	6054	6084
Mean for harvest	5709	5959	6303	5917	
	Harvest (H)	Nitrogen (N)		HxN	
L.S.D. (.05)	NS	NS		NS	
(C.V.%)	14.3	16.8			
SY kg ha^{-1}					
0 kg N ha^{-1}	1361	1361	1573	1378	1418
60 kg N ha^{-1}	1289	1295	1368	1250	1300
Mean for Harvest	1325	1328	1470	1314	
	Harvest (H)	Nitrogen (N)		HxN	
L.S.D. (.05)	NS	105.6		NS	
(C.V.%)	12.6	19.1			
Harvest Index					
0 kg N ha^{-1}	0.245	0.242	0.248	0.239	0.243
60 kg N ha^{-1}	0.224	0.208	0.221	0.208	0.215
Mean for harvest	0.234	0.225	0.234	0.223	

There was no significant influence of the 1985/86 cropping treatments on the succeeding crop of wheat. Therefore only the effect of height of cut of lentil in 1985/86 and the effect of N application in 1986/87 are presented (Table 2.2.3). Although the differences were not statistically significant ($P \leq 0.05$), total biological yield of wheat increased with the height of cut of the 1985/86 lentil crop. Again, applying 60 kg N/ha on wheat crop as compared to no nitrogen application did not have any significant influence on total biological yield but reduced seed yield significantly, through the reduction in harvest index (Table 2.2.3).

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

2.2.5. Lodging in lentil

Lodging is an important factor in lentil mechanical harvesting which may lead to yield losses with certain machine harvesting systems. The degree of lodging varies with the genotype and its interaction with the environment and its cultural manipulation. Little is known about the effect of agronomic practices and environmental factors on the degree of lodging. Research at ICARDA and elsewhere on mechanisms of resistance revealed that factors such as stem thickness, lignification of stem and branching contribute to lodging resistance. Two experiments were conducted at Tel Hadya to investivate (a) the effect of cultural practices on lodging and on machine harvesting and (b) factors contributing to lodging resistance.

2.2.5.1. Effect of agronomic practices on lodging and yield losses from a mechanical harvest

Three regimes of soil moisture (rainfed, one supplementary irrigation at pod filling, two supplementary irrigations at vegetative and pod filling stage), two plant populations (200 and 400 plants/m^2), and two genotypes contrasting in lodging resistance (78S26002 and ILL 4401) were used in a split plot design with factorial arrangement. The plots were evaluated for lodging and yield losses incurred by machine harvesting (double-knife cutter bar).

As shown in Table 2.2.4, lodging was significantly increased by high plant population. There was significant interaction in lodging score between the genotypes and plant population. The resistant genotype (78S26002) lost its comparative advantage with increased plant population. Although non significant, lodging increased with increased soil moisture and apparently there was an interaction between moisture and plant population treatments. The interaction among the 3 factors was non significant but when looking at the combined effect of these factors, lodging score was low at the combination of resistant genotype, low level of moisture and low plant population factors and was high when the combination was reversed. The following array of figures will illustrate this:

Combination of treatments	Lodging score
1. Rainfed + low population + resistant genotype	2.0
2. Rainfed + low population + susceptible genotype	3.3
3. Two supplementary irrigations + high population + resistant genotype	4.7
4. Two supplementary irrigations + high population + susceptible genotype	4.3

Yields were significantly increased by improved moisture supply (Table 2.2.4). 78S26002 gave on average 53% higher grain yield than ILL 4401, thus demonstrating high suitability for mechanical harvest combined with high yield potential.

2.2.5.2. Lodging resistance

Thirty lentil genotypes contrasting in lodging resistance were used to study genetic variation in lodging and its association with other plant traits. Linear correlation revealed a highly significant association between lodging score and plant height at maturity (r= -0.4531**). A bending resistance index (BRI) was calculated as follows to estimate loss in height in relation to lodging:

$$BRI = \frac{\text{Plant height at maturity (cm)}}{\text{Maximum plant height}}$$

The index differed among the lentil genotypes in the study ranging from 0.68 to 0.97. The index was significantly correlated to plant height at maturity (r=0.53**), and lodging score (r=-0.62**). When lodging was induced by bending plants, the induced BRI was also significantly correlated to the lodging score (r=-0.28**).

Miss G. Hanti, Drs. H. Ibrahim and W. Erskine; and Mr. A. Fares (Aleppo University).

Table 2.2.4. Means for lodging score* (L) and seed yield (tons/ha) (Y) of lentil genotypes as affected by plant population and soil moisture.

Plant population (plants/m^2)	Genotypes: 78S26002		Genotypes: ILL 4401		Soil moisture regimes: Rainfed		Soil moisture regimes: One supplementary irrigation		Soil moisture regimes: Two supplementary irrigation		Populations means	
	L	Y	L	Y	L	Y	L	Y	L	Y	L	Y
200	2.7	2.1	3.7	1.4	2.7	1.8	3.5	2.1	3.3	1.4	3.2	1.8
400	4.1	2.1	3.9	1.4	3.3	1.8	4.2	2.1	4.5	1.2	4.0	1.7
Mean	3.4	2.1	3.8	1.4	3.0	1.8	3.8	2.1	3.9	1.3		
			L	Y				L	Y		L	Y
L.S.D. (.05)			0.39	0.2				NS	0.4		0.39	NS
L.S.D. (.05) interaction			0.56	NS				NS	NS			

* Lodging was scored on a scale of 1 to 5, 1 = lodging absent, 5 = more than 75% lodged plants.

2.3. Lentil Insects and their Control

The overall objective is to develop an integrated pest management system as illustrated in Fig. 1.3.1. In addition to the continous monitoring of the occurrence and status of insect pests and natural enemies, research will focus on the establishment of economic injury levels and control recommendations for Sitona spp., the primary insect pest on lentil in the region. Since screening for host plant resistance has not been successful other control methods are needed. Several parasites of Sitona are known, and increased emphasis will be given to the possibilities of biological control. This first requires a survey of naturally occuring parasites, which then can be studied for their biological and ecological characteristics and effectiveness. Chemical control studies will concentrate on development of economic and practicable methods, e.g. testing for optimum dosages of insecticides. The effect of agricultural practices such as planting date on Sitona infestation will be studied in cooperation with FRMP so that recommendations can be given.

Available information on the importance of storage pests in lentil in the ICARDA region is insufficient and a survey will be conducted to identify the actual and potential bruchid species so that control recommendations can be developed.

2.3.1. Control recommendations for Sitona spp.

To further determine the economic importance of Sitona spp. in relationship to meterological data, damage levels and seed yields were studied at three locations with different rainfall using two treatment levels of carbofuran. At Breda (low rainfall, 244 mm) a high infestation of 80% nodules damaged was found (Fig. 2.3.1). The carbofuran treatment reduced the nodule damage to less than 5% but did not result in yield increases. Thus no correlation existed between nodule damage and yield. At Tel Hadya (intermediate rainfall, 357 mm) the carbofuran treatments both at the lower and the recommended rate significiantly reduced nodule damage and increased seed yield (Fig. 2.3.1). No difference was found between the two dosages. At Jinderiss (high rainfall, 600 mm) nodule damage was significantly lower with carbofuran application, but the yield increase was non-significant. This experiment indicated that equivalent control was achieved with the lower and higher dosage of carbofuran which is in confirmity with last season's results. However, some points still need further clarification such as the low or non-existant correlation between nodule damage and yield. It could be due to compensation by intact nodules or high availability of nitrogen in the soil. Next season before planting soil samples will be taken and analysed for nitrogen.

To establish the critical level of nodule damage that causes an economic loss and the lowest effective dosage of carbofuran the effect of different treatment levels of carbofuran on the Sitona spp. infestation was studied. The percent leaflet and nodule damage, which give good indications of the extent of damage early and later in the season respectively, at four dosages of carbofuran, are shown in Fig. 2.3.2. Significantly higher leaflet and nodule damage were found only in the check and lowest carbofuran treatments, whereas no significant differences existed between the other dosages. The biological and seed yields showed the same tendency, but because of high variability, the yield increases resulting from the carbofuran treatment were non-significant (Fig. 2.3.3).

In cooperation with the weed control section the effect of two planting dates with and without carbofuran treatment were studied in on-farm trials at seven locations (Table 2.3.1). Generally the plots sown in early January showed less nodule damage than those sown in mid-November. The highest Sitona spp. infestations of 62 and 66% nodule damage were found in early plantings without carbofuran treatments. These findings confirm last season results that early planting of lentils can increase Sitona spp.

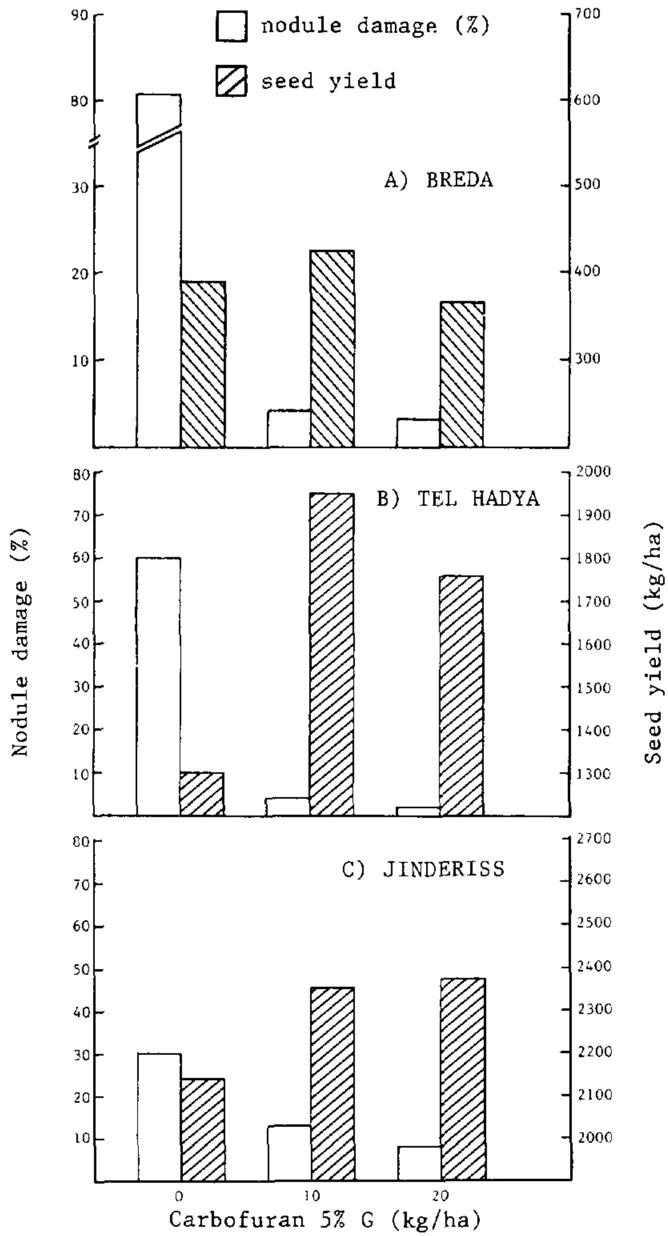


Figure 2.3.1. Effect of two treatment levels of Carbofuran on Sitona spp. damage and seed yield of Syrian Local Small lentils at Breda (A), with low rainfall, Tel Hadya (B), with intermediate rainfall and Jinderiss (C), with high rainfall. 1986/87. (B and C on following page)

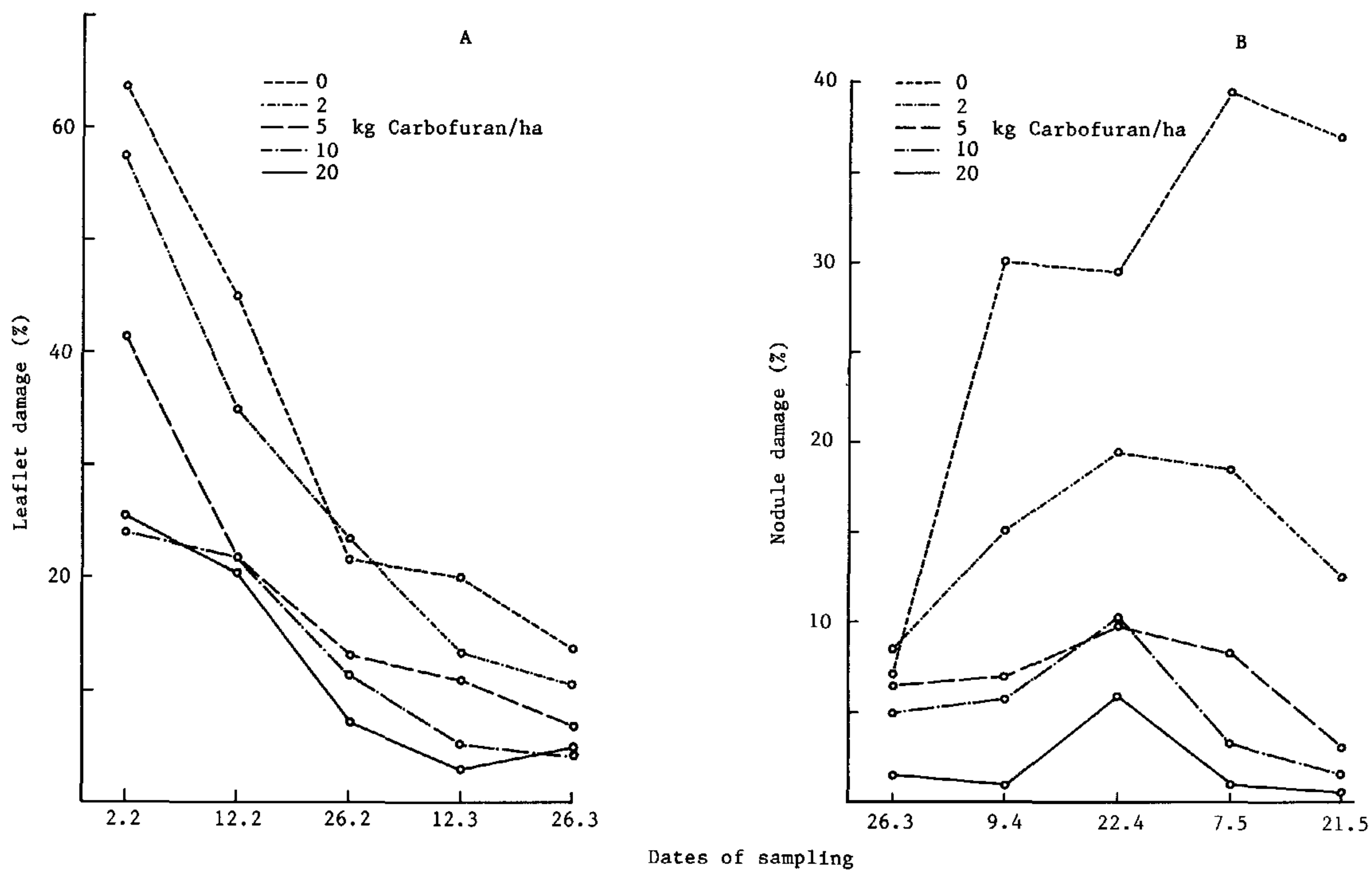


Figure 2.3.2. Leaflet (A) and nodule (B) damage of Syrian local lentil by <u>Sitona</u> spp. at different treatment levels of Carbofuran (G5%). Tel Hadya, 1986/87.

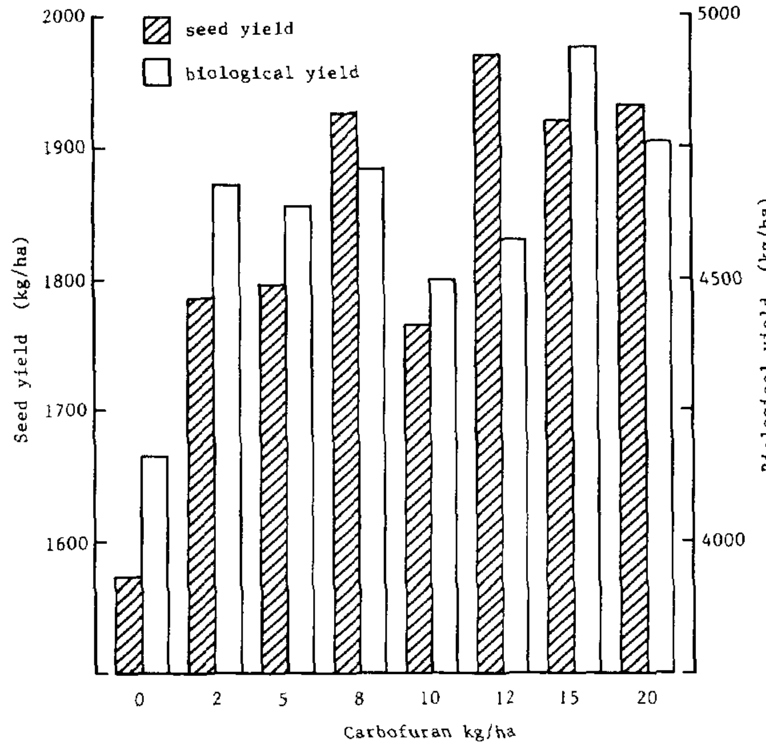


Figure 2.3.3. Effect of different treatment levels of Carbofuran G5% for Sitona spp. control on seed and biological yield of Syrian local large lentil. Tel Hadya, 1986/87.

infestation, necessitating a control treatment. Other insect-pests such as thrips, aphids and pod borer were closely monitored but generally reached low levels not causing significant damage. Only at Jinderiss were relatively high populations of thrips found, but it is questionable whether these cause economic damage. The thrips were identified by Dr. R. Zur Strassen (Senckenberg Museum Frankfurt) as *Kakothrips robustus* (Krel), *Thrips angusticeps* Krel and *Haplothrips niger*, (Obsarn).

Dr. S. Weigand.

Table 2.3.1. Effect of early and late planting and carbofuran (G5%) treatment on *Sitona* spp. damage levels in lentil at different locations, 1986/87.

Location	% nodules damaged				
	Early planting		Late planting		
	No treatment	Carbofuran	No treatment	Carbofuran	LSD(.05)
Tel Hadya	36.0	10.5	2.0	3.5	14.4
Rashaf	45.0	32.0	30.5	14.5	77.3
Tal Raf'at	66.0	3.0	56.0	1.0	43.5
Alkamyie	62.5	21.0	17.0	1.0	33.5
Maa'ra	45.5	5.5	27.0	0.5	27.5
To'am	25.0	6.5	17.5	2.0	14.4
Tamana	30.0	4.5	21.5	6.0	55.3

2.4. Lentil Physiology and Agronomy

Lentil physiology research focuses on the common stresses, particularly drought, so that beneficial plant traits conferring yield advantage under stressful environments are identified and improved screening techniques developed to identify genotypes with a tolerant reaction to the stresses.

Lentil agronomy research in collaboration with Farm Resource Management Program focuses on development of production technologies which can be transferred to national programs for testing and adoption.

2.4.1. Study of drought tolerance and moisture use in lentil genotypes

Response of diverse genotypes of lentils to total seasonal moisture supply was investigated by growing the crop under rainfed conditions at Tel Hadya (340.1 mm seasonal moisture supply) and Breda (244.6 mm seasonal rainfall) and also at Tel Hadya under two additional levels of moisture supply through reduction by using a rain-out shelter from October to December (272.6 mm of seasonal rainfall received) and giving supplemental irrigation (525.1 mm of moisture received).

In all, two supplemental irrigations were given: 100 mm on 23 April when all genotypes had initiated flowering, and 85 mm at podding stage on 15 May. Soil moisture studies were conducted on nine genotypes to determine evapotranspiration and water-use efficiency under rainfed conditions in Tel Hadya. Soil moisture deficit (percent below field capacity) at 'maximum effective rooting depth' prior to the first irrigation ranged from 11.1 to 13.6% among genotypes.

Averaged over all genotypes, both seed and biological yields were closely related to seasonal moisture supply (Table 2.4.1). At each level of moisture supply both seed and biological yields varied significantly among genotypes. At the lowest level of moisture supply (Breda, 241.1 mm rainfall), ILL 16 gave the highest seed yield, followed by ILL 223, ILL 4354 and ILL 1861 (Table 2.4.1). In Tel Hadya where moisture supply was cut at the beginning of the season (272.6 mm rainfall), high seed yields were obtained from ILL 4354, ILL 16, ILL 223, ILL 8 and ILL 9 (Table 2.4.1). Significant variations in response to moisture supply were observed among genotypes which could be categorized into three broad groups: genotypes that gave high seed yield under limited moisture supply in Breda and were very responsive to increasing moisture supply e.g. ILL 16; genotypes that gave low seed yield under limited moisture supply at Breda but were very responsive to increasing moisture supply e.g. ILL 101; and genotypes that gave moderate yield under limited moisture supply of Breda and were moderately responsive to increasing moisture supply e.g. ILL 4401 (Fig. 2.4.1).

Soil moisture profiles at maximum recharge and at maturity for nine genotypes under rainfed condition in Tel Hadya are given in Fig. 2.4.2. As in 1985/86 season, there were variations in maximum depth of water extraction in the soil profile. ILL 16, ILL 101 and ILL 793 extracted water from deeper soil profiles than other genotypes. In the first 90 to 120 cm of the soil profile, ILL 9, ILL 793, ILL 8 and ILL 4400 extracted a greater volume of soil moisture than other genotypes (Fig. 2.4.2). ILL 8, ILL 101, ILL 223

Table 2.4.1. Effect of total seasonal moisture supply on seed and biological yields (kg/ha) of diverse lentil genotypes sown in Breda and Tel Hadya, 1986/87.

		Seed yield in kg/ha					Biological yield in kg/ha				
		Breda	Tel Hadya				Breda	Tel Hadya			
Genotype	Origin	Rainfed (244.6mm)	Rain cut (272.6mm)	Rainfed (340.4mm)	Irrigated (525.1mm)	Mean	Rainfed (244.6mm)	Rain cut (272.6mm)	Rainfed (340.1mm)	Irrigated (525.1mm)	Mean
ILL 8	Jordan	127	1644	2189	3166	2333	1303	5106	5406	8117	6210
ILL 9	Jordan	172	1599	1766	3354	2240	1596	5101	5104	8564	6256
ILL 16	Jordan	324	1783	1919	3304	2335	1509	4654	5177	8521	6117
ILL 101	Syria	66	953	1379	3269	1867	1088	4077	4824	8332	5744
ILL 223	Iran	260	1689	1989	3263	2313	1395	4791	5289	8116	6065
ILL 470	Syria	225	928	1328	2355	1537	1089	3457	4424	7163	5014
ILL 793	Egypt	57	805	1156	2458	1473	583	3830	4477	8055	5454
ILL 1861	Sudan	251	1249	1595	2948	1931	1319	4417	4868	8444	5909
ILL 4349	USSR	28	676	1000	2154	1277	869	3912	4322	7601	5278
ILL 4354	Jordan	255	1881	1962	3289	2377	1514	5157	5177	8117	6150
ILL 4400	Syria	75	1223	1254	2925	1801	1324	4486	4626	7947	5686
ILL 4401	Syria	220	1368	1433	2346	1716	1233	4258	4669	7262	5396
ILWL 7			179	182	261	207		879	834	1063	925
Mean		172	1229	1473	2699		1235	4163	4553	7485	
			(M)	(G)	MxG		(M)	(G)	MxG		
L.S.D.(.05)		48.7	129.1	243.8	425.1	244.7	428.5	565.8	1032		
C.V. (%)		19.8	14.9	16.7		13.8	16.5	13.0			

(M) = moisture, (G) = genotype

and ILL 16 had the highest water use efficiency in terms of total biological yield, and in terms of seed yield ILL 8, ILL 223 and ILL 16 had the highest water use efficiency (Table 2.4.2).

Table 2.4.2. Total evapotranspiration (Et) and water-use efficiency (WUE, kg/ha/mm) for total biological yield (TBY) and seed yield (SY) for different lentil genotypes under rainfed conditions at Tel Hadya, 1986/87.

Genotype	Et (mm)	WUE (kg/ha/mm) for	
		TBY	SY
ILL 8	242.0	22.34	9.05
ILL 9	271.1	18.82	6.51
ILL 61	242.2	21.37	7.92
ILL 101	213.1	22.64	6.47
ILL 223	244.0	21.68	8.15
ILL 793	250.3	17.89	4.62
ILL 4349	253.8	17.03	3.94
ILL 4400	325.8	14.20	3.85
ILL 4401	239.0	19.54	6.00

In 1985/86, the effective moisture supply in Breda was 218 mm and seed yield ranged between 561 and 112 kg/ha while in 1986/87, seasonal moisture supply was 244.6 mm and seed yield was less varying from 324 to 28 kg/ha. The two year study has shown that varying available moisture allows for selection for crop response to moisture supply. Genotypes which extracted more water and had higher water use efficiency tended to give highest yields. The results show that in the low moisture range used in this study (Breda), it is not only the total seasonal moisture supply that affects yield but other factors such as rainfall distribution and perhaps temperature. Measurements of canopy temperature and/or plant water potential in future studies may help to better identify limiting factors.

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

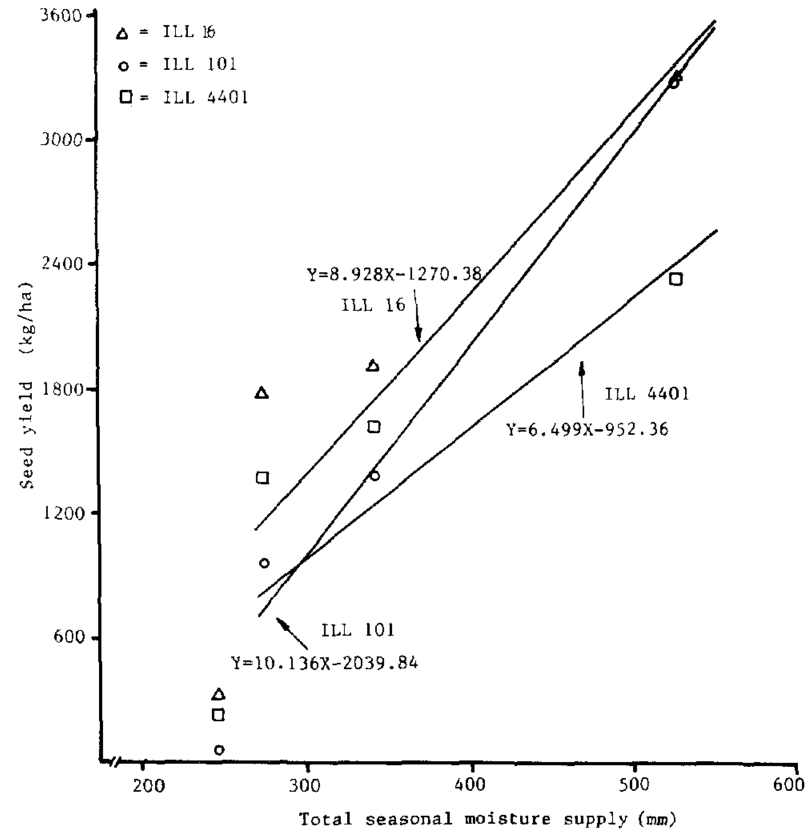


Figure 2.4.1. Relationship between total seasonal moisture supply with seed yield of ILL 16, ILL 101 and ILL 4401. 1986/87.

2.4.2. Chemical Weed Control in Lentil

An experiment was conducted at Tel Hadya during 1986/87 growing season (343 mm rainfall). The effect of weeds on crop yield loss and the role of some new selective herbicides on weed control and crop yield loss was studied using Syrian local small lentil cultivar (ILL 4401). Some of the herbicides have already been tested in field experiments and some are newly developed and being tested for the third year at ICARDA region. The trial was conducted as RCB design with four replications.

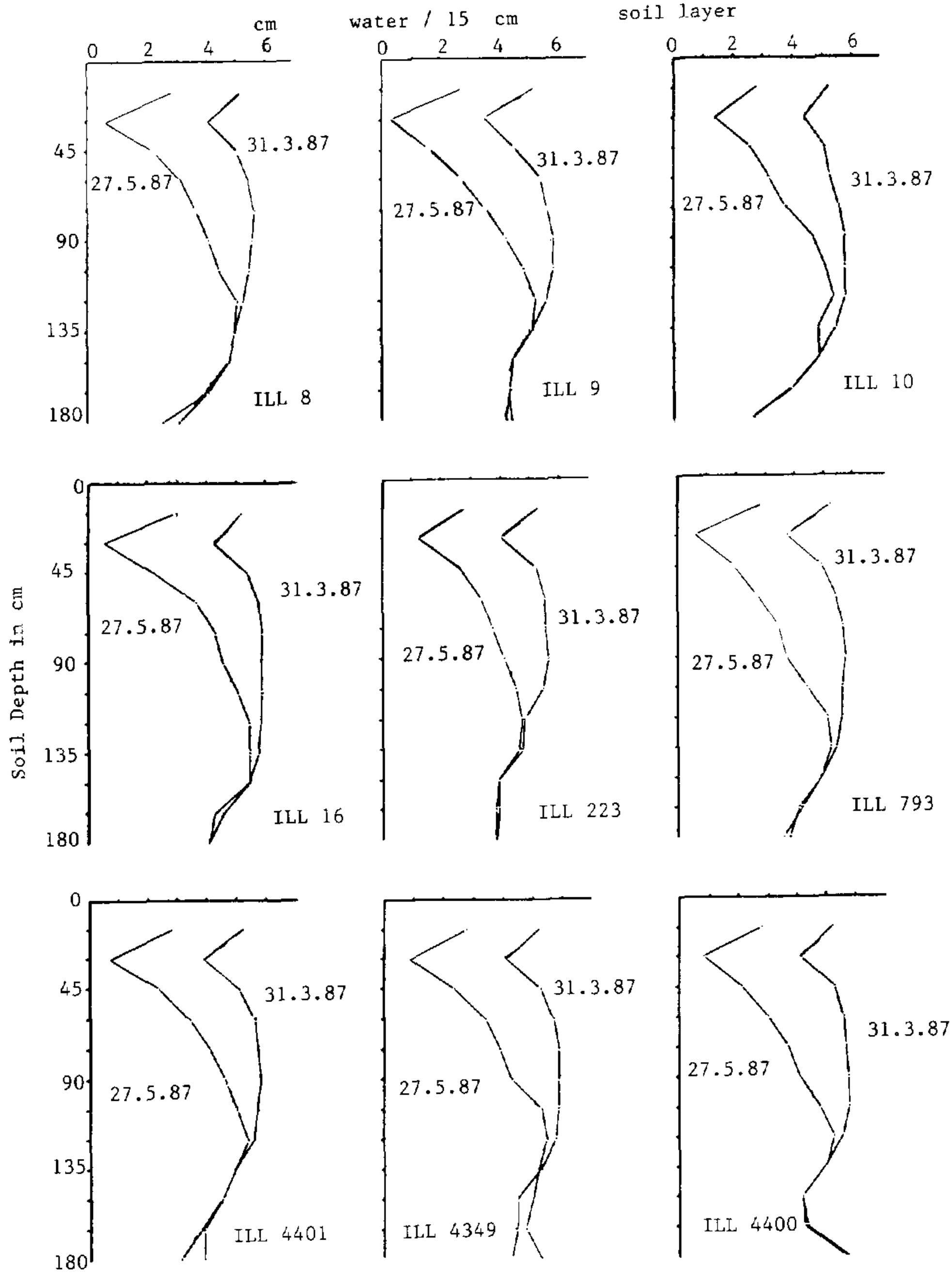


Figure 2.4.2. Soil Moisture content in different soil layers (cm water/15cm soil layer) at highest recharge (31.3.1987) and at physiological maturity of some contrasting lentil genotypes under rainfed condition. Tel Hadya. 1986/87

The level of weed infestation was rather low with the following dominant species: Sinapis arvensis, Phalaris brachystachys, Vaccaria pyramidata, Cephalaria cyriaca and Carthamus syriacus. In general 95% of the weeds were broad leaved.

Weeds caused only 10% reduction in seed yields due to the low infestation level (Table 2.4.3). Post-emergence application of dinoseb acetate + fenoxyprop ethyl appeared to be the best herbicide treatment resulting in the highest seed and biological yields, statistically different from the weedy check. Pre-emergence application of dinoseb acetate + monolinuoron was the next best combination (Table 2.4.3). Previously recommended herbicides dinoseb acetate + fluazifob butyl as post- and cyanazine + pronamide and codal as pre-emergence were less effective.

Table 2.4.3.Effect of weed control on seed and total biological yield of lentil and on weed dry weight, Tel Hadya, 1986/87.

Treatment	Rate of appln. (kg a.i./ha)	Time of appln.	Lentil yield Seed	Lentil yield Biological (kg/ha)	Total weeds (kg/ha)
Weedy check	-	-	1349	3539	243
Weed-free check	-	-	1493	3882	0
Cyanazine + pronamide	0.5 + 0.5	Pre-em	1215	3149	57
Terbutryne + pronamide	2.0 + 0.5	Pre-em	849	2018	38
Denoseb acetate + fluazifob butyl	1.0 + 0.5	Post-em	1390	3491	62
Codal	1.5	Pre-em	1282	3004	100
Secbumetron	0.5	Pre-em	0	0	73
Carbetamide + terbutryne	1.5 + 2.0	Pre-em	1340	3215	140
Carbetamide	1.5	Pre-em	1254	3443	97
Imazaquin	0.15	Pre-em	1160	3610	38
Imazaquin	0.15	At-em	434	2083	67
Imazaquin	0.10	Post-em	0	0	75
Fomesafen + fluazifob butyl	0.2 + 0.5	Pos-em	15	189	78
Fenoxyprop ethyl + dinoseb acetate	0.15 + 1.0	Post-em	1622	4171	64
Dinoseb acetate + monolinuoron	1.0	Pre-em	1527	4057	123
L.S.D. (0.05)			287	691	65
C.V. (%)			20	18	77

Secbumetron as pre-, and fomesafen + fluazifob butyl and imazaquin as post-emergence applications were completely phytotoxic to plants, with no yield obtained. Imazaquin applied at emergence reduced yield remarkably. These herbicides have been removed from the experiments for next year.

Drs. M. Pala and S. Silim.

2.5. Lentil Microbiology

Lentil is a traditional crop in the Mediterranean region, and populations of native soil rhizobia bacteria are generally adequate to produce root nodules, the site of nitrogen fixation. However, with introduction of improved cultivars replacing traditional plant types, and particularly with movement into new areas of production, it is possible that significant economic yield increases can be obtained through application of selected superior types of Rhizobium.

The main objective of microbiology research in FLIP is to determine whether legume productivity and hence soil fertility can be increased through manipulation of this plant bacteria partnership. Activities can be divided into: a) determination of the necessity for inoculation under various condtions, accomplished through an international network evaluation of native rhizobial effectiveness; b) inoculant improvement, including selection of strains for effectiveness, competetiveness, and survival ability in soils; c) inoculant technology improvement; and d) economics of N fixation, through measurement of N fixed under diverse conditions and the fate of fixed N in cropping systems.

Rhizobium strain evaluation and collection

Evaluation of Rhizobium germplasm under controlled conditions is the first step toward providing appropriate inoculation technology where it is needed. Using a greenhouse nitrogen-free aseptic hydroponic gravel culture system, 20 strains newly acquired and in the collection were screened against three cultivars for their capacity to fix nitrogen over a range of plant germplasm. From this evaluation, five strains were chosen as clearly superior, for utilization in further experiments. Additional genetic material collected within the ICARDA region and obtained from international culture collections will be included in this screening activity on a continuing basis.

As a part of its activities supporting work in National programs, Microbiology section provided more than 40 different strains to scientists in 12 countries in the form of cultures or as inoculants. Collection of new strains from the region for evaluation is a cooperative ongoing effort assisted by FLIP and national program scientists.

Necessity for inoculation

Field trials designed to determine the necessity for inoculation were distributed as International Fertility Rhizobium trials throughout the region; 18 trials were conducted in 11 countries. Trials were also conducted at two sites in Syria. These trials utilize treatments of plus and minus nitrogen, so nitrogen fertilized plants may be compared to symbiotic plants, at two levels of P/K fertility. Where plants given applied nitrogen respond significantly over symbiosis-reliant plants, improvement of N fixation through inoculation may be possible.

No data have yet been received by ICARDA from 1986/87 international trials but cooperators have communicated that in many areas a potential response to inoculation is indicated. At these sites, inoculation response trials will be conducted in 1987/88.

Strain-cultivar field trials

During 1986/87 season, three lentil cultivars were evaluated at two locations with three selected rhizobia strains, to determine

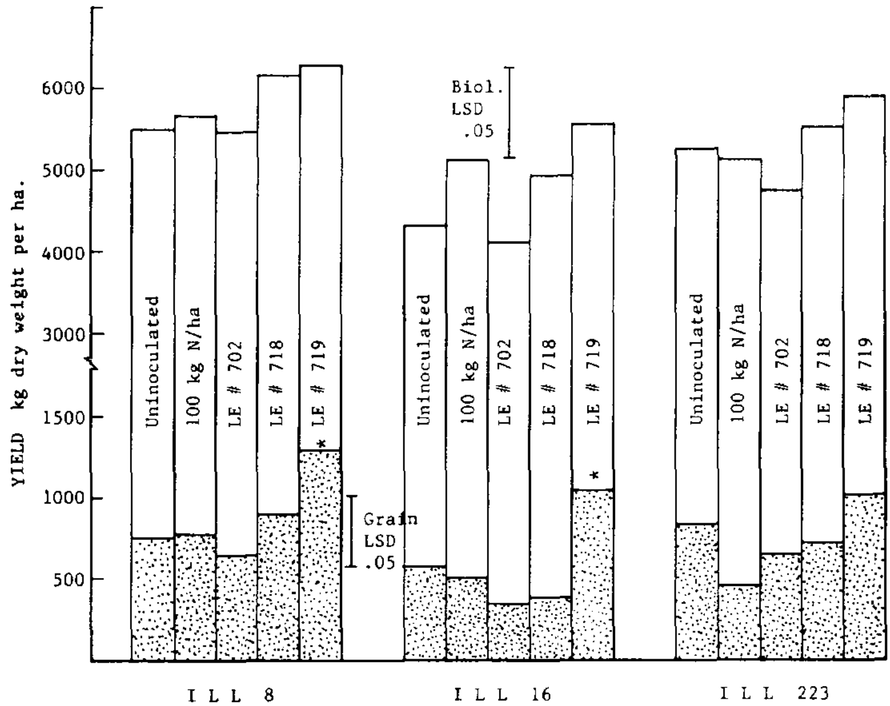


Figure 2.5.1. Field evaluation of three selected Rhizobium strains with released lentil cultivars. Tel Hadya, 1986-87.

cultivar and site specific interactions with rhizobia strains. The strains chosen were 'best guess' in terms of their effectiveness and competetiveness, as greenhouse facilities were previously unavailable for strain selection work.

At Breda, where lentil had a history of cultivation, soil contained more than 10,000 lentil rhizobia per gram. In this trial, the uninoculated control exceeded all treatments with all cultivars, including significantly higher grain and straw yield over the treatment receiving 100 kg N per hectare in split applications.

In Tel Hadya, experiments were severely affected by Orobanche infestation, and grain yields averaged about 800 kg per hectare. In this trial, significant responses to inoculation with strain 719 were obtained on both ILL 8 and ILL 16, two popular local cultivars (Fig. 2.5.1). Application of 100 kg N had no effect, or decreased grain yield as compared to the uninoculated control. Results from this trial indicate a potential for increasing N fixation and yields in lentil, if competetive effective strains of rhizobia are used.

Dr. D. Beck.

2.6. Lentil Quality

Lentil improvement is focussed on increasing both seed and straw yield, while research on seed and straw quality at ICARDA aims to maintain current nutritional levels. The routine quality tests on seed include seed size, cooking quality, protein content and decortication and on straw cover protein content, in vitro digestibility and fibre content.

2.6.1. Decortication studies

The decortication work commenced in 1984 was extended to a study of the influence of growing location and genotype on decortication efficiency. The earlier work had shown that 30 minute soaking combined with 2 hours standing time in cold air were optimum for large (over 4.5 mm) and medium (4.0-4.5 mm) microsperma lentil, whereas a 5-minute soak followed by 30 minute standing time was optimum for smaller (3.5-4.0 mm) seeds. For the present work 22 genotypes were planted in three locations (Tel Hadya and Breda in Syria and Terbol in Lebanon), replicated twice. All samples were represented into fractions of seeds of different size using sieves, and the proportion of each fraction recorded. Decortication was carried out on the 4.0-4.5 mm size range. The analysis of variance is summarized in Table 2.6.1.

The strong influence of growing location on cooking time and all seed characteristics was verified, and significant genotypeXlocation interactions occurred for all parameters except the percentage of dehulled, and dehulled + non-dehulled seeds. The absence of either a location effect or a genotypeXlocation

Table 2.6.1. Summary of lentil fractionation/dehulled study, 1986-87 (Tel Hadya, Breda, Terbol).

Parameter	F-Value and LSD				
	Location		Genotype		Interaction
	F	LSD (P=0.05)	F	LSD (P=0.05)	F
100-seed weight (g)	133.2**	0.11	18.4**	0.31	1.60*
Cooking time (min)	109.5*	2.9	3.17*	5.7	1.83*
% dehulled	0.4	NS	18.1**	12.2	0.24 NS
% non-dehulled	13.2**	1.4	29.3**	4.4	4.20*
% of seeds over 5.0mm	7.9**	6.6	14.6**	4.0	2.15*
% of seeds 4.5-5.0 mm	1630.9**	2.7	9.21**	7.9	2.48*
% of seeds 4-4.5 mm	315.5**	6.2	8.9**	8.5	1.62*
% of seeds 3.5-4.0 mm	26.0**	4.5	8.31**	4.5	2.93*
Dehulled + non-dehulled	1.73	NS	0.46NS		1.15NS

* P = 0.05, ** P = 0.01

interaction for the percentage of dehulled seeds is useful information for breeding programs. Even more important is the lack of genotypic significance in the percentage of dehulled + non-dehulled lentils, since the implication is that the breeder need not be concerned about dehulling properties. In a lentil-processing operation seeds which are not dehulled are recycled so that the combination of dehulled plus non-dehulled seeds represents the total recovery from the lentils received at the factory. A statistically significant negative correlation ($r = -0.52$, $N = 132$) between 100 seed weight (HSW) and the proportion of lentils which remained undehulled after the first passage indicated that smaller seeds may be more difficult to dehull. This conclusion was supported by a significant positive correlation between percent dehulled seeds and HSW ($r = 0.50$) and a negative correlation between percent seeds dehulled and percent small seeds of less than 4.0 mm ($r = -0.45$).

Drs. P.C. Williams and W. Erskine

3. KABULI CHICKPEA IMPROVEMENT

The kabuli chickpea improvement project is a joint venture with ICRISAT, India. Of the four main regions where chickpea is grown, the Mediterranean region and Latin America mostly produce kabuli type chickpea. Only a small percentage of area under chickpea in the Indian subcontinent and East Africa is of the kabuli type. It 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. Leaf miner in the Mediterranean region and Heliothis in other regions are major insects. Kabuli chickpea is mainly grown as a rainfed crop, except in South Asia and Central America, where it is grown with supplemental irrigation.

In West Asia and North Africa, where the crop is currently spring sown, yield is expected to increase substantially by introducing winter sowing. Major efforts are underway to stabilize chickpea productivity by breeding for resistance to various stresses, such as diseases (blight and wilt), leaf miner insect, cold, and cyst nematode.

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: 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 1987 several new research initiatives were started. The screening for cyst nematode resistance began in association with the Istituto di Nematologia Agraria, C.N.R., Bari, Italy. In collaboration with the Department de Patologia Vegetal, Cordoba, Spain, screening germplasm for resistance to Fusarium wilt began at Cordoba. Research on wild Cicer species started in collaboration with the Genetic Resource Program. A graduate student initiated mutation research to develop new genetic variability.

3.1.1. Release of cultivars by national programs

One of the major objectives of the program is to strengthen the National Agricultural Research Systems (NARS) by providing diverse nurseries to enable them to develop and release varieties for their farmers. A total of 19 lines have been released in nine countries by NARS by selecting appropriate types from the international nurseries (Table 3.1.1). Seventeen of these have been released for winter sowing in the Mediterranean region. Two are released for spring sowing in the Mediterranean region and one for the sub-tropics indicating that material generated in a Mediterranean environment at ICARDA can also be useful at different locations.

Two lines, ILC 482 and FLIP 83-98C, are at the final stage of evaluation and pre-release multiplication in Lebanon. Jordan has included FLIP 83-46C in large scale demonstration. Three cultivars namely FLIP 81-293C, FLIP 82-161C and FLIP 82-28C have been included for catalogue trial in Morocco. Tunisia has selected FLIP 82-239C

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
Cyprus	Yialousa (ILC 3279)	1984	Tall type
	Kyrenia (ILC 464)	1987	Large-seed
Iraq		1987	Details awaited
Italy		1987	Details awaited
Morocco	ILC 195	1987	Tall type
	ILC 482	1987	High yield, wide adaptation
Spain	Fardan (ILC 72)	1985	Tall type, high yield
	Zegri (ILC 200)	1985	Mid-tall, high yield
	Almena (ILC 2548)	1985	Tall type, high yield
	Alcazaba (ILC 2555)	1985	Tall types, high yield
	Atalaya (ILC 200)	1985	Mid-tall, high yield
Sudan	Shendi	1987	High yield
Syria	Ghab 1 (ILC 482)	1982/86	High yield, wide adaptation
	Ghab 2 (ILC 3279)	1986	Tall type, cold tolerant
Tunisia	ILC 3279	1986	Tall type
	FLIP 83-46C	1986	Large seed, high yield
	Be-sel-81-48	1986	Large seed, fusarium wilt resistant
Turkey	ILC 195	1987	Tall, medium seed, cold tolerant
	ILC 482	1987	High yield, wide adaptation

Note: All chickpea genotypes listed above are resistant to ascochyta blight and released for winter sowing except Be-sel-81-48 and Kyrenia (which are for spring sowing) and Shendi (which is for short winters of Sudan).

and FLIP 84-182C and Algeria FLIP 84-139C, FLIP 84-60C and FLIP 84-182C for the final stage of evaluation and pre-release multiplication. In Syria, FLIP 82-115 and FLIP 82-150 are at final year of on-farm trials.

NARS Scientists and Dr. K.B. Singh

3.1.2. Winter sowing

Chickpea is spring-sown in the Mediterranean region but by sowing in early winter with ascochyta blight and cold tolerant lines, the yield can be substantially increased. A comparison of spring versus winter sowing has been made over four years (1983/84 to 1986/87) at three sites (Tel Hadya, Jinderiss and Terbol), using common breeding lines in all trials in each year. As to the weather conditions, 1984/85 winter was one of the coldest in the last 50 years, and spring of 1983/84, especially at Tel Hadya, was the driest. Tel Hadya is the driest of the three sites, Terbol the wettest and Jinderiss the intermediate, with long term average seasonal rainfall of 330, 575 and 475 mm, respectively. Tel Hadya, Jinderiss and Terbol are located at 282, 210 and 890 m above sea level. The seed yield is summarized in Figure 3.1.1. The winter-sown trials over four seasons produced mean yield of 1750 kg/ha against 1153 kg/ha yield of spring sown trials, giving an average increase of 52%.

Dr. K.B. Singh

3.1.3. Screening for multiple stresses

In the past two seasons efforts were made to screen about 800 breeding lines to ascochyta blight, cold, leaf miner, cyst nematode, and Fusarium wilt. The lines that were found resistant to individual biotic or abiotic stress are listed below.

3.1.3.1. Ascochyta blight

Forty two lines including FLIP 83-13C, 83-14C, 83-15C, 83-21C, 83-22C, 83-28C, 83-35C, 83-45C, 83-46C, 83-47C, 83-48C, 83-60C, 83-72C, 83-97C, 85-27C, 83-38C, 84-78C, 84-79C, 84-80C, 84-81C, 84-83C, 84-85C, 84-86C, 84-87C, 81-91C, 84-92C, 84-93C, 84-102C, 84-112C, 84-126C, 84-133C, 84-145C, 84-158C, 84-182C, 85-25C, 85-27C, 85-28C, 85-31C, 85-32C, 85-39C, 85-40C, 85-86C, were found resistant to ascochyta blight with a rating of 3 on a 1-9 scale. Many other lines showed 4 (moderately resistant) and 5 (tolerant) ratings. For a commercial cultivar with field resistance ratings 4 and 5 are acceptable. The screening was done in the field against a mixture of races 1, 2, 3, and 4.

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

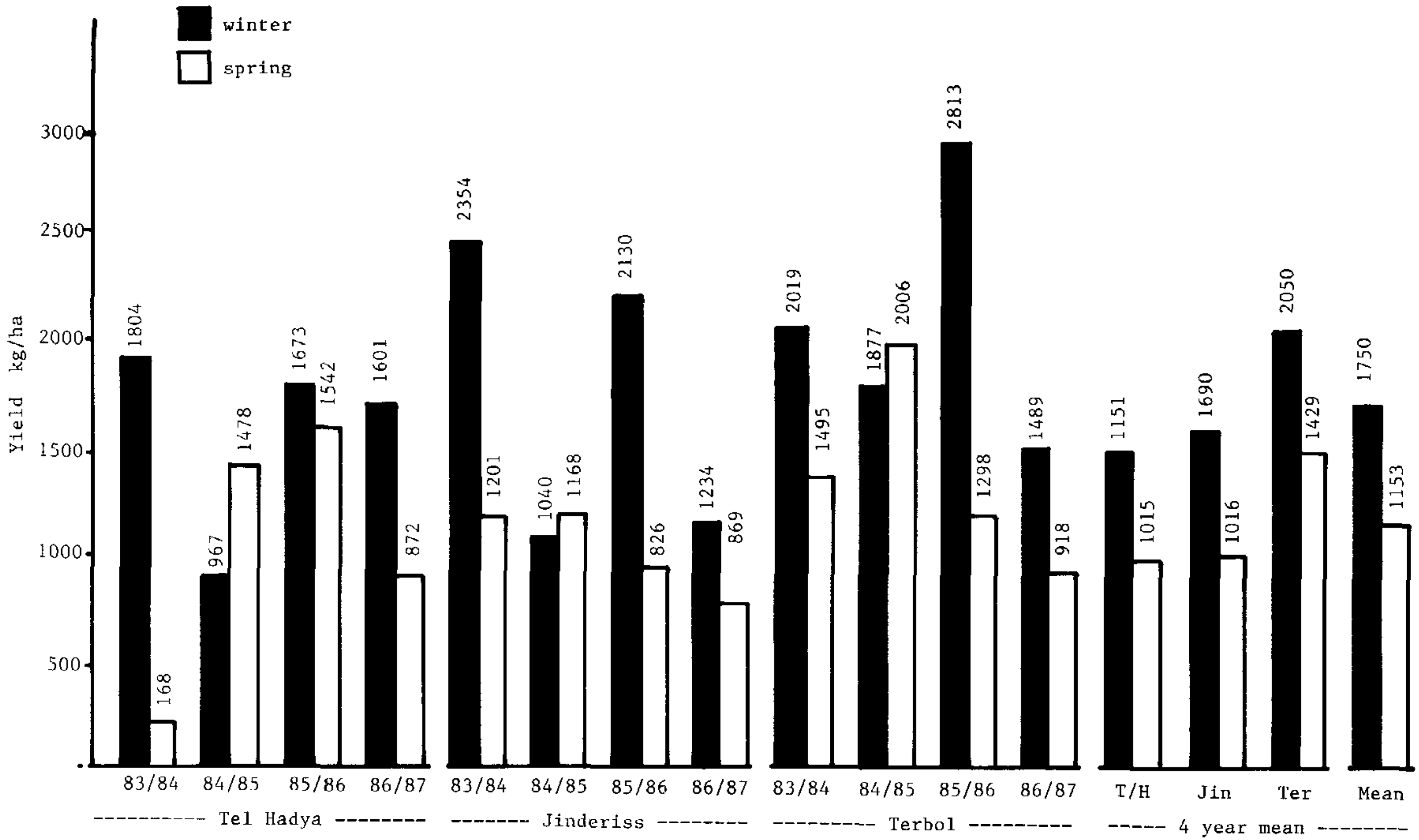


Figure 3.1.1. Mean seed yield of 72, 96, 96, and 98 entries of chickpea grown during winter and spring in Syria and Lebanon.

3.1.3.2. Fusarium wilt

Fusarium wilt caused by Fusarium oxysporum f. sp. ciceri has been a serious problem in North Africa and parts of South Europe, especially in Italy and Spain in spring-sown kabuli chickpea. Since the facility to work on this disease at ICARDA does not exist, we earlier initiated some work in collaboration with the national program in Tunisia where facilities for wilt resistance screening have been developed. Since races are known to exist in this pathogen, we have now started an additional collaboration with the Department de Patologia Vegetal, Cordoba, Spain, to further investigate this problem.

A total of 735 breeding lines were sown with two susceptible checks, JG62 and PV60, in the wilt sick plot at Santaella in Spain during 1986/87. Both susceptible checks were sown after every 10 test entries. The material was evaluated for percent dead plants two months after sowing and then again a month later. The duration of the crop was three and a half months. PV60 had a mortality rate between 80 and 100% throughout the nursery showing that disease severity in the field was uniform. However, the mortality rate in JG62 was variable. Six lines (0.82%) were rated resistant namely FLIP 82-78C, 84-43C, 84-130C, 85-29C, 85-30C, and 85-37C (Table 3.1.2.). These will be sown again for confirmation.

Professor R.M.J. Diaz (Spain) and Dr. K.B. Singh

3.1.3.3. Leaf miner

Both the 1985/86 and 1986/87 seasons were favorable for screening against leaf miner (Liriomyza ciceri) at Tel Hadya Farm. A total of 737 breeding lines were evaluated on a 1-9 scale. None of the lines showed a rating of 1-4 and only two lines, namely FLIP 82-3C and FLIP 84-92C, had a 5 rating. The remaining lines showed susceptibility (6 to 9 rating) (Table 3.1.2).

Leaf miner development and spread is highly dependent on weather. We are attemting to develop a technique to produce a uniform epidemic of leaf miner by multiplication and controlled release of the insects in the test plots.

Drs. S. Weigand and K.B. Singh

3.1.3.4. Cyst nematode

The chickpea cyst nematode Heterodera ciceri Vovlas, Greco et Di Vito, causes severe damage to chickpea in certain parts of Syria. Microplot experiments demonstrated that at population densities above 64 eggs and juveniles of cyst nematodes per cm^3 soil the yield of chickpea was zero. The use of nematicides for control being impractical, the best way to control the nematode is through the use of resistant cultivars which unfortunately are currently not available. Therefore, an effort was made to screen germplasm lines for reaction to cyst nematode in the plastichouse during 1986/87.

Screening was conducted on 740 breeding lines. Ten seeds of each line were sown in two five liter pots filled with sterilized soil (20.1% sand, 33.2% silt, 46.0% clay and 0.6% o.m.) artificially infested with cysts of a Syrian population to give 20 eggs and juveniles per cm^3 soil. A temperature of 16-25^oC was maintained in the plastichouse. A susceptible line ILC 1929 was sown for comparison. Fifty days after emergence plants were uprooted, the roots washed gently and the number of female nematodes counted. Lines were rated by using a 1-9 rating scale, where 1 = no infestation, 3 = 1-5 females per plant root, 5 = 6-20 females, 7 = 21-50 females, and 9 > 50 females.

No line was free of nematodes, but five lines were rated 3 and another 86 lines were found tolerant (Table 3.1.2). All these will be rescreened next season.

Drs. M. Di Vito, N. Greco, K.B. Singh and M.C. Saxena.

Table 3.1.2. Screening of FLIP chickpea breeding lines to ascochyta blight, leaf miner, cold, cyst nematode and Fusarium wilt during 1986/87.

Rating	Ascochyta blight		Leaf miner		Cold		Cyst nematode		Fusarium wilt	
	No. of entries	Percentage	No. of entries	Percentage	No. of entries	Percentage	No. of entries	Percentage	No. of entries	Percentage
1	0	0.0	0	0.0	0	0.0	0	0.0	0	0
2	0	0.0	0	0.0	0	0.0	–	–	–	–
3	42	6.1	0	0.0	6	0.8	5	0.8	6	0.7
4	55	8.0	0	0.0	30	4.0	–	–	–	–
5	100	14.5	2	0.3	128	17.1	86	11.6	8	1.1
6	128	18.6	58	7.9	161	21.5	–	–	–	–
7	156	22.6	652	88.5	165	22.0	178	24.1	18	2.5
8	20	2.9	25	3.4	175	23.3	–	–	–	–
9	188	27.3	0	0.0	85	11.3	471	63.5	704	95.8
Total	689	100	737	100.1	750	100	740	100	736	100.1

3.1.3.5. Cold

A field screening technique for cold tolerance at low to middle elevation in the Mediterranean climate has been developed which consists of (a) advancing sowing date to October to allow the crop to grow up to late vegetative stage before the onset of severe winter, (b) planting of indicator cold susceptible check at frequent intervals and evaluating germplasm only after the susceptible check is killed, and (c) reconfirming tolerant lines for one more season. Also a 1-9 scale for screening germplasm lines for cold tolerance has been developed. The scale is described below: 1 = free = no visible symptoms of damage; 2 = highly resistant = up to 10% leaflets show withering and drying no killing; 3 = resistant = 11-20% leaflets show withering and drying, no killing; 4 = moderately resistant = 21-40% leaflets and up to 20% branches show withering and drying, no plant mortality 5 = tolerant = 41-60% leaflets and from 21-40% branches show withering and drying, up to 5% plant mortality; 6 = moderately susceptible = 61-80% leaflets and from 41-60% branches show withering and drying, 6-25% plant mortality; 7 = susceptible = 80-99% leaflets and 61-80% branches show withering and drying, 26-50% plant mortality; 8 = highly susceptible = 100% leaflets and 81-99% branches show withering and drying, 51-99% plant mortality; and 9 = killed = 100% leaflets and branches show withering and drying, all plants killed.

No line was rated 1 or 2, but six and 30 lines were rated 3 and 4, respectively. One hundred and twenty-eight lines were tolerant (rating 5). (Table 3.1.2).

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

3.1.3.6. Combined resistance to two stresses

No line was resistant to two stresses. However, there were many lines with resistance (R) to one stress and tolerance (T) to another; for example:

1) Ascochyta blight (AB) and fusarium wilt (FW)
   FLIP 85- 30C: T to AB and R to FW
   FLIP 85- 37C: T to AB and R to FW
2) Ascochyta blight (AB) and leaf miner (LM)
   FLIP 84- 92C: R to AB and T to LM
3) Ascochyta blight (AB) and cyst nematode (CN)
   FLIP 85- 52C: T to AB and R to CN
4) Ascochyta blight (AB) and cold (C)
   FLIP 84-112C: R to AB and T to C
   FLIP 84-133C: R to AB and T to C
   FLIP 85- 4C: T to AB and R to C
   FLIP 85- 47C: R to AB and T to C
   FLIP 85- 81C: T to AB and R to C
5) Fusarium wilt and cold
   FLIP 84- 43C: R to FW and T to C
6) Cyst nematode and cold
   FLIP 83- 36C: R to CN and T to C

Efforts are underway to combine genes for resistance to two or more stresses.

3.1.4. Screening genotypes for response to supplemental irrigation

Kabuli chickpea is grown under 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 screen for chickpea response to supplemental irrigation. Two trials, each comprising 24 genotypes, were grown rainfed and with supplemental irrigation during the winter season of 1986/87 at Tel Hadya. A randomized block design with three replications was used. All 48 genotypes had previously been screened during 1985/86. Three irrigations of 40mm each were given.

The seed yield increased by 74 and 70 percent in trial 1 and trial 2, respectively, with supplemental irrigation (Fig. 3.1.2).

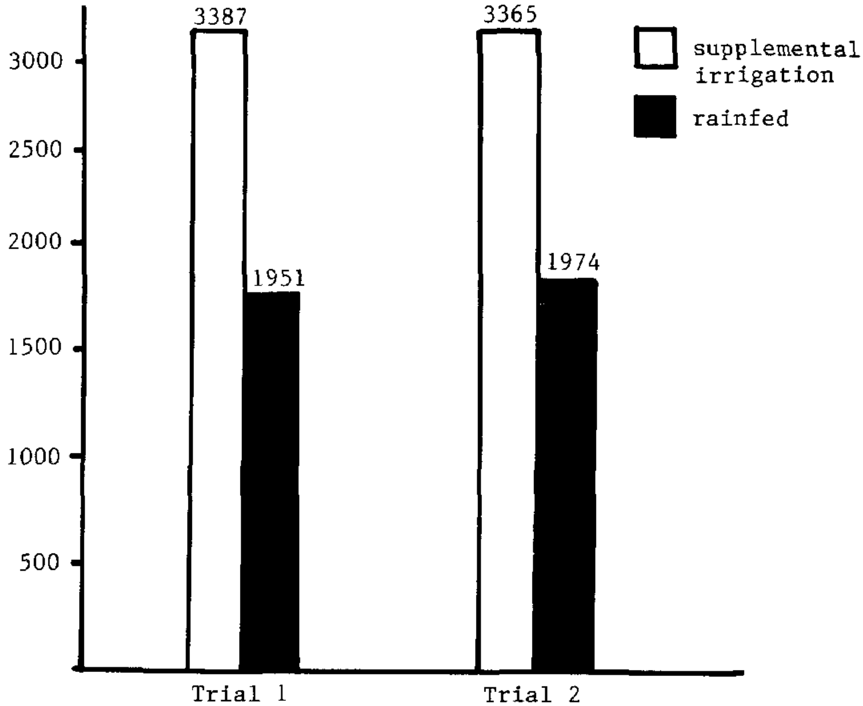


Figure 3.1.2. Mean yield of 24 entries of winter-sown chickpea grown rainfed and with supplemental irrigation at Tel Hadya, Syria, 1986/87.

Most genotypes produced more than 3t/ha with irrigation and less than 2t/ha with no irrigation. ILC 237 produced the highest yield (4487 kg/ha) when irrigated, giving an increase of 91% over no irrigation. Four genotypes doubled their yields with irrigation. The lowest increase was 30% and the highest was 133%.

Screening for two years has helped to identify those lines that consistently responded to supplemental irrigation. The performance of five is shown in Table 3.1.3. Lines which responded to irrigation were average to poor yielding. However, the lines which produced high yields under rainfed conditions also gave a substantial increase in yield on irrigation. Future efforts will be directed to transfer genes for response to irrigation in high yielding lines.

Drs. K.B. Singh and E. Perrier.

Table 3.1.3. Mean seed yield (kg/ha) of the five lines most responsive to irrigation and the five highest yielding lines under rainfed conditions at Tel Hadya, Syria during 1985/86 and 1986/87.

Genotype	1985/86				1986/87				Mean			
	Rainfed	Irrigated	Increase Kg	Increase %	Rainfed	Irrigated	Increase Kg	Increase %	Rainfed	Irrigated	Increase Kg	Increase %
Most responsive lines												
ILC 202	1048	2152	1104	105	1333	2825	1492	112	1191	2489	1298	109
FLIP 83- 53C	1413	2786	1373	97	1788	3476	1688	94	1601	3131	1530	96
FLIP 83- 69C	1254	2452	1198	96	1683	3153	1470	87	1469	2803	1334	91
FLIP 83- 71C	1310	2556	1246	95	1852	3333	1481	80	1581	2945	1364	86
ILC 142	2111	3690	1579	75	1757	3434	1677	95	1934	3562	1628	84
Highest yielding lines under rainfed conditions												
ILC 1272	3127	3254	127	4	2265	4275	2010	89	2696	3765	1069	40
ILC 100	2437	2660	223	9	2582	2947	1365	53	2510	3304	794	32
ILC 613	2556	2754	198	8	2434	3704	1270	52	2495	3229	800	32
ILC 1929	2754	3175	421	15	2095	3397	1302	62	2425	3286	861	36
ILC 136	2317	3151	834	36	2529	3757	1228	49	2423	3454	1031	79

3.1.5. Segregating populations

Four hundred and fifty crosses were made in 1987 to include 350 crosses for breeding requirements of the national programs and the remaining for special studies in Italy, Spain and for graduate students. We succeeded in making as high as 50 crosses during the off-season at Terbol; 300 F_2 bulks and 15,000 F_4 to F_6 progeny rows were grown in the ascochyta blight disease nursery. The F_2 generation was bulk-harvested and 8000 single plants were selected from F_4 and F_5 generations based on maturity, height and seed size. Four hundred and eighty uniform and promising progenies were bulked. When these bulked lines were grown for seed increase in the off-season, only 300 lines matured.

Dr. K.B. Singh.

3.1.6. Yield performance of newly bred lines

Between 241 and 374 lines were evaluated for yield at Tel Hadya and Jinderiss in Syria and Terbol in Lebanon in both winter and spring sowing in several trials. A large number of lines exceeded the check cultivar by a significant margin (Table 3.1.4). Previously few lines exceeded the check by a significant margin, indicating a gradual improvement in yield. The coefficients of variation over trials were low suggesting that the trials were uniform.

The best check entry used in evaluating the newly bred lines is ILC 482 which is high yielding and widely adapted. In the past, there were few breeding lines that were consistently better than ILC 482. During 1986/87, many lines exceeded ILC 482 both in winter and spring sowing (Table 3.1.5) at all the three sites indicating progress made through breeding in yield improvement. Also the new lines are better in resistance to ascochyta blight and cold and in seed size.

National programs need lines suitable for sowing during both winter and spring. We are therefore now breeding genotypes suitable

Table 3.1.4. Performance of newly developed lines during winter and spring at Tel Hadya, Jindiress and Terbol, 1986/87.

Location	Number of entries tested	Number of entries exceeded checks[1]	Number of entries significantly exceeded checks (P =0.05)	Range for CV (%)
		Winter Sowing		
Tel Hadya	374	69	5	9.9-27.3
Jinderiss	299	128	6	12.5-31.2
Terbol	322	106	13	6.7-21.3
		Spring Sowing		
Tel Hadya	322	145	4	12.2-23.9
Jinderiss	241	103	19	11.2-30.9
Terbol	263	62	13	10.2-32.8

1. The best check was ILC 482.

Table 3.1.5. Performance of some of the lines in advanced yield trial as percentage of performance of ILC 482 during 1986/87.

Entry	Tel Hadya	Jinderiss	Terbol
	Advanced Yield Trial		
FLIP 84-120	103	105	115
FLIP 85- 72	117	105	110
FLIP 85- 88	101	115	109
FLIP 85-141	110	110	122
ILC 482	100	100	100

for both seasons. Many lines have performed well over both seasons and across three locations (Table 3.1.6). An international trial initiated from the 1987/88 season containing such genotypes has been distributed to national programs in Algeria, Morocco, Syria and Tunisia.

Dr. K.B. Singh.

Table 3.1.6. Rank performance of lines during the winter and spring seasons in different trials at Tel Hadya (TH), Jinderiss (J) and Terbol (Tr), 1986/87.

Entry	Winter				Spring				Overall
	TH	J	Tr	Mean	TH	J	Tr	Mean	Mean
FLIP 84-182	4	1	1	2.0	1	4	10	5.0	3.5
FLIP 85- 10	4	7	1	4.0	4	6	10	6.7	5.4
FLIP 85-141	1	7	1	3.0	8	6	8	7.3	5.1
FLIP 85-145	5	4	4	4.3	1	3	1	1.7	3.0
S86114	2	7	4	4.3	19	1	5	8.3	6.3
ILC 482	4	11	8	7.8	17	17	6	13.8	10.5

3.1.7. Selection of plants from ILC 482 and ILC 3279 for cold tolerance

During the cold 1984/85 season, both ILC 482 and ILC 3279 were badly damaged by cold taking an 8 rating on a 1-9 scale. Five hundred plants showing tolerance to cold were selected from both ILC 482 and ILC 3279. These selections were further evaluated in the cold tolerance nursery sown in the 1985/86 and 1986/87 seasons an in the ascochyta blight disease nursery in 1985/86.

Twelve selections from ILC 482 showed tolerance to both cold and ascochyta blight (Table 3.1.7). Likewise, six selections from ILC 3279 had resistance to both cold and ascochyta blight (Table 3.1.8). A slight variation was observed for 100-seed weight, plant height and protein content in the selections when compared to original cultivars. These selections and others will be evaluated further for cold tolerance, ascochyta blight resistance, yield and other characters, and might replace ILC 482 and ILC 3279.

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

Table 3.1.7. Performance of selections for cold tolerance from the chickpea cultivar ILC 482 evaluated at Tel Hadya, Syria during 1985/86 and 1986/87.

Selection No.	Cold[a] 1986/87	Asco. blight 1985/86 V/R	100-seed wt. (g)	Plant height (cm)	Protein (%)
ILC 482- 10	4	4/6	25	62	21.7
ILC 482- 11	5	2/5	26	60	21.7
ILC 482- 80	4	3/6	24	60	23.7
ILC 482- 85	5	3/5	28	58	21.2
ILC 482-166	5	3/5	23	65	23.5
ILC 482-167	4	3/4	25	75	24.0
ILC 482-168	5	4/5	26	60	21.7
ILC 482-175	5	3/5	25	67	22.7
ILC 482-335	5	3/5	26	61	22.7
ILC 482-406	5	3/5	27	55	21.9
ILC 482-411	5	3/5	25	56	21.9
ILC 482-441	5	3/5	27	54	21.5
ILC 482	8	5/7	28	58	21.3

a. Scale: 1-9, where 1 = free; 5 = tolerant, and 9 = killed.
b. V/R = evaluation done at vegetative and reproductive stage.

Table 3.1.8. Performance of a few elite lines selected for cold tolerance from the chickpea cultivar ILC 3279 and evaluated for cold and ascochyta blight at Tel Hadya, Syria during 1985/86 and 1986/87.

Selection No.	Cold[a] 1986/87	Asco. blight 1985/86 V/R	100-seed wt. (g)	Plant height (cm)	Protein (%)
ILC 3279- 39	4	3/3	23	85	25.3
ILC 3279-156	4	3/3	25	84	24.6
ILC 3279-170	3	4/6	24	90	26.8
ILC 3279-330	4	3/3	27	80	24.3
ILC 3279-339	4	3/3	27	85	24.2
ILC 3279-361	4	3/3	25	85	24.0
ILC 3279	7	3/5	28	84	23.9

a. Scale: 1-9, where 1 = free; 5 = tolerant; and 9 = killed.
b. V/R = evaluation done at vegetative and reproductive stage.

3.1.8. On-farm trials

3.1.8.1. Syria

The on-farm trials in chickpea are an ongoing effort begun in Syria during 1979/80 to compare the performance of winter sowing with traditional spring sowing, jointly by the Agriculture Research Center (ARC) of the Ministry of Agriculture and Agrarian Reform, Syria, and ICARDA. The major achievement of this collaborative effort has been the release of 'ILC 482' and 'ILC 3279' named, respectively, 'Ghab 1' and 'Ghab 2'. On-farm trials were continued during 1986/87 and results are presented in Table 3.1.9. One line namely FLIP 82-150C excelled over both Ghab 1 and Ghab 2 in Zone A (>350 mm annual rainfall) and Zone B (275-350 mm annual rainfall) in seed yield. This line, which also produced higher yield than Ghab 1 and Ghab 2 during 1985/86, has better seed quality.

Table 3.1.9. Seed yield (kg/ha) of new entries in the on-farm trial, in Syria, 1986/87.

Entry	Zone A[a]	Zone B[b]	Mean
FLIP 81-293C	2045	1104	1776
FLIP 82-115C	1745	979	1526
FLIP 82-150C	2176	1246	1910
FLIP 82-232	2066	1118	1795
Ghab 1	1994	1206	1769
Ghab 2	1848	918	1582

a. Mean yield of 10 locations
b. Mean yield of 4 locations

3.1.8.2. Other countries

The on-farm trial that was started in Syria was extended to other countries with similar objectives. During the 1986/87 season, this activity was carried out by several countries including Jordan, Lebanon, Morocco, Tunisia and Turkey supported by ICARDA. Based on this performance, Morocco and Turkey have released two cultivars namely ILC 195 and ILL 482. The concept of on-farm trials is being adopted by other national programs and the chickpea project is assisting by providing seed and advice.

SMAAR Scientists and Dr. K.B. Singh

3.1.9. Performance of Ghab 1 and Ghab 2 in village project in Syria

In collaboration with the Ministry of Agriculture and Agrarian Reform (SMAAR), ICARDA conducted a village project at 11 sites in Syria. The objective was to demonstrate the performance of newly released cultivars in large plots. Ghab 1 and Ghab 2 was winter-sown on 1 to 10 ha plots and weeds was controlled through herbicide use. All the participating farmers also planted chickpea during spring on plots ranging 1-6 ha in adjacent fields and yields was recorded from those plots. Because of large plot size, yields were sampled from four randomly chosen plots of 100 m^2 from each cultivar. Results are presented in Table 3.1.10. Ghab 1 yielded 1691 kg/ha giving an increase of 70% over local variety sown during spring, whereas Ghab 2 gave an increase of 53%.

SMAAR Scientists and Dr. K.B. Singh.

3.1.10. Economic feasibility of winter sowing

A survey of nine farmers in Syria who had planted chickpea during winter and spring on more than one hectare plot were conducted. The economic return for 1986/87 based on the information collected during the survey is shown in Table 3.1.11.

The winter-sown crop brought twice as much return as the spring-sown crop. Both Ghab 1 and Ghab 2 were equally profitable because Ghab 1 produced more seed yield and Ghab 2 more straw yield. The selling price of Ghab 1 and Ghab 2 were slightly higher than that of local because they are new cultivars. When net return was

Table 3.1.10. Performance of chickpea entries (kg/ha) in village projects conducted in Syria for the season 1986/87.

Location	Efrin	Mharda	Damkheih	Kattineh	Sheikh Ahmed	Ain Dara	Alkamieh	Sheikh Yousef	Ashareneh	Zetan A-Masna	Skelbeih	Mean	Rank
Zone	A	A	A	A	B	A	A	A	A	B	A		
Ghab 1 (winter sown)	1725	3413	1075	1875	1233	1580	1836	1635	1725	1000	1500	1691	1
Ghab 2 (winter sown)	1771	2115	723	1823	1104	-	-	-	1380	-	1700	1517	2
Local check (spring sown)	940	1200	867	-	528	940	1377	607	1200	1082	1200	994	3
C.V. (%)	20.2	8.6	27.9	5.2	13.1	8.9	21.4	11.6	10.4	11.5	3.4		

Zone A = >350 mm annual rainfall; Zone B = 275-350 mm annual rainfad.

Table 3.1.11. 1986-87 chickpea budgets[a] based on survey of nine farmers who produced both spring and improved winter crops in northern Syria.

Season cultivar	Spring Local	Winter Ghab 1	 Ghab 2
Yields			
Seed Yield (kg/ha)	991	1574	1629
Straw Yield (kg/ha)	650	1542	2127
Gross Crop Value[b]			
Seed sales (SL/ha)	10901	17314	17919
Straw sales (SL/ha)	325	771	1063
Total	11226	18085	18982
Costs (SL/ha)			
Tillage	410	310	310
Seed & Seeding	1800	1800	1800
Fertilizer	160	160	160
Weed control	-	1000	1000
Harvest operations	1669	3413	3687
Total variable costs (SL/ha)	4039	6683	6957
Sales - Costs = Profit (SL/ha)	7187	11402	12025
Relative Profits (Spring=1.00)	1.00	1.59	1.67

a. Based on farmer-managed on-farm trials at 9 locations with large plots ($\geq$ 1 ha) of each type at each location.
b. Conservative market prices in 1987: SL 11/kg for seed
SL 0.5/kg for straw

calculated on the same selling price as the local, the winter sowing gave a large profit.

Drs. T. Nordblom and K.B. Singh.

3.1.11. Genetic study

3.1.11.1. Detection of epistasis

The knowledge of the presence of non-allelic interactions for different characters in a crop is important to a plant breeder in deciding appropriate methodologies to be followed for plant improvement. Limited information is available on non-allelic interaction in chickpea. Hence, an attempt were made to discover the existence of epistasis and to determine the additive and dominance variance using a triple test cross analysis in chickpea.

None of the characters investigated exhibited epistasis. In the absence of epistasis, additive and dominance effects were estimated. The results indicated the importance of additive genetic variance for seed yield, biological yield, number of primary branches, number of secondary branches, 100-seed weight, days to flower, number of seeds per pod, dominance genetic variance for days to maturity and both additive and dominance genetic variances for plant height. Selection methods, such as pedigree and bulk, are suggested for the improvement of most characters.

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

3.1.11.2. Inheritance of resistance to ascochyta blight

Inheritance of resistance to race 3 of ascochyta blight (Ascochyta rabiei (Pass.) Lab.) was studied in four resistant lines at ICARDA, Syria from 1983 to 1986. The parents, F_1 and F_2 populations were evaluated for ascochyta blight resistance under artificial epiphytotic conditions in a greenhouse during the 1983-84 season. The F_3 progenies from the selected F_2 resistant plants for each of the four crosses involving resistant and susceptible lines were evaluated for segregation for blight resistance and susceptibility in the greenhouse during the 1985-86 season. The results suggested that a single dominant gene conditioned resistance to race 3 in the four parents, ILC 72, ILC 202, ILC 2956, and ILC 3279. The allelic tests indicated that the resistance gene present in these four resistant lines was the same.

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3.2. Chickpea Diseases and their Control

Because ascochyta blight is the most important disease of chickpea in the ICARDA region, it is important to identify long lasting sources of resistance which can be incorporated in breeding materials. Fusarium wilt and stunt (bean leaf roll virus) are two additional potentially serious diseases of chickpea, and identification of resistant sources to wilt and stunt in kabuli chickpeas and their incorporation into ascochyta blight resistant lines is required. Objectives of the Chickpea Pathology section are as follows:

1. Expose known chickpea germplasm to ascochyta blight and identify sources of resistance by using conventional screening techniques.

2. Establish a highly standarised inoculation procedure to investigate the biochemical mechnaisum(s) for resistance. Nondestructive plant analysis, will be developed to readily identify effective resistance mechanisms which can then be used in hybridization program.

3. Combine efforts with chickpea breeder toward development of high yielding and ascochyta blight resistant chickpea cultivars.

4. Share the resistant material with national programs through cooperative research and nurseries.

5. Monitor the presence of races/pathogenic variability in A. rabiei.

6. Collect information on other chickpea diseases in WANA region and develop cooperative work with National Programs to identify multiple disease resistant sources in chickpea.

7. Study the epidemiology of ascochyta blight of chickpea.

3.2.1. Screening for Ascochyta blight resistance

Seven hundred-forty advanced chickpea lines (FLIP) were screened in the plastic house against six races of A. rabiei. The screening was done between November 86 and April 87 when the temperature was favorable for disease development.

Table 3.2.1. Chickpea lines found resistant to six races of *A. rabiei* in plastic house screening at Tel Hadya, Syria, 1986/87.

Race	Rating scale (1-9) 1	2	3
1	0	F82-177 F82-185 F82-186	113 lines
2	0	F81-58	119 lines
3	0	0	F83-124, F83-125, F83-126, F84-50, F84-168 F84-169, F84-170, F83-135, ILC 1919
4	0	F82-82 F84-129 F85-131	F81-85, F82-24, F82-177, F82-27, F82-113 F82-125, F82-130, F82-133, F82-134, F82-177 F82-190, F83-85, F83-87, F83-96, F83-97, F83-99, F84-90, F84-133, F85-70, F85-84, F85-123, F85-128, F85-133, F85-470, ILC 4935.
5	0	F84-128 F83-14	207 lines
6	0		F85-122

Results of this preliminary screening are given in Table 3.2.1. While there was no line which scored 1 point on 1-9 scale, there were several lines which showed resistance to individual races, except to race 6, to which only one line showed resistance. Promising lines will be evaluated in replicated trial next season.

Promising chickpea lines were screened in growth chambers against race 6 and isolate 'F' (isolated from disease nursery). Isolate 'F' was more aggressive than race 6. Four lines, F85-57, F85-84, F85-131 and ICC-4475, showed tolerant reaction against races 6 and 'F'. Thirty six lines from Pakistan were also screened. Eighteen lines showed tolerant reaction to race 6 and seven showed tolerant reaction to isolate 'F'.

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

3.2.2. Pathologic variability in Ascochyta rabiei

Pathogenic variability in A. rabiei is well recognized but not well understood. Loss of resistance in chickpea cultivars is attributed to exposure to a new race. At ICARDA six races of A. rabiei were identified. There is a need to monitor these pathotypes in farmer's fields so that the breeding for disease resistance becomes a success.

During 1986-87, several isolations of A. rabiei were attempted from resistant and susceptible lines of chickpea from disease nursery and several others locations at Tel Hadya farm. Over 100 isolates were arranged into 8 groups, on the basis of their morphological characters (Table 3.3.2.). These groups were then studied for their reactions on 15 chickpea differentials in controlled environments at 20^{o}C and 12 hrs. light. Seven day old seedlings were inoculated with spore suspension (20,000 spores/ml) and 100% humidity was maintained for 5 days. Observations on disease (1-9 scale) were recorded 10 and 15 days after inoculation. Experiments were repeated to confirm the results.

The isolates (A to H) could be classified into either 'mild' or 'aggresive' groups on the basis of their capacity to infect the plant. Isolates, A, B, C, and G were mild in their reactions across the chickpea lines whereas isolates D, E, F, and H were aggressive. Isolate 'F' was more frequently isolated from Tel Hadya farm this season. The difference in disease reactions was not clear enough to classify them into races. Isolates showed variable aggressiveness rather than virulence. Resistance status of the line was assessed by disease intensity which could be variable under changing environment within the same isolate genotype combinations. More studies are required to define the 'resistance', so that race identification is facilitated.

Dr. M.P. Haware.

Table 3.2.2. Ascochyta rabiei isolates from Tel Hadya farm (February-April 87) grouped on the basis of morphological characters.

Group (source)		Colony color	Pycnidia (u)	Pycnidiospores (u)	No. of Isolate
A	Host debris[1] (June 86), chickpea volunteers from Field 30 (AB Nursery 86)	Brown	154X178	3.8X 9.3	10
B	AB Nursery (87)-ILC 263 and other infected lines	Dark brown	204X251	2.9X10.7	17
C	AB Nursery (87)-ILC 3279 Field 9-ILC 482	Dark brown	164X190	3.2X 8.9	12
D	AB Nursery (87) from leaf spots, also from field 9 and 36	Dark brown	190X218	3.5X10.2	13
E	ILC 1929 from pots on the hill, host debris from AB Nursery (87)	Light brown	154X168	3.0X 9.4	9
F	AB Nursery (87)-ILC 72	Dark black	266X315	5.2X10.7	32
G	From single Perithecium	Black	151X177	3.1X 9.1	3
H	Host debris (June 86)	Dark black	167-191	4.3X10.2	4

1/ The isolate used in studies and stored as group representative.

3.2.3. Host - pathogen relationship: reaction of some chickpea genotypes to Ascochyta rabiei at different growth stages.

Twelve chickpea lines known for their reactions to ascochyta blight were studied for their reactions at various growth stages in a uniform environmental conditions. Chickpea plants aged from 20 to 120 days were inoculated at one time in a plastichouse. They were covered with plastic cages for 7 days for successful infection. The temperature in the plastichouse was 20-25^{o}C.

ILC 743 and 1929 were susceptible to race 3 at all growth stages. Others were resistant to disease in seedling stage. ILC-72, 194, 195, 196, 202, 482, 3279, F82-104, F83-22 and F 84-145 maintained their resistance in vegetative stage at low level. ILC-3279 showed reduced resistance in reproductive stage to race 3. Others were susceptible in reproductive stage. Disease reaction of these chickpea lines to a mixture of 4 races (1, 2, 3, 4,) showed similar trend.

The results indicate that the resistance to ascochyta blight which is assessed by disease intensity (on 1-9 point scale) can be variable with the growth stage of the chickpea crop in a favourable environment for the pathogen. Therefore it is important that the resistance status of the cultivars, identified promising in field screening, should be confirmed over several experiments.

Dr. M.P. Haware.

3.2.4. Epidemiology of Ascochyta blight of chickpea

Studies carried out during 1986-87 indicated that A. rabiei could survive on infected host debris in the field under unfavorable weather conditions of summer and part of winter (up to March). After March, it was difficult to identify and collect chickpea host tissues from the field.

In January '87, 60 plastic pots (30 cm) containing sterilized soil were sown with healthy and surface sterilized (2.5% sodium hypochlorite, 5 min.) chickpea seeds of blight susceptible ILC 1929 and grown in plastichouse. These pots were then distributed at 20 locations on Tel Hadya farm in early February. The plants were examined every two days in the early hours for ascochyta blight symptoms. The weather in March '87 was favorable for ascochyta blight. The presence of blight infecton on the chickpea leaflets during the month of March supported the hypothesis that the inoculum could be disseminated by wind.

Dr. M.P. Haware.

3.2.5. Occurrence of perfect state of A. rabiei

Mycosphaerella rabiei Kovachevski, the perfect state of Ascochyta rabiei (Pass.) Labrousse was first discovered on overwintered chickpea refuse in Bulgaria in 1936 and was subsequently reported from USSR and Greece. Recently it has been reported from Hungary and USA. At Tel Hadya, M. rabiei was discovered in 1987 on overwintered chickpea stem pieces in a field which had been sown with chickpea in December 1985 and was severely infected with ascochyta blight. The field was ploughed in Summer (August 86) and was sown with wheat in December. From November 86 to February 87 the temperatures were low ranging from -2 to + 15^{o}C. From November 86, chickpea host tissues lying on the surface of the soil were regularly collected and were examined critically under the microscope for the presence of perithecia.

In the begining of March 87, perithecia were observed on the overwintered chickpea debris. The perithecia were intermingled with empty pycnidial bodies imbedded in plant tissues. They looked prominent when the shredded bark was removed from the stem. Several observations under the microscope confirmed the formation of perithecia, restricted to infected plant tissues.

Perithecia were dark brown to black, globose with a perithecial beak, ostiolate and measured 82-156u x 125-255u in size. Asci were cylindrical, clavate, curved, pedicellate and 51-70u x 10-16u in size. Ascus contained eight, hyaline, ovoid ascospores which were divided into two unequal cells constricted at the septum and measured 13-20u x 5.5-7.5u. Isolations from single perithecium yielded the cultures of A. rabiei, which were pathogenic to chickpea.

Conditions in eastern Europe and Western Asia appear favorable for the production of perfect state of A. rabiei. Severely cold winter temperatures might be a prerequisite for the production of perithecia on infected tissues. This stage may be an important factor in the dissemination of inoculum in this region. Since in sexual reproduction a diploid phase is brought about by the fusion of two haploid nuclei, new combinations of alleles can arise in next generation.

Dr. M.P. Haware.

3.2.6. Biochemial resistance mechanisms in chickpea lines to *Ascochyta* blight

Artificial inoculations in the field and plastichouse are highly influenced by scarcely controllable environmental conditions resulting in contradictory results. To minimize the impact of this constraint a miniaturized and highly standardized inoculation procedure in growth chambers was established. In this system highly homogenous and vigorous seedlings are grown through control of light, temperature, watering and nutrition. The severity of infection is regulated by a precise duration of leaf wetness which represents the most important factor for disease development.

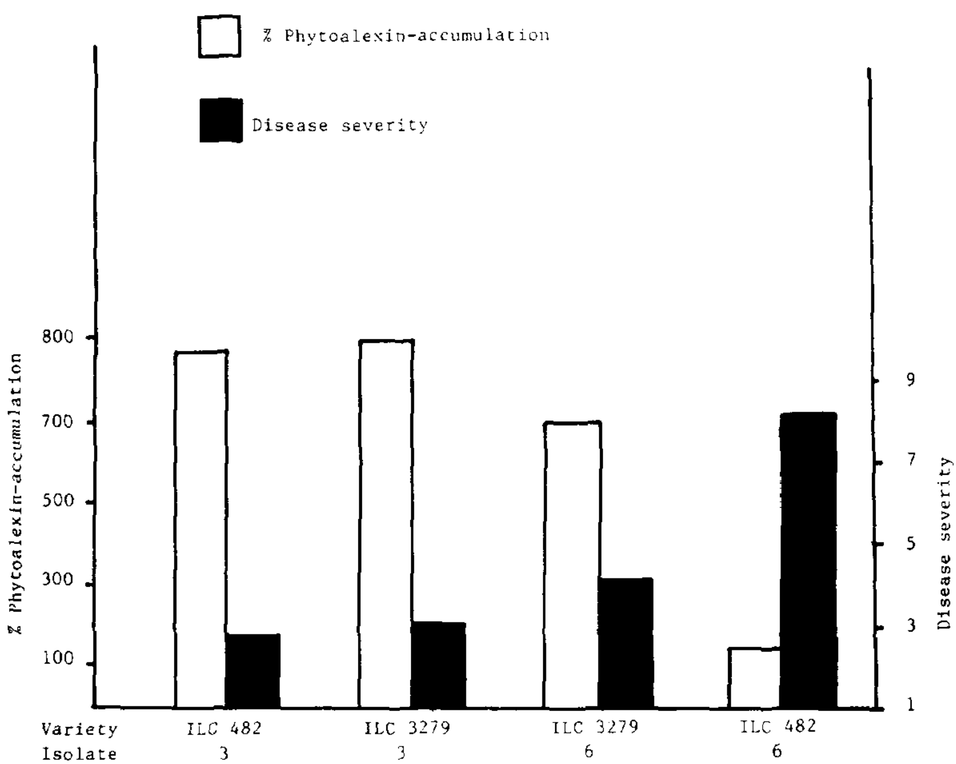


Fig. 3.2.1. Accumulation of the phytoalexin medicarpin and disease severity of chickpea cultivars ILC482 and ILC3279 after infection with spores of *Ascochyta rabiei* isolates 3 and 6. Phytoalexin accumulation determined after inoculation and expressed as percent increase over uninfected control plants. Disease severity was rated 9 days after inoculation by single plant observation.

Using this improved inoculation method it was possible to demonstrate the existence of dynamic, biochemical resistance mechanisms in chickpea lines. Phytoalexin accumulation was demonstrated as one resistance mechanism in chickpea to ascochyta blight. Last years experiments showed that the accumulation patterns could be correlated with degree of resistance of chickpea lines to different virulent isolates of Ascochyta rabiei (Fig. 3.2.1.). The chemical analysis was achieved with a HPLC-system (high-performance - liquid-chromatography). Induced lignification as a response of the host to build up a chemically fortified physical barrier was demonstrated employing a ligninthioglycolic acid procedure (LTGA).

Dr. F. Weigand.

3.3. Chickpea Entomology

The overall objective is to develop an integrated pest management system as illustrated in Fig. 3.3.1. In addition to the continous monitoring of the occurrence and status of insect pests and natural enemies, research will focus on control of chickpea leafminer and Heliothis spp. Screening for leafminer resistance will continue, and because some chickpea lines showing degrees of resistance have been identified studies on the mechanisms of resistance will be initiated. Knowledge of resistance mechanisms may allow miniturization of the resistance screening.

Investigation into biological control is promising, as a whole complex of leafminer parasites is established in the region. These need to be studied for their effectiveness. Chemical control recommendations are developed based upon the monitoring of insect populations and damage to ensure a precise timing of the application.

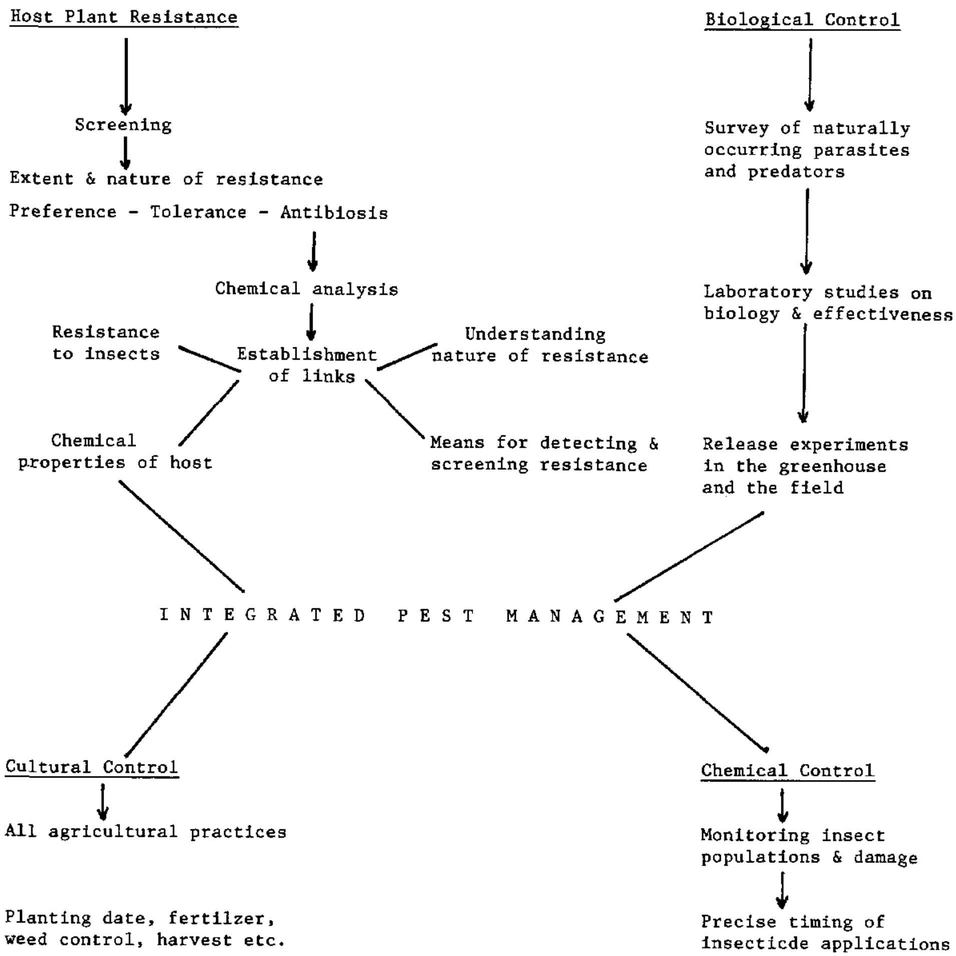
Although during the last year Heliothis spp. did not cause major damage in chickpeas in Syria, population development and density of this insect will be followed by pheromone traps in winter and spring planted chickpeas in on-farm trials in cooperation with FRMP.

Research on storage pests of chickpeas includes resistance screening to Callosubruchus chinensis, as well as testing different methods of protection and control so that safe, economic, practical control recommendations can be given. A survey for chickpea storage pests will also be conducted to identify the importance and distribution of actual and potential storage pests attacking chickpeas.

3.3.1. Control recommendations for leafminer

In winter and spring planted chickpea leafminer damage was measured and critical periods of control determined using 2 insecticides. In winter chickpea no yield increases resulted from any of the applications, although damage levels differed significantly (Table 3.3.1). One application at flowering protected the plants just as well as two or three applications as indicated by the low visual damage score and percent mining. The postflowering application apparently is too late to prevent damage. In spring chickpea the postflowering application was skipped, because of very hot weather during which the plants matured too quickly. In contrast to winter chickpea significant yield increases were found with insecticide application in spring chickpea only at flowering or at pre-flowering and flowering (Table 3.3.2). As in the winter chickpea, the resulting recommendation is to have one application at flowering. The comparison of the two insecticides Nuvacron, which has been used in previous years, and Thiodan indicated that there were no differences in effectiveness for leafminer control. Since Nuvacron has a high toxicity to honeybees, while Thiodan is known to be nontoxic, and because the insecticides are applied during flowering, Thiodan should be prefered.

Figure 3.3.1. Development of an integrated pest management system in food legumes.



Besides the studies on chemical control first observations on the possibilities of biological control were made. A high rate of parasitization was found in some samples. The two dominant species occurring in high densities were identified by Dr. T. Huddleston, British Museum London, as Diglyphus isaea (Walker) (Eulophidae) and Opius monilicornis Fischer (Braconidae). In trap catches several other species of Chalcidoids parasitic on larvae of leafminer were found: Hemiptarsenus zilahisebessi Erdos, Diaulinopsis arenarius Erdos, Chrysonotomyia formosa (Westwood) (Eulophidae) and Systasis sp. (Pteromalidae). Thus a whole complex of natural enemies of the leafminer is established in this region which will be studied further.

Drs. S. Weigand and O. Tahhan and Dr. T. Huddleston (U.K.).

Table 3.3.1. Effect of chemical control with two insecticides for leafminer at different crop growth stages on damage levels and seed yield of winter planted chickpea (ILC 482). Tel Hadya, 1986/87.

Treatment	% Mining May 19	VDS May 18	Seed yield (kg/ha)
1 spray at:			
Preflow+flow+postflow.(Nu)[1]	1	2	1757
Preflow+flow+postflow.(Th)[2]	2	3	1860
flow+postflow.(Nu)	2	3	1780
Flow+postflow.(Th)	2	3	1810
Preflow +postflow.(Nu)	7	4	1788
Preflow +postflow.(Th)	10	5	1864
Postflow.(Nu)	13	4	1773
Postflow.(Th)	16	5	1726
Preflow+flow. (Nu)	1	2	1760
Preflow+flow. (Th)	2	2	1858
Flow. (Nu)	2	2	1838
Flow. (Th)	2	3	1729
Preflow. (Nu)	5	4	1785
Preflow. (Th)	8	4	1775
Check	17	5	1703
L.S.D. (.05)	2.4	1.1	192.6

1. Nuvacran 40, 2 cc/lt
2. Thiodan 35, 1.5 cc/lt

Table 3.3.2. Effect of chemical control with 2 insecticides for leafminer at different crop growth stages on damage levels and seed yield of spring planted chickpea (ILC 482), Tel Hadya 1986/87.

Treatment	% Mining 22 May	VDS 25 May	Seed Yield (kg/ha)
1 Spray at:			
Preflow + flow (Nu)[1]	2	2	1350
Preflow + flow (Th)[2]	4	3	1303
Flow (Nu)	3	2	1325
Flow (Th)	5	3	1373
Preflow (Nu)	11	5	1213
Preflow (Th)	14	5	1240
Check	12	6	1229
L.S.D. (.05)	3.6	0.9	118.3

1. Nuvacron 40, 2 cc/lt
2. Thiodan 35, 1.5cc/lt.

3.3.2. Yield loss study

To further relate the degree of resistance to yield loss and response to chemical control, varieties previously found susceptible (ILC 2512) and resistant (ILC 2319) were grown without and with protection of 1, 2, or 3 insecticide applications. In the susceptible ILC 2512 yield increased with every application to 14.5% with 3 applications and only this was significantly different, whereas with insecticide application in the resistant line yield slightly decreased (Fig. 3.3.2). Although not as pronounced, these results confirmed those of last year in that the susceptible line was high yielding under protected conditions while the resistant line was superior when unprotected. In another experiment, however, in which two susceptible and resistant lines were planted under protected and unprotected conditions, the resistant lines showed higher yield increases with protection than the susceptible ones (Fig. 3.3.3). Leafminer damage was significantly lower in the resistant lines (VDS 3.2 and 3.0) than in susceptible ones having

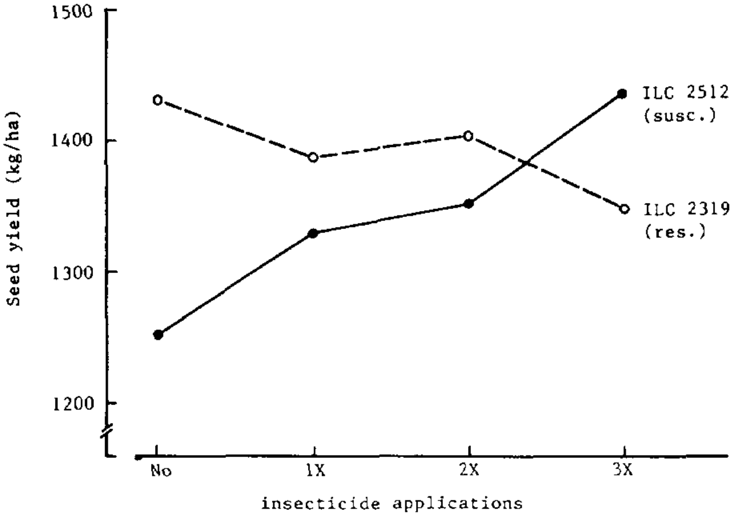


Figure 3.3.2. Seed yield of a susceptible and resistant chickpea line as affected by different numbers of insecticide applications (Nuvacron 40%). Tel Hadya, 1986/87.

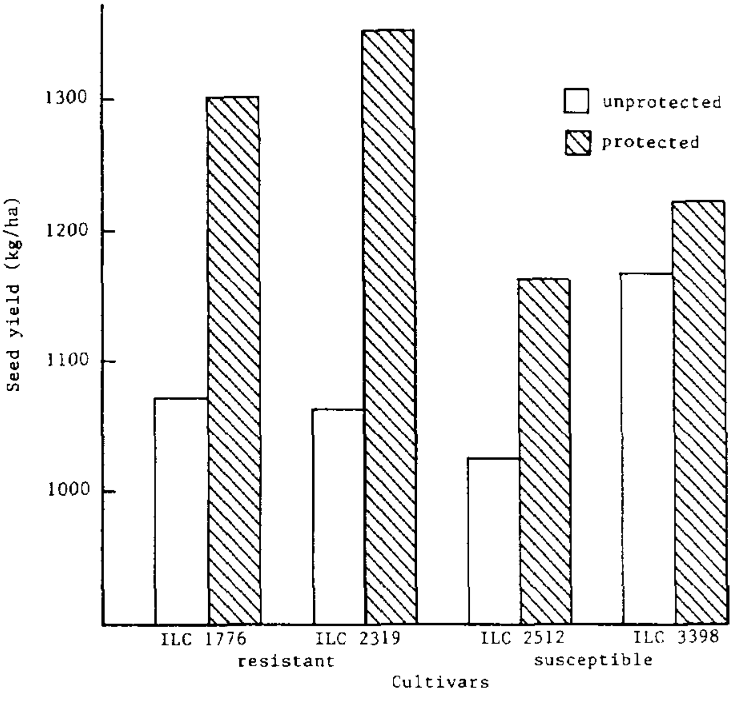


Figure 3.3.3. Seed yield of 2 resistant and susceptible chickpea lines grown with and without protection (2 sprays Nuvacron 40% 2cc/l). Tel Hadya, 1986/87.

VDS of 5.5 and 7.7. It should be noted that in this experiment the yields in general were low, which can probably can be attributed to herbicide damage occurring in some chickpea trials this year.

Dr. S. Weigand.

3.3.3. Sampling methods

Both in resistance screening and the development of control recommendations practical sampling methods for leafminer infestation are needed. The visual damage score proved to be useful and precise as it was highly correlated (r=0.8) with the percent leaflets mined. This last method was refined to be more practical, since the counting of the total number of leaflets is tedious. Instead of leaflets, leaves were counted and the percent of leaves with more than 50% mined leaflets calculated. This method gave the same result and was much faster. A new easy sampling method for leafminer populations using water trays placed between the rows proved also effective. In these water trays the full grown larvae dropping from the leaves to the soil for pupation are collected. These methods will be used and developed further next season.

Drs. S. Weigand and O. Tahhan.

3.3.4. Heliothis spp.

Heliothis spp. were mointored with pheromone traps at seven locations in northern Syria. This season, because of cold and rainy weather in March, Heliothis spp. populations occured late and at low densities and only caused 5-6% pod damage.

One parasitoid was reared from Heliothis larvae and identified as Bracon hebetor (Say) (Dr. T. Huddleston, British Museum London).

Dr. S. Weigand.

3.3.5. Storage pests

Resistance screening to Callosobruchus chinensis was continued with 1120 chickpea lines in 1987. In this lab screening eight adult insects are placed on 50 seeds of each line and the percentage infested seeds and number of progeny produced by one female is recorded. The seed infestation reached up to 100% and number of progeny per female up to 61. From these and previous screening results 32 lines with low infestation (maximum 30%) and low number of progeny per female (maximum 20) were rescreened with 4 replicates. Above results could not be confirmed, because high infestation (between 81-100% infested seeds) was found and the number of progeny per female ranged between 36 and 46. Thus none of these lines can be considered resistant and screening must be continued. At the same time different methods of protection and control (chemicals, vegetable oils) will be tested as an alternative to host-plant resistance.

Drs. O. Tahhan, S. Weigand and K.B. Singh.

3.4. Chickpea Physiology and Agronomy

Research in chickpea physiology centers on determination of appropriate plant ideotype attributes for winter sowing and assessment of genetic variability in response to moisture supply.

Chickpea agronomy research in collaboration with the Farm Resource Management Program focusses on development of production technology which can then be transferred to national programs for testing and adoption.

3.4.1. Response of some promising lines of chickpea to date of sowing

With the development of chickpea lines resistant to cold and ascochyta blight, it is now possible to sow in winter and obtain yield advantage of above 50% over spring sowing. The advantages in sowing chickpea in winter include completion of critical flowering and pod development before soil moisture becomes limiting and temperatures become high. However, in the rainfed areas of the Mediterranean region, when there is a delay in the onset of the rainy season or if there are heavy rains, it may not be possible to plant in December. Therefore, a trial was initiated in 1984/85 season with the following objectives:

1. Evaluate the effect of varying dates of sowing, from winter to spring on yield and to examine how far sowing can be delayed without major loss in productivity.
2. Study variability among genotypes for response to date of sowing.

In Tel Hadya, the mean seed yields for 3 December, 11 January, 3 February and 1 March sowings were, respectively, 1588, 1528, 1459 and 84S kg/ha (Figure 3.4.1). Although there was reduction in yield with each delay in sowing, only the last sowing date (March 1) resulted in significant reduction in yield. In Jinderiss seed yield for 3 December, 11 January, 3 February and 3 March sowings were, respectively, 1619, 922, 746 and 486 kg/ha, indicating steep reduction in seed yield as sowing was delayed. Seed yield in Terbol showed trends similar to Jinderiss; earliest sowing date (4 December) gave highest yield and thereafter each delay in sowing resulted in reduction in yield (Figure 3.4.1). In all the three locations, ILC 482 gave highest mean seed yield (Figure 3.4.1).

The major factor which appeared to have determined high seed yield was the attainment of high total biological yield (r=0.90, 0.95 and 0.85, respectively, for Tel Hadya, Jinderiss and Terbol). In Jinderiss high total biological yield was correlated with high plant density (r=0.68).

The result of 1986/87 season showed trends similar to 1985/86 (see 1986 Annual Report), with December sowing giving superior yields. As in the previous season, the study showed that poor crop estblishment is one of the factors that contributed to low yield in

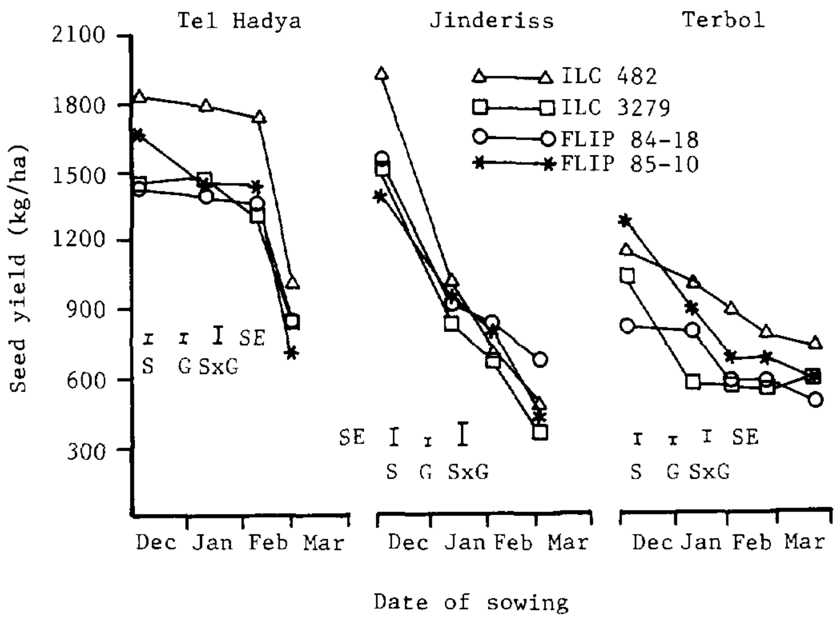


Figure 3.4.1. *Effect of sowing date on seed yield* (kg/ha) of four chickpea cultivars sown in Tel Hadya, Jinderiss and Terbol, 1986/87.

January-late February sowing and when good plant density is attained, less yield loss is incurred by delaying sowing.

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

3.4.2. Performance of spring sown chickpea genotypes under moisture supply gradient

The performance of genotypes under variable moisture supply was studied during 1986/87 season with the following objectives:

1. Investigate the potential of line-source sprinkler as a tool for applying irrigation gradient across the field;
2. Identify genotypic differences for response to moisture supply.

Table 3.4.1. Amount of total irrigation water received (in mm) above 359 mm of rainfall at different distances from the line-source sprinkler at Tel Hadya, 1986/87.

Genotype	Distance from line-source sprinkler						
	1 m	2 m	4 m	6 m	8 m	10 m	14 m
ILC 464	161	152	132	109	74	33	0
ILC 629	"	"	"	"	"	"	"
ILC 1919	"	"	"	"	"	"	"
ILC 1930	"	"	"	"	"	"	"
ILC 4958	"	"	"	"	"	"	"
ILC 10448	"	"	"	"	"	"	"
ILC 10991	"	"	"	"	"	"	"
ILC 82001	"	"	"	"	"	"	"
FLIP 82-73C	"	"	"	"	"	"	"
FLIP 83-2 C	"	"	"	"	"	"	"
FLIP 84-12C	213	201	"	"	"	"	"
FLIP 84-74C	161	152	"	"	"	"	"
FLIP 84-78C	213	201	"	"	"	"	"
FLIP 84-80C	213	"	179	"	"	"	"
FLIP 85-4 C	"	"	132	"	"	"	"
FLIP 85-49C	"	"	132	"	"	"	"

Total moisture supply given over and above the seasonal precipitation (359 mm) varied from 0 mm to 213 mm (Table 3.4.1). In this study, 16 genotypes, including 12 kabuli type and 4 desi type, were used. The desi types had shown promise for terminal drought tolerance at ICRISAT, India.

Time to flowering and maturity varied among genotypes. ICCL 82001 flowered earliest and FLIP 85-4C and FLIP 85-49C flowered latest. Irrigations at the higher level extended reproductive growth by delaying maturity.

Seed yield was influenced significantly by moisture supply. Under rainfed conditions, there were significant differences among genotypes with FLIP 83-2C and ILC 1930 giving the highest yields and ICC 10448, ICC 10991, FLIP 82-73C, FLIP 84-74C, FLIP 85-4C and FLIP 85-49C giving low yields (Table 3.4.2). The use of line-source sprinkler permitted the selection of genotypes for response to

Table 3.4.2. Seed yield (kg/ha) of spring sown chickpea genotypes as affected by moisture supply, Tel Hadya, 1986/87.

Genotype	Irrigation applied (mm) above 359 mm of rainfall							Mean
	161	152	132	109	74	33	0	
ILC 464	2196	2112	1654	1558	1364	1099	1078	1580
ILC 629	2216	1905	1914	1718	1488	1360	1141	1677
ILC 1919	1934	1549	1435	1246	1092	983	1022	1323
ILC 1930	2479	2121	1806	1671	1493	1305	1214	1727
ICC 4958	2416	2126	1761	1624	1453	1304	1141	1689
ICC 10448	1284	1295	898	935	706	594	636	907
ICC 10991	1350	1484	1202	1046	952	769	854	1094
ICCL 82001	1562	1444	1150	1220	1001	827	779	1140
FLIP 82-73C	1983	1962	1744	1607	1356	993	1046	1527
FLIP 83-2 C	2335	1908	1780	1565	1427	1269	1231	1645
FLIP 84-12C	2353	1933	1597	1412	1276	1012	1025	1515
FLIP 84-74C	2155	1906	1585	1482	1173	920	871	1442
FLIP 84-78C	2070	1495	1410	1106	1093	1012	927	1302
FLIP 84-80C	2186	1881	1749	1545	1425	1190	1143	1588
FLIP 85-4 C	2503	2095	1916	1472	1321	989	892	1598
FLIP 85-49C	2153	1999	1684	1439	1153	990	740	1451
Mean	2074	1826	1580	1415	1236	1038	984	

	LSD (5%)	SE	CV %
Genotype	148.8	51.5	16.3
Moisture supply	54.5	19.7	9.4
Interaction	251.1	89.3	

moisture supply. For example, FLIP 85-4C and ILC 1930 showed high response, ILC 629 moderate response and ILC 10991 low response to increasing moisture supply (Fig. 3.4.2).

In conclusion, the study indicates that the line source sprinkler permits screening for genotypic differences in chickpea for moisture requirement. Future study will concentrate on identifying characters responsible for these differences.

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

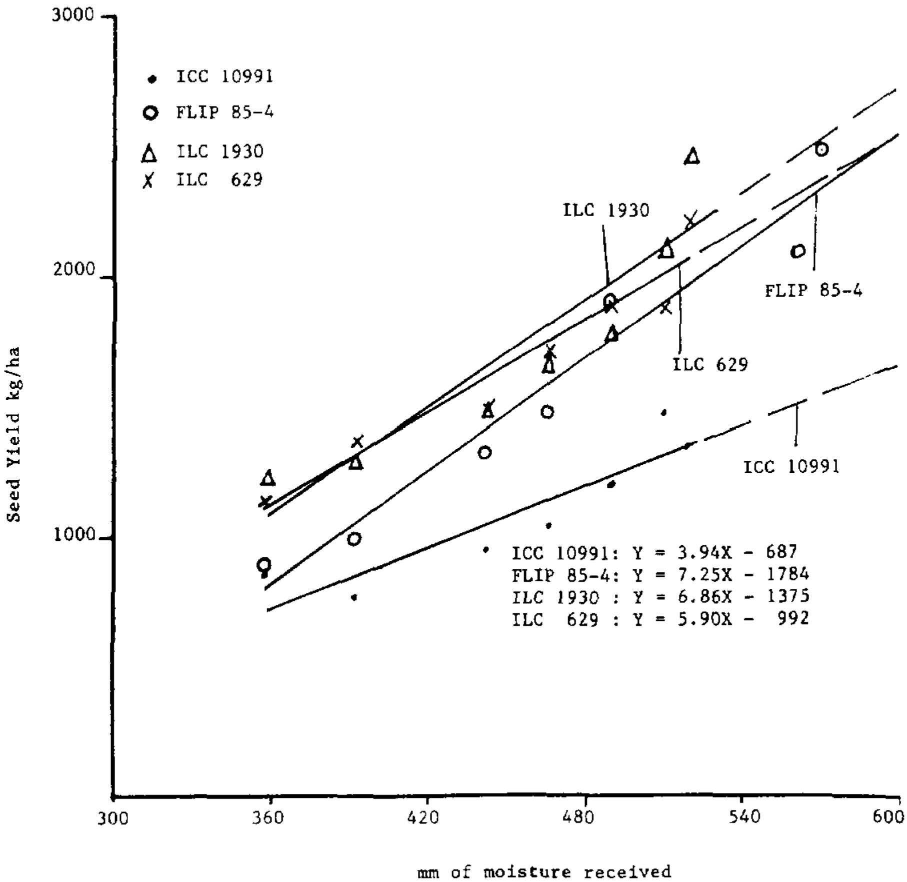


Figure 3.4.2. Relationship between moisture supply and seed yield of four chickpea genotypes with varying moisture response. Tel Hadya, 1986/87.

3.4.3. Response of winter and spring chickpeas to supplemental irrigation

An experiment was initiated during 1985/86 to investigate the effect of supplemental irrigation (one each at flowering and pod setting stages) on six chickpea genotypes (ILC 482, ILC 3279, FLIP 81-57W, FLIP 81-293C, FLIP 84-19C and FLIP 84-80C) sown in winter and spring. This was repeated during 1986/87. Sowing was carried out on 1 December 1986 and 16 February 1987.

Winter-sown genotypes flowered earlier than those sown in spring, with ILC 482 flowering first and ILC 3279 and FLIP 81-57W

Table 3.4.3. Date of start of flowering and number of days from start of flowering to physiological maturity.

Treatments			Winter sowing		Spring sowing	
			Date of start of flowering	Days from flowering to maturity	Date of start of flowering	Days from flowering to maturity
ILC	482	rainfed	8.4.87	46	20.4.87	42
ILC	482	irrigated	8.4.87	54	20.4.87	53
ILC	3279	rainfed	20.4.87	41	4.5.87	36
ILC	3279	irrigated	20.4.87	45	4.5.87	46
FLIP	81-57W	rainfed	20.4.87	36	2.5.87	36
FLIP	81-57W	irrigated	20.4.87	43	2.5.87	45
FLIP	81-293C	rainfed	18.4.87	37	3.5.87	35
FLIP	81-293C	irrigated	18.4.87	46	3.5.87	43
FLIP	84-19C	rainfed	14.4.87	42	4.5.87	31
FLIP	84-19C	irrigated	14.4.87	49	4.5.87	40
FLIP	84-80C	rainfed	14.4.87	45	3.5.87	37
FLIP	84-80C	irrigated	14.4.87	51	3.5.87	48

last. Supplemental irrigation extended the reproductive period of genotypes during both winter and spring sowing (Table 3.4.3). Total dry matter accumulation and partitioning are given in Fig. 3.4.3 for ILC 482 (high yielding and more responsive to irrigation) and FLIP 84-19C (low yielding and less responsive to irrigation). Supplemental irrigation increased total dry matter produced and partitioned to reproductive plant parts (Fig. 3.4.4). In rainfed treatments, dry matter produced/m^2 was higher in winter than spring sowing.

The treatment effects on seed yield are given in Table 3.4.4. In the winter planted crop under rainfed conditions, seed yield ranged from 1924 to 2175 kg/ha; small variation among genotypes. However, when the winter-sown trial was given supplemental irrigation, there were significant variations in seed yield among

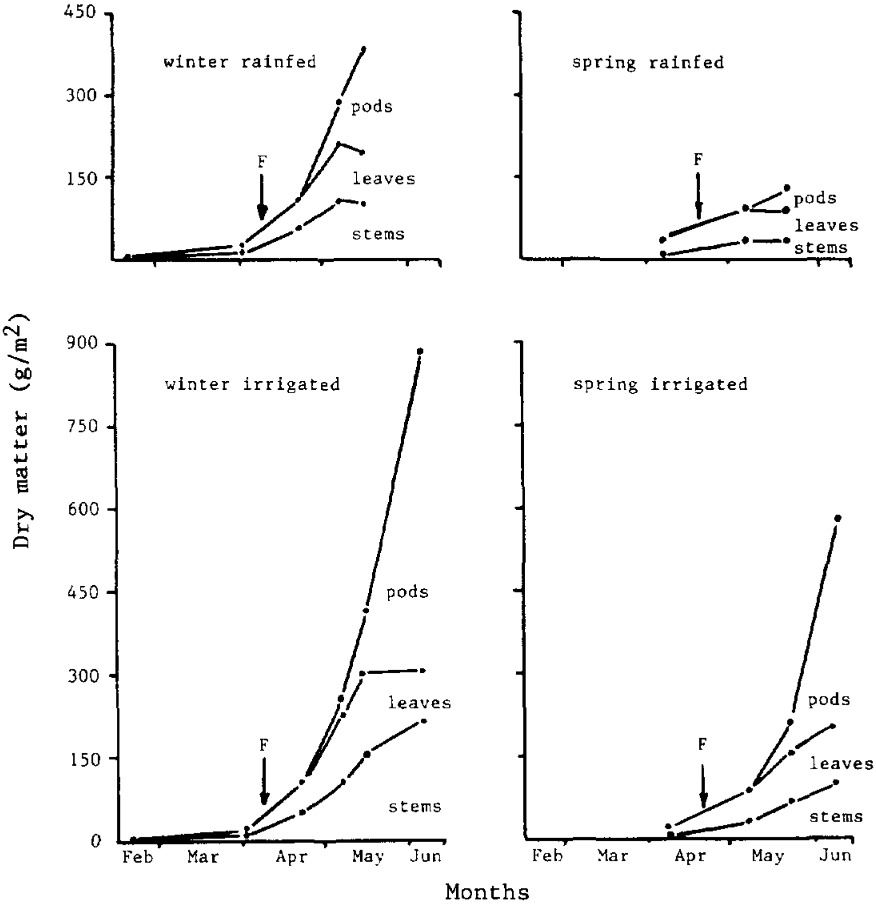


Figure 3.4.3. Dry matter build up and partitioning (g/m^2) in ILC 482 sown in winter and spring with and without supplemental irrigation. Tel Hadya, 1986/87. F = flowering.

gentoypes with ILC 482 giving the highest yield of 3774 kg/ha and ILC 3279 giving the lowest yield of 2663 kg/ha (Table 3.4.4). The percentage seed yield increases due to supplemental irrigation in winter sowing were 74, 23, 74, 69, 45 and 64 for ILC 482, ILC 3279, FLIP 81-57W, FLIP 81-293C, FLIP 84-19C and FLIP 84-80C, respectively. This indicates that ILC 482 and FLIP 81-57W are the best genotypes for winter sowing with supplemental irrigation. In spring sowing under rainfed condition, there were significant variations in seed yield among genotypes, with ILC 3279 giving the lowest and FLIP 81-57W giving the highest seed yield. Where

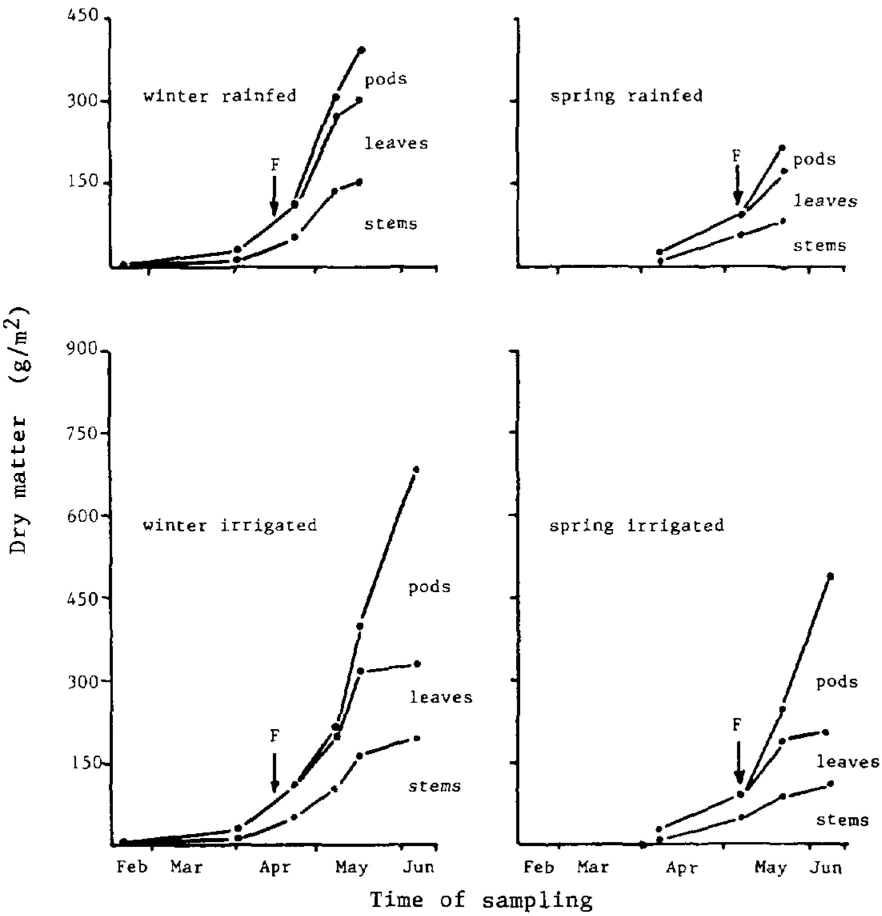


Figure 3.4.4. Dry matter build up and partitioning (g/m^2) in FLIP 84-19 sown in winter and spring with and without supplemental irrigation. F = flowering.

supplemental irrigation was given in spring sowing, FLIP 81-57W gave the highest yield followed by FLIP 81-293C representing 57% and 82% increases, respectively over rainfed treatments.

Soil moisture profile at maximum recharge and at maturity for rainfed treatment of ILC 482 and ILC 3279 are given in Fig. 3.4.5. Both varieties sown in winter extracted water to about similar depth along the soil profile, but in most of the profiles, ILC 3279 extracted a greater volume of water than ILC 482. The larger volume of water extracted by ILC 3279 is expected because of its longer

Table 3.4.4. Seed yield (kg/ha) of chickpea lines as influencd by date of sowing and moisture supply. Tel Hadya, 1986/87.

Genotype	Winter sowing			Spring sowing			Mean for Genotype
	Rainfed	Irrigated	Mean	Rainfed	Irrigated	Mean	
ILC 482	2175	3774	2975	1555	2398	1976	2475
ILC 3279	2159	2663	2411	1154	2281	1717	2064
FLIP 81-57W	2049	3556	2803	1726	2708	2217	2510
FLIP 81-293C	1980	3354	2667	1460	2660	2060	2363
FLIP 84-19C	1924	2792	2358	1551	2273	1912	2135
FLIP 84-80C	1968	3224	2596	1431	2542	1986	2291
Mean	2042	3227		1480	2477		
Mean for sowing		2635			1978		

	Sowing(S)	Genotype(G)	SxG
L.S.D. (.05)	42.5	160.9	227.6
C.V. (%)	2.8	9.9	

growth period. In spring sowing, early maturing ILC 482 extracted more water than late maturing ILC 3279 (Fig. 3.4.5), because the reproductive growth of the later was cut short by high temperatures.

The studies in 1985/86 and 1986/87 have shown that variability exists in chickpea lines in their response to supplemental irrigation with ILC 3279 showing minimum response and ILC 482 and FLIP 81-57W showing maximum response in winter sowing. The study will be continued during 1987/88 with new lines having greater variability in plant height and seed size.

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

3.4.4. Chemical weed control in chickpea

The experiment was conducted at Tel Hadya and on a farmers' field in Afrin (343 mm and 571 mm rainfall, respectively) in 1986/87.

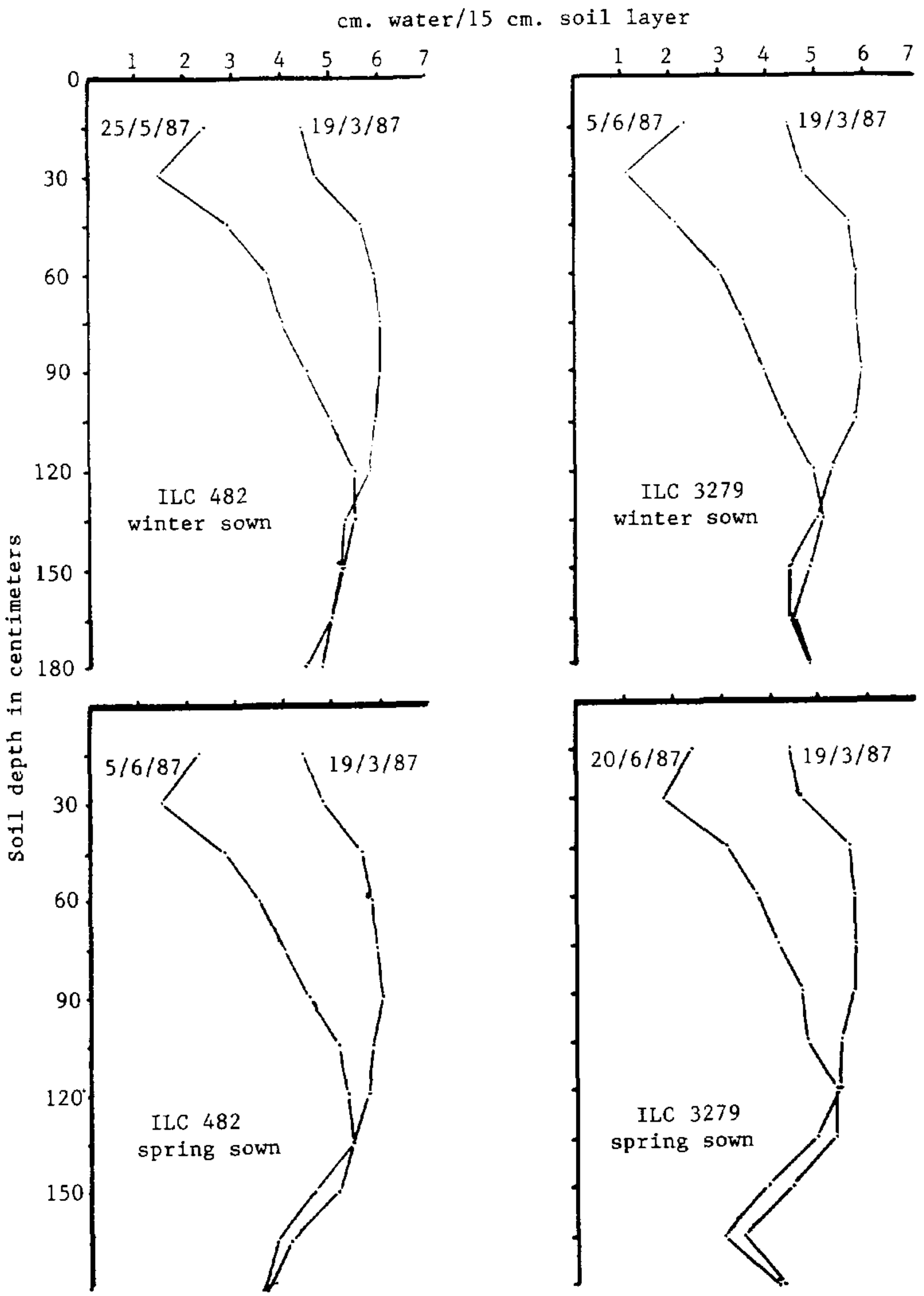


Figure 3.4.5. Soil moisture content in different soil layers (cm water per 15 cm soil layer) at highest recharge and at physiological maturity of rainfed ILC 482 and ILC 3279 sown in winter and spring. Tel Hadya, 1986/87.

The effect of weeds on crop yield loss and the role of some new selective herbicides on weed control and crop yield was studied using Ghab 1 chickpea cultivar.

The level of weed infestation was rather low in Tel Hadya and high in Afrin with the following dominant species; Sinapis arvensis, Phalaris brachystachys, Delphinium spp, Vaccaria pyramidata, Euphorbia helioscopia.

In both sites 98% of the weeds were broadleaves. Weeds caused 20% reduction in seed yield at Tel Hadya while the reduction was about 40% at Afrin due to the higher weed infestation level (Table 3.4.5).

At Tel Hadya post-emergence application of dinoseb acetate + fenoxyprop ethyl appeared to be the best herbicide treatment resulting in the highest seed and biological yields significantly ($P<0.05$) different from the weedy-check plots. Pre-emergence applications of dinoseb acetate + monolinuoron and terbutryne + pronamide were the next best (Table 3.4.5).

At Afrin, pre-emergence applications of prometryne and terbutryne + pronamide gave significant ($P<0.05$) increase in seed and biological yields over the weedy-check. Post-emergence applications of dinoseb acetate + fenoxyprop ethyl proved to be the next best treatment (Table 3.4.5). Imazaquin as pre-, imazaquin as at-emergence, imazaquin and fomesafen + fluazifob butyl as post-emergence applications appeared to be phytotoxic to the crop at both locations. Secbumetron as a pre-emergence application was highly phytotoxic at Tel Hadya (dry site) but not at Afrin (wet site). However, none of these herbicides showed satisfactory performance and will be deleted from the test next year.

Drs. M. Pala and S. Silim.

Table 3.4.5. Effect of weed control on seed and biological yield of chickpea and on weed dry weight, Tel Hadya and Afrin, 1986/87.

Treatment	Rate of appln. (kg ai/ha)	Time of appln.	Yield (kg/ha) and weed dry m. (kg/ha)					
			Tel Hadya			Afrin		
			seed	T.B.Y.	weed	seed	T.B.Y.	weed
Weedy check	-	-	956	2306	523	1308	3568	2616
Weed-free check	-	-	1211	2707	0	2164	5030	0
Cyanazine + pronamide	0.5 + 0.5	Pre-em	900	2186	362	1606	4356	1740
Terbutryne + pronamide	2.0 + 0.5	Pre-em	1022	2385	70	1976	5104	343
Dinoseb acetate + fluazifob butyl	1.0 + 0.5	Post-em	918	2118	311	1314	3616	924
Codal	1.5	Pre-em	1004	2725	130	2108	5286	958
Secbumetron	0.5	Pre-em	584	1341	44	1648	4396	1135
Carbetamide + terbutryne	1.5 + 2.0	Pre-em	464	1936	215	1700	4802	358
Carbetamide	1.5	Pre-em	918	2327	367	1756	4652	1769
Imazaquin	0.15	Pre-em	724	1797	213	1260	3552	1321
Imazaquin	0.15	At-em	511	1751	182	764	2672	397
Imazaquin	0.10	Post-em	425	1034	297	838	3444	949
Fomesafen + fluazifob butyl	0.2 + 0.5	Post-em	739	1626	125	954	2390	1142
Fenoxyprop ethyl + dinoseb acetate	0.15 + 1.0	Post-em	1206	2684	220	1908	4918	1167
Dinoseb + monolinuoron	1.0	Pre-em	1064	2409	434	1350	4000	2425
L.S.D. (0.05)			236	420	167	429	908	957
C.V. (%)			20	14	50	19	16	63

* $p<0.05$

3.5. Chickpea Microbiology

Chickpea is a traditional crop in the Mediterranean region, and populations of native soil rhizobia bacteria are generally adequate to produce root nodules, the site of nitrogen fixation. However, with introduction of improved cultivars replacing traditional plant types, and particularly with movement into new areas of production, it is possible that significant economical yield increases can be obtained through application of selected superior types of Rhizobium.

The main objective of microbiology research in FLIP is to determine whether legume productivity and hence soil fertility can be increased through manipulation of this plant bacteria partnership. Activities can be divided into: a) determination of the necessity for inoculation under various conditonis, accomplished through an international network evaluation of native rhizobial effectiveness; b) inoculant improvement, including selection of strains for effectiveness, competetiveness, and survival ability in soils; c) inoclulant technology improvement, to overcome constraints in production and application of incoculants; and d) economics of N fixation, through measurement of N fixed under diverse conditions and the fate of fixed N in cropping systems.

3.5.1. Rhizobial Studies

Rhizobium strain evaluation and collection

Evaluation of Rhizobium germplasm under controlled conditions is the first step toward providing appropriate inoculation technology where it is needed. Using a greenhouse nitrogen-free aseptic hydroponic gravel culture system, 60 strains newly acquired and in the collection were screened against three cultivars for their capacity to fix nitrogen over a range of plant germplasm. From this evaluation, seven strains were chosen as clearly superior, for utilization in further experiments. Additional genetic material collected within the ICARDA region and obtained from international culture collections will be included in this screening activity on a continuing basis.

To evaluate the effectiveness of superior strains under natural conditions, a system utilizing microbiologically and physically intact soil cores was devised. Lengths of PVC pipe used to collect intact sections of soil are utilized as experimental containers for growing plants in the plastichouse. Screening of four selected strains in several soils with different cultivars demonstrated the necessity for Rhizobium strain evaluations in soils; one strain chosen as superior in aseptic gravel culture failed completely in two of the soils tested. In soils where native populations of chickpea rhizobia were less than 1000 per gram of soil, response to inoculation with three of the strains was marked by significant increases in amounts of N fixed. Where native rhizobial populations were measured at more than 1000/gm soil, small or no increases in fixation were observed with inoculation in cores.

As a part of its activities supporting work in national programs, Microbiology section provided more than 40 different strains to scientists in 12 countries in the form of cultures or as inoculants. Collection of new strains from the region for evaluation is a cooperative ongoing effort assisted by FLIP and National Program scientists.

Necessity for inoculation

Necessity for inoculation is evaluated in soil core plastichouse experiments in treatments with and without nitrogen, so that plants reliant solely on N fixed in symbiosis with native rhizobia can be compared to plants supplied with ample nitrogen from the soil.

During 1986/87, 15 sites were surveyed from representative chickpea growing regions of Syria. Of these, 7 responded significantly to N and 8 did not. Those responding to N application generally contained less than 500 chickpea rhizobia per gram of soil, and will probably show a response to inoculation with effective competetive strains. Those not responding to N represent soils containing high populations of effective rhizobia.

Field trials designed to determine the necessity for inoculation were distributed as International Fertility Rhizobium Trials throughout the region; twenty trials were conducted in 9 countries. Trials were also conducted at sites in Syria to confirm results of the plastichouse methodology. These trials utilize essentially the same methodology as soil core experiments, where nitrogen fertilized plants are compared to symbiotic plants, at two levels of P/K fertility.

No data have yet been received by ICARDA from 1986/87 international trials but cooperators have communicated that in many areas a potential response to inoculation is indicated. Within Syria, trial results conformed closely with soil core experiment results. Where high populations of native rhizobia were present, as in Jindiress and Tel Hadya, a yield depressing effect or no response was obtained with addition of 100 kg N/ha. Where native rhizobia existed in lower numbers, such as in Breda, a significant response to N fertilization was obtained indicating deficiency in the symbiotic system.

Strain-cultivar field trials

During 1986/87 season, three chickpea cultivars (including newly released Syrian varieties Ghab 1 and Ghab 2) were evaluated at three locations with three selected rhizobia strains, to determine cultivar and site specific interactions with rhizobia strains. The strains chosen were 'best guess' in terms of their effectiveness and competetiveness, as greenhouse facilities were previously unavailable for strain selection work.

At Tel Hadya field, where chickpea had a history of cultivation and inoculation, soil contained about 2000 chickpea rhizobia per gram. In this trial, only cultivar ILC 195 demonstrated a significant 600 kg/ha grain yield response to inoculation

(Fig. 3.5.1). Other cultivars gave slightly increased grain yields of 150-400 kg/ha with strain no. 31, but differences were not significant. A significant response of cultivars Ghab 1 and Ghab 2 to nitrogen application indicates that full potential for fixation in these cultivars is not being exploited, and that further increases in yield may be obtained by inoculation with selected effective competetive strains of rhizobia.

In Breda, where no indigenous chickpea rhizobia were detected, the crop was severely limited by lack of moisture. However, response both to nitrogen and inoculation was significant as expected.

Jindiress is a traditional chickpea cultivation area, and native rhizobia are present at more than 10,000 per gram of soil. Here, grain yield in all cultivars was depressed (as compared to uninoculated treatment) by addition of 100 kg N (Fig. 3.5.2). Strain numbers 27 and 25 also decreased yield, indicating infection but less effective fixation than with the native strains. Only strain 31 induced grain yield equivalent to the native rhizobia.

Non-nodulation isoline

Measurement of N-fixation is best accomplished using ^{15}N dilution methods, which require a non-fixing reference crop that can be used to estimate the proportion of plant nitrogen obtained from fertilizer and soil. Up to the present, there has not been available a line of kabuli chickpea lacking the nodulation characteristic. Such a line would add considerable accuracy to measurements of N fixed in chickpea.

Evaluation of a suspected non-nodulating isoline, SEL 83TH 44410-1/3, was conducted in plastichouse experiments. Plants grown in a low N soil were inoculated with a multistrain inoculum and evaluated for N-fixation using in-situ acetylene reduction analysis and visual (plant color) symptoms. Plants displaying lack of acetylene reduction and nitrogen deficiency symptoms were

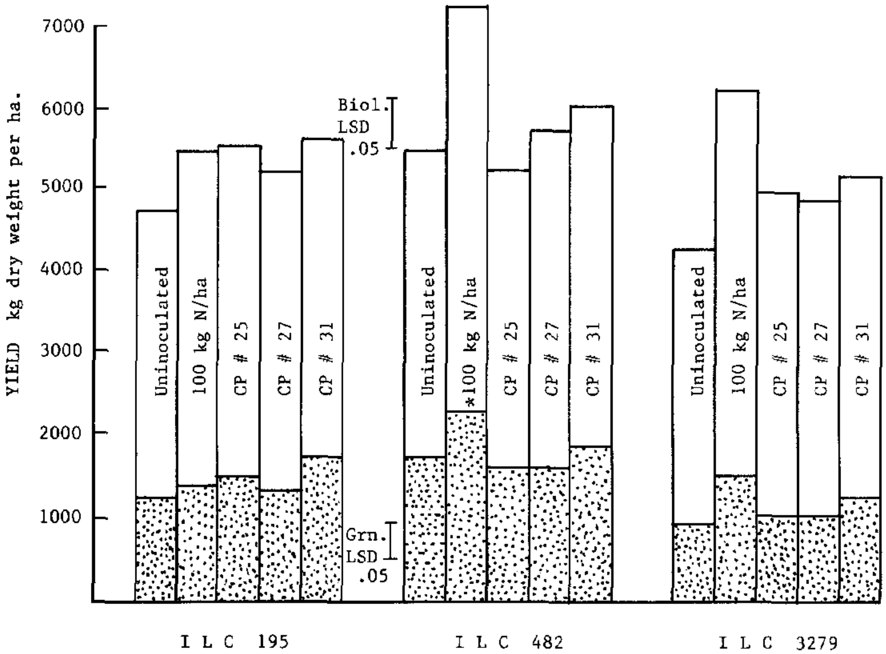


Figure 3.5.1. Field evaluation of three selected Rhizobium strains with released chickpea cultivars. Tel Hadya, 1986-87.

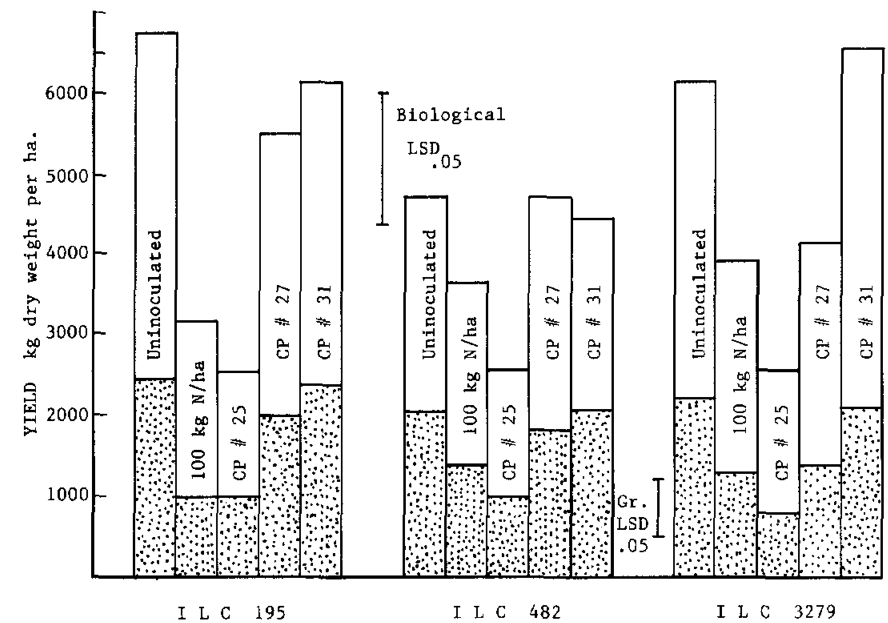


Figure 3.5.2. Field evaluation of three selected Rhizobium strains with released chickpea cultivars. Jinderiss, 1986/87.

subsequently supplied with nitrogen for seed production. Seed increases will be exposed to a wide range of rhizobial germplasm to assure that the effect is not specific in nature.

Dr. D. Beck.

3.5.2. VA-Mycorrhiza studies

To further verify the role of vesicular-arbuscular mycorrhiza (VAM) in mineral nutrition and growth of legume crops under semi-arid conditions, field studies were carried out. Across the several locations included in the studies, root systems of all test crops (chickpea, fababean, lentil, and barely) were heavily infected with different types of endomycorrhizal fungi. Often over 70% of the root system was mycorrhizal, and no sample was found showing root infections of less than 30%.

The influence of phosphate fertilization on VAM-plant-systems was tested at different sites, and rotational effects were investigated. The intensity of VAM-infection in most experiments was not severely affected by levels of phosphate fertilization. Even when root growth was enhanced by fertilizer, mycorrhizal root length increased correspondingly (Fig. 3.5.3), resulting in more or less uniform infection levels. Infection ratings tended to be somewhat lower in the upper soil layer, and also when high levels of phosphate were applied. This stability of high colonization indicates a flexibility of the symbiotic relationship with respect to plant nutritional conditions. When compared to other crops chickpea had the smallest root systems, but possessed the highest VAM-infection intensities.

The ubiquity of VA-mycorrhiza in agricultural fields in Northern Syria provides difficulties for the exact determination of the fungal contribution to plant growth as no non-mycorrhizal check can be evaluated.

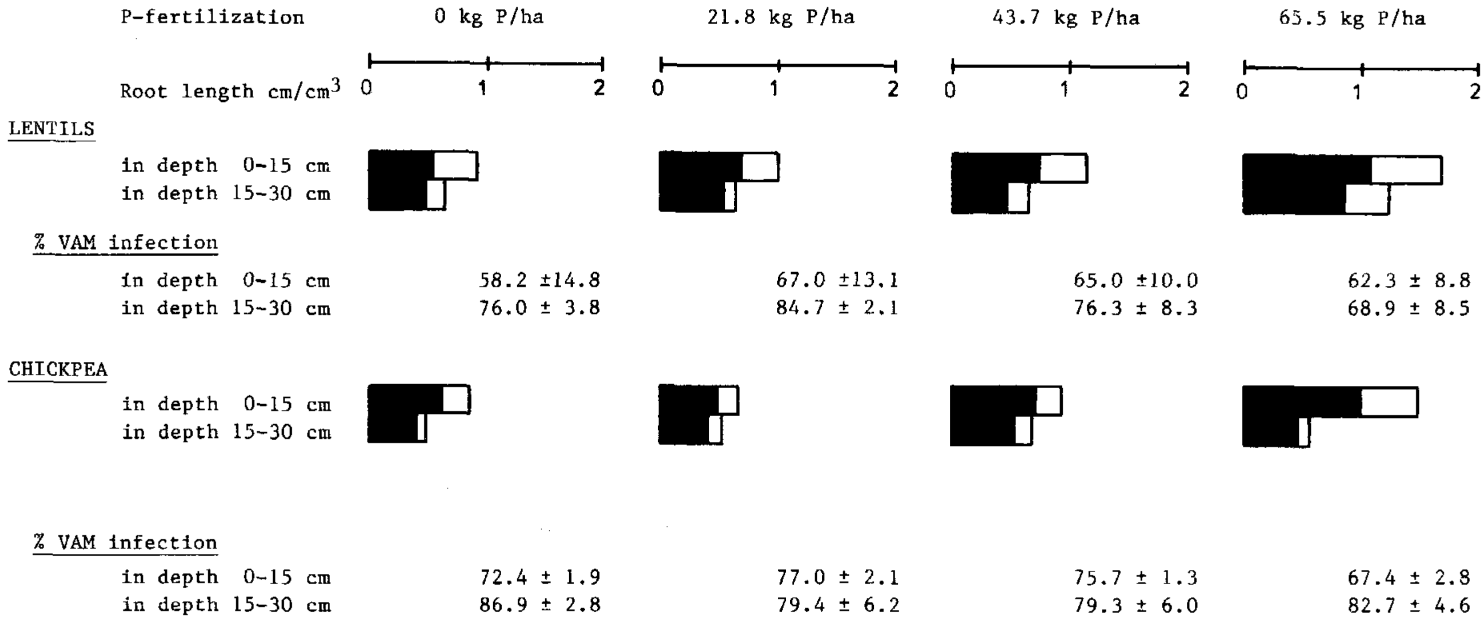


Figure 3.5.3. Total root length, length of VAM infected roots (indicated by shading), and percentage infection of roots with vesicular-arbuscular mycorrhiza (± standard deviation) of lentils (ILL 4401) and chickpea (ILC 3279) sampled from a field site at Jeb Kass, Syria, at 100% flowering.

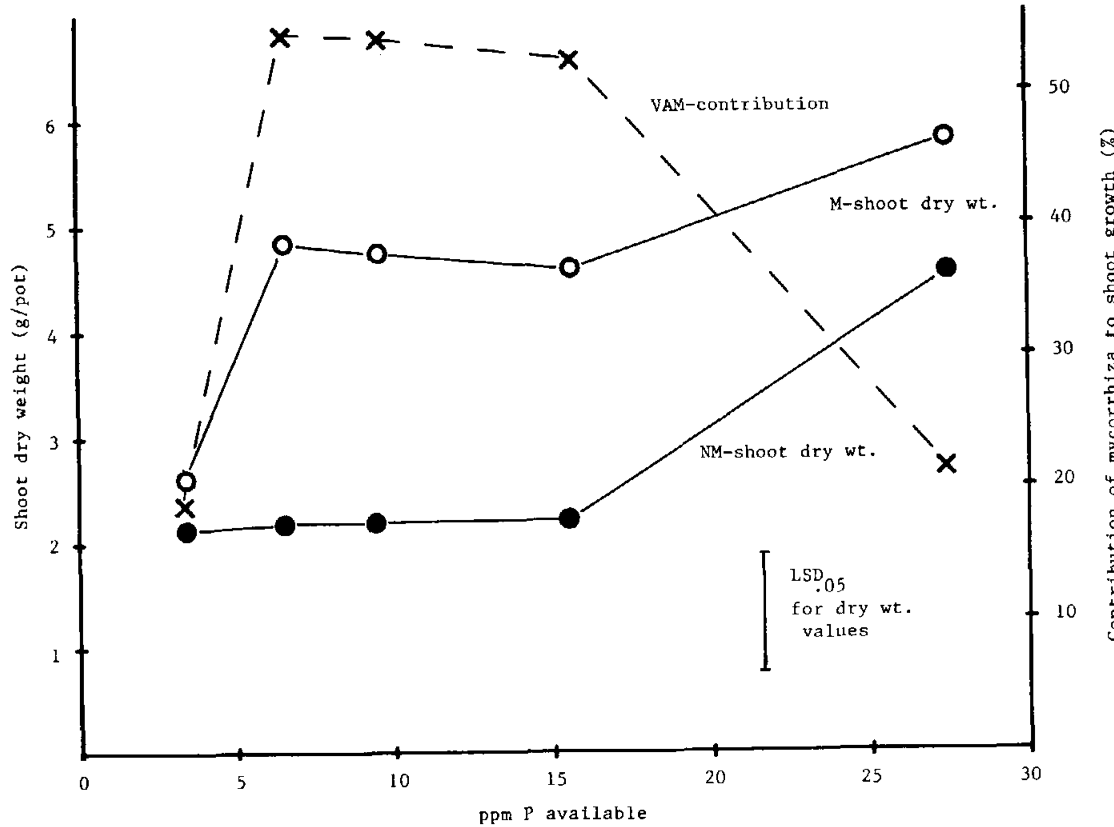


Figure 3.5.4. Shoot dry weight of chickpea plants (ILC 482) either inoculated with a mixture of indigenous VA-mycorrhiza fungi (M) or non-infected (NM), and percentage contribution of VA-mycorrhiza to plant growth as influenced by levels of available phosphate in the growing medium (soil* sand mixture), at 100% flowering.

In pot experiments with field soils artificially made free of mycorrhiza propagules (by steam sterilization), a large dependence of chickpea growth on mycorrhizal infection was found under low to medium phosphate supply conditions (Fig. 3.5.4). Plant growth was depressed by more than 50% in the absence of mycorrhiza. Low to medium levels of available P are typical for most agricultural fields in the area. The magnitude of these effects attained in pot studies is dependent on environmental factors such as temperature or water supply.

All results indicate a prominent role of VA-mycorrhiza in plant growth of legumes and cereals under semi-arid conditions, mediated through better phosphate nutrition, and possibly additional effects such as improved water relations and disease resistance. More physiological field studies are presently being undertaken to quantify the symbiotic relations, and to explore possibilities for manipulation of the symbiosis in order to increase legume yield stability.

Mr. E. George, Mr. E. Weber (University of Hohenheim) and Dr. *M.C. Saxena.*

3.6. Chickpea Quality

The focus of chickpea improvement is an increase in seed yield and its stability, while the quality research aims to maintain current nutritional standards of seed. This covers both the physical properties of seed and its end-use quality.

3.6.1. Influence of irrigation on quality parameters of kabuli chickpea

Kabuli chickpea is grown extensively under irrigation, particularly in the Nile Valley area, Indian subcontinent, and even in parts of Syria. The *influence of irrigation on the* quality *of the crop* was studied by growing replicated plots of 60 genotypes (58 plus two checks) under rainfed and irrigated conditions. Quality parameters studied included protein content, 100-seed weight (HSW) and cooking time (CT). The results are summarized in Table 3.6.1.

Table 3.6.1. Influence of irrigation on quality of kabuli chickpea.

	Irrigated		Rainfed	
	Mean	SD	Mean	SD
Protein (%)	19.51	1.3	20.71	1.2
HSW (g/100 seeds)	38.6	9.0	43.9	9.7
CT (minutes)	134	18.8	132	16.0

The results, for the 1985/86 season, showed a highly significant increase in yield, as a result of the irrigation. This was accompanied by a decrease in protein content and 11% reduction in HSW. Cooking time increased slightly despite the reduction in seed size. This suggested that irrigation had the effect of either increasing the density of agglomeration of the endosperm, or decreasing permeability of the seed coat, or both. Significant genotypeXtreatment interaction occurred for HSW and CT, and to a lesser extent protein content.

3.6.2. Protein content of as-eaten kabuli chickpea

Although the familiar chickpea is a hard, more-or-less round, beige-colored seed, it is never eaten in this form. Chickpea may be eaten green, soaked and either mashed or cooked and eaten whole, or roasted in some form and eaten dry, as a snack food. The protein contents of several forms of kabuli chickpea foods were determined, and reported on dry matter basis, and on the basis of the moisture content at which they are eaten. Moisture was determined by a two-stage oven method to avoid loss during sample preparation. Protein was determined "as is", with careful attention paid to sample weight. Results of protein and moisture determinations are summarized in Table 3.6.2. Results represent means of four replications.

Table 3.6.2. Composition of cooked and uncooked kabuli chickpea.

	Mean	SD[a]	High	Low
Protein content whole seed DB %	22.7	1.19	24.03	20.95
Protein content soaked seed as is %	9.29	0.51	9.74	8.69
Protein content soaked seed DB %	21.03	0.98	21.69	20.12
Protein content soaked cooked seed as is %	7.23	0.56	7.65	6.53
Protein content soaked cooked seed DB %	20.21	0.85	21.36	19.35
Protein content unsoaked cooked seed as is%	6.40	0.62	7.29	5.59
Protein content unsoaked cooked seed DB %	20.52	0.89	21.70	19.71
Protein content green seeds as is %	6.70	0.45	7.52	6.26
Protein content green seeds DB %	20.49	0.92	21.28	18.77
Protein content roasted cooked seed DB %	21.40	0.87	22.59	20.09
Moisture content soaked seed %	55.82	1.16	56.81	53.89
Moisture content soaked cooked seed %	64.29	2.63	66.79	61.81
Moisture content unsoaked cooked seed %	68.53	2.67	72.34	64.65
Moisture content green seeds %	67.25	2.46	70.12	63.32

a. SD = Standard deviation

Several points are apparent:

1. There was little relationship (r = 0.15) between the protein contents of mature and green chickpea (dry basis). This indicated that protein accumulation continued at different rates between the period from green seed stage and mature stage, for individual lines. Protein contents (dry basis) of mature chickpea seeds was strongly negatively related to moisture content. The protein content of soaked chickpea on dry basis (DB) was highly correlated to that of the "as is" seeds, whereas the DB: as is protein contents of soaked/cooked, or cooked seeds were not so strongly correlated. This suggested that water was inbibed to different degrees by individual lines during cooking.

2. Protein contents of chickpea appears to increase by an average of about 2.2% or about 11% of the protein between the green and mature stages. Relative increases in protein ranged from 2 to over 20% for individual genotypes.

3. Average moisture contents of soaked, soaked and cooked, and unsoaked and cooked chickpea were respectively 55.8, 64.3 at 68.5%, showing that moisture content increased during cooking,

presumably as the result of starch gelatinization, and that this effect was more pronounced if chickpeas were cooked without presoaking.

4. Chickpea lost on an average about 10% of their protein content as a result of cooking. Only part of this could be accounted for in the cooking liquor.

5. There was little relationship between the dry basis and "as is" protein contents of cooked chickpea regardless of whether they were soaked. This implied that changes in the pattern of imbibation of water and other factors involved in cooking may interact to reduce the significance of genotypic differences in protein content, with regard to the actual nutritional value of the cooked chickpea.

6. Roasted chickpea is apparently the most nutritious of the various preparations of chickpea studied, having over 20% protein as eaten.

4. DRY PEA IMPROVEMENT

Research on dry pea (Pisum sativum L.) was initiated at ICARDA in 1986/87 following a grant from the Ministry for Economic Cooperation, Federal Republic of Germany (BMZ). Since extensive work has been conducted in a number of institutions in the developed countries and the limited work carried out earlier in ICARDA had indicated that pea seems to be less specifically adapted to particular environments, no additional breeding effort is underway at ICARDA. The work on pea improvement is therefore concentrated in the following areas:

a. Evaluation of genetic material from institutes working on dry pea in developed and developing countries and identification of superior genotypes 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 national programs for testing and adaptation.

4.1. Genetic Evaluation and Preliminary Yield Trial

Two trials namely Genetic Evaluation Trial (GET) and Preliminary Yield Trial (PYT) were conducted during the season at Tel Hadya.

The genetic evaluation trial comprised 222 test entries originating from 23 countries and three checks. These 225 entries were grown in augmented block design with three repeated checks. The biological yield ranged from 707 kg/ha (for accession number 29) to 5243 kg/ha (for accession 27); for seed yield from 0 kg/ha (for accession numbers 185, 192, 194, 202, 204 and 206) to 2309 kg/ha (for accession number 34) and 0 percent (for accession numbers 192, 194, 198, 204, and 206) to 62 percent (for accession number 32) for harvest index.

The PYT comprised 97 test entries, selected from germplasm collection maintained at ICARDA on the basis of various

Table 4.1.1. Seed yield (kg/ha) of the 6 highest yielding entries in Pea Preliminary Yield Trial conducted at Tel Hadya during 1986/87.

Entry Name	Seed yield (kg/ha)
Accession no. 62	2060
Accession no. 32	1852
" " 226	1731
" " 7	1700
" " 25	1633
" " 2	1628
" " 8 (Check 1)	847
" " 9 (Check 2)	1605
" " 59 (Check 3)	1238
L.S.D. (0.05)	1147
C.V. (%)	23

morphological attributes, and three checks grown as a 10x10 triple lattice. Seed yield for the entries varied from 209 kg/ha to 2059 kg/ha. Six entries including accessions 62, 32, 226, 7, 25 and 2 exceeded the local check in seed yield (Table 4.1.1).

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

4.2. Comparative performance of pea varieties of diverse origin at various sowing dates

A study was initiated during the 1986/87 season to test the performance of selected cultivars of diverse origin when sown early and late. Twenty cultivars of pea were sown on 11 December 1986, 1 February 1987 and 3 March 1987, representing early and mid-winter and early spring sowings.

Table 4.2.1. Seed yield (kg/ha) of pea genotypes as influenced by date of sowing at Tel Hadya, Syria, 1986/87.

Genotype	11.12.86		1.2.87		3.3.87		Mean	
	Y	R	Y	R	Y	R	Y	R
Kelvedon Wonder	2095		1643	7	1062	5	1600	5
Despe	2159	10	1400		819		1460	
Maro	1839		1773	4	1027	6	1546	
Filby	2213	6	1711	5	825		1583	7
Upton	2243	5	1608	8	795		1550	10
Scout	2179	7	1516	9	861		1518	
Early Onward	1875		1499	10	892		1422	
Sprite	2173	9	1490		1111	3	1591	6
Syrian local	1918		1151		868		1312	
Petit Provincale	2614	1	2074	1	1397	1	2028	1
Baf	2304	3	1833	3	999	7	1712	3
Dark Skin Perfection	2045		1261		916		1408	
Alaska	2043		1668	6	1159	2	1623	4
Small Sieve Freezer	2267	4	1422		967	9	1552	9
Progretta	1864		1320		937	10	1374	
Frisson	2541	2	2027	2	982	8	1850	2
Onward	1801		1183		655		1213	
Kodiak	2176	8	1449		1091		1572	8
Facima	2080		1478		822		1460	
Mean	2121		1544		956			

	Date	Genotype	Interaction
L.S.D. (.05)	76.1	104.2	180.5
C.V. (%)	12.8	8.5	

Y = yield in kg/ha; R = rank

The early winter-sown trial produced the highest mean yield (2121 kg/ha) followed by mid-winter-sowing (1544 kg/ha) and spring-sown (956 kg/ha) (Table 4.2.1). Clearly, early winter sowing is the best date of sowing at Tel Hadya. One genotype 'Petit Provinciale' gave the highest yield in all the three sowings. Cultivars 'Frisson' and 'Baff' were respectively second and third highest yielding during early winter and mid winter sowing. These genotypes and other promising lines will be evaluated next season.

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

4.3. Weed Control and Soil Water Use in Dry Peas

As a part of a Ph.D. thesis for the University of Giessen (West Germany), experiments were initiated during 1986/87 season to study the effect of weed competition on soil water availability for dry peas under rainfed conditions. In all experiments a broad-leafy 'Syrian Local' pea variety was used.

Besides volunteer barley, major weeds occurring were Sinapis arvensis, Scorpiurus muricatus, Coronilla scorpioides and later species of Euphorbia and Carthamus. In addition, considerable infestation with Orobanche spp. was noted. A range of pre- and post-emergent herbicides was tested to achieve effective weed control and to determine crop tolerance. Results are given in Table 4.3.1. Yields of control (hand weeded twice 45 and 86 days after emergence) and weedy treatments, were 1483 kg/ha and 1312 kg/ha respectively. Among the herbicides tested, Propycamide and Methabenzthiazuron (0.5 and 2.5 kg a.i./ha) appeared promising with pre-emergent application producing 11% higher seed yield than the weedy check. A post emergent application consisting of a mixture of Fluazifop-butyl and Bentazone (0.5 and 1.0 kg a.i./ha) had good control of grasses and broad-leafed weeds and yielded 5% more than the weedy check.

In a second experiment to determine the optimal time and frequency of hand weeding, the results indicate that hand weeding carried out once after tendrils formed seemed to be sufficient (Table 4.3.2). However, a second weeding before the flower bud stage led to an additional increase in seed yield.

Emphasis was put on recording soil moisture content within the weed control experiments by using the neutron probe. Charge and discharge of the profile were monitored during the growth period. Differences in soil water availability were calculated at 15 cm intervals along the soil profile.

A high weed population in particular before flowering of pea resulted in higher water usage, hence lower seed yields.

Table 4.3.1. Effect of chemical weed control on yield of peas and on weed dry weight. Tel Hadya, 1986/87.

Herbicide	Rate kg a.i./ha	Appln. time	Pea seed yield (kg/ha)	Pea straw (kg/ha)	Weed dry weight (kg/ha)
Dinoseb-acetate + Monolinuron	2.0	pre-em	994*	2476*	936*
Propycamide + Methabenzthiazuron	0.5 + 2.5	pre-em	1459	3302	79
Cyanazine	0.75	pre-em	1264	3233	574
Fluazifop-butyl + Bentazone	0.5 + 1.0	post-em	1381	3341	169
Propycamid and Dinoseb-acetate + Bentazone	1.5 and 1.0 + 1.0	pre-em and post-em	1174	3061	171
Hand weeding			1483	3607	26
Weedy			1312	3464	458
L.S.D. (.05)			NS	NS	227
C.V. (%)			16.3	11.1	61.2

* Phytotoxicity, values excluded from analysis.

Table 4.3.2. Effect of hand weeding on yield of peas and on weed dry weight, Tel Hadya, 1986/87.

Treatment application (days after emergence)	Pea seed yield (kg/ha)	Pea straw (kg/ha)	Weed dry weight (kg/ha)
27	1160	3032	196
70	1307	3231	10
86	1342	3128	45
27 + 65	1288	3370	3
27 + 86	1315	3341	48
70 + 86	1360	3559	2
Weedy check	1065	3270	512
L.S.D. (.05)	NS	NS	72
C.V. (%)	24.2	12.8	41.6

Differences between the treatments were small due to the high variation of the soil itself. Results, therefore, have to be confirmed in the following season.

Mr. S. Schlingloff, Drs. M.C. Saxena and J. Alkaemper.

5. INTERNATIONAL TESTING PROGRAM

The international testing program on faba bean, lentil, and kabuli chickpea is the major vehicle for the dissemination of genetic materials and improved production practices to the national program scientists in and outside the ICARDA region. The genetic materials comprise early segregating populations and elite lines with wide and specific adaptation, special characteristics like large seed size, tall types suited to mechanical harvesting, early maturity, etc., resistance to biotic (disease and insect pests) and abiotic (cold) 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 NARS. Increasing diversification of nurseries to meet the changing needs of the NARS is evident from Fig. 5.1.1.

These tests identify genotypes with specific and wide adaptation and the performance data permits assessment of genotype X environment interaction and help in targetting breeding efforts for specific agroecological conditions. Through conduct of agronomic trials, research on optimum agronomic practices for different agro-ecological conditions is encouraged to sustain yields brought about by use of newer cultivars.

The results for 1985/86 season have been analyzed and the report is in preparation. The salient features of 1985/86 international nursery report are presented here. There has been continuous increase in return of data from cooperators in recent past and for the 1985/86 season the return was 57 percent. We hope that increased follow up will improve this statistic in future. A number of cooperators requested large quantities of seed of some elite lines identified by them from the international nurseries/trials supplied by ICARDA and we have attempted to meet their requests.

Table 5.1.1. Food Legume International Nurseries supplied for 1987/88 season.

Crop	International trial/Nursery	No. of sets
Faba Bean		
	Yield Trial, Large-Seed (FBIYT-L-88)	36
	Yield Trial, Small-Seed (FBIYT-S-88)	35
	* Yield Trial, Determinate (FBIYT-D-88)	32
	Screening Nursery, Large-Seed (FBISN-L-88)	45
	Screening Nursery, Small-Seed (FBISN-S-88)	27
	* Screening Nursery, Determinate (FBISN-D-88)	39
	F_4 Nursery ($FBIF_4N$-88)	18
	Ascochyta Blight Nursery (FBIABN-88)	20
	Chocolate Spot Nursery (FBIABN-88)	25
	Rust Nursery (FBIRN-88)	17
	Faba Bean Southern Latitute Regional Trial (FBSLRT-88)	9
	Fertility-Rhizobium Evaluation Trial (FBFRT-88)	8
	* Inoculation Response Trial (FBIRT-88)	9
	Weed Control Trial (FBWCT-88)	9
	Orobanche Chemical Control Trial (FBOCCT-88)	14
	Sub Total	343
Lentil		
	Yield Trial, Large-Seed (LIYT-L-88)	66
	Yield Trial, Small-Seed (LIYT-S-88)	39
	* Yield Trial, Early (LIYT-E-88)	25
	Screening Nursery, Large-Seed (LISN-L-88)	66
	Screening Nursery, Small-Seed (LISN-S-88)	40
	Screening Nursery, Early (LISN-S-88)	60
	Screening Nursery, Tall (LISN-T-88)	55
	F_3 Trial (LIF_3T-88)	19
	F_3 Trial, Early (LIF_3T-88)	19
	* Cold Tolerance Nursery (LICTN-88)	15
	* Ascochyta Blight Nursery (LIABN-88)	17
	Fertility-Rhizobium Evaluation Trial (LFRT-88)	17
	* Inoculation Response Trial (LIRT-88)	16
	Weed Control Trial (LWCT-88)	31
	Sub Total	485
Chickpea		
	Yield Trial Spring (CIYT-Sp-88)	48
	Yield Trial Winter, Mediterranean Region (CIYT-W-MR-88)	56
	Yield Trial Winter, Sub-Tropical Region (CIYT-W-STR-88)	29
	Yield Trial Large Seed (CIYT-L-88)	69
	Yield Trial Tall (CIYT-W-MR-T-88)	58
	Screening Nursery Winter (CISN-W-88)	56
	Screening Nursery Spring (CISN-Sp-88)	41
	F_4 Trial (CIF_4T-88)	39
	Ascochyta Blight Nursery: Kabuli (CIABN-A-88)	29
	Leaf-miner Nursery (CILN-88)	12
	Cold Tolerance Nursery (CICTN-88)	33
	Fertility-Rhizobium Evaluation Trial (CFRT-88)	22
	* Inoculation Response Trial (CIRT-88)	19
	Weed Control Trial (CWCT-88)	31
	Sub Total	568

* New nurseries added.

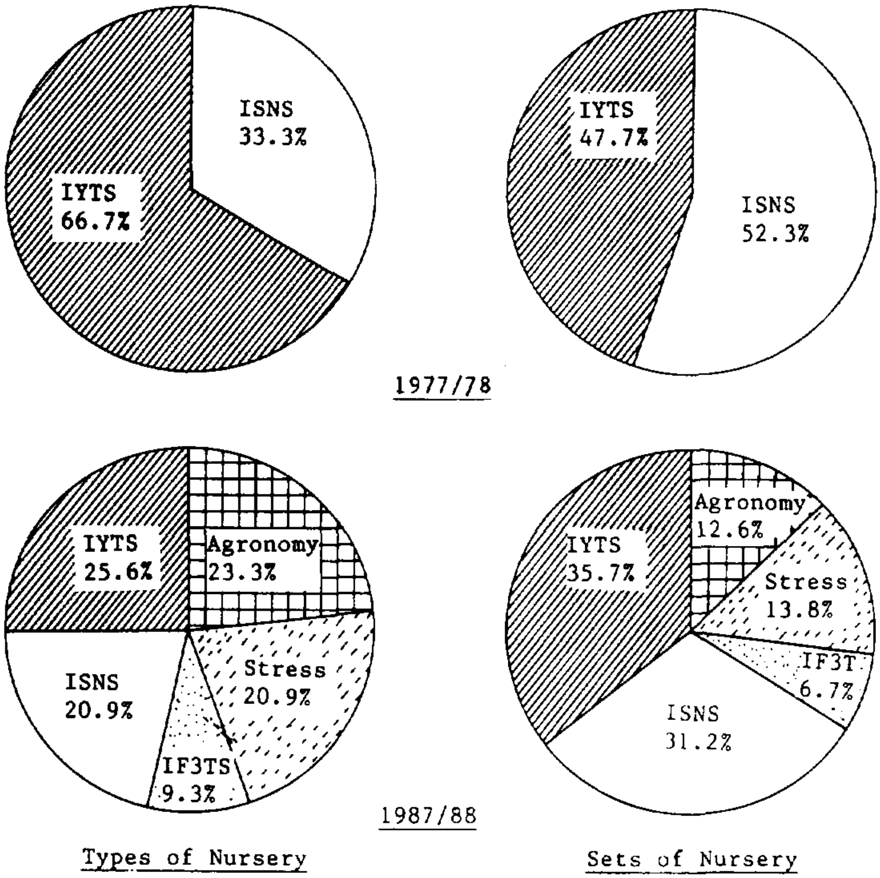


Fig. 5.1.1. Diversification and distribution of nurseries during 1977/78 and 1987/88

5.1. Faba Bean

Results of the Faba Bean International Yield Trial-Large seed (FBIYT-L) indicated that only at one location, Terbol in Lebanon, some of the lines outyielded the local check by a significant ($P \leq 0.05$) margin.

The Faba Bean International Yield Trial-Small Seed (FBIYT-S) revealed that at Larrisa in Greece, Elvas in Portugal, Terbol in Lebanon, and Dhamar in Yemen, yield of some entries exceeded the respective local checks by significant margins. Across locations, the five hightest yielding lines were: X 77SD70 (80S 46121), X 77TA60 (80S 43977), X 77SD 13(80S 45727), ILB 32 (74TA91), and X 75TA150 (80S 50088).

In the Faba Bean International Screening Nursery-Large Seed (FBISN-L) at many locations, a large number of test entries exceeded the respective local checks but margins were significant (at $P \leq 0.05$) only at Sakha in Egypt and Ankara in Turkey.

In the Faba Bean International Screening Nursery-Small Seed (FBISN-S) only at two locations namely Ankara in Turkey, and Beja in Tunisia were some of the test entries significantly superior to respective local checks.

The Faba Bean International F_3 Nursery ($FBIF_3N$) results reported from 16 locations revealed that in at least 13 locations some of the F_3 populations exceeded the local check in seed yield. But only at Toshevo in Bulgaria, Tarquinia in Italy, Ras Rajel in Tunisia and Ankara in Turkey were some of the populations statistically superior. The five best populations across locations were: S84065, S84063, S84053, S84064 and S84127. Some cooperators selected superior plants for further evaluation and use in their breeding program.

The Faba Bean International Ascochyta Blight Nursery (FBIABN) was reported from 5 locations. Across locations, only three entries namely 80 Lat. 14427, 80 Lat. 14435-1 and 80 Lat. 15035-2 were tolerant (getting a rating of 1-4).

The results of Faba Bean International Rust Nursery (FBIRN) were reported from three locations. All the lines at Debre Zeit rated 5 or more. Although various lines were reported as resistant at Deir-ez-Zor and Debre Zeit, but none of the lines was resistant across locations.

The results of Faba Bean International Chocolate Spot Nursery (FBICSN) reported from Cambridge-Shire in U.K. and Al-Ghab in Syria revealed that the ratings were 5 or more for all entries. However, the results from Giza in Egypt, Bega in Tunisia, and Holetta in Ethiopia revealed that seven entries namely 81 Lat. 24640-2A, -24694-2A, -24698-1, -24857-1, -24857-2, -24948-1B, and -24948-6 were resistant across locations.

The Faba Bean Weed Control Trial (FBWCT) results were analyzed for 5 locations for seed yield and the ANOVA were significant for only three locations. Only at two locations were treatments significantly superior to the respective weedy check. The common effective treatments included pre-emergence application of:

i) Bladex @ 1.0 kg a.i./ha

ii) Igran @ 2.0 kg a.i./ha + Kerb @ 0.5 kg a.i./ha.

iii) Bladex @ 0.5 kg a.i./ha + Kerb @ 0.5 kg a.i./ha.

The Faba Bean Orobanche Chemical Control Trial was only reported from Tarquinia in Italy. All the treatments exceeded the control by a significant margin in seed yield. The effective treatments were i) application of glyphosate @ 0.08 kg a.i./ha at 15 days after flowering (T_5) once, and ii) at the beginning of flowering twice at 15 days interval.

The Faba Bean Fertility Inoculation Trial (FBFIT) reported from Dhamar in Yemen revealed that inoculation along with application of 50 kg P_2O_5 per hectare increased seed yield by a significant margin over the uninoculated, unfertilized control.

The Faba Bean International Plant Population Trial (FBPPT) was reported from Dhamar in Yemen. Although there were no differences among row spacings, plant populations and interaction between row spacing and plant population were significant. The best plant population was 45 plants per square meter and the best combination was with 40cm row spacing.

5.2. Lentil

Twenty locations were analysed for seed yield for Lentil International Yield Trial-Large Seed (LIYT-L). At ten locations, namely Sakha in Egypt, Breda in Syria, Karaj in Iran, Diyarbakir in Turkey, Orunda in Cyprus, Elvas in Portugal, Terbol in Lebanon, Madrid in Spain, Dhamar in Yemen and Kufra in Libya, some of the entries exceeded the local check in seed yield by a significant margin. The five heaviest yielding lines across locations were ILL 5750, ILL 5582, ILL 4606, ILL 5668, and ILL 5748.

The results of Lentil International Yield Trial-Small Seed (LIYT-S) revealed that out of 18 locations analysed, at 13 locations (Guelma in Algeria, Shandweel in Egypt, Beqa'a and Terbol in Lebanon, Kufra in Libya, Chakwal in Pakistan, Elvas in Portugal, Madrid in Spain, Breda and Tel Hadya in Syria, Menzel Temime in Tunisia, Diyarbakir in Turkey, and El-Kef in Tunisia) some of the test entries exceeded the respective local checks in seed yield by a significant margin. The five heaviest yielders in this trial were FLIP 84-58L, FLIP 84-29L, 78S 26004, FLIP 84-27L and FLIP 84-44L.

The results for seed yield for LISN-L, LISN-S, LISNT-T and LISN-E for 25, 19, 23, and 17 locations, respectively, revealed that at 11, 10, 15 and 5 locations some of the test entries exceeded the respective checks by a significant margin. The five heaviest yielders across the locations for these nurseries are given in Table 5.2.1. Among the best yielding lines in LISN-E, FLIP 86-21L, FLIP 84-112L, and FLIP 86-41L were among the earliest flowering lines (range 103-105 days to flower).

Table 5.2.1. The best five lines across locations in lentil screening nurseries 1985/86.

	Name of Nursery			
	LISN-L	LISN-S	LISN-T	LISN-E
1	FLIP 84-115L	FLIP 86- 29L	78S 26052	ILL 5249
2	FLIP 84- 15L	FLIP 84- 22L	FLIP 85- 38L	FLIP 84- 12L
3	FLIP 86- 2L	FLIP 84- 16L	FLIP 86- 35L	FLIP 86- 21L
4	FLIP 86- 22L	FLIP 86- 31L	FLIP 85- 35L	FLIP 86- 41L
5	FLIP 86- 13L	FLIP 86- 32L	FLIP 84- 44L	FLIP 86- 57L

The results from Lentil International F_3 Trial (LIF_3T) and F_3 Trial-Early (LIF_3T-E) reported from 9 and 6 locations 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. The best yielding crosses in LIF_3T included X84S101, -126, -182, -178 and, -76; and in LIF_3T-E included, X84S 328, -48, -325, -326, and -324. All these populations in LIF_3T-E were comparatively earlier in flowering.

Out of four locations reporting Lentil Weed Control Trial (LWCT) the ANOVA were significant for only two locations. Gesagard @ 1.5 kg a.i./ha appeared to be the effective herbicide at both locations namely Bahteem in Egypt and Diyarbakir in Turkey. At Diyarbakir, Tribunil @ 2.0 kg a.i./ha was also almost equally effective.

The Lentil Plant Population Trial (LPPT) was reported only from Diyarbakir in Turkey. The ANOVA revealed that there were significant differences in row spacings, and the 20 cm row spacing gave significantly higher seed yield than 30, 40 and 50 cm row spacings. The differences between different plant populations (100, 200, 300 and 400 plants/m sq.) were, however, not significant.

The Lentil International Fertility-cum-Inoculation Trial (LFIT) was reported from 3 locations. The ANOVA was significant at Serai Hawrang (Pakistan) and Diyarbakir (Turkey). The treatment T_5 (Inoculation + P_2O_5 at 50 kg/ha) gave significantly higher yield than the uninoculated and unfertilized control at both the locations. At Serai Hawrang, further increase in seed yield was observed when 1 kg a.i. of Carbofuran per hectare was applied in addition to T_5.

5.3. Chickpea

The seed yield data for Chickpea International Yield Trial-Spring (CIYT-S) revealed that a large number of entries exceeded the respective local checks by a significant margin at Khroub in Algeria, Al-Ghab and Tel Hadya in Syria and El-Kef and Oued Meliz in Tunisia. The five best entries across the locations were ILC 482, ILC 1929, FLIP 82-236C, FLIP 83-3C and FLIP 83-53C with seed yields ranging from 1267 kg/ha to 1458 kg/ha.

The seed yield data for Chickpea International Yield Trial-winter-Mediterranean Region (CIYT-W-MR) revealed that at a large number of locations namely, Khroub in Algeria, Toshevo in Bulgaria, Montpelliar in France, Larissa in Greece, Islamabad in Pakistan, Badajoz and Sevilla in Spain, Heimo and Tel Hadya in Syria and Beja, Mateur, Menzel, Temime and Qued Meliz in Tunisia, some of the entries exceeded the respective local check by a significant margin. The five best entries across locations included, FLIP 83-47C, FLIP 83-48C, ILC 482, FLIP 82-128C, and FLIP 83-71C. The seed yields for these entries ranged from 2200 to 2288 kq/ha. For the first time the entries in this trial had a medium to large seed size ranging from 29 to 39 g per 100-seed.

In the Chickpea International Yield Trial-Sub-Tropical Region (CIYT-STR), a few entries exceeded the respective local check by a significant margin at various locations. These locations included Sidi Bel Abbes in Algeria, Islamabad in Pakistan, and Beja, El-Kef, Oued Meliz and Ras Rajel in Tunisia. The five highest yielders across locations were FLIP 83-22C, ILC 482, FLIP 83-72C, FLIP 82-150C and FLIP 82-239C.

The Chickpea International Yield Trial-Large-Seed (CIYT-L) revealed that at Khroub in Algeria, Mallawi in Egypt, Karaj in Iran, Arbil in Iraq, Metaponto in Italy, Islamabad in Pakistan, Tel Hadya in Syria, and Beja in Tunisia, some of the test entries exceeded the respective local check by a significant margin. The five heaviest yielders across the location were ILC 132, ILC 116, ILC 451, ILC 482, and ILC 76 with a range of 1440 - 1530 kg/ha.

The adjusted seed yields in Chickpea International Screening Nursery Winter (CISN-W) revealed that in Setif in Algeria, Toshevo in Bulgaria, Shandweel in Egypt, Terbol in Lebanon, Pulawy in Poland, Madrid in Spain, Deir-ez-Zor, Jinderiss and Tel Hadya in Syria, Beja 1, Beja 2 and El-Kef in Tunisia; and Diyarbakir in Turkey, some of the entries exceeded the respective local check by a significant margin. The five heaviest yielders across the locations included FLIP 84-178C, FLIP 84-122C, FLIP 84-60C, FLIP 84-182C, and FLIP 84-159C.

The Chickpea International Screening Nursery Spring (CISN-S) was reported fom 23 locations. Out of 17 locations using local checks, only at 5 locations did some of the test entries exceed the local check by a significant margin. The five best yielding lines across locations included FLIP 84-92C, FLIP 84-145C, FLIP 84-163C, FLIP 84-143C and FLIP 84-62C.

The Chickpea International F_4 Trial reported from 12 locations showed that at eight locations the F_4 populations were at least among the 9 highest yielders. The five highest yielding populations across locations were X83TH7, X83TH2, X83TH58, X83TH64 and X83TH136.

The results of Chickpea International Ascochyta Blight Nursery (CIABN) were reported from 12 locations. At three locations there was no Ascochyta infestation. At Faisalabad in Pakistan none of the entries was rated less than 6. Similarly at Marrow in Jordan all the entries rated between 5 and 9, and at Tarquina in Italy between 5-9 with the exception of ILC 72 which took rating of 4. Although the ratings for different entries varied greatly at other locations only two entries namely ILC 202 and FLIP 83-46C were rated resistant (with 1 to 4 rating) across locations. Another desi line which was tested at Islamabad in Pakistan and Cordoba in Spain was also rated as resistant.

The Chickpea International Leaf Miner Nursery, reported from 6 locations, revealed that leaf miner infestation was high at Tel Hadya and Idleb (Syria), Montpellier (France), and Eskisheshir (Turkey). A large number of entries were rated between 1-5 across locations and were tolerant.

The Chickpea Weed Control Trial (CWCT) reported from seven locations revealed that weeds in chickpea cause a heavy yield loss at all locations. The pre-emergence spray treatments namely i) Tribunil @3.0 kg a.i./ha ii) Igran @ 3.0 kg a.i./ha, and iii) Maloran @ 3.0 kg a.i./ha + Kerb @ 0.5 kg a.i./ha and iv) Tribunil @ 3.0 kg a.i./ha + Maloran @ 1.5 kg a.i./ha + Kerb @ 0.5 kg a.i./ha were effective across locations.

From the Food Legume International Nursery materials, new varieties of chickpea, namely, Kyrenia (ILC 464) in Cyprus, ILC 195 and ILC 482 in Turkey, and ILC 3279 in Tunisia; two new varieties of lentil namely Idleb 1 (78S 26002) in Syria and Firat 87 (75Kf 36062) in Turkey; and one variety of faba bean namely Barkat (ILC 1269) in Iran, were released for general cultivation during 1986/87.

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6. OROBANCHE STUDIES

Broomrape or Orobanche sp. are holoparasitic plants belonging to the Orobanche family. The main distribution is the Mediterranean and West Asian region. Production of food legumes is seriously affected primarily by two Orobanche species, Orobanche crenata and Orobanche aegyptiaca. O. crenata shows preferance to parasitize faba bean, pea and chickpea but also occurs on lentil. O. aegyptiaca is mostly seen on lentil.

Attempts to control this parasitic weed has not been very effective in the past. A new approach was begun with the aim to develop an integrated control of the parasite. Several control measures have been tested separately for the last two seasons, including soil solarization, different sowing dates, old and new herbicides and single plant selection of resistant cultivars. Studies on the effect of Orobanche seed density were also initiated. Research efforts will move toward integrated of these measures to study the combination effect on Orobanche control.

Orobanche studies are conducted in close collaboration with the University of Hohenheim with special funding from GTZ, Federal Republic of Germany.

6.1. Soil Solarization 1986/87

To confirm last year's results and to get more detailed information on solarization a new field trial was conducted in 1986/87, following the procedure of last year's trial. Four solarization periods were tested (0, 30, 40 and 40 days just before planting).

The temperature measured during the experiment was about 7°C lower compared to the previous year. The reduction in number and dry weight Orobanche through solar heating took place but was not as clear as last year because of the lower temperature attained during the mulching period and the low Orobanche infestation level in the soil (Figs. 6.1.1, 6.1.2).

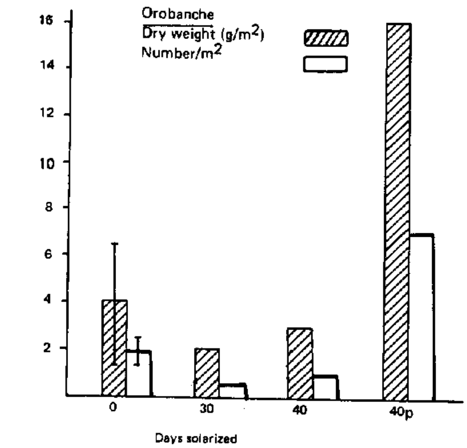

Fig. 6.1.1. Effect of solarization on *Orobanche* infestation in faba bean Tel Hadya 1986/87. Subscript p refers to treatment receiving solarization just prior to planting, when temperatures reached are not as high.

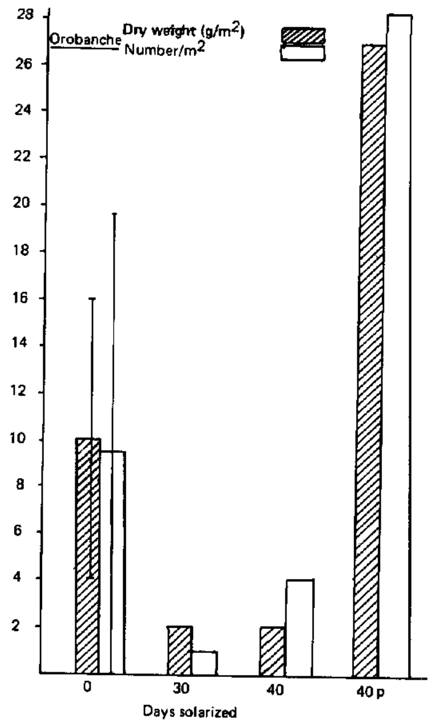

Fig. 6.1.2. Effect of solarization on orobanche infestation in lentil Tel Hadya 1986/87.

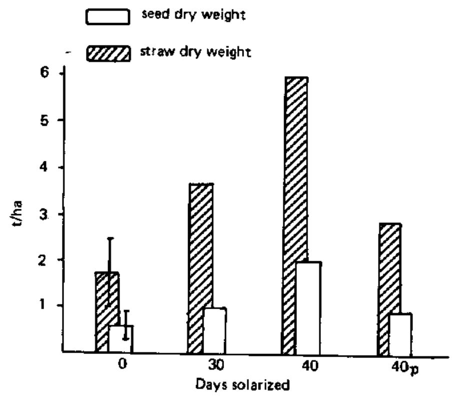

Fig. 6.1.3. Effect of solarization on yield of faba bean(ILB 1814) Tel Hadya 1986/87.

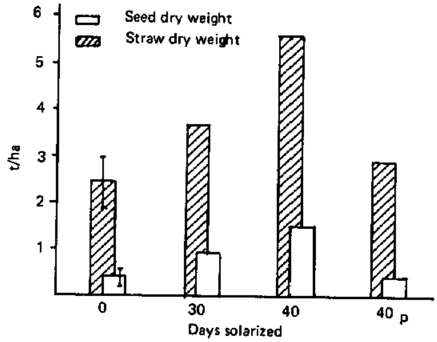

Fig. 6.1.4. Effect of solarization on yield of lentil(ILL 4401)– Tel Hadya 1986/87.

Solarization for 40 days just before planting increased the number and dry weight of orobanche in crop of faba bean and lentil. This might be due to the moist, low temperature conditions under the plastic cover which preconditioned the seeds resulting in a decrease of seed dormancy and therefore stimulated more orobanche seeds to germinate (Figs. 6.1.1, 6.1.2).

Seed yield of faba bean and lentil was significantly increased 4-5 times after 40 days of solarization when compared to the control (Figs. 6.1.3, 6.1.4).

Number of weed species and weed dry weight was decreased, the latter by 70-87% (Figs. 6.1.5, 6.1.6). As in the previous year the two legume weed species, (Coronilla scorpioides and Scorpiurus muricatus) were not affected by solarization, while the noxious weed Phalaris brachystachys was controlled well.

Free living nematodes up to 15 cm depth were extracted from the soil, classified and counted to evaluate the effect of solarization. Depending on the genus they were reduced by 83-100% after 40 days solar heating the soil (Fig. 6.1.7). The root nematode Pratylenchus thornei on faba bean was 100% controlled after 30 and 40 days of solarization (Table 6.1.1.).

Table 6.1.1. Influence of soil solarization on Pratylenchus thornei on faba bean at flowering stage.

Duration of solarization (days)	Pratylenchus thornei (no./10 g root)
0	18
30	0
40	0

It has been shown that with less than 100 rhizobium bacteria/g of soil, crops will respond significantly to inoculation with

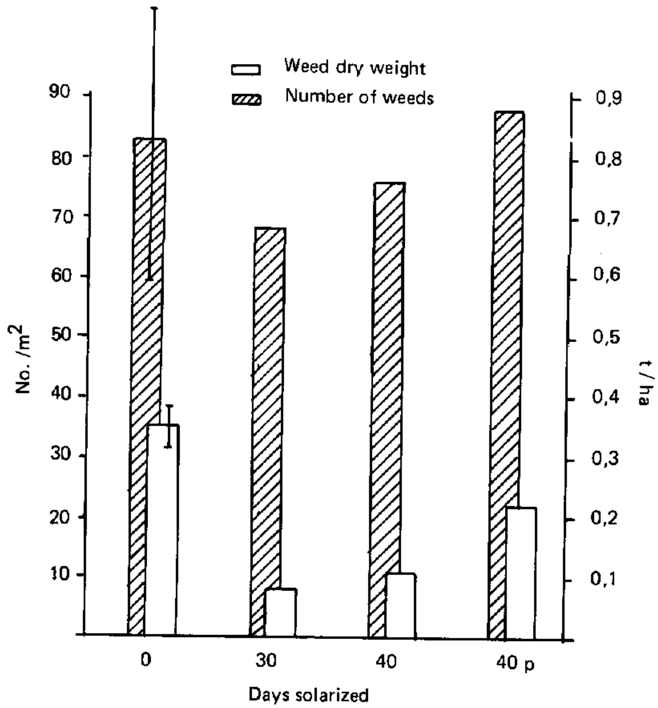

Fig. 6.1.5. Effect of solarization on weed infestation in faba bean—Tel Hadya 1986/87.

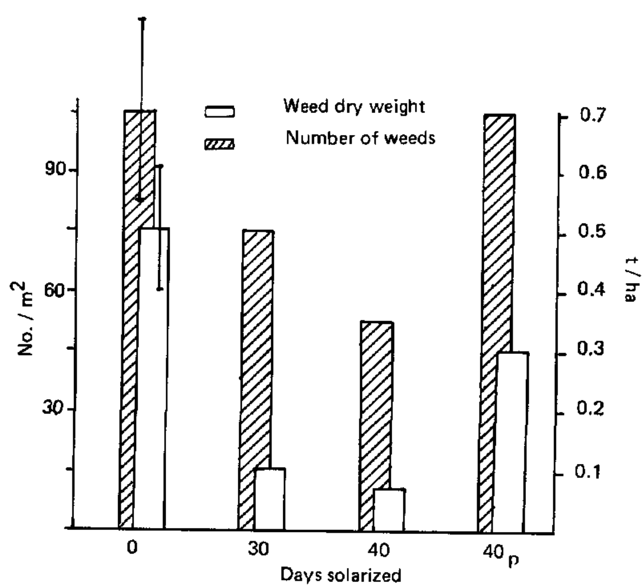

Fig. 6.1.6. Effect of solarization on weed infestation in lentil—Tel Hadya 1986/87.

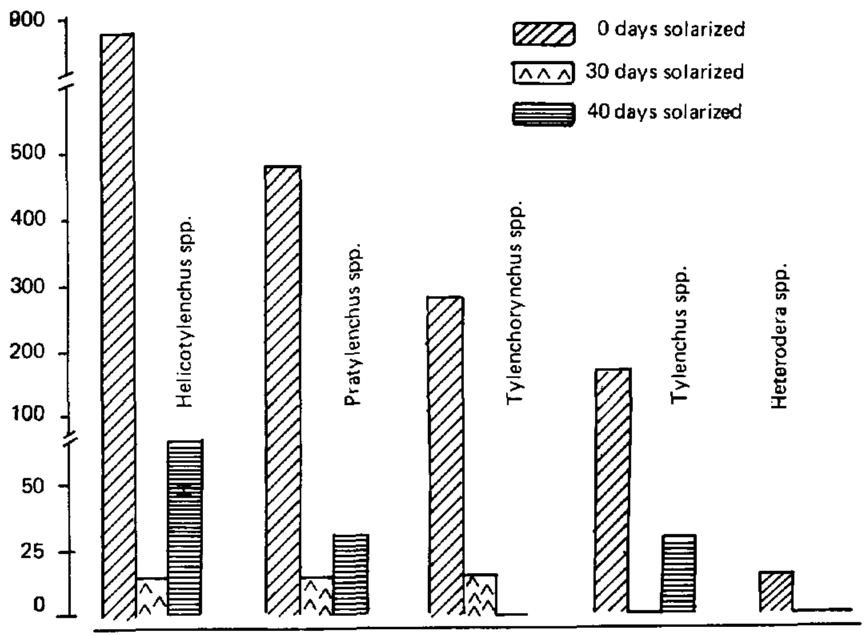

Fig. 6.1.7. Number of nematodes in 500 cm^3 of soil after soil solarization (soil samples taken up to 15 cm depth in 4 reps) – Tel Hadya 1986/87.

rhizobia. Most probable number studies (MPN) of the treated soils indicated that solarization for 40 days will lead to a significant decrease in native rhizobial population, to the extent that N fixation will be affected (Table 6.1.2). Further studies should be conducted to determine to what extent N fixation and soil mineralization are affected.

Table 6.1.2. Effect of solarization on Rhizobium leguminosarum populations in soil (sampling depth to 40 cm).

Days of solarization	Rhizobium population (no. per g soil) before solarization	Rhizobium population (no. per g soil) after solarization
0	> 10,000	> 10,000
30	> 10,000	3,430
40	> 10,000	45

6.1.1. Residual effect of the solarization 1985/86

In 1985/86 season a solarization trial was conducted in Tel Hadya. The residual effect of those treatments on Orobanche control was further studied this season to obtain more information on the long lasting effects of this control measure. For this reason the old plots remained uncultivated so as not to bring up the orobanche seeds from the deeper layer. The plots were cropped with faba bean as a host plant. The residual effect of solarization is clearly shown in the yield data. Seed yield of faba bean was increased from 1.7 t/ha in the control to 3.0 t/ha in the 40 days treatment, a 75% yield increase (Fig. 6.1.8).

The number of orobanche was reduced by 93% one year after solarization when compared to the control (Fig. 6.1.9). Also weed infestation was significantly decreased by about 75% (Fig. 6.1.10). Like the year before the two weed species Coronilla scorpioides and Scorpiurus muricatus were not controlled by solarization.

The root lesion nematode Pratylenchus thornei which was well controlled last year was able to re-establish its population as is shown in Table 6.1.3.

Table 6.1.3. Residual effect of solarization on Pratylenchus thornei.

Solarization (1985/86) (days)	Pratylenchus thornei (no./10g root)
0	106
40	83

The results of the residual effect of solarization are quite promising and the trial will continue again for next season in order to obtain more data for economic evaluation.

Drs. J. Sauerborn, M.C. Saxena, D. Beck and Mr. H. Masri.

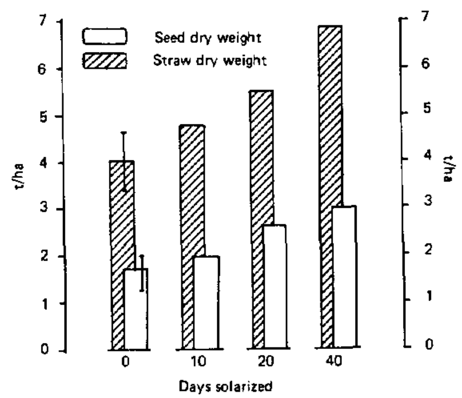

Fig. 6.1.8. Residual effect of solarization in 1985/86 on faba bean yield–Tel Hadya 1986/87.

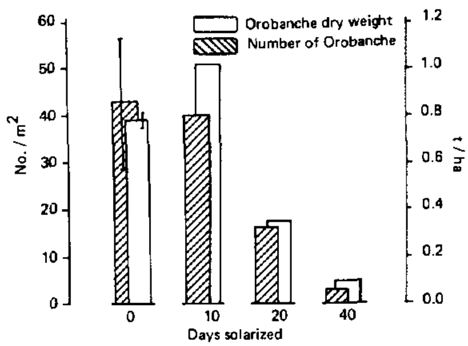

Fig. 6.1.9. Residual effect of solarization in 1985/86 on Orobanche infestation in faba bean – Tel Hadya 1986/87.

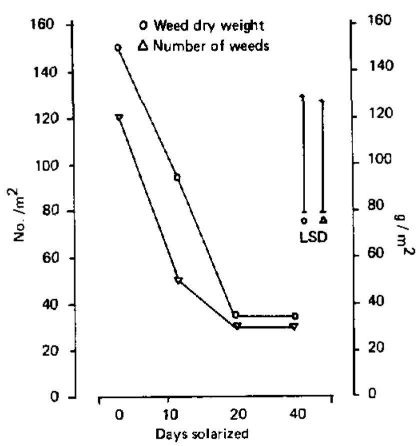

Fig. 6.1.10. Residual effect of solarization in 1985/86 on weed infestation in faba bean – Tel Hadya 1986/87.

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

Investigations on this subject were continued in 1986/87 to confirm the results and observations from last season. Studies of the subterranean stages of *Orobanche* showed that delayed sowing can contribute to a lower orobanche attachment and therefore may be part of an integrated management practice to control orobanche.

In faba bean and lentil the number and dry weight of orobanche was significantly decreased with later sowing by 90-95% (Figs. 6.2.1, 6.2.2). At the same time seed yield was initially increased and was highest when the crop was sown at the beginning of December (Figs. 6.2.1, 6.2.2). Further delay resulted in a decrease of yield because of the shortened vegetative period.

The first orobanche attachments were observed under the binocular microscope by end of November when the crop was sown mid October (Fig. 6.2.3). The time interval between crop emergence and first orobanche attachment become longer when the sowing was delayed. For the first sowing date (Oct. 15) orobanche attachment was observed only 27 days after crop emergence. In the latest sowing (Dec. 15) more than 50 days elapsed before the first attachment occurred, because low temperature conditions in the soil are not conducive to orobanche development. On the other hand the time interval between first attachment and emergence of orobanche became shorter when sowing was delayed. In general the life cycle of the parasite was reduced by about 45-55 days through late sowing.

From the results it can be deduced that a delay in sowing of susceptible crops has a clear effect in reducing the number and time of initial orobanche attachment resulting in a higher crop yield. The reduction in vegetative period for the crop might be counterbalanced by using an early maturing variety. The next season will be used to study these combined effects.

Drs. J. Sauerborn, M.C. Saxena and Mr. H. Masri.

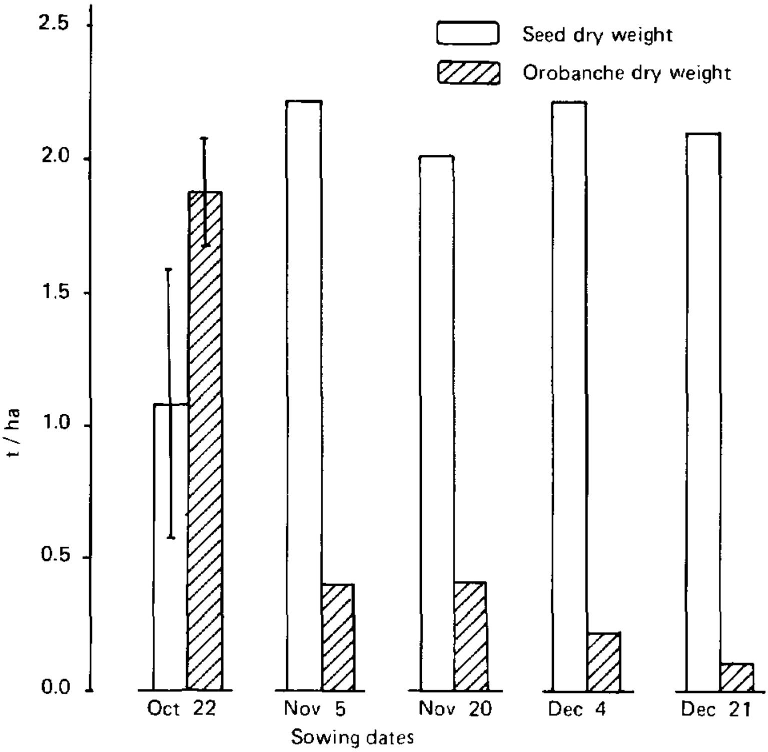

Fig. 6.2.1. Effect of sowing date on Orobanche spp. dry weight (d. w.) and seed yield of faba bean (ILB 1814) – Tel Hadya 1986/87.

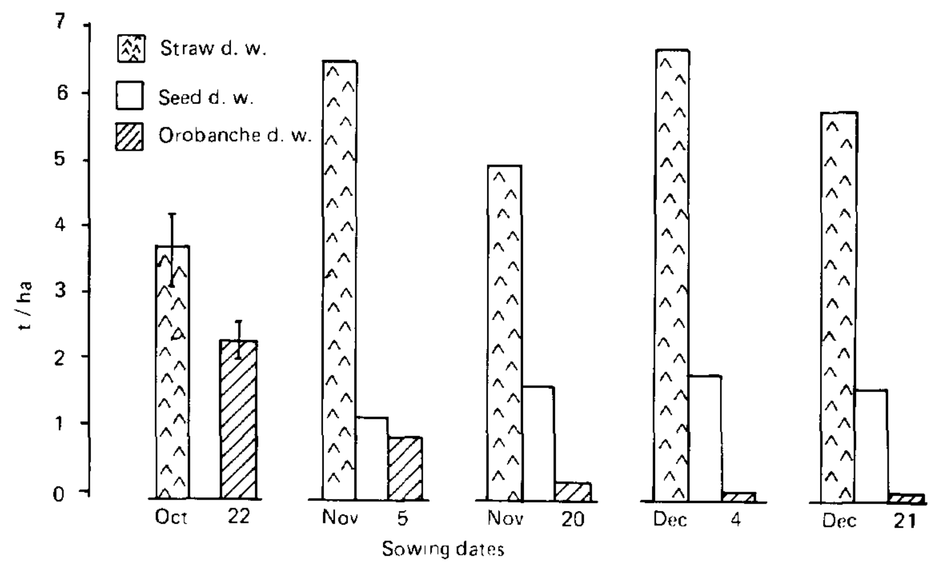

Fig. 6.2.2. Effect of sowing date on Orobanche spp. dry weight (d. w.) and yield of lentil (ILL 4401) – Tel Hadya 1986/87

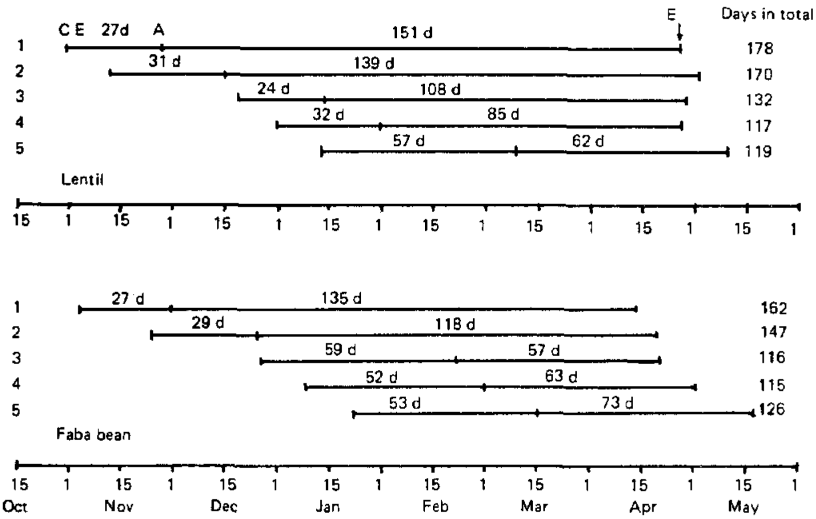

Fig. 6.2.3. Time of crop emergence (CE), Orobanche attachment (A) and Orobanche emergence (E) in dependency of different sowing dates (1 – 5) – Tel Hadya 1986/87.

6.3. Chemical Control of Orobanche spp.

6.3.1. Evaluation of herbicides in legume crops

Following the results from last year the effect of two herbicides Imazaquin (Scepter) and Glyphosate (Lancer) on Orobanche control was tested in faba bean, lentil and chickpea at Tel Hadya.

Use of Glyphosate for Orobanche control in faba bean has been known for years but there are still problems in timing and dosage. Scepter was tested in 1985/86 for the first time and proved effective. The experiments of 1986/87 were conducted to obtain more information on timing and number of herbicide applications necessary for Orobanche control and optimum herbicide dose for high efficiency combined with low phytotoxicity. The herbicides were applied pre- and post-emergence, once or twice at several doses with a knapsack sprayer at a volume of 400 l/ha using Hyspray as a wetting agent.

From all treatments tested in faba bean, Scepter sprayed at a dosage of 10g a.i/ha at tubercle stage of Orobanche and 15 days thereafter gave the best result. The number of Orobanche per m^2 was reduced by 98% (Fig. 6.3.1) while seed yield was slightly increased (Fig. 6.3.2). Scepter reduced the number of Orobanche effectively and yield was also high with only one spraying at tubercle stage at a dosage of 10 or even 5g a.i./ha. Higher dosages or other times of application, for example pre-emergence, were not effective in increasing yield because of impaired crop growth.

Lancer applied twice at 80g a.i./ha controlled Orobanche by 99% but faba bean seed yield was decreased by 28% because of phytotoxicity (Fig. 6.3.2). Phytotoxicity of Lancer was assessed by percentage of crop injury compared to the control and was well correlated with plant height and crop cover (Table 6.3.1).

Table 6.3.1. Effect of different herbicides on growth of faba bean.

Herbicide	Dosage (kg a.i./ha)	Time of application	Phytotoxicity EWRS-scale	Plant height (cm)	Crop cover (%)	% Orob.d.w. of total biomass
Control			1	67	95	2.2
Hyspray	5%		1	69	94	3.8
Scepter	0.08	pre	3	56	80	0.2
"	0.02	post	1	65	95	2.4
"	0.02 +0.01	post tubercle	1	68	97	0.02
"	0.01	tubercle	1	67	97	0.1
"	0.01	tubercle 2 x	2	72	99	0.01
"	0.005	tubercle	1	71	95	1.05
"	0.005 +0.0075	tubercle +15 d thereafter	1-2	69	92	0.2
Lancer	0.04 +0.08	post tubercle	1	62	91	3.7
"	0.08	tubercle 2 x	3	57	74	0.0
LSD (0.05)			-	6.4	8.7	-

Scepter and Lancer reduced the number of emerged Orobanche spikes per m^2 up to 100% in lentil depending on dosage and timing of application (Fig. 6.3.3), but no increase in yield could be observed because of phytotoxicity effects (Fig. 6.3.4). Best results were

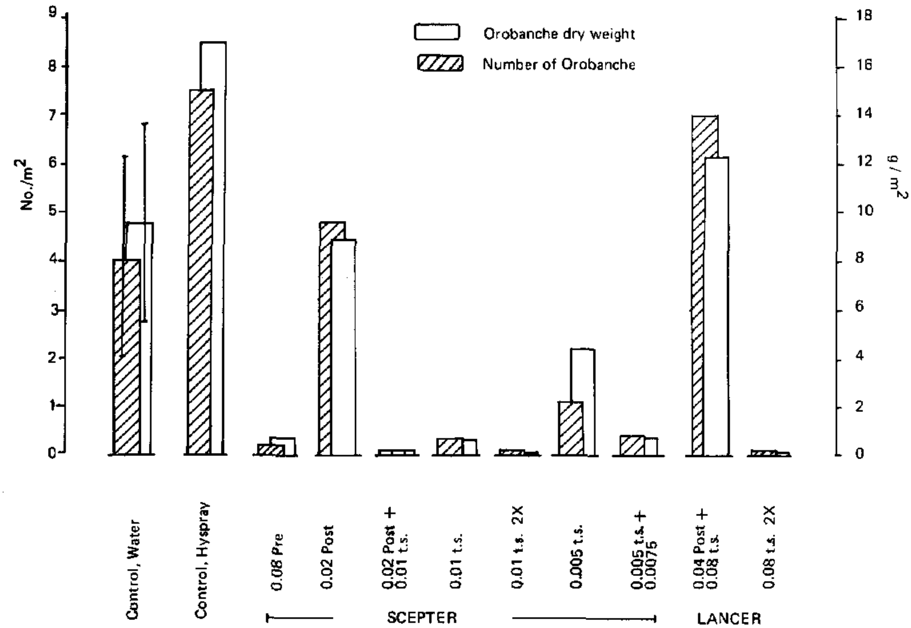

Fig. 6.3.1. Effect of different herbicides on Orobanche control in faba bean (ILB 1814) – Tel Hadya 1986/87.
(t.s. = tubercle stage of Orobanche)

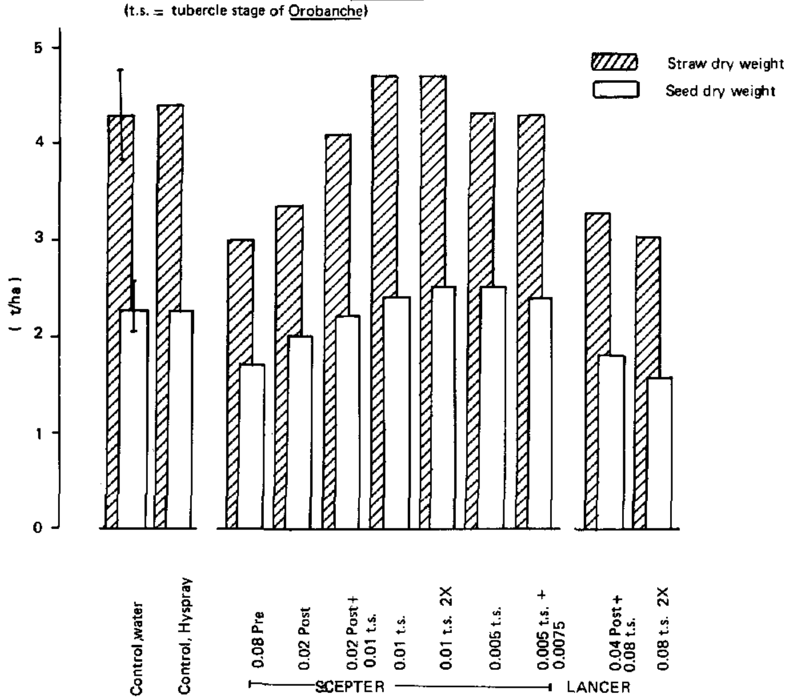

Fig. 6.3.2. Effect of Orobanche spp. control by different herbicides on yield of faba bean (ILB 1814) – Tel Hadya 1986/87.
(t.s. = tubercle stage of Orobanche)

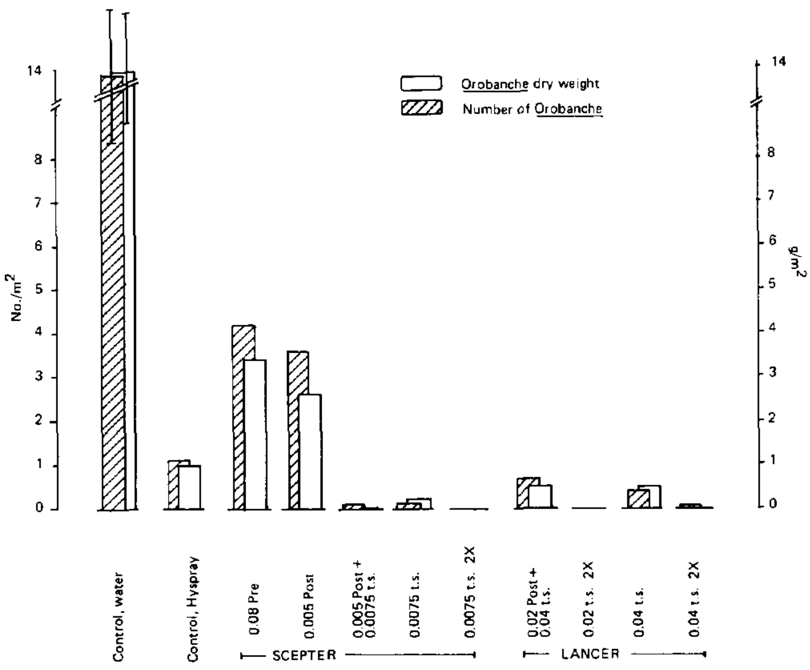

Fig. 6.3.3. Effect of different herbicides on Orobanche control in lentil (ILL 4401) – Tel Hadya 1986/87. (t.s. = tubercle stage of Orobanche)

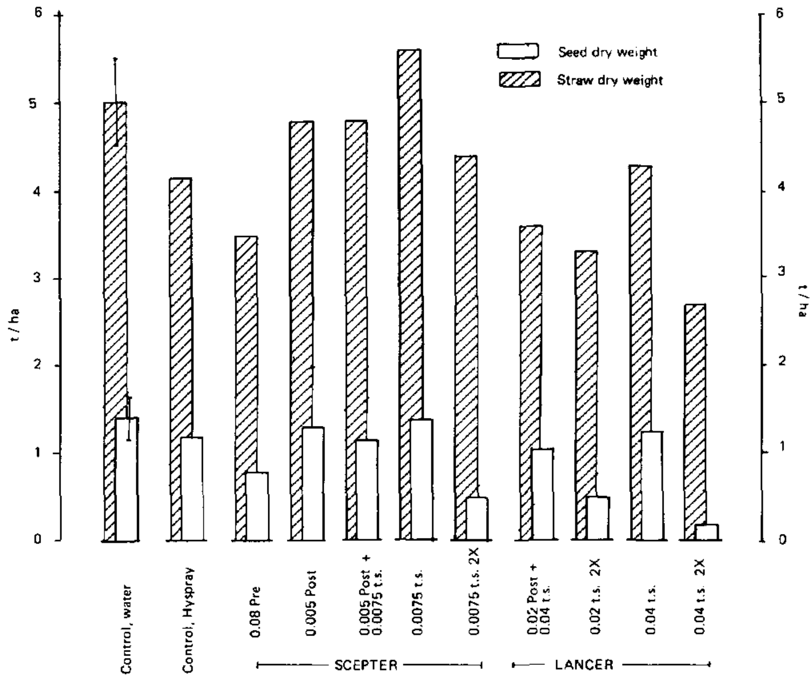

Fig. 6.3.4. Effect of Orobanche spp. control by different herbicides on yield of lentil (ILL 4401) – Tel Hadya 1986/87. (t.s. = tubercle stage of Orobanche)

Table 6.3.2. Effect of different herbicides on growth of lentil.

Herbicide	Dosage (kg a.i./ha)	Time of application	Phytotoxicity EWRS-scale	Plant height (cm)	Crop cover (%)	% Orob.d.w. of total biomass
1 Control			1	28	98	2.75
2 Hyspray	5%		2-3	27	70	0.2
3 Scepter	0.08	pre	2	28	92	10.0
4 Scepter	0.005	post (10cm)	1	29	100	0.55
5 Scepter	0.005 +0.0075	post tubercle	1-2	29	94	0.0
6 Scepter	0.0075	tubercle	1	30	100	0.03
7 Scepter	0.0075	tubercle 2 x	3	25	83	0
8 Lancer	0.02 +0.04	post tubercle	2	24	86	0.13
9 Lancer	0.02	tubercle 2 x	3	24	81	0
10 Lancer	0.04	tubercle	1-2	26	89	0.11
11 Lancer	0.04	tubercle 2 x	4	25	78	0
LSD (0.05)				2.1	8.8	

obtained using Scepter at a rate of 7.5g a.i./ha applied once at tubercle stage. Phytotoxicity was measured using the EWRS-scale during crop growth and even the wetting agent (Hyspray) caused crop damage (Table 6.3.2).

In chickpea, the Orobanche infestation was low so that the effect of the herbicides on Orobanche control could not be studied. In general chickpea was susceptible to all herbicide treatments which resulted in yield decreases of up to 48% compared with the control.

In summary Scepter is a very promising herbicide for Orobanche control because of its high efficiency, and the low dosage required. The optimum rate in faba bean ranges between 7.5 and 10g a.i./ha sprayed twice. In lentil the effective rate lies between 5-7.5g a.i./ha. Best time of application was found at tubercle stage of Orobanche for both crops.

6.3.2. On-farm evaluation of herbicides in faba bean

At five different locations in Syria two herbicides, Lancer (Glyphosate) and Scepter (Imazaquin), were tested in on-farm trials to evaluate them under different climatic conditions. Four locations were irrigated while in Achane the faba bean grew under dry land conditions. The highest orobanche infestation was measured in Jableh where orobanche dry weight was 4.5 t/ha; lowest infestation was in Al-Bab with 0.36 t/ha (Fig. 6.3.5).

Orobanche dry weight was reduced by two Lancer applications at a rate of 80g a.i./ha, sprayed at tubercle stage of orobanche and 15 days thereafter, by an average of 80% (48-100%) over all locations. Control in the coastal area was poor with 48 and 56% orobanche dry weight reduction (Fig. 6.3.5). Because a high infestation level still existed in the field no yield could be observed. In all other locations yield was increased, in Al-Bab up to 53% (Fig. 6.3.6).

Scepter sprayed once at tubercle stage of orobanche at a dosage of 20g a.i./ha was not effective in controlling orobanche in the coastal region. Although orobanche dry weight was reduced by 48-63%, there was no yield at all. At the three other locations seed yield was increased by 5-16% while orobanche was reduced up to 93%.

The results show that under the climatic conditions found in the coastal area Lancer and Scepter did not prove effective, although they controlled orobanche at the other locations. Together with a temperature effect the high general level of orobanche infestation in the coastal areas plays a large role in faba bean culture. Another set of trials should be conducted to test the number of herbicide applications necessary for orobanche control under these circumstances.

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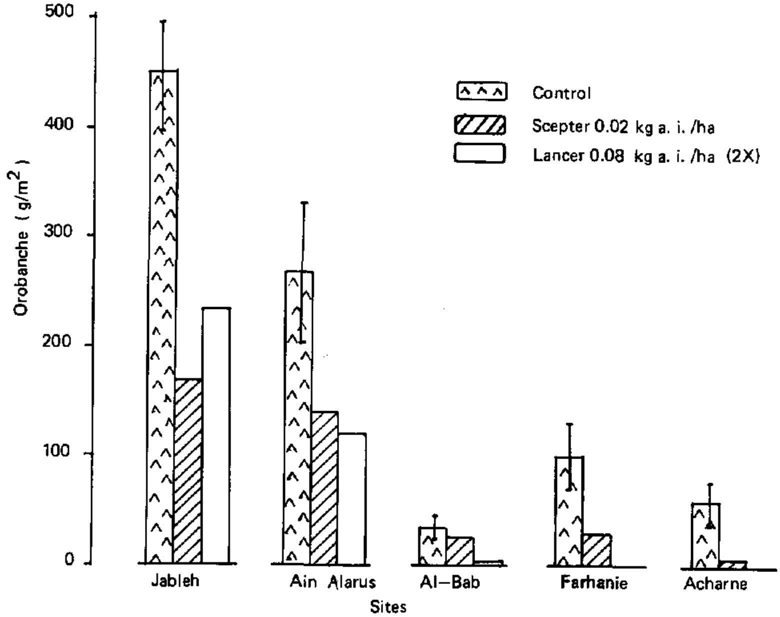

Fig. 6.3.5. Effect of herbicide application on Orobanche spp. dry weight at different sites in Syria – 1986/87.

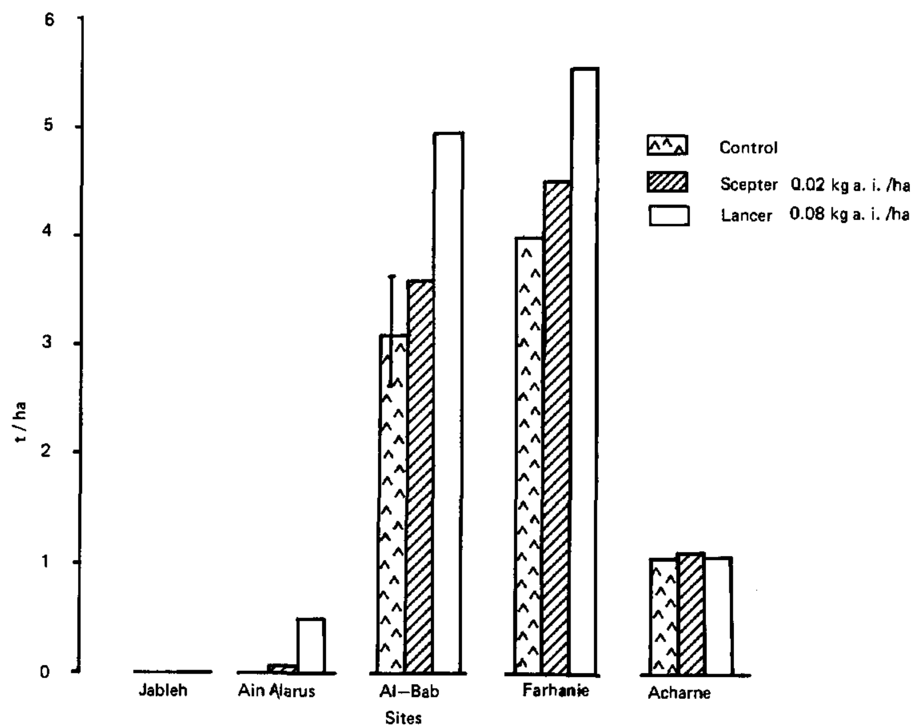

Fig. 6.3.6. Effect of herbicide application on faba bean yield at different sites of Syria – 1986/87.

6.4. Single Plant Selection for <u>Orobanche</u> Resistance in the Population Giza 402

As a continuation of this work started in 1985/86 a set of about 370 single faba bean plants of Giza 402 were tested under screen house conditions in 1986/87. For more detail on the method see last year's program report.

Only 10 plants out of 370 were found to be free of emerged orobanche, but still had orobanche attached underground. Their number ranged between 1-11. An increasing number of emerged orobanche shoots per plant resulted in a significant reduction of pods and plant dry weight of faba bean (Fig. 6.4.1).

Multiplied seeds of promising plants from last season were rescreened in 5 reps but no plant was free of orobanche. Further investigation will continue with the low infested plants.

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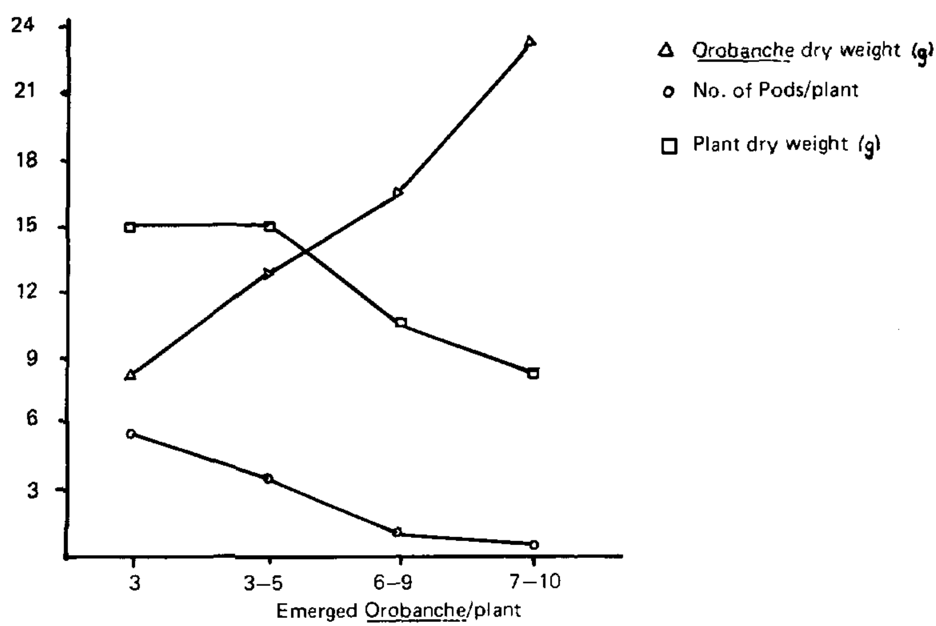

Fig. 6.4.1. Effect of Orobanche infestation on yield components of faba bean plants (Giza 402)

6.5. Orobanche crenata Seed Density in the Soil

A pot experiment in the field at Tel Hadya was conducted to study the effect of different seed densities of Orobanche crenata in the soil on growth of faba bean to obtain information on the critical level of orobanche infestation in the soil. In pots, embedded in the ground and filled with 8 kg of soil, eight different orobanche seed loads (0-1g/pot) were tested in 10 replications.

Up to 28,000 orobanche seeds/m^2 caused no reduction in faba bean yield. Yield was slightly decreased with about 56,000 seeds/m^2. With ca. 280,000 orobanche seeds/m^2 a poor yield can be expected and with more than 500.000 seeds/m^2 yield will drop to zero (Fig. 6.5.1.).

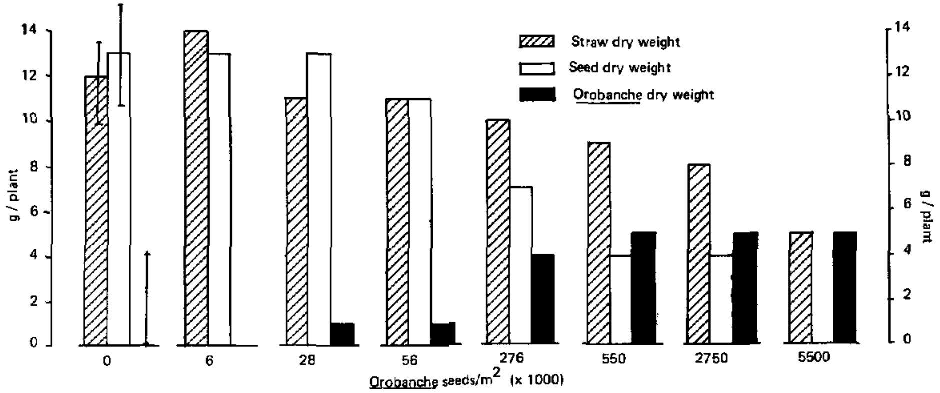

Fig. 6.5.1. Effect of Orobanche seed rate in the soil on Orobanche infestation and faba bean yield – Tel Hadya 1986/87.

This season the number of emerged orobanche shoots/m^2 was 60, when calculated over all locations and trials. When we calculate only a low seed production rate of 20,000 seeds per orobanche shoot we get 1.2 million orobanche seeds/m^2. These figures indicate that without control measures in most fields of the area only a poor yield can be expected, and continued cropping of faba bean will lead to an eventual zero yield.

The effect of increasing orobanche seed load in the field was demonstrated clearly in our experiment. Yield components of faba

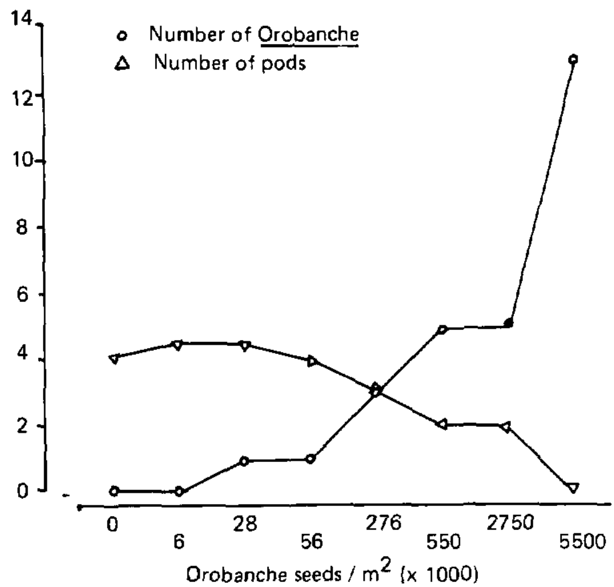

Fig. 6.5.2. Effect of Orobanche seed rate in the soil on Orobanche infestation and pod set of faba bean – Tel Hadya 1986/87.

bean like number of pods, dry weight of seed and straw was reduced while number of orobanche and dry weight was increased with higher orobanche infestation levels in the soil (Figs. 6.5.1, 6.5.2). The negative correlation between orobanche seed load in the soil was higher with seed yield of faba bean (-0.66) than it was between the number of emerged orobanche and faba bean seed yield (-0.47).

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7. STUDIES ON NEMATODES

Investigations on nematodes of chickpea and lentil in Syria, undertaken since 1982, have shown that the cyst nematode (Heterodera ciceri), the root-knot nematode (Meloidogyne artiellia), and the root lesion nematode (Pratylenchus thornei) are the most noxious to these food legumes. In the past years research was designed to give more insight into the biology and host range of the above nematodes, pathogenicity of H. ciceri, and chemical control of P. thornei. Attempts were also made to select chickpea and lentils tolerant or resistant to at least one of these nematodes. In 1986/87 more effort was made to study biology and pathogenicity of M. artiellia and screen chickpea germplasm for its resistance to H. ciceri. Moreover, field experiments were established to confirm previous results on the chemical control of P. thornei on chickpea and to ascertain the feasibility of crop rotation in controlling cyst and root-knot nematodes.

7.1. Relationship between population densities of Meloidogyne artiellia and yield of chickpea.

M. artiellia is noxious to chickpea, but previously no information was available on the potential amount of yield loss that the nematode could cause to both winter and spring sown chickpea. Therefore two experiments were undertaken to establish the relationship between a range of population densities (0.058 - 155.5 eggs/cm^3 of soil) of M. artiellia and yield of chickpea grown in microplots at Bari, Italy. Results show that M. artiellia is highly pathogenic to both winter and spring chickpea. A tolerance limit of 0.14 eggs of M. ariellia/cm^3 soil was derived for winter chickpea. The estimated tolerance limit of the spring chickpea was lower (0.016 egg/cm^3 soil) and nearly 85% of the yield was lost at 1 egg/cm^3 soil. The reproduction rate of the nematode estimated after harvest of chickpea was about 26 at the lowest initial population densities and decreased as the initial population increased.

7.2. Control of Heterodera ciceri and Meloidogyne artiellia by crop rotation.

Because of low benefit of chickpea and of high cost of nematicides and their negative effect on population, chemical control is rather difficult. Crop rotation instead has proven effective in controlling many pests and diseases with narrow host ranges. Therefore two experiments, one in a field infested with H. ciceri and the other on a field infested with M. artiellia were undertaken at Tel Hadya to control these nematodes by crop rotation. Six crop sequences were replicated five times in each experiment (Tables 7.2.1 and 7.2.2), with alternate host and non host plant species for two nematodes. The first result on the effect of crop rotation on chickpea yield will be available in June 1988. However the nematode soil population observed last July had declined to about 40% (Table 7.2.3) of that at sowing in the plots sown with a non host plant (wheat) and to 64% in those sown with lentil. In the plots planted to chickpea and grasspea, both hosts for H. ciceri, the nematode population at harvest was about 2.5 times that at sowing (Table 7.2.3). Lentil is also considered a good host for H. ciceri and therefore the reduction of the nematode population observed in the plots planted with this pulse needs to be confirmed.

7.3. Chemical control of root lesion nematode (Pratylenchus thornei)

Pratylenchus thornei has a wide host range making its control by crop rotation difficult. Therefore during the last three years attempts were made to reduce yield losses of chickpea by using nematicides. Two field trials were established at Tel Hadya in 1986/87, one with winter chickpea and the other with spring chickpea, to control the nematode by furrow split application of different rates of Aldicarb (Table 7.3.1), at sowing and at plant emergence. All treatments increased grain yield by 12-25% on winter chickpea and by 51-76% on spring chickpea. Numbers of nematodes in the chickpea roots were greatly suppressed by Aldicarb especially in

Table 7.2.1. Crop sequences for the control of the chickpea cyst nematode, *Heterodera ciceri*, at Tel Hadya, Syria.

Treatments	Crop sequences			
	I Year 86/87	II Year 87/88	III Year 88/89	IV Year 89/90
1	Lentil +	Chickpea +	Lentil +	Chickpea +
2	Wheat *	Chickpea +	Wheat *	Chickpea +
3	Chickpea +	Wheat *	Barley *	Chickpea +
4	Wheat *	Barley *	Wheat *	Chickpea +
5	Lathyrus +	Chickpea +	Lentil +	Lathyrus +
6	Lathyrus +	Wheat *	Barley *	Lathyrus +

* non host; + host

Table 7.2.2. Crop sequences for the control of the root-knot nematode, *Meloidogyne artiellia*, at Tel Hadya, Syria.

Treatments	Crop sequences			
	I Year 86/87	II Year 87/88	III Year 88/89	IV Year 89/90
1	Wheat +	Chickpea +	Wheat +	Chickpea +
2	Oat *	Chickpea +	Oat *	Chickpea +
3	Chickpea +	Oat *	Lentil **	Chickpea +
4	Oat *	Lentil**	Oat *	Chickpea +
5	*Vicia sativa*+	Lentil**	Oat*	*Vicia sativa*+
6	*V. dasycarpa***	Lentil**	Oat *	*V. dasycarpa***

* non host; ** poor host; + host

Table 7.2.3. Effect of different crops on soil population of *Heterodera ciceri* at Tel Hadya, Syria.

Crop	Eggs of *H. ciceri*/g soil		% of *H. cicer* population
	At sowing 17/11/86	At harvest 7/7/87	at harvest
Lentil +	13.6	8.7	64
Wheat *	12.6	4.5	36
Chickpea +	12.3	29.5	240
Wheat *	16.1	7.0	43
Lathyrus +	15.9	27.3	172
Lathyrus +	11.3	37.7	334

* non host; + host

Table 7.3.1. Effect of Aldicarb on the numbers of Pratylenchus thornei found in the roots and on the yield of winter and spring chickpea.

Treatment	Nematodes/5g roots		Biological yields ($g/6.3\ m^2$)		Grain yields ($g/6.3\ m^2$)	
	Winter chickpea	Spring chickpea	Winter chickpea	Spring chickpea	Winter chickpea	Spring chickpea
Aldicarb 5+5 kg a.i./ha	10.8	1.7	4978	3308	2506	1789
Aldicarb 5+2.5 kg a.i./ha	57	10.3	4501	2894	2263	1535
Aldicarb 2.5+5 kg a.i./ha	33.4	4.3	4920	2983	2503	1605
Control	267.7	1183.3	4129	1929	2077	1016
LSD ($P \leq 0.05$)	76.1	358.8	398	411	195	224

those of spring chickpea. These results confirm those obtained in the previous year and show that Aldicarb is more effective on spring than on winter chickpea.

7.4. Survey of plant parasitic nematodes of chickpea and lentil in Syria

Investigations on the occurrence of nematodes of food legumes was extended in 1987 in the north-east of Syria, near the Iraqui and Turkish border and in the Ghab Valley, where chickpea and lentil are cultivated intensively. Pratylenchus spp. were the nematodes most frequently extracted from the root of lentil (37%) and especially chickpea (72%), and in greater numbers in the north-east of the country where up to 2200 specimens/g roots were found. Only two root samples of chickpea and one of lentil contained few juveniles of root-knot nematodes. Pratylenchus spp. was encountered in four root samples of chickpea but not on lentil. Observations of soil samples revealed nearly the same nematofauna observed in the past years, except that Heterodera ciceri was not found in these areas.

7.5. Reaction of chickpea germplasm lines to Heterodera ciceri.

Though yield losses caused by nematodes can be suppressed in different ways, the use of resistant varieties is easy, safe and effective. Unfortunately no varieties of chickpea are known to be resistant to H. ciceri. Therefore 2001 chickpea lines of C. arietinum and twenty wild lines of the ICARDA germplasm were tested for their reaction to H. ciceri (Table 7.5.1). None of the chickpea lines was found free of nematodes, but 20 (1%) were rated 2 (Tables 7.5.2 and 7.5.3), 482 (24%) were rated 3, and 1499 (75%) were rated 4 and 5. The root infestation of the wild lines of Cicer species, reported in Table 7.5.1, was low on two lines of Cicer bijugum, but high on the other species. It is noteworthy that some lines had low infestation. However, reaction to H. ciceri needs to be confirmed and their performance under field conditions investigated.

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Table 7.5.1. Screening collections of Cicer species for resistance to Heterodera ciceri at Tel Hadya, Syria, 1986/87.

Cicer species	Accession no.	Rating*
Cicer bijugum	ILWC 7	3
" "	" 8	2
" "	" 34	2
Cicer chorassanimcum	" 23	5
Cicer cuneatum	" 37	5
Cicer echinospermum	" 35	5
Cicer judaicum	" 4	5
" "	" 4-2	5
" "	" 20	5
" "	" 30	4
" "	" 31	5
" "	" 38	5
Cicer pinnatifidum	" 9	5
" "	" 29	5
" "	" 29-1	5
" "	" 29-2	5
Cicer pinnatifidum + judaicum	" 33	5
Cicer reticulatum	" 21	5
" "	" 36	5
Cicer yamashitae	" 3=1	4

* Rating scale: 0 = free from nematode,
5 = highly infested with nematode.

Table 7.5.2. Screening chickpea germplasm lines for resistance to *Heterodera ciceri* at Tel Hadya, Syria, 1986/87.

Rating scale*	No. of accessions	% of total
0	0	0.0
1	0	0.0
2	20	1.0
3	482	24.1
4	531	26.5
5	968	48.4
Total	2001	100.0

* See Table 5 for rating scale.

Table 7.5.3. Chickpea lines found promising for their reaction to *Heterodera cicer* at Tel Hadya, Syria, 1986/87.

Entry	Rating	Entry	Rating
ILC 15	2	ILC 923	2
ILC 20	2	ILC 958	2
ILC 94	2*	ILC 1208	2
ILC 250	2	ILC 1259	2
ILC 633	2	ILC 1260	2
ILC 750	2	ILC 5141	2
ILC 751	2	ILC 5180	2
ILC 826	2	ILC 5251	2
ILC 844	2	ILC 5267	2
ILC 847	2	ILC 5270	2

* Resistance confirmed; for others requires reconfirmation.

8. COLLABORATIVE PROJECTS

8.1 ICARDA/IFAD Nile Valley Project

The 1986/87 season was the second year of the third phase of this special project which now covers Ethiopia in addition to Egypt and Sudan. The objectives of this project have already been described in the 1983/84 annual report and also in special publications issued by the Center. A comprehensive six year report of the project has been prepared and will be published shortly. This year, research work had, as usual, a heavy 'on-farm' emphasis with a proportion of resources and efforts devoted to the back-up research. In Ethiopia, a pilot production/demonstration program was started for the first time, with the involvement of farmers and extensionists. In Egypt and Sudan, the project was marked by increased interaction between project scientists and extension workers in providing support to production programs. The major project highlights of research during the 1986/87 season are described here.

8.1.1. Program in Egypt

8.1.1.1. Pilot demonstration plots in El-Minia and Fayoum

Cooperation between NVP scientists and the staff of the Agricultural Development Project (ADP) in El-Minia and Fayoum was strengthened in extending the faba bean production package developed in the NVP to farmers. The extension specialists and village agents of the ADP in the two governorates were trained by subject matter specialists of the NVP.

The recommended 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. Other practices recommended included sowing in early November, Orobanche control with glyphosate, aphid control with Pirimor and frequent irrigation during flowering and pod setting.

In El-Minia the demonstration plots, selected by the extension agents, occupied 833 ha involving 1117 farmers in 95 villages across the 9 districts of the governorate. In addition, three villages were selected to concentrate extension efforts on production technology. Yield estimates of demonstration farmers fields as compared to those outside the demonstration showed an average increase of 310 kg/ha (11.0%) in seed yield and 450 kg/ha (9.1%) in straw yield (Table 8.1.1). The average profitability (net benefit as % of total cost) was 134 and 92% respectively, for the 'demonstration' and 'outside demonstration' farmers in the nine districts. In Fayoum four villages in two districts were chosen to demonstrate the improved production package to farmers and nine one hectare demonstration plots were grown. As an average over all demonstration plots in Fayoum Governorate, the test package increased seed yield by 600 kg/ha (19.1%) and straw by 1020 kg/ha (22.9%). The profitability of the recommended package was 225% as against 170% for the traditional practices (Table 8.1.2).

8.1.1.2. Pilot demonstration of orobanche control in El-Minia Governorate

Eight demonstration trials of 1.5 hectare each in two districts in Minia Governorate were conducted by NVP researchers 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 gm in 500 l water per hectare at flower initiation and repeated 15 days later. Optimum levels of N and P fertilizers and seed rate were used. Lancer was sprayed by the farmers in the presence of NVP scientists and extention agents. The control package gave positive and consistent seed yield increase ranging from 0.38 t/ha (11.5%) to 1.49 t/ha (73.5%) with an average of 0.74 t/ha (29.1%). The average increase in straw yield was 2.44 t/ha (59.5%). The recommended practices reduced the number and dry weight of Orobanche by 63.3% and 71.5%, respectively. The profitability of this package was 349.9% against 226.6% for traditional practice (Table 8.1.3).

Table 8.1.1. Average seed and straw yields (t/ha) and economic evaluation of in- and out-of-demonstration farmers in El-Minia Governorate, Egypt, 1987.

	In demonst.		Out demonst.		Difference	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Yield (t/ha)*:						
Seed	3.14	0.61	2.83	0.75	0.31	0.52
Straw	5.38	1.92	4.93	1.28	0.45	0.76
Economic Evaluation:						
Total variable costs (LE/ha)	945		1075		-130	
Net benefit (LE/ha)	1268		983		285	
Profitability (%)	134		92		42	

* Seed price (LE/ton) 548.4
Straw price (LE/ton) 80.0

Table 8.1.2. Average seed and straw yields (t/ha) and economic evaluation of in- and out-of-demonstration farmers in Fayoum Governorate, Egypt, 1987.

	In demonst.		Out demonst.		Difference	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Yield (t/ha):						
Seed	3.75	0.65	3.15	0.51	0.60	0.34
Straw	5.47	1.00	4.45	0.69	1.02	0.51
Economic Evaluation:						
Total variable costs (LE/ha)	877		855			
Net benefit (LE/ha)	1976		1504			
Profitability (%)	225		170			

Table 8.1.3. 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, 1987.

	In demonst.		out demonst.		Difference	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Yield (t/ha):						
Seed	3.28	0.57	2.54	0.64	0.74	0.41
Straw	6.24	2.64	4.44	1.54	1.80	1.68
Orobanche:						
No. of spikes/m^2	9.0	5.1	24.5	9.9	15.5	9.4
Dry weight (g/m^2)	28.2	23.6	99.1	45.9	70.5	41.2
Economic Evaluation:						
Total variable costs (LE/ha)	511		535			
Net benefit (LE/ha)	1787		1213			
Profitability (%)	350		227			

8.1.1.3. Researcher-managed on-farm trials on method of sowing and seed rates in El-Minia, Kafr El-Sheikh and Behaira Governorates

In El-Minia two trials were conducted to test different sowing methods under full and minimum tillage systems, and seed rates at the farmers' and test levels under zero tillage. In the first trial, the test method involved use of rotavator (instead of chisel ploughing) for seed-bed preparation with seed broadcast followed by one hoeing (broadcast hoeing method) to cover seed under minimum tillage at high seed rate (230.7 kg/ha), and gave 0.28 t/ha higher seed yield and 0.36 t/ha higher straw yield over the broadcast and plough method. This test method gave higher net benefits and profitability (Table 8.1.4). In the second trial, conducted under zero tillage, plant population at the test level of seed rate was higher than farmers' level, which was reflected by higher seed yield at two sites with an average increase of 0.26 t/ha.

In Kafr El-Sheikh four trials were carried out to compare the broadcast hoeing method at two seed rates with the farmers no-till planting methods. Over all sites, the broadcast hoeing method resulted in better emergence at either rate than farmers' method, and average seed and straw yields were increased at the recommended seed rate (184.5 kg/ha) by 12.0% and 7.4%, respectively.

Table 8.1.4. Average seed and straw yields (t/ha), net benefit (LE/ha) and profitability (%) of different sowing methods and seed rates in El-Minia Governorate, Egypt, 1987.

	Sowing method							
	Broadcast/ One hoeing		Broadcast/ 2 ploughings		Broadcast/ 3 ploughings		Seed drill	
	Seed rate (kg/ha)							
	184.5	230.7	184.5	230.7	184.5	230.7	184.5	230.7
Yield (t/ha):								
Seed	2.94	3.34	2.94	3.05	2.76	3.14	2.92	3.64
Straw	5.43	5.81	5.58	5.15	4.74	5.14	5.28	6.59
Economic Evaluation:								
Total variable cost (LE/ha)	463	473	479	489	486	539	472	482
Net benefit (LE/ha)	1584	1824	1580	1595	1407	1594	1552	2042
Profitability (%)	343	387	330	326	289	296	329	423

In Behaira two trials were conducted to study the broadcast hoeing method and the 'Dutzi' seed drill method at different seed rates. The highest seed yield was obtained with the two sowing methods when plant populations were close to the optimum (27-32 plants/m^2). Seed yield was increased by 12.5% with the seed drill method at the high seed rate over the broadcast hoeing method.

8.1.1.4. Back-up research

Research was conducted in the fields of agronomy, genetic improvement, pathology, entomology, microbiology, Orobanche control, soil fertility and plant nutrition, mechanization and nutritional quality. Results are contained in the Proceedings of the VIII Annual Coordination Meeting held in Cairo, 13-17 Sept. 1987. Only a few major findings are presented here.

In an Orobanche chemical control study including 15 treatments conducted at Giza in a soil naturally infested with Orobanche seeds, glyphosate (Lancer) as foliar post-emergence with two sequential sprays at 0.064 kg a.i. in 500 l water/ha proved the best followed by Scepter as foliar post-emergence spray at 0.09 kg a.i. in 500 l water/ha.

Four promising lines derived from a cross between ILB 938 and Giza 3 were evaluated for foliar disease resistance and yield potential, with and without chemical treatments of Dithane M45. Three lines 461/845/83, 461/847B/83 and 461/841/83 were significantly less infected with chocolate spot, rust and alternaria leaf spots than Giza 3. Results from the last three years (1985-1987) indicated that the four lines 461/845/83, 461/847B/83, 461/837A/83 and 461/841/83 gave 21.4%, 16.9%, 16.8% and 12% higher yield than the commercial cultivar Giza 3. Seed of these lines are being multiplied for wider testing before release.

8.1.2. Program in Sudan

8.1.2.1. Pilot production/demonstration program in Gandatu Agricultural Scheme, northern region

A pilot production/demonstration program was conducted for the first time in the Gandatu Agricultural Scheme (Shendi area) to compare an improved package of management consisting of early planting, frequent irrigation, and pest control, with farmers' practices. Eight production plots were chosen to represent the different sections of the scheme. The size of the individual plots ranged from 1.6 to 7 ha, with a total of 29.3 ha. Neighboring farms of similar sizes were used for comparison. Inputs of variable factors are shown in Table 8.1.5.

The effect of the package on grain yield was highly significant (Table 8.1.6), recording yield increase over the traditional practices in neighboring fields ranging from 0.23 to 1.72 t/ha with an average of 1.0 t/ha (46% increase). Economic evaluation indicated that use of the package was profitable with an average

Table 8.1.5. Inputs of variable factors in the pilot production/demonstration plots and neighboring fields in Gandatu scheme, in Sudan, 1987.

Plot No.	Pilot prod./demonst. plots			Neighboring fields		
	Sowing date	No. of Irrigations	No. of pesticide sprayings	Sowing date	No. of Irrigations	No. of pesticide sprayings
1	5/11	9	1	15/11	6	-
2	1/11	10	1	20/11	6	1
3	1/11	8	2	15/11	6	-
4	2/11	9	1	10/11	6	-
5	1/11	10	2	10/11	6	-
6	2/11	10	1	15/11	5	-
7	1/11	10	1	8/11	5	-
8	1/11	10	1	10/11	6	-
Mean	2/11	9.6	1.3	13/11	5.8	0.1

Table 8.1.6. Average grain yield (t/ha) of pilot production/demonstration plots and neighboring farms in the Gandatu scheme, in Sudan, 1987.

Plot No.	Prod./demonstration plots		Neighboring farms		Yield increase over neighboring farms	
	Total area (ha)	Average yield (t/ha)	Total area (ha)	Average yield (t/ha)	(t/ha)	(%)
1	3.1	2.8	2.9	1.7	1.1	61
2	1.6	3.8	1.7	2.7	1.1	42
3	3.2	2.0	3.7	1.4	0.7	50
4	2.6	3.1	2.7	2.9	0.2	8
5	2.3	2.8	1.9	3.1	-0.3	-9
6	3.7	2.9	3.8	1.2	1.7	148
7	5.9	3.5	5.8	2.7	0.8	31
8	7.0	3.6	7.0	2.2	1.4	65
Mean	3.7	3.2	3.7	2.2	1.0	46.0

increase in net benefits of LS 2165/ha over farmers' practices, associated with a marginal rate of return of 1099% (Table 8.1.7). Moreover, sensitivity analysis indicated that the profitability of the package was stable over considerable variation in either total variable costs or faba bean price. These results are in conformity with the findings of the previous pilot production/demonstration plots at Aliab, Zeidab and Sayal Schemes.

8.1.2.2. Pilot production/demonstration plots in the new areas in Sudan

As a part of the continued efforts to bridge the gap between faba bean production and consumption in Sudan, new ventures are being undertaken to extend production of the crop to the irrigated central schemes. The high potential of faba bean cultivation in the new areas has been demonstrated over the last four years from yield maximization and production plots at Gezira, Rahad and New Halfa. In continuation of the efforts to extend faba bean cultivation to

Table 8.1.7. Partial budget of pilot production/demonstration plots in the Gandatu scheme, in Sudan, 1987.

	Package farmers		Neighboring farmers
Benefits:			
Av. yield (kg/ha)	3145		2155
Field price (LS/kg)	2.386		2.386
Gross benefits (LS/ha)	7504		5142
Variable costs:			
Total cost of irrigation (LS/ha)	382		229
Total cost of pest control (LS/ha)	47		3
Total variable costs (LS/ha)	429		232
Net benefits (LS/ha)	7075		4910
Diff. in net benefits (LS/ha)		2165	
Diff. in variable costs (LS/ha)		197	
Marginal rate of return (%)		1099	

the new areas twenty five farmers in Gezira, five in Rahad and ten in New Halfa were assisted with the crop each in an area of 0.42 ha following the production package developed in the NVP at the Gezira Research Station, Wad Medani. The average yield for 23 plots (including those that suffered from water stress) was 2.2 t/ha, with an average net return of Sudanese pound 3972 (Table 8.1.8). In Rahad and New Halfa, efforts should be made to increase productivity to higher acceptable levels before the crop is recommended for commercial production.

Table 8.1.8. Average seed yield, gross and net returns of pilot production-cum-demonstration plots in the Gezira scheme in Sudan, 1987.

	Gezira							
			Dirweesh*					
	Turabi	Debeiba	1	2	3	Average	Rahad	New Halfa
Average yield (kg/ha)	2279	2996	3249	1050	1300	2175	1084	854
Farm-gate price (LS/kg)	2.391	2.691	2.762	3.095	3.143	2.816	3.829	2.619
Gross returns (LS/ha)	5449	8062	8974	3250	4086	5962	4151	2238
Total variable cost	2029	1927	2400	1640	1955	1990	2394	1826
Net return (LS/ha)	3420	6135	6574	1610	2131	3972	1757	412

* 1 = Wad Hemeidan 2 = Wad Adam 3 = Wad El-Leethi

8.1.2.3. Farmer-managed on-farm trials in northern region of Sudan

A package of improved production practices was evaluated in farmer-managed trials conducted in the Nile Province at 13 sites in El-Basabeir and 9 in Hagare Al Asal and in the Northern Province at 7 sites in Selaim and 6 in Burgeig. The improved package of management consisted of early planting, frequent irrigation and pest control. At Selaim and Burgeig, weed control was also included. The effect of the package on grain yield was highly significant at El-Basabeir, Hagar Al Asal and Selaim with grain yield increases of 1628 (94%), 1307 (62%) and 809 (31%) kg/ha obtained with the improved package over traditional farmers practice, respectively. At Burgeig, however, yield response to the package was negligible due to small increase in seed yield and large increase in total variable cost. Adoption of the improved package was highly profitable in El-Basabeir, Hagar Al-Asal and Selaim with an average increase in net profits of Sudanese pounds 2317, 1764 and 1133, respectively. Sensitivity analysis indicated that these benefits were very stable under large changes in total costs and faba bean prices (Table 8.1.9).

8.1.2.4. Back-up research

Back-up research covering different disciplines was carried out with particular emphasis on faba bean improvement for new areas in Sudan

Table 8.1.9. Average seed yield (kg/ha), gross and net returns (LS/ha) and marginal rate of return (%) of the farmer-managed trial in the faba bean traditional areas in Sudan, 1987.

	El-Basabeir		Hajar El-Asal		Selaim	
	Test Package	Farmers practice	Test package	Farmers practice	Test package	Farmers practice
Average yield (kg/ha)	3357	1729	3424	2117	3425	2616
Farm-gate price (LS/kg)	2.588	2.588	2.629	2.629	2.455	2.455
Gross benefits (LS/ha)	8688	4475	9002	5566	8408	6422
Cost of irrigation (LS/ha)	3920	2046	318	181	3960	3072
Cost of pest control (LS/ha)	24	2	67	5	96	131
Total variable costs (LS/ha)	3944	2048	4243	2571	4056	3203
Net benefits (LS/ha)	4744	2427	4759	2995	4352	3219
Difference in net benefits	2317		1764		1133	
Difference in variable costs	1896		1672		835	
Marginal rate of return (%)	122		106		133	

south of Khartoum. Progress was made in identifying superior genotypes, irrigation practices, insect control, weed control, biological nitrogen fixation and nutritional quality. Mechanization of seeding and harvesting was also investigated and available machines modified for faba bean.

8.1.3. Program in Ethiopia

8.1.3.1. Pilot production/demonstration plots in some selected faba bean growing areas of Ethiopia

Pilot production/demonstration programs on faba bean were for the first time conducted in some selected faba bean growing areas of Ethiopia both under red soil (Netosols) and black soil (Vertisols) conditions. The improved package of management consisted of use of the improved variety (CS20DK), higher seed rate (200 kg/ha), fertilizer application (100 kg DAP/ha), and weeding twice. Grain yield advantage from the application of the recommended package in the red soil areas ranged from 200 kg/ha (18% increase) at Motta to 1420 kg/ha (95% increase) at Chiri with an average of 930 kg/ha (83%) over the farmers' normal practices (Table 8.1.10). Grain yields in vertisols were low compared with those in red soils (Table 8.1.10), especially at Bichena due to waterlogging which results in severe incidence of black root-rot.

Economic evaluation of the demonstration plots showed that the recommended package was profitable and resulted in an average increase in net benefits of 104 and 357 Ethiopian Birr/ha with the AMC and LM prices, respectively (Table 8.1.11).

8.1.3.2. Exploratory survey of the major faba bean producing awraja of the Arsi Administrative Region of Ethiopia

Arsi is the smallest administrative region (Province) in Ethiopia with only three awrajas (Administrative Divisions). These are Chilalo, Ticho and Arba Gugu. Of these, Chilalo is the major faba

Table 8.1.10. Grain yield (kg/ha) of improved and farmers' methods of faba bean production demonstrations in red and black soils, Ethiopia, 1986.

Demonstration site	No. of farmers	Total area	Grain yield (kg/ha) Improved package	Farmers' practice	Difference (kg/ha)	%
Red soils:						
Chiri	1	1.0	2920	1500	1420	95
Lafto Wajetu	1	0.5	2230	1200	1030	86
Wolmera Goro	2	1.0	1650	850	800	94
Mota	2	1.0	1300	1100	200	18
Debre-Tabor	2	1.0	2200	1000	1200	120
Mean			2060	1130	930	83
L.S.D. (0.05)			580			
C.V. (%)			21			
Black Soils:						
Bichena	1	0.5	710	290	420	145
Inewari	2	1.0	2650	900	1750	194
Mean			1680	595	1085	170
L.S.D. (0.05)			NS			
C.V. (%)			35			

Table 8.1.11. Partial budget analysis of the effect of the recommended package of faba bean production in red soil areas, Ethiopia, 1986.

	Improved package	Farmers' practice	Difference
Grain yield (kg/ha)	2060	1130	930
Gross returns			
AMC price (Birr/ha)[1]	618	339	279
LM price (Birr/ha)[2]	1174	644	530
Total variable costs (Birr/ha)	292	116	176
Net benefits			
AMC price (Birr/ha)	327	223	104
LM price (Birr/ha)	883	526	357

1. AMC = Agric. Marketing Corporation price = 0.30 Birr/kg
2. LM = Local Market price = 0.57 Birr/kg

bean producing awraja and therefore, was selected for this study. The major objectives of the survey were to identify and prioritize major faba bean production constraints, and to help design relevant on-farm trials to alleviate these problems.

A total of 30 farmers were interviewed using a non-formal questionnaire. The majority of sample farmers surveyed used the local faba bean cultivars (landraces) due to higher prices of improved variety seeds. The local faba bean cultivars are susceptible both to diseases and insect-pests. Farmers in the sample area are unique in their faba bean production methods using a higher frequency of ploughing, fertilizers and weed control. Considering the present efforts made by these sample farmers in faba bean cultivation, introduction of improved technologies to boost faba bean production in this area should be easily accomplished.

8.1.3.3. Evaluation of faba bean production package on farmers' fields in the Central Highlands of Ethiopia

Evaluation of a production package on farmers' fields with respect to their application and feasibility was initiated in the 1985 cropping season through on-farm trials in Menagesha (Holetta) and Yerer-Kereyu (Debre Zeit) zones of the Shewa Administrative Region. Of the seven agronomic factors tested in different combinations in these two zones improved cultivar, early sowing, weed control and fertilizer application were found most important in increasing faba bean grain yield. In 1986, these four important production factors were evaluated at three locations in the Menagesha zone, and seven locations each in Selale and Yerer-Kereyu zones of the Shewa Administrative Region.

Of the three zones where faba bean on-farm trials were carried out, highest mean grain yield of 1836 kg/ha was obtained from Yerer-Kereyu (Debre Zeit) followed by Menagesha (Holetta) (1263 kg/ha) (Table 8.1.12). The overall mean grain yield was low in Selale because of drainage problems at most locations leading to a higher incidence of black root rot (Fusarium solani). Considering results of both the 1985 and 1986 cropping seasons early sowing resulted in the highest mean advantage of about 80% across the three zones over farmers' traditional practices, and should be considered to increase faba bean production in all the three zones.

Table 8.1.12. Average grain yield (kg/ha) and net benefits (Birr/ha)[1] obtained from individual factor and/or combination of factors in the faba bean on-farm trials in Ethiopia, 1986.

Treatment[2]	Zone					
	Menagesha		Yerer-Kereyu		Selale	
	Yield (kg/ha)	Net benefits (Birr/ha)	Yield (kg/ha)	Net benefits (Birr/ha)	Yield (kg/ha)	Net benefits (Birr/ha)
T1. ABCD	1761	259	2821	461	687	-174
T2. ABcD	1534	288	2029	337	785	-19
T3. AbCd	1472	202	2249	430	1303	204
T4. Abcd	1439	272	1749	390	1450	310
T5. aBCd	947	92	1902	344	449	-2
T6. aBcd	895	157	1459	324	715	134
T7. abCD	1182	139	1894	270	772	-124
T8. abcD	1199	218	1355	232	879	2
T9. abcd	936	170	1065	228	654	113
Mean	1263		1836		855	

1. 1 US dollar = 2.07 Ethiopian Birr.
2. Letters A,B,C, and D denote sowing date, variety, fertilizer and weed control, respectively. Capital letters denote the recommended practice whereas the small letters denote the farmers practice.

8.1.3.4. Back-up research

Back-up research was carried out in Ethiopia in the field of germplasm evaluation and genetic improvement, disease, insect, and weed control, microbiology and nutritional quality. Details are given in the Proceedings of the VIII Coordination Meeting of the NVP.

In order to identify high yielding faba bean varieties, faba bean verification trials, national variety trial and extension variety trial were conducted at several locations. From the released varieties tested At Addet, Sinana CS20DK and NC 58 could be recommended for Sinana and similar agro-ecological zones. An ICARDA derived line 74TA 12050 x 74TA 236 could be utilized for immediate use since it was tolerant to chocolate spot and yielded better than the standard check CS20DK. Based on the results of 3 years (1983-1985) experiments, coll. 111/77 has a wide adaptation across locations and could be used to replace CS20DK.

A survey of faba bean diseases in the major production areas revealed that chocolate spot (*Botrytis fabae*) was the most important disease of faba bean in Ethiopia followed by rust (*Uromyces vicia* fabae) and black root rot (Fusarium solani). The chocolate spot was most prevalent in severe forms in both the mid (1900-2200 amsl.) and the high (2200-3000 amsl.) altitudes. Other potentially important diseases included ascochyta blight for the high altitudes, powdery mildew for the mid and low altitudes, and leaf roll virus for both the mid and high altitudes.

A survey of faba bean storage pests conducted gave a mean bruchid damage figure of 41% and weight loss of 14.4 percent. 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.

8.2. ICARDA North African Food Legume Program

Due to the importance of food legumes in the North Africa Region, ICARDA has posted a senior scientist in Morroco to strengthen national research and technology transfer programs in Morocco, Algeria and Tunisia. IDRC financially contributed to the ICARDA North African activities.

In this report only highlights will be presented since a detailed annual report will be prepared for each country.

8.2.1. Tunisia/ICARDA cooperative project 1986/87

In the Food Legume Cooperative Project between ICARDA and the Institute National de la Recherche Agronomique de Tunisie (INRAT), joint efforts continued on the improvement of all three food legume crops by the multi-disciplinary multi-institutional coordinated team of food legume scientists. The Institute National d'Agronomie (INAT) was involved in disease research and the Office des Cereales conducted verification trials.

The research activities on food legumes in Tunisia are focused at Beja and Kef research stations representing the different agroclimatic conditions of the main production areas. The program continued breeding for high yield, disease resistance, good agronomic attributes and desirable seed quality. Agronomy research was to confirm earlier recommendations on cultural practices and to evaluate the performance of new varieties in farmers' fields. Climatically, the 1986/87 season was characterized by good rainfall exceeding the mean annual level with an even distribution.

8.2.1.1. Faba bean breeding

In both large and small seeded faba bean breeding programs, emphasis continued on the development of high yielding genotypes with durable resistance to *Botrytis fabae*, *Ascochyta fabae*, stem nematode, and *Orobanche*.

In the large-seeded program, 56 advanced breeding lines were tested for yield in three different trials. In all trials several lines outyielded the local check at one or more locations but only three lines did so significantly at one location (Table 8.2.1). Yield increases over the local check ranged between 35% and 47%. Two of these lines (Reina Blanca and 74TA 22) have been tested for several years and locations and showed a stable yield performance (Table 8.2.2). Highest yields of tested entries for Kef and O. Meliz were 4.9 and 5.9 tons/ha, respectively, while the corresponding local check mean yields were 3.9 and 5.5 tons/ha.

Seventy-six small-seeded advanced breeding lines were tested in similar trials at one or more locations. Lines FLIP 83-89FB and 75TA 10 outyielded significantly the check at Beja by 28% and 25%, respectively, and at Kef by 26% and 16%, respectively.

In a systematic disease survey, *B. fabae* was by far the desease most prevalent (81.4% of fields visited) followed by *Alternaria* leaf spot (27.9%) and *Ascochyta fabae* (16.3%). Severity of *B. fabae* was

Table 8.2.1. Grain yield of faba bean lines significantly exceeding, local check mean at least at one location (Beja and/or Kef), 1986/87.

Trial and entry	Beja		Kef	
	Yield (kg/ha)	% of check	Yield (kg/ha)	% of check
	Large Seeded			
FBIYT-L				
- Reina Blanca	4850	147	4141	123
- 74TA 22	4650	143	4708	140
- FLIP 83-17 FB	4392	135	4750	142
- Local check (X)	3245	100	3354	100
- SE ±	693		736	
- C.V. (%)	18.5		17.4	
FBF4 AYTL+S				
- S 84-145	4450	145	5075	110
- Local check (X)	3060	100	4619	100
- SE ±	605		668	
- C.V. (%)	15.8		13.5	
	Small Seeded			
FBAYT-S2				
- 77TA 48	3992	101	4441	114
- 75TA 10	4925	125	4525	116
- FLIP 83-89FB	5050	128	4891	126
- Local check (X)	3937	100	3894	100
- SE ±	546		470	
- C.V. (%)	14.2		11.8	

1. Underlined values are significantly different from check mean at 5% probability level.

Table 8.2.2. Performance of two large seeded lines expressed as percentage of local check yield over years and locations in Tunisia.

Season	74 TA 22 (ILB)			Reina Blanca (ILB 1217)		
	Beja	Kef	Other locations[1]	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
Mean[2]	104	128	113	131	119	117

1. Mateur, 1982/83 and 1983/84; and Oued Meliz 1985/86 and 1986/87.
2. Mean of two trials.

high particularly in the north where up to 70% leaf coverage was found in some fields. Thus it is considered important to increase efforts to solve problems related with screening for Botrytis resistance.

8.2.1.2. Chickpea breeding

The objective of the chickpea breeding program is to develop high yielding genotypes suitable for spring and winter seasons, by identifying sources of resistance to both fusarium wilt and ascochyta blight and incorporating such resistance into high yielding genotypes with good seed quality.

To develop cultivars for winter sowing, 245 advanced breeding lines were tested at one to four locations in nine replicated trials. In addition, 110 lines were tested in non-replicated observation nurseries at two locations. A number of the lines tested yielded 3 to 4 tons/ha which was more than double the yield of local checks in a number of trials (Tabel 8.2.3). With such a large number of high yielding lines, the main selection criterion was on disease tolerance. In Tunisia, like all other North African countries, both A. rabiei and root rot/wilt complex are serious on winter sown chickpea. Wilt is also serious on spring chickpea. Specific crosses were made at ICARDA and targetted for Tunisia to combine resistance to wilt and Ascochyta as well as good agronomic attributes.

Using a wilt-sick plot (WSP), two-cycle systematic screening of germplasm accessions (ICARDA collection) and advanced lines of the breeding program yielded, 18 accessions showing less than 10% wilt incidence which are thus considered resistant to wilt (Fusarium and Verticilium):

ILC 76	ILC 210	ILC 280
ILC 98	ILC 219	ILC 449
ILC 114	ILC 257	ILC 452
ILC 127	ILC 277	ILC 469
ILC 226	ILC 299	ILC 477
ILC 260	ILC 605	ILC 491

Table8.2.3.Multilocation yield performance of chickpea lines yielding significantly higher than local check means at three locations in Tunisia, 1986/87.

Trial abbreviation and line names	Beja Yield (kg/ha)	Beja % of check	Kef Yield (kg/ha)	Kef % of check	O. Meliz Yield (kg/ha)	O. Meliz % of check
CAYT-W4						
- FLIP 84-145C	3833	126	2725	176	2882	325
- Local mean	3042	100	1545	100	888	100
- SE +	554		345		381	
- C.V. (%)	18.8		18.1		13.0	
CIYT MR						
- FLIP 83-93C	3706	133	3096	153	2550	219
- Local mean	2781	100	2019	100	1162	100
- SE +	531		427		500	
- C.V. (%)	17.2		20.1		20.4	
CIYT STR						
- FLIP 82-127C	3468	150	3065	196	3177	147
- FLIP 84-148C	3644	157	2950	189	3005	142
- FLIP 84-161C	3106	134	3190	204	3080	145
- FLIP 84-163C	3362	145	3259	209	3437	162
- Local mean	2315	100	1561	100	2122	100
- SE +	455		533		383	
- C.V. (%)	15.7		19.8		13.5	
CIYT-SP						
- FLIP 81-293C	3425	122	3353	217	3505	205
- FLIP 83-42C	3493	124	3018	195	2837	116
- FLIP 84-60C	3550	126	2950	191	2587	151
- FLIP 84-146C	3887	138	3109	201	3362	196
- FLIP 84-148C	3493	124	2984	193	2542	166
- FLIP 84-149C	3656	130	3512	227	3462	202
- FLIP 84-155C	3343	119	3100	201	3455	202
- FLIP 84-159C	3343	119	3231	209	3117	182
- FLIP 84-164C	3756	133	3337	216	3555	208
- ILC 482	3806	135	3518	228	3300	193
- Local mean	2818	100	1544	100	1712	100
- SE +	315		448		578	
- C.V. (%)	10.0		15.9		18.6	

Artificial screening for resistance to blight is done under both field and laboratory conditions. A number of lines possessed high yield, disease resistance, good seed quality and attributes for mechanical harvest. Those with stable performance over years and locations were pre-selected for eventual release. For example, FLIP 82-239C outyielded the best local check at Kef and O. Meliz by 103 and 198%, respectively, had good seed quality and was fairly resistant to blight (scored 4 and 3.5 in a 1 to 9 rating scale under field and laboratory conditions, respectively). This line also was fairly stable with good yield performance over years and locations (Table 8.2.4). The winter cultivars released in 1986, FLIP 83-46 C and ILC 3279, have continued to perform well this season.

Advanced spring chickpea breeding lines were yield tested at locations in replicated trials. Lines FLIP 83-37C, FLIP 83-48C and FLIP 83-50C yielded 1.7 to 2.1 tons/ha compared to 1.5 tons/ha for the local check mean. FLIP 84-88C outyielded the local check mean (1.6 tons/ha) by 32%. The spring cultivar, Be-Se-48, released in 1986 had good performance this season as well.

8.2.1.3. Lentil breeding

Lentil breeding continued to increase yield level and stability. Particular attention was given to tall erect genotypes with good pod retention to facilitate mechanical.

Lentil improvement covers both large and small seeded types with more emphasis on the former. This season, 163 large seeded

Table 8.2.4. Yield performance of chickpea line FLIP 82-239C over years and locations in Tunisia.

Season	Trial	Beja		Kef		O. Meliz		Ras Rajel	
		Yield (kg/ha)	% of local	Yield (kg/ha)	% of local	Yield (kg/ha)	% of local	Yield (kg/ha)	% of local
1984/85	IYT-STR	2008	103	1818	96	—	—	—	—
	PYT-2	1562	154	1600	130	—	—	—	—
1985/86	IYT-STR	2363	175	325	96	3300	132	407	89
	AYT-W3	2325	150	262	72	2537	101	1082	125
1986/87	AYT-W2	3075	105	3170	203	3165	298	—	—
Mean		2267	137	1435	24	3001	177	745	107

advanced breeding lines were yield tested in 1 to 3 locations. Eight lines outyielded the local check mean significantly at all locations combined (Table 8.2.5). In the small seeded project, out of 23 advanced breeding lines tested, 11 performed well across three locations representing different agroclimatic conditions (Table 8.2.5). Because of its stable performance over years and locations, FLIP 84-103L was pre-selected for release. Averaged over locations, it exceeded the local check by 27%, 14% and 18% in 1984/85, 1985/86 and 1986/87 seasons, respectively.

Table 8.2.5. Multilocation yield performance of small and large seeded lentil lines in comparison with local check in Tunisia, 1986/87.

Trial and lines	Beja		Kef		O. Meliz	
	Yield (kg/ha)	% of local	Yield (kg/ha)	% of local	Yield (kg/ha)	% of local
		Small Seeded				
LIYT-S						
- ILL 1939	2250	124	1350	106	2084	130
- 76TA 66005	2868	159	1667	131	2112	132
- FLIP 84-26L	2868	159	1000	78	1900	118
- FLIP 84-49L	2281	126	1275	100	2206	137
- FLIP 84-58L	2131	118	1580	124	2500	156
- FLIP 84-59L	3193	177	1342	105	2318	144
- FLIP 84-61L	2387	132	1737	136	2125	132
- FLIP 84-62L	2533	140	1325	104	1875	116
- FLIP 84-159L	2858	158	1555	122	2206	137
- FLIP 85-16L	2962	164	1325	104	1981	123
- FLIP 85-31L	2175	120	1637	122	2418	152
- Local Oueslatia (X)	1808	100	1277	100	1606	100
- SE +	470		275		290	
- C.V. (%)	20.0		23.5		14.6	
		Large Seeded				
LAYT-L3						
- FLIP 84-50L	1853	78	1291	132	2650	137
- FLIP 84-125L	2650	112	1154	118	2482	128
- ILL 4606	2362	99	1375	141	2375	122
- Local mean	2387	100	975	100	1941	100
- SE +	364		213		397	
- C.V. (%)	15.5		20.8		20.3	

1. Underline values are significantly different from local check at 5% probability level.
2. Small seeded cultivars released into Tunisia in 1986.

8.2.1.4. Agronomy and on-farm trials

Agronomy studies this season were conducted to verify research findings on cultural practices of direct importance to farmers, on farmers fields in major production areas at six locations in Northern Tunisia: Menzi Bourkiba, M.Tamime, Bou Salem, Teboursouk, Toubraba, and Zaghouan.

Using local faba bean cultivars, early November planting yielded 37% more than that of late December. Narrower inter-row spacing (50 cm) increased yield by 33% when compared to the wider spacing (90 cm) commonly followed by farmers. Igran (3.5 kg a.i./ha) plus Kerb (1.0 kg a.i./ha) were effective in controlling weeds, and the yield obtained was not significantly different from that of manual weeding.

In chickpea on-farm trial, winter sowing yielded almost four times more than spring sowing with two newly released winter cultivars having resistance to ascochyta blight (Table 8.2.6). FLIP 83-46C outyielded the local by 81 and 25% in winter and spring planting, respectively, while ILC 3279 gave the lowest yield in the absence of Ascochyta blight. Narrower spacing (30 cm) gave better yield than wider spacing (45 and 60 cm) with the same population density. Igran (4.0 kg a.i./ha) plus Kerb (1.0 kg a.i./ha) were only partly effective in weed control.

In lentil, narrower spacing (30 cm) also gave better yield than wider spacing (45 and 60 cm). Maloran (2kg a.i./ha) was partly effective in weed control across locations but Maloran plus Kerb (1.0 kg a.i./ha) was more effective in the weedy location, Toubrba.

Table 8.2.6. Yield of winter and spring sown chickpea cultivars in on-farm trials in Tunisia, 1986/87.

Sowing date	Local Amdoun	ILC 3279	FLIP 83-46C	Mean
		Tons/ha		
December 1	1.60	1.30	2.90	1.93
March 2	0.48	0.43	0.60	0.50

8.2.2. Marocco/ICARDA cooperative project

In this project between ICARDA and the Institut National de la Recherche Agronomique (INRA), research was conducted in seven research stations: Jema'Shim, Khemis Zemamra, Ain Nizagh, Sidi Laidi, Merchouch, Guich and Douyet. The first four stations, in South-Central region, are in arid to semi-arid areas with mean annual rainfall of 255 to 288 mm. The last three stations, in North-Central region, are also in semi-arid areas but with more favorable precipitation, with 362, 449, and 457 mm mean annual rainfall, respectively. Research work on faba bean was concentrated in Douyet and Guich, typical of rainfed faba bean growing region of Morocco, while work on chickpea and lentil was done mainly in the locations with less rainfall.

Drought was the main climatic feature of the 1986/87 crop season. Effective rainfall in South-Central stations was 200 mm or less with poor distribution (December was dry and little rainfall was received after February), and in North-Central sites rainfall ranged between 235 to 331 mm, also with poor distribution. Fusarium wilt (Fusarium oxysporum) was prevalent due to high temperature in February and March. The disease reached epiphytotic levels in Khemis Zememra station where both research and seed increase fields were heavily damaged (up to 100%). Contrary to previous seasons, ascochyta blight did not develop. It was only observed localized in two farmers' fields.

8.2.2.1. Faba bean breeding

The faba bean breeding program focuses on high and stable yield with large seed, early maturity, and resistance to diseases, mainly Botrytis fabae. The FAO project on Orobanche, the most serious problem facing the crop, was terminated in 1985/86 and a national program for screening for resistance is being initiated in 1987/88 with ICARDA support. The breeding program this season included maintenance of national germplasm collections (314 accessions), yield testing and observation nurseries of advanced breeding lines, bulk and single plant selections in F_2, F_3, F_4, F_6 segregating populations, and screening for resistance to B. fabae.

In large and small seeded types, 34 advanced lines were yield tested. Though 26 lines exceeded the local check in both trials, none did so significantly.

Utilizing adapted local germplasm, crosses were made at ICARDA and targetted for Morocco and North African conditions and F_4 bulks were provided to the national program for early generation testing under local conditions. Disease development was limited this season because of serious drought. Considering that these selections were mostly made under excessive moisture stress (314 mm, poorly distributed), they are expected to have some tolerance to drought.

8.2.2.2. Chickpea breeding

The chickpea breeding program focuses on the development of high yielding cultivars adapted to winter and spring seasons with good seed quality. Since the merits of winter sowing were well established in previous years, the program put more emphasis on winter and dual season types with resistance to Ascochyta rabiei, large and good quality seed and early maturity. Some emphasis is also put on resistance to leaf miner, Liriomyza cicerina, which is important in both seasons but more so in spring.

In winter chickpea program, 83 advanced breeding lines were yield tested in one to three locations in six replicated trials. In addition, 87 advanced breeding lines were evaluated in a nursery with two replicates. Based on results, FLIP 83-48C, FLIP 84-92C, FLIP 84-99C, FLIP 84-144C, FLIP 84-145C and ILC 482 showed wide adaptation. Some of these lines had tolerance to wilt which needs further verification. The local check was more tolerant to wilt compared with most other tested lines.

During this and the previous two seasons, ten winter lines were retained in national trials since they outyielded the local checks at more than one location. Table 8.2.7 lists these lines in addition to ILC 195 and ILC 482 with their advantages expressed as percentages of local checks. FLIP 81-293C, FLIP 82-93C, FLIP 82-128C, FLIP 82-161C were recommended particularly for large seed size.

To transfer winter chickpea sowing technology to farmers, ten half-hectare on-farm trials were conducted. ILC 482 and local cultivars were evaluated in winter and spring sowing with two agronomic practices: weed control (Igran 3 kg a.i./ha, hand weeding and control) and fertilization 60 kg P_2O_5/ha vs no P). Winter planting gave up to 1.30 tons/ha for local and up to 1.21 tons/ha for ILC 482 while spring planting resulted in crop failure due to drought at nine sites out of ten. Ascochyta blight symptoms were observed only on local cultivars at two fields but damage was not serious due to weather conditions unfavorable for disease development. ILC 482 was seriously affected by Fusarium wilt disease in one field. Igran was effective in weed control at early stages of crop development in winter sowing. Fertilizer application had a positive effect on yield of winter crop depending on soil fertility.

Upon the recommendation made by the National Committee for Selection of Seeds and Plants, ILC 195 and ILC 482 were officially registered and approved for release in October, as the first two winter chickpea cultivars in Morocco. These two lines have proven to be superior in yield over local cultivars with stable performance over seasons and locations (Table 8.2.7 and 8.2.8). In addition, they are tolerant to ascochyta blight disease to which local cultivars are susceptible. They are comparable in maturity to locals.

In the spring chickpea program, advanced breeding lines were yield tested in replicated trials at Merchouch and in a non-replicated observation nursery. The highest ten yielding lines in both trials are presented in Table 8.2.9. None of the tested lines performed better than the local. Factors which contributed to

Table 8.2.7. Performance of promising winter chickpea lines expressed as percentage of local check yields at locations and seasons in Morocco.

	J. Sihim		Sidi Laidi	Merchouch			Douyet			Mean	
	1984/85	1985/86	1985/86	1985/86	1986/87	1986/87	1984/85	1985/86	1986/87	Yield (kg/ha)	% of local
FLIP 81-293C	105	109	113	257	94	102	75	179	98	1802	126
FLIP 82-91C	96	94	121	267	104	-	139	174	98	1842	136
FLIP 82-93C	109	122	143	234	104	-	128	174	88	1868	138
FLIP 82-115C	81	158	167	230	98	-	122	147	84	1805	136
FLIP 82-127C	113	118	135	274	88	100	94	166	105	1862	133
FLIP 82-128C	113	123	110	253	107	97	80	177	98	1862	129
FLIP 82-150C	92	144	100	309	102	-	136	190	93	1994	146
FLIP 82-152C	100	175	106	255	102	-	118	157	92	1925	138
FLIP 82-161C	90	117	127	229	-	99	106	162	—	1772	133
FLIP 82-169C	104	164	171	252	92	-	115	157	96	1920	144
ILC 195*		118	191	206	-	-		170		1930	171
ILC 482*	111	129	171	259	97	115	105	207	94	2027	143
Pch 46 (Local)	100	100	100	100	100	100	100	100	1501	100	

1. Percentages are based on yield data of national yield trials (national and advanced) except for 1984/85 which were based on CIYT-W-MR.
* Released in October, 1987.

Table 8.2.8. Performance of ILC 195 and ILC 482 at different locations in two seasons as presented by Moroccan seed production control services (MARA) for official inscription in catalogue before their release in October, 1987.

Line	Sidi Laidi				Merchouch				Douyet				Ben Yakhlef		Mean	
	1984/85		1985/86		1984/85		1985/86		1984/85		1985/86		1984/85			
	Y	R	Y	R	Y	R	Y	R	Y	R	Y	R	Y	R	Y	R
Pch 37 (local)	781	4	0	4	1180	4	0	4	1281	5	489	4	435	5	595	4
Pch 484	771	5	424	3	1280	3	1293	3	1640	3	1938	3	721	2	1152	3
Pch 46 (local)	1020	3	0	4	1000	5	0	4	1367	4	0	5	516	3	558	5
ILC 195	1052	2	483	1	1790	1	1826	1	1656	1	2469	1	507	4	1398	2
ILC 482	1233	1	459	2	1660	2	1706	2	1652	2	3042	2	801	1	1508	1
Mean	970		273		1360		965		1520		1587		596			
L.S.D. (.05)	NS		467		710		205		NS		602		154			
C.V. (%)	30.6		86.1		26.0		10.7		18.0		19.1		13.0			

1. Y = grain yield in kg/ha, R = rank.

high spring yields in Merchouch were early planting (February 9), high residual moisture in very heavy soil, 135 mm rainfall received after planting and relatively cool weather in April, May and June. CIYT-L was also evaluated for the winter season at K. Zememra. FLIP 84-18C, FLIP 85-5C and FLIP 85-135C showed wide adaptation as potential dual season cultivars.

Screening for resistance to A. rabiei was not possible this season because the disease did not develop naturally. To avoid losing time in testing for resistance, the program is developing facilities for artificial screening at Dar Bouazzeh. Of equal importance is resistance to fusarium wilt for which a sick plot was identified in K. Zememra.

Leaf miner, L. cicerina, was serious this season in winter as well as spring chickpea because of relatively high temperatures in

Table 8.2.9. Grain yield of best ten spring chickpea lines of CIYT-Sp and CIYT-L in comparison with a local check at Marchouch, 1987[1].

CIYT-SP			CIYT-L		
Line	Yield (kg/ha)	% of local	Line	Yield (kg/ha)	% of local
FLIP 82- 73C	1746	166	FLIP 84- 12C	1456	154
FLIP 84- 78C	1742	166	FLIP 84- 15C	1755	186
FLIP 84- 82C	1858	177	FLIP 84- 18C	1777	188
FLIP 84-126C	1929	183	FLIP 84- 19C	1550	164
FLIP 84-146C	2170	207	FLIP 85- 5C	1672	177
FLIP 84-161C	1779	169	FLIP 85- 7C	1972	177
FLIP 84-181C	1929	183	FLIP 85- 61C	1544	164
ILC 482	1829	174	FLIP 85-135C	2110	236
Pch (local)	1050	100	Pch 46 (local)	944	100
Location mean	1702		Location mean	1517	
S.E. ±	32		S.E. ±	57	
C.V. (%)	14.2		C.V. (%)	15.4	
L.S.D. (.01)	453		L.S.D. (.01)	524	

1. Planted February 9, 1987.

February and March. Screening for leaf miner using CILMN under natural infestation indicated that ILC 662, ILC 822, ILC 826, ILC 1000, ILC 2334 and ILC 3397 were less attacked than other lines.

8.2.2.3. Lentil breeding

In both small and large seeded lentil, the breeding program focuses on high and stable yield, early maturity, acceptable seed quality and mechanical-harvesting charactersitics (tall, erect types with resistance to pod shattering).

This season, 52 advanced breeding lines were yield tested at two locations (Merchouch and Sidi Laidi). In all trials a number of lines exceeded the local check at more than one location and 22 lines did so significantly at Sidi Laidi, where grain yield levels were low due to the severe drought (effectively 185 mm rainfall poorly distributed) and extensive nodule damage by Sitona larvae. At Merchouch, yields were higher in both seed types due to favorable conditions in spite of moisture stress. Best yielding lines are presented in Table 8.2.10. Out of these lines, four (76TA 66005, small seeded; and Precoz, 74Ta 19, and 78S 26002, large seeded) showed exceptional performance and wide adaptation over season and locations (Table 8.2.11). Due to its earliness and good seed quality, Precoz (ILL 4605) was recommended for catalogue evaluation.

8.2.2.4. Agronomy

Agronomy research on food legumes in Morocco included studies on sowing dates, planting pattern and population density, weed control, the need for Rhizobium inoculation, planting and harvesting methods.

In studies on dates of planting in chickpea using six genotypes, winter sowing increased yield by 47 and 177% in Merchouch (331 mm) and J. Shim (200 mm), respectively. It is apparent that advantage of winter sowing is greater in drier environments. In another study, 11 November planting gave 19 to 35% more yield than 2 December and 12 January planting dates, respectively.

Table 8.2.10. Performance of best yielding small and large seeded lentil lines in comparison to local cultivars in Morocco, 1986/87.

Line	Small seeded (LIYT-S) Sidi Laidi[1] Yield (kg/ha)	% of local	Marchouch[2] Yield (kg/ha)	% of local	Line	Large seeded (LIYT-L) Marchouch Yield (kg/ha)	% of local
ILL 1339	317	184	975	114	ILL 4605	1350	138
76TA 66005	343	199	1016	119	74TA 19	1358	139
FLIP 84-26L	365	212	1134	133	78S 26002	1383	142
FLIP 84-29L	386	224	1022	120	FLIP 84-27L	1373	142
FLIP 84-75L	310	180	1128	132	FLIP 84-76L	1429	147
FLIP 84-82L	415	241	1247	146	FLIP 84-148L	1421	146
L 24 (local)	172	100	853	100			
Location mean	268		853			1145	
S.E. ±	29		148				
L.S.D. (.05)	109		418			522	
C.V. (%)	21.6		35.5			27.5	

1. Effective rainfall 196 mm, poorly distributed and nodule damage by Sitona spp.
2. Effective rainfall 315 mm, poorly distributed.

Studies on planting patterns and population density were conducted on all three food legumes. In faba bean, 60 plants/m^2 gave higher yield (2.92 tons/ha) compared to 45 (2.61 tons/ha) and 30 (2.44 tons/ha) plants/m^2 averaged over four different inter-row spacings (30, 40, 50 and 60 cm). Narrow inter-row spacing of 20 cm gave higher yield (1.21 tons/ha) compared to 30 cm (1.06 tons/ha), 40 cm (.97 tons/ha) and 50 cm (.83 tons/ha). A lentil population density of 200 plants/m^2 gave higher yield than 100, 300 and 400 plants/m^2. The highest yield (1.45 tons) was achieved with 200 plants/m^2 and 20 cm inter-row spacing.

In a faba bean weed control trial, Bladex (0.5 kg a.i./ha) plus Kerb (0.5 kg a.i./ha) and Bladex (0.5 kg/ha) were effective in controlling weeds at Douyet and yields were 11 and 19% higher than unweeded check. In winter chickpea, Igran (3 kg a.i./ha) was used in on-farm trials and up to 37% increase in yield was obtained by some farmers. However, it was only effective at early stages of

Table 8.2.11. Yield performance of promising small and large seeded lentil lines in comparison to local checks at different locations and season in Morocco.

Line	1983/84		1984/85		1985/86				1986/87			
	Marchouch		J. Shim		Sidi Laidi		Marchouch		Marchouch		Mean	
	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	Yield (kg/ha)	% of local
Small Seeded												
- 76TA 66005	1771	173	2098	128	-	-	2291	117	1016	119	1794	128
- L 24 (local)	1025	100	1640	100	-	-	2090	100	853	100	1402	100
Location mean	1509		1774				1853		853			
C.V. (%)	16.6		17.6				14.0		35.5			
			Marchouch									
Large Seeded												
- Precoz (ILL 4605)	1338	115	649	331	1330	125	1880	127	1350	115	1309	134
- 74TA 19	1248	107	345	176	1360	128	2200	147	1358	116	1302	133
- 78S 26002	1324	113	321	164	1810	171	2400	162	1383	118	1448	148
- L 56 (local)	1167	100	196	100	100	1480	100	975	100	976		
Location mean	1200		350		1435		2100		1145			
C.V. (%)	23.3		49.5		20.9		11.0		27.8			

crop development. In Sidi Laidi, Igran (3 kg a.i./ha) plus Kerb (0.5 kg a.i./ha) were also effective in winter chickpea. Weeds are a major constraint to productivity of food legumes in Morocco and hence these results are of great value.

In need-to-inoculate studies, as part of the BNF network of ICARDA, the need for inoculation was apparent in chickpea in vertisols where grain yield response to N fertilization was 48.6 and 36.0% without and with phosphorus fertilization, respectively. Results in faba bean and lentil were inconclusive due to severe drought and serious nodule damage due to Sitona spp. which was up to 97 and 100% in lentil and faba bean, respectively.

In a study on planting and harvesting methods in lentil, drilled and broadcast planting exceeded conventional sowing (with animal-drawn local plough) by 15 to 30% in grain yield and 115 and 103% in straw yield, respectively, when harvesting was done manually. However, when harvesting was done by a simple side mower and a combine harvester, the advantage of drilled and broadcast planting were counter balanced by losses of grain and straw which were four to five times more than hand harvesting. Straw yield of hand harvesting was double and triple that for side mower and combine harvester, respectively. Straw is not valued as high in North Africa as in the West Asia Region, so mechanical harvesting has a good future.

8.2.2.5. Off-season site

The efficacy of Annaceur Research Station as an off-season summer nursery was established for chickpea, faba bean and lentil. Such an off-season site will increase efficiency in breeding work in Morocco and may also be of use to other North-African food legume programs as well as base program at Tel Hadya, Syria, where similar sites are not available.

8.2.2.6. National seminar

The first 'National Seminar on Food Legumes in Morocco' was held from 7-9 April at Settat, Morocco to review past work on major food legumes and to give opportunity for all national food legume researchers to exchange information on their research work and to develop cooperative multidisciplinary research programs on food legume improvement. During the seminar 19 research papers were presented in various disciplines: 16 by national scientists, 2 by coordinators of food legume programs in Tunisia and Algeria and one by ICARDA. The seminar concluded with a set of recommendations on research priorities and strategies. All contributions during the seminar will be published in a proceedings. Recommendations serve as a guideline for future strategy in Morocco. The seminar also helped in strengthening the North African Regional Network on food legume research as there was active participation of key scientists from Algeria and Tunisia in this meeting.

8.2.3. Algeria/ICARDA cooperative project 1986/87

A cooperative project on strengthening food legume research and technology transfer began this season between ICARDA and Institute de Development des Grandes Culture (IDGC) to further strengthen the cooperation between ICARDA and Algeria. In the project , Algerian and ICARDA scientists worked together at three levels of experimentation at the Wilayet of Sidi-Bel-Abbes (SBA) including back-up research on-farm verification trials and demonstration plots. Research included both breeding and agronomic studies and was also conducted at research stations, in Tiaret, Setif, Khroub and Guelma. On-farm activities were conducted in four agroclimatic zones: Zone I, 400-600 mm rainfall; Zone II, 400 mm average; Zone III, 350 mm; and Zone IV, 200-300 mm.

SBA station in the northwest represents semi-arid low-rainfall areas, Tiaret and Setif represent semi-arid high plateau areas and Khroub and Guelma in the north east represent higher rainfall areas.

Serious drought was the main feature of the growing season in SBA, Tiaret and Setif (285, 380 and 344 mm respectively, with little recieved after mid March). To the contrary, higher rainfall than normal characterized the season in the northeastern areas (Khroub and Guelma with 600-700 mm rainfall well distributed). The wide difference in results obtained in different locations is thus due to a differences in climatic conditions.

8.2.3.1. Back-up research

Back up research in faba bean, chickpea and lentil included selection for higher and stable yield through the evaluation of ICARDA germplasm, genetic stocks, and advanced breeding lines. In addition, agronomic studies were conducted to identify appropriate cultural practices.

8.2.3.1.1. Faba bean breeding

Breeding work on faba bean focuses on high and stable yield with disease resistance and large seed. In both large and small seeded types, 46 advanced breeding lines were yield tested in two replicated trials (IYT-L and IYT-S) in one to four locations. Because of serious drought in early spring in SBA, faba bean suffered most compared to other food legume crops. The high temperature and severe moisture stress at the critical flowering stage caused flower abortion and stunted plants because of dessication. Yields were negligible in most entries of both seed types. However, yields as high as 4.77 and 5.97 tons/ha were obtained in large seeded types at Khroub and Guelma, respectively, because of favorable weather conditions. At Guelma, 20 tested entries exceeded the local check (4.37 tons/ha) with yield increase up to 37%. At Khroub, the best yielding test line (Reina Blanca) yielded (4.77 tons/ha) as much as the check Seville Giant which is an improved commercial variety. The selections 79S 4, ILB 1217 and to some extent ILB 1814 were well adapted to both locations (Table 8.2.12).

Table 8.2.12. Performance of selected faba bean entries from FBIYT-L-87 at two locations in Algeria, 1986/87.

Pedigree	Guelma Yield (kg/ha)	Guelma % of check	Guelma Rank[1]	Khroub Yield (kg/ha)	Khroub % of check	Khroub Rank[1]	Mean (kg/ha)
FLIP 82-25FB	5458	125	5	3143	66	16	4301
FLIP 82-54FB	5682	131	2	3346	70	12	4514
79S 4	5563	128	3	4296	90	3	4930
79S 653	5531	127	4	3229	68	13	4380
ILB 1814	5969	137	1	3911	82	4	4940
ILB 1217	5073	117	10	4773	100	1	4923
Check[2]	4374	100	21	4770	100	2	4572
Location mean	4909			3387			
SE ±	531			373			
L.S.D. (.05)	1510			1061			
C.V. (%)	18.7			19.1			

1. Rank is out of the total 24 entries.
2. Checks were local and Seville Giant at Guelma and Khroub, respectively.

Table 8.2.13. Yield performance of selected winter chickpea lines in comparison with local check (Rabat 9) in national replicated trials in Khroub, 1986/87.

Trial	No. of Entries	Yield (kg/ha) Rabat 9 (local)[1]	Yield of tested entries Range	Yield of tested entries Mean
- Variety confirmation	12	0.46	1.66 - 2.84	2.32
- 3rd year trial	12	0.33	1.43 - 3.44	2.73
- 2nd year trial A	20	0.42	0.37 - 2.74	1.36
- 2nd year trial B	20	0.75	2.10 - 3.08	1.72
- 2nd year trial C	20	0.26	1.73 - 3.02	2.47
- 1st year trial A	15	1.46	1.73 - 2.51	2.29
- 1st year trial B	15	1.56	2.20 - 3.24	2.75
Mean		0.75	1.60 - 2.98	2.38

1. Seriously affected by *Ascochyta* blight.

Disease screening is to date based on natural infestation, which may be unpredicable and non-uniform in severity. This season Botrytis fabae and bean leaf-roll virus were prevalent and serious; the former in the northeastern part and the latter in SBA. Botrytis and dry weather conditions prevailed in early spring and caused severe yield reductions. Insect pests including aphids and Sitona spp. (larvae feeding on nodules) were also serious and require investigation into control measures.

8.2.3.1.2. Chickpea breeding

Breeding work in chickpea focuses on high yield with resistance to Ascochyta rabiei and cold tolerance with adaptation to winter and spring planting.

To identify genotypes adapted to the winter sowing, 145 advanced breeding lines were evaluated in 12 replicated trials in 1 to 5 locations. While a number of lines outyielded significantly the local check in various locations, almost all lines did so in Khroub where 'Rabat 9", the local check, was either completely killed or badly damaged by ascochyta blight. This season, the disease developed only at Khroub, though most tested lines showed no serious symptoms. In seven national trials, mean yield of 'Rabat 9' was 0.75 /ha while that of all tested entries was 2.38 ha. Several selected lines outyielded 'Rabat 9' by more than 5 times (Table 8.2.13). In Variety Confirmation trial, ILC 616, ILC 195 AND P 15-713/321 yielded 2.86, 2.70 and 2.66 t/ha, respectively, while 'Rabat 9' yielded 0.46 t/ha. In 3rd year trial, FLIP 81-40W, ILC 236, and FLIP 82-16C yielded 3.35, 2.95 and 2.89 t/ha, respectively, while 'Rabat 9' yielded 0.33 t/ha. In all national trials, ILC 482 confirmed its superiority and adaptation in Khroub region. Similarly, because of consistent yield performance over years and resistance to ascochyta blight, ILC 195 and ILC 3279 are being increased for demonstration and eventual release in northeastern areas in spite of their small seed size. ILC 3279 also performed well in demonstration plots in Sidi Bel Abbes. Out of 15 lines selected in national trials in SBA for advanced yield testing five lines were recommended for on-farm verification trials. Their yield advantages over two local checks ranged between 10 to 57%.

In international trials, a number of lines exceeded local checks significantly in all locations, even in the absence of ascochyta blight (Table 8.2.14). In Guelma, root rot/wilt complex was serious and the local 'Rabat 9' was most heavily hit causing up to 100% yield loss. The disease was also serious in Tiaret and SBA. In Khroub 21 lines of CIYT-SP-87 (grown in winter) outyielded the local check significantly with a range of yield levels from 2.03 to 3.73 tonst/ha compared to 0.54 tons for the local.

The spring chickpea program was limited to yield testing of 34 advanced breeding lines in one national (2nd year) and one international (CIYT-SP) trial in Sidi-Bel-Abbes. Because of drought, trial means were 285 and 127 kgt/ha, respectively. Though few lines exceeded the local checks, none did so significantly.

Pathology work on A. rabiei was done in cooperation with the Institute National d'Agronomy (INA). Nine isolates were tested under controlled conditions for virulence using 13 resistant chickpea genotypes (Table 8.2.15). The most virulent isolate was from Tessalh to which only one genotype (ILC 191) showed tolerant reaction. ILC 249, ILC 482 and ILC 3279 showed tolerance to most isolates.

8.2.3.1.3. Lentil breeding

Lentil breeding work focuses on high yield and early maturity with acceptable seed quality and mechanical harvest characteristics (tall and erect types).

In both large and small seeded lentil, 133 advanced breeding lines were yield tested in eight replicated trials in 1 to 4

Table 8.2.14. Multilocation yield performance of chickpea lines evaluated in international trials in Algeria, 1986/87.

Trial and line	SBA		Setif		Khroub		Guelma	
	Yield (kg/ha)	Rank[1]	Yield (kg/ha)	Rank	Yield (kg/ha)	Rank	Yield (kg/ha)	Rank
CIYT-L-87								
- FLIP 84-19C	972	6	1130	4	2432	2	1120	11
- FLIP 85- 3C	1042	4	1174	1	2111		875	13
- FLIP 85- 5C	715	11	998	7	2366	4	2073	6
- FLIP 85- 7C	1132	2	1053	6	1765	14	1349	9
- FLIP 85-54C	1076	3	938	9	1869	14	3109	1
- FLIP 85-56C	1319	1	868	14	1669	15	2781	4
- FLIP 85-61C	694	13	1150	2	2507	1	1042	12
- FLIP 85-135C	715	12	1132	3	2170	5	1786	8
- Local check	993	5	794	16	747	16	0	16
SE ±	114		95		189		351	
L.S.D. (.05)	329		275		736		1015	
C.V. (%)	22.9		16.6		16.0		36.9	
CIYT-W-MR-T-87								
- FLIP 84-20C	779	9	1157	2	2794	4	—	—
- FLIP 84-32C	1021	1	1160	1	2421	17	—	—
- FLIP 84-182C	882	3	1021	4	3088	1	—	—
- FLIP 85-19C	944	2	1012	6	2721	7	—	—
- Local check	722	13	926	10	0	24	—	—
SE ±	123		109		234			
L.S.D. (.05)	351		310		666		—	
C.V. (%)	29.5		21.0		15.7		—	
CIYT-W-MR-87								
- FLIP 83-48C	917	8	1111	5	—	—	2094	6
- FLIP 83-71C	875	14	1078	6	—	—	2598	1
- FLIP 84-79C	792	18	1153	4			2102	5
- FLIP 84-144C	1099	3	1182	3	—	—	672	19
- FLIP 84-145C	1291	1	1262	1	—	—	1340	12
- FLIP 84-158C	1026	4	1057	7	—	—	977	15
Local check	880	12	764	24	—	—	430	23
SE ±	110		101		—		564	
L.S.D. (.05)	312		284		—		1592	
C.V. (%)	25.1		20.1		—		86.5	

1. Rank is out of total number of lines evaluated in each trial: CIYT-L, 16 lines; CIYT-W-MR-T and CIYT-W-MR, 24 lines each.

Table 8.2.15. Disease reaction of 13 chickpea lines to 9 isolates of *Ascochyta rabiei* in Algeria, 1986/87.

Chickpea lines	Isolates from								
	Sebdou	78.SBA.193	ILC 136	AT.161/14	B.Slimane	ILC 3279	T.Ouzou	Tessalh	SI
Rabat 9	HS	HS	HS	HS	HS	HS	HS	HS	HS
Sebdou	HS	HS	HS	HS	HS	HS	HS	HS	
Abdellys	HS	HS	HS	HS	HS	HS	HS	HS	HS
A.T.161.14	HS	HS	HS	HS	HS	HS	HS	HS	
ILC 3279	S	R	R	R	HS	T	T	S	HR
NEC 105	S	R	T	R	S	T	S	S	R
ILC 190	S	R	S	S	S	S	T	S	S
ILC 191	R	HR	HR	S	T	R	R	T	T
ILC 72	T	R	T	R	S	T	T	S	S
ILC 482	R	R	T	T	S	R	R	S	T
ILC 484	S	T	T	S	S	T	S	S	T
78.SBA.193	S	S	S	S	S	S	S	T	
ILC 249	T	R	R	R	S	R	T	S	T

HS = highly susceptible; HR = highly resistant; T = tolerant; S = susceptible; R = resistant.

locations. In all trials , 15 lines exceeded the improved local check 'Syrie 229'. However, yield advantages of all lines were less than 10% except for one (FLIP 84-152L) where the yield advantage was 21% at Guelma. FLIP 84-27L and FLIP 84-152L yielded 3.22 and 3.62 t/ha while the local yielded 3.00 t/ha. In Sidi-Bel-Abbes 16 lines were selected out of national trials for evaluation in on-farm verification trials and 11 lines were selected out of international trials for replicated yield testing.

In three non-replicated observation nurseries (LISN-L, LISN-T, LISN-E) evaluated in an augmented design in one to three locations, 28 lines yielded significantly more than local checks by 27-172%. High yielding, tall, erect and early types were selected for replicated yield testing. In F_3 (LIF_3T) and F_4 population in SBA, 19 lines were also selected for yield testing.

8.2.3.1.4. Agronomy

Agronomic studies included date of planting, seeding rate, chemical weed control and mechanical harvesting of lentil and chickpea. In SBA, some of these studies were conducted for verification on farmers' fields while in other locations they were at the back-up research level. In a chickpea study at Khroub on varieties x planting dates x seeding rates, winter (December) planting gave 69 to 75% more yield than spring (March) planting in three genotypes (Rabat 9, ILC 482 and ILC 3279). Seeding rate of 140 kg/ha resulted in highest yield in winter planting while in spring sowing rates of seeding of 100, 120, and 140 kg/ha yielded similarly but more than 80 kg/ha. Highest yield (3.26 t/ha) was obtained with ILC 482 planted in winter at 140 kg/ha.

In chickpea weed control trial (CWCT), Igran (3kg a.i./ha) and Maloran (2.5 kg a.i./ha) plus Kerb (0.5 kg a.i./ha) as pre-emergence treatments were 100 and 95% effective in controlling weeds and gave 11 to 10% more yield than manual weeding, respectively.

8.2.3.2. Verification trials

Verification trials were conducted on varietal performance, chemical weed control and mechanical harvesting on farmers' fields in the three agroclimatic zones (I, II and III).

In faba bean, the two cultivars Seville Giant (1.13 t/ha) and New Mammoth (0.83 t/ha) yielded higher than the local check Aquadulce (0.75 t/ha) in Zone I. Considering the serious drought this season, these yield levels were economically acceptable. In winter chickpea in Zone II, five early-maturing lines (Sebdou, ILC 190, ILC 482, ILC 4131, NEC 105) were superior in yield (1.30 to 1.38 t/ha) compared to other lines under reduced moisture. Due to its consistant performance over years, earliness and resistance to blight, ILC 482 will be demonstrated to farmers next season. In lentil, lines 79 S.B.A., Balkan 755, NEL 1889 and 76 TA 124 yielded 0.5 to 0.6 t/ha in Zone III in spite of the serious drought while Syrie 229 (0.46 t/ha) and NEL 1889 (0.57 t/ha) were superior to the local check L.B. Chile (0.11 t/ha) in Zone II. Because of consistant performance over years, NEL 1899 and ILL 4400 will be demonstrated to farmers next season.

In weed control, the pre-emergence treatment Maloran (1.5 kg a.i./ha) plus Kerb (0.5 kg a.i./ha) was most effective on lentil whereby yield was almost double that of the unweeded check and only 10% less than that for manual weeding.

Mechanical harvesting verification studies confirmed the advantages of combine-harvester (3 m wide header) in lentil and spring chickpea. Comparing two planting dates in lentil, mid-December planting reduced grain loss up to 9.2% compared to early January planting in addition to 41% increase in yield. Economically, manual harvesting in lentil resulted in great economic loss (912 Algerian dinars/ha) while direct combining gave a net profit (69 AD/ha) in spite of very low yields due to dry sessions. In spring chickpea, because of high grain loss by direct combining, both manual and combined harvesting were equally profitable while simple cutter-bar harvesting reduced profit by 21%. Mechanical harvesting by combine-harvester with 3 m wide header will be demonstrated to farmers in both lentil and chickpea after some modifications.

8.2.3.3. Demonstration plots

Demonstration plots were planted in farmers' fields in all agroclimatic zones in Wilayet Sidi Bel Abbes to transfer improved production packages in both chickpea and lentil. In chickpea, the package included new varieties (ILC 3279 and Sebdou), winter planting and pre-emergence chemical weed control (Maloran, 3 kg a.i./ha plus Kerb, 0.5 kg a.i./ha). In spite of 4 to 6 weeks delay in winter planting and serious drought, the improved package yielded more than double that of farmers practices (spring planting of traditional cultivars) across locations (Table 8.2.16). Yields at all locations were low because of moisture stress in early spring and delayed winter planting. Being resistant to ascochyta blight, the line ILC 3279 will be released to farmers after seed increase.

Table 8.2.16. Yield of winter and spring chickpea in on-farm demonstration plots in Sidi-Bel-Abbes, 1986/87.

Planting season + Varieties	Zone + Farm				Mean
	Ouaddah (I)	Haboul (II)	Zidane (III)	Menzlia (IV)	
Winter[1]			kg/ha		
- ILC 3279	300	500	300	360	365
- Sebdou	250	480	250	-	327
Spring[2]					
- Local cultivar	100	300	25	200	156

1. Winter planting dates: Ouaddah, Jan. 27,'87; Haboul, Jan 12,'87; Zidane, Jan 11,'87; Menezlia, Dec 30,'86.
2. Spring planting dates: late February to early March.

In lentil, two improved cultivars and chemical weed control (Patoran, 2 kg a.i./ha) were demonstrated in three agroclimatic zones. In Haboul Farm (Zone II), Syrie 229 and Balkan 755 yielded 500 kg/ha and 350 kg/ha, respectively, compared to the traditionally grown local cultivar 5 L.B. Chile which produced no grain after being dessicated by high temperature and moisture stress in March and April. Syrie 229 is being released to farmers with appropriate planting recommendations.

Scientists NAR national programs and Dr. M. Solh.

9. TRAINING

FLIP continued to pursue its policy of strengthening National Research Programs through intensive training activities. As shown in Table 9.1.1 this was achieved through offering diverse training opportunities to participants from a large number of collaborating countries. A total of 165 participants received training in various disciplines; the number includes those that participated in the 'in-country' training courses.

Table 9.1.1. Summary of training courses in the Food Legume Improvement Program, 1987.

Type of Training	Topics	No. of Participants	No. of Countries Represented
1. Training courses at Aleppo	Crop Improvement, Biological Nitrogen Fixation, Lentil Harvest Mechanization	32	21
2. In-country training courses	Crop Improvement, Crossing technique	99	3
3. Individual non-degree training	Breeding, Pathology, Microbiology, Agronomy, Data Processing, Quality	28	8
4. Individual degree training	Agronomy, Breeding, Physiology, Lentil Harvest Mechanization	6	4
	Total	165	36

9.1. Group Training

9.1.1. Food legume residential course

The annual residential course at Tel Hadya research station was conducted from 1 March to 18 June, 1987 and attended by 18 participants from 12 countries (Table 9.1.2). Participants received training on research skills for the improvement of faba bean, lentil, and kabuli chickpea from a multidisciplinary team of scientists. Complementary areas such as farming systems approach, data analysis, and report writing were also covered.

Table 9.1.2. Participation in group training in the Food Legume Improvement Program, 1987.

Type of training	Duration	Name of Country	No. of participants
A. Residential			
Food Legume Improvement	3.5 months	Algeria, China, Egypt Ethiopia, Iraq, Jordan, Morocco, Sudan, Syria, Turkey, N. Yemen, S. Yemen	18
B. Short Courses			
- Field Techniques in Biological Nitrogen Fixation (in collaboration with PFLP)	2 weeks	Tunisia, Turkey, Algeria, Jordan	7
- Lentil Harvest Mechanization (in collaboration with Univ. of Jordan)	10 days	Turkey, Jordan, syria, Morocco, Algeria	7
C. In-Country Training Course			
- Cereal and Food Legume Improvement (in collaboration with CP)	Oct 1986 - July 1987	Algeria, Sidi Bel Abbas	
		Part I	37
		Part II	20
		Part III	10
- Crossing Technique	4 days	Algeria	20
- Crossing Technique	8 days	Ethiopia	12

9.1.2. Lentil harvest mechanization training course

FLIP conducted the second "Lentil Harvest Mechanization Course", held in 3-11 May, 1987, and attended by seven trainees from five countries (Table 9.1.2). As in the first course solutions to the lentil harvest problem were tackled in an integrated manner. Topics covered in the course focused on breeding and agronomy, harvest machinery, on-farm trials and economics.

We intend to follow-up with participants of both courses through provision of technical advice to develop on-farm trials of lentil harvest mechanization in their countries. It is hoped that this network will provide a means of transferring this vital technolology.

9.1.3. Field techniques in biological nitrogen fixation

As research on biological nitrogen fixation (BNF) is important to the sustainability of yield in food and forage legume crops, the Food Legume Improvement Program and Pasture, Forage and Livestock Improvement Program jointly conducted the "Field Techniques in BNF" training course from 22/2 - 5/3, 1987 at ICARDA's headquarters in Aleppo, Syria. The course was attended by seven participants from four countries. Focus in the course was on practical aspects of biological nitrogen fixation research in the field and the laboratory. The major subject areas covered included Rhizobium/legume symbiosis, ecology of rhizobia, field experimentation, measurement of N-fixation, management effects on N-fixation, and inoculum production.

9.1.4. In-country courses on hybridization techniques

Two in-country courses on "Hybridization Techniques" were conducted: one during September 10-17, 1986 in Ethiopia and a second during March 21-24, 1987 in Algeria. The course in Ethiopia was financed by ICARDA/IFAD Nile Valley Project on Faba bean. The trainees in both courses were instructed in the planning of crossing blocks, management of a crossing field and the technique of crossing by theoretical and practical excercises.

9.1.5. Cereal and food legume improvement in-country course

The Cereal and Food Legume Improvement Programs jointly conducted a course at Sidi Bel Abbes, Algeria. The course was composed of three phases which spanned the whole cropping system. The total number of trainees from research stations and production/extension institutes was 67 for all three phases.

Topics covered in the course were as follows:

phase I: On-farm research concepts, planting, note taking for agronomic and disease parameters.

phase II: Notes taking in breeding, agronomy, disease, insect, and weed control trials.

phase III: Harvest loss assessment at harvest, data analysis, and interpretation.

The course was an opportunity for interaction between staff in research and production institutes which is a vital step in the extension of station generated technologies to farmers.

9.2. Individual Training

The Food Legume Improvement Program offered individualized training opportunities to research scientists and technicians from national programs. Topics covered, duration, countries, and numbers of participants are shown in Table 9.2.1. The syllabi for these categories of trainees were tailored to suit the needs of participants.

9.3. Graduate Research Training Program

Through the Graduate Research Training Program links with regional universities were strengthened. This allowed the students and their supervisors to make use of advanced facilities and services at ICARDA for research in partial fulfillment of the requirements of the degree. The number of candidates for degree training increased considerably in 1987 as compared to 1986 (Table 9.3.1).

Dr. H. Ibrahim

Table 9.2.1. Participation in individual non-degree training in the Food Legume Improvement Program, 1987.

Topic	Name of Trainees	Country	Duration
1. Breeding	Mohamed Benhoumt	Morocco	1.5-19.5.87
	Ali Ustun	Turkey	15.4-30.4.87
	Husni A. Abu Khaled	Syria	22.3-23.4.87
	Abdul Mashi Nasif	Syria	22.3-23.4.87
	Alem Berhe w/Selassie	Ethiopia	11.2-31.5.87
	Abebe Tullu	Ethiopia	9.1-30.6.87
2. Pathology	Mahmood Al Ze'ebi	Syria	15.3-15.4.87
	Jorge Velandia	Colombia	15.3-15.4.87
	Mohamed Ibrahim Amer	Egypt	11.2-11.3.87
	Ragab Fathi Desouki	Egypt	11.2-11.3.87
	Naji Abu Zeid	Egypt	
3. Microbiology	Bahij M. El Moustafa	Syria	15.3-31.3.87
	Khawla Abdulla Gaid	Sudan	17.3-17.4.87
	L'Habib Mabsout	Morocco	6.3-15.4.87
4. Agronomy	Moustafa H. Mustafa	Sudan	11.4-14.5.87
	Sidiri Ahmad Mohamed	Tunisia	12.4-14.5.87
5. Data Analysis	Eid Al Masri	Syria	1-15 Feb 87
	B. Benseddik	Algeria	1-15 Feb 87
6. Quality	Khaled Debech	Tunisia	7.6-9.7.87
	Hassan Sahyouni	Syria	
	Hamit Koksel	Turkey	19.6-1.7.87
	Babiker Babiker	Sudan	
	Tahir El Nour	Sudan	
7. Entomology	Munir Sabri Yousif	Syria	31.3.-7.5.87
8. Training methodologies (training of trainer)	Imad Eddin S. Osman	Sudan	24.1.87-24.1.88
	Ahsanul Haq	Pakistan	Three years
9. Crossing techniques	Magda El Sharif	Sudan	25.3-27.4.87
10. Computer use in data analysis	Chernet Assefa	Ethiopia	19.6-3.9.87

Table 9.3.1. Participation in Individual-Degree Training in the Food Legume Improvement Program, 1987.

Name	Degree	Registered in University	Registered in Country	Duration
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
Stefan Kachelries	Ph.D	Giessen	Germany	2 years
Mohamed El Bashir	M.Sc	Khartoum	Sudan	2 years
Ahsanul Haq	Ph.D	Punjab	Pakistan	3 years

10. PUBLICATIONS

10.1. Journal Articles

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Beck, D.P. and Roughley, R.J. 1987. Biological nitrogen fixation as a limitation to food legume production in Asia. Special edition Plant and Soil (In press).

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Greco, N., Di Vito, M., Reddy, M.V. and Saxena, M.C. 1986. Effect of Mediterranean cultivated plants on the reproduction of Heterodera ciceri. Nematol. Medit. 14:193-200.

Greco, N., Di Vito, M., Saxena, M.C. and Reddy, M.V. 1987. Investigations on Heterodera ciceri in Syria. Nematologica (In press).

Hanounik, S.B. and Robertson, L.D. 1987. Resistance of Vicia faba germplasm to blight caused by Ascochyta fabae. Plant Disease (In press).

Hanounik, S.B. and Robertson, L.D. 1987. New sources of resistance in Vicia faba to chocolate spot caused by Botrytis fabae. Plant Disease (In press).

Malhotra, R.S. and Singh, K.B. 1987. Detection of epistasis in chickpea. Euphytica (In press).

Singh, K.B., Erskine, W., Robertson, L.D., Nakkoul, H., and Williams, P.C. 1987. Influence of pretreatment on cooking quality parameters of dry food legumes. Journal of the Science of Food and Agriculture (In press).

10.2. Conference Papers

Beck, D.P. and Materon, L.A. 1987. A program of optimizing response to legume inoculants. In: Proceedings of the Second Conference of the African Association for Biological Nitrogen Fixation. Cairo, Egypt. (In press).

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11. STAFF

Staff changes

Dr. M.C. Saxena, Program Leader Food Legume Improvement Program, proceeded on one year sabbatic leave to the International Atomic Energy Agency/Food and Agriculture Organization (IAEA/FAO), Vienna, Austria in July 1987. Dr. K.B. Singh, ICRISAT outposted chickpea breeder, was appointed Acting Program Leader during Dr. Saxena's absence. Dr. Susanne Weigand joined the program in late 1986 as the Food Legume Entomologist. She is from the Federal Republic of Germany and has been educated at the University of California, Riverside, USA and University of Bonn, West Germany. Dr. Franz Weigand, husband of Susanne, joined the program as Post-doctoral Fellow (North Africa). ICRISAT has posted Dr. M.P. Haware in the ICARDA/ICRISAT Kabuli Chickpea Project as the Chickpea Pathologist, who joined in November 1986. Miss Oreib Tahhan joined the program as a Post-doctorate Fellow in Entomology after completing her Ph.D. from the Reading University, U.K.

Dr. K.H. Linke from the Federal Republic of Germany joined the program as a Post-doctoral Fellow in Orobanche research during July 1987, following departure of his predecessor Dr. J. Sauerborn in March 1987. Dr. Linke worked for his Ph.D. on Striga, another parasitic weed. Dr. Geletu Bejiga, an Ethiopian citizen, joined the Program as a Post-doctoral Fellow in September 1987 to strengthen chickpea breeding. Mr. Bashir A. Malik, Project Coordinator (Pulses) in Pakistan, joined the program as a visiting scientists and will work for his doctoral thesis research on the genetics of resistance to ascochyta blight in chickpea. Mr. M.A. Haq, also from Pakistan, joined the program as a research associate in the training section and will also conduct research for his Ph.D. degree. The position of the post-doctoral fellow in the dry pea specially funded project remained vacant, but will be filled in 1988.

Staff list

M.C. Saxena	Program Leader/Agronomist-Physiologist (on sabbatic leave from July)
K.B. Singh	Chickpea Breeder (ICRISAT) and Acting Program Leader (from July)
D. Beck	Microbiologist
S.P.S. Beniwal	Breeder/Pathologist (Ethiopia)
W. Erskine	Lentil Breeder
M. Habib Ibrahim	Senior Training Scientist
S.B. Hanounik	Faba Bean pathologist (Lattakia)
M.P. Haware	Chickpea Pathologist (ICRISAT)
L.D. Robertson	Faba Bean Breeder
M. Solh	Plant Breeder (Morocco)
S. Weigand	Entomologist
M. EL-Sherbeeny	Post Doc. Fellow Faba Bean Breeding (NVP)
A. Hussain	post Doc. Fellow Lentil Breeding
R.S. Malhotra	Intl. Trials Scientists
J. Sauerborn	Post Doc. Fellow Orobanche (GTZ)*
S.N. Silim	Post Doc. Fellow Agr./Physiology
O. Tahhan	Post Doc. Fellow Entomologist
F. Weigand	Post Doc. Fellow N. Africa Pathology
K.H. Linke	Post Doc. Fellow Orobanche (GTZ)
Geletu Bejiga	Post Doc. Fellow Chickpea Breeding
Lang Li-juan	Visiting Scientist
B.A. Malik	Visiting Scientist
Stefan Schlingloff	Visiting Research Associate
Thomas Bambach	Visiting Research Associate
Edwin Webber	Visiting Research Associate
M.A. Haq	Assistant Training Scientist-Fellow
Gaby Khalaf	Research Assistant
Fadel Afandi	Research Assistant
M.Y. Naser Agha	Research Assistant
Siham Kabbabeh	Research Assistant
Munzer Kabakabji	Research Assistant
Lina Khoury	Research Assistant
Samir Hajjar	Research Assistant
Nabil Ansari	Training Assistant
Hani Nakkoul	Research Assistant
Ibrahim Ammouri	Research Assistant
Bashar Baker	Research Assistant
Nabil Tarabulsi	Research Assistant
Riad Ammaneh	Research Assistant
Suheila Arslan	Research Assistant
Abdullah Joubi	Research Assistant
Fawzi Merjaneh	Research Assistant*
Hasan Masri	Research Assistant
Mahmoud Hamzeh	Research Assistant
Fadwa Khanji	Senior Research Technician
Amir Farra	Senior Research Technician
Pierre Kiwan	Senior Research Technician (Terbol)
Murhaf Kharboutly	Senior Research Technician
Moaiad Lababidi	Senior Research Technician

Elias Zod	Research Technician (Lattakia)
Aida Naimeh	Research Technician (Terbol)
Joseph Karaki	Research Technician (Terbol)
Ghazi Khatib	Research Technician (Terbol)
George Rizk	Research Technician (Terbol)
Ahmed Samara	Research Technician (Terbol)
Omar Labban	Research Technician
Aida Djanji	Research Technician
Fadwa Zaabalawi	Research Technician*
Ahmed Obaji	Research Technician
Khaled El-Debl	Research Technician
Mohamed S. Hayani	Research Technician
Mohamed I. Maarawi	Research Technician
Rafat Azzo	Research Technician
Mariette Franjieh	Research Technician
Bernadette Jallouf	Research Technician
Diab Ali Raya	Research Technician
Samir Zahran	Research Technician*
Abdul Rahim Osman	Researcg Technician
Hasan EL Hasan	Research Assistant
Ziad Sayadi	Research Technician
Elias Kaadeh	Research Technician
Siham Kabalan	Research Technician
Nidal Kadah	Research Technician
Mohamed I. EL- Jassem	Research Technician
Ahmad B.A. Karim	Research Technician
Mohamed Al-Sayed	Research Technician
Mohamed Issa	Research Technician
Hisham Kredi	Research Technician
Abdel K. Bounian	Research Technician
Gulizar Haidar	Program Secretary
Rania Barrimo	Senior Secretary
Nawal Saroukhan	Secretary*
Hasna Boustani	Secretary
Mary Bogharian	Secretary
Nuha Sadek	Secretary
Ibrahim Mustafa	Driver
Naaman Ajanji	Driver
Abdullah El Khaled	Stores Attendant
Hussein El-Humeidi	Farm Labourer
Ahmed El-Halabi	Farm Labourer*
Asaad Omar Al-Darwish	Attendant I-Driver
Ali Deeb Zahlout	Guard (Lattakia)
Kokab Hammoud	Office Attendant (Lattakia)

* Left during the year.

12. Experiment Station Weather 1986/87 Season

Weather during 1986/87 exhibited a number of peculiarities, which made it a better than average season at the wetter sites (Terbol, Jindiress, Tel Hadya) and resulted in poor yields at the drier site (Breda).

One factor contributing to the difference was a steeper than normal geographical gradient of rainfall which persisted throughout most the season (Table 12.1). Jindiress received 127% of the long-term average seasonal rainfall total; Terbol received 120%, 108% for Tel Hadya, and 88% for Breda. The 300 mm annual isohyet appeared to mark the boundary between areas with higher than average and lower than average rainfall. This was exacerbated by a parallel gradient of temperatures, which is reflected in the number of frost days observed at the various stations. This rose from 20 at Jindiress (the wettest- location - which is only 2/3 of the long-term average), to 39 at Tel Hadya (average 37). and 47 at Breda (average 43). With the exception of February, the cropping season on the whole was somewhat cooler than average with minimum temperatures being rather milder in the wetter than at the drier sites (Figure 12.1).

The season started very early, with germinating rains falling during the first week of November at all sites. A prolonged spell of dry and cold weather followed which lasted until December 18. Such a combination of a dry spell of 38 days following heavy rains early in November is without parallel in over 50 years of weather records from Aleppo. The drought and cold virtually stopped crop growth soon after emergence. Rainfall resumed just in time to save the crops, and milder, rainy weather prevailed until the third week of February, broken only by another spell of dry and cold weather during mid-January. The period from the last week of January until mid-February was especially mild except in the drier areas where minimum temperatures dropped close to zero or below zero too frequently to permit vigorous crop growth. Rainfall effectively stopped at all sites during the second week of April. This is

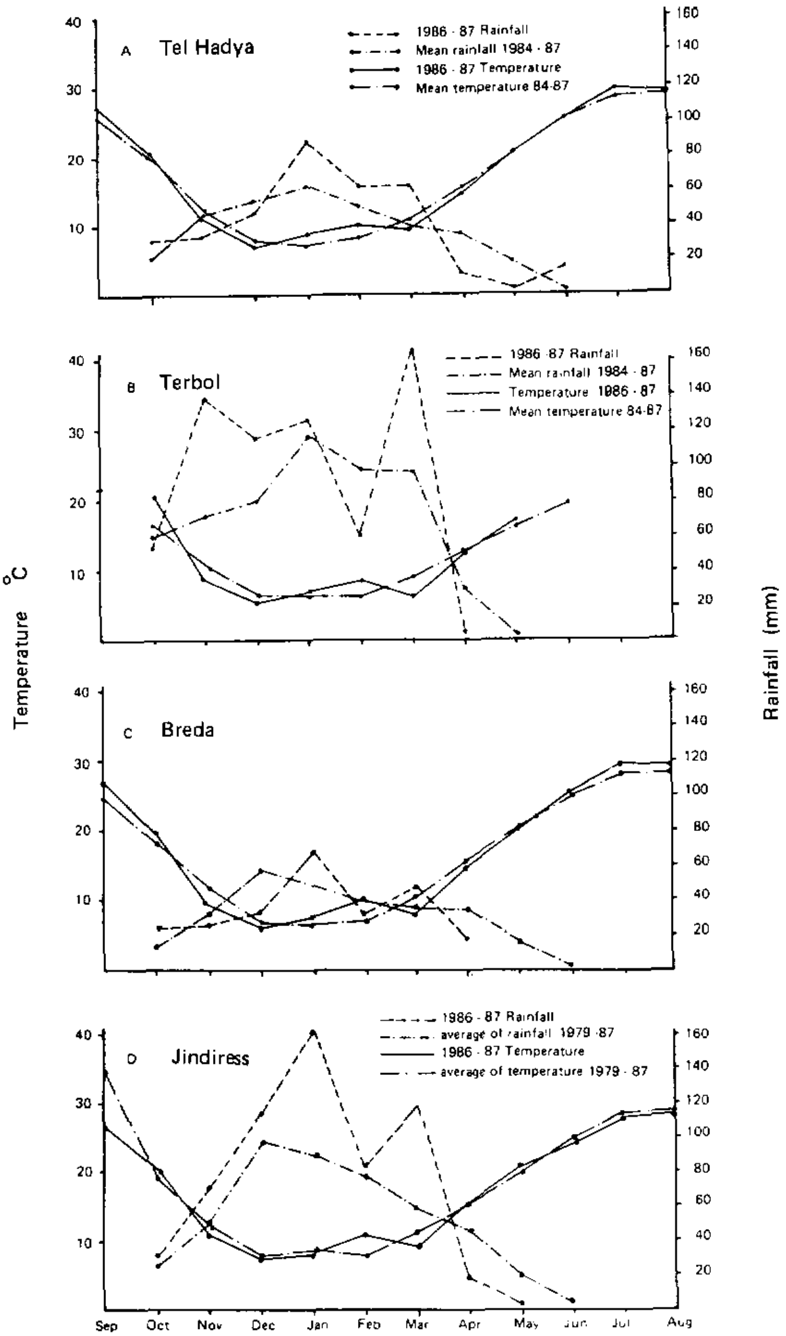

Fig. 12.1.1. Long term and 1986/87 distribution of rainfall and temperature at experiment stations in Tel Hadya (A), Terbol (B), Breda (C) and Jinderiss (D).

Table 12.1. Monthly precipitation (mm) for the 1986/87 season and the long term averages.

	Sep Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun*	Total
Terbol										
1986/87 Season	52	140	118	127	62	167	8	0		674
Long term average	60	72	80	116	98	96	30	8		560
% of long term average	87	194	148	109	63	174	27			120
Jindiress										
1986/87 Season	30	71	115	162	83	119	19	3	0	601
Long term average	25	51	98	92	76	6	45	19	3	472
% of long term average	119	138	117	175	109	196	42	15		127
Tel Hadya										
1986/87 Season	31	33	47	89	63	63	13	3	15	358
Long term average	21	45	54	66	52	42	32	16	4	331
% of long term average	148	75	87	134	122	151	39	17	375	108
Breda										
1986/87 Season	23	25	33	67	32	47	17			245
Long term average	14	31	57	49	38	35	34	16		279
% of long term average	165	81	58	135	82	134	51			88

somewhat earlier than usual, but due to prevailing cool weather and an adequate supply of soil moisture, crop yields were not adversely affected at the wetter sites. This is in contrast to the drier location, where much of the already low soil moisture evaporated directly from the soil surface because the crop had failed to cover the ground.

Although of no consequence to agriculture, another weather extreme of 1987 deserves recording. On August 7 the screen temperature at Tel Hadya reached an all-time high of 47.6°C. The other sites recorded similar, though slightly lower temperatures. *How exceptional such temperatures are is illustrated by the fact* that according to our knowledge 44°C have never been exceeded since weather stations were first established in the region in the first half of this century.

Evaluation courtesy of FRMP.

المركز الدولي للبحوث الزراعية في المناطق الجافة
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1988