LEGUME PROGRAM

Annual Report for [illegible]

LEGUME PROGRAM
1991 ANNUAL REPORT

1. INTRODUCTION

1.1. General

In a continuing effort to enhance the complementarity of research and improve the efficiency of use of available resources, ICARDA decided in September 1990 to consolidate research and training on improvement of food legumes and annual feed legumes under one group - the Legume Program (LP). The aim of this program is to encourage and support national efforts in West Asia and North Africa (WANA) and other developing countries in improving the productivity and yield stability of cool season food legumes (lentil, chickpea, faba bean, dry pea) and annual feed legumes (mainly vetches and chicklings) and enhance their role in increasing the sustainable productivity of cereal-based, rainfed farming systems.

The process of devolution to national programs of the responsibility for the improvement of faba bean, which is generally grown under relatively assured moisture-supply, was continued to phase out the research at ICARDA. The ICARDA faba bean breeder and pathologist, who transfered faba bean research to the scientists of INRA, Morocco, at Douyet Research Station near Fes, left the Program in September 1991. The final phase of the transfer is being handled by the ICARDA legume scientist posted at Fes.

Consistent with the Center-wide strategy of focusing on the dry areas, research efforts on legumes adapted to dry environments were increased. Researchers from LP and other ICARDA programs worked on specific research projects in multidisciplinary teams, often working with national program scientists. Research on kabuli chickpea was conducted jointly with the International Crop Research Institute for Semi-Arid Tropics (ICRISAT). We continued collaboration with institutions in the industrialized countries on basic research, particularly in the application of biotechnological tools in crop improvement.

Although the improvement research on lentil, kabuli chickpea, dry pea and forage legumes was centred at ICARDA Tel Hadya, several ICARDA testing sites in Syria (Breda, Maadar and Jinderess) and in the Beka'a valley of Lebanon (Terbol and Kfardan) were also used. Breeding material was advanced through an additional generation during summer at Terbol research station for kabuli chickpea and lentil and at Annaceur (Atlas mountains, Morocco) for faba bean. Several national program research sites were jointly used for strategic research on the development of breeding material with specific resistance to some key biotic and abiotic stresses because of the presence of ideal screening conditions there.

1.2. Weather Conditions

The weather conditions during the 1990/91 season at Breda, Tel Hadya, Jinderess and Terbol are depicted in Figures in Section 11. As during 1989/90, this season was again drier than the long-term average, adversely affecting crop growth and yield. For example, at Tel Hadya, the rainfall upto middle of March was 36% less than the long-term average (164 mm in 1990/91 compared with long-term average of 258 mm) causing severe early season drought. By the end of the growing season the total rainfall was only 290 mm compared with the long-term average of 328 mm. Winter temperatures were mild; hence, screening for cold tolerance was in-effective this season at Tel Hadya. Wide fluctuation in temperature, both maximum and minimum, occurred in March. Open-pan evaporation and the maximum temperature commenced to rise sharply in April. By mid May the atmospheric drought increased with day temperatures rising above 30°C and open-pan evaporation ranging from 10 to 12 mm/day, accompanied by strong winds (ca 250 km/day reaching at times to 600 km/day) forcing crops to mature over a relatively short period of time.

1.3. Achievements

A summary of the major achievements of the program in research, training and networking activities during the 1990/91 season is given below:

1.3.1. Kabuli Chickpea

Yields of chickpea are low and unstable in WANA, but improvement is possible through the adoption of winter sowing in low altitude regions. Trials at three ICARDA sites (Tel Hadya, Jinderess and Terbol) for eight years (1983/84 to 1990/91) with more than 100 newly bred lines per year have shown that winter-sown chickpea produces 71% or 659 kg/ha higher yield than spring-sown chickpea. The yield increase from winter sowing rises to 133% with the top 10% yielding genotypes. Winter sowing is expanding in WANA with the area estimated at 30,000 ha for 1990/91. Adoption studies in Syria and Morocco showed that farmers realize the advantage of winter sowing.

National programs have made good use of ICARDA enhanced germplasm. Eight cultivars including two in Algeria (FLIP 84-79C and FLIP 84-92C), two in Iraq (ILC 482 and ILC 3279), one in Syria (Ghab 3 = FLIP 82-150C), two in Tunisia (FLIP 84-79C and FLIP 84-22C) and one in Turkey (Akcin = 87AK 17775) were reported released in 1991. Thirteen NARSs have selected 47 lines for pre-release multiplication and/or on-farm trials.

To stabilize chickpea production, efforts continued in breeding for stress resistance. Evaluation of 20,000 germplasm accessions for Ascochyta blight resistance over last ten years has resulted in the identification of five sources of resistance (ILC 200, ILC 6482, ILC 4475, ICC 6328 and ICC 12004). Resistance of a few kabuli accession to Fusarium wilt was confirmed, as also resistance of ILC 5901 to leaf miner. Three kabuli accessions (ILC 6104, ILC 6118 and FLIP 87-59) were identified as drought resistant. ILC 8262 and ILC 482 mutant were confirmed as best sources of tolerance to cold out of 10,000 accessions evaluated so far.

Evaluation of over 1,300 ICARDA breeding lines for Ascochyta blight resistance using six races of Ascochyta rabiei revealed that three lines (FLIP 84-79C, FLIP 85-86C and FLIP 90-103C) had a highly resistant reaction (rating 2 on 1-9 scale).

Accessions of annual wild Cicer species have been found to possess resistance to multiple stresses. Three separate interspecific crossing programs were initiated to transfer genes for (a) cold tolerance, (b) cyst nematode resistance, and (c) seed yield. The first backcrosses have been made for all three traits.

A karyotype analysis of eight annual Cicer species revealed two groups: (i) C. arietinum, C. reticulatum and C. echinospermum, (ii) C. bijugum, C. cuneatum, C. judaicum, C. pinnatifidum and C. yamashitae. Within each group, it is possible to obtain fertile hybrids through crossing.

DNA fingerprint derived molecular markers were used to follow the interspecific crosses. Attempts are also being made to identify markers that may be linked with the genes that contribute to Ascochyta blight resistance. In collaboration with the University of Frankfurt, the application of Polymerase Chain Reaction (PCR) technology is also being studied. DNA fingerprinting was also used to study variability in Ascochyta rabiei to facilitate disease resistance breeding.

Studies were initiated using host pathogen-race combinations on the components of resistance to Ascochyta blight as this information will help in developing partial resistance. Disease severity rating was negatively related with the 'latent period' (LP) for infection and positively with 'lesion size' (LS) and 'lesion growth rate' (LGR). High disease severity ratings (DSR) were always accompanied by a simultaneous occurrence of high LGR, high pycnidia number (PN) produced per lesion, short LP and high sporulation (SPO). Low DSRs were associated with low LGR, low PN, long LP and very low SPO.

Leafminer (Liriomyza ciceri) and podborer (Helicoverpa armigera) damage was reduced by spray of neem extract. However, the protective effect lasted for only 7 - 10 days. Studies on chickpea/leafminer interaction revealed that leaf exudates were among the factors imparting host resistance. Control of the seed bruchid Callosobruchus chinensis in storage could be achieved upto 6 months by use of such insecticides as Actellic or K-othrin (@ 0.5 g/kg seed). Use of 3 ml neem seed oil with 20 g salt per kg seed also provided acceptable seed protection.

In studies of the need for inoculation with Rhizobium to improve N_2 fixation, the symbiotic effectiveness of resident rhizobial population at 38 chickpea growing sites in Syria was evaluated using a hydroponic N-free system and two chickpea cutlivars (ILC 195 and ILC 482). The ability to fix N in an N-free system (where plant N = fixed N), as compared to uninoculated plants fed adequate combined N for maximum growth, gave the test of symbiotic efficiency. Soils of more than half tested sites contained native population with low symbiotic efficiency, where inoculation with selected superior strains was consistently positive.

Our chickpea rhizobia collection (100 strains) was characterized by collecting data on symbiotic effectiveness with a range of improved cultivars, salt and heat tolerance and intrinsic antibiotic resistance (IAR). IAR characterization separated the collection into four district regional groups. Polyclonal antisera for highly effective strains from each group are under preparation for strain identification using ELISA technique.

Studies on response of diverse chickpea genotypes to varying soil moisture supply using the line-source sprinkler irrigation revealed that yield increased linearly with increasing moisture supply. However, genotypes differed in their linear regression estimates of intercept and slopes. A crossing program to combine high intercept value with high slope may, therefore, yield recombinants with both drought tolerance and also a positive response to improved moisture supply.

1.3.2. Lentil

Progress in the use of ICARDA enhanced germplasm occurred in all the three contrasting agroecological regions (the low land Mediterranean region, the high lands and the southern latitude region) on which our breeding efforts are targeted. With the release of three cultivars (Arbolito in Argentina, Sazak-91 in Turkey and Crimson in USA) during 1991, the total number of cultivars released so far has reached 25 in a total of 18 countries. In addition 16 lines are in the pre-release multiplication or on-farm testing by NARSs in the Mediterranean region, four in high lands, nine in the southern latitude region in Asia and Africa, four in Argentina and one in China.

Nearly 250 crosses were made and handled in a bulk-pedigree method using off-season generation advancement. The international breeding nurseries have evolved and diversified from the stage of provision of yield trials to supply of an additional wide range of crossing blocks/resistant sources and segregating populations for each of the three major target agro-ecological regions. There was an increase in the number of entries provided by NARSs in the international trials.

Screening of lentil lines for vascular wilt at seedling as well as adult stage revealed that three lines (ILL 6434, -6991 and -6995) were most promising and these will be shared with NARS in the form of Lentil International Fusarium Wilt Nursery. Re-screening for wilt resistance at adult stage of 41 wild accessions, which were resistant to wilt in seedling stage, revealed that eight accessions were highly resistant. Some of these also showed resistance to Ascochyta blight. Of the four wild lentil species/subspecies, L. nigricans subsp. ervoides had highest proportion of accessions showing resistance to Ascochyta blight.

Over 120 accessions of wild relatives of lentil were evaluated for various agronomic characters and valuable variation for earliness was observed, which can be used in lentil improvement. Screening of these accessions for drought and increased moisture supply using line-source sprinkler at Breda showed interesting variability, which could be useful in breeding program. DNA fingerprinting, using digoxigenin labeled oligonucleotides as probes, was tested to detect genetic variability within and between the subspecies of Lens. More enzyme/probe combinations have to be tested to get useful banding patterns.

Lentil harvest mechanization was promoted in Northern Syria in cooperation with the General Organization of Agricultural Mechanization. An impact of these efforts was evident from increase in the area harvested by swathe-mower in Kameshly in 1990.

Field evaluation of four strains of lentil rhizobia, which were earlier selected after large scale greenhouse screening of 250 different isolates, revealed that strain '739' from Syria and '760' from Portugal produced significant yield responses of ca. 20% and 40%, respectively, across four different lentil cultivars in the presence of native lentil rhizobia at Tel Hadya. These results indicate a potentially important role for lentil inoculation with selected Rhizobium strains.

The effect on the nitrogen status of plants and yield of the feeding of Sitona crinitus larvae on lentil nodules was studied at four locations in northern Syria using a soil application of Carbofuran or seed treatment with Promet insecticide. The insecticides reduced nodule damage and increased the nitrogen status of plants at flowering. The adverse effect of Sitona damage on nitrogen nutrition of lentil was particularly conspicuous at Alkamiye, where untreated plots showed typical symptoms of nitrogen deficiency, emphasising the importance of Sitona control for the dryland agriculture. Studies on control of the seed bruchid Callosobruchus chinensis in storage showed that although insecticides Actelic and K-othrin were the most effective agents, satisfactory control could also be obtained by treating the produce with olive oil + salt.

1.3.3. Faba bean

The ICARDA faba bean research team at Douyet research station took appropriate steps to transfer the improvement research to Moroccan scientists and established close links between this group and the other NARSs in North Africa. Offices, pathology laboratory, seed preparation laboratory, screenhouse facilities for pure line breeding and field facilities for disease screening research were established. Faba bean improved germplasm, including inbred and advanced lines with disease resistance, closed flowers, determinate growth habit, and IVS trait were transferred. North African Regional Yield Trials and Orobanche nurseries were initiated. Verification trials to transfer Orobanche resistant lines to Moroccan farmers were initiated.

The NARSs continued to make good use of ICARDA enhanced germplasm and expanded their own varietal improvement programs. In Syria, Hama 15 (a selection from ILB 1270) was released. In Egypt, Giza 461 and Reina Blanca have been released because of superior yield and resistance to foliar diseases. In Sudan, Shambat 75 and Shambat 104 have been released for non-traditional faba bean growing areas.

Determinate lines are in on-farm trials in China and Syria. In Tunisia, three lines have been selected for pre-release multiplication because of their superior yield in drought conditions over last three years. In Algeria, 14 lines are in multilocation tests. The line ILB 1814 is in pre-release multiplication in Iraq and Chile. In Ethiopia, a cross bulk has been purified and is now in pre-release multiplication.

Major progress during the 1990/91 season was made in developing Orobanche resistant faba bean. Three selections 18009, 18035 and 18105, which were previously rated as Orobanche resistant, were verified in naturally infested fields of farmers, where they gave significantly higher yields, and much less Orobanche infestation than Aquadulce, the check. Seeds of these lines are being multiplied. An integrated system for the control of Orobanche was tested at Douyet, which could further improve the performance of Orobanche tolerant cultivars.

Studies on the control of Bruchus dentipes on farmers' field in Syria showed that two applications of such insecticides as Metyphon, Fastac, and Dimethoate at early pod setting and 2 weeks later resulted in significant reduction of insect infestation in faba bean.

1.3.4. Forage Legumes

In spite of the diversity of feed legume species in the Mediterranean region, few have been used specifically as feedcrops, and little improvement effort has gone in them. Our goal therefore has been to develop improved cultivars of species currently in use by farmers and examine the potentiality of alternative wild species found in areas receiving 250-500 mm rainfall. The two genera intensively evaluated are vetches (Vicia spp.) and chicklings (Lathyrus spp.)

Evaluation of improved lines of common vetch (V. sativa) in Morocco resulted in identification for release of IFLVS 1812/2083, which shows good resitance to Orobanche. Studies at Quetta showed that Vicia villosa ssp. dasycarpa was well adapted to cold and harsh environments of highlands.

Pod shattering is a serious problem in the common vetch. Crosses between nonshattering lines and dehiscent high yielding types were made. Superior families with complete indehiscence were selected and distributed to NARSs in WANA.

Subterranean vetch (Vicia sativa ssp. amphicarpa) was identified as a potentially important species for developing ley farming because of the hardness of the seeds produced underground. Barley grown after underground vetch produced significantly higher grain and forage yield than barley after barley.

A crossing program was initiated to reduce the neurotoxin (BOAA) content of high yielding and well adapted genotypes of Lathyrus sativus using a parent with low BOAA content.

The seasonal evapotranspiration of various feed legumes in this drought year was similar to that of food legumes but feed legumes were superior in water-use efficiency (WUE). Vicia narbonensis and Lathyrus sativus had the highest WUE for total biological yield and Vicia narbonensis for seed yield.

1.3.5. Dry Pea

Of 72 new accessions received from different institutions, 10 high yielding selections were retained for evaluation of their performance at ICARDA sites in Syria and Lebanon with a view to incorporate them in the

Pea International Adaptation Trial. The optimum plant density for conventional leaf-type pea was 36 plants/m^2 as against 80 plants/m^2 for the leafless types, both under rainfed and assured moisture conditions.

1.3.6. International Nurseries

A total of 956 sets of 35 different nurseries of chickpea, lentil, chicklings, vetches and pea were distributed to more than 135 cooperators in 55 countries for the 1991/92 season. Stability analysis of various lentil and chickpea international yield trials permitted identification of genotypes with wide adaptation.

1.3.7. Training and Networking

The Nile Valley Regional Program and the North African Regional Program developed and distributed their own regional yield trials and nurseries. Joint training and travelling workshops in these regional programs helped the NARSs in their crop improvement work. Group training was conducted at ICARDA in the form of short specialized training courses, besides the in-country and sub-regional training courses. Specialised courses at ICARDA included: 'Insect Control', 'Biology and Control of Orobanche', 'Advanced Breeding Methodologies', 'DNA Molecular Marker Techniques', '<u>Rhizobium</u> Technology' and 'Mechanical Harvesting of Legumes'. In-country and sub-regional courses covered 'Faba bean Improvement' in Morocco, 'Legume Hybridization' in Jordan, 'Winter Chickpea Technology' in Tunisia and Turkey, 'Computer Application and Biometry' in Ethiopia, and 'Legume Seed Porduction' in Jordan. A total of 187 participants received training in the improvement of lentil, chickpea, faba bean and forage legumes through these courses.

A seminar on 'Lentil in South Asia' was held in New Delhi jointly with the Indian Council of Agric. Research. The seminar aimed to review research on lentil in South Asia as a base line for future activity in the region. Invited papers were presented by key lentil scientists from Bangladesh, India, Nepal, Pakistan and Sri Lanka.

2. KABULI CHICKPEA IMPROVEMENT

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

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

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

2.1. Chickpea Breeding

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

1. <u>Mediterranean region</u>: (a) winter sowing: resistance to Ascochyta blight, tolerance of cold, suitability for machine harvesting, medium to large seed size (30% of resources); (b) spring sowing: cold tolerance at seedling stage, resistance to Ascochyta blight and Fusarium wilt, tolerance of drought, early maturity, medium to large

seed size (30% of resources);

2. Indian subcontinent and East Africa: resistance to Ascochyta blight and/or Fusarium wilt, drought tolerance, early maturity, small to medium seed size, response to supplemental irrigation (20% of resources);

3. Latin America: resistance to Fusarium wilt, root rot and viruses, large seed size (5% of resources);

4. High elevation areas: spring sowing, cold tolerance at seedling stage, resistance to Ascochyta blight, terminal drought tolerance, early maturity, and medium to large seed size (15% of resources).

K.B. Singh

2.1.1. Use of Improved Germplasm by NARSs

2.1.1.1. International nurseries and trials

During 1991, 17,950 chickpea entries including breeding lines were furnished to 45 countries. Eighty-two percent of the international trials and nurseries were furnished to the developing countries and the remaining 18% to the industrialized countries (Table 2.1.1).

Table 2.1.1. Number of entries furnished in the form of international yield trials and nurseries and breeding lines during 1991.

Country	Trial and nursery		Breeding line (no.)	Total entries (no.)
	No. of sets of trial/nursery	No. of entries		
Algeria	27	881	-	881
Argentina	5	168	-	168
Australia	9	287	30	317
Bhutan	9	264	-	264
Brazil	1	23	-	23
Bulgaria	3	105	5	110
Canada	-	-	820	820

Cont'd.

Table 2.1.1. Cont'd.

Country	Trial and nursery		Breeding line (no.)	Total entries (no.)
	No. of sets of trial/nursery	No. of entries		
Chile	7	251	-	251
China	3	69	-	69
Cyprus	4	173	-	173
Egypt	9	250	-	250
Ethiopia	9	343	-	343
France	8	302	-	302
Germany	-	-	6	6
Greece	5	169	-	169
Guatemala	2	73	-	73
Hungary	4	182	-	182
India	15	517	171	688
Iran	24	965	-	965
Iraq	12	391	-	391
Italy	14	493	57	550
Jordan	13	316	8	324
Lebanon	7	240	12	252
Libya	5	133	-	133
Mexico	6	235	-	235
Morocco	11	359	35	394
Myanmar	2	62	-	62
New Zealand	5	160	-	160
Oman	3	69	-	69
Pakistan	24	1023	-	1023
Peru	4	181	-	181
Portugal	6	247	-	247
Qatar	1	23	-	23
Saudi Arabia	7	197	-	197
Spain	15	481	1082	1563
Srilanka	2	73	-	73
Sudan	7	169	-	169
Syria	39	1437	100	1537
Thailand	1	23	-	23
Tunisia	34	1514	-	1514
Turkey	56	2044	-	2044
U.S.A.	3	123	22	145
USSR	7	224	63	287
Yemen	4	154	-	154
Yugoslavia	4	146	-	146
Total	436	15,539	2411	17,950

The nurseries were in demand from all the six continents from Chile to China and from Canada to Australia-New Zealand. On the other hand, requests for breeding lines came from the developed countries only. Overall, 19% more entries were supplied during 1990. The kabuli chickpea network is well established among chickpea scientists.

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

2.1.1.2. On-farm trials

Five chickpea lines were selected by the Directorate of Agriculture and Scientific Research (DASR), Ministry of Agriculture and Agrarian Reform from the ICARDA/ICRISAT international trials and together with ICARDA conducted researcher-managed trials throughout Syria from 1988/89 to 1990/91. The number of locations varied from 12 to 18. All the three years turned out to be dry. Based on superior performance, two lines were identified for pre-release multiplication and demonstration (Table 2.1.2). FLIP 84-15C had the same yield and score for Ascochyta blight and cold, but it had 50% larger seed size and 30% more height than previously released Ghab 1. This will meet consumers' demands for large seed size and farmers' demands for easy machine harvesting. Because of FLIP 83-98C, better resistance to Ascochyta blight than Ghab 1 was accepted. FLIP 84-15C is recommended for the entire country and FLIP 83-98C only for coastal Syria, where Ascochyta blight develops naturally.

On-farm trials were jointly conducted in Lebanon. ICARDA provided assistance in the conduct of on-farm trials in Algeria, Iraq, Jordan, Morocco, and Tunisia.

NARSs scientists, K.B. Singh and S.P.S. Beniwal

2.1.1.3. Pre-release multiplication of cultivars by national programs

Fifty-seven lines have been chosen by 13 NARSs from the ICARDA/ICRISAT international trials for pre-release multiplication and on-farm tests (Table 2.1.3). However, we do not have full information from many countries. Barring three selections from germplasm collection, all the remaining are developed through hybridization. All the new lines have

Table 2.1.2. Seed yield and some other characters of five chickpea lines as compared to check cultivar Ghab 1 in the on-farm test in Syria, 1988/89 to 1990/91.

Entry	Seed yield (kg/ha)				Protein content (%)	100-seed[c] weight (g)	Plant[c] height (cm)	Days to[c] flower (no.)	Ascochyta blight score	Cold score
	1988/89	1989/90	1990/91	Mean						
FLIP 83-47C	1457	1307	1477	1414(5)[a]	22.8	32	43	121	3[b]	3[b]
FLIP 83-48C	1378	1400	1490	1423(4)	21.6	33	42	121	3	3
FLIP 83-71C	1378	1431	1423	1411(6)	22.1	33	43	121	3	3
FLIP 83-98C	1351	1492	1498	1447(3)	23.0	34	45	119	3	3
FLIP 84-15C	1459	1503	1462	1475(2)	22.5	42	49	119	6	4
Ghab 1	1429	1462	1536	1476(1)	22.9	28	42	117	6	4

a/ Figure in parentheses is the rank.
b/ Score: 1 = free from damage; 9 = all plants killed.
c/ Mean of three years.

resistance to Ascochyta blight and tolerance to cold. They have large seed size, thus they meet consumers' requirements. If grown in winter, they attain a height of over 40 cm and can be harvested by machine. Seed of some of the promising lines is being multiplied at ICARDA to meet the potential demand of NARSs.

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

Table 2.1.3. Chickpea lines identified for pre-release multiplication and on-farm testing by NARSs in recent years.

Country	Line
Afghanistan	ILC 482, FLIP 81-3C, FLIP 81-24C, FLIP 81-70C, FLIP 81-71C, FLIP 81-75C, FLIP 82-4C, FLIP 82-9C, FLIP 82-16C, FLIP 82-20C
Algeria	FLIP 83-49C, FLIP 83-71C, FLIP 84-109C, FLIP 84-145C, FLIP 85-17C, 79TH 101-2, 80TH 177
Cyprus	FLIP 85-10C
Egypt	ILC 202, FLIP 80-36C
Iraq	FLIP 81-269C, FLIP 82-142C, FLIP 82-169C
Jordan	ILC 496, FLIP 84-15C, FLIP 85-5C
Lebanon	FLIP 85-5C, FLIP 84-15C
Libya	ILC 484, FLIP 84-79C, FLIP 84-93C, FLIP 84-144C
Morocco	FLIP 83-48C, FLIP 84-79C, FLIP 84-145C, FLIP 84-182C
Pakistan	FLIP 81-293C
Syria	FLIP 83-98C, FLIP 84-15C, FLIP 86-5C, FLIP 86-6C
Tunisia	FLIP 83-47C
Turkey	FLIP 81-70C, FLIP 82-74C, FLIP 82-161C, FLIP 82 -269C, FLIP 83-31C, FLIP 83-41C, FLIP 83-47C, FLIP 83-77C, FLIP 84-79C, FLIP 85-13C, FLIP 85-14C, FLIP 85-15C, FLIP 85-60C, 87AK 71112

2.1.1.4. Release of cultivars by NARSs

NARSs in 16 countries have released 41 lines as cultivars (Table 2.1.4). Thirty-five of them have been released for winter sowing in the Mediterranean region, seven for spring sowing including two in China and two for winter sowing in more southerly latitudes to be sown with irrigation.

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

Table 2.1.4. Kabuli chickpea cultivars released by different national programs.

Country	Cultivars released	Year of release	Specific features
Algeria	ILC 482	1988	High yield, wide adaptation
	ILC 3279	1988	Tall, high yield
	FLIP 84-79C	1991	Cold tolerant
	FLIP 84-92C	1991	Large-seeded
China	ILC 202	1988	High yield, for Ginghai pr.
	ILC 411	1988	High yield, for Ginghai pr.
Cyprus	Yialousa (ILC 3279)	1984	Tall, cold tolerant
	Kyrenia (ILC 464)	1987	Large-seeded
France	TS1009 (ILC 482)	1988	High yield, cold tolerant
	TS1502 (FLIP 81-293C)	1988	High yield
Iraq	ILC 482	1991	High yield, wide adaptation
	ILC 3279	1991	Tall, cold tolerant
Italy	Califfo (ILC 72)	1987	Tall, high yield
	Sultano (ILC 3279)	1987	Tall, high yield
Jordan	Jubeiha-2 (ILC 482)	1989	High yield, wide adaptation
	Jubeiha-3 (ILC 3279)	1989	High yield, tall
Lebanon	Janta 2 (ILC 482)	1989	High yield, wide adaptation
Morocco	ILC 195	1987	Tall, cold tolerant
	ILC 482	1987	High yield, wide adaptation
Oman	ILC 237	1988	Irrigation responsive
Portugal	Elmo (ILC 5566)	1989	High yield
	Elvar (FLIP 85-17C)	1989	High yield
Spain	Fardan (ILC 72)	1985	Tall, high yield
	Zegri (ILC 200)	1985	Mid-tall, high yield
	Almena (ILC 2548)	1985	Tall, high yield
	Alcazaba (ILC 2555)	1985	Tall, high yield
	Atalaya (ILC 200)	1985	Mid-tall, high yield
Sudan	Shendi (ILC 1335)	1987	Irrigation responsive
Syria	Ghab 1 (ILC 482)	1986	High yield, wide adaptation
	Ghab 2 (ILC 3279)	1986	Tall, cold tolerant
	Ghab 3 (FLIP 82-150C)	1991	High yield, wide adaptation
Tunisia	Chetoui (ILC 3279)	1986	Tall, high yield
	Kassab (FLIP 83-46C)	1986	Large-seeded, high yield
	Amdoun1 (Be-sel-81-48)	1986	Large-seeded
	FLIP 84-79C	1991	High yield
	FLIP 84-92c	1991	Large-seeded, high yield
Turkey	ILC 195	1986	Tall, cold tolerant
	Gunei Sarisi (ILC482)	1986	High yield, wide adaptation
	Damla 89 (FLIP 85-7C)	1990	High yield, large-seeded
	Tasova 89 (FLIP 85-135C)	1990	High yield, large-seeded
	Akcin (87AK71115)	1991	High yield

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

2.1.2. Screening for Stresses Tolerance

2.1.2.1. Land races

Screening of germplasm lines was initiated in 1978 for Ascochyta blight (Ascochyta rabiei [Pass.] Lab.) in 1979 for cold, in 1981 for leaf miner (Liriomyza cicerina Rond), in 1982 for seed beetle (Callosobruchus chinensis L.), in 1986 for cyst nematode (Heterodera ciceri Vovlas, Greco et Di Vito), in 1987 for Fusarium wilt (Fusarium oxysporum Schlecht. emnd Synd f.sp. ciceri [Padwick] Snyd. & Hans) and in 1989 for drought. The number of lines evaluated between 1978 and 1991 for different stresses are shown in Table 2.1.5. The 1990/91 evaluations included 3396 lines for resistance to Ascochyta blight, 1283 lines to cyst nematode, 594 lines to leaf miner and 2970 lines to cold. Resistant sources have been identified for Ascochyta blight, Fusarium wilt, leaf miner, and cold, but no source of resistance was found for seed beetle and cyst nematode. Resistant sources have been freely shared with NARSs and are used in crossing blocks.

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

Table 2.1.5. Reaction of chickpea germplasm accessions to some biotic and abiotic stresses at Tel Hadya between 1978 and 1991.

Scale	Ascochyta blight	Fusarium wilt	Leaf miner until 1990	Leaf miner until 1991	Seed beetle	Cyst nematode	Cold until 1990	Cold until 1991
1	0	0	0	0	0	0	0	0
2	0	2	0	19	0	0	0	0
3	0	0	0	93	0	0	15	13
4	5	26	8	148	0	0	120	648
5	9	57	201	162	0	0	657	525
6	1444	155	509	68	164	621	502	489
7	1833	251	1167	97	185	907	707	242
8	1185	584	8	5	1551	0	1796	345
9	14867	1547	3538	2	3253	5705	2165	708
Total	19343	2636	5478	594	5153	7233	5978	2970

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

2.1.2.2. Wild Cicer species

Evaluation of eight annual wild Cicer species continued for the fourth year to identify sources of resistance to different stresses. The highest susceptibility rating from the four-year evaluation of a line has been taken as the actual rating for that line. The results are summarized in Table 2.1.6. The evaluation during 1990/91 included 70 new accessions for resistance for resistance to Ascochyta blight, 77 lines to leaf miner and 17 lines to cold. Sources of resistance were found for all six stress factors, including Ascochyta blight, Fusarium wilt, leaf miner, seed beetle, cyst nematode, and cold. Wild species were the only source of resistance so far found for seed beetle and cyst nematode and had higher level of resistance than the cultivated species for Fusarium wilt, leaf miner, and cold. The most important species for resistance to different stress factors was C. bijugum, while C. yamashitae was the least important. There is a need to evaluate the resistance of existing collections to other important stresses and to collect additional accessions for evaluation.

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

2.1.2.3. Listing of resistance

Sources of resistance identified for Ascochyta blight, Fusarium wilt, leaf miner, and cold in cultivated species are listed in Table 2.1.7. These have been used in breeding programs at ICARDA and elsewhere. Differential disease race-patterns caused some lines to be resistant at ICARDA but susceptible elsewhere.

Sources of resistance in wild Cicer species for Ascochyta blight, Fusarium wilt, leaf miner, seed beetle, cyst nematode, and cold are given in Table 2.1.8. Efforts are underway to transfer genes for resistance for cold and cyst nematode from some wild to cultivated species.

K.B. Singh

Table 2.1.6. Reaction of germplasm accessions of *Cicer* spp. to some biotic and abiotic stresses at Tel Hadya, Syria during 1987/88, 1988/89, 1989/90 and 1990/91.

Scale[a]	Blight		F. wilt		Leaf miner		Seed beetle		Cyst nematatode		Cold	
	No.	species[b]	No.	species	No.	species	No.	species	No.	species	No.	species
1	0	0	72	1,4,5,6,7	5	3,5,6,8	20	1,3,4,5,7	2	6	0	1
2	1	2	0	0	30	2,3,5,6	12	1,5,6,7	1	0	36	1,7
3	4	1	7	1,5,7	27	4,5,6,7	4	1,7	17	1,6,7	37	1,4,5,6,7
4	2	5,6	15	1,5,6,7	20	1,4,5,6,7	3	1,6,7	0	1	38	1,4,5,6,7
5	22	5,6	6	5,6,7	55	1,5,6,7	3	3,5	24	1,7	10	6
6	29	1,5,6	4	5,6	26	1,4,5,6,7	8	1,5,7	0	1,8	9	5,6,8
7	24	1,4,5,6	4	6	33	1,5,6,7,8	18	2,4,5,7	34	5,7,8	11	2,5,6,8
8	30	4,5,6,7	0	0	1	8	52	2,5,6,7,8	0	1,5,6,7,8	13	5,6
9	81	2,3,4,5,6,7,8	5	6	3	1,8	10	5,6,8	114	2,3,4,5,6,7	41	2,3,5,7,8
Total	193		113		200		130		192		195	

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

Table 2.1.7. Sources of resistance to biotic and abiotic stresses identified between 1978 and 1991.

Stress	Source of resistance
Ascochyta blight	ILC 72, ILC 182, ILC 187, ILC 200, ILC 2380, ILC 2506, ILC 2956, ILC 3279, ILC 3856, ILC 4421, ILC 5586, ILC 5902, ILC 5921, ILC 6043, ILC 6090, ILC 6188.
Fusarium wilt	ILC 54, ILC 240, ILC 256, ILC 336, ILC 487.
Leaf miner	ILC 316, ILC 992, ILC 1003, ILC 1009, ILC 1216, ILC 2622, ILC 5594, ILC 5901.
Cold	ILC 794, ILC 1071, ILC 1251, ILC 1256, ILC 1444, ILC 1455, ILC 1464, ILC 1875, ILC 3465, ILC 3470, ILC 3598, ILC 3746, ILC 3747, ILC 3791, ILC 3857, ILC 3861, Mutant of ILC 482.
Drought	FLIP 87-59C, ILC 6104, ILC 6118

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

2.1.2.4. Multilocation evaluation of chickpea germplasm and breeding lines for resistance to Ascochyta blight

One hundred ninety-one chickpea lines comprising 40 desi (ICC) and 31 kabuli (ILC) germplasm accessions and 120 kabuli breeding (FLIP) lines were evaluated for Ascochyta blight resistance at 48 disease-endemic locations in 20 countries (Algeria, Bangladesh, Bulgaria, Cyprus, Egypt, France, Greece, India, Iran, Italy, Jordan, Lebanon, Morocco, Pakistan, Portugal, Spain, Syria, Turkey, Tunisia, and U.S.A.) over a period of seven years (1983-1989). These lines were tested through the Chickpea International Ascochyta Blight Nursery (CIABN). The evaluations were done in the field under both natural and artificial epiphytotic conditions. The blight severity of lines was scored following a 9-point

Table 2.1.8. Sources of resistance (rating 1 or 2 on a 1-9 scale) in wild Cicer species to biotic and abiotic stresses.

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

scale, where 1 = free from disease, and 9 = all plants killed. Although there was considerable variation in the reaction of the lines across seasons and locations, a few lines (including ILC 72, ILC 182, ILC 201, ILC 202, ILC 2380, ILC 2956, ILC 3279, ILC 3868, ILC 3870, ILC 4421, FLIP 82-191C, FLIP 83-46C, FLIP 83-49C, FLIP 83-72C, FLIP 83-97C, FLIP 84-

85C,FLIP 84-93C, and ICC 3932) showed resistance in 50% or more of the locations or tests in which they were evaluated. The kabuli germplasm accessions that showed broad-based resistance originated either from the U.S.S.R. or Bulgaria; and the single desi accession, ICC 3932, originated from Iran. Most of the resistant kabuli germplasm accessions were late in maturity, tall in stature, semi-erect in growth habit with small pea-shaped seed, while the newly developed breeding lines had medium to late maturity, medium to tall stature, and large and ram-shaped seed.

M.V. Reddy, K.B. Singh and R.S. Malhotra

2.1.3. Germplasm Enhancement

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

2.1.3.1. Cold

F_3, F_4 and F_5 generations of crosses between cold-tolerant lines of diverse origins were grown during 1990/91. Although the winter was mild, it did provide an opportunity to eleminate cold-susceptible plants. Eighty-four, 131 and 146 plants were selected in F_3, F_4, F_5 generations, respectively. M_4 plants of ILC 3279 did not show promise, hence they were rejected.

Ten F_2 and four F_3 populations of interspecific crosses of cultivated species with C. echinospermum and C. reticulatum were grown. Up to 100 plants each of kabuli type and desi type with cold tolerance were selected.

R.S. Malhotra and K.B. Singh

2.1.3.2. Ascochyta blight

2.1.3.2.1. Mutation studies

Induced mutation has been sometimes used in disease resistance breeding to obtain resistant plants. The chickpea cultivars ILC 1929 and ILC 3279, which have desirable agronomic traits but have no to moderate levels of resistance to Ascochyta blight, respectively, were treated by exposing seeds to 40, 50 and 60 kR of gamma irradiation and ethylmethane sulphate (EMS) at a concentration of 0.1% or 0.2%. The M_4 generation was sown at Tel Hadya during 1990/91 and the field was exposed to six races of Ascochyta blight. Disease severity ratings were taken on an individual plant basis twice in the season, first at the vegetative stage for stem infection (mid April for ILC 1929 and mid May for ILC 3279) and at the podding stage for stem and pod infection (early June). Only resistant plants with a disease rating of 3 (on a scale of 1-9) were further evaluated at the podding stage.

Of the total of 3274 plants of ILC 1929 observed, only 2 plants had a disease rating of $\geq$ 4. At the podding stage, however, the disease severity rating ranged from 6-8 and the pod infection from 3-8 (on 1-9 scale). All of the untreated ILC 1929 plants used as a check received a rating of 9 (complete kill) from the first reading. Of the total 10,084 single plants tested of the ILC 3279 genotype, 64 plants had a DSR of $\geq$ 3 in the first rating. At the second stem infection readings, only 50 plants were resistant of which only 26 also had a pod infection rating of $\leq$ 3 (Table 2.1.9). Of the 115 ILC 3279 plants screened as nonmutant checks, only one plant was resistant.

K.B. Singh and W. Khoury

2.1.3.2.2. Pyramiding of genes for resistance

Six crosses between different parents resistant to Ascochyta blight have been made in an attempt to pyramid genes for resistance. The F_2 populations were planted in the field in Tel Hadya during 1990/91 and the field was exposed to six races of Ascochyta blight. Disease severity readings on individual plants were taken twice in the season, the first for stem infection and the second for both stem and pod infection only on those plants that were resistant in the first reading.

Table 2.1.9. Frequency distribution of the disease severity ratings (DSR) on stems of the ILC 3279 plants exposed to different mutagenic agents.

Treatment	DSR									Total no. plants
	1	2	3	4	5	6	7	8	9	
40 kR	0	0	20	231	873	712	190	36	17	2079
50 kR	0	1	13	151	714	1086	435	36	14	2450
60 kR	0	1	13	88	563	947	508	17	15	2152
0.1% EMS	0	1	9	79	488	760	380	16	5	1738
0.2% EMS	0	0	6	63	334	708	504	39	11	1665
Total	0	3	61	612	2972	4213	2017	144	62	10084
Control	0	0	1	1	36	52	23	2	0	115

A total of 198 plants out of 2036 plants from different crosses were resistant to stem infection. Of those, however, only 160 plants were resistant to pod infection and those have been harvested and will be further tested in the next season to confirm their resistance. Dr. K.B. Singh.

K.B. Singh and W. Khoury

2.1.3.3. Combined resistance to cold and Ascochyta blight

Six F_2 populations, and F_3, F_4 and F_5 progenies were grown in cold and Ascochyta blight nursery. The winter was mild, but Ascochyta blight developed in epidemic form. Plants having a rating of 3 or less for both stresses were selected. We selected 12, 17, 23, and 130 plants from F_2, F_3, F_4 and F_5, respectively.

K.B. Singh and R.S. Malhotra

2.1.3.4. Tall stature

Five hundred plants from each of six crosses between tall lines of diverse origins and types were grown. Three crosses did not have any promising tall plants, hence those populations were rejected. Fifty tall plants from the remaining three crosses were bulk harvested and grown in summer nursery. Ninety-six tall F_3 plants were selected in the off-season.

K.B. Singh

2.1.4. Development of Improved Germplasm for Wheat-based Systems

Two breeding methods, namely (1) back-pedigree method for breeding cold and Ascochyta blight-resistant chickpeas and (2) bulk-pedigree method for breeding cold, Ascochyta blight- and drought-tolerant chickpeas, have been developed at ICARDA. The first method was described in the program annual report of 1989 and the second one in the annual report of 1990. Both methods take full advantage of the off-season nursery and cultivars are developed in a period of four years. Following these methods a number of lines have been bred and shared with NARSs and have been released as cultivars.

K.B. Singh

2.1.4.1. Segregating generations

During the 1990/91 season, 361 crosses were made, of which 242 were grown in the off-season during 1991. F_2, F_3 and F_4 bulks were grown in the period between the off-season and main season (Table 2.1.10). About 15,000 progeny rows were grown between winter and spring seasons. A total of 412 promising and uniform F_5 and F_6 progenies were bulked. These bulked lines were grown in the off-season and purified seeds have been harvested for multi-season evaluation.

The 1990/91 season had a mild winter, hence effective selection for cold tolerance could not be made. Ascochyta blight developed in epiphytotic form and effective selection was made against this stress. Since this season was a dry year, it provided an opportunity to select material resistant to drought. Like winter, summer was mild. Therefore, the material was advanced well in summer nurseries.

K.B. Singh

Table 2.1.10. Chickpea breeding material grown at Tel Hadya during winter and spring and at Terbol during off-season, 1990/91.

Generation	No. of bulk/ progeny grown	No. of plants selected	No. of bulked progenies
F_0	361	-	-
F_1	242	-	-
F_2 Bulk	266	-	-
F_3 Bulk	422	-	-
F_3 Progeny	79	-	-
F_4 Bulk	310	5857	-
F_4 Progeny	542	75	-
F_5 Progeny	8829	2737	96
F_5 Progeny (Large)	140	239	3
F_5 Progeny (Tall)	79	366	72
F_5 Progeny (Early)	1638	607	37
F_6 Progeny	2030	-	83
F_6 Progeny (Large)	279	-	29
F_6 Progeny (Tall)	837	-	92
Total:			
$F_2/F_3/F_4$ Bulks	998	9881	412
$F_3/F_4/F_5/F_6$ Progeny	14453		

2.1.4.2. Yield performance of newly bred lines

Two hundred and eighty-eight newly bred lines were evaluated in preliminary yield trials (PYTs) and 168 lines in advanced yield trials (AYTs) for yield at three locations (Tel Hadya, Jinderess and Terbol) and in two seasons (winter and spring). Several lines were superior in yield over the check, although only a few were significantly better (Table 2.1.11). The 1990/91 season was favorable at Terbol station and a few lines produced over 4 t/ha seed yield. Although yields were low at Tel Hadya due to drought, the winter-sown trials produced 250% more yield in PYTs and 128% in AYTs indicating the superiority of winter chickpea over spring. Furthermore, the yield of winter chickpea was more than 100% over spring chickpea in both PYTs and AYTs.

K.B. Singh

Table 2.1.11. Performance of newly developed lines during winter and spring at Tel Hadya, Jindiress and Terbol, 1990/91.

Location and season	No. of trials	Entries			Yield		Range for	
		Tested	Exceeding check	Signif. exceeding check	Mean of location	Mean of highest yield (kg ha)	C.V. (%)	LSD ($P \leq 0.05$) (kg ha)
<u>Tel Hadya</u>								
-Winter	19	456	219	17	616	838	7-22	87-303
-Spring	19	456	28	9	211	547	13-70	85-254
<u>Jindiress</u>								
-Winter	19	456	162	14	1420	1912	11-23	271-738
-Spring	19	456	51	2	1171	1579	11-22	269-548
<u>Terbol</u>								
-Winter	19	456	87	21	3120	4066	6-17	359-1206
-Spring	19	456	85	13	1163	1512	10-21	228-494
<u>Overall</u>								
-Winter	19	456	-	-	1719	-	-	-
-Spring	19	456	-	-	848	-	-	-

2.1.4.3. Evaluation of breeding lines to six races of A. rabiei

In the 1980s (1980-89), we developed 1344 chickpea lines including 970 resistant and 374 tolerant lines. Screening of breeding material was done by inoculating plants with (a) diseased debris collected in the previous years (1980-83), (b) diseased debris supplemented by spore suspension prepared from four races and (c) diseased debris supplemented by spray of spore suspension prepared from six races. Of the 970 resistant lines, only 117 lines or 12% lines remained resistant when they were screened against disease debris and six races of A. rabiei in 1991 (Table 2.1.12).

A comparison between inoculation by diseased debris alone and diseased debris plus four races to disease debris plus six races revealed that 9.95% of lines found resistant when using debris were also resistant when debris plus six races were used, whereas 18.07% of lines found resistant using debris plus four races were resistant when debris plus six races were used. Proper conclusions cannot be drawn from 1989 screening because the disease did not develop in epidemic form because of an extremely dry and warm spring. However, 117 lines were found resistant using debris and six races and three of them (FLIP 84-79C, FLIP 85-86C and FLIP90-103C) had a 2-rating. These resistant lines will be valuable in the future breeding program.

2.1.4.4. Winter sowing

2.1.4.4.1. Performance of newly bred lines at ICARDA sites

A comparison of spring versus winter sowing has been made over eight years (1983/84 to 1990/91) at three sites (Tel Hadya, Jinderess and Terbol), using common breeding lines (testing between 72 and 486 lines). The winters of 1984/85, 1988/89, and 1989/90 were more severe than normal and the springs of 1983/84, 1988/89, 1989/90, and 1990/91 (especially at Tel Hadya) were drier than normal.

The seed yield data in Fig. 2.1.1 showed that winter-sown trials on average produced 1586 kg/ha against 927 kg of spring-sown trials, giving 71.1% or 659 kg/ha more yield. The yield differences between winter and

Table 2.1.12. Evaluation of breeding lines developed between 1980 and 1989 resistant to six races of Ascochyta blight under field conditions at Tel Hadya, Syria, 1990/91.

Scale	1980		1981		1982		1983		1984		1985		1986		1987		1988		1989	
	a	c	a	c	a	c	a	c	b	c	b	c	b	c	b	c	b	c	c	c
1	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
2	0	0	1	0	8	0	116	0	0	1	20	1	0	0	0	0	0	0	1	0
3	30	0	132	3	165	13	10	2	120	20	44	3	2	0	22	0	2	2	19	2
4	0	0	37	19	74	17	0	3	29	17	26	4	29	0	17	0	21	4	75	6
								Tolerant												
5	0	1	47	62	11	61	0	25	20	55	20	11	53	13	28	7	47	2	21	19
6	0	0	15	52	3	66	0	21	8	45	18	38	9	34	20	27	17	7	5	54
								Susceptible												
7	0	0	0	45	0	92	0	63	0	33	0	35	0	33	0	29	0	17	0	39
8	0	0	0	16	0	12	0	11	0	3	0	11	0	5	0	6	0	33	0	1
9	0	27	0	35	0	0	0	1	0	2	0	27	0	8	0	5	0	22	0	0
Total	30	28	232	232	261	261	126	126	177	176	130	130	93	93	87	74	87	87	121	121

a = evaluation against diseased-plant debris
b = evaluation against diseased-plant debris + 4 races
c = evaluation against diseased-plant debris + 6 races

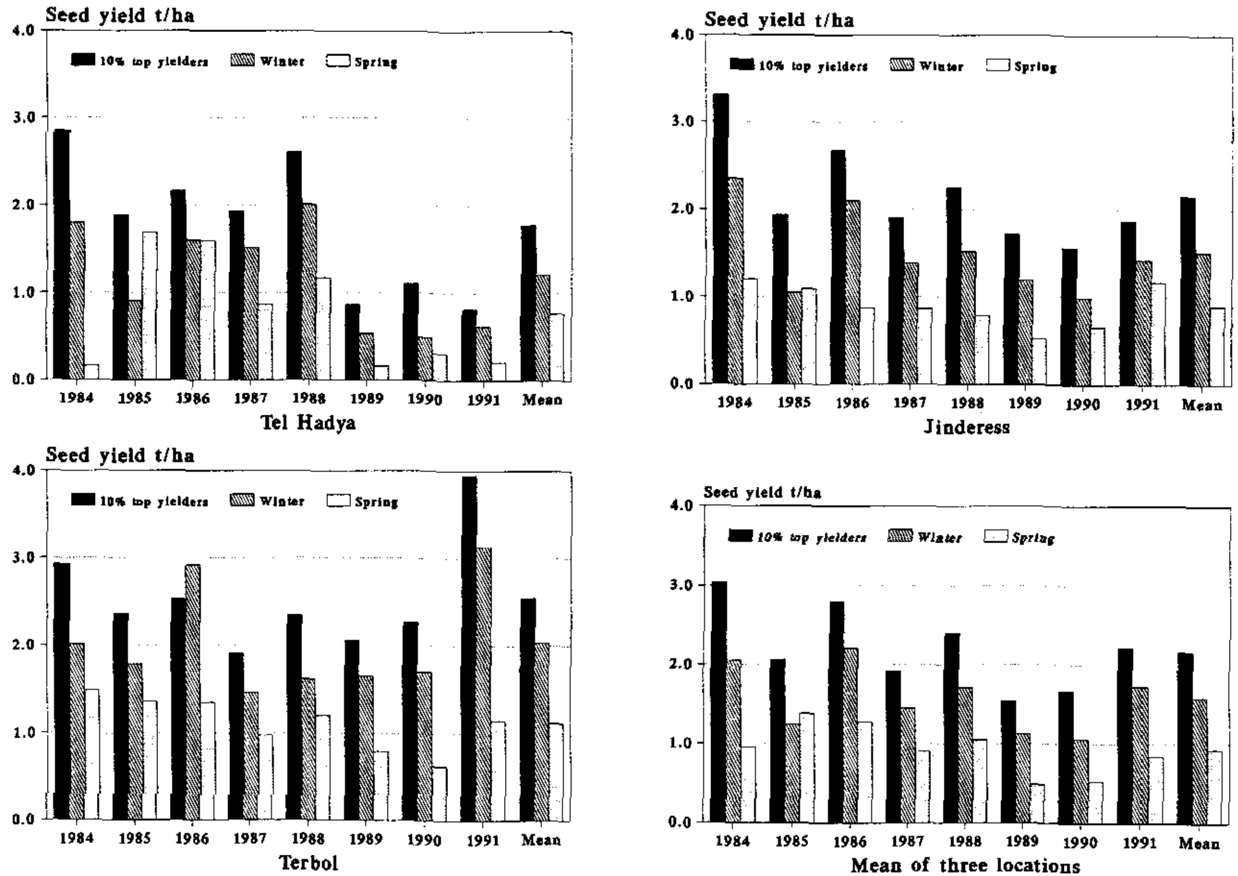


Figure 2.1.1. Mean seed yield (kg ha^{-1}) of chickpea grown in winter and spring at three locations and eight years.

spring were larger during dry seasons than in normal seasons. During an abnormally cold year (1984/85), yields of winter-sown trials were lower than spring-sown trials. But this trend was reversed during the 1988/89 and 1989/90 seasons which were also very cold, because of deliberate selection for cold tolerance since 1984/85. Breeders usually select the top 10% for further evaluation and possible release; this 10% top yielders in winter sowing produced 133.0% or 1233 kg/ha more than the mean yield produced in spring over eight years. Many lines produced more than 4 t/ha seed during winter especially in the favorable environment of Terbol. Obviously, there is a big advantage of winter sowing over spring.

K.B. Singh

2.1.4.4.2. Adoption of winter chickpea in the Mediterranean environment
Adoption of winter chickpea by farmers began in Cyprus during the 1984/85 season and by 1990/91 nearly all spring chickpea area was replaced by winter chickpea. Syrian farmers were next to adopt winter chickpea and by 1990/91 an estimated 10,000 ha was sown during winter. All eastern Mediterranean countries including those in West Asia, North Africa and southern Europe (Table 2.1.13) have introduced winter sowing. The technology has been accepted, but the major bottleneck in speedy spread of winter chickpea is the non-availability of seed. The concept of winter sowing of chickpea in Mediterranean environments has reached other continents. California (U.S.A.), which grew chickpea during spring, has now introduced winter sowing in Central Valley. Nearly all chickpea area in western Australia is sown in winter. Likewise Chile has introduced winter sowing of chickpea.

It is encouraging to note that winter chickpea area is increasing as is evident from Figure 2.1.2. The area increased from 1000 ha in 1988 to an estimated 30,000 ha in 1991. It is expected that the adoption rate will increase because of higher availability of seed.

Table 2.1.13. An estimation of adoption of winter chickpea in the Mediterranean environment.

Country	Estimated area (ha) 1990/91
West Asia	
Cyprus	1500
Iraq	500
Jordan	1000
Lebanon	1000
Syria	10000
Turkey	2500
North Africa	
Algeria	500
Egypt	4000
Morocco	1000
Tunisia	1000
Europe	
France	400
Italy	2000
Portugal	1000
Spain	2500
Australia	
Western Australia	400
North America	
U.S.A. (California)	1500
South America	
Chile	100
Total	30,900

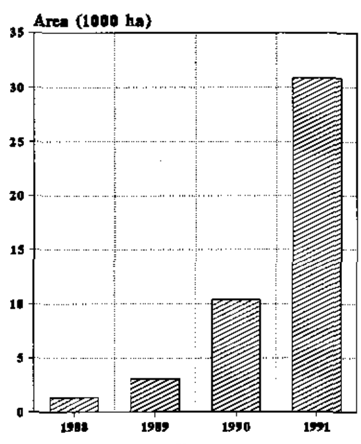


Figure 2.1.2. Estimated adoption of winter chickpea in the Mediterranean environemnt.

2.1.5. Strategic Research

2.1.5.1. Studies on drought tolerance

Chickpea is considered to be a drought-tolerant crop, but little research has been conducted on kabuli chickpea in a Mediterranean environment. A line-source sprinkler system is being used to evaluate genotypic differences, but a screening technique is necessary that permits evaluation of a large number of germplasm and breeding materials for tolerance to drought. Since the crop experiences terminal drought, it was thought worthwhile to test the effect of delayed spring sowing to accentuate the stress effects to permit identification of genotypic differences in drought tolerance. An experiment with four sowing dates, 28 Feb (normal sowing date), 10 Mar, 20 Mar, and 30 Mar and 25 genotypes varying in maturity, plant height, seed size, and seed yield, was conducted at Tel Hadya during 1990. This study indicated that sowing on Mar 20 or 30 can be effective in distinguishing drought and heat-susceptible lines from tolerant ones. Following this lead, we chose to repeat this experiment by sowing on 28 Feb and 20 Mar 1991 with and without irrigation. The plot size was 4 rows, 4 m long with 30-cm row spacing. Split-plot design was used with three replications for each date. Observations were collected on 15 morphological, phenological and seed characters. In addition, the amount of soil moisture was determined at sowing, and plant count at emergence and maturity, percent of emergence, and canopy temperatures at late vegetative, flowering and pod filling stages were recorded.

Mean performance of genotypes for 14 characters at each date and for rainfed and irrigated conditions is shown in Table 2.1.14. There was a gradual reduction in the performance for all characters with delay in sowing from first to second date. However, seed size and yield, biological yield and harvest index were higher with irrigation over rainfed. Mean seed yield of 26 genotypes on two dates of sowing and two water regimes are given in Table 2.1.15. Some genotypes, namely FLIP 87-58C, FLIP 87-59C, ILC 6104, and ILC 6118 produced good yield on both dates of sowing under rainfed conditions, but their performance under irrigated conditions was just average. On the contrary, other genotypes such as FLIP 85-142C, ILC 72, ILC 3279 and FLIP 86-12C produced little yield on the first date of sowing, but virtually no yield was produced by them on the second date of sowing under rainfed conditions. Their performance under irrigated conditions was equally bad. The former group of genotypes was early in maturity while the latter group was late in maturity. The irrigation treatment was included to obtain potential yield to enable comparison with the yield obtained under moisture stress conditions. The best performing lines under rainfed conditions (i.e., drought tolerant ones) produced 50-60% of the potential yield on the first date of sowing and 35-45% of the potential yield on the second date of sowing, whereas the drought-susceptible lines produced less than 10% of the potential yield. There was no association between the performance of genotypes under rainfed and irrigated conditions.

Table 2.1.14. Mean performance of different characters on two dates and two levels of moisture regimes during the 1991 spring.

Characters	Dates of planting: 28 Feb		20 Mar		Mean		Genotype mean
	Rain	Irrig.	Rain	Irrig.	Rain	Irrig.	
Days to flowering	59	59	48	50	54	55	55
Vigor[a]	2.3	1.9	2.8	2.8	2.6	2.4	2.5
% Ground cover	53	82	33	57	43	70	57
Days to maturity	90	101	81	91	86	96	91
Plant height (cm)	26	32	20	26	23	29	26
Primary branches	7.8	8.9	7.0	7.4	7.4	8.2	7.8
Secondary branches	12.1	20.7	9.8	13.3	11.0	17.0	14.0
No. of pods	15	33	13	34	14	34	24
No. of filled pods	12	29	11	29	12	29	21
% of filled pod	63	87	52	86	58	87	73
100-seed weight (g)	23	27	23	27	23	27	25
Seed yield (kg/ha)	288	786	102	676	195	731	463
Biol. yield (kg/ha)	1074	2471	635	2025	855	2248	1552
Harvest index (%)	25	32	20	37	23	35	29

[a] Scale: 1 = most vigorous; 5 = least vigorous.

Table 2.1.15. Yield performance (kg/ha) on two dates and at two levels of moisture regimes during the 1991 spring.

Entry	Dates of planting								
	28 Feb			20 Mar			Mean		
	Rain Y(R)	% of irrig.	Irrig. Y(R)	Rain Y(R)	% of irrig.	Irrig. Y(R)	Rain Y(R)	% of irrig.	Irrig. Y(R)
ILC 72	9(25)	1.5	595(22)	1(24)	0.6	166(26)	5(25)	1.3	381(25)
ILC 3279	76(22)	9.7	783(14)	8(21)	3.6	220(25)	42(21)	8.4	502(21)
FLIP 85-142C	5(26)	1.9	265(26)	3(23)	0.6	465(21)	4(26)	1.1	365(26)
FLIP 86-12C	78(21)	12.8	611(21)	4(22)	1.3	318(24)	4(22)	0.9	465(23)
ICCV 88504	193(19)	29.5	654(17)	0(25)	0.0	584(18)	97(20)	15.7	619(20)
ICCV 88512	59(23)	6.1	969(5)	22(19)	5.3	412(23)	41(22)	5.9	691(17)
ILC 1929	332(11)	34.8	953(7)	120(11)	12.8	936(5)	226(12)	23.9	945(6)
ILC 482	316(13)	37.9	833(13)	98(13)	13.4	731(10)	207(14)	26.5	782(9)
ILC 1919	246(18)	45.8	537(24)	48(16)	11.4	421(22)	147(18)	30.7	479(22)
FLIP 87-5C	296(15)	45.3	653(18)	231(5)	26.7	865(7)	264(9)	34.8	759(13)
FLIP 87-7C	421(7)	38.7	1087(3)	83(14)	8.3	999(3)	252(10)	24.2	1043(2)
FLIP 87-8C	405(8)	33.0	1227(2)	187(7)	23.3	803(8)	296(7)	29.2	1015(3)
FLIP 87-51C	365(9)	47.7	766(15)	129(10)	11.4	1135(1)	247(11)	26.0	951(5)
FLIP 87-58C	559(1)	65.0	860(10)	284(2)	47.1	603(17)	422(1)	57.7	732(15)
FLIP 87-59C	492(3)	55.8	882(8)	289(1)	42.8	676(13)	391(2)	50.1	779(10)
FLIP 87-80C	48(24)	12.2	393(25)	0(25)	0.0	531(20)	24(24)	5.2	462(24)
FLIP 87-85C	493(2)	51.4	960(6)	138(9)	24.2	570(19)	316(5)	41.3	765(12)
ILC 710	322(12)	52.3	616(20)	55(15)	5.6	987(4)	189(15)	23.6	802(7)
ILC 830	284(17)	50.6	561(23)	48(16)	6.8	704(12)	166(16)	26.2	633(19)
ILC 1130	289(16)	33.8	856(11)	14(20)	2.0	714(11)	152(17)	19.4	785(8)
ILC 1141	182(20)	17.3	1052(4)	24(18)	2.7	898(6)	103(19)	10.6	975(4)
ILC 1687	346(10)	54.3	637(19)	202(6)	26.6	759(9)	274(8)	39.3	698(16)
ILC 1748	310(14)	44.1	703(16)	113(12)	16.9	669(14)	212(13)	30.9	686(18)
ILC 6104	438(6)	50.1	875(9)	224(4)	33.6	666(15)	331(4)	42.9	771(11)
ILC 6118	474(4)	55.9	848(12)	257(3)	39.2	655(16)	366(3)	48.7	752(14)
ICC 4958	450(5)	35.4	1270(1)	164(8)	15.1	1088(2)	307(6)	26.0	1179(1)
Mean	288	36.6	786	102	15.1	676	195	26.7	731
C.V.									46.1
SE of difference between two date means									98
SE of difference between two entry means									87.2
SE of difference between two entry means at the same level of the date									174.4
SE of difference between two date means for the same entry mean or for different levels of the entry									

[a] Y = seed yield in kg/ha, R = rank.

Correlation coefficients were estimated between seed yield and 13 variables on all four environments (Table 2.1.16). Under rainfed conditions, seed yield was significantly correlated with earliness (flowering and maturity), plant vigor, shoot biomass and 100-seed weight in both dates of sowing. Seed yield with was not correlated plant height, branching and pod characters. Under irrigated conditions, only shoot biomass was associated with seed yield.

Table 2.1.16. Correlation of seed yield with other variables on two dates and two levels of moisture regimes at Tel Hadya in the 1991 spring.

Variable	Date of sowing			
	(28 Feb)		(20 Mar)	
	Rainfed	Irrigated	Rainfed	Irrigated
Days to flowering	-0.6122	-0.3839	-0.6412	-0.4039
Plant vigor	-0.7479	-0.4442	-0.6538	-0.2941
% Ground cover	0.7402	0.3823	0.3235	0.5848
Days to maturity	-0.4783	-0.0180	-0.3657	-0.0381
Plant height (cm)	-0.2191	-0.0398	0.2187	-0.2611
Primary branches	-0.2667	-0.2515	-0.1448	0.2165
Secondary branches	0.2425	0.0081	0.1018	0.3852
Pod number	0.3852	0.2561	0.2409	0.3677
Filled pod	0.3314	0.2990	0.3370	0.3179
% filled pod	-0.0850	0.4272	-0.2130	-0.0435
Shoot biomass (kg/ha)	0.7164	0.6856	0.7774	0.6344
Harvest index (%)	0.9141	0.7918	0.3550	0.3900
100 seed weight (g)	0.5156	0.3434	0.7080	0.2987

Based on two years' results, it is concluded that early flowering and early plant vigor are the two most important traits associated with drought tolerance, functioning as escape mechanisms. Although study has been conducted only one year with and without irrigation, it seems that breeding material and germplasm could be screened under drought-stress conditions. In the first year of study, 20th March was found most appropriate to screen material, whereas the second year results indicate that both 28 February and 20 March are suitable dates for sowing material for drought tolerance studies.

K.B. Singh and M.C. Saxena

2.1.5.2. Study on plant ideotype

The chickpea plant in the present form is inefficient in utilization of additional inputs (nutrients and water). The short stature of the plant makes it difficult to harvest by machine. As a result, improvement in seed yield has been limited. Therefore, there is a need to tailor the chickpea plant such that it gives high seed yield utilizing inputs efficiently and can be harvested by machine. We selected from breeding material five different plant types: tall stature, long fruiting branches, tree type, bushy, and prostrate. In each class, three genotypes were chosen with nearly the same maturity period. This experiment was conducted during 1989/90 and repeated during the 1990/91 season. The trial was sown in the (first week of Dec) with three replications at two row spacings (30 cm and 45 cm apart). The plot size was 6 rows of 4 m long.

Observations were recorded on seed yield and 12 other characters. The tree type group produced the highest seed yield (2596 kg/ha) followed by the bushy type group (2566 kg/ha) (Table 2.1.17). The prostrate types produced the lowest yield (1788 kg/ha). Spacings did not influence the seed yield greatly. Most groups produced slightly higher yield at wider spacing except the group with tall genotypes. Furthermore, plant type alone did not make a group high yielding. Of course, genotypes with prostrate growth habit did not produce high yield, and should be dropped from ideotype studies. It seems that genes for yield occur in different plant types which should be exploited in a planned hybridization program.

K.B. Singh

Table 2.1.17. Seed yield and other attributes as influenced by different plant type and row spacing at Tel Hadya, Syria, 1990/91.

Characters	Prostrate type			Tree type			Tall type			Long fruiting			Bushy type		
	30cm	45cm	Mean	30cm	45cm	Mean	30cm	45cm	Mean	30cm	45cm	Mean	30cm	45cm	Mean
Days to flowering	132	134	132	125	126	126	129	129	129	125	125	125	123	122	123
Days to maturity	169	171	170	168	167	168	170	171	171	167	166	167	165	165	165
Plant height (cm)	12	17	15	42	42	42	53	50	52	50	51	51	45	46	46
Stem length (cm)	45	57	51	49	51	50	60	64	62	57	59	58	50	55	53
Nodes/main stem	20	23	22	22	20	21	24	25	25	23	22	23	21	21	21
Canopy width (cm)	77	84	81	30	30	30	28	31	30	32	29	31	27	29	28
Primary branches	4.0	4.2	4.1	3.4	3.6	3.5	3.3	3.3	3.3	3.7	3.6	3.7	3.9	3.8	3.9
Secondary branches	11.3	7.8	9.6	6.8	6.3	6.6	7.1	6.9	7.0	6.1	5.9	6.0	6.7	6.9	6.8
Pods/plant	31	34	33	28	26	27	26	28	27	24	24	24	31	28	30
Seeds/plant	26	32	29	30	29	30	22	25	24	23	24	24	28	26	27
B. yield (kg/ha)	4424	5382	4903	5547	6240	5894	5891	6240	6111	5381	5526	5454	5327	5685	5506
Seed yield (kg/ha)	1760	1816	1788	2543	2648	2596	2193	2135	2164	2187	2299	2243	2537	2595	2566
100-seed weight (g)	30	31	31	30	30	30	34	34	34	33	30	32	31	32	32

2.1.5.3. Autumn sowing

After developing winter chickpea technology for the medium to low elevation areas of the Mediterranean region, we investigated the possibility of autumn sowing of chickpea. We chose 12 lines including eight lines having resistance and/or tolerance to both Ascochyta blight and cold, two released cultivars of Syria for winter sowing and two cold-susceptible lines. The plot size was 4 m long, rows spaced at 45 cm apart. Split-plot design was used with dates of sowing as main plots and entries as subplots with three replications. The experiment was sown on three dates including autumn (1 Oct), winter (1 Dec) and spring (1 Mar) and was conducted for three years from 1988/89 to 1990/91. Since autumn-sown plots had to be irrigated, the entire experimental plot was irrigated to provide equal moisture regimes. In 1988/89 the autumn-sown plots were damaged by herbicide hence no results were obtained. In 1989/90, a severe spell of cold occurred on 17 Mar 1990 suddenly with temperature falling to -8.9°C. Hence all the autumn-sown entries were killed, while winter sown crop was partly damaged and spring-sown crop completely escaped the cold damage. In 1990/91 the autumn-sown crop grew well but in early April it developed severe infestation of Orobanche spp. The yield data for 1990/91 season are given in Table 2.1.18. On an average, autumn-sown trials produced 566 kg/ha yield against 902 kg of winter-sown trial, giving 59.4% lower yield. It is concluded from this study that the presently available chickpea lines are not suitable for autumn sowing because of their susceptibility to herbicide, cold and Orobanche. There may be additional problems associated with autumn planting.

2.1.6. Studies on Wild Cicer Species

2.1.6.1. Karyotype analysis

The detailed karyotype analysis of eight annual Cicer species, viz. C. arietinum, C. bijugum, C. cuneatum, C. echinospermum, C. judaicum, C. pinnatifidum, C. reticulatum and C. yamashitae, was carried out by applying the new computerized image analysis system.

Table 2.1.18. Seed yield of autumn-, winter- and spring-sown chickpeas at Tel Hadya, Syria, 1990/91.

Entry	Seed yield (kg/ha)		
	Autumn	Winter	Spring
ILC 4421	652	773	384
4596	813	994	672
5556	691	995	614
6091	974	501	590
6255	516	1196	605
6260	470	913	434
6269	469	1128	457
6909	685	839	331
482	302	925	1044
3279	291	897	415
533	660	748	521
FLIP 81-16C	272	915	748
Mean	566	902	568
C.V. (%)	47.2	22.53	426.3
L.S.D. at 5%	453	344	253

The karyomorphological parameters (chromosome length and arm ratio) were utilized for computing the karyotypic symmetry of each species with two classification methods. With Stebbins's method, the species were arranged in three categories or groups, different for asymmetry level (evolution). Greiluber and Speta's method, which uses the Resemblance Between Chromosomes and Symmetric indices, sorted the eight species in two groups, 1st group: C. arietinum, C. reticulatum and C. echinospermum; 2nd group: the remaining five species. Within each grouping, it is possible to obtain fertile hybrids through crosses.

B. Ocampo, G. Venora, A. Errico, K.B. Singh and F. Saccardo

2.1.6.2. Interspecific hybridization

Interspecific hybridization among the nine annual Cicer species was studied from 1987 to 1990. The objectives were to make crosses among

Cicer species and to explore the possibility of improving chickpea (Cicer arietinum L.) through the introgression of genes from the wild Cicer species. A 9 x 9 diallel cross comprising all the nine annual Cicer species (one cultivated and eight wild) was attempted during the 1987/88 season and the F_1s were studied during the 1988/89 season. During the 1989/90 season, data were collected from F_1s, F_2s, and parents from the four out of eight successful crosses. We confirm the earlier findings that crosses can be made between C. arietinum and C. reticulatum, C. bijugum and C. judaicum, and C. pinnatifidum and C. judaicum. Included in new findings were that (a) F_2 and later generation seeds were produced from the cross C. arietinum x C. echinospermum and its reciprocal, and (b) C. echinospermum and C. reticulatum can be crossed. Third, high hybrid vigor (up to 153%) was observed in F_1s of two crosses, C. arietinum x C. echinospermum and C. arietinum x C. reticulatum, which was retained to an extent of 20% in F_2s. This suggests the possibility of improving seed yield in chickpea through introgression of genes from wild Cicer species. Other conclusions from this investigation were that cultigen should be used as a female parent in interspecific hybridization and more cultigens should be used if the objective is to develop high-yielding cultivars.

K.B. Singh and Mr. B. Ocampo

2.1.6.3. Confirmation of new interspecific crosses

Confirmation was obtained of new interspecific crosses (C. arietinum x C. echinosperimum and C. echinospermum x C. reticulatum). We confirmed that C. arietinum C. can be crossed echinospermum and C. echinospermum can be crossed with C. reticulatum as reported last year. Earlier we succeeded in making crosses of C. arietinum with C. echinospermum using kabuli type, but this year we confirmed that such crosses are possible using both desi and kabuli types. We collected information on 12 characters including seed yield in F_1 of seven interspecific crosses using kabuli and desi cultigen and two wild annual species mentioned above (Table 2.1.19). Unlike previous study, no significant heterosis for seed yield was observed in seven interspecific crosses. It seems that heterosis may not be expressed in all cross combinations, but it is present only in certain

Table 2.1.19. Analysis of seed yield and 11 other variables of parents and F_1s in interspecific crosses of <u>Cicer</u> grown at Tel Hadya, Syria, 1990/91.

Parent/F_1		Days to flower	Days to mature	Plant height (cm)	Canopy width (cm)	Primary branch (no.)	Secondary branch (no.)
<u>C</u>. <u>arietinum</u> kabuli	(K)	130.0 bc[1]	185.5 ab	41.5 a	57.0 ab	3.9 abcd	19.0 ab
<u>C</u>. <u>arietinum</u> desi	(D)	126.0 cde	176.5 bc	38.2 ab	45.8 def	4.4 ab	10.3 b
<u>C</u>. <u>echinospermum</u>	(E)	134.5 b	176.0 c	10.3 e	40.4 efg	3.9 abcd	12.0 b
<u>C</u>. <u>reticulatum</u>	(R)	126.5 cde	181.0 ab	15.5 e	44.6 def	4.4 ab	15.2 ab
F_1 between	KD	129.0 cd	173.0 c	33.5 b	56.5 abc	3.6 bcd	12.3 b
	DK	130.0 cd	176.5 bc	35.1 ab	48.3 cde	3.1 cdef	10.2 b
	KE	127.5 cde	182.0 ab	35.8 ab	58.0 ab	5.0 a	21.8 a
	EK	145.0 a	183.0 a	9.0 e	32.0 g	2.5 ef	11.5 b
	KR	124.0 e	180.0 ab	31.5 bc	64.3 a	4.1 abc	18.9 ab
	RK	128.0 cde	180.0 ab	25.3 cd	49.4 bcde	2.4 f	13.2 ab
	DE	134.0 ab	179.5 ab	25.0 cd	37.7 fg	2.8 def	11.0 b
	DR	125.0 de	178.0 abc	33.8 b	53.1 bcd	3.9 abcd	15.3 ab
	RD	124.5 de	183.5 a	23.6 d	55.7 abc	3.4 bcdef	15.7 ab

[1] Analysis was done following Duncan's multiple range test, where entries having same letters are not significantly different at 5% level.

Cont'd.

Table 2.1.19. Cont'd.

Parent/F_1		Pods/plant (no.)	Seeds/plant (no.)	Seed yield/plant (g)	Biol. yield/plant (g)	Harvest index	100-seed weight (g)
C. arietinum kabuli	(K)	146.1 a[1]	134.7 ab	38.9 a	77.3 a	0.49 a	29.0 ab
C. arietinum desi	(D)	100.6 ab	107.6 bc	23.1 b	44.7 bc	0.54 ab	21.5 d
C. echinospermum	(E)	34.9 d	30.9 ef	4.2 c	11.8 d	0.38 c	13.7 e
C. reticulatum	(R)	45.9 bcd	38.0 ef	4.7 c	17.3 cd	0.22 ef	14.7 e
F_1 between	KD	146.1 a	163.9 a	41.3 a	74.3 a	0.56 ab	24.0 cd
	DK	84.6 bcd	98.6 bcd	25.3 b	41.9 bcd	0.60 a	26.0 bc
	KE	94.2 abc	75.0 cde	22.7 b	61.3 ab	0.38 c	30.2 a
	EK	49.5 bcd	21.5 ef	6.0 c	22.9 cd	0.25 def	26.5 abc
	KR	65.5 bcd	55.2 def	13.3 bc	37.5 bcd	0.31 cde	24.4 cd
	RK	52.0 bcd	40.5 ef	9.5 c	22.9 cd	0.38 c	23.2 cd
	DE	36.6 cd	26.2 ef	6.2 c	15.9 cd	0.34 cd	21.5 d
	DR	29.4 d	19.6 f	3.8 c	18.9 cd	0.20 f	20.2 d
	RD	57.3 bcd	44.0 ef	7.3 c	24.7 cd	0.23 ef	15.9 e

[1] Analysis was done following Duncan's multiple range test, where entries having same letters are not significantly different at 5% level.

specific cross combinations. However, higher heterosis was observed when cultigen was used as a female parent than when wild accession was used as a female parent.

K.B. Singh and B. Ocampo

2.1.6.4. Study of transfer of "yield genes" from wild to cultivated species

Material including parents, F_1, F_2, F_3 and F_4 bulks of four interspecific crosses were grown at Tel Hadya, Syria during the winter of 1990/91. Data have been collected for 12 characters in all the four crosses. While data are being compiled for others, results of yield from one cross are shown in Table 2.1.20.

Table 2.1.20. Seed yield of parents and F_1 to F_4 generations of a cross C. arietinum (ILC 482) x C. echinospermum (ILWC 35), grown at Tel Hadya, Syria, 1990/91.

Generation	Yield (g/plant)	
	Mean and S.D.	Range
C. arietinum (ILC 482)	17.9 ± 1.14 ab[1]	5.8 - 30.2
C. echinospermum (ILWC 35)	6.1 ± 0.58 d	2.0 - 11.7
F^1	22.1 ± 3.55 a	8.8 - 52.1
F_2 bulks	10.7 ± 1.60 cd	0.7 - 36.8
F_3 bulks	19.0 ± 1.03 a	0.2 - 60.0
F_4 bulks	13.5 ± 0.87 bc	0.4 - 37.8

1/ Analysis was done following Duncan's multiple range test, where entries having same letters are not significantly different at 5% level.

Heterosis occurred in population means in F_2 to F_4 generations, indicating thereby that plants with yield higher than the cultigen can be selected. Granted those plants may have many undesirable attributes but they will be useful in a crossing program for generating high-yielding lines.

K.B. Singh and B. Ocampo

2.1.6.5. New cross combinations

We crossed four cultigens with C. bijugum, C. judaicum and C. pinnatifidum and produced some seeds. They will be evaluated next season for genuineness of their crosses.

K.B. Singh B. Ocampo

2.1.6.6. Transfer of genes from wild to cultivated species

Three separate programs to transfer gene(s) from wild Cicer species to cultivated species for (a) resistance to cyst nematode, (b) cold tolerance and (c) yield genes have been initiated. The first backcrosses has been made.

K.B. Singh and R.S. Malhotra (ICARDA), N. Greco, and M. Di Vito (Italy)

2.1.7. Quality of Chickpea

2.1.7.1. Protein content in newly developed lines

The differences in the protein content of chickpea from winter and spring sowing have been studied since 1987/88. There was little differences in the protein content because of date of sowing (Table 2.1.21 and 2.1.22).

K.B. Singh

Table 2.1.21. Mean protein content (%) of the entries grown in two seasons (winter and spring) and four years (1987/88, 1988/89, 1989/90 and 1990/91 at Tel Hadya, Syria.

Year	No. of entries		Season	
	Winter	Spring	Winter	Spring
1987/88	120	120	20.94	19.85
1988/89	120	120	22.46	22.27
1989/90	223	225	22.74	26.09
1990/91	286	248	24.42	23.81
Mean	-	-	22.64	23.01

2.1.7.2. Survey of usage of chickpea in Syria

A detailed survey of various types of usage of chickpea in Syria was conducted in 1991 in collaboration with the University of Deir Azzor.

Table 2.1.22. Mean protein content (%) in 13 preliminary yield trials grown during winter and spring at Tel Hadya, Syria, 1990/91.

Name	No. of entries		Protein content		C.V. (S.E.)	
	Winter	Spring	Winter	Spring	Winter	Spring
PYT-L1	22	14	23.85	22.76	1.543 (0.260)	1.479 (0.238)
PYT-L2	22	17	24.58	23.46	1.582 (0.275)	1.228 (0.203)
PYT-T	22	12	24.97	24.37	2.419 (0.427)	1.688 (0.291)
PYT-E1	22	22	23.80	24.11	1.722 (0.29)	1.043 (0.177)
PYT-E2	22	21	24.86	24.01	1.239 (0.218)	1.125 (0.191)
PYT-1	22	21	24.41	24.88	1.903 (0.329)	1.188 (0.209)
PYT-2	22	22	24.39	22.99	1.241 (0.214)	1.638 (0.266)
PYT-3	22	17	24.57	23.31	1.147 (0.199)	0.745 (0.123)
PYT-4	22	19	24.75	23.52	1.45 (0.254)	1.268 (0.211)
PYT-5	22	21	24.23	23.64	1.262 (0.216)	1.282 (0.214)
PYT-6	22	22	24.47	24.42	2.127 (0.369)	1.537 (0.265)
PYT-7	22	22	23.92	24.34	1.272 (0.198)	1.394 (0.240)
PYT-8	22	18	23.61	23.56	1.527 (0.255)	1.025 (0.171)
Mean	286	248	24.42	23.81		
Check	2	2	24.44	23.60		

E = Early; T = Tall; L = Large.

While a detailed report is being prepared, a few salient points are described here. Twenty-four types of preparations are made from chickpea. An important finding was that chickpea is used as a yeast substitute in cake preparation. Consumers prefer the large-seed size in the villages, whereas they like medium-seed size in the cities. Chickpea consumption was highest in those villages where it is produced followed by that in cities. In villages where chickpea is not produced, it is either not consumed or it is consumed very little. The most preferred usage of chickpea in the cities in descending order is Hommos-Bi-tehineh, Falafel, Burghol-Bi-Hummos, Riz-Bi-Hommos, and Ekdameh Malha, whereas in the villages, the most important chickpea preparations are Burghol-Bi-Hommos, Hommos-Bi-Bannadora and Hommos-Bi-Laban. Obviously, different preparations are made from chickpea in villages compared with cities.

A. El-Saleh, K.B. Singh and M.C. Saxena

2.2. Application of Molecular Techniques in Chickpea Improvement

2.2.1. DNA Fingerprinting in Chickpea

Ascochyta blight is best controlled by host-plant resistance. Identification of resistant genotypes with classical field and greenhouse selection procedures depends on availability of inoculum and results are strongly influenced by environmental variations. Selection is restricted to those generations when the breeding material is exposed to the disease. Selection of potential parents for crossing and breeding material with high level of resistance could be improved if molecular marker-assisted selection could be done. Our objective is to produce DNA fingerprint-derived molecular markers which are closely linked to loci (genes) contributing to Ascochyta blight resistance. To develop these markers, DNA fingerprint-derived fragments which correlate with the trait of blight resistance have to be identified in F_2 and subsequent populations. Fig. 2.2.1 and 2.2.2 show, as a successful model, the segregation of DNA fingerprint-derived fragments in two crosses between Cicer arietinum and Cicer echinospermum.

To identify fragments which correlate with the trait of blight resistance, parents with contrasting reaction to Ascochyta rabiei were used to develop the necessary F_2 population Fig. 2.2.3. These will be fingerprinted soon.

In collaboration with the University of Frankfurt, Germany, the application of Polymerase Chain Reaction (PCR) technology was further pursued. To develop informative primers more than 30 oligodeoxynucleotides have been synthesized and evaluated. Fig. 2.2.4 shows the amplification fingerprints generated with the duplex (upper panel) or simplex approach (lower panel) for different species Cicer and different cultivars of chickpea. The amplification fingerprints are somatically completely stable and both sets of primers discriminate readily between the different Cicer species. The amplification fingerprints are relatively homogeneous in the various accessions.

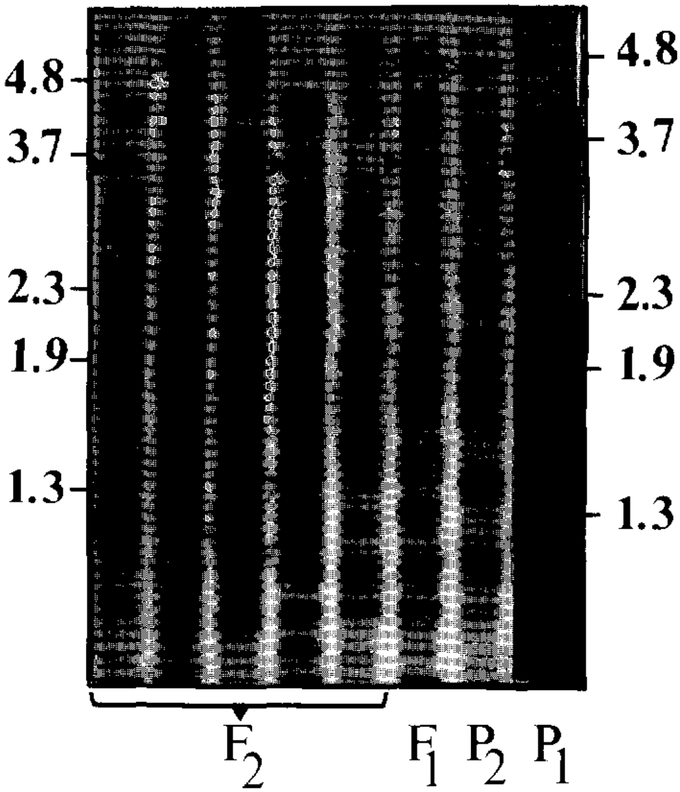


Figure 2.2.1. Segregation of parental differences in a cross between Cicer echinospermum x Cicer arietinum. Chickpea material used included: P_1: Cicer echinospermum (ILWC 35/S-1), P_2: Cicer arietinum (ILC 3279), F_1: 1 individual of ILWC 35/S-1 x ILC 3279, F_2: 5 individuals from the offspring of selfed F_1 plants. Genomic DNA was extracted, TaqI digested, vacuum blotted onto a nylon membrane and hybridized with the digoxigenin-labeled oligonucleotide $(GATA)_4$ *(non-radioactive)*. Note the segregation of Cicer arietinum fragment (white triangles) and Cicer echinospermum fragment (black triangle) in the F_2 population. Positions of molecular weight markers are indicated, in kilobases, at the left-hand side for P_2, F_1, F_2 and at the right-hand side for P_1.

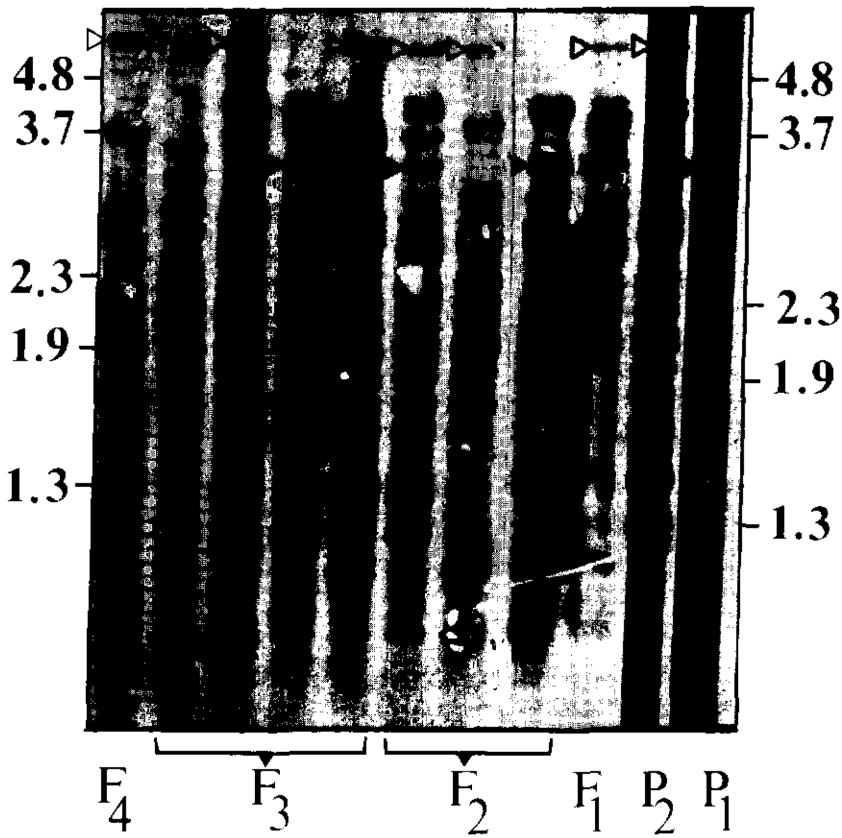


Figure 2.2.2. Segregation of parental differences in a cross between Cicer echinospermum x Cicer arietinum. Chickpea material used includes:

P_1: Cicer echinospermum (ILWC 35/S-1)
P_2: Cicer arietinum (ILC 482)
F_1: 1 individual of ILWC 35/S-1 x ILC 482
F_2: 3 individuals from the offspring of selfed F_1 plants
F_3: 4 individuals from the offspring of selfed F_2 plants
F_4: 1 individual from the offspring of selfed F_3 plants
For explanations see legend to Fig. 2.2.1.

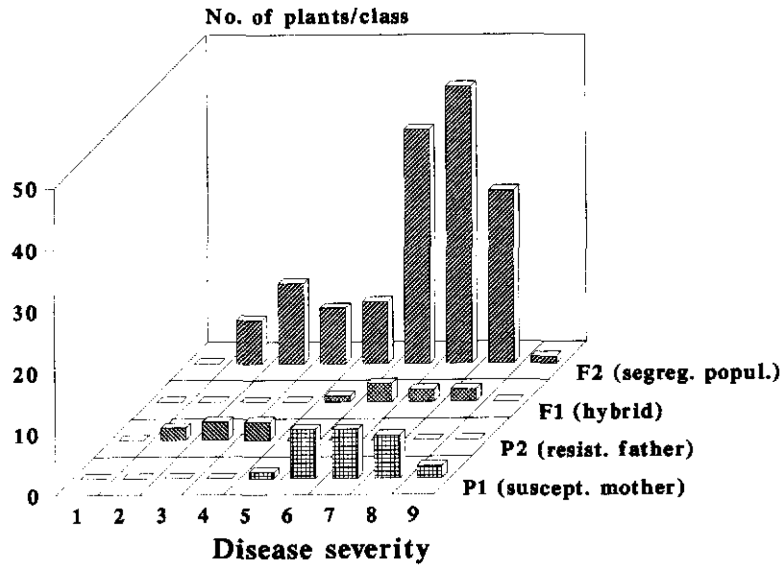


Figure 2.2.3. Distribution frequency of disease rating. Readings were taken 9 days after inoculation A. rabiei with isolate 6. ILC 1272 was used as susceptible female and ILC 3279 as resistant male parent.

2.2.2. DNA Fingerprinting in Ascochyta rabiei

Programs for disease control and resistance breeding in chickpea depend on the reliable identification and characterization of A. rabiei pathotypes and populations. The classical biological pathotyping technique, using a set of different host genotypes, is laborious, time-consuming, and requires strict standardization of test conditions. A reliable characterization of the genetic make-up of different strains of Ascochyta rabiei, their levels of aggressiveness, their extent of variability, geographic distribution and their genotypic and phenotypic interaction(s) with the host plant is, therefore, very difficult to achieve by means of biological pathotyping.

Therefore, two innovative approaches to differentiate between various A. rabiei isolates were introduced. The first approach is using a DNA fingerprinting technique that is based on the detection of hypervariable

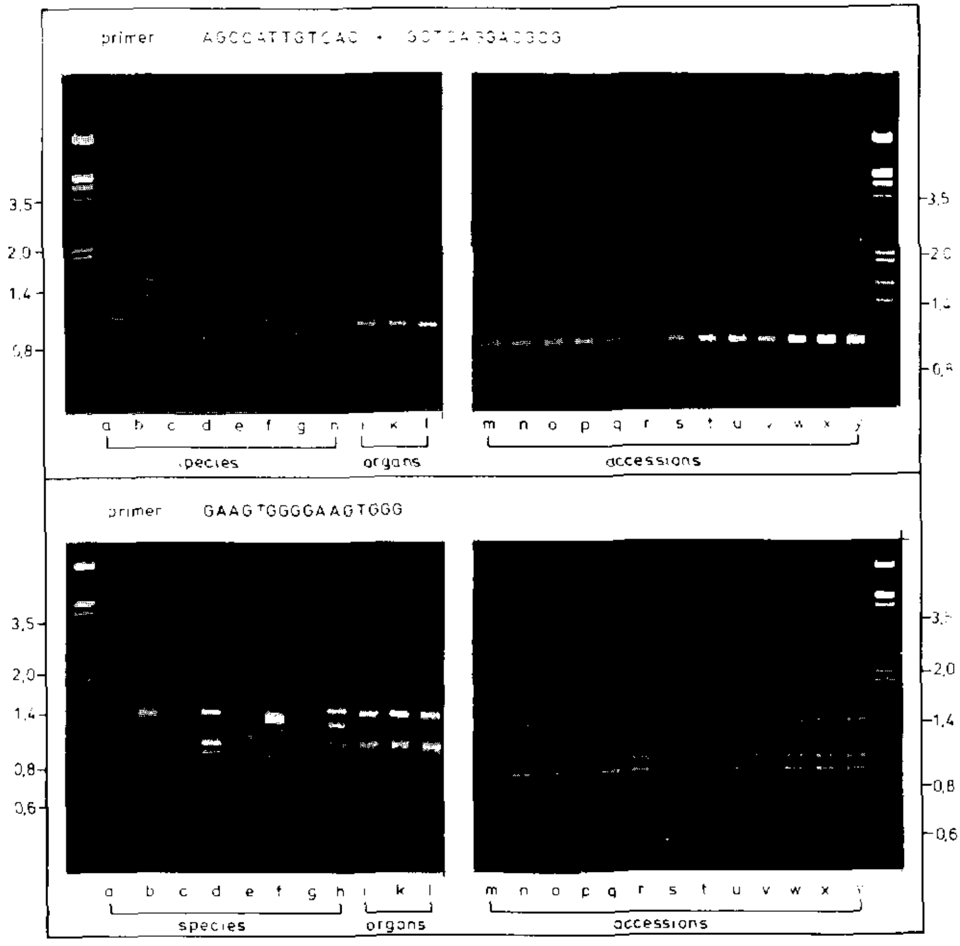


Figure 2.2.4. DNA amplification fingerprinting (RAPD, random amplified polymorphic DNA) of genomic DNA of various Cicer species (a-h), different organs of one Cicer arietinum plant (ILC 3475)(i-l) and thirteen Cicer arietinum accessions (m-y): a) Cicer yamashitae, b) Cicer pinatifidum, c) Cicer judaicum, d) Cicer reticulatum, e) Cicer chorassanicum, f) Cicer bijugum, g) Cicer cuneatum, h) Cicer echinospermum, m) ILC 72, n) ILC 195, o) ILC 263, p) ILC 464, q) ILC 482, r) ILC 613, s) ILC 1272, t) ILC 1929, u) ILC 3279, v) FLIP 81-293, w) FLIP 82-150, x) FLIP 84-15, y) FLIP 84-15. The synthetic oligodeoxynucleotide primers and primer combinations used are indicated above the respecitve photos. Molecular weight markers are indicated in kilobases.

restriction fragment length polymorphism (RFLPs) in the fungal genome. DNA fingerprinting relies on the presence of a particular class of repetitive DNA in the fungal genome. This class consists of short motifs which are tandemly arranged to form long, more or less homogeneous, arrays. Two characteristics qualify this kind of sequence for DNA fingerprinting. First, the tandem repeats are dispersed throughout the genome (multilocus appearance). Second, the tandemly arranged repetitions exhibit a high degree of polymorphism, mainly resulting from different copy numbers of the basic motifs. To detect the polymorphism, ^{32}P-endlabeled oligonucleotide probes (radioactive) have been used in previous studies. In the present study, we applied a non-radioactive DNA fingerprinting using digoxigenin-labeled probes. The results (Fig 2.2.5) showed that non-radioactive DNA fingerprinting of A. rabiei was

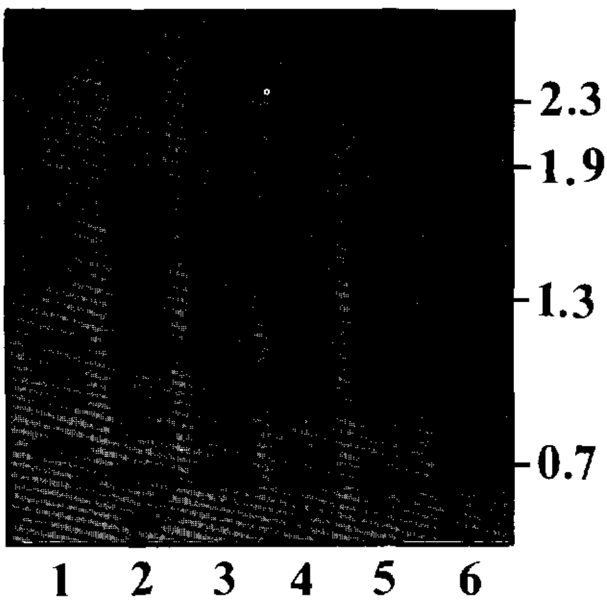


Figure 2.2.5. Non-radioactive DNA fingerprinting of Ascochyta rabiei isolates with synthetic oligodeoxynucleotides. Total DNA was isolated from lyophilized mycelia derived from single-spored cultures. After digestion woth HinfI, the restriction fragments were electrophoresed in 1.2% agarose gel (10 ug/lane). The gel was vacuum blotted onto a nylon membrane and hybridized to a digoxigenin-labeled $(GATA)_4$ probe. Lanes 1-6 represent DNA from fungal isolates No. 1, 2, 3, 4, 5 and 6. Positions of molecular weight markers are indicated in kilobases.

successful and as informative as the radioactive procedure. Results also confirmed the findings that isolates 1,2,3 and 4 are definitely different using the enzyme/probe combination HinfI/$(GATA)_4$ whereas isolates 3 and 5 as well as isolates 4 and 6 share an identical fingerprint pattern. Since this method avoids the use of radioactivity, it is easier to be adopted in many laboratories.

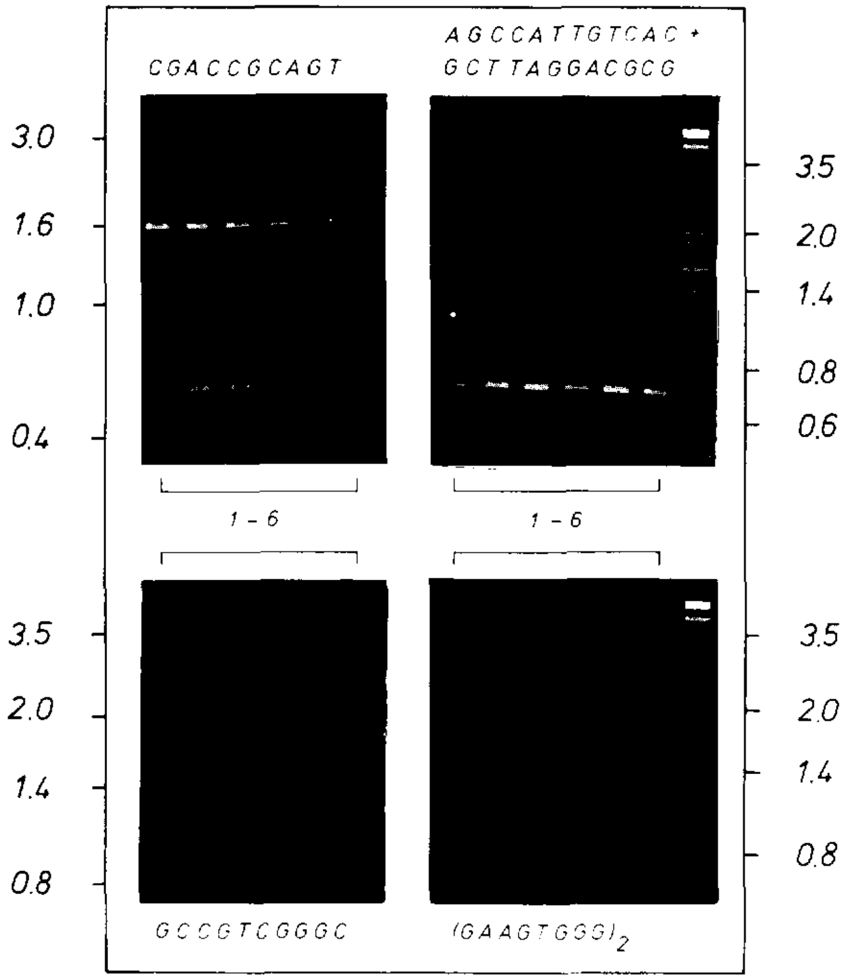


Figure 2.2.6. DNA amplication fingerprinting (RAPD, random amplified polymorphic DNA) of genomic DNA ofthe chickpea pathogen A. rabiei. The DNA of six pathotypes was isolated and the synthetic oligodeoxynucleotide primers indicated above and below the photos used for simplex or duplex amplification. The amplified products were electrophoresed in 1.2% agarose gels and stained with ethidium bromide.

In a second approach genomic DNA of the six isolates was amplified using oligodeoxynucleotide primers and Taq DNA polymerase (non-radioactive). Since the target sequences for the primers used are randomly dispersed throughout the genome the technique is called RAPD (random amplified polymorphic DNA). The results (Fig. 2.2.6) showed that the amplification fingerprints generated with single primers or primer combinations detect either no variation (left panels) or low variation (right panels). The duplex primer approach allows to discriminate isolate 4 and 6, the most aggressive isolates, from the residual isolates. More primers and primer combinations have to be evaluated until the discriminating power of the RFLP technique will be achieved. Once this is achieved, RAPD will be superior over RFLP because of substantial savings in costs and time needed for DNA pathotyping of Ascochyta rabiei isolates.

2.3. Chickpea Pathology

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

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

2.3.1. Screening for Ascochyta Blight Resistance

2.3.1.1. Segregating generations

The 1990-92 season was the first year of an effective evaluation of chickpea segregating generations against six races of A rabiei. The results of screening are shown in Table 2.3.1. A total of 402 F_6 progenies were rated 3. Many F_5 lines also showed a rating of 3 and 4. Thus these large number of resistant lines allowed the breeder to bulk promising and uniform progenies as possible future cultivars. Also, thousands of plants resistant to A. rabiei in F_2 were bulk harvested to be grown in the off-season. The resistant plants in F_4 generation were harvested individually.

Table 2.3.1. Reaction of F_2 to F_6 generations to Ascochyta blight at Tel Hadya, 1990/91

Generation[1]	Reaction on a 1-9 scale									Total
	1	2	3	4	5	6	7	8	9	
F_2 Bulks	0	0	4	9	28	51	40	23	22	177
F_3 Bulks	0	0	0	5	33	66	48	18	14	184
F_4 Bulks	0	0	17	35	38	76	47	38	40	291
F_5 Progeny-TH	0	0	141	182	455	957	696	235	922	758
F_5 Progeny-TR	0	0	22	78	192	585	272	83	54	1286
F_5 Progeny-L	0	0	2	8	23	35	44	17	11	140
F_5 Progeny-T	0	0	6	15	30	24	4	0	0	79
F_5 Progeny-E	0	0	59	45	66	109	256	87	198	820
F_6 Progeny-L	0	0	13	16	34	54	22	10	11	160
F_6 Progeny-T	0	0	74	61	123	135	46	1	0	440
F_6 Progeny	0	0	315	130	130	146	173	123	43	1060

[1] Abbreviations used were: TH = Tel Hadya; TR = Terbol; L = large; T = tall; and E = early

2.3.1.2. Screening of new germplasm

ICRISAT furnished 795 kabuli and 2214 desi accessions. These were evaluated in the disease nursery and the results are shown in Table 2.3.2. Ten lines had a rating of 3 and 17 lines a rating of 4. Majority of the lines (2851 lines or 94.7%) took a rating of 9. Resistant lines will be evaluated in the greenhouse and field in the next season.

Table 2.3.2. Reaction of 3009 new chickpea germplasm accessions to a mixture of six races of A. rabiei.

	Disease reaction of A. rabiei									
Type of chickpea	1	2	3	4	5	6	7	8	9	Total
Kabuli	0	0	4	2	5	3	26	31	724	795
Desi	0	0	6	15	20	23	14	9	2127	2214
Total	0	0	10	17	25	26	40	40	2851	3009

2.3.1.3. Screening of breeding lines

All breeding lines (1615) developed between 1981 and 1990 were evaluated using disease infested debris and inoculation with six races . Results are shown in Table 2.3.3. Two lines, FLIP 84-79 and FLIP 90-103C, were rated 2 and another 57 lines rated 3 and 78 rated 4. Although they were never evaluated against six races except those bulked in 1989, yet several of them were resistant. There were 1215 lines which were susceptible (6-9 rating) including 309 which were killed. It seems that pathotypes in debris may be different and need investigation.

2.3.1.4. Confirmation of previously resistant lines

Thirty-two kabuli accessions and 634 desi accessions, previously identified as resistant germplasm (rating 1-4) using diseased plant

Table 2.3.3. Reaction of breeding lines inoculated by diseased plant debris and a mixture of six races of _A_. _rabiei_ in the field, Tel Hadya, 1990/91

Breeding	Disease reaction on 1-9 scale								
lines	1	2	3	4	5	6	7	8	9
Number	0	2	57	78	263	350	441	115	309
Per cent	0.0	0.12	3.53	4.83	16.28	21.67	27.31	7.12	19.13

debris and mixture of four races of _A_. _rabiei_, were evaluated against a mixture of six races and diseased plant debris during 1990/91. Eight kabuli and four desi lines had a 2 rating (Table 2.3.4). Another 44 lines had a 3 rating. Among kabuli accessions, none of the lines were rated 7-9, whereas in desi accessions 75 lines were rated 7-9. Lines with 2-3 ratings will be reevaluated next season.

Table 2.3.4. Field reaction to inoculation with diseased debris and a mixture of six races of 32 kabuli and 634 desi germplasm accessions earlier found resistant using diseased plant debris and a mixture of four races, Tel Hadya, 1990/91.

	Disease Reaction on 1-9 scale								
Entry	1	2	3	4	5	6	7	8	9
Kabuli									
Number	0	8	10	5	6	3	0	0	0
Per cent	0.00	25.00	31.25	15.63	18.75	9.38	0.00	0.00	0.00
Desi									
Number	0	4	34	60	337	124	21	3	51
Per cent	0.00	0.63	5.36	9.43	53.15	1956	3.31	0.47	8.04

2.3.1.5. Evaluation of wild Cicer species to A. rabiei in the field and greenhouse

Field and greenhouse screening was done of 160 and 193 lines, respectively, for resistance to six races of A. rabiei. A number of lines were found resistant with 2-4 ratings (Table 2.3.5.). Rating was more normally distributed in wild accessions, whereas in case of cultigen it was heavily skewed towards susceptibility.

K.B. Singh, M.V. Reddy, W. Khoury, and S. Kababeh

Table 2.3.5. Reaction of wild Cicer species against a mixture of six races of A. rabiei in the field and greenhouse, Tel Hadya, 1990/91

	Disease Reaction on 1-9 scale								
Entry	1	2	3	4	5	6	7	8	9
Field									
Number	0	13	36	9	17	15	16	20	40
Per cent	0.00	7.83	21.69	5.42	10.24	9.04	9.34	12.05	24.10
Greenhouse									
Number	0	23	4	32	38	37	36	17	6
Per cent	0.00	11.92	2.07	16.58	19.69	19.17	18.65	8.81	3.11

2.3.2. Studies on the Pathogenic Variability in A. rabiei using a Host Differential Set

The characterization of the fungal isolates for their virulence is based on the differential reaction of a set of genotypes upon their inoculation with these isolates. Several sets of differentials for the characterization of A. rabiei on chickpea have been proposed at ICARDA but none has been standardized. Experiments were conducted to test these genotypes as differentials and develop a standard set for future use.

Twenty-six genotypes were chosen for this experiment, but owing to seed inavailability or poor germination, only 19 lines were used. The experiment was conducted in the growth chamber 'Conviron' using 6 isolates from our Ascochyta* culture collection earlier identified by Reddy & Kabbabeh (1984) as race 1 to 6. The genotypes were planted in small trays with 5 plants per genotype per replication and with three replications each. Ten-day-old seedlings were inoculated with a spore suspension of an isolate at a concentration of 200,000 spores/ml.The trays were then covered for 2 days and incubated at 20 C/18 C day and night temperature. Disease severity readings were taken on the seedlings 7, 14 and 21 days after inoculation on a 1-9 scale.

The reaction of the individual plants of a single genotype within a single replicate was often variable depending on the genotype. The variability was possibly because the seeds were not originating from a single plant, but were bulked seeds. Table 2.3.1 represents the average disease severity readings (DSR) 7 days after inoculation and the corresponding resistance classification (R=resistant; IR=incompletely resistant; S=susceptible) for each of the 19 genotypes studied. The seperation between R, IR and S in Table 2.3.6 was followed for comparison with the procedure adopted by earlier workers. From Table 2.3.6, no discrimination was possible among the races tested on the 19 genotypes. If, however, a classification for resistance is considered whereby discrimination between S and R only is done, a differential set of genotypes could be proposed for use (Table 2.3.7). The separation between R (DSR<=4) and S (DSR>4) is justified if we consider that DSR=4 indicates only stem girdling whereas stem breakage starts with DSR=5.

Our results differed with those obtained by other workers. The differences were not reduced when we, as other workers, used DSR as the maximum DSR obtained by a cultivar rather than the average DSR as indicated in Table 2.3.6. Inconsistency in the reactions of genotypes to the various races could also be observed in the already published

---

* M.V. Reddy, and S. Kabbabeh, 1984. Plant Dis. 69,177.

Table 2.3.6. The reaction of the various chickpea genotypes, used as differentials for identification of Ascochyta rabiei races, expressed as the average disease severity rating and the resistance group (R, IR, S)*.

Line	Race 1	2	3	4	5	6
ILC72	2.5 R	2.7 R	2.9 R	2.7 R	4.5 IR	2.6 R
ILC 182	3.5 IR	3.3 IR	3.0 R	2.7 R	3.3 IR	3.1 IR
ILC 191	4.2 IR	3.7 IR	4.8 IR	3.7 IR	3.9 IR	3.1 IR
ILC 194	3.4 IR	2.3 R	2.9 R	5.7 S	2.6 R	5.2 S
ILC 200	2.1 R	3.1 IR	3.4 IR	2.5 R	3.3 IR	2.5 R
ILC 201	6.5 S	7.4 S	7.1 S	7.1 S	7.8 S	5.3 S
ILC 202	4.8 IR	2.7 R	5.5 S	3.1 IR	2.8 R	3.9 IR
ILC 249	2.8 R	3.3 IR	3.7 IR	6.8 S	2.9 R	5.3 S
ILC 482	2.5 R	3.1 IR	3.6 IR	3.8 IR	2.6 R	4.1 IR
ILC 484	3.6 IR	4.9 IR	5.1 S	5.1 S	5.1 S	5.8 S
ILC 1929	6.8 S	8.1 S	7.1 S	6.5 S	8.2 S	5.7 S
ILC 2956	2.8 R	2.5 R	2.1 R	2.1 R	2.4 R	3.7 IR
ILC 3279	2.8 R	2.4 R	2.5 R	2.4 R	2.5 R	2.5 R
FLIP 83-28	3.5 IR	2.8 R	3.4 IR	4.1 IR	2.7 R	4.3 IR
ICC 1591	2.9 R	4.6 IR	5.2 S	5.6 S	3.6 IR	6.6 S
ICC 1903	3.3 IR	2.7 R	3.4 IR	5.2 S	2.8 R	6.1 S
ICC 2232	2.7 R	4.2 IR	4.9 IR	5.7 S	6.4 S	5.3 S
ICC 3996	2.1 R	2.0 R	1.3 R	3.8 IR	1.9 R	4.7 IR
ICC 4107	1.8 R	2.2 R	1.6 R	5.8 S	2.2 R	5.0 S

* R = disease severity rating < 3, IR = disease severity rating 3-5, S = disease severity rating > 5.

reports. Inconsistency is rarely seen in the genotypes of complete resistance or complete susceptibility, but with those showing incomplete resistance (in earlier reports called tolerance). This would indicate that the genotypes we are dealing with do not have a gene-for-gene relationship with the "races" considered. The disease severity rating given by a researcher in cases of incomplete resistance is dependent on several factors besides the actual resistance level of the genotype. One is the time of disease scoring. The DSR taken 7, 14 and 21 days after inoculation in our experiment usually increased on genotypes of IR reactions so that the classification of their reaction often changed to S with time.

The differential set of chickpea genotypes in Table 2.3.7 is not recommended as a standard one. Although it is apparently simple and straightforward, many R or S reactions are indeed incomplete resistant reactions and may hence lead to confusing results. It is necessary that more work be done using pure seeds, i.e. single seed descents; standardize the methodology of inoculation and disease evaluation; look for more genotypes showing complete resistance or susceptibility to certain isolates; and undertake a genetic analysis of the resistance genes in the genotypes we are dealing with vs. the virulence genes of the corresponding pathogen isolates.

Table 2.3.7. Reaction of the set of the differential chickpea genotypes to the six races of Ascochyta rabiei*.

Genotype	Race					
	1	2	3	4	5	6
ILC 72	R	R	R	R	S	R
ILC 249	R	R	R	R	R	S
ICC 4107	R	R	R	S	R	S
ILC 202	S	R	S	R	R	R
ILC 484	R	S	S	S	S	S
ILC 3279	R	R	R	R	R	R
ILC 1929	S	S	S	S	S	S

* R indicating a disease severity rating <= 4,
S indicating a disease severity rating > 4.

2.3.3. Components of Resistance to A. rabiei in Chickpea

The components of resistance to a certain disease in a genotype are often an indication of their partial resistance level. A detailed study of the resistance components is needed first to establish their importance in determining the rate of disease development in the field. Few studies have been made so far on the components of resistance to A. rabiei in chickpea although differences in the disease development in the field have been observed for some genotypes. Studies were, therefore, conducted on 19 genotypes using 6 races of the pathogen individually. The genotypic reaction to the different races ranged from a hypersensitive reaction or complete resistance to various levels of susceptibility. The study was conducted on 10-day-old seedlings grown in trays and kept in a growth chamber under controlled conditions. The plants were covered for 48 hrs upon inoculation then incubated at 20 C/18 C day and night temperature. The components of resistance measured on the plants were the following:

1. Latent period (LP): time period in days between inoculation and the first appearance of pycnidia on lesions.
2. Lesion size (LS): Two lesions per plant were marked and their size was measured at 2-day intervals.
3. Lesion growth rate (LGR): From the lesion size the rate of expansion was calculated as the change in size over time.
4. Pycnidial number per lesioned tissue (PN): The number of pycnidia produced per 5 cm of lesioned stems was counted under the microscope (three lesioned tissue pieces were observed per genotype/race combination).
5. Pycnidial size (PS): The size of the pycnidia produced on the diseased stem areas was measured under the microscope. Twenty pycnidia were randomly measured and the size averaged per genotype/race combination.
6. Sporulation capacity (SPO): The sporulation of infected plants was measured after cutting the plants, incubating the cut tissues in a moist chamber for 48 h, then soaking them in a fixed amount of water for 4 h to allow for spore release.

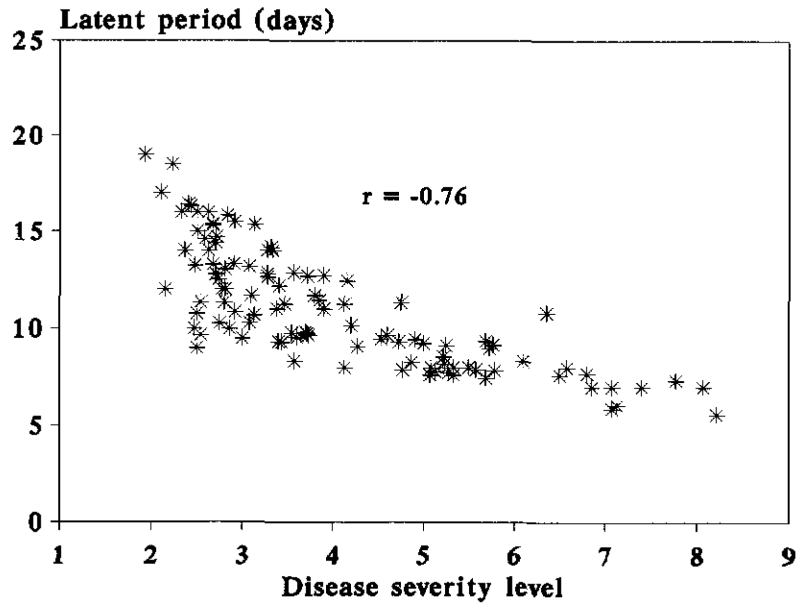
The average disease severity rating (DSR) of the genotypes for the various races ranged from 1 to 8. The DSR was significantly correlated with many of the components of resistance measured (Table 2.3.8).

Table 2.3.8. The correlation between the disease severity rating (DSR) and the various components of resistance measured on seedlings of various chickpea genotypes.

Component of resistance	Correlation coeff. (r)	Significance level (P)	No. of observations
LP	-0.758	< 0.001	108
LGR	0.743	< 0.001	113
LS	0.900	< 0.001	114
PN	0.750	< 0.001	114
PS	-0.124	0.097	110
SPO	0.665	< 0.001	114

* For explanation of the components of resistance refer to text.

The average latent period (LP) varied greatly for the different genotype-race combinations with a minimum latent period of 5 days for several of the highly susceptible genotypes. Other genotypes did not have spores even one month after inoculation. The latent period was highly correlated with the DSR with $r = -0.76$. The relationship between DSR and LP was, however, more of a hyperbolic nature (Fig. 2.3.1). The LP varied only a little (between 5 and 10 days) for DSR > 4.5. Small decreases in the DSR at levels < 4.5 (moderate to resistant reactions) were accompanied by a large increase in the LP. Thus LP is a better indicator of the resistance level for the less susceptible genotypes. A transformation of the LP values into 1/LP linearized the relationship and improved the correlation coefficient to $r=0.82$ (Fig. 2.3.1).



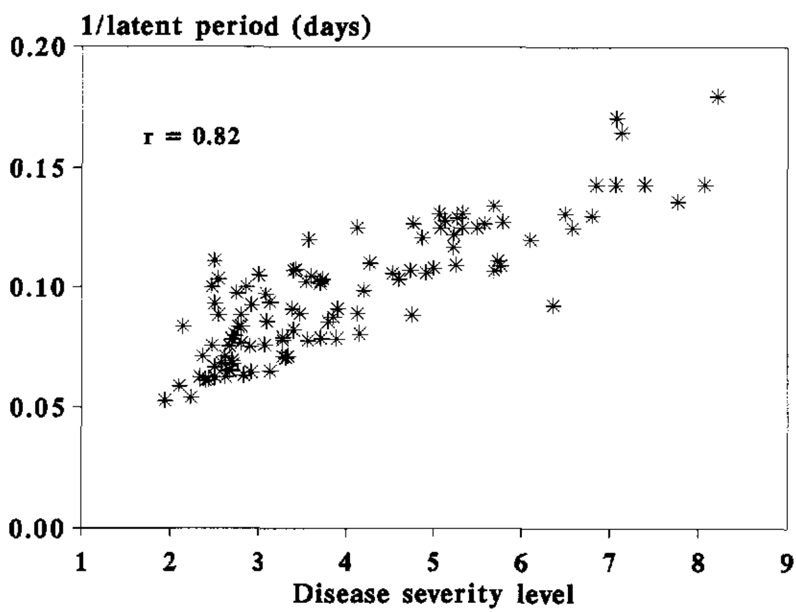


Figure 2.3.1. Relationship between the latent period and the disease severity level on seedlings of 19 chickpea genotypes incoculated with 6 races of <u>Ascochyta</u> <u>rabiei</u>.

Lesion growth rates (LGR) were calculated for each period of two days. All LGRs were positively correlated with the disease severity. The LGR between the fifth and seventh day after inoculation had, however, the highest correlation coefficient (r=0.74).

The lesion size (LS) 7 days after inoculation was by far the most reliable indication of the disease severity with a correlation coefficient of r=0.90 (Fig. 2.3.2). The high correlation between the DSR and LS is expected since the score used to estimate severity is based on the lesion size and the incidence of stem breakage. The correlation coefficient did not improve when LS 10, 12 or 14 days after inoculation were correlated with the disease. This is because in very susceptible cultivars lesions quickly began to coalesce after 7 days of incubation and stems started to break making lesion measurements impossible.

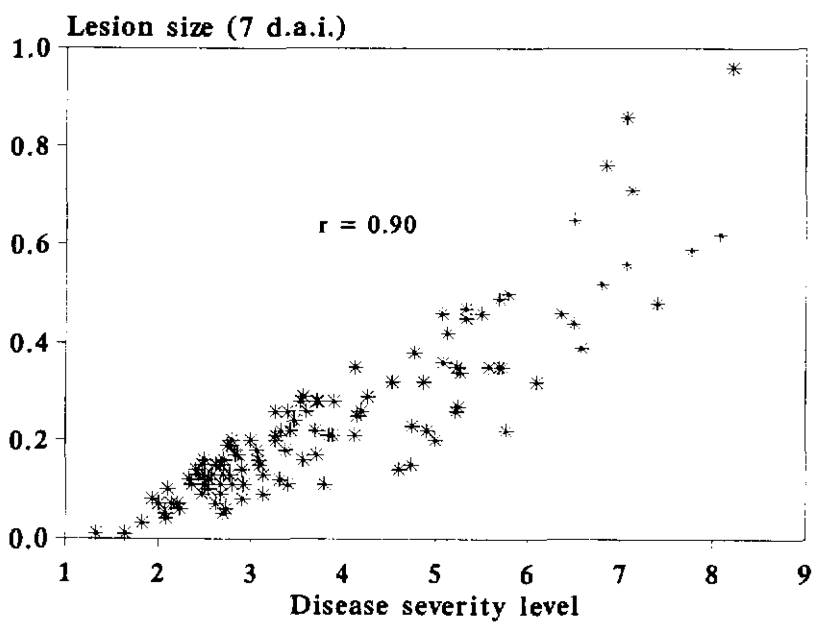


Figure 2.3.2. Relationship between the lesion size and the disease severity level on seedlings of 19 chickpea genotypes inoculated with 6 races of <u>Ascochyta rabiei</u>.

The pycnidial number (PN) was also highly correlated with the disease, but was negatively correlated with the pycnidial size.

The pycnidial size (PS) was a resistance component which was not directly related to the disease severity. PS of the different A. rabiei races on the various genotypes was more a characteristic of the race than of the resistance level of the genotype (Table 2.3.9).

Table 2.3.9. The average pycnidial size (standard deviation in parentheses) produced on seedlings of 19 chickpea genotypes infected by 6 races of Ascochyta rabiei.

	Race					
	1	2	3	4	5	6
Pycnidial size in (um)	154.9 (37.51)	147.7 (35.88)	132.3 (31.69)	108.1 (32.39)	133.0 (34.72)	117.9 (39.14)

The sporulation level (SPO) of the various genotype-race interactions varied greatly with some resistant genotypes producing no spores at all whereas others produced up to an average of 324 million spores per gram of tissue.

High disease severity ratings were always accompanied by a simultaneous occurrence of high LGR, high PN produced per lesioned tissue, short LP and high SPO (Fig. 2.3.3). The low DSR was accompanied by low LGR, low PN, long LP and very low SPO. With the intermediate levels of disease severity (DSR=3-5), no such clear constellations of the resistance components could be observed. A close interaction between LP and LS was observed (r=-0.71). Such an interaction could indicate that a certain lesion size should be reached before the pycnidial production starts. Further tests are needed to check if the same components of resistance that were critical for the disease at the seedling stage remain so at the flowering and podding stage of the various genotypes.

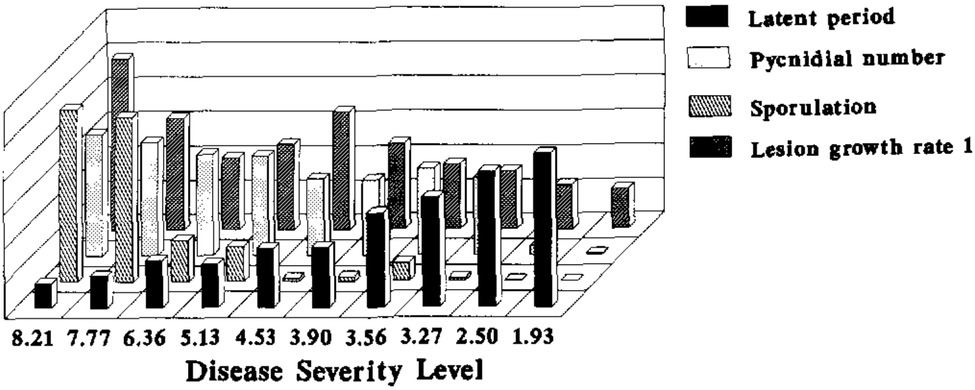


Figure 2.3.3. Interaction among the components of resistance to Ascochyta blight in chickpea genotypes at various diseases everity levels (components expressed relative to the amximum reached in each case).

2.3.4. Pattern of Disease Development of Ascochyta Blight Epidemics on Chickpea under Field Conditions

The experiment was conducted to analyse the development of Ascochyta blight in field epidemics. This is part of a study done to identify quantitative epidemiological characteristics which could be used in resistance breeding against the disease. The progress of the disease on chickpea genotypes with different growth habits and various levels of resistance was to be followed in terms of incidence of branches with lesions, with girdling and with breakage. The anatomy of the disease development on the branches was to be related to the overall disease rating given to a genotype and to some of the components of resistance measured on these genotypes at the seedling stage.

Nine chickpea genotypes (ILC and ICC lines) differing in their susceptibility to Ascochyta blight were planted in the field each in a ca. 100 m^2 plot. Thirty plants per plot were randomly selected and tagged while the plants were still in the seedling stage. The plots were then exposed to a blight epidemic and regular readings on each of the tagged plants were taken at 7 to 10-day intervals throughout the growing season. Readings were taken on plant growth characteristics, number of branches with lesions, with girdling or with breakage, initial appearance of pycnidia on the leaf and stem lesions, and the pod infection. In addition, a disease severity rating was given to each plant at every date of reading.

The disease progress curves of the 9 genotypes are shown in Fig. 2.3.4. The genotypes were all susceptible to the disease with the final disease severity rating at the late podding stage ranging between 5.4 and 7.3 on a 1 to 9 scale. Comparing the disease progress curves of the 9 genotypes, one can separate the genotypes into 3 susceptibility groups, with ICC 3606 and Flip 84-79 being the less susceptible and ILC 482 and ILC 6189 the more susceptible ones. This seperation of the genotype susceptibility becomes clearer when we compare the maximum disease severity rating reached (Ymax), the area under the disease progress curve (AUDPC) and the latent period measured under field conditions for the different genotypes (Table 2.3.10). The less susceptible genotypes have clearly a smaller AUDPC and a longer latent period. The relationship between the latent period and the disease level, however, is less pronounced in the highly susceptible genotypes. These results further

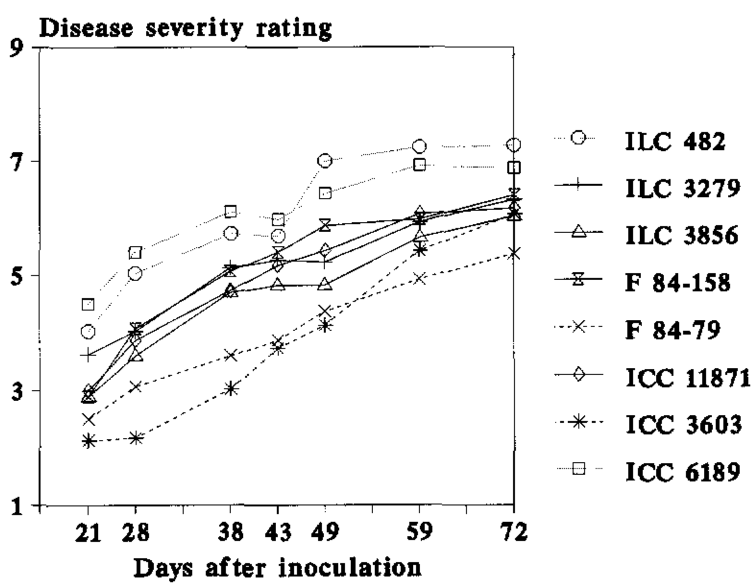


Figure 2.3.4. Disease progress curves of 9 chickpea genotypes under field epidemics of Ascochyta blight in Tel Hadya, 1991.

confirm the results obtained in the studies on the components of resistance to the pathogen on chickpea seedlings in the growth chamber.

Looking at the relative incidence of stem lesions, girdling and breakage over time, the importance of the lesion expansion rate or the lesion size becomes obvious. In Fig. 2.3.5, showing as an example some of the studied genotypes, the highly susceptible ones (ILC 482 and ILC 6189) show a very quick shift from lesioned stems towards girdled or broken stems. Accordingly, the secondary inoculum arising from pycnidiospores developing on lesioned tissues would have little chance of infecting healthy tissue and hence may not reach the sporulating stage. This pattern of disease progress would thus resemble a simple interest rate of growth where the disease development and the final disease level are a direct result of the level of the primary inoculum. The amount of primary inoculum, arising from infected seeds or plant debris, would thus become the critical factor for the blight epidemic. In the less susceptible genotypes showing a reduced lesion growth rate, the latent period would then become a critical factor for the speed of the epidemic development in the field. The rate of disease progress will be proportional to the development of new lesions and secondary inoculum with time.

W. Khoury

Table 2.3.10. The maximum disease severity reached (Ymax), the area under the disease progress curve (AUDPC), and the latent period (LP50) measured under field epidemics for the nine genotypes tested.

Genotype	Ymax	AUDPC	LP50 *
ILC 482	7.3	322.87	28
ICC 6189	6.9	315.98	23
F.84-158	6.4	269.12	27
ILC 3279	6.3	265.60	23
ICC 11871	6.2	260.66	27
ICC 12023	6.6	255.22	24
ILC 3856	6.0	245.49	28
F.84-79c	5.4	209.79	38
ICC 3606	6.1	204.08	43

* Latent period measured as the period in days between inoculation and the time when 50% of the plants showed pycnidia on lesioned stems.

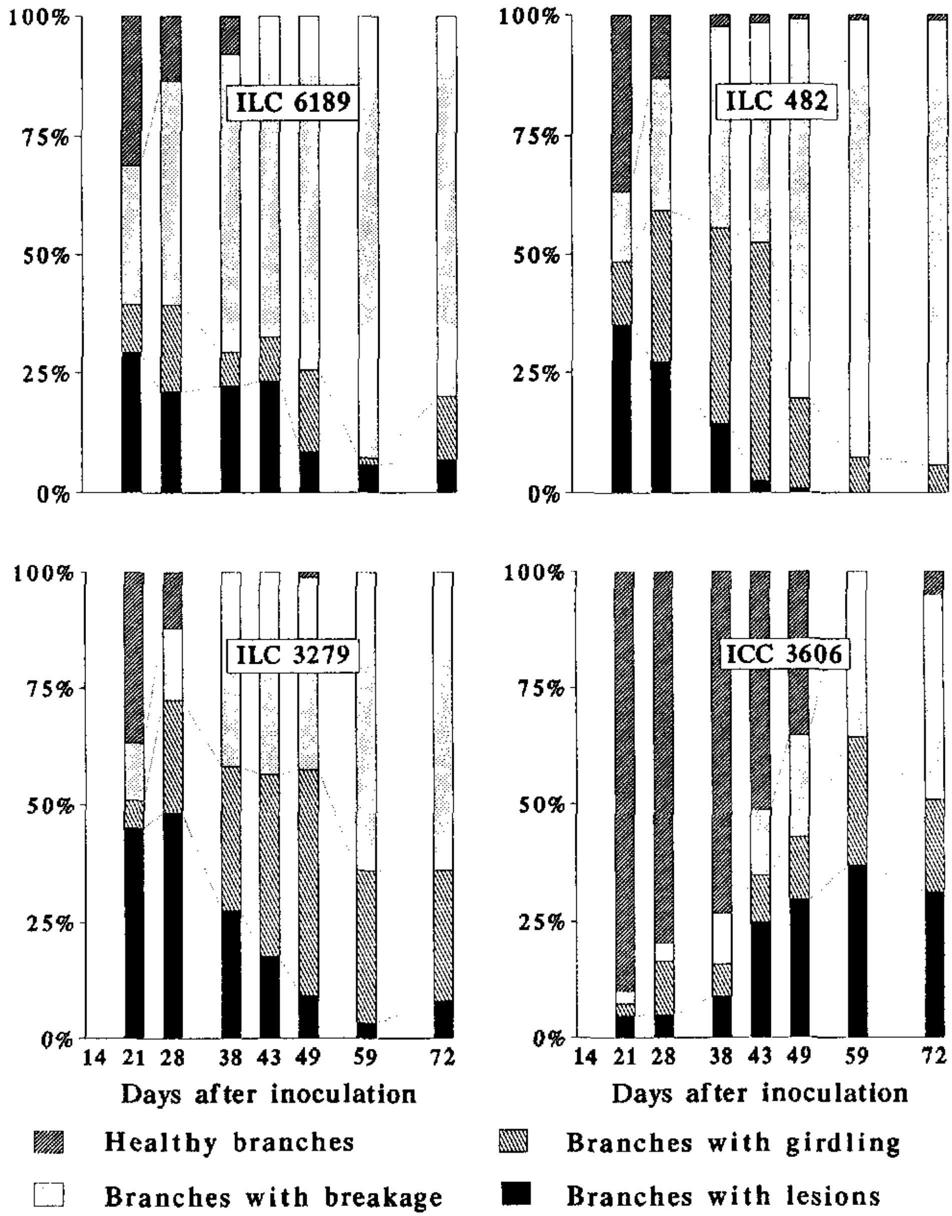


Figure 2.3.5. Progress of the Ascochyta blight epidemics in terms of percent branches with lesions, girdling of breakage for some chickpea genotypes under field conditions, Tel Hadya, 1990/91.

2.4. Chickpea Entomology

Studies on control methods and host plant resistance for chickpea leafminer, the effect of cultural methods and different times of insecticide application on podborer infestation and methods for protection of seeds in storage were continued.

2.4.1. Chickpea Leafminer

2.4.1.1. Chemical control of leafminer

Because of the promising results in the past the effectiveness of neem (Azaderichita indica) extract applications for leafminer (Liriomyza cicerina) control in spring-sown chickpea was tested at three on-farm locations (Sheikh Yousef, Squeilbye and Alkamiye) in addition to Tel Hadya this season. Three sprays consisting of 0.5 kg neem seeds per 10 L water at a rate of 500 L/ha applied in early April, mid and end of May were compared with one spray of Thiodan (2 cc/L at 500 L/ha) applied in late April at Sheikh Yousef and Squeilbye and early May at Alkamiye and Tel Hadya (Fig. 2.4.1). Check plots were sprayed 3 times with water (500 L/ha) on the same dates as the neem extract. At Sheikh Yousef the percent mining was not high, but still significantly reduced by neem and Thiodan. Seed yield was increased by both treatments, but only by Thiodan significantly. At Squeilbye the leafminer damage was highest of all locations and on the second sampling date significantly lower in neem-sprayed plots (26%) than in check plots (49.4%) as well as in Thiodan-sprayed plots (40%). Apparently the effect of the Thiodan application on 29 April did not last until end of May. The low seed yield in the neem treatment was caused by nematode damage. At Alkamiye leafminer damage was very low and no treatment effects observed. At Tel Hadya both treatments significantly reduced the mining on the first sampling date and Thiodan significantly increased seed yield, which, however, was also due to control of podborer, as 13% pod damage was recorded in the check. Interestingly, pod damage was also reduced significantly by the neem spray. These results confirm that neem extract effectively reduces the percent mining, but has the limitation of not

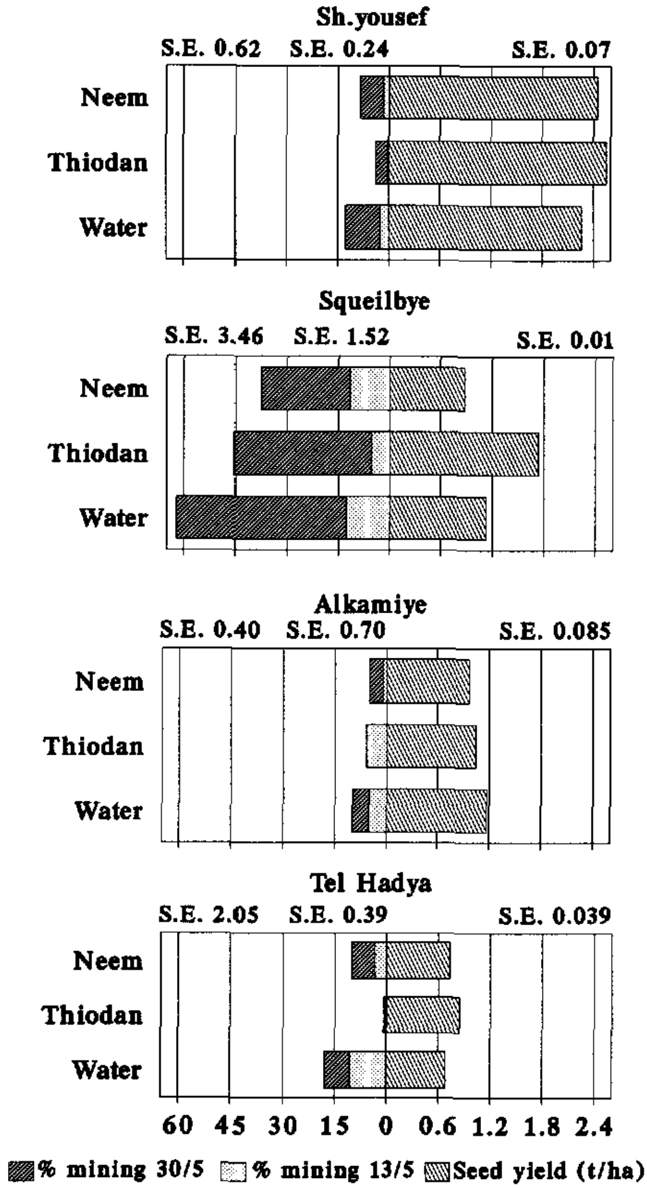


Figure 2.4.1. Effect of five applications of neem extract as compared to one spray of Thiodan 35(s cc/L) on leafminer infestation and seed yield in chickpea at Tel Hadya and farmer's fields, 1990/91.

having a lasting effect for more than 7 to 10 days, thus requiring close monitoring and more frequent application than insecticides.

S. Weigand

2.4.1.2. Host plant resistance to leafminer and podborer

The previously selected, 8 promising chickpea lines were grown in winter and spring together with the susceptible check (Syrian Local, ILC 1929) without and with the protection of 1 and 2 applications of Thiodan 35 (2 cc/L). Since leafminer infestation started late this season, the damage in winter-sown chickpea was very low. In spring-sown chickpea both chickpea lines and insecticide application had significant effects on leafminer damage. In local and ILC 5655 without and even with one insecticide application the percent mining taken on 16 May ranged between 20 and 30% and was significantly higher than in ILCs 316, 394, 655, 1048 with 12 to 15% mining and ILCs 1216, 3828, 5901 with less than 10% mining (Fig. 2.4.2). Seed yields were low, especially as some of the promising lines are late maturing. However, ILC 5901, which has the highest degree of resistance, also had yields comparable to Syrian Local. The yield increases with insecticide applications are due to control of both leafminer and podborer, as podborer infestations were high this season.

The percent pod damage by Helicoverpa armigera was recorded in 10 plants per plot of all treatments in winter- and spring-sown chickpea. Infestation was higher in winter- than in spring-sown chickpea lines reaching 26% pod damage (Fig. 2.4.2). In both sowing dates significant differences in pod damage were found between genotypes with ILCs 1216, 3828, 5901 having lowest damage (12 to 16%) in winter sowing and ILCs 3828, 655, 1048, 1216, 316, 5901 (4 to 8%) in spring sowing. One application of Thiodan effectively reduced the pod damage in winter and spring sowing. Only in the winter-sown chickpea was pod damage further reduced by the second application, but not significantly. Because of high pod damage in winter-sown chickpea the development of this important pest has to be followed in future.

S. Weigand

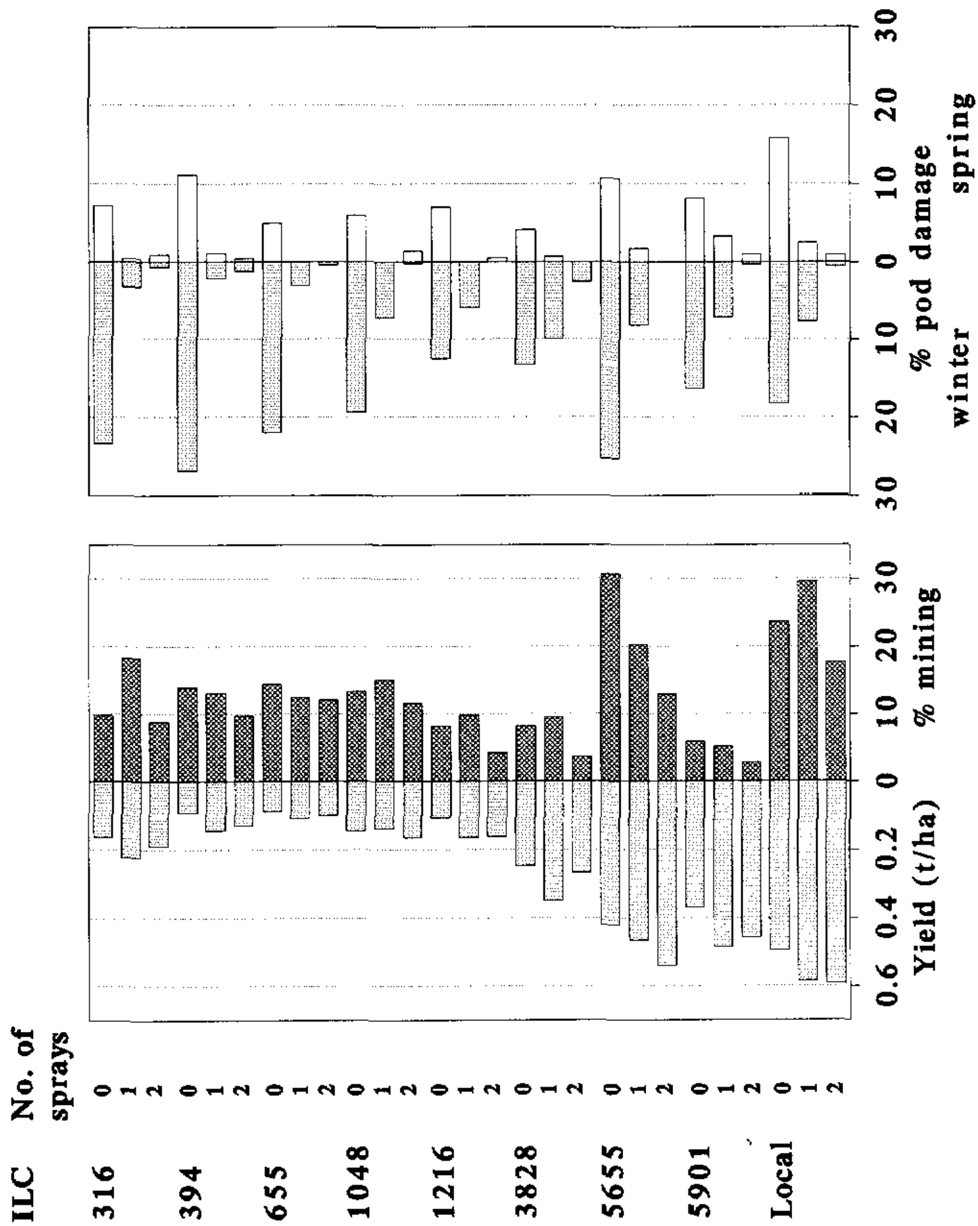


Figure 2.4.2. *Leafminer infestation* and seed yield in different spring-sown chickpea lines and percent pod damage in winter- and spring-sown lines with no, one, and two insecticide applications (Thiodan 35, 2 cc/L), Tel HAdya, 1990/91.

2.4.1.3. Chickpea/leafminer interaction

The effect of leaf exudates on leafminer infestation was studied in 6 chickpea lines with different degrees of resistance. Fifteen adult leafminers were released for 24 h into a cage with plants of the 6 lines and the number of feeding punctures and mines were counted. The same experiment was conducted after removal of the leaf exudates by a phosphate-buffer solution. In plants with exudate the number of feeding punctures was significantly higher in ILCs 655, 1929 and 3398 than in ILCs 316, 1216 and particularly ILC 5901 which had the lowest damage (Table 2.4.1). When the exudates were removed the number of feeding punctures increased in the three resistant lines but did not change in the moderately resistant and susceptible lines indicating that the leaf exudates are a factor of resistance to leafminer. However, other factors are likely to contribute to resistance, as for example in ILC 5901 the number of feeding punctures was lower even after removal of the exudates. ILC 5901 was confirmed as the line with the highest degree of resistance to leafminer. It apparently also has some resistance to Ascochyta blight, as it was the only line of the international chickpea leafminer nursery withstanding the severe Ascochyta blight infestation in Morocco.

S. Weigand, K.B. Singh, H. Rembold (FRG) and C. Weigner

Table 2.4.1. Number of feeding punctures and leaf mines of <u>Liriomyza cicerina</u> per plant of six chickpea lines as affected by the presence of leaf exudate.

Chickpea line	Reaction	With exudate		Without exudate	
		Punctures	Mines	Punctures	Mines
ILC 5901	r	21.1	1.9	53.0	2.4
ILC 316	r	44.4	4.4	75.2	3.1
ILC 1216	r	41.9	3.1	82.1	5.2
ILC 655	mr	91.5	9.1	90.2	6.1
ILC 1929	s	96.3	11.8	106.6	10.7
ILC 3398	s	82.7	10.3	77.8	5.9

r = resistant; mr=moderately resistant and s = susceptible

2.4.2. Chickpea Podborer

The experiments on some aspects of integrated control of podborer (Helicoverpa armigera and Heliothis viriplaca) were continued for the third and last year at Izraa Research Station in southern Syria. In general podborer populations and infestations were higher than last season, but comparable to the 1988/89 season.

In the experiment on the effect of 5 sowing dates on podborer infestation in 3 chickpea cultivars (Ghab 1, Ghab 2, Local) the highest pod damage was found in December-sown chickpea (43 to 53%) (Table 2.4.2). In the February and March sowings pod damage was lower and about 24%, except for Ghab 2 which because of its late maturity at the last sowing date only had a few pods and therefore a high percent pod damage. In all cultivars the yield was highest in the first 2 sowing dates. At all sowing dates the yield of Ghab 2 was the lowest, mainly due to its late maturity.

Table 2.4.2. Effect of 5 sowing dates on podborer infestation and grain yield of 3 chickpea cultivars, Izraa, 1990/91.

Sowing	No. of % pod infested %				Yield (kg/ha)			
date	Ghab1	Ghab2	Local	Mean	Ghab1	Ghab2	Local	Mean
3 Dec 90	45.6	53.2	48.6	49.2	566	325	527	473
30 Dec 90	43.8	43.5	44.7	44.0	540	315	505	453
23 Jan 91	34.8	40.8	41.0	38.8	315	200	456	327
16 Feb 91	24.2	33.9	24.1	27.4	215	110	222	183
10 Mar 91	21.4	44.4	23.8	29.9	72	0	124	65
LSD (P<0.05):								
Dates				1.8				8.8
Cultivars				1.2				7.0
Two dates, different cultivars cultivars				3.1				13.9

In the experiment on the effect of plant density on podporer damage the lowest damage was found at the lowest plant density of 20 plants/m^2 and the highest at the highest plant density of 50 plants/m^2 in all 3 chickpea cultivars (Table 2.4.3). This confirms the results of the last 2 seasons. The yield was highest at the density of 25 plants/m^2 and lowest at the highest density in all cultivars.

Table 2.4.3. Effect of plant density on podborer infestation and grain yield of 3 chickpea cultivars, Izraa, 1990/91.

Plant density (plants/m^2)	No. of pods infested (%)				Yield (kg/ha)			
	Ghab1	Ghab2	Local	Mean	Ghab1	Ghab2	Local	Mean
20	34.1	36.3	34.5	35.0	506	305	467	426
25	40.1	42.5	38.8	40.4	564	327	516	469
33	37.9	46.1	43.5	42.5	529	314	488	444
50	53.3	57.8	53.6	54.9	463	284	461	403
LSD (P<0.05%):								
Plant density			1.9				11.6	
Cultivars			2.6				8.8	
Two plant densities at different cultivars			3.9				19.5	

To determine the best time of insecticide application to control podborer, Thiodan 35 (6 cc/L) was sprayed at 6 different dates in Ghab 2 and local cultivars. In both cultivars the insecticide application on 25 April resulted in the lowest pod damage of 8.2% and 8.9% and highest yields of 411 and 620 kg/ha for Ghab 2 and Local, respectively, compared with 49.1% pod damage and 303 kg/ha yield in untreated Ghab 2 and 45.4% damage and 447 kg/ha in untreated Local (Fig. 2.4.3). For Syrian Local the best date of application was the same as in the last season, at podsetting; for Ghab 2 it was at flowering/early podsetting but 10 days earlier than the last year. The results show that early sprays are not effective as they do not provide control until maturity.

The conclusions of the three years of experiments are:

- Advancing chickpea sowing date increased the percent pod infestation, but yields were still higher in this dry area.
- Increasing plant density from 20 to 25, 33, 50 plants/m^2 increased percent pod infestation. Yields were highest in all 3 cultivars at 25 plants/m^2.
- Insecticide application at flowering/podsetting (Thiodan 35, 6 cc/L) resulted in the lowest pod damage and highest yield.

Work will be continued on monitoring podborer populations with pheromone traps and evaluation of percent pod damage in chickpea entomology experiments.

A. Saoud, F. Samara (Damascus University) and S. Weigand

2.4.3. Protection of Chickpea Seeds in Storage

The most effective traditional methods of seed protection were retested along with additional treatments including neem seed oil. Chickpea seeds (ILC 482) were treated on December 14 with the following substances (per kg seed):

Actellic, 0.5 g/kg seed (Act)
K-othrin, 0.5 g/kg seed (K-Oth)
Olive oil + salt + water, 5 ml+20 g+10 ml (K + S + W)
Olive oil + salt, 5 ml+20 g (O + S)
Olive oil + water, 5 ml+10 ml (O + W)
Salt + water, 20 g+10 ml (S + W)
Neem seed oil + salt + water, 3 ml+20 g+10 ml (N + S + W)
Neem seed oil + salt, 3 ml+20 g (N + S)
Neem seed oil + water, 3 ml+10 ml (N + W)

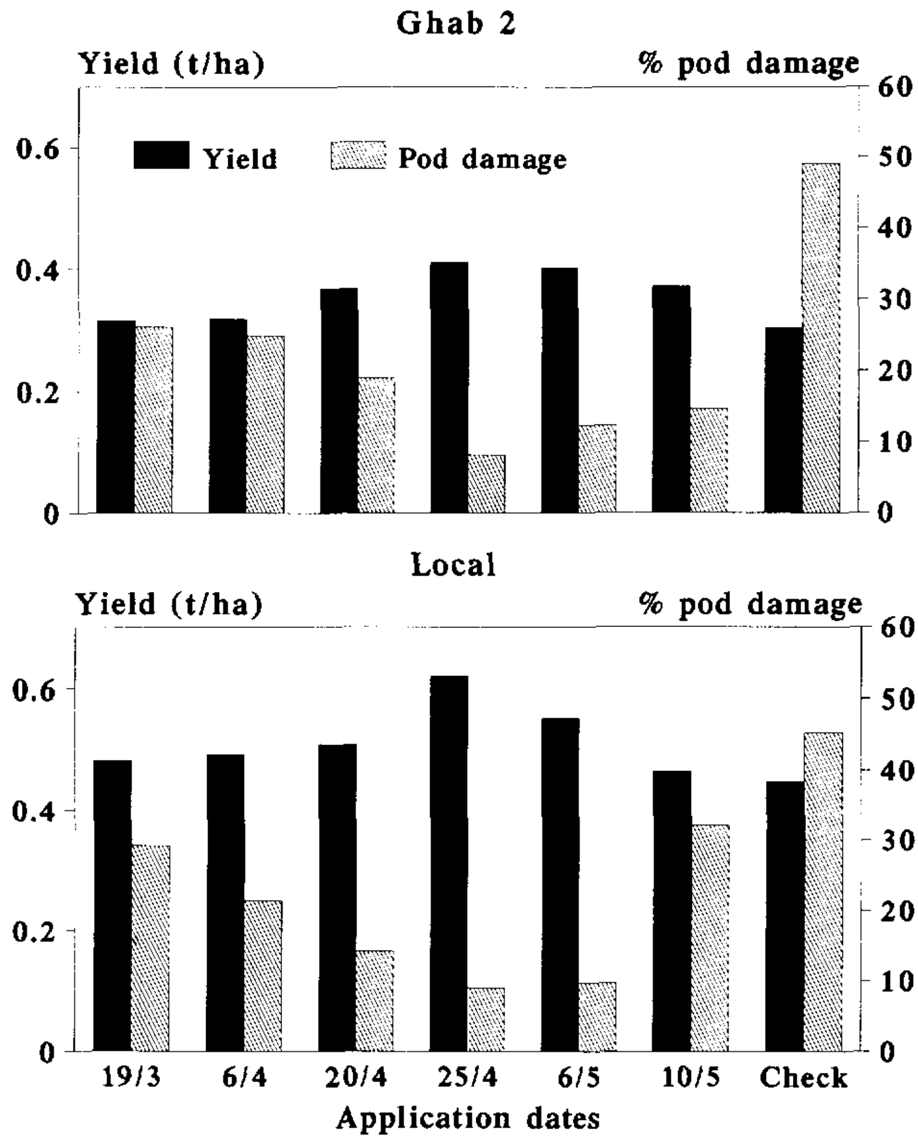


Figure 2.4.3. Effect of date of insecticide appliction (Thiodan 35, 6 cc/1) on seed yield and pod damage of two chickpea cultivars, Izraa, 1990/91.

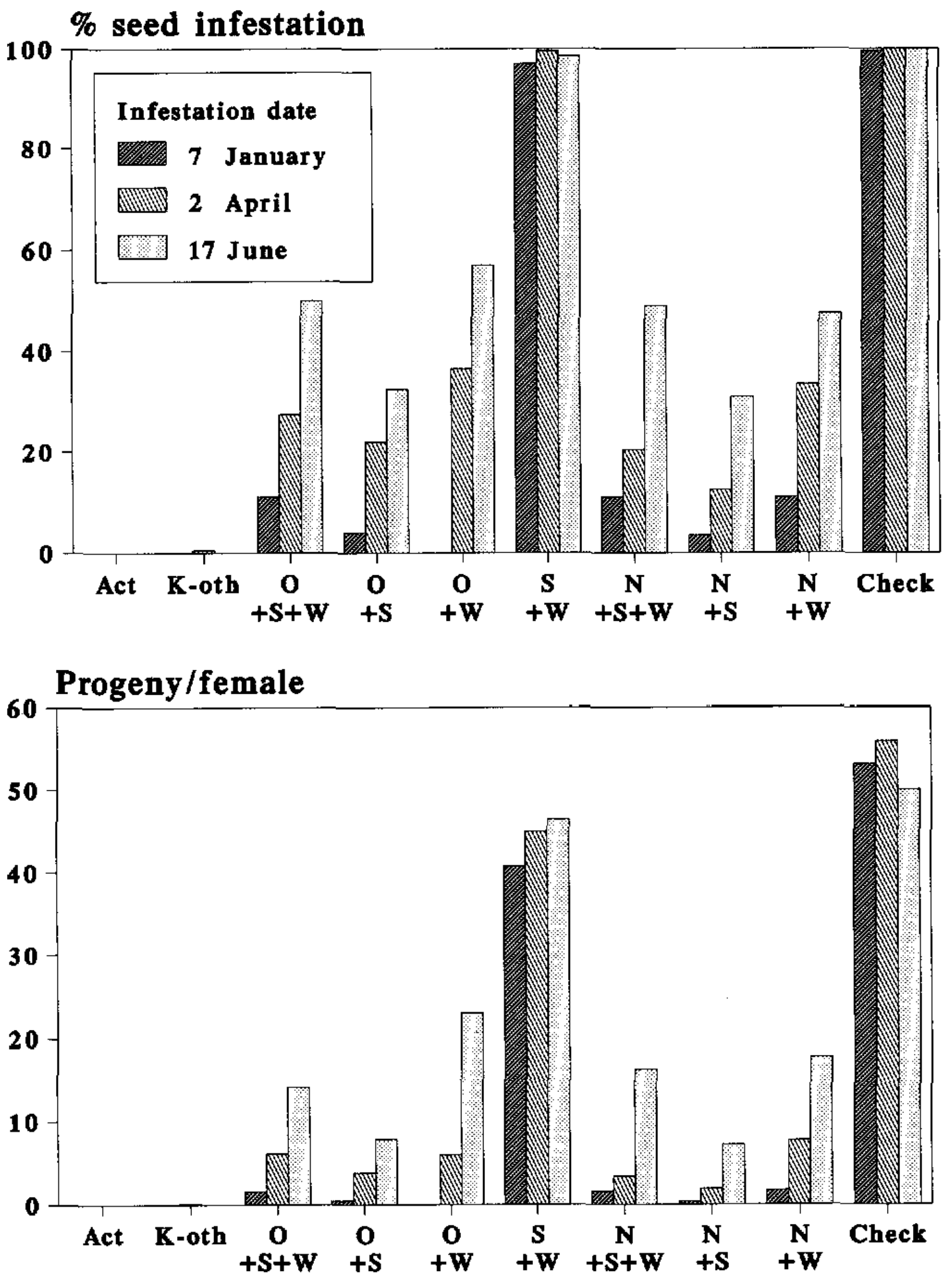


Figure 2.4.4. Effect of two insecticides and alternative treatments on the number of progeny and percent seed infestation with Callosobruchuus chinensis in stored chickpea on 7 Jan, 2 April and 17 June 1991 (3 weeks, 4 month and 6 months after the seed treatments).

After 3 weeks, 4, and 6 months (7 January, 2 April, 17 June) 50 seeds were infested with 4 female and 4 male Callosobruchus chinensis and the number of progeny per female and percent infestation counted after 1 month. The insecticides provided the most effective control for the complete period of 6 months (Fig. 2.4.4). Except for the salt + water all other treatments were effective for 3 weeks giving only 1 to 2 progeny per female. The effectiveness then decreased, but progeny per female and seed infestation were only half of the untreated check even after 6 months. Olive oil + salt and neem seed oil + salt were the most effective treatments giving 7.9 and 7.2 progeny per female and 32.5 and 31% seed infestation after 6 months, respectively, compared with 50 progeny and 100% infestation in the check.

S. Weigand

2.5. Chickpea Biological Nitrogen Fixation

2.5.1. Estimation of N_2 Fixation and Residual N Effect of Legumes on Subsequent Wheat Using ^{15}N

Trials to investigate the role of food and forage legumes in rotation with wheat through contribution of BNF were initiated during 1990-91 season at two locations of varying rainfall (Tel Hadya and Terbol) using a 2-course rotation. Effect on following cereal of legume treatments in comparison with continuous wheat and fallow-wheat over a 6-year period will allow evaluation of legume contribution in a farming systems approach. Both phases of the rotation are grown each year. Phase I includes legume treatments, in which quantities of N fixed are measured using ^{15}N methodology. Phase II is planted with wheat, in which varying levels of N fertilization allow calibration of N contribution from phase I treatments against yield and N-uptake from added N fertilizer. From phase I treatments, N contributions from soil and fixation in the legume crop can be obtained, from which potential N contribution to soil is calculated. With phase II treatments, fertilizer use efficiency (FUE), as well as amount of fixed N from the previous crop treatment (soil A_N

value) can be measured using ^{15}N enrichment data. In addition, contributions from phase I treatments can be calibrated against yield and N-uptake from N fertilizer added to following cereal crop (fertilizer replacement value).

Phase I (legume) treatments include:

1. winter-planted chickpea, inoculated
2. winter-planted chickpea, uninoculated
3. spring-planted chickpea, inoculated
4. spring-planted chickpea, uninoculated
5. lentil
6. lentil with promet seed treatment for sitona control
7. dry peas
8. dry peas with promet seed treatment
9. faba bean (Syrian local large)
10. Vicia sativa ssp. dasycarpa
11. Vicia narbonensis
12. Lathyrus sativus
13. wheat
14. fallow, weed-free

Yield data from legume treatments in this first year of the rotation trial reflected the differences in rainfall at the two locations (Fig. 2.5.1). Vicia narbonensis responded spectacularly to the increased rainfall at Terbol, with biological yield of 10,610 kg/ha compared with 2967 kg/ha at Tel Hadya. Winter-sown chickpea responded significantly to inoculation with a superior Rhizobium strain at both locations with 26% and 53% increases in seed yield at Tel Hadya and Terbol, respectively. Spring-sown chickpea performed similarly at both locations, with no significant differences between treatments or locations. Promet, used to control nodule feeding by Sitona larvae, significantly increased biological yields in lentil at Terbol, and in peas at both locations (Fig. 2.5.1).

It is expected that legume N_2 fixation data obtained from ^{15}N analysis will parallel yield trends, and that yield of the subsequent cereal crop will be affected by the quantities of N taken up from the soil in different legume treatments. N_2 fixation data from 1990/91 and subsequent cereal yields and fertilizer use efficiency (91/92) will be reported in next season's Legume Program report. The trial is designed to continue for a 6-year period, to quantify the legume N effect in legume-wheat rotations.

D.P. Beck and M.C. Saxena

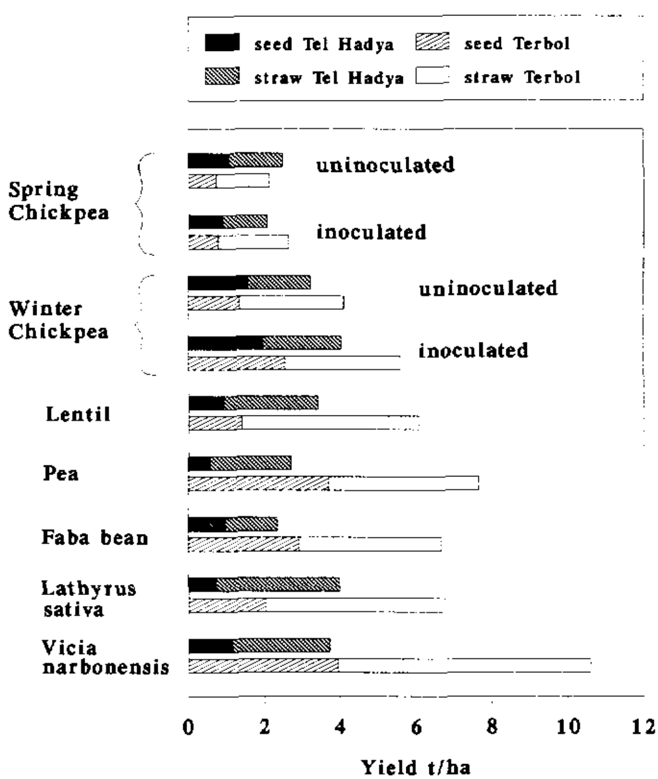


Figure 2.5.1. Total biolgocial and seed yields of legumes grown in Terbol and Tel Hadya, 1990/91.

2.5.2. Evaluation of the Necessity for Inoculation of Chickpea in Syria
Evaluation of the necessity for inoculation forms an important component of strategy in N_2 fixation improvement, as it allows the investigator to focus efforts in those areas where response to inoculation with improved strains is most likely. The absence of nodules, indicating absence of rhizobia nodulating chickpea, clearly demonstrates that inoculation is needed. However, ICARDA research has shown that specific strain-cultivar interactions occur in chickpea, and the necessity for inoculation may also exist where introduced cultivars cannot express their full capability for N fixation in symbiosis with native rhizobial populations which have developed in coadaptation with local landraces.

Earlier tests of a greenhouse technique to determine the need to inoculate confirmed the usefulness of this methodology in evaluating native rhizobial populations (1990 Legume Program Annual Report). Symbiotic effectiveness, evaluated using a hydroponic N-free system, gave a very reproducible and accurate estimation of necessity for inoculation and, in addition, gave accurate estimations of soil rhizobia populations. During 1991, a total of 38 sites in Syria were evaluated for the presence and symbiotic effectiveness of rhizobia on 2 chickpea cultivars (ILC 195 and ILC 482), as a preliminary to field testing of selected inoculant strains. Indigenous populations were characterized by their ability to fix N in an N-free system (where plant N = fixed N), as compared to plants fed adequate combined N for maximum growth and uninoculated controls.

Of the soils tested, more than half contained resident rhizobial populations that were of low effectiveness on chickpea (Table 2.5.1). In separate tests, response to inoculation with selected superior strains was consistently positive in soils where the measured symbiotic efficiency of the native population was less than 50%. The results clearly show that general statements regarding the need to inoculate in large regions of Syria cannot be made. In Kamishly area, for example, soils from Himo Station and Derbaseyeh contained effective chickpea rhizobia, but in Malkeyeh, Bayendour, Hinnaweiyeh, and Kazmeiyeh populations were of low effectiveness.

Table 2.5.1. Symbiotic efficiencies of native rhizobial populations for chickpea-growing areas of Syria.

Location	Province	Efficiency (%)	Location	Province	Efficiency (%)
Al-Hader	Aleppo	87	Himo Station	Kamishly	82
Jinderiss	Aleppo	77	Kafar Sandal	Idleb	73
Hama Station	Hama	73	Alkamiyeh	Aleppo	70
Shiekh Yousef	Idleb	66	Derbaseyeh	Kamishly	64
Afrin	Aleppo	62	Homs Station	Homs	60
Sukeilbeyeh	Ghab	58	Tal Sahhan	Idleb	57
Nawa	Daraa	55	Deir Sawan		54
Mourek	Idleb	54	Izra Research Station		52
Beftamoun	Idleb	52	Ghab Station		50
Taftanase	Idleb	48	Deir Kaak	Aleppo	47
Tel Hadya	Aleppo	46	Kafar Nouran	Aleppo	45
Jillin Stn	Daraa	44	Mennes	Rouge Valley	43
Tamanaa	Idleb	43	Malkeyeh	Kamishly	40
Salameyeh	Hama	40	Hamdaneyeh	Idleb	38
Banias	Lattakia	38	Al Howeiz	Lattakia	36
Breda Station	Aleppo	33	Bayendour	Kamishly	30
Hinnaweiyeh	Kamishly	29	Kazmeiyeh	Kamishly	27
Thaala	Sweida	22	Azaz	Aleppo	20
Tal Jibbin	Aleppo	15	Ta-om	Idleb	13

The above effectiveness values are average results from two cultivars. Because of prevalent strain-cultivar interactions noted in earlier studies, it is essential in such screening to take into consideration the cultivar(s) which may be inoculated, so that the screening can be tailored to the cultivar. Despite this complexity, these results indicate considerable scope for improvement of chickpea yields through the practice of inoculation with selected superior strains, particularly where improved cultivars are used.

2.5.3. Chickpea Strain Characterization

The ICARDA Rhizobium collection is maintained and tested as a service to NARS cooperators throughout the world for mandate crop rhizobia strains. Objectives of characterization are to select sets of highly effective and competitive strains which are distinguishable through various identification methodologies. Characterization of the ca. 100 strains contained in the chickpea rhizobia collection was completed during 1991; data on symbiotic effectiveness with a range of improved cultivars, salt and heat tolerance, and intrinsic antibiotic resistance (IAR) were collected, and will be included in a database catalogue to be available in early 1992.

IAR characterization separated the collection into 4 distinct groups. These clusters also generally followed a regional alignment as follows: Group I, Indian subcontinent; Group II, N. Africa; Group III, W. Asia and S. Mediterranean Europe; and Group IV, Turkey. Polyclonal antisera for highly effective strains from each group are under production, for identification of strains under in vivo conditions using the ELISA (enzyme linked immunosorbent assay) technique. These strains, which include CP39 (USA), CP42 (India), CP48 (Morocco), CP54 (Morocco), CP51 (Cyprus), CP54 (Morocco), and CP69 (Turkey), are included in a regional project to test competitiveness and survival under varying agroenvironments. These strains and antisera are available on request to NARS cooperators.

2.5.4. Chickpea Strain x Type Compatibility

The two groups of Cicer arietinum cultivars, kabuli and desi, probably have different centers of origin. It has been suggested that the large-seeded kabuli types originated somewhere in the eastern Mediterranean region, and the desi from Ethiopia; both regions are in ICARDA's mandate. Considering the large degree of strain-cultivar interactions for nodulation and N_2 fixation in chickpea, it was postulated that Rhizobium strains isolated near the relevant centers of origin may show a propensity for infectiveness and effectiveness with cultivars from the respective group.

Twenty rhizobia strains of differing origin and variable effectiveness on kabuli chickpea were tested for compatibility with two desi-type genotypes and three divergent kabuli-type genotypes in a greenhouse experiment using the N-free aseptic system described previously. Of the 20 strains, several showed large differences in average effectiveness on kabuli and desi types. Although some strains followed the expected pattern, the origin of the strains did not always coincide with postulated compatibility. Two Indian strains, for example, performed significantly better on kabuli types, while isolates from Spain and the U.S.A. were more efficient fixers with desi types.

In many cases, isolates have been imported with seed or inoculants, and may have originated far from the point of isolation. Further studies have therefore been initiated in cooperation with the Microbial Ecology Department of the University of Lyon, France, using DNA/DNA hybridization, RFLP and DNA profiles to determine if two distinct types of chickpea rhizobia exist. Early results indicate two distinct types, as well as clear differences from all other species of Rhizobium. A clearer classification of Cicer rhizobia will follow further tests on genetic makeup of strains and their host compatibility.

D.P. Beck

2.6. Chickpea Physiology and Agronomy

Developing chickpea genotypes which are better adapted to a range of soil moisture environments is an important objective of chickpea improvement work at ICARDA. Thirty-six promising genotypes (G) were studied to identify combined drought resistance and higher responsiveness to increasing available soil moisture supply.

2.6.1. Response of Genotypes to Varying Soil Moisture Supply

This experiment was similar to the one conducted last year at Tel Hadya (pages 107-111, FLIP Annual Report 1990), but with 36 different genotypes. The aim was to test whether line-source sprinkler system could be effective in identifying genotypic differences in the tolerance to drought and in the responsiveness to increased moisture supply. Sowing was done on 10-3-1991 and a post-sowing irrigation was applied on 16-3-1991. Emergence occurred between 24/3 and 28/3 1991. A gradient of soil moisture (IL) was created by supplemental irrigation on 6 dates (on 10/4, 22/4, 30/4, 9/5, 19/5, 29/5, and 7/6, 1991) by a line-source sprinkler irrigation method. The extremes of IL were 293 mm (rainfed) and 458 mm (the best-watered treatment).

Rainfall at Tel Hadya was 293 mm this year compared with 233 mm during 1989/90, but was lower by 11% compared with 328 mm, the long-term site mean. Effects of G, IL and G x IL were all significant in seed yield (SY) and total biological yield (TBY).

Responses to increased moisture supply both in seed yield (SY) and total biological yield (TBY) were large and significant with each increased level of moisture supply (Table 2.6.1). Between the rainfed and the best-watered treatments SY was three times and TBY 2.4 times higher. This suggests that growth and seed yield of chickpea are greatly reduced by drought. In contrast to lentil, harvest index was significantly higher in the increased moisture supply treatments (Table 2.6.1).

Table 2.6.1. Effect of total seasonal moisture supply (rainfall + supplementary irrigation) on the mean seed yield (SY), total biological yield (TBY) and harvest index (HI) of 40 chickpea genotypes, Tel Hadya, 1990/91.

Total seasonal moisture (mm)	SY (kg/ha)	TBY (kg/ha)	HI (%)
458	1820	4396	41.9
428	1807	4385	41.8
398	1465	3580	41.2
368	1162	3042	38.3
338	920	2468	36.9
308	782	2159	35.4
293	605	1829	32.2
SE (±)	32.3	65.9	0.74
LSD ($p<0.05$)	63.3	129.2	1.45
CV%	23.6	18.9	17.25

A linear response to increased moisture supply was observed both in SY and TBY across the 36 chickpea genotypes studied (Fig 2.6.1). Linear regression estimates of intercepts and slopes for the 36 genotypes are given in Table 2.6.2. Genotypes ILC 1929, FLIP 88-36 C, FLIP 88-79C, ICC 10448, and ICC 10991 had higher intercept than the rest. Genotypes ILC 613, FLIP 88-7C and FLIP 88-87C had higher slope than the rest of genotypes. A high intercept is indicative of a good performance under drought conditions and a high slope of greater responsiveness to increased moisture supply. A close negative correlation between the intercepts and slopes both for SY and TBY (Fig 2.6.2) for the few genotypes studied, suggests that it may be difficult to find amongst exisiting cultivars chickpea genotypes that would combine both best drought resistance and response to increasing moisture supply. A crossing program using lines with contrasting intercept and slope values may yield recombinants with improved values for both.

M.C. Saxena and N.P. Saxena

Table 2.6.2. Estimates of intercepts and slopes of a linear regression analysis of seasonal moisture supply with seed yield (SY, kg/ha) and total biological yield (TBY, kg/ha), and the corresponding R^2 values.

Genotype	SY (kg/ha)			TBY (kg/ha)		
	Estimate	Slope	R^2	Estimate	Slope	R^2
ILC 100	-1823	7.87	.95	-3393	17.44	.96
ILC 262	-1319	7.38	.68	-2714	16.72	.70
ILC 464	-2340	9.55	.97	-3984	19.72	.97
ILC 613	-2737	10.84	.97	-4763	22.36	.96
ILC 629	-2224	8.83	.96	-5208	22.69	.99
ILC 1272	-2051	9.20	.97	-3349	17.67	.96
ILC 1687	-1782	8.47	.92	-3296	17.00	.94
ILC 1919	-1020	6.76	.62	-2143	14.28	.80
ILC 1929	-603	4.26	.87	-1542	10.00	.87
ILC 1930	-2056	5.85	.97	-3378	16.92	.98
ILC 2629	-1460	6.82	.96	-2574	14.75	.97
ILC 3116	-1426	7.80	.96	-2786	16.29	.96
F 82-73C	-2073	8.00	.98	-3024	16.4	.97
F82-2C	-1814	7.95	.89	-3082	17.17	.93
F84-80C	-2059	8.38	.98	-4017	19.46	.97
F85-4C	-1727	7.1	.93	-2373	15.9	.99
F85-49C	-1823	6.81	.81	-3555	17.65	.93
F88-5C	-2623	9.34	.88	-5224	22.47	.95
F88-7C	-3086	11.32	.98	-5138	23.71	.97
F88-11C	-1522	6.57	.89	-2674	15.53	.87
F88-13C	-1611	8.04	.93	-2303	14.25	.91
F88-15C	-2200	8.34	.93	-4562	21.65	.91
F88-23C	-1856	9.65	.94	-3365	19.73	.94
F88-36C	-962	7.16	.98	-1438	13.74	.98
F88-50C	-1869	9.26	.97	-2600	16.35	.87
F88-55C	-1997	8.62	.95	-3634	19.36	.93
F88-58C	-1796	9.41	.97	-3452	19.32	.98
F88-72C	-1183	6.99	.8	-2452	15.3	.97
F88-78C	-2043	9.39	.92	-3539	18.12	.94
F88-79C	-517	6.18	.83	-2605	17.50	.70
F88-83C	-1467	7.03	.85	-2944	16.00	.86
F88-84C	-1693	7.88	.99	-3190	16.4	.98
F88-86C	-2018	8.91	.93	-3294	17.71	.95
F88-87C	-2517	9.86	.98	-4129	19.2	.99
ICC 4958	-1083	7.21	.88	-1259	12.12	.88
ICC 10448	-287	3.22	.90	-803	7.84	.90
ICC 10991	-498	3.63	.88	-1038	7.96	.85
ICCL 82001	-1096	5.72	.90	-2308	11.99	.93
ANNIGERI	-1489	7.85	.99	-2056	13.37	.92
K 850	-1549	7.08	.97	-3272	15.35	.97

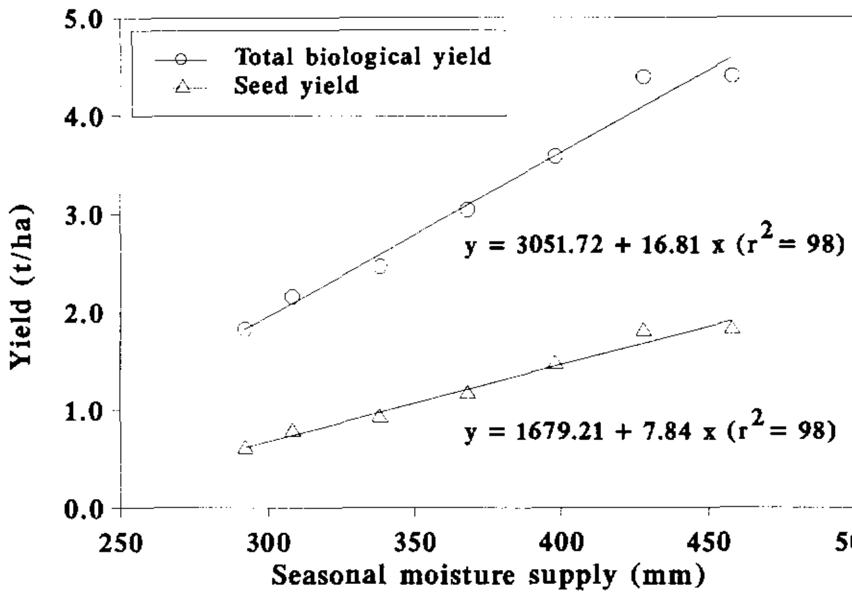


Figure 2.6.1. Relationship between seasonal total mositure supply and seed and biological yields of 36 chickpea genotypes, Tel Hadya, 1991.

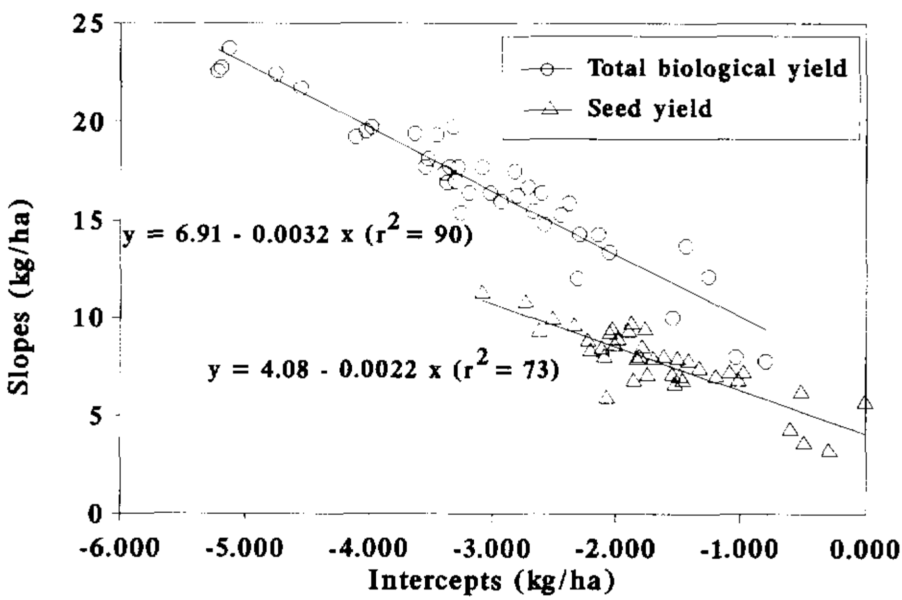


Figure 2.6.2. Relationship between the slope and the intercept of the regression of yield with total seasonal mositure supply.

3. LENTIL IMPROVEMENT

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

3.1. Lentil Breeding

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

3.1.1. Base Program

3.1.1.1. Breeding scheme

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

Approximately 250 crosses are made annually and handled in a bulk-pedigree system using off-season generation advancement. This season we used Terbol Station at 950 m elevation for the first time for the summer nursery. Day length had to be extended to 16 hrs by supplementary light.

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

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

Segregating populations targeted for the different regions are distributed with emphasis placed on relevant constraints, providing breeding material for national programs for selection and cultivar development in situ. In the Mediterranean area selection for response to varied moisture supply is conducted at ICARDA stations in Lebanon and Syria. Lines and segregating populations with specific characters are supplied through the International Testing Network.

3.1.1.2. Yield trials

Selections from the breeding program for West Asia and North Africa are tested in preliminary and advanced yield trials at three locations varying in their annual average rainfall, namely Breda (long-term average annual rainfall total 281 mm) and Tel Hadya (328 mm) in Syria and Terbol (545 mm) in Lebanon. During the 1990/91 season the rainfall was below the long-term average at all sites with 241, 288, and 499 mm received up to the end of June at Breda, Tel Hadya and Terbol, respectively. Biomass followed the rainfall gradient with mean biomass yields at Breda, Tel Hadya and Terbol of 2.0, 2.1, and 8.0 t/ha, respectively. A summary of the results of the yield trials is given in Table 3.1.2.

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

Location	Terbol		Tel Hadya		Breda	
Total seasonal rainfall (mm)	499		288		241	
	S	B	S	B	S	B
Number of trials	9	9	15	15	9	10
Number of test entries*	195	195	309	309	188	211
% of entries sig. (P<0.05) exceeding best check**	1.0	8.2	6.5	4.5	8.5	3.3
% of entries ranking above best check (excluding above)	32.3	33.8	37.9	31.4	46.3	37.0
Yield of top entry (kg/ha)	4146	11411	1066	3272	772	2882
Best check yield (kg/ha)	3482	8185	434	2219	575	2073
Location mean (kg/ha)	3135	7993	388	2096	577	2001
Range in C.V. (%)	7-21	7-12	14-37	7-17	6-17	6-14
Mean advantage of lattice over RBD (%)	11.4	21.4	13	59	15.7	7.1

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

At Tel Hadya there was a high infestation of both pea aphid (*Acyrthosiphon pisum*) and black bean aphid (*Aphis craccivora*) reducing yields in the yield trials, which were assessed for aphid damage. The distribution of natural infestation was uneven, as attested by highly significant replicate effects for aphid damage score in nine out of 12 trials. In only three trials were there significant differences between genotypes for aphid damage. In these three cases, aphid damage was significantly and negatively correlated to biomass, grain and straw yields. At Terbol the yields of lentil were among the highest recorded with biomass peaking at 11.4 t/ha and seed yield reaching 4.1 t/ha. It should, however, be remembered that these are only small-plot yields.

For seed yield the percentages of lines significantly outyielding the best check were 1.0, 6.5 and 8.5 % at Terbol, Tel Hadya and Breda, respectively. More test lines merely ranked above the best check for seed yield, representing 32, 38 and 46 % of the total lines tested at Terbol, Tel Hadya and Breda, respectively. The results for biomass follow the general pattern shown by those for seed yield.

W. Erskine

3.1.1.3. International nurseries

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

This year there has been an increase in the number of entries in international trials provided by national programs. It is our aim to increase the input into the international testing program of national programs. Included in 1992 international trials were two lines from the Soviet Union, three from Faisalabad, Pakistan and one from Islamabad, Pakistan. Other entries have been supplied by NARSs and are in multiplication for inclusion in next season's trials.

3.1.1.4. Screening for vascular wilt resistance

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

Annual Report 1988).

A total of 183 lines of cultivated lentil were screened for their reaction to wilt at the seedling stage in the 1990/91 season. The lines were rated on a 1-9 scale with rating 1 = resistant and rating 9 = all plants killed. Seventy-seven lines gave ratings < 3 and will be re-screened in an adult-stage screening trial next season.

The 44 most resistant lines in the seedling test of the 1989/90 season were screened this year in pots infested with the causal organism to evaluate their performance at a different, later stage of growth. Plants were rated twice, two months and five months after sowing. Most lines were resistant at two months, confirming last year's results. But, by five months, only three lines (ILL 6434, -6991 and -6995) showed tolerance to wilt (rating <5). These resistant lines will be shared with national programs in the international nursery - Lentil International Fusarium Wilt Nursery (LIFWN).

Results of LIFWN-90 from the national program in Egypt indicate that the material was challenged with a mixture of vascular wilt and eight other soil-borne pathogens both in pots and in a sick-plot in the field. Six of the 13 test entries were rated highly resistant to this root rot/wilt disease complex.

Last year a total of 221 accessions of wild lentil, comprising *Lens culinaris* subsp. *orientalis*, *L. culinaris* subsp. *odemensis*, *L. nigricans* subsp. *nigricans*, *L. nigricans* subsp. *ervoides*, and *Vicia montbretii* (syn. *Lens montbretii*) from nine countries, were tested for their reaction to vascular wilt. The screening was done at the seedling stage with the same methodology as for the cultivated lentils and a wide range in reaction to wilt was observed (FLIP Annual Report 1990).

This year, the 41 most resistant wild accessions in the seedling-stage test were re-screened for their reaction to wilt at the adult stage in pots. The overall mean score in adult stage reaction to wilt was 5.4

on a 1-9 scale as against <3.0 at seedling stage. The high mean score at the adult stage indicates that most of those accessions rated resistant at the seedling stage became susceptible at the adult stage. However, some accessions retained their resistant reaction from the seedling stage into the adult stage. The most wilt resistant accessions in the adult stage are listed in Table 3.1.3. Resistance was found within L. culinaris subsp. orientalis, L. nigricans subsp. nigricans, and L. nigricans subsp. ervoides.

W. Erskine and B. Bayaa (Aleppo University)

3.1.1.5. Screening for resistance to Ascochyta blight

Ascochyta blight (Ascochyta lentis) is considered to be among the most important biotic stresses affecting the crop's productivity, particularly in Canada, Ethiopia and parts of the Indian sub-continent and the region of West Asia and North Africa. Losses are not only to the standing crop, but also to the seed quality from infection in the swathe. Chemical control is too expensive for practical blight control and host-plant resistance is the most feasible and environmentally sound means of disease management. Sources of resistance to Ascochyta blight have been identified within the cultivated lentil and they are in use in breeding. We have searched for alternative sources of resistance to blight among wild lentils.

A total of 245 accessions of wild lentil and three accessions of V. montbretii were screened for reaction to Ascochyta blight. The accessions ranged in reaction on a 1-9 scale from highly resistant (1 score) to susceptible (9 score). The overall distribution in Ascochyta scores among accessions is shown in Figure 3.1.1. All accessions of V. montbretii were resistant. There were some resistant accessions in each wild subspecies. Within Lens subspecies the percentage of resistant accessions ranged from 41% in L. nigricans subsp. ervoides, 34% in L. culinaris subsp. odemensis and 24% in L. culinaris subsp. orientalis to only 9% within L. nigricans subsp. nigricans (Table 3.1.4).

Table 3.1.3. Mean Fusarium wilt score of the most resistant wild lentil accessions with their reaction to Ascochyta blight and country of origin.

Accession No. (ILWL)	Subspecies	Origin	Disease scores* Wilt	Ascochyta
79	L. culinaris subsp. orientalis	Turkey	1.25	4.8
138	L. nigricans subsp. ervoides	Syria	1.43	1.0
70	L. culinaris subsp. orientalis	Iran	2.00	5.3
113	L. culinaris subsp. orientalis	Turkey	2.13	6.4
59	L. nigricans subsp. ervoides	Turkey	2.32	1.9
28	L. nigricans subsp. nigricans	Yugoslavia	2.50	4.8
15	L. nigricans subsp. nigricans	France	2.57	2.2
27	L. nigricans subsp. nigricans	Yugoslavia	2.61	2.3

* 1-9 scale; 1 = highly resistant and 9 = highly susceptible.

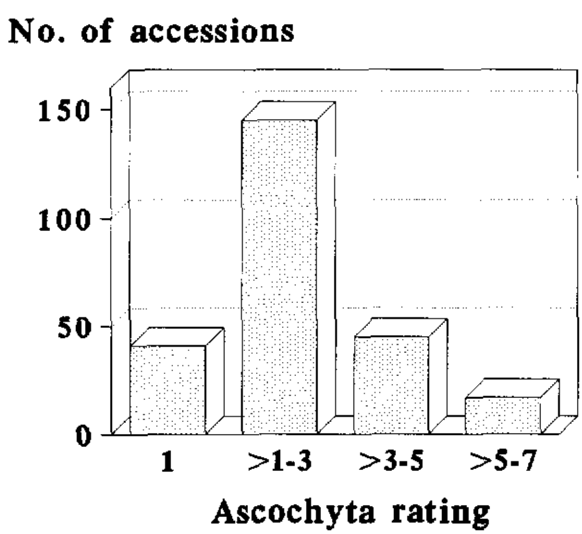


Figure 3.1.1. Number of wild lentil accessions in four rating groups for reaction to Ascochyta blight based on a scale with 1 = highly resistant and 9 = highly susceptible.

Table 3.1.4. Accession numbers of wild lentil accessions resistant to Ascochyta blight. Underlined accessions were immune to Ascochyta with disease scores of 1 in all ratings.

Species/ subspecies	Accession numbers (ILWL*)
L. culinaris subsp. orientalis	4, 7, 69, 77, 80, 84, 86, 88, 93, 94, 117, 118, 121, 146, 180, 181, 248, 257, 277, 302, 304, 315, 330, 331
L. culinaris subsp. odemensis	20, 116, 166, 168, 170, 172, 173, 174, 203, 238, 254, 300
L. nigricans subsp. nigricans	110, 190, 311
L. nigricans subsp. ervoides	41, 45, 50, 58, 63, 123, 128, 129, 130, 133, 134, 136, 138, 139, 141, 142, 158, 184, 185, 186, 193, 206, 207, 208, 259, 261, 262, 263, 269, 276, 274, 285, 294, 303, 318, 323
V. montbretii	12, 107, 283

* ILWL : International Legume Wild Lentil.

A total of 78 accessions with disease scores below 3 were then re-screened against ascochyta blight. Among them were 30 accessions which retained their strongly resistant reaction of a disease score of 1. An additional 48 accessions had disease scores between 1 and 3. The accession numbers of resistant accessions are given in Table 3.1.4.

The high proportion of resistant accessions within L. nigricans subsp. ervoides may be due to its shady habitat which contrasts with the open habitats of the other wild lentils. Under shade, the humidity is high and we may postulate that natural selection has evolved resistant forms under disease pressure, which prevails under such conditions.

There was a higher frequency of resistant accessions originating from Syria (45%) than from Turkey (21%) over all sub-species. This may be caused by our use of a Syrian isolate of the pathogen in screening. The hypothesis is testable by a test of pathogenicity using isolates from both countries.

W. Erskine, A. Hamdi and B. Bayaa (Aleppo University)

3.1.1.6. Screening for resistance to rust

Rust is the major fungal pathogen of lentil in the Indian sub-continent, Ethiopia and Morocco. We initiated systematic screening for resistance last season in collaboration with the Moroccan national program in a disease 'hot-spot'. Previously, screening had been undertaken on an opportunistic basis. The results of this year's screening are given in this report under the subsection North Africa.

3.1.1.7. Screening for resistance to *Orobanche*

Broomrape (*Orobanche* spp.) is a major cause of yield loss in lentil in some Mediterranean countries. One approach to *Orobanche* control is through the use of host-plant resistance. Variability within the crop to *Orobanche* attack is low and no resistance has been identified despite extensive screening of germplasm. We are, therefore, exploring wild *Lens* species for sources of resistance. A total of 128 accessions of wild lentil, comprising 54 accessions of *Lens culinaris* subsp. *orientalis*, 16 of *L. culinaris* subsp. *odemensis*, 22 of *L. nigricans* subsp. *nigricans*, and 36 of *L. nigricans* subsp. *ervoides*, have been screened using the petri-dish technique for *Orobanche*. None of the accessions showed a resistant reaction and we will screen additional wild germplasm next season.

K.-H. Linke and W. Erskine

3.1.1.8. Morphological variation in the genus *Lens*

As there are contradictory interpretations of the *Lens* species relationships and their identification, we studied various morphological characters in a survey of variation between and within *Lens* species to find characters, other than crossability, that distinguish the subspecies

Table 3.1.5. Number of accessions, means, ranges and standard deviation for morphological characters of Lens species accessions grown in the plastic house in 1990/91.

Characters	Species/ subsp.	L. culinaris culinaris	L. culinaris orientalis	L. culinaris odemensis	L. nigricans nigricans	L. nigricans ervoides
No. of accessions		10	48	10	14	39
Plant habit	Range	5	1,2,3,4.3	1,2,3	2,3,4	1,2,3,4
Length of the first bifoliate leaflet	Mean	10.5	6.7	6.5	4.9	5.1
	Range	8.2-13.6	4.7-8.1	5.6-7.4	4.6-5.5	3.2-6.9
	Sd.	1.7	0.79	0.58	0.34	0.73
Width of the first bifoliate leaflet	Mean	3.6	2.3	1.4	2.9	2.1
	Range	2.6-5	1.4-3.1	1.1-1.9	2.1-3.7	1.1-2.9
	Sd.	0.78	0.40	0.28	0.47	0.35
Ratio of length/ width of leaflet	Mean	3.0	3.1	4.8	1.8	2.5
	Range	2.3-3.7	2.2-4.4	4.0-6.5	1.3-2.6	2.0-3.0
	Sd.	0.37	0.43	0.84	0.33	0.28
No. of leaflets/ leaf	Mean	12.4	8.9	8.8	8.4	6.6
	Range	10-15	6-13	7-11	7-10	5-8
	Sd.	1.4	1.5	1.3	0.80	0.83
Leaf pubescence	Mean	2.4	2.2	2.2	2.4	1.4
	Range	2-3	1-3	1-3	2-3	1-2
	Sd.	0.52	0.83	0.79	0.51	0.49
Stipule shape	Range	1	1	2	2	2
Stipule margin	Range	1	1	2	2	2
Stipule angle	Mean	1.3	1.3	1.7	1.9	1.3
	Range	1-2	1-2	1-2	1-3	1-2
	Sd.	0.48	0.47	0.48	0.33	0.44
Corolla color	Mean	1.2	2.0	2.3	2.7	2.2
	Range	1-2	1-3	2-3	2-3	1-3
	Sd.	0.42	0.61	0.48	0.47	0.47
Tendril development	Range	1,2	1,2	1,2	1	1,2

Plant habit: 1: prostrate 2: decumbent 3: ascendent 4: semi-erect 5: erect
Leaf pubescence: 1: lanceolate; 2: semi-hastate
Stipule margin: 1: entire; 2: dentate
Stipule angle: 1: horizontal; 1: semi-vertical; 3: vertical
Corolla color: 1: standard whitish, whitish-blue veins
2: standard light purple or bluish
3: standard dark purple blue
Tendrils 1: undeveloped; 2: developed

L. culinaris subsp. odemensis from L. nigricans subsp. nigricans (previously both included in one species).

The number of accessions of each subspecies, means and ranges for the 11 characters studied are given in Table 3.1.5. All accessions of

Table 3.1.5. Number of accessions, means, ranges and standard deviation for morphological characters of Lens species accessions grown in the plastic house in 1990/91.

Characters	Species/ subsp.	L. culinaris culinaris	L. culinaris orientalis	L. culinaris odemensis	L. nigricans nigricans	L. nigricans ervoides
No. of accessions		10	48	10	14	39
Plant habit	Range	5	1,2,3,4.3	1,2,3	2,3,4	1,2,3,4
Length of the	Mean	10.5	6.7	6.5	4.9	5.1
first bifoliate	Range	8.2-13.6	4.7-8.1	5.6-7.4	4.6-5.5	3.2-6.9
leaflet	Sd.	1.7	0.79	0.58	0.34	0.73
Width of the	Mean	3.6	2.3	1.4	2.9	2.1
first bifoliate	Range	2.6-5	1.4-3.1	1.1-1.9	2.1-3.7	1.1-2.9
leaflet	Sd.	0.78	0.40	0.28	0.47	0.35
Ratio of length/	Mean	3.0	3.1	4.8	1.8	2.5
width of leaflet	Range	2.3-3.7	2.2-4.4	4.0-6.5	1.3-2.6	2.0-3.0
	Sd.	0.37	0.43	0.84	0.33	0.28
No. of leaflets/	Mean	12.4	8.9	8.8	8.4	6.6
leaf	Range	10-15	6-13	7-11	7-10	5-8
	Sd.	1.4	1.5	1.3	0.80	0.83
Leaf pubescence	Mean	2.4	2.2	2.2	2.4	1.4
	Range	2-3	1-3	1-3	2-3	1-2
	Sd.	0.52	0.83	0.79	0.51	0.49
Stipule shape	Range	1	1	2	2	2
Stipule margin	Range	1	1	2	2	2
Stipule angle	Mean	1.3	1.3	1.7	1.9	1.3
	Range	1-2	1-2	1-2	1-3	1-2
	Sd.	0.48	0.47	0.48	0.33	0.44
Corolla color	Mean	1.2	2.0	2.3	2.7	2.2
	Range	1-2	1-3	2-3	2-3	1-3
	Sd.	0.42	0.61	0.48	0.47	0.47
Tendril development	Range	1,2	1,2	1,2	1	1,2

Plant habit: 1: prostrate 2: decumbent 3: ascendent 4: semi-erect 5: erect
Leaf pubescence: 1: lanceolate; 2: semi-hastate
Stipule margin: 1: entire; 2: dentate
Stipule angle: 1: horizontal; 1: semi-vertical; 3: vertical
Corolla color: 1: standard whitish, whitish-blue veins
2: standard light purple or bluish
3: standard dark purple blue
Tendrils 1: undeveloped; 2: developed

the cultivated lentil had an erect plant habit, whereas accessions of other subspecies varied widely from prostrate to semi-erect. Subspecies ervoides had the lowest number of leaflets per leaf, which were slightly pubescent. As this subspecies also had the smallest leaflets and seeds (reported elsewhere), it appears to be the most phenotypically unique of Lens subspecies. Stipule shape and margin are major diagnostic characters distinguishing the species L. nigricans, on the one hand, from the L. culinaris subspecies culinaris and orientalis, on the other hand. However, L. culinaris subsp. odemensis has a similar semi-hastate stipule shape to L. nigricans subsp. nigricans. The ranges within the subspecies odemensis and nigricans overlapped for all characters, except length and width of the first bifoliate leaflets (and their ratio), suggesting that these traits distinguish between the subspecies.

3.1.1.9. Evaluation of wild relatives of lentil for agronomic characters

One hundred and twentyone accessions of Lens species were grown at Tel Hadya under field conditions and in the plastic house in the 1990/91 season to evaluate phenological and yield characters. Some accessions of L. culinaris subsp. orientalis were earlier to flower and mature than the earliest cultivated check ILL 4605; this precocity will be of value to the crop improvement program (Table 3.1.6). For the other agronomic characters studied, these was no obviously valuable variation within the wild species for transfer to the cultivated lentil. Our efforts will now focus on screening wild lentil germplasm for stress characters.

3.1.1.10. Screening wild relatives of lentil for drought tolerance

Susceptibility to moisture stress is a key factor in rainfed lentil production in the Mediterranean region. In the absence of information on the tolerance of wild relatives of lentil to drought we aimed to identify the reaction of wild relatives of lentil to drought stress. A field trial was conducted at Breda (annual rainfall of 274 mm on long-term basis) under line-source sprinkler irrigation system using 121 lentil accessions representing all subspecies of genus Lens. The water regime ranged from rainfed (241 mm total rain received) to rainfed + supplementary irrigations (total water supply of 348 mm).

Table 3.1.6. Mean, ranges of accession means, and standard deviations for phenological and reproductive characters of *Lens* species grown under field (F) and plastic house (P) conditions at Tel Hadya in the 1990/91 season.

Species		*L. culinaris*						*L. nigricans*			
		culinaris		orientalis		odemensis		nigricans		ervoides	
Subspecies		F	P	F	P	F	P	F	P	F	P
No. of access.		10	10	48	48	8	10	11	14	28	39
Biological	Mean	39.4	8.3	16.7	14.4	7.7	16.8	14.7	14.2	19.6	16.3
yield/plant	Ra.	10-66	3-13	4-54	6-30	4-15	9-21	5-24	4-25	8-49	3-35
(mg)	Sd.	15.7	3.6	9.9	5.8	4.7	4.0	6.8	5.1	12.2	7.2
Seed yield/	Mean	8.2	2.1	2.2	3.9	0.34	5.9	1.8	2.0	3.0	2.5
plant (mg)	Ra.	0.9-18	0.6-3	0.1-11	0.2-10	0.1-0.8	0.4-7	0.2-4	0.1-8	0.1-17	0.4-6
	Sd.	4.7	0.72	2.1	2.1	0.28	1.2	1.5	2.1	3.8	1.7
Straw yield/	Mean	31.2	6.2	14.5	10.4	7.3	10.9	12.9	12.2	16.6	13.9
plant (mg)	Ra.	7-56	1-12	4-43	4-25	3-15	5-14	5-22	3-19	6-40	4-34
	Sd.	14.5	3.6	8.1	4.7	4.7	3	6-1	4	9.4	6.4
Harvest	Mean	22	30	12	28	5	36	10	13	11	15
index (%)	Ra.	2-40	22-55	1-29	1-55	2-10	29-37	2-23	1-32	1-26	3-35
	Sd.	11.4	14.2	6.0	11.2	3.1	4.0	5.9	10.0	7.3	7.6
Time to	Mean	108	109	109	121	110	113	119	153	120	138
flower	Ra.	98-121	79-136	97-13	186-167	102-120	104-118	105-132	117-169	113-135	111-158
(day)	Sd.	8.8	16.9	8.2	18.6	6.7	6.2	8.1	11.5	4.9	13.3
Time to	Mean	150	162	150	171	150	165	159	182	160	179
maturity	Ra.	136-157	126-178	130-166	136-189	141-158	159-174	149-161	178-189	141-164	165-190
(day)	Sd.	7.3	14.5	7.3	9.5	6.3	5.3	3.7	3.5	4.6	6.2
Repro.	Mean	42	53	41	49	40	52	40	29	41	40
period	Ra.	32-54	41-69	23-54	19-71	29-52	44-66	29-54	9-46	22-53	22-58
(day)	Sd.	8.0	8.9	6.5	11.8	8.0	6.1	6.9	11.8	6.2	9.2

Accessions of L. culinaris subsp. culinaris were on average the earliest to flower as their average number of days to flower was 86 (Table 3.1.7). Irrigation prolonged the vegetative growth period for all subspecies. The average seed and straw yields over accessions showed that subsp. culinaris produced the highest seed yields, and that subsp. orientalis gave the highest seed and straw yields among wild subspecies.

The three subsp. odemensis, nigricans, and ervoides performed similarly for seed yield (128 kg/ha) under rainfed conditions. Yields increased with water supply, but the percentage varied over subspecies. Thus, accessions of subsp. orientalis and odemensis showed an increase over rainfed conditions of 50% in seed yield with irrigation, whereas the seed yield of subsp. ervoides increased by 156% with irrigation. The high irrigation response and susceptibility to drought of accessions of L. nigricans subsp. ervoides may be due to their natural adaptation to a shady humid habitat.

There was a significant genotype x water regime interaction for both seed and straw yield, indicating that there was variation between individual accessions in their response to drought stress. For example, the percentage of seed yield increase with increased water supply among accessions of subsp. ervoides ranged from 20.2% for ILWL 291 to 500% for ILWL 262. The accessions within each subspecies producing the highest seed yield under rainfed conditions are shown in Table 3.1.8. ILWL 73 of L. culinaris subsp. orientalis, originating from Cyprus, gave the highest seed yield among wild lentils of 722 kg/ha and the highest water use efficiency of 3.4 kg/ha per mm water supplied. The accession ILWL 294 of L. nigricans subsp. ervoides produced the highest rainfed straw yield of 2202 kg/ha.

A. Hamdi and W. Erskine

3.1.1.11. Relationships among economic characters in lentil

Lentil is grown as seed for human consumption and for its straw as a livestock feed, particularly in West Asia. Consequently, the yield of

Table 3.1.7. Means and ranges of time to flower, seed yield (SY) and straw yield (STY) of wild *Lens* accessions grown under two water regimes at Breda in the 1990/91 season.

Species	Rainfed			Rainfed + irrigation			Seed yield increase over rainfed (%)
	Days to flower	SY (kg/ha)	STY (kg/ha)	Days to flower	SY (kg/ha)	STY (kg/ha)	
L. *culinaris*							
ssp. *culinaris*	86	1360	1800	92	2656	3552	95
	79-99	526-2688	456-3140	82-115	480-3840	1560-5384	0-72
ssp. *orientalis*	92	192	808	97	288	1368	50
	80-120	28-722	243-2184	81-130	59-864	416-3960	20-110
ssp. *odemensis*	90	128	384	93	192	1720	50
	81-105	41-528	179-828	86-100	39-1088	200-7304	0-322
L. *nigricans*							
ssp. *nigricans*	102	128	688	109	200	1280	56
	89-116	45-298	251-1184	99-117	57-387	40-5872	27-30
ssp. *ervoides*	101	128	664	103	328	1592	156
	92-116	25-388	280-2202	92-114	20-4504	336-10180	0-1061

seed and its quality, together with straw yield, are primary economic traits. Knowledge of the magnitude and type of relationship between economic traits in a crop profoundly affects the approach to be taken in plant improvement. With genetic variances and covariances it is possible to predict the expected response to selection for one economic trait and expected correlated responses in other traits. The breeder often selects individuals that deviate from trends in associations. Correlations are due to genetic or environmental causes, with genetic correlations resulting from either the pleiotropic effects of genes on different characters or linkage between genes affecting characters. Recombination can break linkages but can have no effect on correlation caused by pleiotropy.

Table 3.1.8. Seed yield (SY), straw yield (STY) and water use efficiency (WUE) of the highest-yielding accessions of different Lens species grown under rainfed conditions at Breda in 1990/91.

ILWL	species	SY (kg/ha)	STY (kg/ha)	(WUE) ($kg\ ha^{-1}\ mm^{-1}$) SY	STY
L. culinaris					
73	ssp. orientalis	722	777	3.37	3.63
309	ssp. orientalis	364	978	1.70	4.57
330	ssp. orientalis	532	1610	2.49	7.52
175	ssp. odemensis	258	350	1.20	1.64
L. nigricans					
311	ssp. nigricans	298	1158	1.39	5.41
260	ssp. ervoides	388	671	1.81	3.14
294	ssp. ervoides	342	2202	1.60	10.29
298	ssp. ervoides	322	1034	1.50	4.83
Average of all sub. sp. culinaris		1360	1800	6.36	8.41

There are several reports of the associations among yield, its components, and phenological characters in lentil based on few, relatively similar lines grown in single environments. But as heritability and genetic correlations apply only to the material and sites studied, the results have often been inconsistent because of inadequate sampling of genotypes and environments. So we examined associations between economic characters in lentil over a wide range of both genetic material and environments in West Asia. The first part of the study concerned correlations within large samples of the world lentil collection grown in two seasons (1370 accessions in 1978/79 and 2293 accessions in 1979/80), and the second part covered a smaller sample of genetic material from the collection (34 diverse accessions) sown over a wider range of conditions comprising 10 environments.

The results (Table 3.1.9) showed similar phenotypic correlations over two seasons, contrasting in rainfall (1978/79 total seasonal rainfall 247 mm; 1979/80 total seasonal rainfall 424 mm), in the world lentil collection. Similar genetic and phenotypic correlations were also shown by the smaller sample of germplasm over 10 environments (Table 3.1.10). These results indicate the low importance of covariance due to environmental and genotype-environment interaction effects.

Seed yield was positively correlated with straw yield, indicating selection for either character will increase the other trait, confirming previous research at ICARDA.

Seed yield was correlated to each of the yield components - positively with pod number/plant and 100-seed weight, and negatively with seed number/pod. It is possible to compare statistically the efficiency of indirect selection for yield via the yield components. But as component selection has been unsuccessful in the past - probably because of yield component compensation - and measuring yield is much less time-consuming than counting/measuring components, selection for yield components is not justified.

Table 3.1.9. Phenotypic correlations among the characters studied in 1978-79 (upper) with 1370 germplasm accessions and 1979-80 (lower) seasons with 2293 germplasm accessions.

Character	Straw yield (kg/ha)	No. of seeds/ pod	100-seed weight (g)	Plant height (cm)	Time to flower (d)	Time to maturity (d)	Lowest pod height (cm)	Harvest index	Seed protein content (%)
Seed yield (kg/ha)	0.43**	-0.02	0.10**	0.12**	-0.39**	-0.42**	-0.06	0.54**	-0.28**
	0.54*	-0.13**	0.29**	NA	-0.04	NA	0.08	0.34**	-0.34**
Straw yield		-0.30**	0.45**	0.66**	0.21**	0.32**	0.61**	-0.45**	0.19**
		-0.30**	0.47**	NA	0.52**	NA	0.40**	-0.55**	-0.03
No. of seeds/pod			-0.65**	-0.40**	-0.17**	-0.36**	-0.44**	0.26**	0.05
			-0.62**	NA	-0.20**	NA	-0.22**	0.20**	0.11**
100-seed weight				0.54**	0.10**	0.43**	0.56**	-0.31**	-0.09*
				NA	-0.30**	NA	0.37**	-0.25**	-0.04
Plant height					0.35**	0.55**	0.78**	-0.48**	0.11**
					NA	NA	NA	NA	NA
Time to flower						0.82**	0.54**	-0.67**	0.52**
						NA	-0.36**	-0.61**	0.37**
Time to maturity							0.68**	-0.78**	0.45**
							NA	NA	NA
Lowest pod height								-0.62**	0.30**
								-0.31**	0.06
Harvest index									-0.51**
									-0.31**

*, ** significant at the 5% and 1% levels, respectively.
NA, not available

Table 3.1.10. Phenotypic (upper) and genotypic (lower) correlations for the characters studied on 30 diverse randomly selected lentil lines grown in a total of 10 environments in the 1984-85 and 1985-86 seasons.

Character	Straw yield/ plant	No. of seeds/ pod	100-seed weight	No. of pods/ plant	Plant height	Time to flowering	Time to maturity	Harvest index	Seed protein content	Cooking time
Seed yield	0.34**	-0.50**	0.32**	0.71**	0.15**	-0.36**	-0.17**	0.51**	-0.10*	0.29**
	0.34	-0.51	0.33	0.73	0.14	-0.36	-0.17	0.51	-0.10	0.30
Straw yield		-0.64**	0.60**	0.05	0.78**	0.70**	0.81**	-0.63**	0.56**	0.48**
		-0.67	0.62	0.05	0.79	0.72	0.84	-0.65	0.59	0.50
No. of seeds/pod		-0.83**	-0.12**	-0.53**	-0.24**	-0.42**	0.18**	-0.16**	0.41**	
			-0.85	-0.11	-0.56	-0.24	-0.44	0.19	-0.19	-0.45
100-seed weight			-0.27**	0.59**	0.26**	0.48**	-0.88**	0.17**	0.95**	
				-0.29	0.61	0.27	0.49	-0.93	0.18	0.96
No. of pods/plant					-0.13**	-0.33**	-0.35**	0.59**	-0.15*	-0.26**
					-0.15	-0.37	-0.40	0.62	-0.18	-0.27
Plant height						0.62**	0.74**	-0.58**	0.52**	0.54**
						0.65	0.80	-0.63	0.58	0.56
Time to flowering							0.92**	-0.91**	0.59**	0.19**
							0.95	-0.96	0.63	0.20
Time to maturity							-0.88**	0.59**	0.40**	
								-0.93	0.64	0.42
Harvest index									-0.57**	-0.23**
									-0.61	-0.24
Seed protein content										0.15**
										0.17

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

Straw yield was positively correlated with plant size (plant height and lowest pod height) and with phenological development (time to flower and time to maturity). A late switch from vegetative growth to reproductive growth favors the development of a large vegetative canopy and a high straw yield, and prejudices seed yield development. Although increased height is desirable for a mechanized harvest, it is known that excessive height results in lodging. The characters of plant size were also correlated with those of phenology.

Experience with the crop shows that this correlation is based on a transient linkage since it is possible to recombine earliness with plant size. In contrast, the correlations between the characters describing plant size, such as between plant height and lowest pod height, and between the phenological characters (time to flower and time to maturity) are probably largely pleiotropic in nature.

Among seed-quality characters, the correlation between protein content and seed yield was small and negative, whereas the correlation of protein with straw yield was small but positive. This suggests that the current ICARDA goals of selection for seed and straw yield will not have a major correlated effect on seed protein content. The association between seed protein and 100-seed weight was also weak indicating that selection for particular seed-size types will not greatly affect protein content.

Seed size (100-seed weight) was positively and significantly correlated with cooking time (r=0.96) as found earlier at ICARDA. During cooking, water is gradually imbibed by the cotyledons and cooking time is the period required for imbibition by the entire cotyledonary volume. If the rate of imbibition by the cotyledon is relatively constant over genotypes, then since seed size closely reflects cotyledonary volume, the relationship between seed size and cooking time may be largely pleiotropic.

Because of the strength of the relationship it is unnecessary to screen early generation lentil genotypes for cooking time, since for all practical purposes, the cooking time is predictable on the basis of seed size.

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

3.1.1.12. Heritability and combining ability of yield, its components and time to flower in lentil

As there is a paucity of information on the inheritance of economic characters in lentils, we studied the variability generated in a diallel cross between eight diverse genotypes of yield, its components and earliness in the F_1 and F_2 generations.

The mean performances of the eight parents are given in Table 3.1.11. The results showed that general combining ability effects (GCA) were of major importance for number of seeds/pod, 100-seed weight, time to flowering and straw yield/plant. Seed yield/plant and number of pods/plant showed the predominant role of specific combining ability effects (SCA).

The characters 100-seed weight and time to flowering, which had high additive component values, gave high estimates of narrow sense heritability. The estimates of heritability for number of seeds/pod was relatively low owing to the high environmental variances (error variances) associated with this trait. By contrast, those traits which had high non-additive component values showed lower estimates of broad and narrow sense heritabilities than other characters. For example, seed yield/plant gave the lowest value of broad-sense heritability ($b^2_{n.s.}$=0.0) among all characters.

Thus selection between crosses for seed yield/plant will be futile. However, because specific combining ability was a major effect for this character, it was affected by non-allelic interaction. It is thus possible that estimates of non-additive components include a substantial proportion of epistatic effects, besides dominance effects. Therefore, superior F_1s are expected to throw out desirable transgressive segregants, provided that desirable complementary genes and epistatic effects are coupled in the same direction to maximize seed yield. There were seven such superior crosses which exhibited useful heterosis and high SCA effects. Most of these crosses maintained their superiority in the F_2 generation.

There were strong correlations between GCA effects and parental means for number of seeds/pod, 100-seed weight, time to flower and straw yield, indicating that parental means provided a good prediction of general combining ability and hence hybrid performance. Seed yield/plant and number of pods/plant showed non-significant correlation coefficients between general combining ability and parental means, confirming that non-additive effects are of considerable importance for these traits.

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

Table 3.1.11. *Parental means with the origins and standard errors* together with the narrow-sense heritabilities from the F_1 and F_2 generation of an eight-parent diallel cross.

Accession no. (ILL)	*Origin*	*Seed* yield/ plant (g)	*Straw* yield/ plant (g)	*Number* of seeds/ pod	100- seed weight (g)	Number of pod/s plant	Time to flower (days)
784	Egypt	1.13	1.60	1.76	3.5	19	112
5486	Egypt	0.83	1.87	1.50	3.1	18	101
5584	Jordan	1.30	1.87	1.02	5.0	26	107
4605	Argentina	1.27	1.63	1.62	4.5	18	100
2501	India	0.60	0.67	1.70	2.2	16	104
5674	ICARDA	1.53	2.67	1.28	5.8	21	109
274	Greece	1.23	3.10	1.37	3.5	26	124
121	Turkey	0.93	2.00	1.56	2.8	21	126
S.E.±		0.37	0.44	0.17	0.13	6.1	1.1
$h^2_{n.s.}$	F_1	0.0	36.4	11.2	60.0	72.7	56.3
	F_2	21.0	37.3	3.3	50.0	64.4	74.3

3.1.2. Use of Germplasm by NARSs

3.1.2.1. Advances for the Mediterranean region

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

Table 3.1.12 lists lentil lines released as cultivars and Table 3.1.13 gives those lines selected for pre-release multiplication by NARSs and/or in on-farm trials.

In Syria the lines with red-cotyledon 78S26013 (ILL16) and ILL 5883 are in the final year of large-scale testing prior to possible release. On-farm trials are planned to test FLIP84-147L and FLIP87-5L in Jordan, and to test FLIP86-22L and FLIP87-56L in Lebanon next season.

In Iraq the large-seeded line 78S26002 is in pre-release multiplication. The lentil line ILL 1939 has been offered for registration by the South-East Anatolian Research Institute in Turkey.

In North Africa two lines (FLIP84-103L and 78S26002) have been identified by the national program for pre-release multiplication in Tunis as a supplement to 'Neir' and 'Nefza' already released. In Algeria the national program has selected ILL 468 and ILL 1889 for pre-release multiplication. In Libya the line 78S26002 is in pre-release multiplication.

Lentils in Morocco suffered less from rust than in the previous three seasons but a high level from some other diseases such as stem rot, and both Botrytis and Ascochyta blights. ILL 4605 was earlier released on the basis of its resistance to rust, but it also has a tolerant reaction to Ascochyta blight. Three other lines (FLIP86-16L, FLIP 87-19L and FLIP87-22L) with resistance to rust are now entering their final year in the catalogue trials, among which FLIP87-22L has the most resistant reaction to Ascochyta blight. FLIP86-15L entered catalogue trials last season on the basis of its yield and rust resistance.

National Agricultural Research Systems

Table 3.1.12. Lentil cultivars released by national programs.

Country	Cultivar name	Year of release	Specific features
Algeria	Syrie 229	1987	High yield, good seed quality
	Balkan 755	1988	High yield, good seed quality
	ILL 4400	1988	High yield, good seed quality
Argentina	Arbolito(ILL 4650x-4349)	1991	High yield, tall and early
Australia	ILL 5750	1989	High yield
Canada	Indianhead (ILL 481)	1989	Green manure
Chile	Centinela (74TA470)	1989	Rust resistant, high yield
China	FLIP 87-53L	1988	High yield, Qinghai province
Ecuador	INIAP-406 (FLIP 84-94L)	1987	Rust resistant, high yield
Egypt	Precoz (ILL 4605)	1950	For intercropping in sugarcane
Ethiopia	R 186	1980	High yield
	ILL 358	1984	Rust resistant, high yield
Jordan	Jordan 3 (78S 26002)	1990	High yield, standing ability
Lebanon	Talya 2 (78S 26013)	1988	High yield, standing ability
Morocco	Precoz (ILL 4605)	1990	Rust resistant, high yield
Nepal	Sikhar (ILL 4402)	1989	High yield
Pakistan	Manserha 89 (ILL 4605)	1990	Ascochyta & rust resistance
Syria	Idleb 1 (78S 26002)	1987	High yield, reduced lodging
Tunisia	Neir (ILL 4400)	1986	Large seeds, high yield
	Nefza (ILL 4606)	1986	Large seeds, high yield
Turkey	Firat '87 (75Kf 36062)	1987	Small seeds, high yield
	Erzurum '89 (ILL 942)	1990	Spring sowing, high yield
	Malazgirt '89 (ILL 1384)	1990	Spring sowing, high yield
	Sazak-91 (NEL 854)	1991	Winter sowing, red cotyledon
U.S.A.	Crimson (ILL 784)	1991	Yield in dry areas

Table. 3.1.13. Lentil lines in pre-release multiplication or on-farm testing by NARSs.

Test region	Line
Mediterranean region	
Algeria	ILL 468, ILL 1889
Iraq	78S26002
Jordan	FLIP84-147L, FLIP87-5L
Lebanon	FLIP86-22L, FLIP87-56L
Morocco	FLIP86-16L, FLIP86-15L, FLIP87-19L, FLIP87-22L
Syria	78S26013, ILL 5883
Tunisia	FLIP 84-103L, 78S26002
Turkey	ILL 1939
High elevation	
Iran	ILL 4400, ILL 4605
Pakistan	FLIP84-4L, FLIP85-7L
S. latitudes	
Egypt	ILL 4605
Ethiopia	FLIP86-12L, FLIP86-16L, FLIP86-18L
Nepal	ILL 2578, ILL 4404
Pakistan	ILL 2573
Yemen	ILL 4605, FLIP84-14L
Others	
Argentina	FLIP84-100L, FLIP86-12L, FLIP87-23L, 74TA19
China	ILL 504

3.1.2.2. Advances for southern-latitude region

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

There are three strong lentil breeding programs in Pakistan with two in Faisalabad and the remaining program in Islamabad. Over the last five years ICARDA has worked closely with these programs in joint selection as the focus of a thrust to broaden the genetic base of lentils in South Asia. The National Uniform Lentil Yield Trial 90/91 of Pakistan comprised 10 test entries, of which five entries were selected directly from ICARDA international trials and five entries are local selections from ICARDA-supplied segregating populations. Reports for the local variety release committee are being prepared by the Pulses Directorate, Ayub Agriculture Research Institute for both 86642 (ILL 2573) and 87519, a local selection from an ICARDA cross.

The major production problem in Bangladesh addressable through breeding is rust. We have been making targeted crosses for Bangladesh of rust resistance sources with the local susceptible cultivar 'L5' in the base program at Tel Hadya. Selections have now been made in Bangladesh of adapted rust-resistant plants in the F_3 generation from this material.

During the 1989/90 season ILL 4605 was included in every crossing block in India on the basis of its large seed and combined resistance to rust and Ascochyta blight. During the 1990/91 season there were a total of 60 test entries in the All-India Coordinated lentil trials, of which 12 entries come from crosses with ILL 4605 as a parent.

Nepal grows more than 100,000 ha of lentil spread between the Terai area adjacent to India and the Mid-Hills. The lentil cultivar 'Sikhar' (ILL 4402) was released to farmers in Nepal for cultivation in the Terai region in 1989.

In Ethiopia FLIP85-33L (ILL 5871) and FLIP86-38L (ILL 6024) have been identified by the National Program with resistance to both rust and Ascochyta blight and also good seed type and yield. FLIP86-38L was previously identified in Pakistan as multiple-disease resistant.

National Agricultural Research Systems

3.1.2.3. Advances for high-altitude region

The high-altitude region primarily consists of those regions of Afghanistan, Iran, Pakistan and Turkey where lentil is normally grown as a spring crop because of the severe winter cold. This season at Ankara the national program of Turkey has again demonstrated that winter-sown lentil has a higher yield potential than the spring-sown crop providing there is sufficient winter-hardiness in the cultivar. In the Lentil International Cold Tolerance Nursery at Ankara the checks were susceptible to cold and were killed and the lines ILL 468, -1918, -465 and -983 were tolerant and selected in descending order of merit.

The line 1066-1, a single plant selection made at Eskisehir from ILL 854, is a large-seeded, red-cotyledon line that was released for winter sowing on the central plateau of Turkey during 1991.

In Iran the lines ILL 4400 and -4605 are promising in the Ardabil region.

The lines FLIP84-4L and FLIP85-7L are in the pre-release stage at the Arid Zone Research Institute, Quetta, Pakistan on the basis of their cold tolerance and larger seed size than the local cultivar.

National Agricultural Research Systems

3.1.2.4. Advances in other areas

Cultivar 'Crimson' has been released in USA as a result of single plant selection of ICARDA-supplied germplasm (ILL 784).

National Agricultural Research Systems

3.2. Application of Biotechnology in Lentil Improvement

The genus Lens has recently undergone taxonomic revision of its species based on crossability relations and fertility of hybrids. Members of the genus were grouped into two biological species:

1. Lens culinaris comprising ssp. culinaris (cult.), ssp. orientalis (wild), and ssp. odomensis (wild).
2. Lens nigricans comprising ssp. nigricans (wild), and ssp. ervoides (wild).

However, this grouping did not fully agree with the results from some studies examining variation within and between biological species based on morphological traits and isozyme markers. Therefore, proper taxonomic classification of the Lens species and subspecies is still not perfectly resolved.

Additionally, we would like to know more of genetic variability within the wild subspecies. Breeders knowing the variability could better target the exploitation of the respective susbspecies.

We are applying DNA fingerprinting, using digoxigenin in labeled oligonucleotides as probes, to detect genetic variability within and between the subspecies. The results (Fig. 3.2.1) have shown that using the enzyme/probe combination TaqI/$(GATA)_4$ the degree of polymorphism within the wild accessions is too high to distinguish between the wild subspecies. On the other hand the banding patterns of the cultivated subspecies Lens culinaris ssp. culinaris differ from banding patterns of all the wild subspecies. More enzyme/probe combinations have to be tested to reduce the degree of polymorphism within the subspecies so that subspecies typical banding patterns will appear.

In addition we are trying to overcome the crossability barrier between the two subspecies using an ovule-embryo rescue technique. The degree of successful wide crossing is strongly influenced by the genotypes used, but no criteria are currently available to select the most promising genotypes from these subspecies.

3.3. Lentil Harvest Mechanization

3.3.1. On-farm Testing of Lentil Harvest Mechanization in North-West Syria

Lentil harvest is the major production problem in the Mediterranean region because of the high cost of labour. Systems of mechanization have been developed to decrease the cost of production of the crop.

In Syria the major traditional production areas of lentil were in Aleppo and Idlib Provinces until the end of the 1980, when harvest

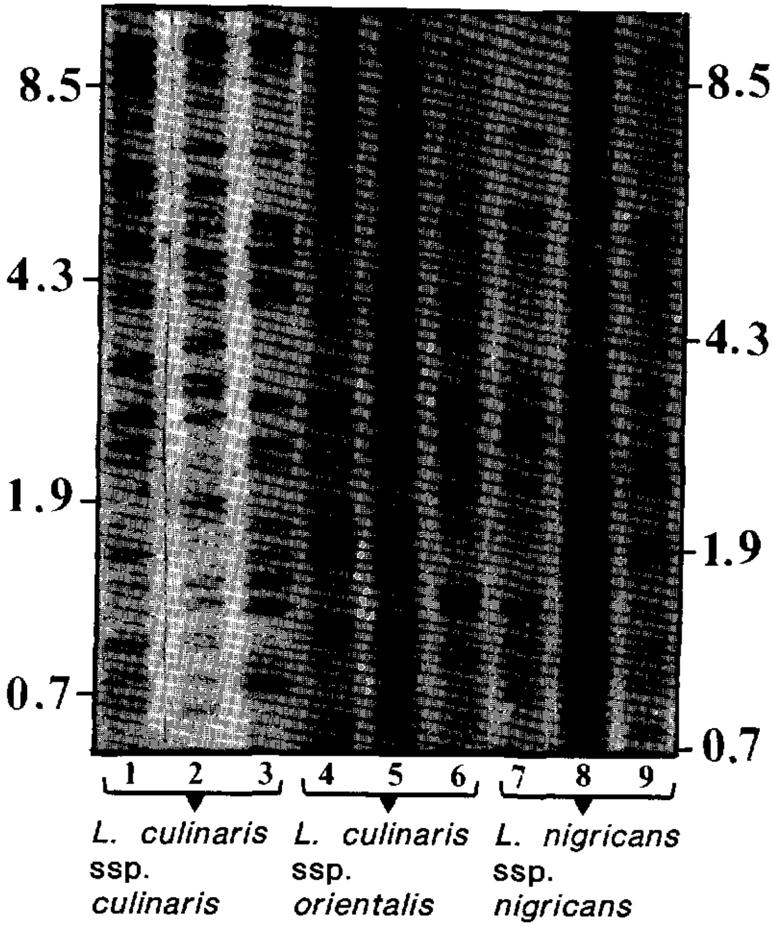


Figure 3.2.1. Non-radioactive fingerprinted lentil. After digestion with TaqI, the restriction fragments were electrophoresed in agarose gels. The gels were vacuum blotted onto nylon membrances and hybridized to a digoxigenin-labelled $(GATA)_4$ probe. Lanes 1-3 represent three accessions of Lens culinaris ssp. culinaris (ILL 6228, ILL 6005 and ILL 5744), lanes 4-6 represent three accessions of Lens culinaris ssp. orientalis (ILWL 315, ILWL 314 and ILWL 104) and lanes 7-9 represent three accessions of Lens nigricans ssp. nigricans (ILWL 19, ILWL 305 and ILWl 320). Positions of molecular weight markers are indicated, in kilobases, at the left-hand side for the gel with the Lens culinaris ssp. culinaris accessions, at the right-hand side for the Lens culinaris ssp. orientalis and Lens nigricans ssp. nigricans accessions.

mechanization in the Kameshly area increased the lentil area dramatically in the northeast of the country. In Kameshly about 80,000 ha of lentil were sown in 1989 and approximately 25% were harvested by swathe-mower in 1990. By contrast, there is no lentil harvest mechanization in the Aleppo and Idlib Provinces.

As part of the cooperation between ICARDA and the General Organization of Agricultural Mechanization (GOAM), Syria, an experiment was conducted at Sahel el Rouge farm during the 1990-91 season on lentil harvest mechanization to compare harvest methods commonly used in Kameshly Province under the conditions of North-West Syria.

Three hectares of lentil, split between the cultivars Hurani 1 and Idlib 1, were sown in November, 1990 following the management practices recommended to farmers in the Kameshly area. A comparison was made of the result of harvest by three methods: (i) hand harvest, (ii) swathe-mower, and (iii) combine harvester. Measurements of yield potential, and both losses and yields from hand and machine harvest were made.

The total seasonal rainfall was about 450 mm and crop growth was good. The average plant height of the local cultivar Hurani 1 was 54.6 cm. Overall, the mean yield of seed was 1561 kg/ha and that of straw 5912 kg/ha (Tables 3.3.1 and 3.3.2). Idlib 1 outyielded Hurani 1 in seed yield but not in straw yield. The high values of the standard errors reflect the heterogeneity not only in crop growth over the experimental area but also the variation in the performance of the harvest equipment.

Losses from the swathe-mower averaged 25.1% for seed and 40.2% for straw. The seed losses were particularly high. Last year we measured seed yield losses on farmers' fields in the Kameshly area, where the average loss of seed on the bare ground was $4.7 \pm 0.97\%$, but the range in losses among fields was from 0 to 22%. This year the crop was swathed at an overripe stage indicating the sensitivity of harvesting by swathe-mower to the stage of crop maturity.

Table 3.3.1. Seed yield and losses from hand and machine harvest of lentil at Sahel el Rouge 1991. Values in parentheses are standard errors.

Method	Character	Overall	Hurani 1	Idlib 1
Hand	Yield (kg/ha)	1561 (37)	1460 (35)	1762 (63)
Swathe-mower	Yield (kg/ha)	1168 (182)	1033	1439
Swathe-mower	Losses (%)	25.1	29.2	14.2
Combine	Yield (kg/ha)	1276 (220)	1088	1654
Combine	Losses (%)	26.6	31.7	18.8

Table 3.3.2. Straw yield and losses from hand and machine harvest of lentil at Sahel el Rouge 1991. Values in parentheses are standard errors.

Method	Character	Overall	Hurani 1	Idlib 1
Hand	Yield (kg/ha)	5912 (178)	6040 (261)	5658 (174)
Swathe-mower	Yield (kg/ha)	3521 (229)	3365	3833
Swathe-mower	Losses (%)	40.4	44.3	28.9
Combine	Losses (%)	100	100	100

Seed losses from the combine harvester averaged 26.6%. All straw was considered lost from the combine harvester. Last year in Kameshly the average seed loss measured from the combine harvester working on farmers' fields was similar at 20.9 ± 5.25%.

W. Erskine and the General Organization of Agricultural Mechanization, Syria

3.3.2. Lodging in Lentil as Affected by Plant Population, Soil Moisture and Genotype

Losses in lentil from machine harvest increase with lodging, hence standing ability is a desirable character in lentil. As agronomic management is an important factor in lentil mechanization systems, we conducted an experiment to investigate the effects of levels of soil moisture (rainfed, 50 mm supplementary irrigation applied once and applied twice) and plant population (200 and 400 plants/m^2) on the lodging and on the associated losses from a mechanical harvest of two genotypes contrasting in standing ability (ILL 8 and 4401) in two seasons at Tel Hadya, N. Syria. In a second experiment character association with lodging was investigated over 30 lentil genotypes in both seasons.

The study showed that high levels of plant population or soil moisture reduced standing ability in lentil (Figure 3.3.1). However, the mechanisms, by which each factor mediates its effect, differ. An increase in plant population reduced stem diameter, which results in more lodged plants. In contrast, moisture effects on stem diameter were negligible. High soil moisture led in this experiment to high biological yield resulting in a high ratio of shoot weight to basal stem area, a

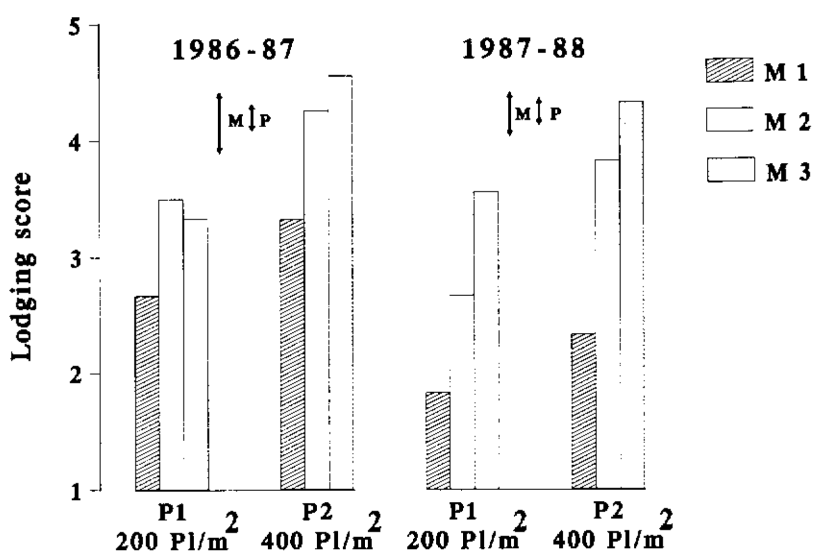


Figure 3.3.1. Means and standard errors (arrows) averaged over genotypes for lodging score in lentil as affected by soil mositure (M1-M3) and plant population (P1-P2) levels in two seasons.

situation that predisposed plants to lodging. High soil moisture due to late rain or supplementary irrigation may loosen the anchorage of plants and hence contribute to increased lodging. Machine harvest losses in biological yield, compared with hand harvest, increased from 12% under rainfed conditions to 24% at the highest level of soil moisture.

The superiority of genotype ILL 8 over ILL 4401 in standing ability was due to the higher biological yield at which the crop was predisposed to lodging. At higher levels of biological yield a rule of thumb was derived whereby a two-tonne increase in biological yield led to a one point increase in lodging score. Data from three different sites in the 1984/85 season confirm the generality of the rule of thumb.

It has been suggested that stem diameter be used in single plant selection for standing ability, because of its strong correlation with lodging score. In this study the association of lodging score was significant at r= -0.21, but too low for use in selection. As the association of stem diameter with standing ability is apparently not always strong, it appears more practicable to use supplementary irrigation as a tool to artificially induce lodging to screen breeding material in very dry years; with the caveat that excessive soil moisture levels are to be avoided in order to retain differences between lines, which disappear at very high levels of soil moisture.

H. Ibrahim, W. Erskine, G. Hanti, A. Fares (University of Aleppo)

3.4. Lentil Biological Nitrogen Fixation

3.4.1. Strain Evaluation for Improved N_2 Fixation in Commercial Lentil Cultivars

During several years of field trials at Tel Hadya measurements of lentil yield and N_2 fixation response to inoculation with a standard set of selected strains revealed that 10-15% crop and N yield increases could be obtained under conditions of adequate rainfall, but inoculation consistently failed to increase the proportion of N derived from fixation. No strain-cultivar interactions have been observed.

Following a large-scale greenhouse screening effort of ca. 250 newly collected and existing lentil rhizobia isolates for symbiotic effectiveness, four highly effective new strains of different origins were selected for field evaluation on four diverse commercial cultivars. Of the four strains, strains 739 from Syria and 760 from Portugal produced significant yield responses in the cultivars (Table 3.4.1). Average yield increases across cultivars were 21 and 18% (biological) and 42 and 37% (seed) for strains 739 and 760, respectively. It is interesting to note that increases from the mixed-strain inoculants were less than those obtained from individual strains (Table 3.4.1). Application of fertilizer N significantly increased biological yields, but not seed yields. The coefficient of variation for seed yield was very high owing to late Orobanche infestation.

Table 3.4.1. Yield effects of inoculation with 2 strains in individual and mixed culture on four lentil cultivars in the field, Tel Hadya, 1990-91.

Cultivar	Treatment	Biological yield (kg/ha)	Seed yield (kg/ha)
ILL 8	Uninoc	2920	620
	LE-739	3410.*	909.*
	LE-760	3311	848
	739+760	3142	708
	120 kg N/ha	3439.*	771
ILL 16	Uninoc	2312	496
	LE-739	3038.*	849.*
	LE-760	2935.*	836.*
	739+760	2788.*	727
	120 kg N/ha	3043.*	765
ILL 4605	Uninoc	2491	843
	LE-739	2818	1000
	LE-760	2801	958
	739+760	2560	862
	120 kg N/ha	2875	949
ILL 5700	Uninoc	2527	657
	LE-739	3113.*	918
	LE-760	3003.*	902
	739+760	2726	733
	120 kg N/ha	3045.*	855

* indicates significant difference ($P<0.05$) from uninoculated treatment.

These results indicate a potentially important role for lentil inoculation with the selected Rhizobium strains. A wider evaluation of the competitiveness and effectiveness of these strains in soils of Egypt, Syria and Tunisia is underway.

D. Beck and W. Erskine

3.5. Lentil Physiology

Identifying lentil genotypes which are better adapted to a range of soil moisture environments is an important objective of lentil improvement work at ICARDA. Some promising genotypes were studied to identify combined drought resistance and higher responsiveness to increasing available soil moisture supply. Shoot and root traits of these genotypes were also characterized and correlated with the seed yield to identify traits association, if any, with the combined drought resistance and responsiveness to increased moisture supply. Since terminal drought and heat stress always occur together in field conditions, effects of these two factors were studied in factorial combinations of genotypes (G), supplemental irrigation levels (IL), and temperatures (T, imposed by placing plastic covers over the canopies) treatments in a field experiment.

3.5.1. Response of Genotypes to Varying Soil Moisture Supply

This experiment was similar to the one conducted last year at Breda (pages 156-158, FLIP Annual Report 1990), but with 12 different genotypes. Sowing was done on 28-11-1991 and a post-sowing irrigation was applied on 19-1-1991. Emergence occurred on 25-1-1991. A gradient of soil moisture IL was created on 6 dates by a line-source sprinkler irrigation method. The extremes of IL were 241 mm (rainfed) and 376 mm (most well-watered treatment).

Rainfall at Breda was 241 mm this year compared with 185 mm during 1989/90, but was lower by 12% compared with 274 mm, the long-term site mean. Effects of G, IL and G x IL were all significant in seed yield (SY) and total biological yield (TBY).

Response to irrigation, both in SY and TBY, were large and significant with every increasing level of moisture supply (Table 3.5.1).

Between the rainfed and the most well-watered treatments SY and TBY were both more than doubled. This signified a loss of more than 50% due to drought. Effects of irrigation on harvest index were small and non-significant (Table 3.5.1). In the 1988/89 season the SY (14-74 kg/ha) and harvest indices (0.05 to 0.14) were drastically reduced at the drier end of the line-source because of the severe drought conditions that prevailed (Table 3.5.1, FLIP Annual Report 1989/90).

Table 3.5.1. Effect of total seasonal moisture supply (rainfall and supplementary irirgation)on the mean seed yield (SY) and total biological yield (TBY) of 12 diverse lentil genotypes, Breda, 1990/91.

Total seasonal moisture (mm)	Seed yield (kg/ha)	Total biological yield (kg/ha)	Harvest index
241.3	699	2015	0.36
256.3	770	2241	0.35
286.3	994	2720	0.37
316.3	1259	3407	0.37
346.3	1534	4234	0.36
376.3	1745	4590	0.38
S.E. (±)	68.8	75.3	0.01
LSD (P<0.05)	197.3	208.6	0.04
CV (%)	20.8	16.3	24.4
F test	*	*	NS

* Significant at P = <0.05.

A linear response to irrigation was observed both in SY and TBY across the 12 lentil genotypes studied (Fig. 3.5.1). Linear regression estimates of intercepts and slopes for the 12 genotypes are given in Table 3.5.2. A high intercept is indicative of a good performance under drought conditions and a high slope of greater responsiveness to increased moisture supply. A close correlation between the intercepts and slopes both for SY and TBY (Fig. 3.5.2) for the few genotypes studied, suggests that it may be difficult to find lentil genotypes that would combine both best drought resistance (ILL 6437 and ILL 6442) and the largest response to irrigation (ILL 6773 and ILL 6790) (Table 3.5.2). Genotypes that would combine these traits (ILL 6451 and ILL 6207) would be average in performance in both the environments and not necessarily the top yielders in any of the two extreme environments.

3.5.2. Characterization of Genotypes

The 12 lentil genotypes studied for responsiveness to varying seasonal moisture supply and 15 others were planted on 15 Dec 1991 in a RBD with 4 replications. Emergence was not uniform and therefore a post-sowing irrigation was applied on 13 Jan 1991. Dates of emergence ranged from 17 to 27 Jan 1991. Genotypes were characterized for morphological, growth, and yield attributes (Tables 3.5.3 and 3.5.4). These attributes were then correlated with SY, TBY, and HI (Table 3.5.5).

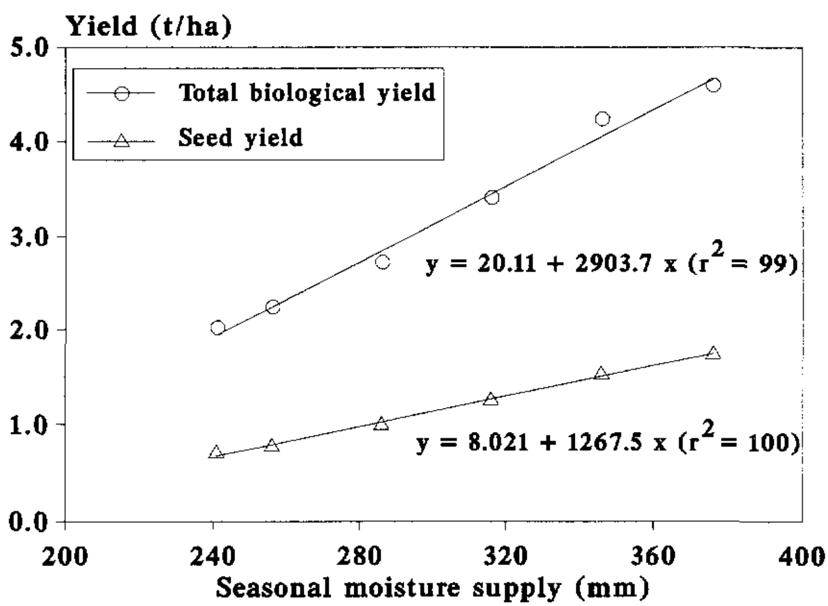


Figure 3.5.1. Relationship between seasonal moisture supply and response in SY and TBY (mean of 12 genotypes) Breda, 1990/91.

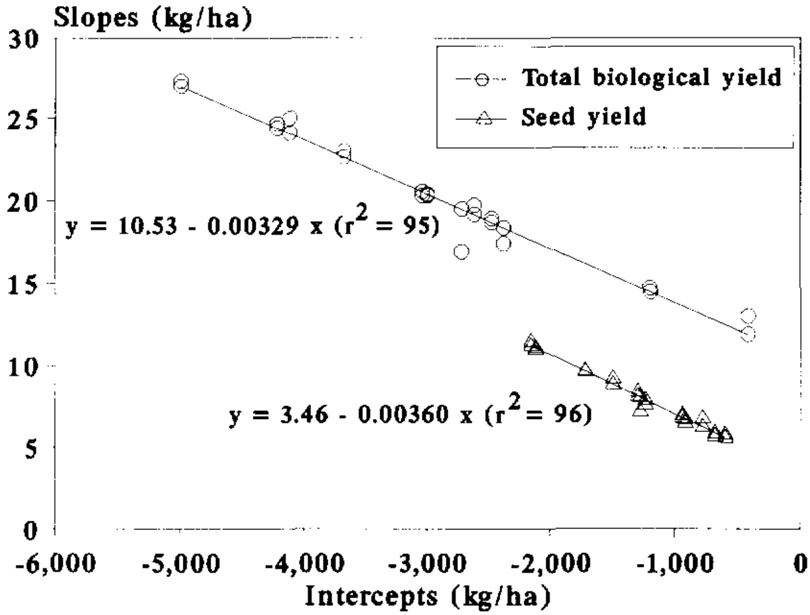


Figure 3.5.2. Relationship of the slope and intercept of the regression between seasonal moisture supply and seed and total biological yields of different lentil genotypes.

Table 3.5.2. Linear regression estimates of intercepts, slopes, SEM (±), and R^2 (adjusted for d.f.) of total seasonal soil moisutre supply (mm) with seed and total biological yield of 12 lentil genotypes, Breda, 1990/91.

	Seed yield (kg/ha)					Total biological yield				
	Intercept		Slope			Intercept		Slope		
Genotype	Estimate	SE (±)	Estimate	SE (±)	R^2	Estimate	SE (±)	Estimate	SE (±)	R^2
ILL 6192	- 775	304.1	6.8	0.99	0.90	- 451	1399.6	13.1	4.55	0.59
6206	-1309	459.4	8.4	1.49	0.86	-3002	617.3	20.3	2.0	0.95
6207	-1245	221.3	7.6	0.72	0.96	-2374	604.3	17.4	1.96	0.94
6247	-1498	56.6	9.2	0.18	0.998	-4114	526.7	25.0	1.71	0.98
6434	-1722	198.7	9.7	0.65	0.98	-3685	594.6	23.0	1.93	0.97
6435	- 919	275.4	6.5	0.90	0.91	-2623	519.6	19.7	1.69	0.96
6437	- 674	348.1	5.7	1.13	0.83	-1207	1033.5	14.7	3.36	0.78
6442	- 591	407.4	5.8	1.32	0.78	-2476	457.1	18.9	1.49	0.97
6451	-1275	258.3	7.2	0.84	0.93	-2729	703.9	16.9	2.29	0.91
6473	-2128	368.8	11.0	1.20	0.94	-4215	875.4	24.7	2.85	0.94
6484	- 948	386.3	7.0	1.26	0.86	-3034	447.2	20.3	1.45	0.97
6490	-2157	169.1	11.5	0.55	0.99	-4994	516.4	27.3	1.68	0.98

Table 3.5.3. Genotypic differences in growth vigor on 13 March (VIG 13.3) and 21 April (VIG AND 21.4), % ground cover on these dates (GC 13.3 and 21.4) and seeds per pod (NSPO) in 26 genotypes of lentil, Tel Hadya, 1990/91.

Genotype	VIG13.3	VIG21.4	GC13.3	GC21.4	NSPO
ILL 6192	2.25	2.00	48.75	78.75	1.17
ILL 6206	2.38	2.13	50.00	78.75	1.18
ILL 6207	2.88	2.50	35.00	67.50	1.02
ILL 6247	2.25	2.00	50.00	80.00	1.12
ILL 6434	3.38	3.13	31.25	66.25	1.46
ILL 6435	2.38	1.50	45.00	76.25	1.09
ILL 6437	2.25	2.08	47.50	81.25	1.02
ILL 6442	2.75	2.63	40.00	71.25	1.07
ILL 6448	2.50	2.45	42.50	75.00	1.23
ILL 6451	2.75	2.50	36.25	73.75	1.23
ILL 6456	3.63	3.30	28.75	63.75	1.19
ILL 6458	2.63	2.25	32.50	71.25	1.19
ILL 6773	3.00	2.75	37.50	70.00	1.18
ILL 6778	2.63	2.38	33.75	71.25	1.44
ILL 6783	2.48	2.08	40.00	77.50	1.24
ILL 6784	3.25	3.13	31.25	63.75	1.20
ILL 6790	2.83	2.53	38.75	70.00	1.14
ILL 6810	2.38	2.08	42.50	77.50	1.41
ILL 6811	2.88	2.50	33.75	71.25	1.33
ILL 5782	3.00	2.50	46.25	78.75	1.23
ILL 5604	2.63	2.13	37.50	75.00	1.33
ILL 4605	2.45	2.20	40.00	77.50	1.30
ILL 5582	2.70	2.23	36.25	77.50	1.24
ILL 4349	2.38	2.00	45.00	80.00	1.04
ILL 4400	3.25	2.88	35.00	71.25	1.13
ILL 4401	3.35	2.95	32.50	65.00	1.43
Grand mean	2.64	2.32	37.69	70.74	1.17
S.E. of mean	0.13	0.15	1.70	1.69	0.08
LSD at 5%	0.36	0.43	4.79	4.76	0.23
C.V. (%)	9.61	13.08	9.03	4.78	13.87
F value	26.34	16.79	32.61	79.45	10.66
Significance	***	***	***	***	***

Table 3.5.4. Clustering of genotypes using Scott-Knot method for growth vigor, ground cover, and seeds/pod in 26 lentil genotypes, Tel Hadya, 1990/91.

Clusters for the variable, Vigor 52 DAE

Group 1:
ILL 6456, 6434, 4401, 4400, 6784

Group 2:
ILL 6773, 5782, 6207, 6811

Group 3:
ILL 6790, 6451, 6442, 5582, 6458, 5604, 6778

Group 4:
ILL 6448, 6783, 4605, 6435, 6810, 4349, 6206, 6437, 6192, 6247

Group 5:
ILL 6432

Clusters for the variable, Vigor 91 DAE

Group 1:
ILL 6456, 6434, 6784, 4401, 4400

Group 2:
ILL 6773, 6442, 6790, ILL 6207, 6451, 5782, 6811, 6448

Group 3:
ILL 6778, 6458, 5582, 4605, 5604, 6206, 6437, 6783, 6810, 4349, 6192, 6247, 6435

Group 4:
ILL 6432

Clusters for the variable, % ground cover 52 DAE

Group 1:
ILL 6247, 6206, 6192, 6437

Group 2:
ILL 5782, 4349, 6435, 6810, 6448

Group 3:
ILL 6442, 6783, 4605, 6790, 5604, 6773, 6451, 5582

Group 4:
ILL 6207, 4400, 6811, 6778, 4401, 6458, 6434, 6784, 6456

Group 5:
ILL 6432

Clusters for the variable, % ground cover 91 DAE

Group 1:
ILL 6437, 4349, 6247, 6206, 6192, 5782, 6783, 6810, 5582, 4605, 6435, 5604, 6448, 6451

Group 2:
ILL 6442, 6458, 6811, 4400, 6778, 6773, 6790

Group 3:
ILL 6207, 6434, 4401, 6784, 6456

Group 4:
ILL 6432

Clusters for the variable, number of seeds/pod

Group 1:
ILL 6434, 6778, 4401, 6810, 5604, 6811, 4605

Group 2:
ILL 5582, 6783, 6448, 6451, 5782, 6784, 6456, 6458, 6773, 6206, 6192, 6790, 4400, 6247, 6435, 6442, 4349, 6437, 6207

Group 3:
ILL 6432

Although correlation coefficients of various traits were highly significant with SY, none of the individual factors accounted for more than 40% variation in SY, TBY, and HI. The highest correlations were with percent ground cover at 19 DAE and seeds/pod (Table 3.5.5). Genotypic differences for % ground cover ranged from 63 to 80%, and for seeds/pod from 1.0 to 1.5 (Table 3.5.3). Vigor explained a relatively smaller proportion of variation compared with the above two traits. Further characterization of genotypes with more number of seeds/pod, for differences in early vigor and ground cover, are likely to be useful.

3.5.3. Genotypic Characterization for Root Traits

Lentil genotypes were characterized for root and shoot traits under non-limiting conditions of soil moisture. Thirteen genotypes were grown in long plastic bags of 1-m length filled with the Calcic Rhodoxeralf

Table 3.5.5. Coefficient of correlation of various growth traits and yield components of rainfed lentil at Tel Hadya, 1990/91 (based on 26 genotypes and 4 replications, n=108).

Character (mean value)	SY	TBY	HI
Vigour[1] on 52 DAE[2] (2.6)	0.4690	0.4735	0.5094
Vigour[1] on 91 DAE (2.3)	0.3795	0.3949	0.4367
% ground cover on 52 DAE (37.9)	0.4812	0.5506	0.4537
% ground cover on 91 DAE (70.7)	0.5891	0.6490	0.5824
Primary branch number (1.8)	0.2081	0.4464	0.1784
Shoot weight g/pl 52 DAE (0.08)	0.1251	0.4979	0.0428
69 DAE (0.31)	0.2034	0.4224	0.1414
91 DAE (1.22)	0.3514	0.5437	0.2842
Seed number/pod (1.17)	0.5819	0.4580	0.6514
100 seed weight g (3.56)	0.2438	0.5017	0.2005
SY (983 kg/ha)	1.0	0.6277	1.0
TBY (3069 kg/ha)	0.6277	1.0	0.8301
HI (0.31)	0.8301	0.2433	0.2433

[1] = rated on a 1-5 scale; 1 = least vigorous, 5 = most vigorous.
[2] DAE = days after emergence (mean date of emergence 20 Jan).

topsoil collected from the field. The treatments were replicated 4 times. Periodic samples were taken, beginning from 10 days after emergence (DAE) until the flowering time. Measurements were made at each sampling time for root length, root volume, root weight, shoot length, and shoot weight. Root/shoot ratios were computed for each of the sampling stage.

Genotypic differences in all the root and shoot traits except for the root/shoot ratios were significant at most of the growth stages. Roots of ILL 5582, -5604, and -6004 were longer than those of the other genotypes (Table 3.5.6). The root and shoot lengths were closely correlated (r values ranging form 0.6 to 0.7, n=39). We plan to study the genotypes with longer root length for water extraction pattern and relative drought tolerance in future studies.

Table 3.5.6. Root length per plant (cm).

Genotypes	Date of Observation 11/3	18/3	25/3	1/4	8/4	14/4	22/4
ILL-6004	24.53	28.83	29.13	34.33	45.27	48.03	56.37
ILL-5582	27.17	21.80	31.17	29.33	41.67	44.20	62.67
ILL-5782	20.90	22.97	30.17	32.43	37.50	39.43	47.93
ILL-2126	22.27	28.00	29.80	35.40	32.03	47.63	51.37
ILL-5604	22.97	24.03	33.10	38.30	36.37	53.77	58.67
ILL-4401	22.37	30.67	26.20	26.00	37.77	39.97	50.83
ILL-4349	18.67	27.00	27.77	35.63	32.30	41.83	40.73
ILL-4400	22.23	26.97	28.63	36.90	39.13	30.50	50.57
ILWL-7	5.27	17.22	19.50	27.80	28.27	28.53	41.33
ILWL-11	9.83	16.07	18.13	28.27	23.50	31.10	42.73
ILWL-175	9.88	15.57	20.70	16.67	22.27	29.23	32.60
ILWL-180	17.40	24.90	23.97	24.07	31.97	41.33	31.10
ILWL-181	7.17	14.23	24.13	28.77	36.13	33.80	37.40
Grand mean	17.74	22.94	26.34	30.30	34.17	39.18	46.48
S.E. of mean	2.04	2.84	2.51	5.22	3.54	4.58	6.34
LSD at 5%	5.94	8.28	7.32	15.23	10.34	13.36	18.51
C.V.	19.88	21.42	16.50	29.82	17.96	20.23	23.64
F value	12.60	3.82	3.54	1.35	3.59	3.11	2.39
Significance	***	**	**	NS	**	**	*

3.5.4. Genotypic Differences in Heat Tolerance and Interaction with Irrigation

This experiment was conducted at Tel Hadya in a split-plot design with three factors: irrigation levels (IL, rainfed and supplementary irrigated), genotypes (G, four), and heat stress (T, two levels) in three replications. Planting was done on 10 Dec 1990 and emergence occurred on 17 Jan 1991. A uniform (30 mm) post-sowing irrigation was applied on 2/1/1991 to ensure proper plant stand establishment. The irrigated treatment received 250 mm irrigation water + 290 mm rainfall.

A large reduction in seed yield due to heat stress was observed (Table 3.5.7). Yield loss due to heat stress was similar in magnitude to the yield loss due to drought. Genotypic differences in SY response to heat stress were significant. ILL 4400 was the most susceptible genotype and ILL 4401 the most tolerant.

Effect of heat stress on TBY was equally large and significant but the effect on HI was not (Table 3.5.7). It was because the decrease in SY and TBY occurred in similar proportion in response to heat stress.

Table 3.5.7. Effect of heat stress and irrigation in four lentil genotypes on seed yield (SY), total biological yield (TBY) and harvest index (HI), Tel Hadya, 1990/91.

Parameter		Treatment: Control	Treatment: Heat stress	SEM (±)
SY		1405	614	45.7
TBY		5596	2680	67.5
HI		0.23	0.24	NS
		Irrigated	Rainfed	
SY		1298	721	35.2
TBY		4162	4114	NS
HI		0.30	0.18	0.006
SY	Control (C)	1964	847	57.7[a]
	H. stress (H)	631	595	49.8[b]
TBY	Control (C)	5938	5253	167.1[a]
	H. stress (H)	2386	2974	216.2[b]
HI	Control (C)	0.33	0.16	0.008[a]
	H. stress (H)	0.26	0.20	0.009[b]

		ILL 5582	ILL 4400	ILL 4401	ILL 5604	SEM (±)
SY	C	1813	1003	1422	1384	100.0[a]
	H	598	456	974	524	102.8[b]
	Mean	1205	729	1148	954	72.7
TBY	C	5880	5711	5661	5130	317.8[a]
	H	2617	2731	2870	2602	358.6[b]
	Mean	4249	4221	4265	3816	53.5
HI	C	0.31	0.17	0.25	0.26	0.013[a]
	H	0.23	0.18	0.31	0.21	0.015[b]
	Mean	0.27	0.17	0.28	0.23	0.010

a = for comparing means with different levels of heat stress treatment.

b = for comparing means with same level of heat stress treatment.

Response to moisture supply was masked in the heat stress treatment, otherwise it was large in the control treatment.

M.C. Saxena and N.P. Saxena

3.6. Lentil Entomology

The effect of damage by Sitona crinitus on lentil yield and nitrogen fixation was further studied and also related to different moisture supply levels. For storage insect pests methods of protection were studied in the field and the store.

3.6.1. Effect of S. crinitus on Lentil

This season experiments on Sitona damage and control were conducted at Tel Hadya, Jinderess and two on-farm locations, Alkamiye and Afrin. During the past seasons no response to Sitona control has been found at the drier locations, therefore these were no longer included. At Tel Hadya and Jinderess 2 dosages of Carbofuran (10 and 20 kg/ha 5% G) and 2 dosages of Promet (12 and 25 ml/kg seed) were tested. ^{15}N technique was used to quantify nitrogen fixation. At Tel Hadya with 293 mm rainfall the lower treatment level of Promet increased lentil seed and biological yield, the higher dosage only biological yield significantly, indicating that the lower dosage is effective (Fig. 3.6.1). Carbofuran treatments increased lentil yield, but not significantly. At Jinderess, with 418 mm rainfall, yields were comparatively low this season. Carbofuran was found more effective than Promet treatments, increasing seed and biological yield significantly at both treatment levels.

At Jinderess plant samples were taken once in April and shortly before harvest and analysed for nitrogen content, which did not show significant differences due to treatments, although the nodule damage was 78.9% and significantly reduced by all insecticide treatments (Table 3.6.1). The nitrogen yields, however, were significantly higher with Carbofuran and Promet treatments.

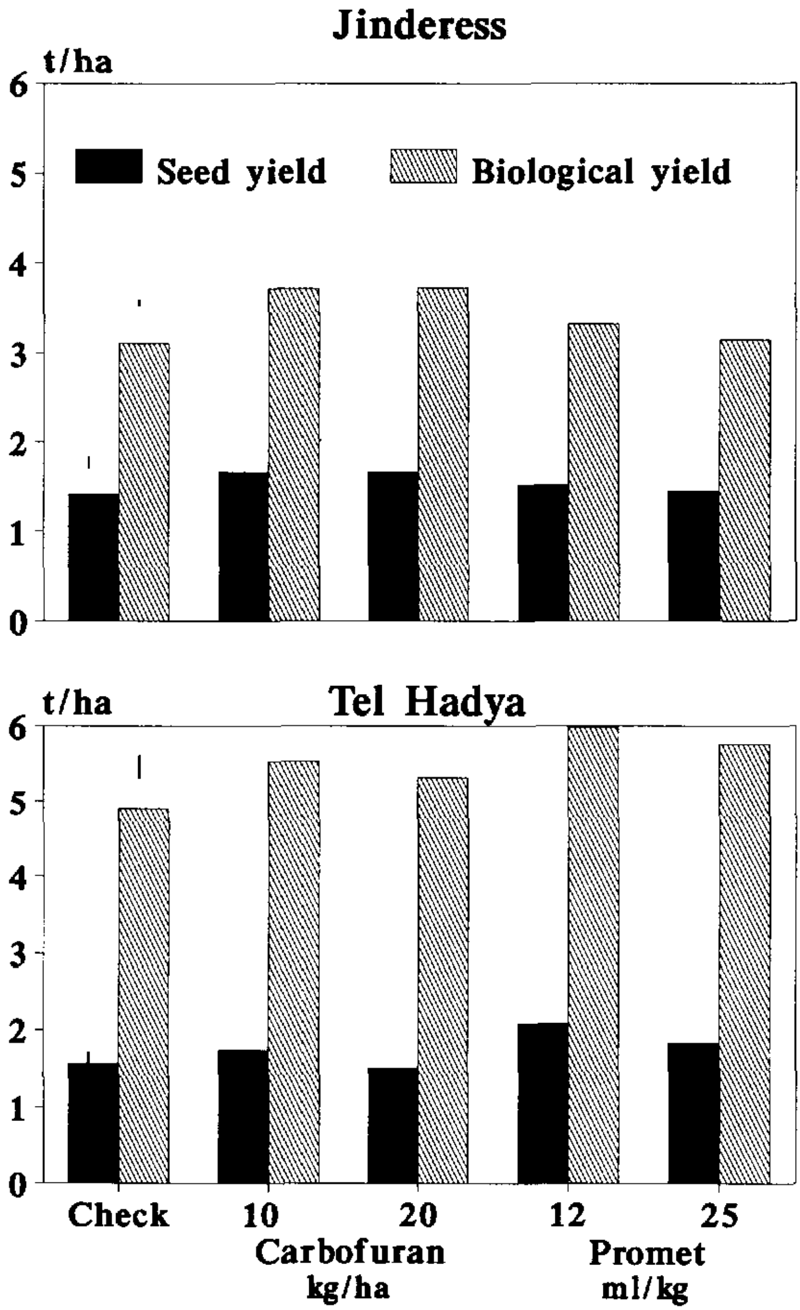


Figure 3.6.1. Effect of application of Carbofuran and Promet on lentil seed and biological yield at Jinderess and Tel Hadya, 1990/91.

Table 3.6.1. Effect of Carbofuran (10 kg/ha 5% G, C 10) and Promet (12 ml/kg seed, P 12) treatment on lentil percent nitrogen content, seed yields, total biological yields, and nitrogen yield and nodule damage by Sitona at 3 locations in Syria, 1990/91.

Location	Treatment	%N 25/4	%N 8/5	Lentil yield (kg/ha) Seed	Lentil yield (kg/ha) Total	N yield (kg/ha)	% nodule damage 23/4
Jinderess	Check	2.78	2.42	1410	3110	74.7	78.9
	C 10	2.62	2.38	1662	3717	88.4	1.9
	P 12	2.83	2.45	1518	3326	81.6	0.3
	S.E.M.			58.9	133.9	1.7	2.0
	LSD 5%			NS	412.5	5.9	6.3
Afrin	Check	3.16	2.45	1070	3339	81.6	76.2
	C 10	3.55	2.45	1397	4658	114.0	25.5
	P 12	3.41	2.43	1426	4401	107.0	9.9
	S.E.M.			43.2	218.8	4.2	4.4
	LSD 5%			149.4	757.2	14.4	15.3
Alkamiye	Check	2.38	2.35	532	1694	40.0	66.5
	C 10	2.82	2.38	729	2392	57.3	10.7
	P 12	2.85	2.55	685	2132	54.4	6.2
	S.E.M.			96.2	197.1	6.1	4.1
	LSD 5%			NS	681.9	NS	14.4

At the two on-farm sites only the lower dosages of Carbofuran and Promet were tested. The soil at Alkamiye had a pH of 7.8, Olsen P about 9.5 ppm and total nitrogen content of about 900 ppm. At Afrin the respective values were pH 8.0, Olsen P > 7 ppm, total nitrogen content about 800 ppm. The nitrogen analysis of plant samples taken in April showed higher nitrogen content in Carbofuran and Promet treatments at both locations (Table 3.6.1). Especially at Alkamiye very clear differences between the untreated and treated plots were visible with the untreated plots and borders showing typical nitrogen deficiency symptoms. At the time of harvest the plant nitrogen contents in general were lower than at earlier stage of growth. Only at Alkamiye a small difference between treatments was found. At Afrin lentil seed yields and biological yields as well as nitrogen yields were significantly increased and nodule damage significantly decreased by both Carbofuran and Promet treatment. At Alkamiye yields in general were low. Carbofuran and Promet increased seed, biological and nitrogen yield but differences were not significant except due to Carbofuran in total biological yields.

The feeding damage of the Sitona adults was assessed twice (end of January and February) using the visual damage score (VDS 1-9). Promet effectively suppressed feeding at all locations, whereas in the Carbofuran treatment some feeding occurred, especially at Afrin (Fig. 3.6.2). At Tel Hadya feeding was very low this season.

Oviposition of S. crinitus was monitored by counting the number of eggs extracted from 100 cc soil samples taken at 2-week intervals. Compared with last season oviposition started later and was lower. At

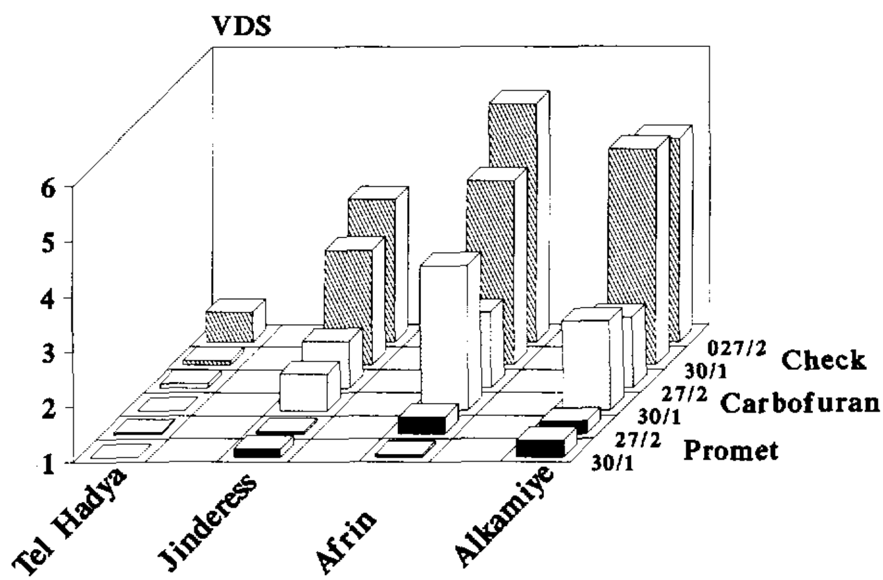


Figure 3.6.2. Effect of Carbofuran (10 kg/ha 5% G) and Promet (12 ml/kg seed) treatment on Sitona feeding damage in lentil measured by visual damage score on 2 dates at 4 locations in northern Syria, 1990/91.

Tel Hadya and Alkamiye oviposition only began in late and mid-January, whereas at Jinderess and Afrin eggs were already laid in the beginning of January (Fig. 3.6.3). This can be related to the lower rainfall during December/January at Tel Hadya and Alkamiye. Since the eggs need high soil moisture for development it can be suspected that soil moisture is one factor inducing oviposition to ensure normal egg development. Promet treatment greatly reduced the number of eggs at all locations. Carbofuran was not as effective, particularly at Afrin, where numbers were even higher than in the check.

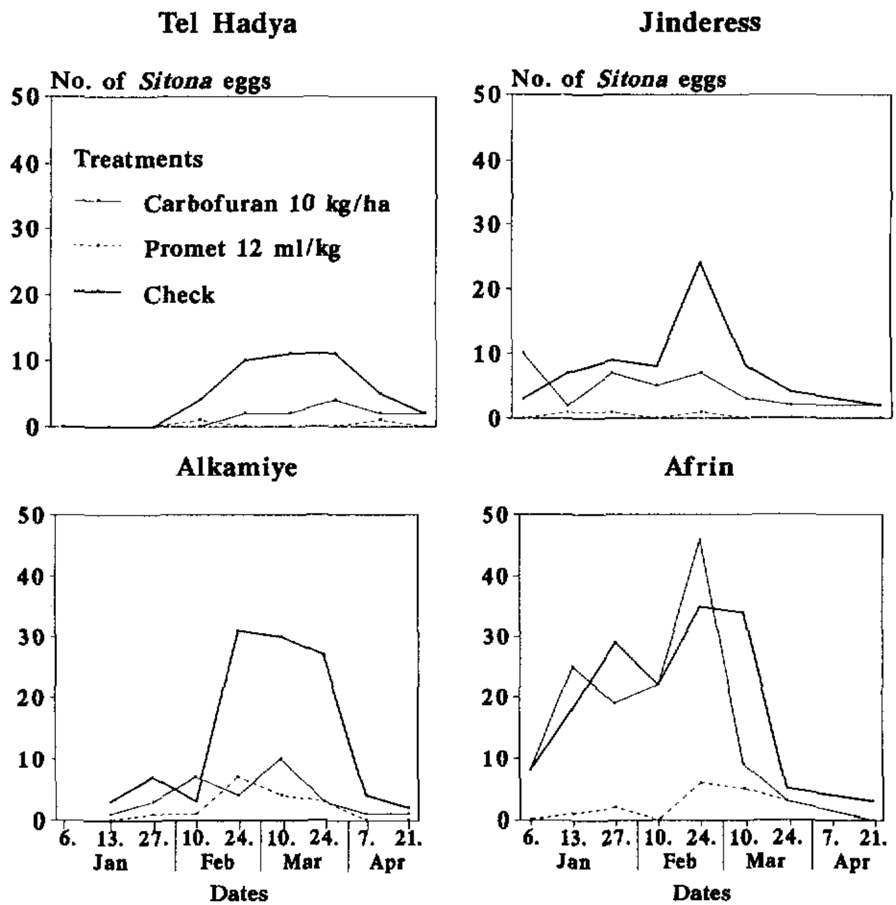


Figure 3.6.3. Mean number of Sitona crinitus eggs extracted from 100-cc soil samples with and without Carbofuran or Promet treatment at 4 locations, Syria, 1990/91.

The mean nodule damage at 4 sampling dates over a 6-week period is presented in Fig. 3.6.4. At Tel Hadya and Alkamiye virtually no nodule damage was present at the first sampling date in mid March, whereas at Jinderess and Afrin already about 40 % damage was noted. At all locations the highest nodule damage was recorded in mid-April which was almost 1 month later than last season. Promet and Carbofuran significantly reduced nodule damage at all dates and locations.

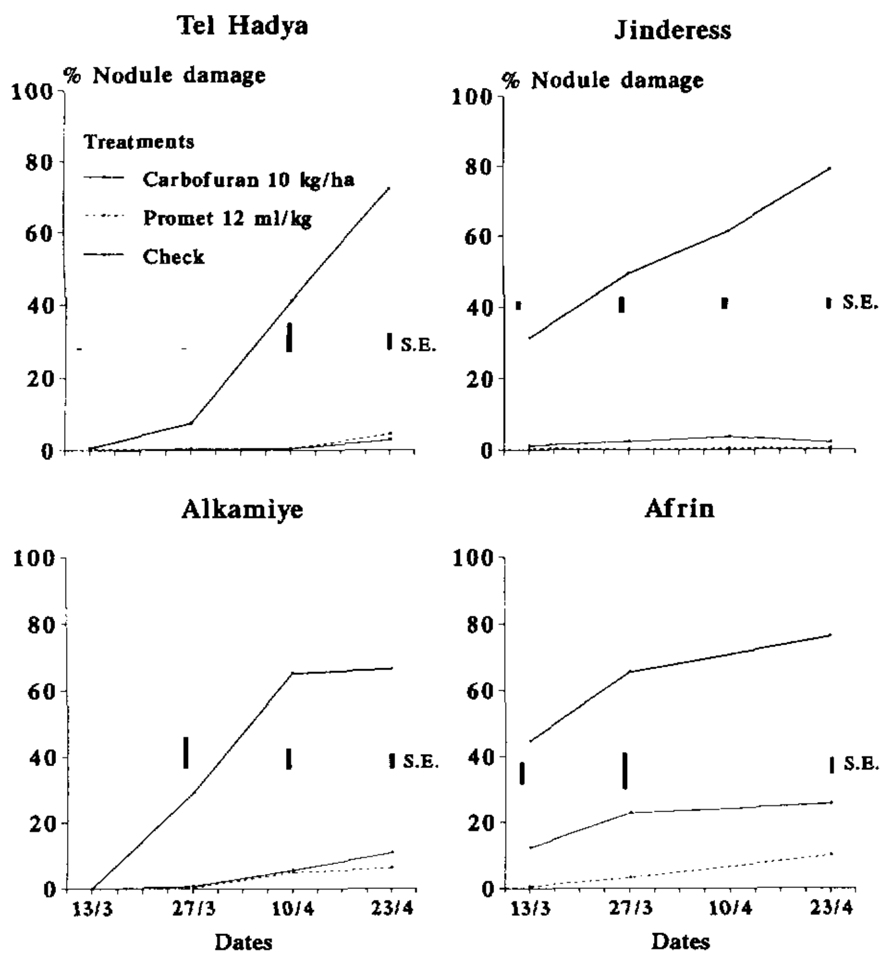


Figure 3.6.4. Effect of Carbofuran and Promet application on <u>Sitona</u> damage to nodules in lentil at 4 locations, Syria, 1990/91.

As in the previous year regression studies confirmed that low feeding damage is associated with lower oviposition which in turn results in lower nodule damage. The number of eggs laid/100 cc soil (y_1) at the peak in the end of February was related to the visual damage score in the end of January (x_1) in a quadratic fashion described by the equation $y_1=12.82x_1-0.643838x_1^2-9.81$ with a multiple correlation coefficient of 0.73 ($P<0.01$) (Fig. 3.6.5). The percentage of damaged nodules (y_2) in mid-April was related to the number of eggs (x_2) at the peak in late February, again in a quadratic pattern described by the equation $y_2=5.281884x_2-0.092166x_2^2-12.14$ with a multiple correlation of 0.87 ($P<0.01$). The direct relationship between visual damage score (x_1) and nodule damage (y_2) was weaker but exponential and could be described by the equation $y_2=5.30-0.81934x_1+3.085118x_1^2$ with a multiple correlation coefficient of 0.64 ($P<0.01$). The curves tended to be very similar last season.

S. Weigand

3.6.2. Effect of Sitona Control at Various Levels of Moisture Supply

Past studies have shown that the nodule damage in lentil by Sitona varies with the seasonal rainfall and therefore the efficacy of insecticide treatments also varies. To quantify these relationships an experiment was conducted at Breda evaluating the efficacy of Sitona control with Carbofuran and Promet at various levels of moisture supply using the line source sprinkler system. The moisture levels evaluated were 122, 107, 57 and 0 mm supplemental irrigation in addition to 244 mm rainfall. The ^{15}N technique was used to quantify nitrogen fixation. Plant samples were taken in April and May for nitrogen analysis.

In general differences in seed and biological yield between Sitona control treatments at the same moisture level were not large (Table 3.6.2). At the highest moisture level yields were highest in the untreated check, but at the lower moisture levels both Carbofuran and Promet treatments resulted in small, but nonsignificant increases of seed and biological yield. The nodule damage was significantly reduced by both treatments at all moisture levels. The plant nitrogen content showed differences due to treatments at both sampling dates. In May the

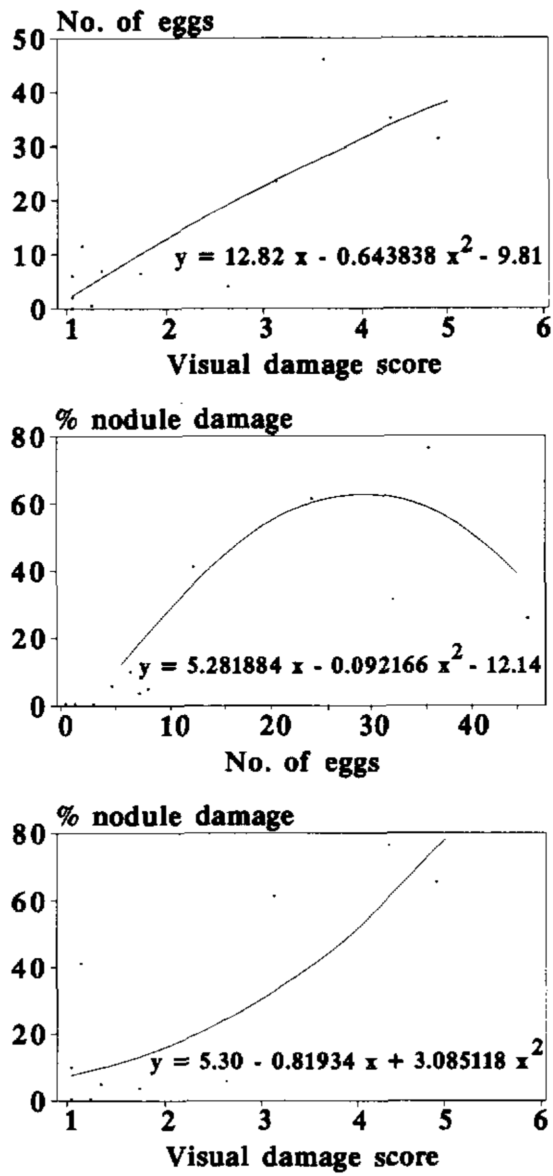


Figure 3.6.5. Relationship between Sitona visual damage score and number of eggs per 100 cc soil sample, number of eggs and percent nodule damage, visual damage score and percent nodule damage in lentil based on observations at 4 locations in 1990/91.

Table 3.6.2. Effect of 4 moisture supply levels, Carbofuran (10 kg/ha 5% G, C 10) and Promet (12 ml/kg seed, P 12) treatment on lentil percent N content, seed, total and nitrogen yield and nodule damage by Sitona at Breda, 1990/91.

Moisture level*	Treatment	%N 25/4	%N 8/5	Lentil yield (kg/ha) Seed	Lentil yield (kg/ha) Total	N yield (kg/ha)	% nodule (damage) 25/4
366 mm	Check	3.07	2.38	1703	3759	89.4	65.9
366 mm	C 10	3.15	2.46	1471	3280	80.1	9.4
366 mm	P 12	3.17	2.40	1556	3343	80.0	3.4
	S.E.M.		0.06	94.7	249.9	5.6	4.2
	LSD 5%		0.06	NS	NS	NS	14.7
351 mm	Check	3.10	2.38	1381	3083	73.3	70.4
351 mm	C 10	3.33	2.38	1485	3216	77.0	3.6
351 mm	P 12	3.25	2.62	1492	3234	84.8	2.9
	S.E.M.		0.05	133.3	284.8	7.8	4.1
	LSD 5%		0.05	NS	NS	NS	14.2
301 mm	Check	3.10	2.39	1074	2376	56.6	56.2
301 mm	C 10	2.94	2.53	1161	2668	67.6	2.8
301 mm	P 12	3.10	2.53	1197	2763	69.6	2.1
	S.E.M.		0.09	77.0	160.8	4.8	4.3
	LSD 5%		0.09	NS	NS	NS	15.0
244 mm	Check	2.94	2.76	496	1391	38.2	71.4
244 mm	C 10	3.17	2.69	611	1696	45.5	0.8
244 mm	P 12	3.04	2.78	505	1470	41.1	1.4
	S.E.M.		0.10	86.1	191.9	6.0	2.9
	LSD 5%		NS	NS	NS	NS	10.0
STD between 2 moisture level means for the same or different levels of Sitona control				189.3	341.4		5.7
LSD (5%)				381.4	692.9		12.2

* Moisture levels were 244 mm rainfall plus 122, 107, 57 and 0 mm irrigation.

percent nitrogen was significantly higher in plants with Carbofuran or Promet treatment except for the lowest moisture level. Carbofuran and Promet increased the nitrogen yield over untreated control at moisture levels of 351, 301 and 244 mm, but differences were not significant. Although differences between moisture treatments were not great this season, which was partly owing to late rainfall decreasing the differences between moisture supply levels, some tendency could be seen that at the highest as well as the lowest moisture supply level Sitona control only has little effect on lentil yield.

S. Weigand and M.C. Saxena

3.6.3. Storage Insect Pests

3.6.3.1. Control of Bruchus ervi

Different insecticides were tested in a farmer's field (Termanin, western Aleppo) for their effectiveness to control Bruchus ervi, the important storage pest of lentil infesting the developing seeds in the field. Two applications of Metyphon EC 50 (1 ml/L), Fastac (0.25 ml/L) and Dimethoate (1 ml/L) at early podsetting and 2 weeks later were used. Samples were harvested of each plot of which 25 g seeds were evaluated for infestation from August to November. In August, 3 months after harvest, only in a few seeds could infestation be detected, but numbers increased as the adults completed development (Fig. 3.6.6).

The final infestation of 20 to 26% was quite this season. None of the treatments reduced the infestation. Possibly the effectiveness was reduced by rainfall occurring after the insecticide applications. More effective control methods need to be developed as B. ervi is an important direct pest and 20% seed infestation results in seed losses of the same order.

S. Weigand, M.El-Ahmed (ARC Syria)

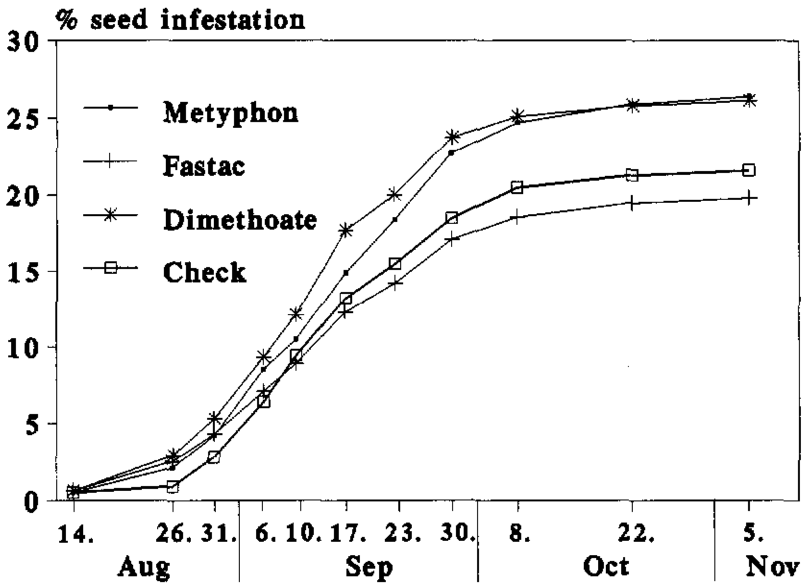


Figure 3.6.6. Effect of two applications of different insecticides in lentil at farmers field on the percent seed infestation by Bruchus ervi recorded 3 to 5 months after harvest, 1990/91.

3.6.3.2. Protection of lentil seeds in storage

The multivoltine species Callosobruchus chinensis also causes considerable losses in lentil. The traditional methods of seed protection found to be most effective last season were combinations of olive oil (5 ml/kg seed), salt (20 g/kg) and water (10 ml/kg seed). These were retested in comparison with the 2 insecticides Actellic (0.5 g/kg seed) and K-othrin (0.5 g/kg seed).

In addition Neem seed oil (3 ml + 10 ml water/kg seed) was included in the experiment. All seeds were treated with the respective substances on 14 December 1990. After 3 weeks, 4 and 6 months (7 January, 2 April, 7 June) 300 lentil seeds were infested with 4 female and 4 male C. chinensis and the number of progeny per female and percent infestation counted after 1 month. The insecticides provided most effective control with Actellic giving complete and K-othrin high level of protection even after 6 months (Fig. 3.6.7). Except for the salt + water all other

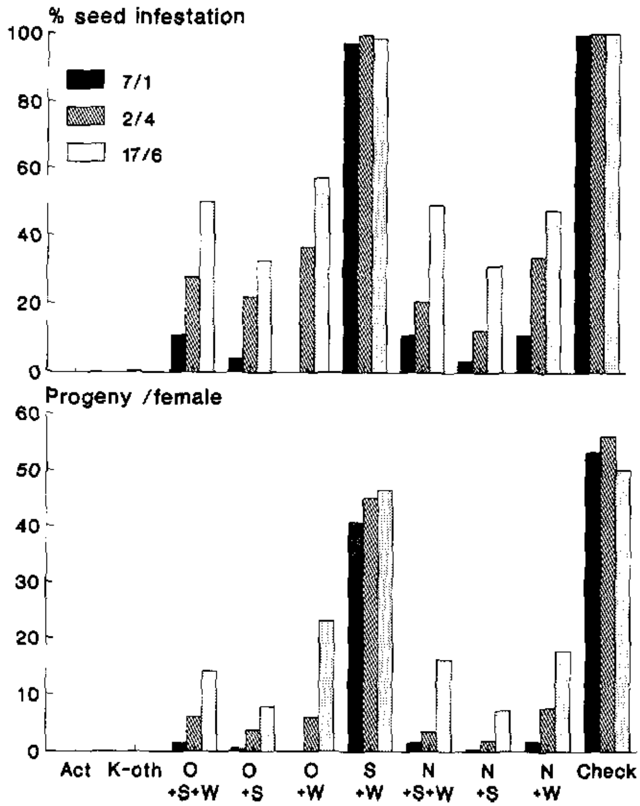


Figure 3.6.7. Effect of two insecticides and alternative treatments on the percent seed infestation and number of progeny per female of Callosobruchus chinensis in stored lentil.

treatments were effective for 3 weeks giving 1 to 2 progeny per female and a low seed infestation. The effectiveness of the Neem seed oil then decreased and 45 and 79 % infestation was found after 4 and 6 months, respectively.

In the olive oil treatments infestations were significantly lower than in the check even after 4 and 6 months. The treatment of olive oil + salt was the most effective, confirming previous results. Thus it could be used by farmers to effectively protect lentil stored for human consumption for a period of 4 to 6 months.

S. Weigand

4. FABA BEAN IMPROVEMENT

Faba bean is predominantly grown in wheat-based farming systems in the WANA region, mainly in medium-rainfall environments (above 450 mm). For this reason, Douyet Research Station near Fes, Morocco, was chosen as the site for the transfer of faba bean improvement research from ICARDA to INRA, Morocco. The goal of faba bean improvement research has been to make the crop more competitive with other crops, thereby halting the decline in faba bean area over the past 20 years. With faba bean as a more appealing alternative to continuous cereals, a more sustainable farming system could be developed in the medium-rainfall areas of WANA.

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

4.1. Transfer of Faba Bean Improvement Research to North Africa

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

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

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

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

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

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

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

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

(g) Two two-week faba bean improvement courses (breeding/ pathology) were conducted in collaboration with INRA and ENA-Meknes. These courses hosted 14 participants from six different countries in 1990 and 20 participants from seven countries in 1991.

While all efforts have been made to transfer ICARDA's faba bean research to INRA, Morocco, to accomplish this transfer by December 1991 in a way that will ensure continuity of research is not possible. The INRA faba bean breeder and agronomist were only in place in February 1990 and the pathologist in September 1991. Since those personnel had little previous faba bean experience, the minimum on-the-job training needed would be three to four years. Furthermore, INRA, Morocco, quite correctly, desires to send these staff abroad for Ph.D. training to have a well-trained faba bean improvement program.

For the above reasons, major efforts were made in developing a bilateral grant proposal to support a faba bean project in Morocco. This proposal has made provision to provide necessary facilities for the INRA faba bean program and an operating budget. Also, there is provision for a scientist to be recruited internationally to back up the INRA faba bean team in this transition period. German Ministry for Cooperation (BMZ) has been approached also to provide funds for running a 'North African Faba Bean Research Network' so that the faba bean improvement work in the region continues to make progress and use the material generated by ICARDA in the past after ICARDA core funding stops.

4.2. Faba Bean Breeding

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

4.2.1. The Season in Morocco

In general, the weather conditions at Douyet in 1989/90 were favorable for faba bean growth (Fig. 4.2.1). A total of 493 mm of rainfall was received during the season. During February through April 30% of the total rainfall was received, and October through December received 45% of the total.

4.2.2. Use of Enhanced Germplasm by National Programs

Iran released 'Barakat' for green pod production in 1987 because of higher green pod and dry seed yield, and because of partial resistance to

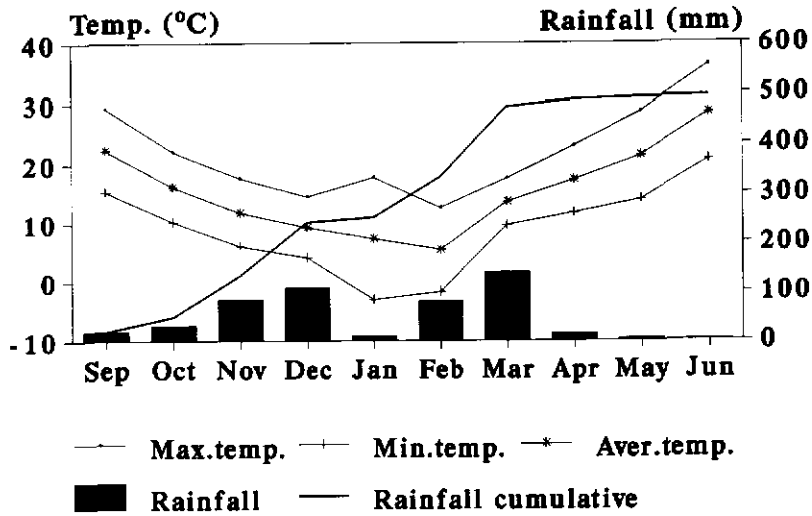


Figure 4.2.1. Mean monthly maximum, minimum and averge temperature, monthly total rainfall and cumulative rainfall during 1990/91 at Douyet Station, Morocco.

chocolate spot and Ascochyta blight. Line 80S43977 has been released as 'Favel' in Portugal in 1989 because of high yield and large seed size. In Syria Hama 15, a selection from ILB 1270 was released in 1991. In Ethiopia a cross bulk has been purified and is now in pre-release multiplication. In Egypt Giza 461 and Reina Blanca have been released because of superior resistance to foliar diseases. In Sudan Shambat 75 and Shambat 104 have been released for the nontraditional faba bean-growing areas and Selaim Medium Large (DLM) for the traditional areas.

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

Table 4.2.1. Use of ICARDA lines by National Programs.

Country	Line	Use
Algeria	14 lines	Multilocation testing
Chile	ILB 1814	Pre-release multiplication
China	Flip 86-146FB[1]	On-farm trials 3 lines Large scale increase, 1 ha each
Egypt	ILB 1270	Released as Reina Blanca
Egypt	Giza 461	Botrytis-resistant variety developed using ILB 938
Ethiopia	74TA12050x74TA236	Pre-release multiplication
Iran	ILB 1269	Released as 'Barakat'
Iraq	ILB 1814	Pre-release multiplication
Portugal	80S43977	Released as 'Favel'
Syria	Hama 15	Released (Sel. of ILB 1270)
	80S44027	On-farm trials
	Flip 84-239FB[1]	
Tunisia	80S80028, S82003-3, S82113-8	Pre-release multiplication
	ILB 1270	Large-scale increase

[1] Determinate line.

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

Resistance to pests constitutes the bulk of specific requests of national programs, namely, resistance to Orobanche, chocolate spot, stem nematodes, Ascochyta blight, and rust. Egypt has used ILB 938, a disease resistance source to develop Giza 461 which has been released with resistance to chocolate spot and rust (Table 4.2.2).

Crosses have also been made between large-seeded types such as Aquadulce and New Mammoth with local landraces at the request of national programs, and F_2/F_3 populations were provided (Table 4.2.2). In 1988, F_3

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

Year	Country	No. of lines or crosses	Type of material
1989	Algeria	339	Disease-resistant lines for yield testing in screening nursery
1989	Algeria	96	Determinate lines in screenig nursery
1987	Egypt	1250	BPL's aphid screening
1982-88	Egypt	1	ILB 938 used for crosses to develop disease-resistant varieties
1988	Egypt	600	BPL's aphid screening
1988	Egypt	200	Early generation lines for screening
1988	Egypt	19	F2 populations-IVS
1989	Egypt	600	BPL's aphid screening
1980-89	Ethiopia	1	Cross bulk purified for variety release
1984-89	Ethiopia	27	Lines in advance and national yield trials
1984-89	Ethiopia	532	Early generation lines in screening nurseries
1988	China	617,33	F3 progenies; F3 Bulks Chinese Disease resistant; IVS, deter. populations and progenies
1987	Morocco	200	F2 population and F3 derived progenies
1988	Morocco	96	Crosses made for disease resistance, IVS, and determinate
1989	Morocco	339	Disease-resistant lines for yield testing in screening nurseries
1989	Morocco	96	Determinate lines in screening nursery F2 population IVS
1988	Sudan	19	F2 populations-IVS
1988	Sudan	10	F2 populations - earliness (Sudan, Chinese)
1988	Tunisia	190	Lines for disease screening nursery
1989	Tunisia	339	Disease-resistant lines for yield testing in nursery
1989	Tunisia	96	Determinate lines in screening nursery
1990	China	3	Crosses for large-seeded N87033, N87043, and N87035
		229	F3 progeny rows
1990	Egypt	600	BPL's for aphid resistance screening
1990	Tunisia	500	BPL' for <u>Orobanche</u> resistance screening
		500	BPL' for stem nematode resistance screening
1990	Morocco	500	BPL's for stem nematode resistance screening
1991	Libya	32	Crosses
1991	South America	24	Crosses

populations with the IVS (independent vascular supply) trait were supplied to China, Egypt, Sudan, and Morocco at their request. In 1990, crosses were made at Douyet and at Cordoba, Spain to combine Orobanche resistance with large seed and long pods of Aquadulce. Also, crosses were made at Douyet to combine Orobanche and chocolate spot resistance. Backcrosses to the Orobanche resistance sources were made in 1991. In 1991, 24 crosses were made for South America and 32 crosses were made for Libya.

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

L.D. Robertson

4.2.3. Germplasm

With the transfer of ICARDA core faba bean improvement research to INRA, Morocco and phasing out of all activities in Syria, the only research activity on faba bean at ICARDA will be with germplasm collection, evaluation and maintenance. However, the faba bean project is also concerned about germplasm evaluation. In 1990/91 the Moroccan germplasm collection (269 accessions) was evaluated for 37 descriptors of the IBPGR/ICARDA faba bean descriptor list. Distributions for seed yield, days to flowering, number of leaflets per leaf, plant height, height of lowest pod bearing node, pods per plant, pod length, seeds per pod and hundred seed weight are given in Figs. 4.2.2 to 4.2.10.

There were 55 accessions with yields of 5 t/ha or greater which will be evaluated further for their yield performance in breeding trials (Fig. 4.2.2). The mean flowering date was 95 days with most accessions flowering after 92 to 96 days (Fig. 4.2.3). There were 6 unifoliate lines (Fig. 4.2.4). Mean plant height was 105 cm with most accessions between 100 and 110 cm tall (Fig. 4.2.5). The height of the lowest pod-bearing node varied from 14 to 42 cm with an average of 25 cm and most accessions between 18 and 30 cm (Fig. 4.2.6). Pod per plant averaged 3.5 with most lines with 2 to 5 pods per plant (*Fig.* 4.2.7). Pod length averaged 9.5 cm with a range from 6 to 15 cm (Fig. 4.2.8). Seeds per pod averaged 3.1 with most accessions between 2.5 and 3.5 seeds/pod (Fig. 4.2.9). There were three peaks for 100- seed weight, one at 80 g, one at 130 g and one at 260 g (Fig. 4.2.10).

Correlations among seed yield, date of flowering, plant height, pods/plant, pod length, 100-seed weight, pods/node and seeds/pod are given in Table 4.2.3. The highest correlation with seed yield was with 100-seed weight (r = 0.50**). However, pods/plant and seeds per pods had strong negative correlations with seed yield (r = -0.48 and -0.40, respectively). This is because of compensatory relations of 100- seed weight (r = -0.48** and -0.50**) with pods/plant and seed/pods, respectively.

Z. Fatemi and L.D. Robertson

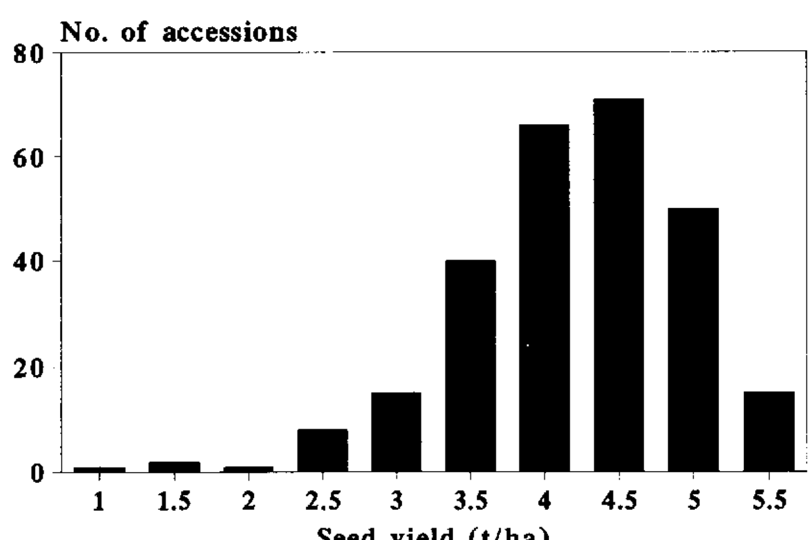


Figure 4.2.2. Frequency distribution of the Moroccan faba bean collection of 269 accessions for seed yield.

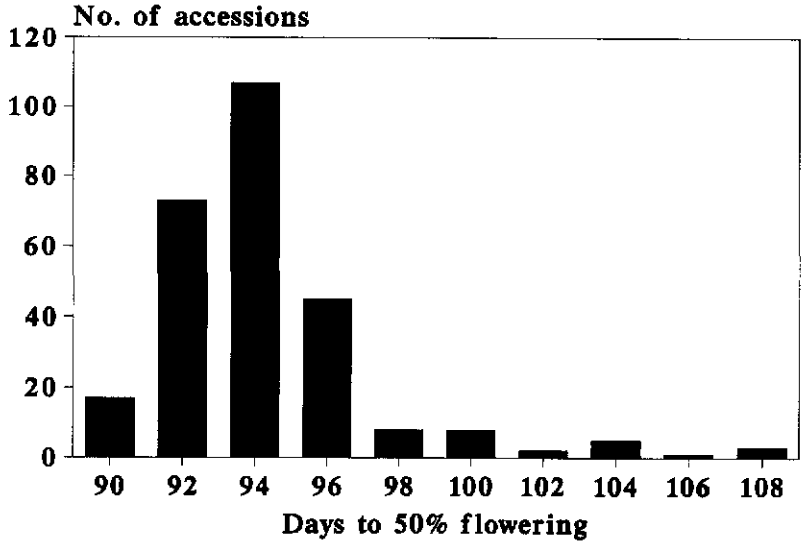


Figure 4.2.3. Frequency distribution of the Moroccan faba bean collection of 269 accessions for days to 50% flowering.

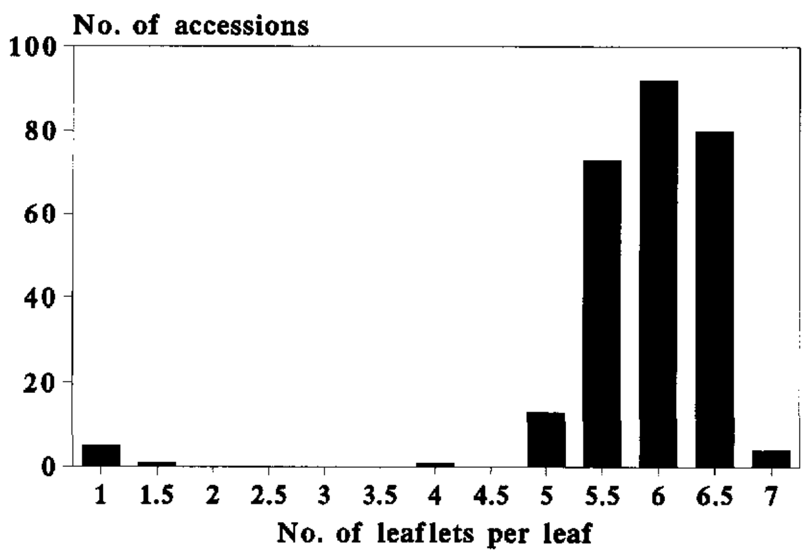


Figure 4.2.4. Frequency distribution of the Moroccan faba bean collection of 269 accessions for the number of leaflets/leaf.

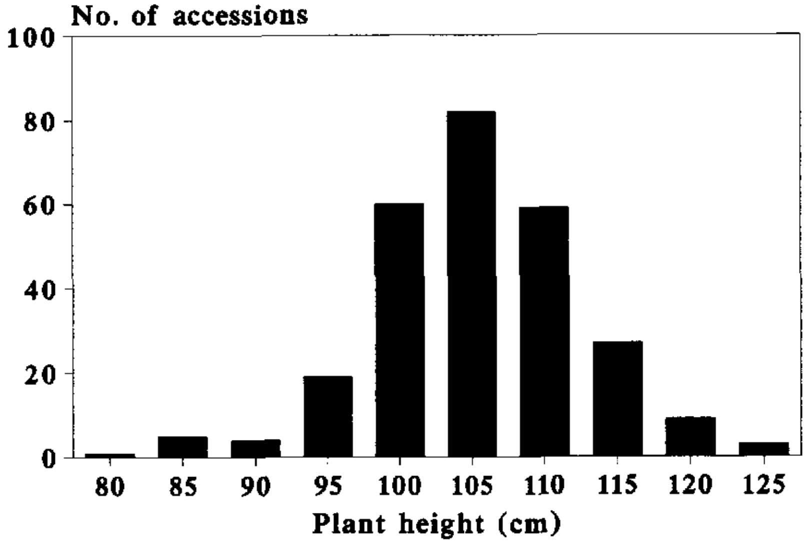


Figure 4.2.5. Frequency distribution of the Moroccan faba bean collection of 269 accessions for plant height.

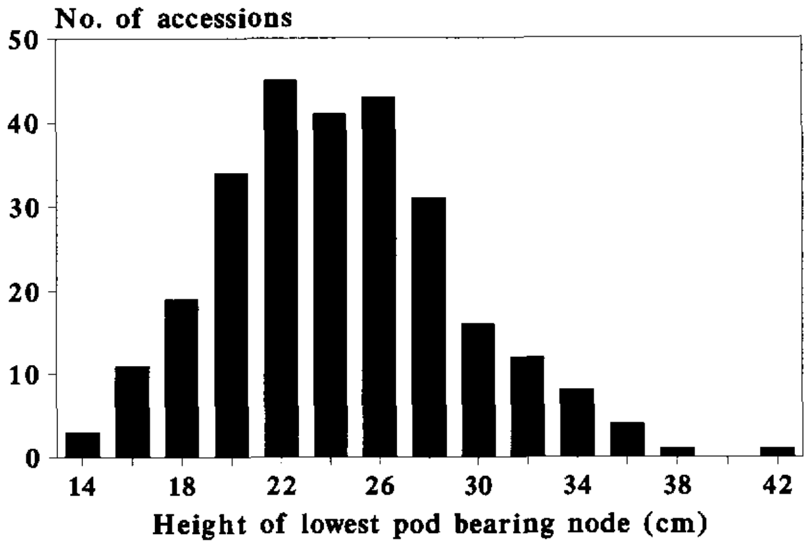


Figure 4.2.6. Frequency distribution of the Moroccan faba bean collection of 269 accessions forheight to lowest pod-bearing node.

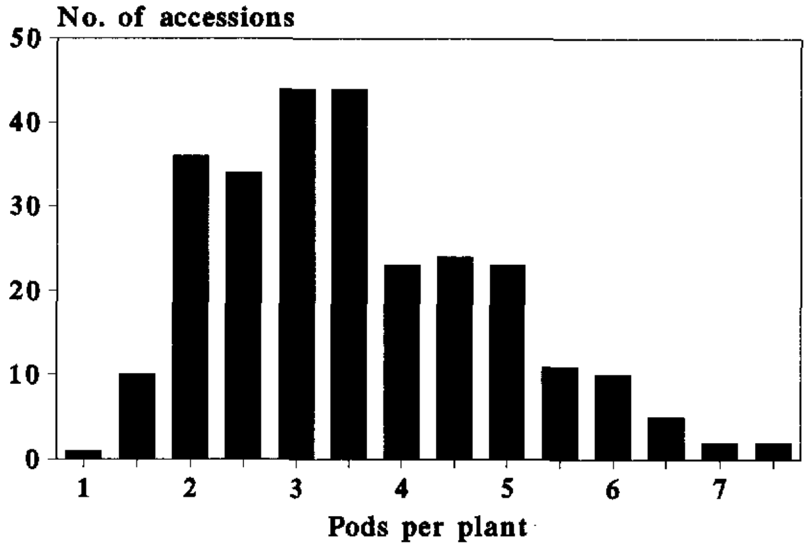


Figure 4.2.7. Frequency distribution of the Moroccan faba bean collection of 269 accessions for pods/plant.

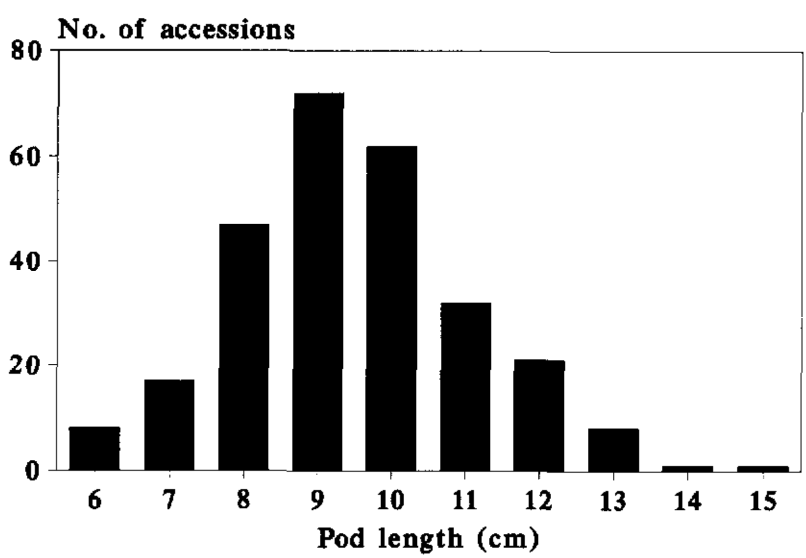


Figure 4.2.8. Frequency distribution of the Moroccan faba bean collection of 269 accessions for pod length.

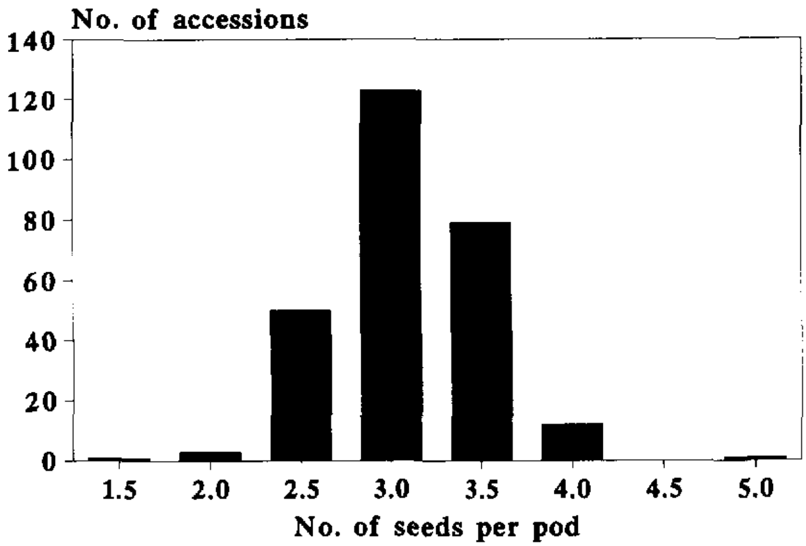


Figure 4.2.9. Frequency distribution of the Moroccan faba bean collection of 269 accessions for no. of seeds/pod.

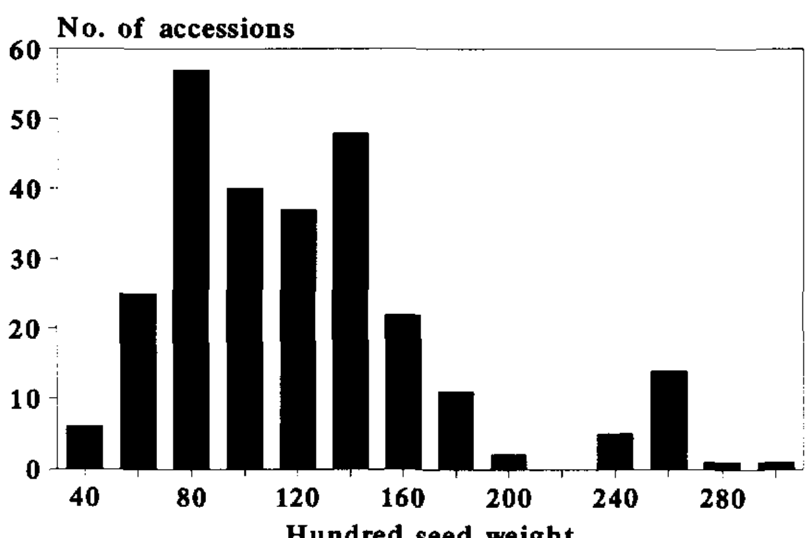


Figure 4.2.10. Frequency distribution of the Moroccan faba bean collection of 269 accessions for 100-seed weight.

Table 4.2.3. Correlations among seed yield, date of flowering, plant height, pods per plant, pod length, 100-seed weight, node and seeds per pod for 269 Morocco germplasm accessions grown at Douyet Morocco 1991.

Descriptor	Seed yield	Date of flowering	Plant height	Pod/ plant	Pod length	100-seed weight	Pods/ node
Date of flowering	-0.46**	1.00	0.29**	0.20**	-0.26**	-0.30**	0.31**
Plant height	-0.04	0.29**	1.00	0.07	-0.10**	-0.07	0.16**
Pod per plant	-0.44**	0.20**	0.07	1.00	-0.43**	-0.50**	0.65**
Pod length	0.47**	-0.26**	-0.12*	-0.44**	1.00	0.35**	0.41**
100-seed weight	0.50**	-0.30**	-0.07	-0.51**	0.35	1.00	0.48**
Pods per node	-0.48**	0.31**	0.16**	0.65**	-0.42**	-0.48**	1.00
Seeds per pod	-0.40**	0.23**	0.12**	0.92**	-0.33**	-0.50**	0.61

4.2.4. Development of Trait-specific Genetic Stocks

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

4.2.4.1. Germplasm for Orobanche resistance

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

However, considerable progress has been made with material received from Spain that used the Orobanche-tolerant line from Egypt-F 402. Fifty progenies from the cross (F402 x INIA06) x F402 were tested in artificially heavily infested fields in 1988 and 1989 in Syria and 1989 in Morocco. A total of 85 single-plant selections were rated as highly resistant, compared with the local susceptible check.

Three selections (18009, 18035, and 18105) were consistently rated as resistant to Orobanche at both Douyet, Morocco and Lattakia, Syria compared with a local check in adjacent rows. The yield potential of these selections was compared with that of the widely grown commercial cultivar "Aquadulce" at Douyet Agricultural Research Station in Morocco in 1989/90. In 1990/91 these lines were grown in verification trials at five sites in Morocco. (See section 4.2.5.2 for discussion of results).

When the 85 selections from 1989 and new material from Spain (184 lines) were tested in 1989/90, many resistant selections from the crosses were found (47 from previous years and 144 of the new lines). Results from 1989/90 and 1990/91 showed these had a lower number of Orobanche shoots/faba bean plant and Orobanche shoot dry weight/faba bean plant compared with the local susceptible check, Aquadulce (Figs. 4.2.11 and 4.2.12).

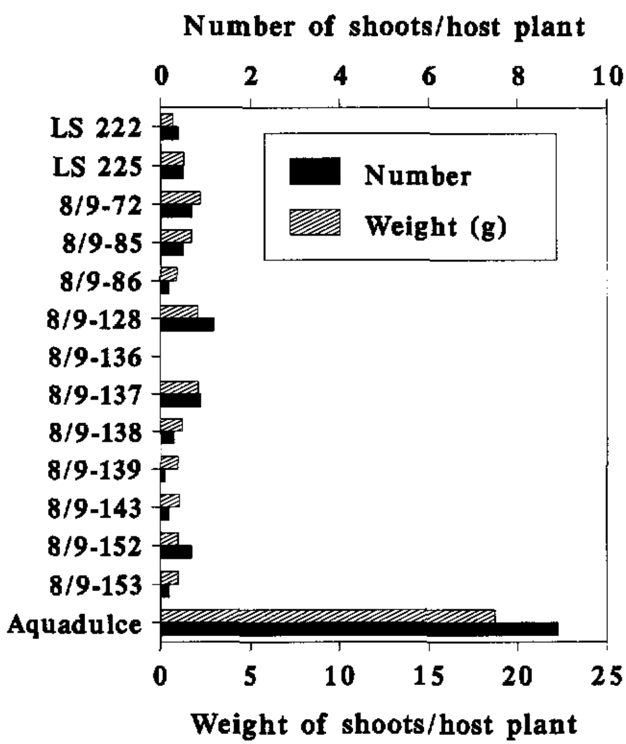


Figure 4.2.11. Orobanche incidence in some promising faba bean lines in naturally infested field at Douyet research station during 1990/91.

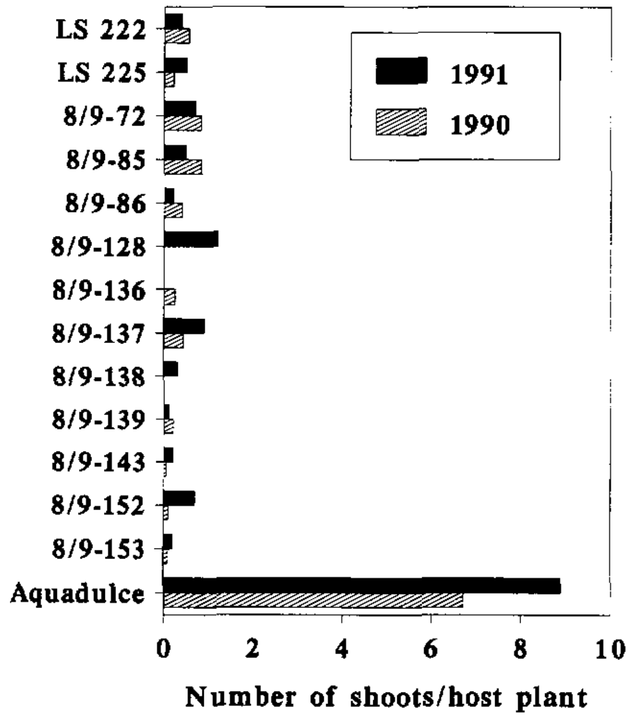


Figure 4.2.12. Incidence of Orobanche infestation in some promising faba bean lines in naturally infested field at Douyet research station during 1989/90 and 1990/91.

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

Z. Fatemi, L.D. Robertson, S.B. Hanounik and S.P.S. Beniwal

4.2.4.2. Development of disease-resistant inbred lines

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

4.2.4.3. Recombination of disease resistance with local adaptation

This activity was shifted to Douyet in 1989. Several technicians were trained at Douyet in crossing and 58 crosses were made with North African lines for disease resistance in 1990 and 156 crosses in 1991. Crossing in 1991 emphasized combining Orobanche resistance and large seed, long pods, and combining resistances to Orobanche and chocolate spot.

Table 4.2.4. Some of the most important inbred sources for resistance to 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, L82003, L82009
Ascochyta blight	BPL 74, 230, 365, 460, 465, 471, 472, 646, 818, 2485, ILB752, L83118, L83120, L81124, L83125, L83127, L83129, L83136, L83142, L83149, L83151, L83155, L83156, L832001
Rust	BPL 7, 8, 260, 261, 263, 309, 406, 417, 427, 484, 490, 524, 533, 539; Sel. 82 Lat. 15563-1, 2, 3, 4
Stem nematode	BPL 1, 10, 11, 12, 21, 23, 26, 27, 40, 63, 88, 183

1. There are several sublines of most sources listed.

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

Faba bean in most of the ICARDA region is grown in wheat-based farming systems where there is adequate rainfall/supplementary irrigation. Faba bean is used to a large extent as a green vegetable with the requirement of large seeds and long pods. Small-seeded faba bean is used as forage. To be competitive with other crops in this farming system faba bean has to have high and stable yield. This necessitates genotypes with resistance to Orobanche crenata, Botrytis fabae, Ditylenchus dipsaci, Ascochyta fabae and Uromyces fabae. Emphasis was therefore placed on developing such germplasm, and for 1990/91 most crosses involved at least one pest-resistant parent.

4.2.5.1. Yield potential of indeterminate faba bean

The season had a good distribution of rainfall. C.V.s ranged from 9.6 to 17.8% for trials grown at Douyet and the trial means ranged from 3117 to 4191 kg/ha.

The highest yield in replicated trials was 5.4 t/ha. A total of 100 lines outyielded the best check and 9 significantly outyielded the check (Aquadulce) (Table 4.2.5).

Table 4.2.5. Results of faba bean yield trials at Douyet and Jamaa shim, 1989-90.

Trial	No. of test entries	No. of lines >		Seed yield (kg/ha)			
		Check	Significant	Trial mean	Best lines mean	Check mean	C.V. (%)
FBNARYT-L Douyet	21	11	1	4152	5141	4117	17.8
FBNARYT-S Douyet	23	7	0	4106	4610	4344	11.0
FBAYT-L-1	33	12	0	4191	4972	4364	11.3
FBAYT-L-2	46	18	1	3991	5135	4125	15.8
BAYT-S-1	23	3	1	3959	4194	4401	9.6
FBAYT-Det-1	46	1	0	3399	3881	3949	12.0
FBPYT-L-1	46	4	0	3585	4785	3966	16.6
FBPYT-L-2	46	34	5	4100	5391	3893	10.6
FBPYT-S-1	3	10	1	4182	5197	4360	10.8
FBPYT-Det-1	46	0	0	3117	4422	4312	15.5

4.2.5.2. On-farm verification of O. crenata-resistant faba bean lines

There was close collaboration with the Extension Department of Meknes, to demonstrate control of O. crenata by the use of three resistant lines (Sel.88.Lat. 18009, 18035 and 18105) in naturally infested farmers' fields. These lines showed a high level of resistance to O. crenata and produced greater yields than the local susceptible cultivar Aquadulce, which was almost completely destroyed in adjacent rows. Farmers requested these lines despite their small seed size (50-70 g/100 seeds).

Data from 1990 at one location and 1991 at five locations are presented in Tables 4.2.6 and 4.2.7. It is clear that where there was

Table 4.2.6. Grain yield at five locations in 1991 and one location in 1990 in Morocco of faba bean verification trial.

Entry	1990	1991					
	Douyet	Douyet	CT	Ghania	Saiss	Fes	Mean
18105	1120	397	2808	2191	3252	3105	2351
18035	1220	272	2698	2888	3022	3692	2514
18009	1230	276	2980	1989	3380	2671	2259
Aquadulce	440	0	0	2045	2045	3583	1616
S.E.D.	114	194	1598	1198	390	349	----
Mean	1003	315	2828	2278	3026	3264	2185

Table 4.2.7. Number of Orobanche shoots per faba bean plant for five location in 1991 and one in Morocco for faba bean verification trial.

Entry	1990	1991					
	Douyet	Douyet	CT	Ghania	Saiss	Fes	Mean
18105	0.40	3.90	0.63	3.70	0.30	0.30	1.77
18035	0.65	3.30	0.73	4.63	0.13	0.17	1.79
18009	0.80	3.73	0.43	4.03	0.27	0.23	1.74
Aquadulce	5.00	11.57	3.73	6.67	1.87	0.73	4.91
S.E.D.	0.25	0.71	0.24	2.16	0.22	0.39	----
Mean	1.71	5.63	1.83	7.02	0.64	1.95	2.55

heavy Orobanche infestation the yields of the resistant lines were much higher then Aquadulce. Over five sites in 1991 the resistant lines were 46% higher yielding than Aquadulce and they had 64% less Orobanche shoots/faba bean plant than Aquadulce. Similar results can be seen for 1990.

Z. Fatemi, L.D. Robertson, S.B. Hanounik and S.P.S. Beniwal

4.2.5.3. Segregating populations

This year 889 single plant selections were made in segregating populations and progeny rows grown at Douyet, Morocco for chocolate spot resistance and determinate and IVS plant type. These will be planted as progeny rows at Douyet, and at Meknes (for disease resistance screening). At Meknes 1274 single plant selections were made for resistance to chocolate spot. All nurseries were inoculated artificially and scored for disease reaction using ICARDA's 1-9 rating scales. In the preliminary screening nurseries 210 selections were made for preliminary yield trials next year.

Z. Fatemi, S.B. Hanounik, L.D. Robertson and S.P.S. Beniwal

4.2.6. Development of Alternative Plant Type

4.2.6.1. Determinate and IVS faba bean genetic stocks

The determinate habit is of potential importance in faba bean production areas which are either irrigated or are highly fertile. Its use should curtail excessive vegetative growth and subsequent lodging, and should give a corresponding increase in harvest index. Work has been considerably reduced on determinates with the shift to North Africa and the crossing program was terminated. Efforts will be made to consolidate gains and maintain the improved genetic stocks derived from the crossing program.

Because of independent vascular supply (IVS) to each flower, the IVS lines produce more pods in each raceme because flower shedding is greatly reduced. In the 1989/90 season 491 selections were made for IVS in segregating populations at Douyet and 177 disease-resistant IVS selections were made at Meknes. Work was carried out using the new, earlier flowering IVS source based on Sudanese Triple White. A total of 79 selections were made in 19 F_2 populations at Douyet in 1991; half of these involved a disease-resistant parent. At Meknes 251 selections were made for IVS in segregating populations. Work will continue with emphasis on large seed size and disease resistance.

Z. Fatemi and L.D. Robertson

4.2.6.2. Closed flower genetic stocks

With tightly closed flowers, outcrossing can be as low as 5%. Until last season, populations and progenies from crosses with the available sources of closed flower character have been very late. At Tel Hadya 49 single plant selections could be made for closed flower and earliness in F3 and F4 progeny rows. These were used in Morocco in 1989/90 for making additional crosses to continue to obtain adaptation to the Mediterranean environment and 47 additional single plant selections were made. In 1990/91 13 single plant selections were made in 15 F_5 populations and 29 F_6 single plant selections with earliness and large seed size were also made.

Z. Fatemi and L.D. Robertson

4.2.7. North African Regional Nurseries

North African regional yield trials, large and small, were distributed in the 1989/90 season to Morocco and Algeria. Tunisia and Libya were added in 1990/91. Many lines exceeded the local check (Aquadulce) (Tables 4.2.8 and 4.2.9).

An Orobanche regional nursery was also initiated in 1989/90 and distributed to Morocco, Algeria and Tunisia. In this nursery the faba bean lines 18009, 18035 and 18015 were tested further in Morocco, and in Algeria and Tunisia in naturally infested fields to study their resistance to different populations of O. crenata in the region. These lines were rated as resistant to the parasite across all locations, except to a population of Orobanche foetida which occurs in the area of

Table 4.2.8. Seed yield for the North Africa Regional Yield Trial-Large in 1989/90.

Pedigree/Accession No.	Seed yield (kg/ha) Douyet
FLIP 82-30 FB	3913
FLIP 82-45 FB	4055
FLIP 84-107 FB	4632
FLIP 84-128 FB	3895
FLIP 84-147 FB	4234
FLIP 85-89 FB	114
FLIP 86-35 FB	3938
FLIP 86-36 FB	3783
FLIP 87-26 FB	4134
FLIP 87-70 FB	4500
FLIP 87-137 FB	3749
FLIP 87-140 FB	5141
FLIP 87-147 FB	4299
FLIP 88-1 FB	3758
FLIP 88-2 FB	3844
S82113-8	4130
79S4	4466
80S44027	4304
80S80028	4369
80S80125	3739
Reina Blanca	3314
Aquadulce	4539
Local Check 1	4157
Local Check 2	3655
C.V. (%)	17.8

the testing site near Beja in Tunisia. There is an urgent need to identify new sources of resistance to this population of the parasite.

Results from 1991 are presented in Table 4.2.10. At Douyet there was an extremely severe infestation of Orobanche. Aquadulce (which was also the local check) yielded no seed and had eight times the number of Orobanche shoots per faba bean plant as the most resistant line and 4.5 times the amount of the mean of all test lines.

Z. Fatemi, L.D. Robertson, S.B. Hanounik and S.P.S. Beniwal

Table 4.2.9. Seed yield for the North Africa Regional Yield Trial-Small in 1989/90.

Pedigree/Accession No.	Seed yield (kg/ha) Douyet
FLIP 82-9 FB	4174
FLIP 82-35 FB	3826
FLIP 83-106 FB	4473
FLIP 84-46 FB	4260
FLIP 84-48 FB	4190
FLIP 84-59 FB	4610
FLIP 85-13 FB	4125
FLIP 85-28 FB	4835
FLIP 85-48 FB	4165
FLIP 86-80 FB	3810
FLIP 86-85 FB	4548
FLIP 86-86 FB	4423
FLIP 87-77 FB	3619
FLIP 88-3 FB	3881
FLIP 88-4 FB	3690
FLIP 88-6 FB	3689
76TA56267	3762
B87148	4036
B87149	4219
B87249	4391
B87258	3714
B87259	4497
B87263	3702
Local Check	4343
C.V. (%)	11.0

Table 4.2.10. Results of regional _Orobanche_ nursery for 1990/91 at Douyet.

Line	Seed yield (kg/ha)	No. _Orobanche_/ faba bean plant
18009	609	1.95
18025	535	3.45
18035	538	2.60
18054	385	3.50
18105	692	5.40
Aquadulce	0	16.00
Local check	4	15.30
C.V. (%)	153%	63%

4.3. Faba Bean Diseases

Low and unstable faba bean yields in North Africa are due mainly to several important diseases. The wide prevalence and severity of these diseases has introduced some significant changes in faba bean cultivation in the region. Two of these, viz., broomrape (Orobanche crenata) and chocolate spot (Botrytis fabae), have forced farmers to either give up faba bean cultivation or to significantly reduce it, whereas other seed-borne pathogens like Ascochyta fabae and Ditylenchus dipsaci have caused the enforcement of new quarantine regulations which have halted faba bean exports from infested areas. Research in faba bean pathology concentrated on finding new sources of resistance to the major pathogens and incorporating them into high-yielding backgrounds results of which are reported under 4.2.4.1. Work on Orobanche was done to understand the relationship between seed load in relation to a susceptible and a resistant variety, and its integrated control.

4.3.1. Relationship between Seed Load of O. crenata and Faba Bean Yield

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

The effect of the initial seed load of O. crenata on faba bean yield was investigated through a pot experiment. Different quantities of Orobanche seeds (based on an average count of 250 seeds of Orobanche/mg seed) were mixed thoroughly with Orobanche free soil from Douyet Station to obtain a series of 3, 5, 9 and 22 seeds per cc soil. The Orobanche-free soil served as control. These seed loads were determined by a centrifugational extraction method employing a flocculation solution of 1.16 g $MgSO_4$/ml of water. A fixed ammount of soil (5652 cc) with different Orobanche seed load was filled in each pot (20 cm size) and placed in an insect-proof field cage. A susceptible faba bean cultivar Aquadulce was sown in one set and a resistant line Sel.88.Lat. 18009 in another. One plant was maintained in each pot. A completely randomized block design was used with three replications.

In general, grain yields of the resistant line 18009 were significantly higher than those of the susceptible cultivar Aquadulce at all Orobanche seed loads except at 0 seed load (Orobanche-free soil) where Aquadulce outyielded line 18009 by 39% (Fig. 4.3.1). Averaged over seed loads, line 18009 gave three times more grain yield than Aquadulce. The susceptible line failed to yield any grains at seed loads of 9 and 22 seeds/cc soil, whereas the resistant line at these loads yielded as much as in the Orobanche-free situation.

On average, a considerably lower number of Orobanche shoots (2.7 shoots/plant) developed on the resistant line than on the susceptible one (10.5 shoots/plant). Also, in general, the number of Orobanche shoots per plant increased with an increase in the seed load in both lines although the extent of successive increase was lower in the resistant line than in the susceptible one (Fig. 4.3.1). Also, on average, weight of Orobanche shoots per plant increased with an increase in the seed load. The Orobanche shoot weight in the resistant line was 44% of the susceptible one. These may explain higher grain yield in the resistant line.

Further work is needed on the relationship between Orobanche seed load and yield losses in faba bean. The information generated will help plan integrated measures for Orobanche control and for predicting yield losses.

4.3.2. Integrated Control of Orobanche in Faba Bean

Considering the problems associated with Orobanche control by individual methods, it was considered important to attempt its integrated control by employing resistant varieties, chemical control and sowing date. Therefore, an experiment was conducted in an Orobanche-infested field at Douyet Station in RCB with four replications. Three faba bean varieties, two resistant (18105 and 18035) and a susceptible (Aquadulce), were each sown on three different dates (24 Oct 1990, 18 Nov 1990 and 10 Jan 1991) in 10 m^2 plots. Spraying the crop with glyphosate or water alone were additional treatments. Spraying was done twice with glyphosate (184 ml/ha) on 11 and 26 March for 24 Oct sowing, on 24 March and 11 April for 18 Nov sowing and on 18 April and 2 May for 10 Jan sowing. Observations were recorded on grain yield (based on 2.5-m^2 area harvested) and its yield-contributing factors, biological yield and number and dry weight of Orobanche shoots.

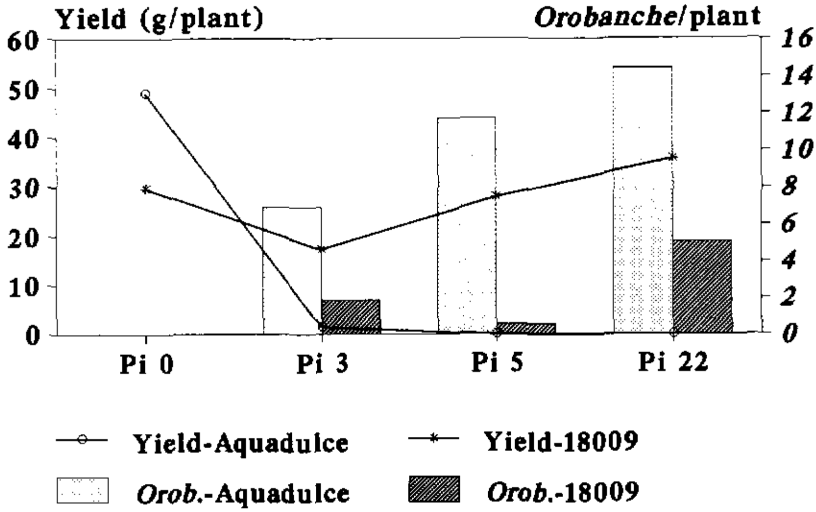


Figure 4.3.1. Effect of seed load on the number of Orobanche shoots/faba bean plant and faba bean seed yield/plant in two faba bean genotypes.

Faba bean grain yield was significantly affected by the three varieties. On an average, 18105 yielded highest (2741 kg/ha) followed by 18035 (2488 kg/ha) with Aquadulce yielding the least (1496 kg/ha) and thus reflecting 45 and 40% increase in yield over Aquadulce, respectively. Similarly, faba bean grain yield was affected by three dates of sowing with 18 Nov sowing yielding highest (2651 kg/ha) followed by 10 Jan (2217 kg/ha) and 24 Oct sowing (1857 kg/ha). Likewise, glyphosate treatment yielded 2804 kg/ha compared with 1679 kg/ha of the untreated plots. The number of pods per plant showed trends similar to the grain yield. Similarly, on average, the least numbers of Orobanche shoots per plant (0.77) were observed in the line 18105 (47% less than Aquadulce) and in 10 Jan sowing date (0.23 and 1/19th of Aquadulce) and the glyphosate-sprayed treatment (0.04 and 1/88th of Aquadulce) whereas the highest numbers were observed in Aquadulce (3.22), 24 Oct sowing date (4.58) and unsprayed treatment (3.59). These correlate with the grain yield obtained in these treatments.

Two-way interaction results between varieties and dates showed significantly higher grain yields in the two resistant lines in 18 Nov sowing date, over the other two sowing dates, whereas Aquadulce yielded higher in the late-sowing date compared with the two earlier ones (Fig. 4.3.2). Similarly, there was a significant interaction between variety and spray treatments with advantage of glyphosate spray being highest in Aquadulce, a 3-fold increase in grain yield (Fig. 4.3.3). A similar significant interaction was observed between sowing dates and spray treatments (Fig. 4.3.4). The highest effect of glyphosate spray (about 3-fold increase in grain yield) was observed in the earliest (24 Oct) sowing and a little less advantage in the later dates. The above interactions were similar for the biological yield, pods per plant and also the number of Orobanche shoots per plant.

Results from this experiment clearly show the choices that we could have in controlling Orobanche. These include resistance variety planted in Nov; resistant or susceptible variety sprayed with glyphosate; and Nov sowing sprayed with glyphosate that will help control Orobanche infestation and increase faba bean grain yields.

S. Hanounik, L.D. Robertson, S.P.S. Beniwal and A. Kalida

4.4. Faba Bean Agronomy

Two trials on faba bean agronomy were initiated at Douyet Research station during the 1990/91 crop season. These were (i) to study the effect of different faba bean plant densities on growth and yield, and (ii) to study the effect of different crops on Orobanche developement in the following faba bean crop.

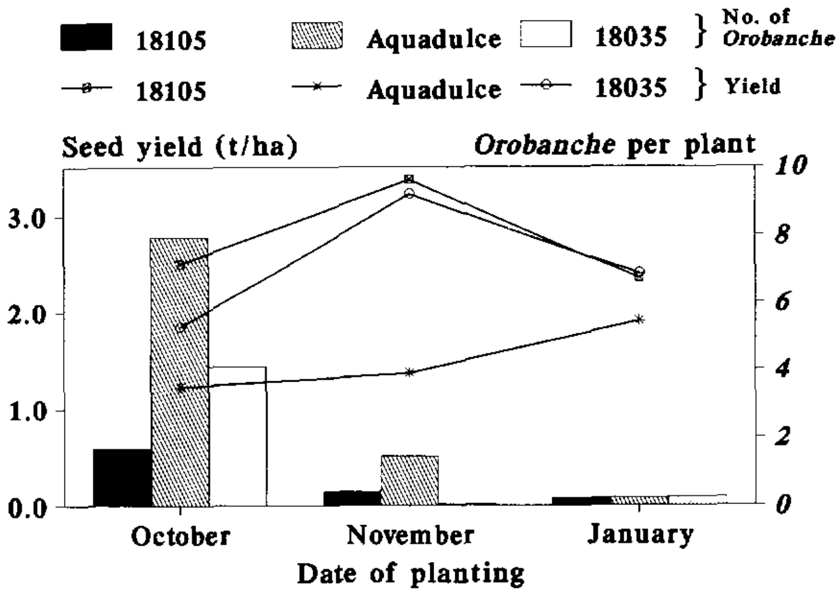


Figure 4.3.2. Interaction between date of planting and faba bean genotypes in affecting number of Orobanche shoots/faba bean plant and yield of faba bean, Douyet, 1990/92.

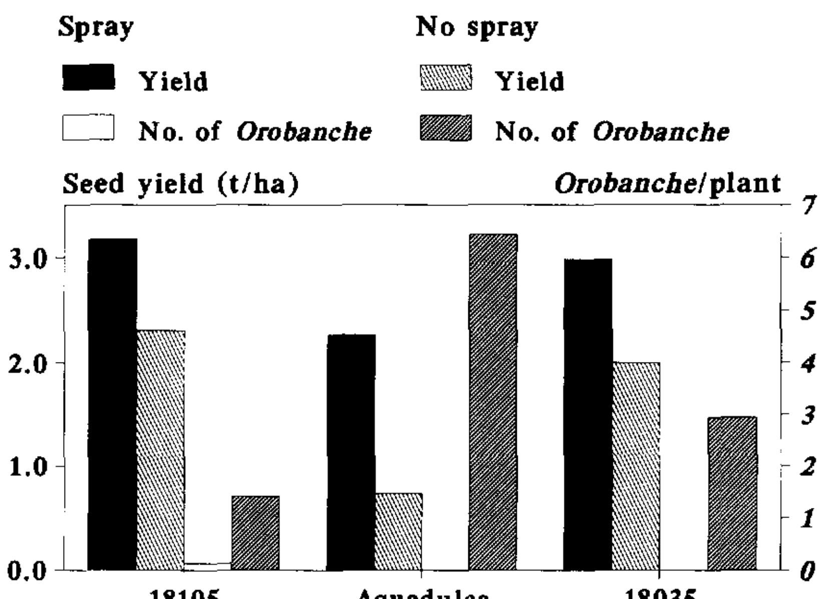


Figure 4.3.3. Interaction between glyphosate spray and faba bean genotypes in affecting the number of Orobanche shoots/ plant and seed yield of faba bean, Douyet, 1990/91.

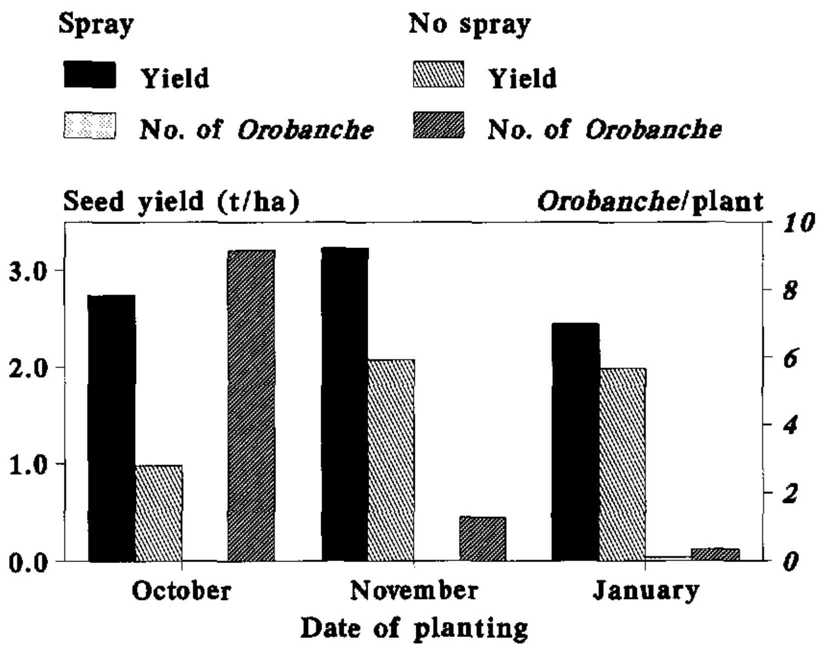


Figure 4.3.4. Interaction between glyphosate spray and date of sowing in affecting the number of Orobanche shoots/plant and seed yield of faba bean, Douyet, 1990/91.

4.4.1. Effect of Faba Bean Plant Density on its Growth and Grain Yield

The experiment was conducted in RCB design with four replications. Four faba bean densities of 5, 12.5, 25 and 40 plants/m^2 were used with inter-row spacing of 100, 40, 40 and 30 cm and within row-spacing of 20, 20, 10 and 8.5 cm, respectively. The plot size was 8 x 8 m. Seeds were hand-sown on 21 Nov 1990. The crop was hand-weeded twice. Diseases and insect pests were controlled by regular chlorathionil and Hostion sprays. No chemical sprays were done to control Orobanche. Observations on branching, height of plant and dry weight were recorded over the growing season. Plots were harvested by 25 May, and observations on grain yield and its components were recorded.

Since no glyphosate treatment was applied, a severe attack of Orobanche was observed in the trial. An increase of plant density from

5 to 40 plants/m² had a depressive effect on the number of branches per plant. The lowest number of branches per plant (2.13) obtained for the highest density explains the high level of competition between plants.

The plant density also affected plant height. Tallest plants (138 cm) were observed in the highest density of 40 plants/m², whereas shortest plants (122 cm) were observed from the lowest density of 5 plants/m².

Data on grain yield and its components are shown in Table 4.4.1. The grain yield ranged from 3313 kg/ha for the lowest density to 1114 kg/ha for the highest one. The densities above 5 plants/m² had lower grain yield because they were more affected by Orobanche and diseases such as chocolate spot and Ascochyta blight.

Table 4.4.1. Effect of four faba bean plant densities on its grain yield and its components.

Treatment	Plants/ m²	Branches/ plants	Pod/ plant	Seeds/ plant	100-seed yield (g)	Yield (kg/ha)
1	5	5.33	8	35	182	3313
2	12.5	3.67	6.3	25.7	164	2271
3	25	2.9	4.7	16	157	1977
4	40	2.13	3.3	9.7	145	1114
Mean		3.51	5.58	21.25	162	2169
CV (%)		8.34	14.32	28.32	6.66	31.2

4.4.2. Effect of Crop Rotation on the Seed Bank of Orobanche

Several two-course rotations are being evaluated for their effect on the development of Orobanche seed bank and productivity of the rotation. This is the first year of this experiment. It is arranged in a split-plot design with four replications in 10 x 3.4 m plots. The main plots are the two phases and the subplots are rotations. The treatments are as follows :

	Phase 1	Phase 2
1.	Faba bean (Aquadulce)	Wheat (Sais)
2.	Faba bean (Giza 402)	Wheat (Sais)
3.	Faba bean (Aquadulce)	Faba bean (Aquadulce)
4.	Faba bean (Giza 402)	Faba bean (Giza 402)
5.	Faba bean (Aquadulce)	Faba bean (Giza 402)
6.	Faba bean (Giza 402)	Faba bean (Aquadulce)
7.	Chickpea (ILC 195)	Wheat (Sais)
8.	Wheat (Sais)	Wheat (Sais)
9.	Faba bean (Aquadulce)	Sunflower (Record)

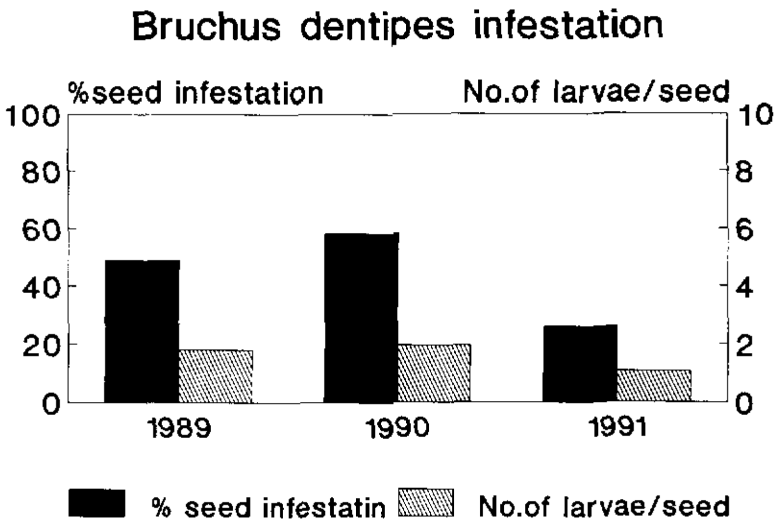
A. Kalida, L.D. Robertson, S. Hanounik, S.P.S. Beniwal

4.5. Faba Bean Entomology

4.5.1. Control of Bruchus dentipes

For the past 3 years different insecticides were tested in a farmer's field (Zitan/Barnaa village) for their effectiveness to control Bruchus dentipes, the dominant storage pest in faba bean. This year the infestation was low with only 26% seed infestation and 28 larvae per 100 seeds as compared to infestations of 50 to 60% and 88 and 75 larvae per 100 seeds in the previous two seasons, 1989 and 1990 (Fig. 4.5.1). In contrast to the first 2 years rainfall in March and April during the oviposition period of B. dentipes was high this year, reducing the flight activity and oviposition and resulting in lower infestation. Two applications of Metyphon (1 ml/L), Fastac (0.25 ml/L) and Dimethoate (1 ml/L) at early podsetting and 2 weeks later were used. The applications of Metyphon and Fastac were most effective and reduced seed infestation from 26 to 13.3 and 15.6%, respectively, confirming last year's results. Dimethoate only slightly decreased the infestation. During the 3-year study 6 insecticides were tested, of which Metyphon, Fastac and Thiodan effectively reduced the infestation, whereas Decis was less effective and Dimethoate and Anthio were not effective.

S. Weigand, H. Mohammed, Y. Azzar (ARC, Aleppo)



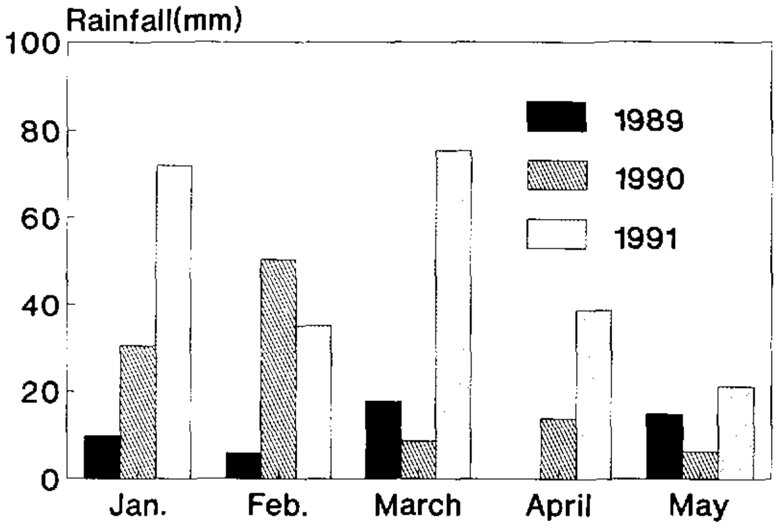


Figure 4.5.1. Monthly rainfall and infestation of faba bean with *Bruchus dentipes* during 3 years, Zitan, Aleppo, Syria.

5. FORAGE LEGUME AND DRY PEA IMPROVEMENT

5.1. Forage Legumes

Annual feed legume crops are one of the alternatives being studied to replace fallow in the cereal-based rotation in dry areas. They are defined as leguminous species sown and harvested in one year for hay, seed or straw especially to feed livestock. They can also be grazed.

The general objective of our forage legume improvement work is to produce improved cultivars of feed legumes from several genera and to target these cultivars to feed livestock in areas with less than 350 mm rainfall. It is also desirable to have widely adapted cultivars that can be recommended for different locations with similar agroecological conditions.

In spite of the diversity of feed legume species in the Mediterranean region, few have been used specifically as feed crops, and they have received virtually no attention from plant breeders. Therefore, our goals are to develop improved cultivars of species currently in use by farmers and to examine some of the alternative wild species found in areas receiving 250-500 mm rainfall. Particular attention is given to feed legume crops for dry areas where annual rainfall is 250-300 mm. In these areas, legume crops are not widely grown and farmers grow cereals, usually barley followed by a fallow year or increasingly, there is cereal monoculture. In view of ICARDA's overall objectives of developing sustainable farming systems, there is a great need for developing legume crops adapted to these dry areas.

The two genera of feed legumes being intensively evaluated are vetches (Vicia spp.) and chicklings (Lathyrus spp.). Of vetches we are selecting or hybridizing genotypes of V. sativa (common vetch), V. villosa subsp. dasycarpa (wooly-pod vetch), V. narbonensis (narbon vetch), V. ervilia (bitter vetch), and of chicklings Lathyrus sativus (common chickling or grasspea), L. cicera (dwarf chickling) and L. ochrus (ochrus chickling).

The most exciting species are narbon vetch, common chickling and dwarf chickling, because of their potential in dry areas and wooly-pod vetch for its potential in the high elevation areas of Balouchistan, where it showed negligible cold damage and produced greater herbage and straw yields than the other legumes. There has also been exploratory work on V. hybrida, V. palaestina, V. panonica, V. sativa subsp. amphicarpa (under ground vetch) and Lathyrus ciliolatus (underground chickling).

5.1.1. Breeding of Forage Legumes

The procedures of developing new feed legume crops are selection from wild types to develop cultivated types, and genetic improvement by hybridization. The two procedures are illustrated in Fig. 5.1.1.

The process of developing cultivated types from wild species involves preliminary evaluation of germplasm for desired characters and progeny tests for selected genotypes (selections), evaluation of selections in preliminary microplot yield trials, evaluation of promising selections in advanced yield trials at two contrasting sites, i.e., Tel Hadya and Breda, and multilocation testing of promising lines in different agro-ecological zones (Fig. 5.1.1). Because there has been so little breeding work on these legumes in the past, our emphasis is on selection from existing wild types. By transferring the forage legumes breeding from PFLP to LP in 1990, more emphasis was given to genetic improvement with the support of other disciplines, e.g., pathology, physiology and entomology, and about 40% of our resources for forage legumes are being using for hybridization and genetic improvement.

We aim to serve national breeding programs through (1) assembling, classifying, maintaining and distributing germplasm, (2) developing and supplying breeding populations with sufficient diversity to be used in different environments, and (3) coordinating international trials to

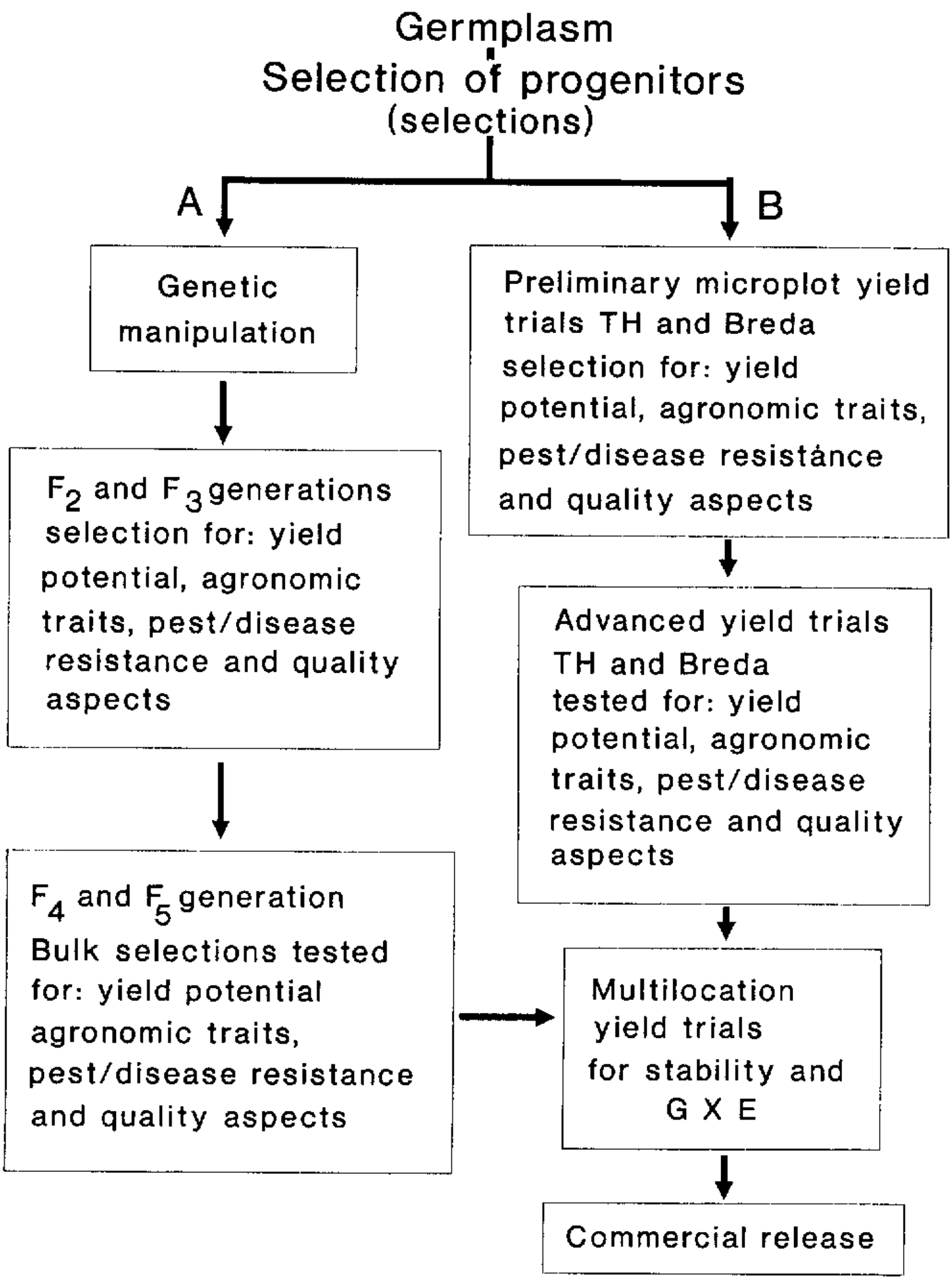


Figure 5.1.1. Structure of forage legumes breeding program: (A) Hybridization (B) Selection.

facilitate multilocation testing and identification of widely adapted cultivars.

Breeding for improved yield is being supplemented by improving the quality; therefore, palatability and nutritive value of the herbage, hay, grain and straw are also considered through our collaboration with PFLP.

In 1990/91, germplasm of narbon vetch was evaluated. Promising genotypes of V. sativa, V. ervilia, V. palaestina, V. hybrida and L. sativus were tested in microplot field trials at Tel Hadya. Promising lines of V. villosa subsp. dasycarpa were tested in advanced yield trials at Tel Hadya, and promising lines of V. narbonensis, L. sativus, L. cicera and L. ochrus, were tested at Tel Hadya (seasonal total rainfall 282 mm) and Breda (seasonal total rainfall 228 mm). After crossing adapted common vetch with ecotypes whose pods do not shatter, selection for adapted non-shattering lines continued into BC_4 generation. After screening common chickling for low neurotoxin (BOAA) content a crossing program was initiated for improving nutritional quality of L. sativus by breeding. A study to investigate the potential of subterranean vetch (V. sativa subsp. amphicarpa) under actual grazing conditions and its effect on the subsequent barley crop was continued. Crosses of V. sativa subsp. sativa and V. sativa subsp. amphicarpa were made and F_1 plants were studied. All the breeding work was done under rainfed conditions without supplementary irrigation.

5.1.1.1. Germplasm evaluation

During the last three seasons at Tel Hadya, attention has been paid to the collection and evaluation of native wild types of forage legumes. Some showed good cold and drought tolerance as well as early and rapid spring growth, early flowering and maturity. Such genotypes could be of value for developing new cultivars.

In 1990/91, one experiment was conducted to assess 100 accessions of narbon vetch (V. narbonensis) in nursery rows in a cubic lattice design with two replicates. The accessions were scored for seedling vigor, winter and spring growth, cold effect, leafiness, time to flowering, % flowering and maturity and grain yield. Genotypic variability for these characters was wide (Table 5.1.1). We identified 25 genotypes for further evaluation and utilization in our breeding program.

Table 5.1.1. Range, mean, standard error and coefficient of variation (%) of eight characters of 100 accessions of narbon vetch.

Characters[a]	Range	Mean	S.E.M. ±	C.V. (%)
Seeding vigor	2.5 - 7.7	4.5	0.55	17.3
Winter growth	2.5 - 7.7	4.5	0.55	17.5
Cold effect	1.0 - 4.8	1.4	0.45	47.0
Spring growth	2.5 - 9.2	6.0	0.77	17.9
Leafiness	2.6 - 9.5	6.3	0.73	16.5
Days to start flowering	113 - 130	120	0.90	1.07
Days to 100% flowering	121 - 138	127	0.97	1.08
Days to full maturity	146 - 170	155	1.5	1.4
Grain yield (kg/ha)	143 -1642	928	157	24.0

[a] On a visual score where 1 = poor; 9 = very good and for cold effect 1 = no damage; 9 = all plants killed by frost.

5.1.1.2. Preliminary microplot evaluation

The study of variation in agronomic traits in microplots is of significant practical value. It helps the breeder to establish a breeding program with defined objectives, and of itself may result in the selection of improved lines. Objective selection for herbage and seed yields and some aspects of nutritive value begins in microplot field trials in the year following germplasm evaluation.

In 1990/91, microplots of four species of vetches (Vicia sativa, V. ervilia, V. palaestina, and V. hybrida) and one species of chickling (Lathyrus sativus) were planted at Tel Hadya in 3-5 m^2 plots arranged in a triple lattice design. For all the species, seed rate was 100 kg/ha and fertilizer was applied at 40 kg P_2O_5/ha. These microplot experiments were in two sets. One set was harvested at 100% flowering to determine herbage yield and the other was harvested at maturity to measure seed and straw yields and other agronomic traits.

Common vetch (V. sativa): Twenty-five selections were tested at Tel Hadya and the results of the ten most promising lines are shown in Table 5.1.2. Herbage yield varied from 1524 to 2565 kg/ha, grain yield ranged from 585 to 928 kg/ha and harvest index from 20.0 to 31.4%. Common vetch was moderately affected by frost. The relatively low grain yields and harvest index were due to low rainfall, because common vetch is adapted to areas of rainfall above 350 mm. Also the delay of the first rain after planting delayed the germination. Two promising lines, IFLVS 2485 and 2506, are characterized by resistance to lodging at maturity and high grain yields and harvest index.

Table 5.1.2. Herbage, biological and seed yields, and harvest index for the best 10 selections of common vetch (V. sativa) in preliminary yield trials at Tel Hadya.

Selection IFLVS	Herbage yield (kg/ha)	Biological yield (kg/ha)	Seed yield (kg/ha)	Harvest index (%)
2484	2028	2856	848	29.7
2485	2238	2863	900	31.4
2486	2265	2806	809	28.8
2487	2270	2849	777	27.3
2492	2023	3016	789	26.2
2500	2336	2966	725	24.4
2503	2138	2833	720	25.4
2505	2539	2797	854	30.5
2506	2441	3033	928	30.6
2560	1999	2836	597	21.1
Grand mean[a]	2179	2731	757	27.7
SEM ±	164	195	56	1.07
LSD (P=0.05)	470	560	160	4.79
C.V.(%)	13.0	12.3	12.8	10.42

[a] Mean for all 25 selections.

Bitter vetch (*V. ervilia*): Sixteen selections of bitter vetch were tested at Tel Hadya (Table 5.1.3). Herbage yield varied from 2132 to 2814 kg/ha, seed yield ranged from 780 to 1298 kg/ha and harvest index from 25 to 38%.

Table 5.1.3. Herbage, biological and seed yields, and seed harvest index of 16 selections of *V. ervilia* in preliminary yield trials at Tel Hadya.

Selection IFLVE	Herbage yield (kg/ha)	Biological yield (kg/ha)	Seed yield (kg/ha)	Harvest index (%)
2508	2713	3161	1097	34
2509	2478	3390	1241	36
2510	2351	3055	1123	37
2511	2614	3889	1298	33
2512	2707	3291	948	30
2513	2132	2837	891	31
2514	2685	3496	1203	34
2415	2506	3215	1245	38
2516	2437	2921	1122	37
2517	2665	2441	780	32
2518	2587	2681	1013	38
2519	2167	3314	895	26
2520	2754	3005	895	29
2521	2322	3287	830	25
2522	2814	3199	1230	38
2563	2245	3314	956	28
Mean	2511	3156	1047	33
SEM ±	185	265	113	2.14
LSD (P=0.05)	535	765	326	6.3
C.V. (%)	12.8	14.5	18.7	11.2

***Vicia palaestina*:** Sixteen selections were assessed in microplots at Tel Hadya (Table 5.1.4). Herbage yield varied from 908 to 1687 kg/ha, whereas seed yields ranged from 167 to 462 kg/ha, and harvest index from 11 to 22%.

Table 5.1.4. Herbage, biological, seed yields and harvest index of 16 selections of V. palaestina in preliminary yield trials at Tel Hadya.

Selections IFLVP	Herbage yield (kg/ha)	Biological yield (kg/ha)	Seed yield (kg/ha)	Harvest index (%)
2523	1194	1821	271	15
2524	968	1832	295	16
2525	1287	1862	240	13
2526	937	1813	356	19
2527	908	1306	194	15
2528	1465	1969	356	19
2529	1433	1961	408	21
2530	1687	2178	416	19
2531	1399	2156	418	19
2532	1417	1501	167	11
2533	1182	1665	313	18
2534	1128	1935	259	13
2535	1266	1608	202	13
2536	1489	2046	466	22
2537	1025	1832	279	15
2538	1184	1901	261	12
Mean	1248	1835	306	16
SEM $\pm$	149	188	40	1.6
LSD (P=0.05)	431	542	118	4.7
C.V. (%)	20.7	17.7	23.0	16.7

Vicia hybrida: Sixteen selections of V. hybrida were tested in microplots at Tel Hadya (Table 5.1.5). Herbage yield varied from 1840 to 2199 kg/ha, whereas seed yields ranged from 273 to 568 kg/ha and harvest index from 10 to 21%. V. hybrida is characterized by a prostrate compact growth habit and slow winter growth followed by rapid spring growth. This makes the species suitable for grazing. The low seed yields and harvest index were partly because of large seed loss in harvesting due to the prostrate growth habit of this species.

Lathyrus sativus: Thirty-six selections were tested at Tel Hadya. Results of the top selections are shown in Table 5.1.6. Herbage yield

Table 5.1.5. Herbage, biological, seed yields and harvest index of 16 selections of V. hybrida in preliminary yield trials at Tel Hadya.

Selection IFLVH	Herbage yield (kg/ha)	Biological yield (kg/ha)	Seed yield (kg/ha)	Harvest index (%)
2539	1862	2510	552	21
2540	1840	2182	297	13
2541	2031	2716	311	12
2542	1949	2418	331	14
2543	1894	2624	477	17
2544	1846	2460	447	18
2545	1925	3001	499	17
2546	2045	2845	493	17
2547	2190	2727	470	18
2548	1950	2403	302	12
2549	2199	3047	568	18
2550	2158	2491	379	14
2551	2044	2971	478	16
2552	1914	2799	356	13
2553	1935	2578	327	12
2554	1901	2537	273	10
Mean	1980	2645	410	15
SEM ±	129	195	33	1.2
LSD (P=0.05)	381	564	97	3.4
C.V. (%)	11.3	12.8	14	13.2

varied from 1262 to 2401 kg/ha with a mean of 1795 kg/ha. Grain yield ranged from 332 to 1006 kg/ha with a mean of 602 kg/ha. Total biological yield ranged from 1997 to 3263 kg/ha, and harvest index from 10 to 34%. The common chickling is characterized by slow winter growth, rapid growth in the spring and long flowering period. The late rain favored attack by powdery mildew (Erisiphi pisi) when pods were forming.

Days to flowering and maturity are important selection criteria. Table 5.1.7 shows the correlation coefficients of days to maturity with some major characters. In the five legume species days to 100% flowering were significantly correlated with maturity. Seed yields and harvest index were significantly and negatively correlated with days to maturity.

Table 5.1.6. Herbage yield at 100% flowering, biological and seed yields and harvest index (%) for the high-yielding 10 selections of common chickling (Lathyrus sativus) in preliminary microplot yield trials at Tel Hadya.

Selection IFLLS	Herbage yield (kg/ha)	Biological yield (kg/ha)	Seed yield (kg/ha)	Harvest index (%)
552	2123	2378	605	25
553	2074	3016	1006	34
554	2321	3263	826	25
556	2401	3157	961	30
557	2050	2717	821	29
558	1940	2083	740	23
559	2108	3110	924	29
560	1903	2902	927	23
561	1799	2483	395	17
562	1787	2737	505	18
Grand Mean+	1795	2623	602	23
SEM ±	132	200	80	2.9
LSD (P=0.05)	375	567	229	8.3
C.V. (%)	15	14	23	22.5

+ Grand mean for 36 selection.

Table 5.1.7. Correlation of days to maturity with other characters in four Vicia spp. and Lathyrus sativus.

Species	Characters: 100% flowering	Dry matter yield	Biological yield	Seed yield	Straw yield	Harvest index
Vicia sativa	0.754 **	-0.333 NS	0.104 NS	-0.539 **	0.422 NS	-0.603 **
Vicia ervilia	0.952 **	-0.401 NS	0.252 NS	-0.554 *	0.635 NS	-0.883 **
Vicia palaestina	0.905 **	-0.084 NS	-0.509 *	-0.746 **	-0.298 NS	-0.735 **
Vicia hybrida	0.951 **	0.272 NS	-0.216 NS	-0.541 *	-0.470 NS	-0.637 **
Lathyrus sativus	0.891 **	-0.705 **	-0.425 *	-0.843 **	-0.047 NS	-0.761 **

* Significant at P=0.05; ** significant at P=0.01; NS= not significant.

These results indicate a clear need to continue the search for early maturing genotypes of the five species, as they will be able to escape drought, which is common late in the season.

Table 5.1.8. gives the summary of microplot field trials in 1990/91. Bearing in mind that the feed legumes can be used for pasture, hay, straw and grain production, this summary can be of use in assessing how the various species will fit into farming systems. Yield levels of V. ervilia and Lathyrus sativus suggest that they could be used by farmers who want straw and grain. V. sativa would be recommended for hay, straw and grain production, whereas V. hybrida and V. palaestina would be suitable for grazing because of their low harvest index and grain yield.

Table 5.1.8. Range of the major attributes of four feed legume speceis evaluated in micrplot field trials at Tel Hadya in 1990/91.

Attributes	V. sativa	V. ervilia	V. hybrida	V. palaestina	L. sativus
Days to 100% flowering	98- 107	97- 108	100 - 109	98 - 110	99 - 120
Frost effect [a]	2- 3	1- 2	1 - 2	2 - 4	1 - 2
Herbage yield (kg/ha)	1524-2564	2132-2814	1840-2199	908-1687	1262-2406
Grain yield (kg/ha)	285- 928	780-1298	273- 568	167- 462	232-1006
Straw yield (kg/ha)	1696-2254	1660-2590	1881-2510	1100-1760	1386-2673
Harvest index (%)	20-31.4	25- 38	10- 21	11- 22	10- 33

[a] on a visual scale where 1 = no damage; 5 = all plants killed by frost.

5.1.1.3. Advanced yield trials

Promising lines which were promoted from the microplot studies last season were tested in advanced yield trials at Tel Hadya and Breda. The relatively low rainfall in 1990/91 gave an opportunity to assess the promising lines for drought tolerance. Promising lines of wooly-pod vetch were tested at Tel Hadya, and lines of narbon vetch, common chickling, dwarf chickling and ochrus chickling were evaluated at both Tel Hadya and Breda. The five experiments were sown and managed in the same way as microplot trials except that the plot size was larger (28 m^2).

Advanced yield trial of wooly-pod vetch: Sixteen lines were tested at Tel Hadya. There were differences in herbage yield, biological yield, seed yield and harvest index. Herbage yield varied from 14116 to 1985 kg/ha and seed yield from 106 to 238 kg/ha (Table 5.1.9).

Table 5.1.9. Herbage yield at 100% flowering, biological, and seed yields and harvest index for 16 promising lines of V. villosa subsp. dasycarpa in advanced yield trials at Tel Hadya.

Lines IFLVV	Herbage yield (kg/ha)	Biological yield (kg/ha)	Seed yield (kg/ha)	Harvest index (%)
2650	1712	2127	238	11
2424	1895	1458	169	11
2431	1482	1681	201	12
2437	1520	1634	106	6
2438	1985	1683	108	6
2441	1411	1858	125	6
2442	1632	1782	146	8
2445	1517	1887	125	6
2446	1563	2043	171	8
2450	1572	1796	127	7
2451	1722	1584	135	8
2455	1650	1708	184	10
2456	1479	1679	140	8
2457	1669	1738	171	10
2439	1576	1874	158	8
2454	1803	1790	186	10
Mean	1643	1770	156	8.8
SEM $\pm$	180	163	25	1.1
LSD (P=0.05)	521	471	72	3.9
C.V. (%)	19	16	30	21.7

Harvest index was very low (6 to 12%). Generally, seed production is low in this species because of high flower drop due to high temperatures during the reproductive period. Seed yield was significantly negatively correlated (r=-0.537, P<0.01) with days to 100% flowering, but there was no association (r=-0.200) between herbage production and days to 100% flowering. Wooly-pod vetch is a frost-tolerant species and it is also resistant to broomrape (Orobanche crenata). Developing early flowering and early maturing varieties of this species may result in increased seed yield.

Advanced yield trials of narbon vetch: Experiments were carried out to assess promising lines of narbon vetch at Tel Hadya and Breda (Table 5.1.10). Yields were greater at Tel Hadya than at Breda, the respective mean biological yields being 3724 and 1237 kg/ha and the mean grain yield being 1929 and 677 kg/ha. Harvest index was also greater at Tel Hadya than at Breda (35 vs. 33%), reflecting the differences in total seasonal precipitation at two locations.

Advanced yield trials of common chickling: Sixteen promising lines were tested. Herbage yield varied from 1427 to 1707 kg/ha and 732 to 1993 kg/ha at Tel Hadya and Breda, respectively (Table 5.1.11). Yields were greater at Tel Hadya than at Breda, except for grain yield. Harvest index varied from 7 to 17% and 16 to 38% at Tel Hadya and Breda, respectively. Common chickling lines were only slightly affected by frost at both sites, and the late season rain favored the appearance of the powdery mildew (Erisiphi pisi) at Tel Hadya at pod formation and pod filling stages.

Advanced yield trials of dwarf chickling: Sixteen promsing lines were tested. At Tel Hadya, herbage yield varied from 1977 to 2383 kg/ha and at Breda from 1336 to 2870 kg/ha (Table 5.1.12). In the mature crop the grain yield varied from 359 to 611 kg/ha and 582 to 824 kg/ha at Tel Hadya and Breda, respecitvely. Generally, dwarf chickling produced more seed and straw than common chickling at both locations. The differences between the two sites were less for dwarf chickling than for the other two chickling species, probably because it flowered earlier and was not affected by frost. The high yields of dwarf chickling at Breda may indicate better drought tolerance.

Table 5.1.10. Biological and grain yields and harvest index of promising lines of narbon vetch (V. narbonensis) grown at Tel Hadya (TH) and Breda (B) in advanced yield trials.

Lines	Biological yield (kg/ha)		Grain yield (kg/ha)		Harvest index (%)	
IFLVN	TH	B	TH	B	TH	B
2761	4064	1786	1244	679	30	38
2380	3441	2051	1220	874	35	42
2383	3885	2136	1414	813	36	38
2387	3441	1608	1370	775	39	47
2388	3816	2070	1303	758	34	36
2390	3767	1973	1305	723	34	36
2391	3664	1768	1346	674	36	38
2392	3796	1972	1336	777	35	39
2393	3978	1878	1250	685	31	36
2461	3649	1730	1100	548	30	32
2462	3864	2104	1221	670	31	32
2464	4165	2303	1266	702	30	29
2465	3544	1860	1044	575	29	31
2466	3626	1758	1051	502	28	29
2467	3458	1996	1103	594	31	30
2468	3312	2002	1098	704	33	34
2469	3858	1808	1220	620	32	34
2470	3597	1852	1134	579	31	31
2471	3856	1697	1301	584	33	34
2473	3658	2008	1227	565	33	28
2474	3576	1623	1150	548	32	33
2475	3994	1919	1261	670	31	35
2476	3923	1919	1310	691	33	36
2477	3820	2356	1399	946	36	40
2478	3797	2042	1246	662	32	31
Mean	3724	1929	1237	677	33	35
SEM ±	442	145	81	50	1.4	1.7
LSD(P=0.05)	638	417	233	143	4.0	4.8
C.V.(%)	10	13	12	13	7.3	8.3

Advanced yield trials of ochrus chickling: In the 1987/88 season, which had mild cold, ochrus chickling produced the highest seed and straw yields of all the feed legumes because of its earliness and its resistance to broomrape (Orobanche crenata). The 1988/89 and 1989/90 seasons gave an opportunity to test the reaction of this species to the

Table 5.1.11. Herbage, biological and seed yields and harvest index for 16 promising lines of common chickling grown at Tel Hadya (TH) and Breda (B) in advanced yield trials.

Lines IFLLS	Herabge yield (kg/ha)		Biological yield (kg/ha)		Seed yield (kg/ha)		Harvest index (kg/ha)	
	TH	B	TH	B	TH	B	TH	B
587	1851	1393	2698	1698	398	638	15	38
504	1671	1019	2280	1403	405	410	17	28
505	1618	753	2317	940	291	210	12	22
508	1883	1108	2470	1363	285	426	11	32
510	1712	805	2771	1097	373	334	13	28
516	1443	822	2414	1287	247	227	10	18
519	1780	993	2545	1129	331	231	12	21
520	1623	863	2272	1333	213	250	9	18
522	1731	1221	2534	1403	359	431	14	32
527	1427	836	2214	1198	226	198	10	16
528	1600	903	2101	1165	295	227	14	19
529	1993	1103	2710	1645	411	534	14	31
530	1753	1022	2525	1338	331	331	13	24
531	1667	1220	2374	1628	318	513	13	30
533	1549	848	1918	1070	283	203	14	18
535	1935	1370	2777	1651	192	325	7	18
Mean	1702	1022	2432	1334	310	343	12	25
SEM ±	102	123	119	137	46	42	1.7	2.4
LSD(P=0.05)	301	357	352	397	131	124	4.9	7.0
C.V.(%)	11	20	9	18	25	21	23	16

cold, which was severe. In that season all ochrus chickling selections were severely damaged by frost, which markedly reduced their total biological yield and grain yield. Plants that survived the cold were selected for further tests in 1990/91 in the form of advanced yield trial of 16 entries. Total biological yield varied from 1833 to 2354 kg/ha and from 167 to 892 kg/ha, at Tel Hadya and Breda respectively (Table 5.1.13). Grain yield ranged from 283 to 519 at Tel Hadya and from 47 to 247 kg/ha at Breda. Ochrus chickling is resistant to Orobanche crenata, and is early flowering. It can, therefore, be an ideal legume for Orobanche-infested areas.

Table 5.1.12. Herbage, biological and grain yields and harvest index for 16 lines of dwarf chickling (Lathyrus cicera), grown at Tel Hadya (TH) and Breda (B) in advanced yield trials.

Lines IFLLC	Herbage yield (kg/ha)		Biological yield (kg/ha)		Grain yield (kg/ha)		Harvest index (%)	
	TH	B	TH	B	TH	B	TH	B
501	2004	1366	2469	1821	359	605	14	33
486	2083	1658	2853	1765	600	596	21	34
487	2339	1851	2929	1939	571	712	19	36
488	2056	1661	2732	1796	521	760	18	42
489	2062	1336	2574	1914	493	632	19	33
490	2115	1419	2636	1593	477	582	18	36
491	1977	1651	2907	1806	606	702	21	38
492	2201	1677	2971	1998	550	732	18	36
493	2383	2870	2688	1929	536	744	20	38
494	2235	1586	2867	1746	525	621	18	35
495	2076	1476	2944	1715	572	663	19	39
496	2335	1590	2906	1712	611	687	21	40
497	2006	1605	2727	1917	590	824	22	43
498	2074	1972	2899	1698	555	659	19	39
499	2022	1500	2694	1782	508	616	19	34
500	1987	1551	2820	2028	486	713	17	36
Mean	2122	1673	2788	1819	535	680	19	37
SEM ±	126	371	108	99	46	38	1.3	2.3
LSD (P=0.05)	326	992	317	290	135	112	3.8	6.8
C.V. (%)	28	20	16	21	15	22	12	11

Table 5.1.14 is a summary of the advanced yield trials in 1990/91, at Tel Hadya and Breda, for three chickling species and one narbon vetch. The susceptibility of ochrus chickling to frost is clear and when rainfall is below 300 mm, its yield decreases. It has also the lowest seed and straw yields at Breda. For these reasons, it is recommended only for regions with mild winter until new genotypes with frost tolerance are available. Dwarf chickling and common chickling produced high grain and straw at both sites; therefore, they are recommended for producing grain and straw in dry areas. Under Breda conditions the average grain yield of narbon vetch was 677 kg/ha and straw yield 1252 kg/ha. These characters make it a suitable crop for producing winter

Table 5.1.13. Biological and grain yields and harvest index of 16 lines of ochrus chickling (Lathyrus ochrus) grown at Tel Hadya (TH) and Breda (B) in advanced yield trials.

Lines	Biological yield (kg/ha)		Grain yield (kg/ha)		Harvest index (%)	
IFLLO	TH	B	TH	B	TH	B
185	1881	777	360	195	19	24
537	1883	635	519	152	27	22
538	1996	531	434	243	21	46
539	1917	601	392	185	20	32
540	1975	826	400	247	20	29
541	1830	481	469	140	25	28
542	1388	335	343	102	25	30
543	1668	167	375	47	22	27
545	1805	490	431	111	24	21
546	1916	711	297	173	15	24
547	1729	644	311	144	17	25
548	2354	892	501	169	21	19
549	1723	598	283	148	16	26
550	1935	384	342	85	17	22
551	1931	456	351	97	17	18
104	1523	500	364	148	23	29
Mean	1841	546	386	149	21	26
SEM ±	178	101	46	28	1.8	3.8
LSD (P=0.05)	514	299	137	82	5.0	11.2
C.V. (%)	17	25	21	25	15	25

stocks of straw and grain to feed sheep. It does not lose its leaves following frost like ochrus chickling. It is also resistant to bird damage at the seedling stage, an attribute which is a major advantage in establishing a good plant population. It is also easy to establish because of its large seeds and can be sown deeper at lower to soil moisture than other legume species.

5.1.1.4. Feed legumes genetic improvement

Breeding common vetch for non-shattering character: Loss of seeds from maturing pods of common vetch constitutes a serious economic problem and

Table 5.1.14. Average of major attributes of four feed legume species grown at Tel Hadya and Breda in advanced yield trials.

Attributes	Narbon vetch	Common chickling	Dwarf chickling	Ochrus chickling
		Tel Hadya		
Frost effect[1]	1.0	1.6	1.1	3.5
Days to maturity	148	159	152	135
Grain yield (kg/ha)	1237	310	535	386
Straw yield (kg/ha)	2487	2122	2253	1428
Harvest index (%)	33	12	19	21
		Breda		
Frost effect	1.1	2.0	2.5	4.1
Days to maturity	145	143	145	130
Grain yield (kg/ha)	677	343	680	149
Straw yield (kg/ha)	1252	991	1139	397
Harvest index (%)	35	25	37	26

[1] On a visual score where 1 = no damage; 5 = nearly killed by frost.

severely restricts the use of the species as a feed legume crop to replace fallow in cereal-fallow rotation. The common vetch grown in fallow lands causes severe "vetch weed" problems in subsequent cereal crops. Also, pod shattering makes harvesting time critical and increases harvest costs.

Work was initiated in 1983/84 to screen a large number of common vetch germplasm accessions for non-shattering pods. Screening was done firstly under normal field conditions and plants were left in the field during July when intense summer heat was conducive to pod shattering. Visual scoring was done using a 0 to 5 scale (0, non-shattering; 5 about 95% shattering). Selected genotypes having non-shattering pods were tested again in the greenhouse where the intense summer heat accentuated pod-shattering even more than what occurs in normal field conditions. Scoring done during July revealed that selections IFLVS 1361, 1416 and

2014 were most promising, but these accessions were associated with undesirable traits such as late flowering, late maturity and low herbage yield.

Crosses were therefore made between those non-shattering genotypes and three promising lines (IFLVS 2650, 716 and 715) but with high proportion of pod shattering. In the F_2 plants non-shattering was observed to be controlled by single dominant gene. The F_1 plants were successfully backcrossed to the shattering parents to reconstitute plants with complete non-shattering, early flowering, early maturity, erect and non-lodging growth habits.

Five superior families were selected from BC_4: IFLVS (NS) 2565, 2558, 2014, 2557 and 1448. These will be distributed to national programs for further testing in different agro-ecological zones.

Studies on the hybrids among V. sativa subsp. sativa and V. sativa subsp. amphicarpa: Species and subspecies hybridization is an important aspect in feed legume breeding to recombine useful genes carried by the parental species or subspecies. Results of the last two years indicated that the ability of underground vetch (V. sativa subspecies amphicarpa) to produce both aerial and underground pods increases its winter hardiness, drought tolerance and persistence under heavy grazing. The disadvantages connected with underground vetch which may limit its utilization are the low rate of vegetative growth, shattering of aboveground pods and the dependence of amphicarpy on edaphic conditions. In contrast, the common vetch V. sativa subsp. sativa grows well under favorable conditions but is not cold and drought tolerant and there are some lines with non-shattering pods.

To increase the productivity of underground vetch and to improve the drought and cold tolerance of the common vetch, work was initiated in 1989/90 to combine specific characters from the two subspecies, to study the compatability between them and to obtain variability from the intraspecific crosses. Crosses were made between Vicia sativa subsp.

amphicarpa selections 2416 and 2660 originating from Turkey and V. sativa subsp. sativa (non-shattering IFLVS 2568 and 1448). Gene markers such as pod, seed, flower and straw colors were used to eliminate F_1 pods which might develop from selfing.

F_1 plants were grown in 1990/91. The high vigor was clearly observed in the F_1 plants carrying few underground pods. Selection will be carried out from F_2 onwards for two types of plants: Vicia amphicarpa with vigorous aboveground growth and V. sativa with cold and drought tolerance.

5.1.2. Rotation Trial: Barley Yields after Underground Vetch (V. sativa subsp. amphicarpa): Underground vetch was grown in 1989/90 in large plots (100 m^2), replicated three times, and allowed to be grazed by sheep at the end of February, end of March and end of April. Plots were also left without grazing along with barley plots. The productivity of this vetch was determined and the amounts of underground seeds under each grazing treatments were estimated.

In 1990/91 season, barley variety Atlas 46 was planted after underground vetch on the same plots and also after the barley plots of 1989/90 season. During the barley phase the seed bank of underground vetch was monitored.

Table 5.1.15 shows the grain and total biological yields of barley, and seed banks of underground vetch at the beginning and the end of the barley phase. Barley after barley produced significantly less yields than barley grown after underground vetch. Grazing of underground vetch had no effects on the productivity of barley. Early grazing of the vetch greatly affected the yield of underground seeds. Seed banks varied from 32 kg/ha for February grazing to 218 kg/ha without grazing. The difference in the vetch seeds found buried in the soil at the beginning and at the end of barley phase would give an indication of germination and hardseededness of buried seeds during the barley phase.

Ali Abd El Moneim

Table 5.1.15. Barley yields (kg/ha) after underground vetch *V. sativa* subsp. *amphicarpa*, grazed at different dates in 1989/90, compared with barley, after barley and seed banks at the beginning and at the end of 1990/91 season.

	1989/90 season treatments						
	V. sativa subsp. *amphicarpa*				Barley		
	Grazed in February	Grazed in March	Grazed in April	No grazing		SE ±	LSD (P=0.05)
Seed yield of barley (kg/ ha)	1966	2035	1925	1909	1599	98.0	227.0
Total biological yield of barley (kg/ha)	4346	4193	3947	3877	3143	215.9	497.9
Seed bank of *V. sativa* subsp. *amphicarpa* at the start of 1990/91 season (kg/ha)	50	130	160	240	-	27.8	75.1
Seed bank at the end of 1990/91 season (kg/ha)	32	95	141	218	-	34.7	85.1

5.1.3. Forage Legume Pathology

Resistance to major stem and leaf diseases is one of the selection criteria for developing productive forage legumes. In 1990/91 season, 25 promising lines of narbon vetch, 16 of wooly-pod vetch, and 16 each of common chickling, dwarf chickling and ochrus chickling were tested under artificial ephiphytotic conditions. Screening for resistance to powdery mildew (Erysiphi pisi f.sp. viciae), downy mildew (Peronospora viciae), Ascochyta leaf-spot and stem blight (Ascochyta pisi f.sp. viciae) and Botrytis blight (Botrytis cinera) was done with the two Vicia spp. Powdery mildew (Erysiphi martii f.sp. lathyri), downy mildew (Peronospora trifoliorum), Ascochyta blight (Ascochyta pisi f.sp. lathyri) and Botrytis blight (Botrytis cincera) were the diseases for which the three chickling species lines were evaluated. A 5-point scale was used: 1 = resistant, 5 = highly susceptible.

Table 5.1.16 shows the reaction of narbon vetch and wooly-pod vetch lines to major diseases. None of the tested lines could be rated as resistant; however, most of the lines were moderately resistant or tolerant.

Results on Lathyrus spp. in Table 5.1.17 revealed that some lines were moderately resistant or tolerant. Most Lathyrus sativus lines were highly susceptible to powdery mildew (11 lines) and ascochyta blight (8 lines). More emphasis will be given to identify sources of resistance to these two diseases.

5.1.4. Nematode Studies

Surveys carried out over the last 5 years revealed that root-knot nematode (Meloidogyne artiella Franklin) and cyst nematode (Heterodera ciceri Volvas, Greco, et Di Vito) attack the roots of Vicia spp. and Lathyrus spp. Therefore, a new objective in our breeding program is to search for nematode resistance in Vicia spp. and Lathyrus spp. and incorporate this resistance in promising cultivars.

Table 5.1.16. Reaction of 25 narbon vetch and 16 wooly-pod vetch lines to major diseases under artificial conditions.

Crops and scores*	Diseases			
	Ascochyta blight	Downy mildew	Powdery mildew	Botrytis blight
Narbon vetch				
1	0	0	0	0
2	7	3	11	3
3	9	14	14	19
4	9	8	0	3
5	0	0	0	0
	25	25	25	25
Wooly-pod vetch				
1	0	0	0	0
2	14	15	1	0
3	2	1	7	11
4	0	0	8	5
5	0	0	0	0
	16	10	10	16

* 1 = Resistant; 5 = Highly susceptible.

In the 1990/91 season 25 lines of narbon vetch and 16 each of wooly-pod vetch, common chickling, dwarf chickling and ochrus chickling were tested for resistance to cyst and root knot nematodes under natural conditions in a heavily infested field where the average number of cyst nematode was 35/100 g soil and of second stage juveniles of root-knot nematode was 1065/100 g soil. These levels are ideal for screening for both kinds of nematodes.

Reconfirmation was done under artificial conditions in the plastic house using the infection rate of 200 eggs of cyst nematode/g of soil and 20 second stage larvae of root-knot nematode/g soil. Seeds were sown in earthen pots with six replicates of each lines and 3 plants/pod. At 100% flowering the plants were uprooted, roots were carefully washed and the density of nematodes measured on a 5-point scale: 1 = no galls,

Table 5.1.17. Reaction of three chickling species lines to major diseases under artificial infection.

Crops and scores*	Diseases			
	Ascochyta blight	Downey mildew	Powdery mildew	Botrytis blight
L. sativus				
1	0	0	0	0
2	0	7	0	4
3	2	9	3	9
4	6	0	2	3
5	8	0	11	0
L. cicera				
1	0	0	0	0
2	15	9	2	0
3	1	7	4	5
4	0	0	9	10
5	0	0	1	1
L. ochrus				
1	0	0	0	0
2	7	11	0	1
3	6	5	5	10
4	3	0	4	5
5	0	0	7	0

* 1 = Resistant; 5 = highly susceptible.

(resistant); 2 = light galling (moderately resistant); 3 = moderate galling (tolerance); 4 = extensive galling (susceptible); and 5 = very extensive galling (highly susceptible).

Results (Table 5.1.18) revealed that none of the accessions of narbon vetch and wooly-pod vetch showed resistance to both nematodes. However, most lines of narbon vetch were moderately resistant to root-knot nematode, and 21 lines were susceptible to highly susceptible to cyst nematode. All the tested lines of wooly-pod vetch were moderately resistant to cyst nematode and 14 lines were also moderatley resistant to root-knot nematode.

Table 5.1.18. Reaction of narbon vetch and wooly-pod vetch lines to root knot and cyst nematodes.

Crops and score*	Nematodes	
	Root-knot	Cyst
	No. of lines	
Narbon vetch		
1	0	0
2	13	4
3	11	15
4	1	0
5	0	6
Wooly-pod vetch		
1	0	0
2	14	16
3	0	0
4	2	0
5	0	0

* 1 = resistant; 5 = highly susceptible.

Results on chicklings indicated that none of the lines of the three chickling speceis showed resistance to root-knot and cyst neamtode (Table 5.1.19). Most lines of the three chickling species were moderately resistant to root-knot nematode. In contrast, cyst nematode attacked most of the lines of common chickling and dwarf chickling. Emphasis will be given to screen larger number of lines for resistance to cyst nematode in Lathyrus spp.

Ali Abd El Moneim

5.1.5. Crop Physiology

5.1.5.1. Growth, development, yield and water use efficiency of food and feed legume crops

Growth, development, yield, and water use efficiency (WUE) of cool-season food and feed legume crops were studied for relative differences

Table 5.1.19. Reaction of common chickling, dwarf chickling and ochrus chickling lines to root knot and cyst nematodes.

Crops and score*	Nematodes	
	Root knot	Cyst
	No. of lines	
<u>Common chickling</u>		
1	0	0
2	15	0
3	1	3
4	0	10
5	0	3
<u>Dwarf chickling</u>		
1	0	0
2	14	0
3	2	6
4	0	10
5	0	0
<u>Ochrus chickling</u>		
1	0	0
2	11	2
3	0	13
4	5	1
5	0	0

* 1 = resistant; 5 = highly susceptible.

between crops and varieties. The objective was to develop a better understanding of the most favorable and synergistic combinations of crop and resources of climate. Such knowledge is useful in identifying appropriate crops and cropping systems for maximum, stable and sustainable exploitation of the limiting available resources for production. Information on some of these and other related aspects is available in literature for individual food legume crops such as chickpea, lentil, faba bean and pea. However, the available information can not be used for studying relative differences in adaptation and performance across crops because of the known strong genotype X environment interactions in cool-season food legume crops. Extrapolating results of experiments conducted across very dissimilar conditions would be inaccurate and could even be misleading. In the case of feed legume crops very little information has been published on these aspects. We therefore studied growth, development and yield formation in two varieties each of eight legumes, four food and feed legume crops.

This experiment was conducted in a split-plot design at Tel Hadya farm. The eight legume crops were randomized in the main plot and the two varieties of each in the sub-plots. Crops and the abbreviations of the genotypes (used for convenience of reference) are listed in table 5.1.20. The treatments were replicated three times. The crops were grown at optimum row spacings and seed rates recommended for each crop.

Hand sowing was done on 18 Dec 1990 and a uniform irrigation of 30 mm was applied by sprinkler irrigation on 20 Jan to facilitate crop establishment. Rainfall until middle of March continued to be deficient (164 mm in 1990/91 compared with 212 mm in 1989/90 and 258 mm the long-term average). Wide fluctuations in temperature, both maximum, and minimum occurred in March. Open pan evaporation and the maximum temperatures commenced to rise in April. By middle of May the atmospheric component of drought increased with the daytime temperatures rising to 30°C and above and open pan evaporation values ranging between 10 and 12 mm/day, accompanied by strong winds (wind run/day in the first fortnight of May was 273 ± 28.8 km, reaching 600 km on some days, compared with 161 ± 26.7 km in the last week of April) forcing crops to mature over a relatively short period of time.

A close correlation (r^2 = 0.81, n=16) between seed size and time of emergence was observed across food and feed legume crops. Emergence of feed legume crops was faster than the food legumes (Fig. 5.1.2).

Rate of water uptake by the seeds was studied in a laboratory experiment at a constant temperature of 25^0 C. It showed a linear relationship for all the crops and their genotypes during the first 11h.

Table 5.1.20. Days to emergence, flowering and maturity in four food and feed legume crops on calcic Rhodoxerol, Tel Hadya, 1990/91.

Crops	Varieties		Days from sowing to		
			emergence	flowering	maturity
Food legumes					
Chickpea (CP)	V1	ILC 482	40	118	159
	V2	ILC 3279	40	125	159
Lentil (Len)	V1	ILL 4401	37	116	147
	V2	ILL 4400	36	115	149
Pea (Pea)	V1	Acc. No.21	39	118	137
	V2	Acc. No.51741	39	112	140
Faba bean (FB)	V1	ILB 1811	46	99	160
	V2	ILB 1814	46	98	160
Feed legumes					
Vicia sativa (Vs)	V1	Acc. No.2541	36	117	139
	V2	Acc. No.715	36	122	144
Vicia narbonensis	V1	Acc. No.67	41	109	136
(Vn)	V2	Acc. No.120	41	113	140
Vicia villosa ssp.	V1	Acc. No.683	35	114	150
dasycarpa (Vvd)	V2	Acc. No. 800	35	116	153
Lathyrus sativus	V1	Acc. No. 347	38	108	148
(Ls)	V2	Acc. No.3	38	107	157
S.E. (±)			0.17	1.4	1.07
L.S.D. ($P \leq 0.05$)			0.50	4.3	3.2

of incubation. The rate of uptake of water was most rapid for faba bean > chickpea > dry peas > Vn (Table 5.1.21). Varietal differences in water uptake between the two varieties of each crop studied were nonsignificant for CP, Vvd and Vs. Chemical constituents of seeds were analyzed to relate water uptake of seeds (Table 5.1.22). In the feed legume crops protein content was high, but soluble sugars and starch were low. Across the food and feed legume crops studied, fat content was the highest in chickpea; potassium content was highest in faba bean followed by chickpea. When water was not limiting, water uptake across food and feed

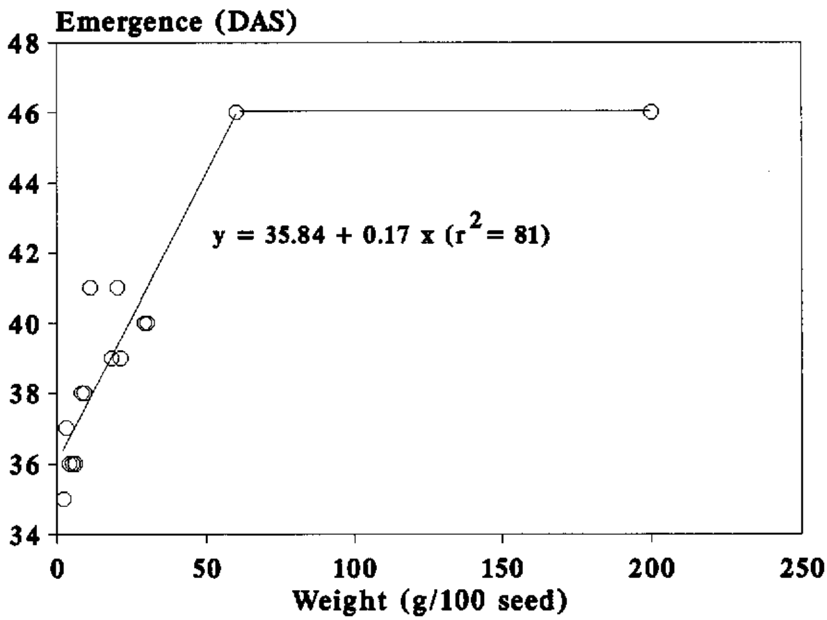


Figure 5.1.2. Relationship between seed size and seedling emergence in days after sowing (DAS) in eight food and eight feed legumes on a calcic Rhodoxerol, Tel Hadya 1990/91.

Table 5.1.21. Varietal differences in the regression estimates of the intercept (g water/10 seeds) and slope (g water 10 seed/h) r^2 and residual mean of squares (m.s.) for a linear fit, in food and feed legume crops.

Crop	Variety	Intercept		Slope		r^2	Residual m.s.
		estimate	±S.E	estimate	±S.E.		
Lentil	ILL 4400	-0.025	0.033	0.0499	0.0043	84.3	0.00393
	ILL 4401	0.022	0.033	0.0256	0.0043		
Chickpea	ILC 482	1.101	0.125	0.1936	0.0162	89.7	0.0550
	ILC 3279	1.116	0.125	0.2013	0.0162		
Faba bean	ILB 1811	0.413	0.408	0.4477	0.0529	97.8	0.5883
	ILB 1814	0.499	0.408	1.5153	0.0529		

Cont'd.

Dry Peas	Acc#21	0.606	0.097	0.1752	0.0126	90.6	0.0336
	Acc#30	0.660	0.097	0.1336	0.0126		
V.v. spp.	683	-0.024	0.024	0.0109	0.0031	33.4	0.00205
dasycarpa	800	-0.013	0.024	0.0084	0.0031		
Vicia Sativa	715	0.043	0.024	0.4640	0.0031	93.1	0.00201
	2541	0.052	0.024	0.0477	0.0031		
V. narbonensis	67	0.395	0.100	0.0948	0.0130	88.7	0.03550
	120	0.248	0.100	0.1744	0.0130		
Lathyrus sativus	3	0.116	0.037	0.0859	0.0061	90.6	0.007795
	342	0.208	0.047	0.0705	0.0061		

Table 5.1.22. Moisture, protein, P, K, fat, soluble sugars, and starch content of food and feed legume crops grown on a Calcic Rhodoxeralf, Tel Hadya, 1990/91.

Crop	Genotype	Moisture (%)	Protein (%)	P (%)	K (%)	Fat (%)	Soluble sugars (%)	Starch (%)
Chickpea	ICC 482	5.6	23.2	0.42	0.71	4.42	7.1	48.6
	ICC 3279	5.3	22.2	0.43	0.77	5.34	6.8	50.2
Lentil	ILL 4400	6.3	27.2	0.41	0.54	0.72	6.7	47.1
	ILL 4401	6.1	26.1	0.35	0.33	0.72	5.7	47.1
Dry pea	Acc#21	6.2	24.2	0.35	0.32	0.94	6.9	51.2
	Acc#30	5.7	29.0	0.40	0.35	1.14	6.9	50.0
Faba bean	ILB 1811	5.8	26.1	0.41	0.79	0.73	5.5	51.8
	ILB 1814	6.5	23.7	0.49	1.14	0.97	7.2	45.0
V. sativa	Acc#715	6.0	30.3	0.50	0.42	0.75	5.4	47.6
	Acc#2541	5.9	28.2	0.45	0.41	0.69	4.9	51.2
V. narbonensis	Acc#67	5.6	28.0	0.42	0.41	0.87	5.5	45.3
	Acc#120	5.8	27.1	0.51	0.47	1.13	5.3	44.7
V. v. ssp. dasycarpa	Acc#683	4.5	30.5	0.46	0.27	0.73	5.2	43.2
	Acc#800	6.4	30.5	0.43	0.24	0.94	5.6	43.2
Lathyrus sativus	Acc#3	4.7	31.0	0.50	0.58	0.76	5.8	42.1
	Acc#347	5.7	29.8	0.46	0.42	0.86	4.9	44.2

legume crops was positively and very strongly correlated with the seed size, mass and volume, and with the potassium content of seeds (Table 5.1.23). Relationship with P was nonsignificant. Among the organic metabolites, relationships with sugars and proteins were relatively small but of similar magnitude, being positive for sugars and negative for proteins. Relationships with fat and starch content were negligible. The relationship of seed potassium content with water uptake is of significant value, provided the relationship is maintained even under water-limiting conditions. It would enable selecting genotypes with high K content of seeds for improving plant stand establishment under limiting seed bed moisture of rainfed conditions.

Table 5.1.23. Correlation between rate of water uptake and some physical parameters, chemical constituents by seeds across food and feed legume crops (n-2= 14).

Seed characteristics	Correlation coefficient
100 seed weight	0.996**
Seed volume	0.996**
K (%)	0.837**
P (%)	0.221
Soluble sugars (%)	0.465*
Starch (%)	0.004
Protein (%)	-0.498**
Fat (%)	0.051

* Significant at $P \leq 0.05$
** Significant $P < 0.01$

Differences in early crop growth rate, between 12 and 21 days after emergence, were large and very closely correlated with the seed size (Fig. 5.1.3). These differences continued to be significant up to the period of rapid seed development. Difference in CGR during the most rapid period of seed filling accounted for nearly 25% of the variation in seed yield, across crops and varieties. Crop growth during the terminal period of seed filling was most rapid, the period during which the

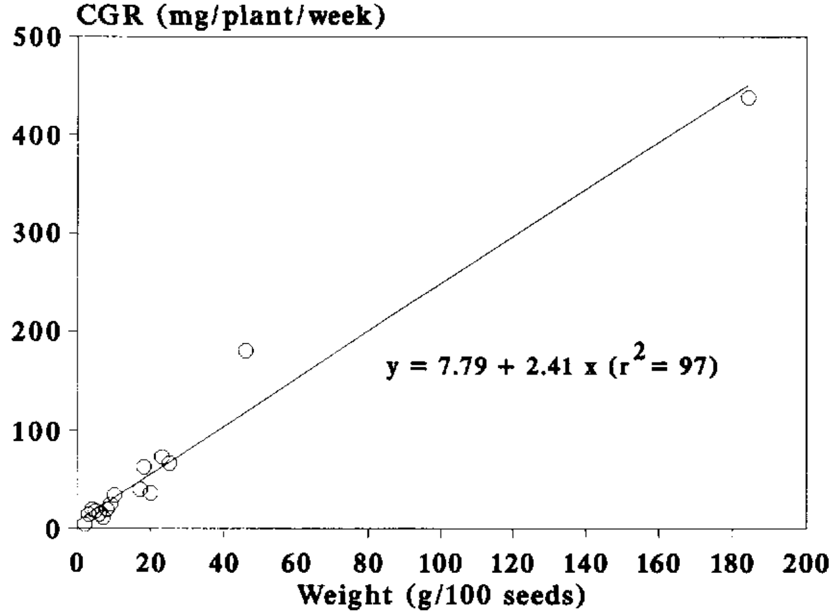


Figure 5.1.3. Relationship between seed size (g/100 seeds) and crop growth rate (CGR = g/pl /week) across 8 food and 8 feed legume species between 12 and 21 days after emergence. ICARDA, 1990/91.

differences between crops and genotypes were minimized and became nonsignificant. Soon after a large decline in CGR occurred for most of the crops.

Flowering commenced in faba bean first, the crop which was last to emerge (Table 5.1.20). Differences in time of flowering of crops were large, but were narrow for maturity (Table 5.1.20). Overall, the seed yield, shoot mass, and harvest index (Table 5.1.24) were low. Ranking of the various crops (mean of the two varieties) for these three characters was as follows:

Seed yield	Vn	CP	FB	Ls	Len	Vs	Pea	Vvd
Total biological yield	Vn	Ls	CP	Vs	Vvd	FB	Len	Pea
Harvest index	FB	Vn	CP	Len	Pea	Vs	Ls	Vvd

Highest total biological and seed yield was recorded in the two varieties of Vn. Seed yield in ILC 482 chickpea was similar to Vn. Genotypes within a crop differed in seed yield, except for pea and Vvd (Table 5.1.24). On the other hand, total biological yield was similar,

Table 5.1.24. Differences in seed yield (SY) and total biological yield (IBY), kg/ha, and harvest index (%)between food and feed legume crops and varieties within a crop species. Tel Hadya, on calcic Rhodoxerol, 1990/91.

Crops	SY (kg/ha)		TBY (kg/ha)		Harvest index(%)	
	Variety	Crops	Varieties	Crops	Varieties	Crops
Chickpea	891		3174		28	
ILC 482	1103		3037		36	
ILC 3279	678		3311		21	
Lentil	644		2492		26	
Syrian Local (Small)	805		2530		32	
Syrian local (large)	483		2453		20	
Pea	466		1950		24	
Acc. No. 21	484		2267		21	
SV 51741	448		1634		28	
Faba bean	886		2534		35	
Syrian Local (small)	802		2183		37	
Syrian Local (large)	971		2885		34	
<u>Vicia</u> <u>sativa</u>	630		2752		23	
Acc No. 2541	745		2762		27	
Acc No. 715	514		2742		19	
<u>Vicia</u> <u>narbonensis</u>	1283		3774		34	
Acc No. 67	1433		4140		35	
Acc No.120	1133		3409		33	
<u>Vicia</u> <u>v</u>. ssp. <u>dasycarpa</u>	416		2706		16	
Acc No. 683	350		2679		13	
Acc No. 800	481		2733		18	
<u>Lathyrus</u> <u>sativus</u>	646		3224		20	
Acc No. 347	517		3163		16	
Acc No. 3	776		3286		24	
SE (±)	70.8	84.2	200.3	236.2	1.9	2.1
LSD (.05)	150.1	180.6	424.7	506.7	4.1	4.4

in general, except for the two genotypes of FB. The larger seeded genotype (ILB 1814) produced higher shoot mass (Table 5.1.24).

Differences in seasonal evapotranspiration loss of soil moisture were nonsignificant between the crops but the differences in WUE between crops were large and significant (Table 5.1.25). Vn and Ls had the highest WUE for total biological yield and Vn the highest WUE for seed yield.

Table 5.1.25. Cumulative evapotranspiration (mm water), shoot mass and seed yield (Kg/ha), and water use efficiency (Kg/mm water used) of shoot mass and seed yield in four food and feed legume crops, on calcic Rhodoxeral, Tel Hadya, 1990/91.

Crops	SY (kg/ha)	TBY (kg/ha)	Et (mm)	WUE (kg/ha/mm) SY	WUE (kg/ha/mm) TBY
V. narbonensis (#67)	1428	4124	220	6.47	18.76
Chickpea (ILC 482)	1000	2853	227	4.40	12.57
Faba bean (ILB 1811)	833	2221	217	3.84	10.24
Lentil (ILL 4401)	857	2701	230	3.72	11.72
V. sativa (# 2541)	718	2709	227	3.16	11.94
Lathy sativus (# 347)	582	3310	217	2.67	15.24
Pea (#21)	524	2394	223	2.35	10.74
V.V. dasycarpa (#683)	382	2445	221	1.73	11.08
S.E. Of mean	117.7	244.1	6.5	0.53	1.26
LSD (P≤0.05)	393.1	816.2	21.7	1.76	4.23
C.V.	21.0	12.1	4.1	20.98	13.98
Variance ratio	7.7	6.34	0.59	7.76	5.12
Significance	NS	*	**	*	**

* Significant at P = 0.05,
** significant at P = 0.01,
NS = Not significant

Early season drought was fairly severe in the 1990/91 season at Tel Hadya. Rainfall was deficient by 36%, compared with the normal up to the time of the first flowering in faba bean (164 mm vs 258 mm, the long-term average). One reason for the low potential productivity of both shoot mass and seed yield could be the shorter crop growth duration caused by both delay in planting and a subsequent delay of 35-40 days in emergence of the crops (Table 5.1.20). Also, crops were forced to mature because of a rapid change in weather conditions during terminal crop growth stages. Under the characteristic pattern of drought that prevailed during 1990/91 season, Vn was the best of the food and feed legume crops studied for both TBY and seed yield. It was also the most efficient user of water. Ls was the second best in TBY but poorer in seed yield compared with chickpea.

N.P. Saxena and M.C. Saxena

5.1.6. Insect Pests

No detailed survey could be done but the crops at Tel Hadya were monitored. Aphids developed on Vicia villosa ssp. dasycarpa and nodules of Vicia spp. and Lathyrus spp. were damaged by Sitona larvae. Armyworm (Spodoptera exigua) was reported to be causing severe damage to Vicia villosa ssp. dasycarpa in Baluchistan.

S. Weigand and Ali Abd El Moneim

5.2. Dry Peas

The pea research at ICARDA was initiated in 1986/87. As extensive varietal improvement work is being done on peas at a number of institutions in the developing and developed countries we intend to capitalise on this research, instead of running our own breeding program, to identify dry pea cultivars adapted to the farming systems of WANA. Our work is concentrated in the following areas:

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

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

5.2.1. Germplasm Collection and Evaluation

Seventy-two accessions (hereafter referred as Acc No.) obtained from various institutions along with 3 repeated checks (Acc No. 223, 224 and 225) were evaluated at Tel Hadya in an augmented block design. The data were recorded on various phenological and morphological characters. Time taken to first flower ranged from 76 days for Acc No. 413 to 104 days for Acc No. 448; time taken from sowing to maturity ranged from 118 days for Acc No. 440 to 132 days for Acc Nos. 380, 383, 402, 412, and 447. The plant height ranged from 22 cm for Acc Nos. 393, 426, and 448 to 49 cm for Acc No. 49. Seed yield varied from 0 to 1365 kg/ha. The highest yielding twenty entries are given in Table 5.2.1.

Table 5.2.1. Seed yield, Adjusted seed yield, days to flowering, days to maturity, plant height, harvest index and leaf type of 20 highest yielding lines in pea germplasm evaluated during 1990/91 at Tel Hadya.

Acc No.	Seed yield (kg/ha)		Days to		Plant	Harvest	Leaf
	yield	Adj. YLD	Flowering	Maturity	height	index	type
425	1365	1116	81	128	49	0.4388	C
422	1250	1095	90	132	42	0.1399	C
428	1183	824	80	125	42	0.4276	C
412	1083	1130	76	132	46	0.4255	C
417	1042	782	80	127	45	0.4202	SL
424	1042	1206	83	122	45	0.4252	C
445	937	678	80	130	38	0.4018	SL
446	896	942	88	127	38	0.4018	SL
386	854	595	86	128	36	0.4457	C
375	833	678	87	130	35	0.2817	C
439	833	574	81	126	38	0.4494	C
372	770	817	87	129	45	0.3274	C
379	688	532	87	131	32	0.3548	C
399	667	713	88	125	37	0.3810	SL
380	646	789	85	132	34	0.2533	C
419	646	692	81	125	43	0.4122	SL
384	625	671	94	128	36	0.3371	C
418	562	623	78	125	47	0.3971	C
387	542	602	96	131	31	0.2826	SL
Range	0-1374	0-1025	72-98	118-132	22-49	0-0.5309	

SL = Semi-leafless, C = Conventional.

5.2.2. Cold Tolerance

Four hundred and forty test entries grown on 1 November at Tel Hadya were evaluated for cold tolerance on 1-9 scale (1 = free of damage, 9 = killed). A total of 136, 262, and 42 accessions took ratings between 2-3, 4-6, and 7-9 respectively. Since the effect of cold was not severe this season because of delayed sowing in November these lines will be rescreened while planting in October for reconfirmation next season.

5.2.3. Preliminary Yield Trial (PPYT)

Forty-eight superior entries selected from the germplasm as well as the Preliminary Yield Trial (PPYT) of 1989/90 were tested during the 1990/91 season in PPYT at two locations, Tel Hadya and Terbol. The germination was extremely poor at both locations and the trials were discarded.

5.2.4. Pea International Adaptation Trial (PIAT)

Twenty-three entries selected from PPYT and PIAT conducted during 1989/90 along with a local check comprised the PIAT. The trial was conducted at Tel Hadya and Jindiress in Syria, and Terbol in Lebanon. The ANOVA for seed yield revealed that 3 entries at Tel Hadya and 17 entries at Terbol excelled the local check by a significant margin (Table 5.2.2). On the basis of average over locations the five best-yielding entries included MG102702, PS 210713, Local Sel 1690, Maitland and Wirrega. The entries PS2106588 and PS510699 were earliest to flower (90 days from sowing) and Maitland was latest to flower (107 days). The plant height ranged from 42 cm (for SV51741) to 63 cm (for ILP56).

5.2.5. Response of Pea Cultivars of Different Leaf Morphology to Varying Plant Population and Moisture Supply

Response of four dry pea lines of different leaf morphology to three population levels was studied under rainfed and supplementary irrigation 125 mm conditions at Tel Hadya. Moisture supply was in the mainplots and the combination of genotypes and plant population in subplots. The genotypes included a semi-leaflets type (Acc. No. 11), a conventional leaf type (Acc. No. 10), a small leaflets type ('Progretta') and a leaf-less type ('Filby'). Population levels were 36, 50, and 80 plants/m^2,

Table 5.2.2. Mean seed yield (YLD=kg/ha) and rank (R), days to flowering (DFLR), days to maturity (DMAT), plant height (PTHT), and harvest index (HI) of entries at Tel Hadya, Jindiress and Terbol in PIAT-91.

Entry Name	Syria				Lebanon		Mean over locations					
	Tel Hadya		Jindiress		Terbol		YLD	R	DFLR	DMAT	PTHT	HI
	YLD	R	YLD	R	YLD	R						
Syrian Local, Aleppo	528	17	1000	15	1612	1	1046	10	105	145	55	0.396
Local Sel 1690	713	4	1472	7	1602	2	1262	3	104	146	59	0.400
Frisson	361	24	1046	14	1263	12	890	18	93	141	46	0.452
SV 51741	602	12	861	20	1020	21	828	21	99	143	42	0.427
Ballet	528	16	880	19	975	23	794	22	96	143	44	0.436
JI 238	454	22	1667	4	1087	17	1069	8	101	144	58	0.380
MG 101197	537	15	1741	1	1205	13	1161	7	102	145	60	0.445
MG 102369	633	9	759	24	1155	14	849	20	94	143	56	0.410
MG 102583	500	20	852	22	1027	20	793	23	98	143	51	0.426
MG 102623	509	19	1148	11	1035	19	897	16	100	145	55	0.398
MG 102702	713	5	1731	2	1468	5	1304	1	102	145	59	0.388
Maitland	667	8	1667	3	1365	8	1233	4	107	145	62	0.365
Collegian	587	13	824	23	1520	4	977	13	97	143	59	0.413
Derrimut	769	3	1213	10	1043	18	1008	12	93	142	51	0.458
Wirrega	689	7	1556	5	1285	10	1176	5	100	144	52	0.433
Early dun	833	1	1407	8	1283	11	1175	6	105	145	59	0.394
ILP 56	519	18	852	21	1438	6	936	14	92	141	63	0.422
Le 25	611	11	926	18	1145	15	894	17	96	143	45	0.457
PS 210713	704	6	1537	6	1547	3	1262	2	97	141	48	0.492
PS 2106588	583	14	1269	9	1300	9	1051	9	90	142	59	0.415
PS 510203	481	21	972	16	1105	16	853	19	93	141	59	0.450
PS 510699	620	10	1139	12	1372	7	1044	11	91	138	52	0.477
Shanxi Province A 292	787	2	954	17	1007	22	916	15	104	144	54	0.414
Local Check	426	23	1102	13	748	24	759	24	97	145	49	0.378
Location Mean	598		1191		1234							
LSD at .05	331		686		325							
C.V. %	34		35		16							

obtained by varying the inter-row distance which was 27.5, 20.0 and 12.5 cm, respectively.

The ANOVA for the seed yield exhibited that the seed yield was increased significantly by improved moisture supply (Table 5.2.3). Variation in plant population caused no significant differences in yield

Table 5.2.3. Seed yield (kg/ha) response of peas of varying leaf morphology to plant population at two moisture regimes, at Tel Hadya, 1990/91.

Moisture (M) and Genotype (G)	Plant population/m^2			
	80	50	36	Mean
Rainfed				
Acc No. 11 (SLL)	620	549	560	576
Acc No. 10 (C)	952	878	659	830
Progretta (C)	452	602	466	507
Filby (LL)	470	435	267	391
Mean				576
Irrigated				
Acc No. 11 (SLL)	993	1120	903	1005
Acc No. 10 (C)	1230	1146	1065	1147
Progretta (C)	1727	1302	1119	1382
Filby (LL)	1045	703	705	818
Mean				1088
Mean				
Acc No. 11 (SLL)	807	835	732	791
Acc No. 10 (C)	1091	1012	862	988
Progretta (C)	1091	952	486	945
Filby (LL)	758	569	705	604
Mean			832	
L.S.D. (at P = 0.05):				
- Moisture regime means		288		
- For comparing 2 G x P means	262			
- For comparing 2 G x P means same level of M	370			
- For comparing two Moisture means at same or different levels of P	447			

in any of the genotypes under rainfed conditions, whereas with supplementary irrigation yield increased significantly for the leafless type (Filby) as population was raised from 36 to 80 plants/m^2. Because of these differential responses, the interaction between genotype and population, averaged over the two moisture supply regimes, was significant. Results suggest that it would be better to use higher population of 50 plants/m^2 for the leafless type both under rainfed and irrigated conditions, whereas for the rest of the genotypes a population of 36 plants/m^2 will be sufficient.

R.S. Malhotra and M.C. Saxena

6. OROBANCHE CONTROL

6.1. Introduction

Orobanche spp. are root parasitic weeds which attack various legume plants and constrain their productivity. Faba bean, lentil, chickpea, field pea and forage legumes are affected by the parasite. The main objective of our research on Orobanche is the development of effective and practical control methods. This work is carried out in collaboration with the University of Hohenheim, Germany.

6.2. Weather Conditions

The season started out exceptionally dry in autumn 1990, with the first substantial rains (11 mm) on 3rd of December. Irrigation was required to have a normal sowing date to ensure good Orobanche development because late sowing reduces Orobanche attack thus reducing the chances of identifying treatment effects. The season was normal with respect to the thermal regime and no severe frost spells occurred. The total rainfall during 1990/91 was 293.5 mm. Although it was lesser than the long-term average, its distribution was good for crop and parasite growth. Taking into account the supplementary irrigation given to assure a normal establishment of the crop, the total seasonal moisture supply in our fields, was similar to a normal year.

6.3. Chemical Control

6.3.1. Faba Bean

The herbicides tested included imazaquin (Scepter), imazapyr (Assault, Arsenal), imazethapyr (Pursuit, Pivot), fosamine (Krenite), chlorsulfuron (Glean) and glyphosate (Roundup) as pre- and/or post-emergence applications (Table 6.3.1). Rates and dates of application were based on results of previous years.

Orobanche infestation in the untreated (check) plots was high with 56.5 emerged shoots/m^2, resulting in a low crop seed yield of 199 kg/ha.

Several treatments resulted in an excellent control of Orobanche (Table 6.3.1); best treatments in terms of Orobanche control and crop seed yield were post-emergence applications of imazethapyr (2 x 20 g a.i./ha), imazaquin (2 x 30 g a.i./ha) and a combination of them. These treatments caused only minor phytotoxicity on faba bean plants. These findings confirm the results of the last season. Chlorsulfuron treatment, which caused high phytotoxicity, and fosamine which gave low efficiancy will not be used in the future testing.

Table 6.3.1. Effect of various herbicides on Orobanche infestation and yield of faba bean, Tel Hadya, 1990/91.

Herbicide rate [g a.i./ha] & methods of application[b]	Orobanche shoots No./m^2	Orobanche shoots Dry weight (kg/ha)	Crop yield Straw (kg/ha)	Crop yield Seed (kg/ha)	Phyto-toxicity (1-9)[a]
1 Imazaquin 2x20 +imazethapyr 2x20	0.0	0.2	1920	68	1.1
2 Imazaquin 2x40	0.0	0.3	1303	798	1.0
3 Imazaquin 2x30	0.6	3.1	1937	1281	1.0
4 Imazethapyr 2x30	0.6	4.1	1829	1061	1.2
5 Imazaquin 2x20 +glyphosate 2x80	0.9	10.6	2079	1064	1.0
6 Imazethapyr 2x20	1.7	17.2	2365	1509	1.0
7 Imazethapyr 100 PRE[2]	1.9	18.8	1576	1242	1.6
8 Imazethapyr 75 PRE	2.8	29.7	1930	1151	2.2
9 Imazethapyr 75 PRE +glyphosate 80	4.3	43.8	1580	1178	3.0
10 Imazapyr 30 PRE	4.4	73.1	1311	1092	2.8
11 Imazapyr 20 PRE +glyphosate 80	4.7	70.9	1106	928	3.2
12 Chlorsulfuron 3 PRE	7.6	112.2	740	678	5.6
13 Imazapyr 20 PRE	17.8	243.6	1631	802	2.1
14 Glyphosate 2x80	44.2	788.1	1805	423	2.9
15 Fosamine 2x80	62.2	1322.5	1522	103	1.1
16 No herbicide	56.5	1162.5	2304	199	1.0
S.E.M. ±	4.1	68.5	218	124	0.19
L.S.D. (P = 5%)	11.6	194.1	618	351	0.58

[a] EWRS Scale 1-9: 1 = no effect, 9 = total damage

[b] All treatments were applied post-emergence of crop, i.e. at tubercle and bud stage of Orobanche development, except those marked 'PRE' which were applied before crop emergence.

Pre-emergence application of 75 or 100 g a.i./ha of imazethapyr reduced the Orobanche dry weight by 97.4 and 98.3 %, respectively, compared to the control, and ensured good seed yield of the crop. In the fields known for heavy Orobanche infestation such a treatment would be appropriate.

6.3.2. Lentil

Several herbicides applied on lentil for Orobanche control resulted in phytotoxicity on the crop in earlier years. Imazaquin (2 x 7.5 g a.i./ha, post-emergence), and imazethapyr (60 g a.i./ha, pre-emergence), which were already tested last year, showed low phytotoxicity on lentil. Hence these were tested again this season. These treatments affected the early crop growth this season: the lentil plants were smaller in size and violet in colour and showed incomplete leaf unfolding. However, towards the end of March, the treated plants recovered, were dark green in colour, and looked healthier than the plants in the untreated plots, which by that time had already turned chlorotic due to high underground attack of Orobanche.

Results (Table 6.3.2.) showed that post-emergence application of imazaquin in the early sown crop, although effective in reducing the amount of emerged Orobanche shoots, failed to improve the crop yield as compared to untreated check. Pre-emergence application of imazethapyr, under these circumstances of heavy attack, was considerably more effective. In the later sowing date, with it's lower Orobanche attack, the 'soft' treatment with imazaquin was right enough to control the parasite but did not harm the crop as did imazethapyr. Thus, the selection of herbicide will have to depend on the level of Orobanche infestation.

6.3.3. Chickpea

Glyphosate (2 x 20 g a.i./ha, post-emergence) which had shown some efficacy in controlling Orobanche in the earlier study, was compared with imazethapyr (60 g a.i./ha, pre-emergence). Imazethapyr was able to control Orobanche (Table 6.3.3), but the crop yields were not increased

Table 6.3.2. Effect of two herbicides on the Orobanche control and yield of lentil, Tel Hadya, 1990/91.

Treatment	Orobanche shoots		Crop yield	
	No./m²	Dry weight (kg/ha)	Straw (kg/ha)	Seed (kg/ha)
ILL 4400, planted on Nov. 17				
No herbicide	62.2	285.7	875	15.9
Imazaquin 2 x 7.5 g a.i./ha POST*	6.2	58.4	896	54.5
Imazethapyr 60 g a.i./ha PRE*	0.1	0.1	1402	663.7
ILL 8, planted on Dec. 31				
No herbicide	7.9	27.5	1566	204.1
Imazaquin 2 x 7.5 g a.i./ha POST	0	0	2717	761.3
Imazethapyr 60 g a.i./ha PRE	0	0	1495	161.3
S.E.M. ±	6.3	35.7	361	123.5
L.S.D. (P=5 %)	13.7	77.8	986	269.3

* POST = Post-emergence application; PRE = Pre-emergence application

Table 6.3.3. Effect of herbicides for Orobanche control in chickpea at Tel Hadya in 1990/91 season.

Treatment	Orobanche shoots		Crop yield	
	No./m²	Dry weight (kg/ha)	Straw (kg/ha)	Seed (kg/ha)
Control	14.5	152.3	1436	382
Glyphosate 2x20 g a.i./ha POST	18.8	181.5	1321	349
Imazethapyr 60 g a.i./ha PRE	2.4	28.5	1145	340
S.E.M. ±	4.4	43.6	157	70
L.S.D. (P = 5 %)	9.6	95.0	343	153

because of the phytotoxicity (chlorosis and stunting). Hence, lower rates of 40 to 50 g a.i./ha of imazethapyr should be tested. As in the previous season ILC 3279 tolerated the herbicides better than did ILC 482.

6.3.4. Narbon Vetch

Information on herbicide tolerance in narbon vetch Vicia narbonensis with regard to Orobanche control is scanty; therefore, imazaquin as a 'soft' herbicide was selected and applied post emergence at a low rate of 2 x 20 g a.i./ha.

A highly significant reduction of 86.7 % in number of Orobanche shoots in the imazaquin treated plots occurred (Table 6.3.4). However, increase in crop seed yield was low (6.4 %) and not significant. Hence, although narbon vetch seems to be rather sensitive to imazaquin, this herbicide effectively protected the crop and reduced the production of Orobanche which otherwise would destroy the seed yield and raise the seed bank of the parasite.

Table 6.3.4. Effect of imazaquin on Orobanche control and yield of Vicia narbonensis, Tel Hadya, 1990/91.

Treatment	Orobanche shoots		Crop yield	
	No./m²	Dry weight (kg/ha)	Straw (kg/ha)	Seed (kg/ha)
No herbicide	52.0	404.0	1084	205.2
Imazaquin 2 x 20 g a.i./ha POST	6.9	89.0	1098	218.3
S.E.M. ±	5.8	24.1	128	26.3
L.S.D. (P = 5 %)	12.7	52.6	278	57.4

6.3.5. Field Pea

Four herbicides were tested in peas. Orobanche infestation was high and Orobanche dry weight in the untreated plots exceeded 0.5 t/ha. In terms of Orobanche control both imidazolinones gave better results than glyphosate (Table 6.3.5). Most treatments induced only minor phytotoxicity, whereas chlorsulfuron resulted in severe damage to the crop (EWRS phytotoxicity rating of 6). Seed yield of the crop was low and there were no significant differences due to the treatments.

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

Table 6.3.5. Effect of herbicides for Orobanche control in field pea at Tel Hadya in the 1990/91 season.

Treatment	Orobanche shoots		Crop yield	
	No./m²	Dry weight (kg/ha)	Straw (kg/ha)	Seed (kg/ha)
No herbicide	75.1	391.2	914	32.2
Glyphosate 2 x 60 g a.i./ha POST	69.5	451.7	1259	15.6
Imazethapyr 2 x 20 g a.i./ha POST	7.2	98.8	1829	27.4
Chlorsulfuron 3 g a.i./ha PRE	5.0	32.4	750	65.5
Imazaquin 40 g a.i./ha POST	1.1	6.2	1707	144.5
Imazaquin 2 x 20 g a.i./ha POST	0.5	5.2	1663	102.2
Imazaquin 2 x 30 g a.i./ha POST	0	0	1791	134.2
S.E.M.	3.7	37.2	183	72.9
L.S.D. (P = 5 %)	11.4	113.4	553	219.6

6.4. Selection of Resistant Genotypes

6.4.1. Forage Legumes

Two accessions of narbon vetch, which in the previous season showed differential reaction to Orobanche infestation, were tested in field heavily infested by the parasite. The accession '578' had 28.1 % less Orobanche shoots than accession '67' (Table 6.4.1). This difference in

Table 6.4.1. Reaction of two accessions of *Vicia narbonensis* to Orobanche at Tel Hadya in the 1990/91 season.

Entry	Orobanche shoots		Crop yield	
	No./m²	Dry weight (kg/ha)	Straw (kg/ha)	Seed (kg/ha)
Acc. 578 (tolerant)	24.6	288.4	1339	417.4
Acc. 67 (suscept.)	35.8	204.5	843	6.1
S.E.M. ±	4.4	53.7	160	69.3
L.S.D. (P = 5%)	10.1	131.5	392	169.7

susceptability to Orobanche was also reflected in the crop yield (Table 6.4.1). The nonsignificantly higher Orobanche dry weight produced on the resistant entry was due to the low underground infestation which permitted good development of the emerged Orobanche shoots. In contrast, the susceptible entry was so severely affected by the underground attack of the parasite, that the host could not support high development of dry weight of emerged Orobanche shoots.

6.4.2. Lentil

Screening of wild lentil for Orobanche resistance was continued using the technique developed earlier; however, no Orobanche free entry could be identified so far.

K.-H. Linke, W. Erskine and M.C. Saxena

6.4.3. Chickpea

The Orobanche resistance of ILC 3279 ('Ghab 2') was confirmed in a field experiment. The straw and seed yield production was higher and Orobanche infestation lower in ILC 3279, as compared to ILC 482 (Table 6.4.2). Therefore, in Orobanche infested areas this cultivar should be prefered.

Table 6.4.2. Reaction of two chickpea lines to Orobanche infestation at Tel Hadya in the 1990/91 season.

Entry	Orobanche shoots		Crop yield	
	No./m^2	Dry weight (kg/ha)	Straw (kg/ha)	Seed (kg/ha)
ILC 482 (suscept.)	15.0	156.3	871	283.8
ILC 3279 (resist.)	8.8	85.3	1730	430.1
S.E.M. ±	2.9	40.2	84	28.9
L.S.D. (P = 5 %)	9.3	128.0	267	91.9

This was further confirmed in a screening test in pots with 12 chickpea entries including ILC 482 and ILC 3279. The latter had the lowest infestation (Fig. 6.1). Highest infestation was found with ILC 3919 and ILC 35. This screening was done using 2500 to 7500 Orobanche seeds/kg soil which earlier were found to represent the critical range of Orobanche seed density in pot experiments with chickpea.

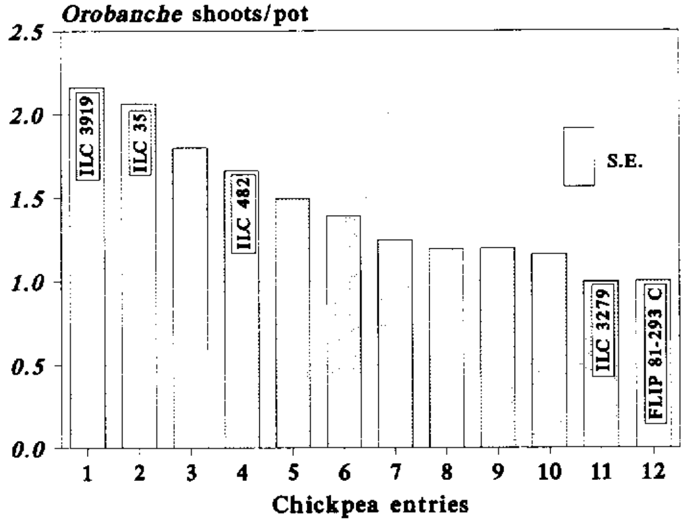


Figure 6.1. Orobanche infestation in 12 genotypes of chickpea in the pot-culture screening during 1990/91

Earlier field observations had indicated that there was a positive association between Orobanche resistance and Ascochyta blight resistance in chickpea. To test this, diverse lines of the Chickpea International Ascochyta Blight Nursery (A) were evaluated for Orobanche attack and the results correlated with the Ascochyta blight score of these lines. A positive correlation of r = 0.461 was found between Orobanche resistance and the blight resistance (Fig. 6.2). Therefore, lines with resistance to Ascochyta blight will be preferred for further screening of chickpea to Orobanche. A common basis for this reaction towards the two parasites could be the production of phytoalexins by chickpea immediately after the infection by the two pathogens. This, however, will require further study.

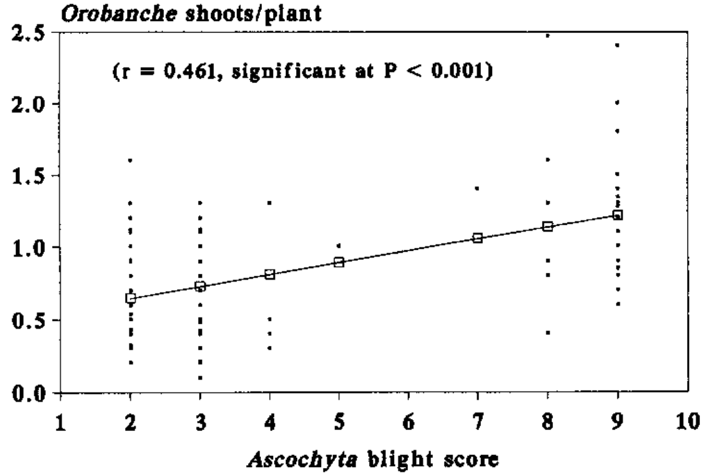


Figure 6.2. Relationship between the Ascochyta blight rating (1 to 9 scale; 1 = disease free, 9 = killed) and Orobanche infestation in the chickpea lines of Chickpea International Ascochyta Blight Nursery (A).

A 1 to 9 rating scale was developed to facilitate the evaluation of Orobanche infestation on chickpea in the field (Table 6.4.3). This score

Table 6.4.3. Scale for evaluation of O. crenata infestation on chickpea.

Score*	Symptoms
1	No emerged Orobanche shoot, no visible damage
2	Up to 5 % plants with emerged shoots
3	6 to 10 % plants with emerged shoots
4	11 to 20 % plants with emerged shoots
5	21 to 40 % plants with emerged shoots
6	41 to 60 % plants with emerged shoots; light chlorosis
7	61 to 80 % plants with emerged shoots; light chlorosis
8	81 to 100 % plants with emerged shoots; chlorosis, leaf drop
9	100 % plants with at least one emerged shoot; no seed production

* 1-4: resistant; 6-8: susceptible; 9: highly susceptible.

is primarily based on the number of emerged shoots of Orobanche, as other symptoms like plant height, chlorosis or defoliation are not uniformly expressed and can not always be attributed to Orobanche attack. The scoring has to be done only after pod setting.

K.-H. Linke, K.B. Singh and M.C. Saxena

6.4.4. Field Pea

Two pea entries which had shown differences in susceptibility to Orobanche in previous season at Tel Hadya, were compared again this season to verify their reaction (Table 6.4.4). Orobanche infestation on the accession '290' was less than on the Syrian Local pea, but seed yield was almost zero for both entries. Without Orobanche infestation, however, the local entry would build up a much larger biomass than acc. 290.

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

Table 6.4.4. Reaction of two entries of field pea to Orobanche infestation, Tel Hadya, 1990/91.

Treatment	Orobanche shoots		Crop yield	
	No./m^2	Dry weight (kg/ha)	Straw (kg/ha)	Seed (kg/ha)
Syrian Local (suscept.)	81.6	782.6	809	3.5
Acc. 290 (resist.)	54.9	352.5	817	3.8

6.5. Biological Control

The agromyzid fly Phytomyza orobanchia is the only insect which has been shown to have potential for biological control of Orobanche.

Yellow sticky traps were placed in the field to monitor the arrival of P. Orobanchia. The first appearance of the fly coincided with the first emergence of the Orobanche shoots (Fig. 6.3). (It also coincided with the appearance of Liriomyza spp., a related fly attacking crops). Its arrival is most probably related to temperature. It was reported from USSR that P. Orobanchia has several generations during the season,

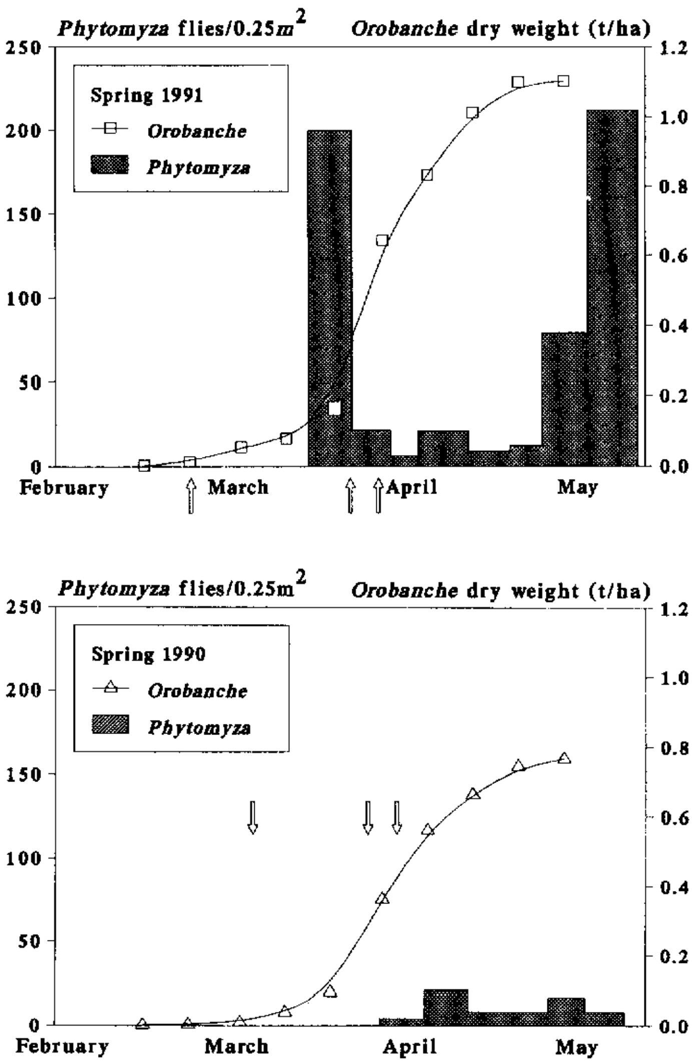


Figure 6.3. Relationship between the appearance of Phytomyza orobanchia and Orobanche spp. in field at Tel Hadya, 1989/90 and 1990/91 seasons. The first arrow indicates the first emergence of Orobanche shoots, the two arrows indicate massive emergence of the Orobanche shoots.

provided climatic conditions are suitable. Time intervals between the generations may vary from 3-8 weeks. The two peaks of Phytomyza occurrence in our results (Fig. 6.3) probably represent two generations. At mid May, however, the collection of insects was stopped as the crop and parasite were harvested.

The number of Phytomyza adults caught weekly in the yellow traps was rather low as compared to the high incidence of larvae in Orobanche shoots. Also the frequency of Liriomyza in the traps was about 100 times more. It is possible that yellow traps were not attractive enough to Phytomyza.

K.-H. Linke, S. Weigand and M.C. Saxena

6.6. Crop Rotation

To study the effect of crop rotation on O. crenata seed bank and parasite infestation and yield of lentil, nine crops (Vicia faba, V. narbonensis, V. villosa subsp. dasycarpa, Pisum sativum, Lens culinaris, Hordeum vulgare, Cuminum cymium, Linum usitatissimum, Coriandrum sativum) were grown in the 1989/90 season in two experiments with 3 and 4 replications, respectively. Fallow plots were included as control. All the Orobanche shoots that emerged during 1989/90 were removed to prevent fresh increase in the seed bank. In the 1990/91 season all the plots of both the experiments were planted with lentil (cultivar ILL 4400) to study the effect of the preceding crops on Orobanche infestation and yield. Sowing of lentil was done on 6 Nov. 1990. Orobanche shoots were pulled before harvesting lentil and their dry matter (85 °C) was determined. Straw and seed yield of lentil was measured. Combined results of both experiments were analyzed and presented in Fig. 6.4.

Compared with the fallow plots, Orobanche dry matter on lentil was significantly reduced when lentil followed narbon vetch, lentil and woolypod vetch. Lentil seed yields after narbon vetch and woolypod vetch were significantly higher than after fallow. The average seed yield of

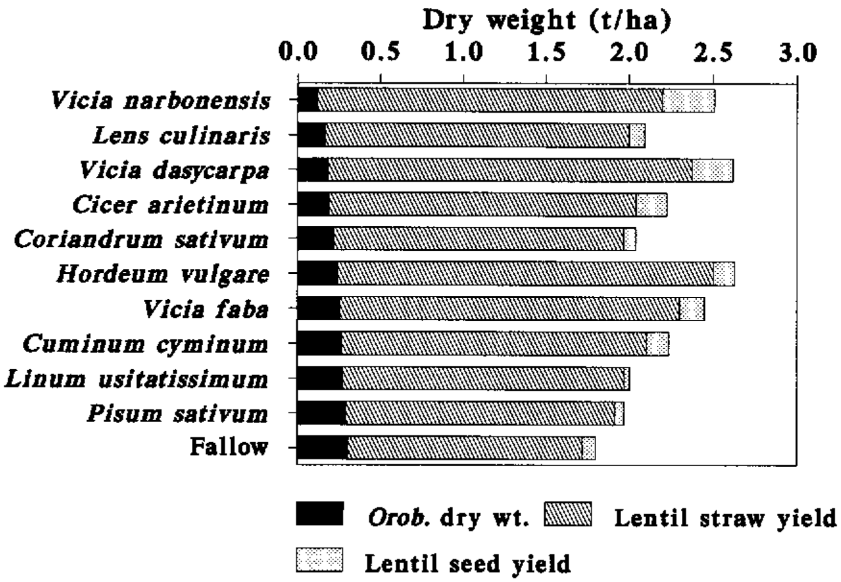


Figure 6.4. Effect of different preceeding crops on the Orobanche dry weight and seed and straw yields of lentil at Tel Hadya, 1990/91. LSD (P = 5%) for Orobanche dry weight = 120.6 kg/ha; crop straw yield = 358.1 kg/ha and grain yield = 122.4 kg/ha.

lentil was however only 133.8 kg/ha. It is possible that inspite of the reduction in the Orobanche seed bank due to the above two crops, it was still too high to permit a normal lentil yield. Lentil straw yield and total biomass were significantly higher after any crop than after fallow, Coriandrum, Linum and Pisum.

The low efficacy of field grown flax (Fig. 6.4) is in contrast to results obtained by others but they studied the effect only in pots or with O. ramosa. It is possible that the reaction of O. ramosa may be different from that of O. crenata.

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

6.7. Nitrogen for Orobanche Control

Field experiments conducted during the last two seasons confirmed the negative relationship between nitrogen content in the soil and Orobanche development on the crop. This season experiments were conducted with faba bean and lentil using nitrogen fertilize rates ranging from 0 to 158 kg N/ha in soil heavily infested by Orobanche. However, they demonstrated only a minor effect of nitrogen fertlizer on the parasite. Therefore, nitrogen fertilizer alone as a tool for Orobanche control does not appear promising. These investigations form part of the Ph.D. work of Ms. M. van Hezewijk, Free University of Amsterdam.

M. van Hezewijk and K.-H. Linke

6.8. Integrated Control

As in the previous years integrated management of Orobanche received high emphasis in the 1990/91 season and the single control methods were evaluated only with the aim of using them in a scheme of integrated control. It was already shown in the previous years that by combination of two simple control techniques nearly 100 % control of the parasite could be achieved, and the adverse effects of some of the single treatments could be minimized.

6.8.1. Faba Bean

The most striking Orobanche control in faba bean in the previous years was obtained by a combination of slightly delayed sowing (3 weeks) and the application of a herbicide. In this context, different rates of new herbicides were tested with normal and 3 week delayed sowing of the crop during 1990/91. In spite of a high infestation (1160 kg/ha dry weight of Orobanche in the check plots), good Orobanche control was achieved with the combination of delayed sowing + imazaquin applied post-emergence at 2 x 40 g a.i./ha or delayed sowing + imazethapyr applied pre-emergence at 100 g a.i./ha (Fig. 6.5). These combinations also substantially increased crop seed yield.

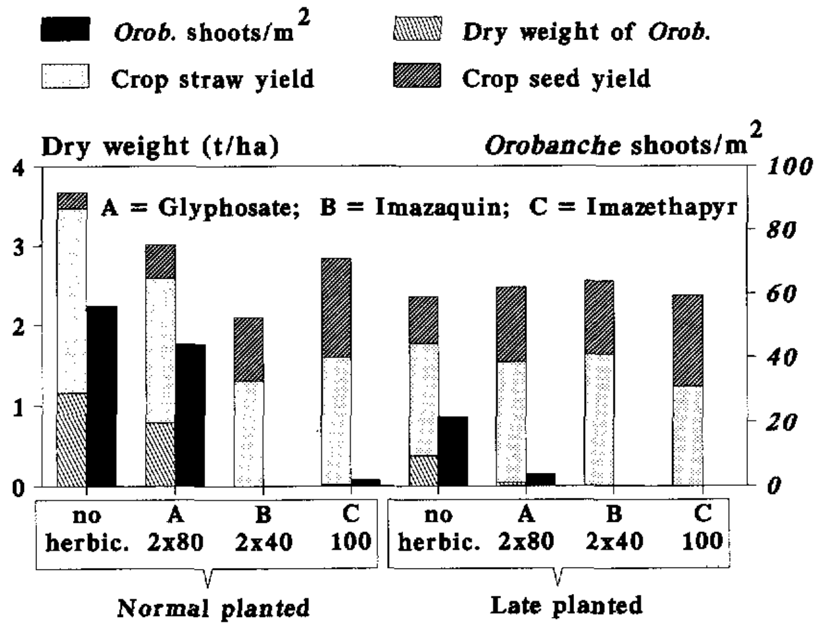


Figure 6.5. Integration of delayed sowing and herbicide application in controlling Orobanche in faba bean, Tel Hadya, 1990/91. S.E.M: Orobanche shoot ± 7.9; Orobanche shoot dry weight ± 131 kg/ha; faba bean seed yield ± 173 kg/ha; straw yield ± 289 kg/ha. N = normal sowing, 23.10.1990; L = late sowing, 13.11.1990.

6.8.2. Lentil

The variety ILL 8 can be sown nearly 25 days later than ILL 4400 without any yield reduction in the absence of Orobanche infestation. Because of this adaptation to late sowing it is suitable for managing Orobanche, by delayed sowing. To further improve the control of Orobanche herbicide treatments having a low rate of a 2 x 7.5 g a.i./ha of imazaquin (post-emergence) or 60 g a.i./ha of imazethapyr (pre-emergence) were tested in combination with the lentil cultivars during 1990/91. The best results were obtained with ILL 8 + imazaquin, which provided full control of the parasite and increased lentil seed and straw yield significantly over the check (Fig. 6.6).

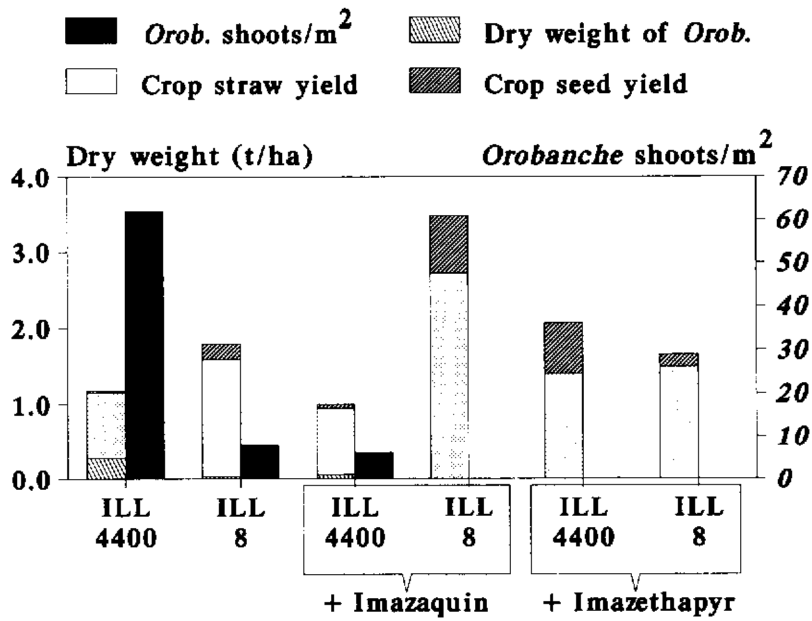


Figure 6.6. Integration of use of less susceptible cultivar and herbicide in controlling Orobanche in lentil, Tel Hadya, 1990/91. S.E.M.: Orobanche shoot ± 5.9; Orobanche dry weight ± 44 kg/ha; lentil seed yield ± 123 kg/ha; straw yield ± 297 kg/ha.

6.8.3. Chickpea

Genotypes (ILC 482 and ILC 3279) and herbicide (0 and 60 g a.i./ha of imazethapyr, preemergence) treatments were tested in a split-plot design to verify the results of last season. The genotype ILC 2379 which has some resistance to Orobanche failed to produce a higher seed yield when the parasite was reduced by herbicide (Fig. 6.7). This was partly due to the crop phytotoxicity caused by the herbicide. Reduction of the chickpea biomass production after application of herbicide was also noticed in the previous years. At present, chickpea appears more sensitive to even low rates of herbicides than to Orobanche attack.

6.8.4. Field Pea

Combinations of three factors were tested including sowing date, herbicide and genotype. The highest effectivity in reducing Orobanche was

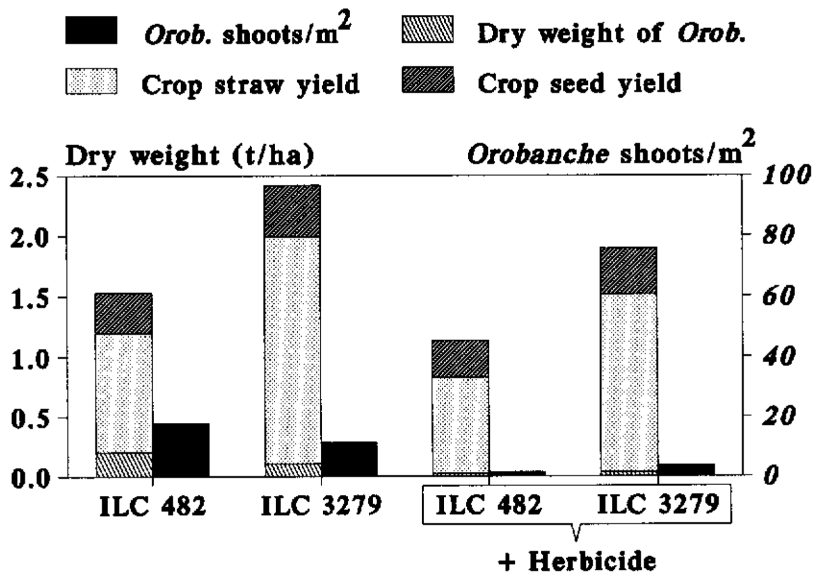


Figure 6.7. Integration of chickpea genotypes (ILC 482 and ILC 3279) and herbicide (H, 60 g a.i./ha imazethapyr) use to control Orobanche, Tel Hadya, 1990/91. S.E.M.: Orobanche shoots ± 5.8; Orobanche dry weight ± 134 kg/ha; chickpea seed yield ± 197 kg/ha; straw yield ± 472 kg/ha.

obtained with post-emergence application of imazaquin (2 x 20 g a.i./ha) (Fig. 6.8), which confirms results of the previous season. Delaying the sowing date from 20 Nov. to 10 Dec. resulted only in a 50 % reduction of the infestation, whereas cropc biomass production simultaneously decreased by 20 % (Fig. 6.8). Genotypic differences were low: the pea accession '290', which earlier was found to have some degree of resistance to Orobanche, was only slightly less infested than the 'Local Pea' in this study.

6.8.5. Narbon Vetch

Three control methods were tested in a split-plot design including sowing date, genotype and herbicide. Reduction of Orobanche compared to the check was highest (87 %) after herbicide application (2 x 20 g a.i./ha imazaquin, post-emergence) followed by that from delayed planting by 14 days (44 %), and resistant genotype (28 %). But increase in crop seed yield was substantial only with the use of resistant genotype. Highest

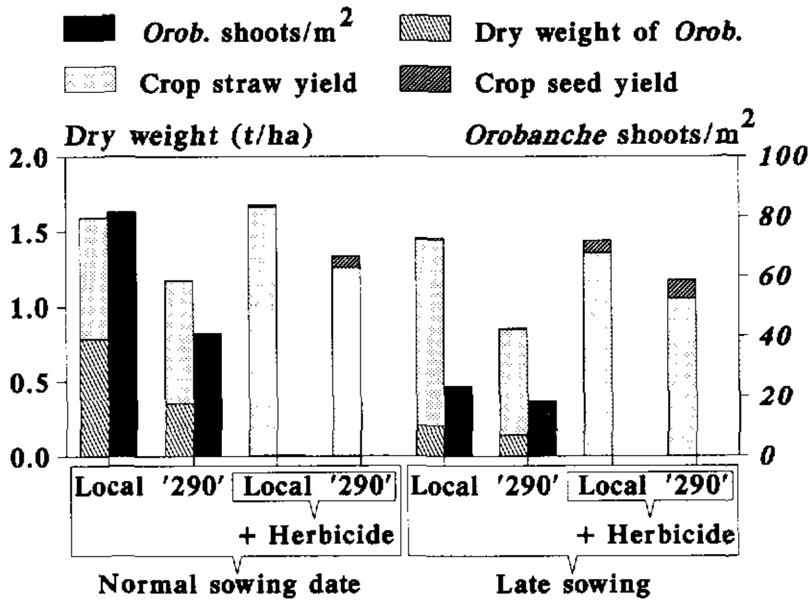


Figure 6.8. Integration of genotype (local and '290'), date of sowing (normal-N, late-L) and herbicide (H, 2x20 g a.i./ha of imazaquin) use to control Orobanche in the field pea, Tel Hadya, 1990/91. S.E.M.: Orobanche shoots ± *6.8;* Orobanche dry weight ± 158 kg/ha; dry pea seed yield ± 14 kg/ha; straw yield 217 kg/ha.

Orobanche control and crop straw yields were obtaied by the combination of all the three factors (Fig. 6.9). Seed yield, however, was sightly higher without herbicide application.

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

6.9. Population Dynamics

6.9.1. Seed Production, Shoots Emerged and Seed Viability of O. crenata

To identify whether there is any relationship between the seasonal moisture supply and the seed production, emerged shoots and seed viability of Orobanche crenata, the data on these parameters were collected in lentil as host crop for 4 seasons, with differing amount of total seasonal moisture supply. The results are presented in Table 6.9.1. Higher the total seasonal moisture supply, higher was the seed production. The growth and development of a total parasite such as

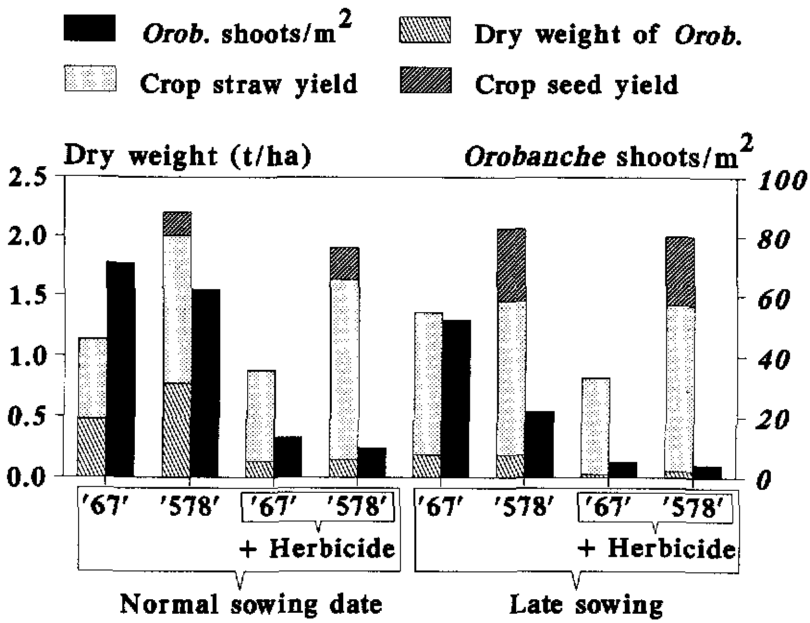


Figure 6.9. Integration of date of sowing (normal-ND, late LD), genotype ('67' and '578') and herbicide (H 2x20 g a.i./ha of imazaquin) use for controlling Orobanche in narbon vetch, Tel Hadya, 1990/91. S.E.M.: Orobanche shoot ± 7.3; Orobanche dry weight ± 58 kg/ha; crop seed yield ± 74 kg/ha; straw yield ± 205 kg/ha.

Orobanche is very much linked with the growth and vigor of the host. Under higher rainfall the lentil growth was better and, therefore, it encouraged development of Orobanche and higher production of parasite seeds. The number of seeds produced amounted to 31.1 million/m^2 in a wet season, as against only 260,000 and 1000 seeds/m^2 in the two dry seasons (Table 6.9.1). The viability of seeds produced in the dry season was lower than those of the wet season. The premature drying of Orobanche shoots, preventing the completion of seed ripening due to lack of adequate moisture supply, might be the cause of this.

In a season favorable for Orobanche growth (1987/88) a low seed bank of 3.5 seeds/kg soil produced no shoot on lentil, whereas with a seed bank of 251 seeds/kg soil 326 Orobanche shoots/m^2 emerged.

Table 6.9.1. Effect of seasonal moisture supply on seed production of O. crenata on lentil.

Season	Rain-fall (mm)	Seed bank/kg soil at planting	Orobanche produced on lentil				
			Undergr. shoots /m²	Emerged shoots /m²	Seed production (mil./m²)	Seed viability (%)	Viable seed (mil./m²)
1987/88	504	616	384.3	326.7	31.1[a]	74.8	23.3
1988/89	234	576	693.7	27.2	0.26[b]	n.r.	n.r.
1989/90	233	347	563.0	1.2	0.001[c]	57.7	0.0007
1990/91	343[e]	350	437.9	46.5	1.2[d]	73.1	0.843

[a] 3500 seeds/capsule, 27.2 capsules/shoot; [b] 1500 seeds/capsule, 6.4 capsules/shoot; [c] 1970 seeds/capsule, 0.5 capsules/shoot; [d] 1897 seeds/capsule; 10.3 capsules/shoot; [e] includes 293 mm precipitation and 50 mm irrigation; n.r. = not recorded.

6.9.2. The Seed Bank of O. crenata

The factors influencing the seed bank of O. crenata can be divided into two, one that affects input, and the other that affects the removal of seed (Fig. 6.10). By far the most important input factor is the seed production on the mother plant with its subsequent seed shed on the ground. The magnitude of this effect is dependent on the suitability of host plant and the climatic conditions. Aspects of transportation of seed by wind, water, man or animal, although of minor importance, become, important as starting point for the development of a seed bank. The two major factors that affect the loss of seed bank are germination of seeds and their decay.

6.9.3. Dormancy of O. crenata Seed

The annual dormancy cycle was investigated in seeds of O. crenata buried in the field, where they were exposed to natural temperature changes. Seeds were removed regularly from August 1989 to July 1991 and tested for their germinability under optimum germination conditions using the synthetic GR 24 as germination stimulant. Seeds were dormant but responded to the stimulant throughout the year; however, towards the end

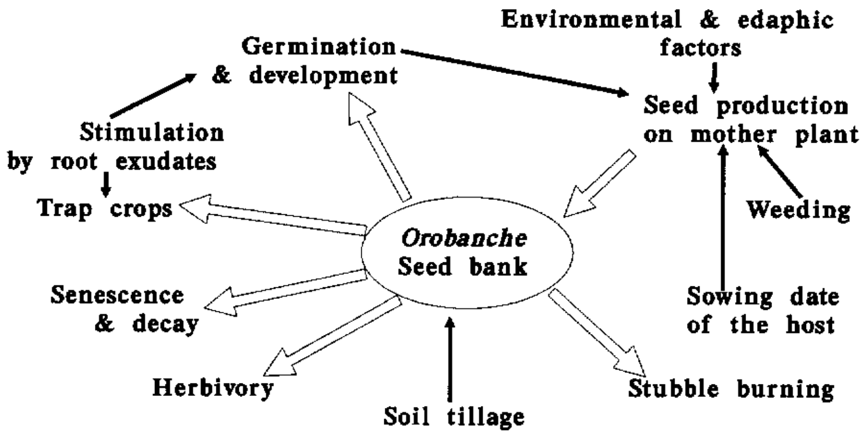


Figure 6.10. Factors influencing the changes in the seed bank of O. crenata. Solid arrows indicate the influencing factor and open arrows show sources of input or removal of seed.

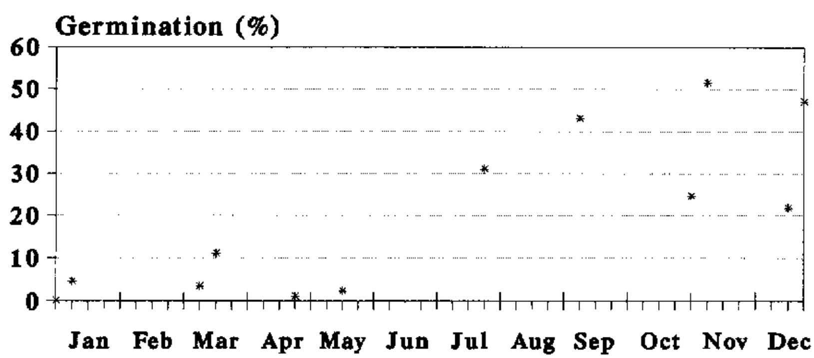


Figure 6.11. Seasonal dormancy cycle in orobanche crenata.

of the dry and hot summer season (September) response to the stimulant increased reaching the maximum value between September and December (Fig. 6.11). Thereafter, response to a stimulant rapidly declined. This seasonal cycle of responsiveness to a stimulant reflects the natural situation, where due to the availability of host and climatic conditions the germination occurs mainly in autumn and only to a low extent in spring. It appears that seeds of O. crenata undergo a conditional dormancy/non-dormancy cycle.

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

7. INTERNATIONAL TESTING PROGRAM

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

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

With recent shift in emphasis of ICARDA activities as per EPR (External Program Review) recommendations, the distribution of all the yield trials and screening nurseries of faba bean to the national programs from ICARDA'S headquarters at Aleppo has been stopped.

Two international trials, Lathyrus Adaptation Trial (ILAT) and Vicia Adaptation Trial (IVAT), which were initiated last season and conducted over a restricted number of locations, were distributed internationally covering a wide range of environments. Thus 956 sets of 35 different types of nurseries (Table 7.1.1) were supplied to various cooperating scientists during the 1991/92 season. Several cooperators requested large quantities of seed of some elite lines identified by them

Table 7.1.1. Legume international nurseries supplied to various national programs for the 1991/92 season.

International Trial/Nursery	No. of sets
Lentil	
Yield Trial, Large-Seed (LIYT-L-92)	50
Yield Trial, Small-Seed (LIYT-S-92)	35
Yield Trial, Early (LIYT-E-92)	40
Screening Nursery, Large-Seed (LISN-L-92)	32
Screening Nursery, Small-Seed (LISN-S-92)	22
Screening Nursery, Early (LISN-E-92)	40
Screening Nursery, Tall (LISN-T-92)	40
F_3 Nursery, Large Seed (LIF$_3$N-L-92)	15
F_3 Nursery, Small Seed (LIF$_3$N-S-92)	10
F_3 Nursery, Early (LIF$_3$N-E-92)	15
F_3 Nursery, Cold Tolerance (LIF$_3$N-CT-92)	5
Cold Tolerance Nursery (LICTN-92)	19
Ascochyta Blight Nursery (LIABN-92)	12
Fusarium Wilt Nursery (LIFWN-92)	20
Rust Nursery (LIRN-92)	8
Chickpea	
Yield Trial Spring (CIYT-Sp-92)	49
Yield Trial Winter, Mediterranean Region (CIYT-W-MR-92)	64
Yield Trial Southern Latitudes-1 (CIYT-SL1-92)	18
Yield Trial Southern Latitudes-2 (CIYT-SL2-92)	15
Yield Trial Latin American (CIYT-LA-92)	14
Screening Nursery Winter (CISN-W-92)	55
Screening Nursery Spring (CISN-Sp-92)	45
Screening Nursery, Southern Latitudes-1 (CISN-SL1-92)	15
Screening Nursery, Southern Latitudes-2 (CISN-SL2-92)	14
Screening Nursery, Latin American (CISN-LA-9)	12
F_4 Nursery, Mediterranean Region (CIF$_4$N-MR-92)	23
F_4 Nursery, Southern Latitudes (LIF$_4$N-SL-92)	9
Ascochyta Blight Nursery: Kabuli (CIABN-A-92)	28
Ascochyta Blight Nursery: Kabuli & Desi (CIABN-B-92)	30
Fusarium Wilt Nursery (CIFWN-92)	31
Leaf-Miner Nursery (CILMN-92)	10
Cold Tolerance Nursery (CICTN-92)	39

Cont'd.

Table 7.1.1. Cont'd.

International Trial/Nursery	No. of sets
Forage Legumes	
Lathyrus spp. Adaptation Trial (ILAT-92)	42
Vicia spp. Adaptation Trial (IVAT-92)	40
Peas	
Adaptation Trial (PIAT-92)	40
TOTAL	956

from the international nurseries/trials for multilocation yield testing and on-farm trials.

The salient features of 1989/90 international nursery results received from cooperators until 31 October 1991, are presented here.

7.1. Faba Bean

Only four trials were supplied to cooperators for 1989/90 season. The results received from the cooperators are reported here.

In the Faba Bean International Screening Nursery-Determinate (FBISN-D) out of 28 locations reporting the yield data, at a large number of locations some determinate entries either exceeded or gave similar yield as the local check. The top five yielders across locations included ILB 1814, FLIP 86-107FB, FLIP 86-145FB, FLIP 86-114FB and FLIP 86-118FB. The top determinate yielder in this nursery gave 11.3% less yield than the indeterminate high-yielding check, ILB 1814, revealing that there was need for further improvement in the yield potential of the determinate lines.

The results on Faba Bean International Ascochyta Blight Nursery (FBIABN) were reported from 5 locations. Seven entries namely, A886, A8812, A8817, A88187, A88233, A88245, and ILB 1814, exhibited rating between 1 and 4, on a 9-point scale, and had better level of resistance compared with others.

The results of Faba Bean International Chocolate Spot Nursery (FBICSN) were reported from five locations. Out of 17 lines, six lines, namely B8827 (L83114), B88140 (ILB 3025), B88142 (ILB3026), B88158 (ILB3026), ILB 1814, and Rebaya 40, occurred most frequently among the tolerant lines with rating 4 or less.

The results of Faba Bean International Rust Nursery (FBIRN) were reported from five locations. Four entries, namely R888 (BPL 2637), R8810 (BPL 406), R8815 (BPL 1179) and R8859 (BPL 663), occurred most frequently among the tolerant lines with rating of 4 or less.

The Faba Bean Weed Control Trial (FBWCT) results were reported for 4 locations for seed yield and the treatment effects were significant. The yield loss due to weeds varied from location to location and ranged between 12.8% and 66.1%. All the weed control treatments at Misurata and pre-emergence application of cyanazine (Fortrol) at 0.5 kg a.i./ha plus 0.5 kg a.i./ha of pronamide (Kerb) and post-emergence application of dinoseb acetate (Aretit) at 1.0 kg a.i./ha plus 0.5 kg a.i./ha fluazifopbutyl (Fusilade) at Zahra in Libya; pre-emergence application of terbuthylazine terbutryne (Topogard) at 0.75 kg a.i./ha, pre-emergence application of cyanazine (Fortrol) at 0.5 kg a.i./ha, pre-emergence application of chlorbromuron (Maloran) at 1.5 kg a.i./ha plus 0.5 kg a.i./ha of pronamide (Kerb), and pre-emergence application of terbutryne (Igran) at 2.5 kg a.i./ha at Cordoba in Spain, were significantly superior to the respective weedy check in the order listed. At Samsun, Turkey none of the weed control treatments proved effective.

7.2. Lentil

Data from 23 locations were analyzed for seed yield for Lentil International Yield Trial-Large Seed (LIYT-L). At ten locations, namely, Sidi Bel Abbes in Algeria; Elvas in Portugal; Gelline and Izra'a in Syria; Terbol in Lebanon; and Erzurum in Turkey, some of the test entries exceeded the respective local check in seed yield by a significant (P = 0.05) margin. The five heaviest yielding lines across locations were FLIP 88-8L, FLIP 87-16L, FLIP 87-17L, FLIP 87-2L, and FLIP 84-147L.

Stability analysis based on the Eberhart and Russell (1966) model for seed yield of LIYT-L entries revealed that both mean squares due to entry x location (linear) and pooled deviations (non-linear portion of genotype x environment interaction) were significant (Table 7.2.1). The perusal of stability parameters for individual entries revealed that the entries FLIP 88-6L, FLIP 86-8L, FLIP 85-35L and FLIP 85-38L had above-average mean yield, a regression coefficient of one and nonsignificant deviations from regression and were thus had wide-adaptation. Three more entries, FLIP 88-8L, FLIP 87-17L, and FLIP 84-147L, having above-average mean yield, regression coefficient greater than 1 and nonsignificant deviations from regression, were specifically adapted to high yield environments.

Table 7.2.1. ANOVA for stability for seed yield for the entries in LIYT-L, LIYT-S, and LIYT-E conducted during 1989/90.

Source of Variation	LIYT-L		LIYT-S		LIYT-E	
	DF	MS(x10^3)	DF	MS(x10^3)	DF	MS(x10^3)
Entry	22	163.501**	22	87.304*	22	241.311**
Entry x location + location	506	293.489**	276	279.911**	161	1514.830**
Location (linear)	1	126562.000**	1	63419.700**	1	226241.000**
Entry x location (linear)	22	96.453**	22	31.966ns	22	221.723**
Pooled deviation	483	41.037**	253	51.907**	138	92.531**
Pooled error	1012	23.572	572	18.204	352	45.563

* Significant at P = 0.05.

The results of Lentil International Yield Trial-Small Seed (LIYT-S) revealed that out of 14 locations, at 9 locations namely, Beni Slimane and Guelma in Algeria; Elvas in Portugal; Diyarbakir in Turkey; Heimo, Idleb and Gelline in Syria; Terbol in Lebanon; and Sarir in Libya, 3, 2, 3, 22, 1, 7, 5, 21 and 5 test entries, respectively, exceeded the local check in seed yield by significant margins. The five heaviest yielders across locations included FLIP 84-51L, FLIP 87-48L, FLIP 86-29L, FLIP 87-26L and FLIP 87-57L. Stability analysis for seed yield for the entries in LIYT-S (Table 7.2.1) revealed that only four entries, FLIP84-29L, FLIP86-29L, FLIP87-49L, and FLIP87-57L having above-average yield performance, regression coefficient of 1, and nonsignificant deviations from regression had general adaptation. A line FLIP87-55L having above-average mean yield, nonsignificant deviations from regression and regression less than 1.0 was adapted to low-yielding environments.

The results of Lentil International Yield Trial-Early (LIYT-E) revealed that at 6 locations (Sidi Bel Abbes, Beni Slimane and Tiaret in Algeria; Faisalabad I (NIAB) and Faislabad (ARC) in Pakistan; and El-safsaf in Libya) out of 9 some of the test entries exceeded the respective local check in seed yield by significant ($P \leq 0.05$) margins. The five heaviest yielders in this trial included FLIP 84-60L, FLIP 84-112L, FLIP 88-45L, FLIP 86-39L and Precoz. Stability analysis of the entries for seed yield in LIYT-E revealed that both entry x location (linear) and deviations from regression (nonlinear) were significant (Table 7.2.1). Two entries, namely FLIP 84-112L and FLIP 88-48L, had above-average yield, nonsignificant deviations from regression and regression coefficient equal to 1, and were thus adaptable. A line from India (Pant L 406) having above-average mean, nonsignificant deviations from regression, and regression more than 1 was responsive to favorable environments.

For Lentil International Screening Nursery - Large (LISN-L), Small (LISN-S), Tall (LISN-T), and Early (LISN-E), the data for seed yield were reported from 14, 11, 14, and 10 locations, respectively. The analyses of data revealed that at 6 locations in LISN-L (Heimo, Izra'a, and Idleb in Syria; Ramtha and Jubeiha in Jordan; and Elvas in Portugal), 9 locations in LISN-S (Jubeiha and Ramtha in Jordan; Terbol in Lebanon; Elvas in Portugal; Aleppo, Gelline, Idleb, and Izra'a in Syria; and Diyarbakir in Turkey), 9 locations in LISN-T (Toshevo in Bulgaria; Lincoln in Canada; Larissa i cn Greece; Caltagirone in Italy; Ramtha in Jordan; Elvas in Portugal; Gelline and Izra'a in Syria; and Diyarbakir in Turkey), and 2 locations in LISN-E (Guelma in Algeria and Islamabad in Pakistan) some of the test entries exceeded the respective local check by a significant margin (P=0.05). The five heaviest yielding lines across the locations in these nurseries are given in Table 7.2.2.

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

	Name of Nursery			
Rank	LISN-L	LISN-S	LISN-T	LISN-E
1	FLIP 88-7L	FLIP 89-25L	FLIP 84-58L	FLIP 89-53L
2	FLIP 87- 15L	FLIP 89-24L	FLIP 88-50L	FLIP 89-50L
3	FLIP 90- 10L	FLIP 89-36L	FLIP 85-33L	Precoz
4	FLIP 90-1L	FLIP 89-37L	FLIP 87-9L	FLIP 89-52L
5	FLIP 84-156L	FLIP 89-21L	Idleb-1	FLIP 87-72L

The Lentil International F_3-Nursery Large (LIF_3N-L), F_3-Nursery Small (LIF_3N-S), F_3-Nursery Early (LIF_3N-E), and F_3-Nursery Cold Tolerant (LIF_3N-CT), were reported from 3, 4, 2, and 3 locations, respectively. At almost all the locations some individual plant selections were made by the cooperators.

The results of Lentil International Cold Tolerance Nursery were received only from 4 locations, namely Setif in Algeria; General Toshevo in Bulgaria; and Eskisehir and Erzurum in Turkey. There was no cold damage at General Toshevo and Setif, at Erzurum there was no germination, and at Eskisehir all the lines were killed by cold.

The results of Lentil International Ascochyta Blight Nursery were received from Islamabad and Faisalabad (Pakistan), Erzurum (Turkey), Lincoln (Newzealand) and Guelma (Algeria). There was no disease infestation at Guelma and Faisalabad. Data were recorded for 7 test entries and only two entries, namely ILL 5725 and ILL 6025 at Erzurum; all the entries except ILL 5599, ILL 5730, ILL 5750 and ILL 6002 at Lincoln in; and all the entries except ILL 5715, ILL 6002 and ILL 6024 at Islamabad were resistant to Ascochyta blight. The entries which took a rating of 4 or less across locations, on a 9 point scale and thus showed disease tolerance included ILL 358, ILL 2532, ILL 3516, ILL 5244, ILL 5588, ILL 5597, ILL 5604, ILL 5684, ILL 5714, ILL 5725, ILL 5751, ILL 5755, ILL 5766, ILL 5988, and ILL 6025.

The results of Lentil International Fusarium Wilt Nursery were reported from 7 locations. There was no disease infestation at Faisalabad in Pakistan, Larissa in Greece, Lincoln in Newzealand, Idleb in Syria, and Guelma in Algeria. At Heimo in Syria, however, entry EL42 took rating of 5 and at Izra'a all the entries were rated between 1 and 3 (on 1 to 9 scale, 1=free 9=killed).

Two of the three locations for which data on seed yield were reported for Lentil Weed Control Trial (LWCT) exhibited significant treatment effects. At Karaj in Iran the yield loss due to weeds was 35.7% and treatment T11 [Pre-emergence application of chlorbromuron (Maloran) at 1.5 kg a.i./ha plus 0.5 kg a.i./ha of pronamide (Kerb)], T12 [Pre-emergence application of prometryne (Gesagard) at 1.5 kg a.i./ha plus 0.5 kg a.i./ha of pronamide (Kerb)], and T5 [Pre-emergence application of chlorbromuron (Maloran) at 1.5 kg a.i./ha] in order of merit were significantly superior to weedy check. At Terbol in Lebanon the yield loss due to weeds was 40% and all the herbicide treatments were significantly superior to the weedy check except T8 [Post emergence application of dinoseb acetate (Aretit) at 0.1 kg a.i./ha plus 0.5 kg a.i./ha fluazifop butyle (Fusilade)].

The results of Lentil International Rhizobium Inoculation Response Trial (LIRT) were reported from 4 locations, Tiaret in Algeria, Toshevo in Bulgaria, Alamaya in Ethiopia and Karaj in Iran. At all these locations the differences between treatments were nonsignificant.

7.3. Chickpea

The seed yield data were analyzed for 17 locations for Chickpea International Yield Trial-Spring (CIYT-SP). A large number of test entries exceeded the respective local check by a significant margin (P=0.05) at four locations, namely Montboucher in France, Papiano in Italy, Tartus in Syria, and Eskisehir in Turkey. The five best entries across the locations were ILC 482, FLIP 84-164C, FLIP 87-85C, FLIP 87-74C and FLIP 87-58C. The stability analysis (Table 7.3.1) revealed that pooled deviations and entry x location (linear) were significant. The entries FLIP 87-74C, FLIP 87-8C, FLIP 87-72C and FLIP 87-59C with above-average seed yield, regression equal to 1.0 and deviations approaching zero had average stability. Some of the entries like ILC 482, FLIP 84-164C, and FLIP84-19C with regression greater than unity, deviations approaching zero and above-average mean yield were with specific adaptation to high-yielding environments.

The seed yield data for Chickpea International Yield Trial-Winter-Mediterranean Region (CIYT-W-MR) revealed that at 16 locations (Athalassa in Cyprus; Sarir in Libya; Tolentino in Italy; Sevilla in Spain; Marow in Jordan; Guelma, Setif and Sidi Bel Abbes in Algeria; Cordoba in Spain; Homs, Heimo, Tartus, Gelline and Al Ghab in Syria; Urfa and Samsun in Turkey) out of 32 some of the entries exceeded the respective local check by a significant margin (P=0.05). The five best entries across locations included FLIP 86-5C, FLIP 84-15C, FLIP 85-60C, FLIP 85-93C and ILC 482. The ANOVA for stability for seed yield indicated that mean squares due to pooled deviations and entry x location (linear) were significant (Table

7.3.1). One entry (FLIP 85-56C) had regression coefficient greater than 1, nonsignificant deviations from regression and high mean yield and was thus responsive to favorable environments. Some of the entries, namely FLIP 85-48C, FLIP 85-74C, FLIP 86-6C and FLIP 85-5C, had regression coefficient equal to 1, deviations from regression approaching zero and the seed yield more than the general mean, and were thus widely adaptable.

Table 7.3.1. ANOVA for stability of seed yield for the entries in CIYT-SP, and CIYT-W-MR, conducted during 1989/90.

Source of variation	CIYT-SP		CIYT-MR	
	DF	MS($x10^3$)	DF	MS($X10^3$)
Entry	22	180.800**	22	758.625**
Entry x location + location	368	654.675**	759	770.174**
Location (linear)	1	232397.000**	1	485613.000**
Entry x location (linear)	22	58.721**	22	284.819**
Pooled deviation	345	20.960**	736	125.928**
Pooled error	374	13.858	748	78.315

* Significant at P = 0.05.

The Chickpea International Yield Trial-Sub-Tropical Region (CIYT-STR) was renamed Chickpea International Yield Trial Southern Latitude-1 (CIYT-SL1). Out of 7 locations for which data were analyzed a few test entries exceeded the respective local check in seed yield by a significant margin at three locations (Wadi Vargat in Oman; Mingora in Pakistan; and Tabuk in Saudi Arabia). The five heaviest yielders across locations were FLIP 87-42C, FLIP 87-60C, FLIP 87-43C, FLIP 86-52C, and FLIP 87-27C.

The Chickpea International Yield Trial Early (CIYT-E) was renamed as Southern Latitude-2 (CIYT-SL2). Results were reported from 4 locations and only at Tel Hadya in Syria two of the test entries exceeded the local check by a significant margin. The five heaviest yielding entries across locations included ILC 1539, ILC 2825, ILC 1687, ILC 2877, and ILC 2694.

The Chickpea International Yield Trial Latin American (CIYT-LA) with extra large seed was conducted for the first time during 1989/90. The results were reported from 6 locations and ANOVA for seed yield revealed that at Santa Lucia in Costa Rica and Sonora in Mexico, 3 and 2 test entries, respectively, exceeded the local check in seed yield by a significant margin (P = 0.05). The five heaviest yielders across locations included ILC 136, ILC 3780, ILC 464, ILC 4183 and FLIP 87-5C.

Results of Chickpea International Screening Nursery-Winter (CISN-W) revealed that at 6 locations out of 24, test entries exceeded the respective local check by a significant margin (P = 0.05). The five heaviest yielders across the locations included FLIP 88-15C, FLIP 88-5C, FLIP 88-20C, FLIP 88-2C, and FLIP 88-7C.

The results of Chickpea International Screening Nursery-Spring (CISN-S) were reported from 14 locations. Only at one location, Mushagar in Jordan, four test entries exceeded the local check in seed yield by a significant (P=0.05) margin. The five best-yielding lines across locations included FLIP 88-75C, FLIP 88-36C, FLIP 88-56C, FLIP 88-74C and FLIP 88-66C.

National Program Scientists, R.S. Malhotra, D. Beck, W. Erskine, S. Hanounik, L.D. Robertson, M.C. Saxena, K.B. Singh and S. Weigand

The results of Chickpea International Screening Nursery for Southernly Latitudes-1 (CISN-SL1), Southernly Latitudes-2 (CISN-SL2) and Latin American (CISN-LA) were reported from 2, 3, and 6 locations, respectively, and some of the test entries exceeded the local check by significant margins at 2, 0, and 1 locations, respectively. The five best entries across locations are given in Table 7.3.2.

Table 7.3.2. The five heaviest yielding lines across locations in different chickpea screening nurseries, 1989/90.

	Name of Nursery				
Rank	CISN-W	CISN-SP	CISN-SL1	CISN-SL2	CISN-LA
1	FLIP 88-15C	FLIP 88-75C	FLIP 88-19C	ILC 1726	ILC 6074
2	FLIP 88- 5C	FLIP 88-36C	FLIP 88-72C	ILC 1396	ILC 3808
3	FLIP 88-20C	FLIP 88-56C	FLIP 88-29C	ILC 1671	FLIP 87- 1C
4	FLIP 88- 2C	FLIP 88-74C	FLIP 88-45C	ILC 1681	ILC 4178
5	FLIP 88- 7C	FLIP 88-66C	FLIP 88-69C	ILC 2858	FLIP 81-293C

The Chickpea International F_4 Nursery Mediterranean (CIF4n-MR) and Chickpea International F4 Nursery Southernly Latitudes (CIF4N-SL) were supplied to cooperators for plant selection for developing their own breeding materials. Several national programs made good use of these nurseries.

The Chickpea International Ascochyta Blight Nursery (CIABN) results were reported from 14 locations. None of the entries was tolerant to Ascochyta blight infestation across locations. Considering the frequency of occurrence of an entry among the tolerant group (with rating up 4 on 1-9 scale), it was clear that five kabuli entries (FLIP 84-79C, FLIP 84-93C, FLIP 84-99C, FLIP 84-112C, and FLIP 84-133C) appeared best as they occurred 11 times in the tolerant group, and were followed by ILC 3279, ILC 5918, ILC 6043, ILC 6188, FLIP 83-21C, FLIP 83-48C, FLIP 84-83C, FLIP 84-92C, FLIP 84-102C, FLIP 84-112C, and FLIP 84-133C which each occurred 9 times in this group. These entries thus exhibited broad based resistance to Ascochyta blight. Similarly, FLIP 87-501C, FLIP 87-509C, and FLIP87-510C among desi lines exhibited better broad based resistance than the rest.

The results of Chickpea International Leaf Miner Nursery (CILMN) were reported from six locations. There was not much infestation at Setif in Algeria and Tel Hadya in Syria. At other locations the susceptible check took a score between 7 and 9 on 1-9 scale. Out of 30 test entries, six entries (ILC 316, ILC 394, ILC 655, ILC 1009, ILC 1216, and ILC 3800) were rated between 1 and 3 (on 1-9 scale) more frequently than others and were thus relatively better in resistance.

For Chickpea International Cold Tolerance Nursery (CICTN) the reaction was reported from seven locations, Setif in Algeria; Tabuk in Saudi Arabia; Diyarbakir and Erzurum in Turkey; Tel Hadya and Breda in Syria; and Terbol in Lebanon. At Tel Hadya and Breda only one entry, ILC 3470 (later purified and renamed as ILC 8262) survived severe winter with a rating of 4. At Erzurum only three entries ILC 668, ILC 3465 and FLIP 86-86C took rating of 3 and were tolerant. Across locations, six entries (*ILC 3465, ILC 3470, ILC 5615, ILC 5668, FLIP 85-93C and FLIP 86-87C*) occurred most frequently among the cold tolerant lines as compared to others.

The data on Chickpea Weed Control Trial (CWCT) was reported from seven locations. The ANOVA for yield revealed significant differences between treatment means. The yield loss due to weeds for the locations showing significant mean square due to weedicide treatments varied from 62.6% to 70.6%. Treatments T5 [pre-emergence application of terbutryne (Igran) at 3.0 kg a.i./ha], T10 [pre-emergence application of cyanazine (Fortrol) at 0.5 kg a.i./ha plus 0.5 kg a.i./ha of pronamide (Kerb)], T11 [pre-emergence application of chlorobromuron (Maloran) plus 0.5 kg a.i./ha of pronamide (Kerb)] and T9 [pre-emergence application of cyanazine (Fortrol) at 0.5 kg a.i./ha plus 0.5 kg a.i./ha of pronamide (Kerb)] at El Safsaf in Libya; treatment T4 [pre-emergence application of terbuthylazine + terbutryne (Topogard) at 0.75 kg a.i./ha], T10, T5 and T11 at Diyarbakir in Turkey; treatment T9, T11, T10 at Terbol in Lebanon; and treatment T11, T12 (pre-emergence application of methabenzthiazuron (Tribunil) at 3.0 kg a.i./ha plus 0.5 kg a.i./ha pronamide (Kerb)) and T10 at Dera-Ismail-Khan in Pakistan were among the superior treatments excelling the weedy check by significant margin.

The results of Chickpea International Rhizobium Inoculation Response Trial (CIRT) were reported from six locations. There were significant differences for seed yield among treatments at Alamaya in Ethiopia, and Setif and Tiaret in Algeria. None of the treatments at Alamaya in Ethiopia; Strain No. 31 and strain No. 44 at Setif in Algeria and Strain No. 31 and strian No. 39 at Tiaret in Algeria excelled the control in seed yield by a significant (P=0.05) margin.

7.4. Pea

The results of Pea International Adaptation Trial (PIAT) were reported from 14 locations. AT seven locations, namely, Tel Hadya in Syria, Terbol in Lebanon, Jindiress in Syria, Athalassa in Cyprus, Sidi Bel Abbes in Algeria, Elvas in Portugal, and Cordoba in Spain, respectively 10, 12, 15, 21, 2, 2 and 21 entries exceeded the local check by a significant (P=0.05) margin. The five best entries overall locations included PS 210713, Local selection 1690, Syrian Local Aleppo, PS 510314 and SV 51741. The stability analysis revealed that none of these five entries was stable in performance. Two other entries, ILP 845, and PS 5106999, with above average yield performance, regression coefficient equal to 1.00, and deviations approaching zero, were stable. Entry Century, with above average seed yield, regression coefficient greater than one and deviations approaching zero, showed specific adaptation to high yielding environments.

7.5. Identification of Superior Genotypes by NARS

The national program scientists participating in the legume International Testing Program identified and reported the release of 10 varieties of chickpea, 5 varieties of lentil and seven varieties of faba bean during 1990/91. Except Precoz (ILL 4605) which was released in Egypt for mixed cropping in sugarcane all other varieties were released for general cultivation (Table 7.5.1). In addition, several lines were identified

Table 7.5.1. Food and forage legume cultivars reported during as released by different national programs during 1990/91.

Country	Cultivars released	Year of release	Specific features
Kabuli Chickpea[1]			
Algeria	FLIP 84-79C	1991	Cold and Ascochyta blight resistance
	FLIP 84-92C	1991	Ascochyta blight resistance
China	ILC 102	1988	For Qinghai province
	ILC 411	1988	For Qinghai province
Iraq	ILC 482	1991	Large seed, Ascochyta blight resistance
	ILC 3279	1991	Tall, Ascochyta blight resistance
Syria	Ghab 3 (FLIP 82-150C)	1991	High yield, cold and Ascochyta blight resistance
Tunisia	FLIP 84-79C	1991	Ascochyta blight and cold resistnce
	FLIP 84-92C	1991	Large seed, Ascochyta blight resistance
Turkey	Akcin (87AK 11115)	1991	Cold and Ascochyta blight resistance
Lentil			
Argentina	Arbolito (ILL 4605 x-4349)	1991	Tall and early
China	FLIP 87-53L (ILL6242)	1988	For Qinghai province
Egypt	Precoz (ILL 4605)	1990	For intercropping in sugarcane
Morocco	Precoz (ILL 4605)	1990	Rust resistance, high yield
Turkey	Sazak'91 (NEL 854)	1991	Winter sowing, red cotyledon
U.S.A.	Crimson (ILL 784)	1991	High yield in dry areas
Faba bean			
Egypt	Reina Blanka	1991	For new areas
	Giza 461	1991	For north delta, disease resistance, high yield
Portugal	Favel (80S 43977)	1989	High yield
Sudan	Sellaim-ML	1990	Large seed, good quality, wide adaptation
	Shambat 75	1991	For El-Rahad area of Sudan, large seed
	Shambat 104	1991	For central region specially Gezira. Large seed, dual purpose (green and dry) use.
Forage Legumes			
Morocco	*Vicia sativa* (ILF-V-1812)	1990	Erect, tolerance to *Orobanche*, high yield, early

[1]. All chickpea cultivars are released for winter sowing, except for Akcin in Turkey which is released for spring sowing.

for multilocation testing, on-farm trials or pre-release multiplication. Also a large number of lines resistant to various stresses were identified and they are being used for direct or indirect exploitation.

National Program Scientists, R.S. Malhotra, K.B. Singh, W. Erskine, L.D. Robertson, M.C. Saxena, S. Weigand, D. Beck, and S. Hanounik

8. COLLABORATIVE PROJECTS

8.1. Nile Valley Regional Program

8.1.1. Egypt

8.1.1.1. Faba bean

Faba bean area and productivity in Egypt have shown continuous increase in the last six years. The area in 1990 was 134,252 ha with an average seed yield of 2.69 t/ha. An increasing adoption by Egyptian farmers of the recommendations emanating from Nile Valley Project appears to be one of the major factors responsible for an increase in the productivity of faba bean in Egypt.

The pilot production-cum-demonstration program was continued during the 1990/91 season, with 120 sites in Minia, 66 in Fayoum, 20 in Beheira and six in Kafer El-Sheikh governorate to compare an improved production package with the practices adopted by the neighboring farmers. Nine different sets of improved production packages were used depending on the region and production problem. As an average of all the demonstrations, the improved package in Menya and Fayoum on the average increased the seed yield by 0.48 t/ha (26%) and straw yield by 0.33 t/ha (12%) over the farmer's practice. In Behaira and Kafer El-Sheikh the corresponding average increases were 0.57 t/ha (43%) and 0.08 t/ha (10.7%), respectively.

In Minia the pilot production-cum-demonstration plots having an improved package of Giza 402 cultivar, sown in early November at a seed rate of 184.5 kg/ha with a fertilizer application of 35.7 kg N and 71.4 kg P_2O_5/ha, weed control by hand or herbicide, aphid control with Pirimor if needed, and optimum water management, gave an increase of 24% in seed yield and 4.3% in straw yield over the neighboring farmers. These increases were highly economical.

In Beheira and Kafer El-Sheikh governorate where chocolate spot disease is common, the newly released disease-resistant cultivar Giza 461 was demonstrated on 19 sites. As an average of both governorates, the new cultivar yielded 43% more seed and 11% more straw as compared to standard commercial cultivar Giza 3.

In the Orobanche-infested areas of Minia, Fayoum, and Beheira, demonstration of integrated Orobanche control was done based on use of Giza cultivar and glyphosate (179 cc of Lancer in 500 liters of water at flowering stage and again 15 days later). Plots in Minia showed on the average an increase of 1.03 t/ha (40%) in seed yield and 1.47 t/ha (19.5%) in straw yield and in Fayoum an average increase of 0.94 t/ha (106%) in seed yield and 1.19 t/ha (54%) in straw yield over the neighboring farmers. The recommended package reduced both the number and dry weight of Orobanche spikes and was highly economical.

In 22 demonstrations in Minia and Fayoum governorate, a reduced rate of glyphosate use (95.2 cc Lancer/ha) in combination with foliar application of mineral nutrients (1% N, 1% P and 2%K) at 500 L/ha was demonstrated in place of the earlier recommended rate of glyphosate which sometimes causes phytotoxicity. This new recommendation was more effective in reducing the Orobanche infestation and increasing yields; the seed yield increased by 13% in Minia and 20% in Fayoum and the respective increases in the straw yield were 17% and 4%. It was also more economical than the old recommendation.

The researcher-managed on-farm trials focused on intercropping of faba bean with ratoon sugarcane in Minia and with sugarbeet in Beheira and Kafer El-Shaikh. Also agronomic practices for the newly released cultivars Giza 461 and Reina Blanca in Kafer El-Sheikh governorate were evaluated.

In Minia, intercropping of two rows of faba bean in between two rows of ratoon sugarcane giving 25 plants of faba bean/m^2 produced highest seed yield compared with single or triple rows of faba bean which gave a faba bean density of 17 and 33 plants/m^2, respectively. Inoculation of faba bean with Rhizobium culture before sowing gave a significant and economic increase in yield of faba bean in this system over uninoculated seed.

In Kafer El-Sheikh, the two newly released faba bean cultivars Giza 461 and Reina Blanca were used for intercropping in sugarbeet fields. One row of one of these cultivars was sown on the opposite side of the 60 cm spaced ridges of sugarbeet one month after sowing sugarbeet. This was compared with pure crop of sugarbeet. Intercropping did not reduce sugarbeet yield and the yield of faba bean was 297 and 448 kg seed/ha for Giza 461 and Reina Blanca respectively, resulting in an increase in the net income by 458 and 747 LE/ha respectively, over the pure crop of sugarbeet (Table 8.1.1).

Table 8.1.1. Effect of intercropping two new cultivars of faba bean with sugarbeet on the yield and economics of production at Kafer El-Sheikh in 1991.

Treatments	Yield (t/ha) Sugarbeet roots	Faba bean	Total income* (LE/ha)
Sugarbeet alone	81.5	0.00	5501
SB + Giza 461	81.2	0.297	5959
SB + R. Blanca	81.8	0.448	6248

* Official price of LE 67.5 and LE 1613/t of sugarbeet and faba bean respectively.

Four on-farm researcher managed trials in Beheira and Kafer El-Sheikh governorate tested the foliar disease resistance of newly released varieties Giza 461 and Reina Blanca against standard cultivar Giza 3 by subjecting them to varying regimes (0, 1, 2, 3 and 4 sprays) of Dithane M45 fungicide. The increase in yield due to full protection with foliar spray of fungicides was least (11.7%) in Giza 461 demonstrating its superior disease resistance in contrast to Giza 3 (22% yield increase) and Reina Blanca (26.6% yield increase due to fungicide protection).

Back-up research was conducted on breeding, agronomy, pathology, entomology, microbiology, Orobanche and weed control, soil fertility and plant nutrition, and nutritional quality. Details of these studies are available in the "Annual Report of the Nile Valley Regional Program - Egypt for 1990-91". Only major highlights are presented here.

In the breeding program 27 faba bean lines were identified as promising for chocolate spot resistance and six families combined foliar disease resistance with high seed yield. Eighteen lines showed tolerance to Orobanche at Giza. Seventeen F_4 and 10 F_6 families recorded lower aphid infestation rates than the check cultivar Giza 402 at Sids research station. All these lines were selected for further evaluation. To develop a fully autogamous faba bean with high level of autofertility and high yield, research work began in 1991 with the screening of 150 genotypes in bee-proof cages, and highly autofertile accessions have been found.

In the calcareous soils at Nubaria, Reina Blanca faba bean showed a significant increase in seed yield by 3 sprays of 2% P_2O_5 (at 30, 60 and 90 days after sowing) compared with a soil application of 35.7 kg P_2O_5/ha. Evaluation of 11 faba bean cultivars for their nitrogen fixation ability using ^{15}N fertilizer at Mallawy research station showed that the percentage of plant nitrogen derived from the atmosphere ranged from 49.6 to 61.7%, with Geiza 402 recording the highest value. In Orobanche chemical control study, combination of Imazapyr (Arsenal 25% EC) at 30 g a.i./ha pre-emergence with glyphosate (Lancer) at 60 g a.i./ha post emergence (7 weeks after sowing) gave better parasite control with less phytotoxicity than the use of glyphosate at standard rate, three times, post-emergence.

The program paid attention to seed multiplication, and 100 t seed of Giza 461 and 45 t seed of Reina Blanca were processed for 1991/92.

8.1.1.2. Lentil

Lentil was grown on 6769 ha in Egypt in 1990/91 with an average of 1.9 t/ha. Nearly 50% of the total area of this crop in Egypt is concentrated in the Delta region because lentil crop was introduced in Sharkia, Dakahlia and Kafer El-Sheikh governorates after the construction of High Dam. The major constraints to lentil production there are water management, diseases, aphids and weeds. A pilot-production-cum-demonstration program was started in this area to demonstrate the possibility of resolving these constraints.

A total of 39 demonstrations (20 at Sharkia, 5 at Dakahlia, 10 at Kafer El-Sheikh and 4 at Baheira governorates) were conducted involving an improved package of one irrigation 4 weeks after sowing, seed rate of 143 kg/ha, weed control using Gesagard at the rate of 2.5 kg a.i./ha as pre-emergence application, control of downy mildew using Ridomil-Mancozeb 58 WP at 205 g/100 l and aphid control using Pirimor. The yield in demonstration plots over neighboring farmers was 9%, 13.2% and 48% higher in Sharkia, Dakahlia and Kafer El-Sheikh, respectively. In Behaira, Precoz cultivar outyielded local cultivar Giza 370 by 26%. Over all the demonstrations, the recommended package increased the seed yield by 11% and straw yield by 12% over neighboring farmers and the economics was better.

Researcher-managed on-farm trials focused on land preparation, seeding rate and irrigation methods for lentil for different cropping systems. Irrigation study showed that two surface irrigations (20 and 50 days after sowing) resulted in a significant increase in seed yield (53%) over farmer's practice of one pre-sowing flooding irrigation to simulate Nile floods, a common tradition in the old lentil-growing area of Egypt which has now gone out of production after the construction of High Dam. Pre-sowing irrigation, with a seed rate of 95 kg/ha and covering seeds by using rotovator, was the optimal package to overcome the problem of poor stand establishment and low yield in rotation with rice under 'Zero-tillage' system.

Back-up research in lentil breeding identified 16 promising entries out of 111 tested entries introduced from ICARDA as they outyielded the best check. Three genotypes (ILL 6024, ILL 5700 and ILL 5782) showed high resistance to root rot in the disease-sick plot. The major seed-borne pathogens associated with seed were Fusarium sp. and Rhizoctonia solani. Weed control studies reconfirmed that pre-emergence application of Gesagard at 1.5 kg a.i./ha either singly or in combination with Kerb (0.5 kg a.i./ha) was the most effective herbicide treatment to control weeds in lentil fields.

8.1.1.3. Chickpea

Area of chickpea in Egypt is limited and there is great interest in the crop in the 'newly reclaimed' areas in the North. Demonstrations were conducted at three locations in Assuit and Behaira governorates using an improved production package comprising chickpea line 531, a seed rate of 95 kg/ha, inoculation with Rhizobium (ICARDA strain 44) and pre-emergence application of Topogard to control weeds. On the average, the improved package gave 23.5% increase in seed yield over the neighboring farmer and this increase was highly economical. The increase was higher in Beheira (39%) than in Assuit (12%).

In the researcher-managed on-farm trials in Assuit, Quena, Ismaillia, Beheira and Alexandria governorate, two breeding lines (L70 and FLIP 84-80C) outyielded the farmers' check cultivar by nearly 37%.

In the back-up research on breeding, 5 accessions were identified and selected for further evaluation (2 progenies of the cross Giza 88 x ILC 365; FLIP 86-21C, FLIP 87-55C and FLIP 88-87C). Inoculation with Rhizobium caused significant increase in yield over uninoculated check and nitrogen application. Nitrogen application itself also resulted in increased yield.

National Scientists from Egypt

8.1.2. Ethiopia

Ethiopia is one of the largest producers of cool-season food legumes with nearly 0.313 m ha under faba bean, 0.136 m ha under chickpea, 0.134 m ha under field pea and 48,000 ha under lentil. These crops are grown for human consumption as well as for export, and farmers realise their value in the crop rotation. Lathyrus is also extensively grown, particularly on heavy soils under moisture supply conditions which are insufficient for chickpea and faba bean. All the crops are grown rainfed and average yields at 1.14 t/ha for faba bean, 0.73 t/ha for chickpea, 0.78 t/ha for field pea and 0.67 t/ha for lentil are rather low. Research is being conducted under the Nile Valley Regional Program on these crops.

8.1.2.1. Faba bean

Pilot-production-cum demonstration program was executed in Arsi, Central Shewa and North-West Ethiopia (Gojam) areas. Demonstrations on 14 locations in Arsi zone using 20 DK genotype at 200 kg seed/ha, 100 kg DAP/ha and hand weeding twice resulted in yield levels ranging from 2.4 to 4.16 t/ha with an overall mean of 3.53 t/ha as against the farmers' yields ranging from 1.2 to 3.33 t/ha. The overall economic benefit over farmers' practice was 43.0% (about 946 Birr/ha) and the marginal rate of return (MRR) on investment was 535%. Demonstrations on 21 sites in Dega and Woina Dege area of the central zone of Shewa showed a 40-207% increase (mean 91%) in yield over farmers' method with an additional net benefit of 932 Birr/ha and a MRR of 393%. Demonstrations on 3 sites in northwest Ethiopia (Gojam) were conducted to show the superiority of the improved variety (20 DK). The improved variety gave a yield increase of 1.12 t/ha (112% increase) resulting in an increase in the net revenue of 470 Birr/ha with a MRR of 307%. Thus, the improved genotype and other components of the improved production package have been passed on to the extension agencies for further popularization in the newer areas.

Popularization of improved faba bean production was followed up in Ada Awraja and benefit from the adoption of the improved package was quantified by comparing the productivity and economic returns of the 'adopter' farmer with the neighboring 'non-adopter'. The farmers adopting the improved method got a higher net benefit with a MRR of 1763%.

Researcher-managed on-farm studies included a diagnostic survey of faba bean production in Anagacha area of Shewa and verification of several agronomic practices. Diagnostic survey covering 35 sample farmers revealedsha that (a) major crops in the order of importance were small cereals, faba bean, field pea and Enset; and (b) major production constraints for faba bean were shortage of arable land, soil erosion, chocolate spot disease, rust and aphid infestation. On-farm verification of improved faba bean varieties at four locations in West Gojam revealed that 20 DK was the best genotype, with a yield of 2.63 t/ha compared with a yield of 1.93 t/ha for 'local' varieties resulting in an additional net revenue of 326 Birr/ha.

On-farm verification of pre-emergence herbicide Terbutryne at 4.0 kg product/ha with hand weeding once in 25-30 days after sowing and no weeding treatment (common farmer practice) revealed that hand weeding once was the best at both Wolmera and Debre Zeit, where faba bean seed yield increased by 23% and 17%, respectively, over unweeded check. Parallel studies on wheat revealed that chemical weed control was more economical than hand weeding in the crop. Hence the labor released from wheat fields on the adoption of herbicide use there could permit weeding in faba bean. This would increase overall economics of the production system.

Back-up research on breeding included national variety trials, regional varietal trial for the Northwest (Adet and Mote), pre-national varietal trial in Bale, development of pure lines of faba bean at Holetta and evaluation of indigenous and exotic faba bean germplasm. The national varietal trial for medium elevation identified MKT-Illubabor and NEB 207 x 74 TA-60 as most promising with a mean yield level of above 2.9 t/ha across 4 locations (Denbi, Kulunesa, Adet and Asasa). These will be considered for release.

Lodging is a serious problem in faba bean in major production areas in Ethiopia, hence there is great interest in the determinate plant type. Several very promising determinate lines have been identified: D-83104-3-1, D-310074-6-2, FLIP-84-240-1, FLIP-86-119-2-1, D-87024-1 and FLIP-86-146-2.

Back-up research in agronomy investigated the yield effect of method and rate of seeding, rate of seeding and weeding frequency, and pre-emergence application of herbicides. Also evaluation of different tillage implements was done. Row sowing was better than broadcast seeding, and a seeding rate of 200 kg/ha appeared optimum at both Bekoji and Kulumsa. Single hand weeding or use of pre-emergence herbicides such as metolachlor + metobromuran or pronamide mixed with terbutryne or cyanazine or methabenzthiazuron proved effective in controlling weeds and increasing the faba bean yields significantly over unweeded check. Nazareth mould board plough was more effective than the local 'Maresha' plough for preparatory tillage in early April to mid-May in the nitosols.

Chocolate spot and rust infestation was common. Six entries were rated as tolerant to chocolate spot and seven entries to rust in the third stage screening for these diseases. In addition, several single plant selections (9 for chocolate spot and 74 for rust) were made. Aphis craccivora and Heliocoverpa armigera were the major insect pests but their infestation was not very high. Screening for aphid resistance at Debre Zeit could, therefore, not be successful.

8.1.2.2. Lentil

Demonstration of improved production package of lentil (improved variety Chalew (NEL 358), 70 kg seed/ha, sowing date mid-July, and one hand weeding) was done at 5 sites in Shewa region in 14 demonstration plots. The improved package gave 70% increase in yield and an additional net benefit of 225 Birr/ha with a marginal rate of return of 284%. On-farm verification of pea aphid control in lentil at 3 locations in Shewa region showed that Pirimor 50% WP at 1 kg product/ha or Dimethoate 40% EC at 725 ml/ha increased seed and straw yield of lentil NEL-358 over unsprayed check, but the marginal rate of return for the treatment was low (only 64%). Insect pests found attacking lentil in Gojam area were cutworm (Agrotis ipsilon) and pod borer (Heliocoverpa armigera). In Mota and Bichena areas of east Gojam aphids (Acyrthosiphon pisum) and thrips (Caliothrip impurus) were most important.

Back-up studies in breeding included evaluation of 24 promising lines under different environmental conditions as represented by Debre Zeit, Sheno and Koka. Because of heavy rains late in the season, Ascochyta blight developed and reduced the productivity of several lines. Across the locations DZ-90-L0052 and DZ-90-L0055 showed good performance with yield levels around 1.3 t/ha. One hundred and seventy-four accessions of local germplasm collection were evaluated at the above three sites and large variability for different agronomic traits observed, which will be used in the breeding work. Four nurseries of advanced lines, two nurseries of segregating populations and one yield trial received from ICARDA were evaluated at Debre Zeit and evaluated for their reaction to rust and Ascochyta blight, besides yield and other desirable traits. Several selections were made, particularly from the LIF_4N-90 and LIF_4N-E-90.

One of the major production constraints of lentil is waterlogging on heavy soil. A trial was therefore conducted at Akaki, Debre Zeit and Denbi to compare the planting of lentil on broadbeds witsrfh furrow (BBF) vs. ridge and furrow (RF) planting. At the heavy soil sites of Akaki and Debre Zeit, the yield was significantly higher in BBF method of sowing compared with the RF method (Table 8.1.2), because the ridges get washed out due to rain and do not permit as good a drain as in BBF.

Table 8.1.2. Effect of seedbed type on the yield of lentil (kg/ha) at different locations in Ethiopia, 1990/91.

Location		Yield (kg/ha) BBF	RF	LSD (P=0.5)	CV %	% increase in yield over RF
Akaki	Seed	1422	474	332	21	200
	Straw	3439	2304	389	17	49
Debre Zeit	Seed	750	483	123	24	55
	Straw	3593	2883	694	13	25
Denbi	Seed	916	766	NS	20	20
	Straw	4551	2596	706	15	27

On-farm verification of this practice at Akaki, Dibandiba and Keteb area, where the lentil crop is grown on vertisols, revealed that there was significant increase in yield by BBF method compared with the RF method, respective increases being 59, 102 and 99% for grain yield and 28, 27, and 59% for straw yield. Economic evaluation showed that BBF method under existing price gave 554% marginal rate of return over the RF method. The only complaint that farmers had about BBF method was that they needed a stronger pair of oxen for BBF maker.

Seven lentil-growing Awrajas of Shewa regions were surveyed for weed species common in lentil field, covering 42 lentil fields on both light and heavy soils. July-planted lentil had more weeds than the crop sown in September to mid-October. On light soils major weed species were Scorpirus muriatus, Setaria pallidefusca and Cyperus spp. whereas on black heavy soils S. muriatus and Brassica spp. were the predominant species. Hand weeding once was better than pre-emergence application of terbutryne at 2 kg a.i./ha in controlling weeds and gave a significant increase in yield over weedy check.

Survey of lentil diseases in Addis Ababa and Shewa region revealed that rust (caused by Uromyces fabae) was the most widespread and damaging disease followed by root rots (caused by Rhizoctonia solani and Sclerotium rolfsii). The latter was mostly present in the crops grown on black clay soils in early July. Farmers tend to delay sowing to September to avoid the problem of root rots. Ascochyta blight (caused by Ascochyta lentis), powdery mildew (caused by Erysiphe spp.) and stem rot (caused by Sclerotinia spp.) were also present. A total of 66 lines selected from ICARDA nurseries and some local accessions were evaluated for rust at Akaki. Most of the entries showed higher level of resistance to rust, particularly the exotic ones. Screening of 75 test entries for Ascochyta blight resulted in identification of 20 entries with tolerant reaction.

8.1.2.3. Chickpea

Improved chickpea variety Mariye with improved production package (seed rate 80 kg/ha end of August to early September sowing, and one hand weeding) was demonstrated on 16 locations in Akaki, Modjo, Tullubollo, Ginchi, Shenkora and Ejere areas of Shewa administrative region. In all locations, improved package gave higher seed yields (40% increase) and 559 Birr/ha additional revenue over the traditional package.

Twenty-five promising chickpea lines, selected from past introductions and preliminary evaluations, were tested at 8 locations for their yield performance and agronomic characters. Most of the selected entries exceeded best check entry significantly and will be tested in the advance yield trials next year.

Nearly 300 local land race collections of chickpea were evaluated at Koka and Akaki stations for various agronomic characters. Large variability was observed. Thirty accessions were selected because of the superior performance over the local check and will be further evaluated. Seventy-four kabuli chickpea lines received from ICARDA were evaluated in 3 trials (CISN-SL_2-90, CIYT-SL-90 and CIF_4N-SL-90) at Debre Zeit and 17 lines and 143 single plants were selected. ILC 2400, 2694, 1824, 2904 and 2910 were early and performed well.

Influence of improved drainage of vertisols on chickpea productivity was evaluated in 1989/90 and 1990/91 at Akaki and Keteba stations using broadbed and furrow (BBF) method in contrast to the farmer's practice of sowing on flat seed-bed late in the season when the danger of flooding is over. Results, averaged over the two seasons (Table 8.1.3), indicated that BBF increased the yields significantly ($P<0.01$) at both the locations. The grain yield increased by 120% at Akaki and 94% at Keteba using BBF and respective increases in straw yield were 63 and 93%. Partial budget analysis revealed that the gross revenue in BBF method increased by 100% over the traditional method and the MRR was more than 250% for the additional investment.

Table 8.1.3. Two-year mean of grain and straw yield of chickpea as affected by sowing method.

Location	Treatment	Yield (kg/ha)	
		Seed	Straw
Akaki	BBF	2021	2757
	Flat	917	1694
	LSD (P=0.01)	717	1033
	CV (%)	18.4	17.3
Keteba	BBF	2181	3451
	Flat	1125	1792
	LSD (P=0.01)	761	959
	CV (%)	16.4	13.8

A survey of different chickpea diseases in Addis Ababa and Shewa administrative regions revealed that wilt/root rot and stunt were most widespread. Stunt was more widespread at flowering stage of crop growth than at earlier stages and the incidence was higher when plant stand was low. Wilt was incited by Fusarium oxysporum f.sp. ciceri, wet root rot by Rhizoctonia solani and collar rot by Sclerotium rolfsii. A wilt and root rot-sick plot has been developed at Debre Zeit which will permit effective screening for these diseases in the future. In order to monitor the variability in the populations of F. oxysporum f.sp. ciceri a national wilt/root rot nursery has been started for evaluation in different chickpea-production areas in Ethiopia.

The insect pests found attacking chickpea were cutworm (Agrotis ipsilon) and pod borer (Helicoverpa armigera) in Mota and Bichena Awarja of east Gojam. The damage from cutworms ranged from 0.5% to 90%, but pod borer was more widespread and pod damage ranged from 8.5% in Getero to 27% in Guseza site. In the survey of field insect pests in Addis Ababa and Shewa administrative region, pod borer was the most common pest and it was also important in Mojo, Ejere, Shenkora and around Awash. Pheromone trap monitoring of the pod borer at Debre Zeit from 1988 to 1990 revealed that moth catch peaked in the dry months of December and January while during the rainy months of April and August the catches were small. This study is being continued along with the collection of data on weather conditions to relate the pod borer population dynamics to weather conditions.

National Scientists from Ethiopia

8.1.3. Sudan

Research on faba bean, chickpea and lentil under the Nile Valley Project was continued for the third season during 1990/91. The work on lentil and chickpea was done in the Nile and Northern provinces whereas work on faba bean was done also in the non-traditional area south of Khartoum. The 1990/91 season had unusually warm temperatures during November and December (3-4°C higher than the normal) which reduced the overall productivity of faba bean by nearly 50%, chickpea by 30% and lentil by 40% compared with the previous season.

8.1.3.1. Faba bean

The pilot production-demonstration program was conducted in the private pump schemes in Shendi area, and in Dongla area in the Selaim basin. In Shendi, adoption of the improved package (early sowing, frequent irrigation and pest control) increased seed yield by 83% over the neighboring farmers who followed traditional practices. In Dongla area, the improved package consisted of a newly released cultivar (Selaim Medium Large-SML), hand weeding and insect-pest control using Folimat. The recommended package increased the seed yield by 20% with a 25% increase in net benefits over the neighboring farmers.

Weed infestation is a major production constraint for faba bean in the traditional growing areas of northern Sudan. Previous back-up research identified Pursuit at 0.05 kg a.i./ha when tank mixed with Goal at 0.24 kg a.i./ha as an effective broad-spectrum herbicide treatment when sprayed before the first irrigation. This was verified in research-managed on-farm trial in Aliab during 1990/91. The treatment gave 95% control of all broad leaf and 82% of all grassy weeds up to 60 days after sowing and increased faba bean yield by nearly 60% over unweeded check, the respective yields being 1.66 and 1.05 t/ha.

Water allocation and its effect on technology adoption by farmers was investigated in the Nile province. It was shown that cash crops like banana and onions compete with faba bean for water allocation. Provision of more water through improved fuel supply and arrangements for spare parts for pumps will help in allocation of more frequent irrigation for faba bean, which is economically a very viable proposition.

Adoption studies in the traditional areas indicated that farmers were selective in adopting the components of the recommended production package. Adoption was better in public than in private schemes. The least adopted component of the production package was the frequency of irrigation.

In the non-traditional faba bean-growing areas, adoption of faba bean was high: nearly 89% of the sampled farmers in Gezira grew faba bean, but mainly on the ridges of irrigation channels. In Rahad, where demonstration was conducted only for one year, the percentage adoption of faba bean was low. It is estimated that nearly 3000 ha of faba bean was sown on irrigation channels and plot partitions in 1990/91 and this area is likely to increase in the coming years because of the increasing price of faba bean.

In the back-up research on faba bean breeding, six yield verification trials were conducted over the entire faba bean-growing area in the country. Genotype 00616 gave the highest seed yield and surpassed the standard check by more than 10%. In the national variety trial in traditional areas, BB7 gave highest seed yield over two consecutive seasons and appears to be tolerant to moisture stress. The line Bulk 1/3 tested in the advanced yield trial gave highest yield in both Sendi and Hudeiba. These lines could be candidates for future release.

In non-traditional areas, the Variety Release Committee approved the release of 'Shambat 104' for the Central region and Shambat 75 for the Rahad area. To facilitate rapid seed multiplication, breeders' seed is being provided to the seed propagation department.

Studies on screening of faba bean genotypes for leafminer resistance revealed that 36 out of 110 lines had good resistance. Evaluation of insecticides for leafminer control showed that Evisect (thiocyclam-hydrogenoxadate) was more effective than Neem extract or Furadan. However, natural parasites of leafminer were better protected when Danitol-S or Neem extract were used.

The fungi associated with root rot and wilt diseases were isolated and identified. These included, among others, Rhizoctonia solani and Macrophomina phaseoli, which are perhaps reported for the first time as causing these diseases in faba bean in Sudan.

Unrestricted weed growth reduced faba bean yield by 72% in Wad Hamid. However, weeds could be effectively controlled by using Pursuit (imezathapyar) alone or tank mixed with Stomp or Goal.

8.1.3.2. Lentil

The strategy of the Sudan government is to expand the lentil area in order to reach self-sufficiency for the crop. To meet this aim, an improved production package of lentil was demonstrated in Wad Hamid and Rubatab areas in the Nile province, as these are the potential areas for future lentil production. The improved package in Rubatab included early sowing in the first two weeks of November, seed rate of 107.1 kg/ha, frequent irrigation (every 10 days), weeds and insect pest control. In Wad Hamid no lentil is currently grown by farmers, hence comparison there was made with chickpea. Lentil gave a yield of 1600 kg/ha and a net revenue (LS 39,122/ha) which was more than double the revenue of traditionally grown chickpea. At Rubatab, where farmers do grow lentil, average seed yield of the improved package was 1889 kg/ha with net benefit of 51,989 LS/ha against yield of 1471 kg/ha and net benefit of 39,327 LS/ha for neighboring farmers. Thus there was a 28.4% increase in yield and 32% increase in net revenue using the improved package over the traditional one.

A diagnostic survey in the area revealed that there was need for further studies on the interaction between sowing method and seed rate, and the interaction of land preparation and sowing method with weed control. Extension services were greatly needed to disseminate the available information to farmers.

Back-up research on lentil breeding was carried out at Rubatab and Wad Hamid. Six promising lines were evaluated in on-farm verification yield trials in both locations. The best lines were ILL 795 and ILL 818 at Wad Hamid and ILL 813 at Rubatab. Back-up research on planting methods, seed rate and weed control revealed that, in Rubatab area, flat planting in hills 25 cm apart produced higher yield than broadcasting the seeds and ridging the soil into 40-cm ridges. There were no significant differences among five seed rates tested, suggesting the possibility of using the low rate of 35.7 kg seeds/ha. In Wad Hamid, spray with Pursuit (0.050 kg/ha a.i.) mixed with Stomp (1.2 kg/ha a.i.) at 70 days after sowing gave the best control of both grasses and broad leaf weeds in lentil.

8.1.3.3. Chickpea

Demonstration of the improved production package was conducted in Rubatab and Wad Hamid, the main chickpea-growing areas in Sudan. Six demonstrations were conducted in Rubatab comparing the improved package (sowing the improved variety 'Shendi' in mid-November with seed rate of 60 kg/ha by broadcasting and ridging, and spraying against insect pests) with the traditional growing of chickpea as practiced by the neighboring farmers. The improved package gave a seed yield increase of 56%, and 60% higher net benefit over traditional practices (Table 8.1.2). In Wad Hamid, ten demonstrations were conducted using three improved production factors (variety Shendi, pest control and irrigation at 15-20 day intervals). The improved package resulted in a seed yield increase of 168%, and 176% higher net benefit over farmers' practices.

Researcher-managed on-farm testing of sowing method and irrigation termination date revealed that ridge sowing was better than flat sowing and that irrigation should not be terminated before 90 days from sowing.

Table 8.1.4. Average seed yield and economic evaluation of in-and-out of demonstration farmers in chickpea areas in Sudan.

	Rubatab		Wad Hamid	
	Indemons-tration	Outdemons-tration	Indemons-tration	Outdemons-tration
Seed yield (kg/ha)*	1190	761	1644	614
Plants/m^2	27.8	22.2	-	-
Total variable cost	5428	3945	7014	3331
Net benefits (LS/ha)	30272	18885	66966	24294

* Seed price (LS/ha) = 45

Back-up research in breeding showed that several introduced lines surpassed best check by about 25% in yield. Fusarium oxysporum f.sp. ciceri, Rhizoctonia bataticola and Rizoctonia solani were isolated from roots of chickpea plants showing wilt/root rot symptoms. This is thought to be the first report of R. solani on chickpea in Sudan. In the sick plot screening of 79 chickpea genotypes for root rot/wilt diseases, ICC 82001 was the only resistant genotype. Pod borer (Heliocoverpa armigera) was the most important insect pest. It was controlled well by the use of such insecticides as Larvin, Sevin or Bolastar.

National Scientists from Sudan

8.2. North African Regional Program

During the 1990/91 crop season, ICARDA continued its collaborative research in food legumes with the national programs of Algeria, Libya, Morocco and Tunisia. The Regional Food Legume Scientist of ICARDA was based at Douyet Research Station of INRA, Morocco, along with the two faba bean scientists for the INRA/ICARDA faba bean project at Douyet. This was the second year of the faba bean project at Douyet aimed at transferring ICARDA's faba bean improvement program to INRA, Morocco.

A large number of research and training activities on food legumes were conducted as a part of the ICARDA/national program collaborative activities. The emphasis, however, continued on germplasm enhancement, transfer of technology and strengthening of national research capabilities through different types of training activities. Also, a greater emphasis was placed on developing and strengthening network activities on food legumes in the four countries of North Africa. Here, only highlights of results of the important activities are given. Detailed information on the collaborative research activities with each national program is available through the national program reports.

8.2.1. Provision of Trials and Nurseries to the National Programs in North Africa

Relevant germplasm of faba bean, chickpea, lentil and pea was provided to the four national programs in the form of international trials and nurseries, details of which are summarized in Table 8.2.1. These trials/nurseries complemented the national and regional trials/nurseries that were developed in collaboration with the national programs.

8.2.2. Regional Research Activities

Emphasis continued on developing network activities in the region. The regional yield trials and nurseries that were organized and conducted in the region are listed in Table 8.2.2.

8.2.3. Algeria

Although ICARDA has been assisting the Algerian food legume program since its inception, special technical assistance has been provided to the food legume program at ITGC's Sidi Bel Abbes Research Station through a joint ITGC/ICARDA project operative since the 1987/88 crop season. However, other research stations of ITGC in the country, namely Tiaret, Saida, Khemis Meliana, Oued Smar, El-Khroub, Setif and Guelma, continued receiving support to facilitate germplasm enhancement through international yield trials and nurseries in food legumes from ICARDA, visits from ICARDA scientists, and training of their food legume research scientists and technicians.

In Algeria, faba bean and chickpea are most important food legumes occupying approximately 45% the total hectarage under food legumes with dry pea and lentil occupying approximately 7.7 and 2.8%, respectively. The objective of the food legume research program is to develop high and stable yielding varieties suitable for mechanization, which is adversely affecting their increase in hectarage. In chickpea, the winter sowing is being encouraged considering its advantage over the traditional spring sowing. In general, breeding for disease resistance and frost tolerance (for high elevation areas) receives top priority in the program.

8.2.3.1. The 1990/91 crop season

The weather conditions during the 1990/91 crop season were favorable for crop growth and development compared with the recent years. Rainfall was sufficient and well distributed throughout the season. It exceeded the last 10-year average and was more than 400 mm at most locations. This, however, encouraged diseases such as Ascochyta blight in chickpea, and chocolate spot and Ascochyta blight in faba bean.

Table 8.2.1. Number of yield trials, screening nurseries, segregating population nurseries and agronomic trials in food legumes provided to the national programs in North Africa, 1990/91.

Country	Number of trials/nurseries															
	Yield trials[a]			Nurseries populations			Segregating trials			Agronomy			Total			
	C	L	P	F	C	L	F	C	L	F	C	L	F	C	L	P
Algeria	6	19	1	9	26	13	0	5	1	0	6	2	9	43	35	1
Libya	3	1	1	3	4	3	0	0	0	1	3	1	4	10	5	1
Morocco	4	2	0	10	16	9	0	2	0	0	2	1	10	24	12	0
Tunisia	7	6	1	9	27	10	0	1	0	1	0	0	10	35	16	1
Total	20	28	3	31	73	35	0	8	1	2	11	4	33	112	68	3

[a] F = faba bean; C = chickpea; L = lentil; and P = Pea.

8.2.3.2. Germplasm enhancement

The number of international yield trials and nurseries provided by ICARDA's legume program to Algeria are listed in Table 8.2.1. Although these were raised at different research stations of ITGC depending upon the need, the majority of them were raised at Sidi Bel Abbes station.

Table 8.2.2. Regional yield trials and disease nurseries in North Africa, 1991.

Activity	Responsability
A. <u>Yield Trials</u>	
1. FBNAYT-L-91	Morocco
2. FBNAYT-S-91	Morocco
3. NACEYT-91	Tunisia
4. NALEYT-91	Morocco
B. <u>Disease Nurseries</u>	
1. FBNAR Orobanche-91	Morocco
2. FB Chocolate Spot-91	Morocco
3. FB Ascochyta Blight-91	Morocco
4. CP Ascochyta Blight Trap-91	Tunisia/Morocco
5. CP Wilt Trap-91	Tunisia/Morocco

8.2.3.2.1. Faba bean

Of the 17 entries tested in the preliminary yield trial (Botrytis), two (S 84081-10-2-1-1 and S 84 118-33-1-1-1) significantly outyielded both the check varieties. In the multilocation yield trial-I, varieties FLIP 82-30FB (large-seeded) and FLIP 83-105FB (small-seeded) yielded as much as the standard check Aquadulce at both Tessala and SBA station.

In the faba bean North Africa Regional Yield Trial-Large-1991 (FBNARYT-L-91), FLIP 82-30FB was the highest yielder (2342 kg/ha) followed by FLIP 87-26FB (Table 8.2.3). The standard check Aquadulce yielded 1366 kg/ha. In the FBNARYT-S-91, FLIP 83-106FB was the highest yielder (2335 kg/ha) followed by 76TA 56267 (2309 kg/ha) which were significantly superior to the check (Table 8.2.4).

All the five lines in the Faba Bean North Africa Regional Orobanche Nursery-1991 (FBNARON-91) showed good resistance to <u>Orobanche</u> at Oued Smar station compared with Aquadulce (Table 8.2.5). Highest grain yield (4058 kg/ha) was obtained in line 18009 compared with 69 kg/ha of

Aquadulce.

Now, a good faba bean program has been established at Sidi Bel Abbes station and it is expected that new faba bean lines with higher and stable yields would soon be made available from the program for cultivation in the region.

Table 8.2.3. Results of faba bean North Africa regional yield trial-large-1991.

Line	Yield (kg/ha) Morocco (Douyet)	Algeria (Tessala)	Tunisia (Beja)	Mean
FLIP 82-30FB	3913	2342	3306	3187
FLIP 82-45FB	4055	1297	3419	2924
FLIP 84-107FB	4632	1643	4144	3473
FLIP 84-128FB	3895	1439	4794	3376
FLIP 84-147FB	4234	1299	4319	3284
FLIP 85-89FB	4114	1591	4025	3243
FLIP 86-35FB	3938	1288	3425	2884
FLIP 86-36FB	3783	1845	3350	2993
FLIP 87-26FB	4134	2100	3388	3207
FLIP 87-70FB	4500	1504	3544	3183
FLIP 87-137FB	3749	977	4144	2957
FLIP 87-140FB	5141	1774	4500	3805
FLIP 87-147FB	4299	1246	3988	3177
FLIP 88-1FB	3758	1624	3975	3119
FLIP 88-2FB	3844	1459	3756	3020
S 82 113-8	4130	1844	4663	3546
79 S4	4466	1035	3844	3115
80 S44027	4304	1332	3806	3147
80 S80028	4369	1550	3525	3148
80 S80135	3739	1991	3769	3166
REINA BLANCA	3314	1477	3869	2887
AQUADULCE	4539	1366	4266	3390
LOCAL LARGE	----	----	4013	4013
MATEUR	----	----	4300	4300
MATEUR	----	----	3900	3900
LOCAL CHECK 1	4157	1277	----	2717
LOCAL CHECK 2	3655	1221	----	2438
SE±	----	----	485.4	----
CV%	17.8	26.8	12.4	----
Mean	4111	1520	3921	----

Table 8.2.4. Results of faba bean North Africa regional yield trial-small-1991.

Line	Yield (kg/ha) Morocco (Douyet)	Algeria (Tessala)	Tunisia (Beja)	Mean
FLIP 82-9FB	4174	1841	3869	3295
FLIP 82-35FB	3826	1419	3394	2880
FLIP 83-106FB	4473	2335	3919	3576
FLIP 84-46FB	4260	1651	4144	3352
FLIP 84-48FB	4190	1681	3938	3270
FLIP 84-59FB	4610	2098	4538	3749
FLIP 85-13FB	4125	1942	4100	3389
FLIP 85-28FB	4835	2275	4644	3918
FLIP 85-48FB	4165	1865	4094	3375
FLIP 86-80FB	3810	2295	4306	3470
FLIP 86-85FB	4548	1682	4019	3416
FLIP 86-86FB	4423	1676	3763	3287
FLIP 87-77FB	3619	1863	4175	3219
FLIP 88-3FB	3881	2282	3725	3269
FLIP 88-4FB	3690	1667	2931	2763
FLIP 88-6FB	3689	1429	3481	2866
76 TA56267	3762	2309	4225	3432
B 87148	4036	1302	3731	3023
B 87149	4219	1481	3688	3129
B 87249	4391	1097	3425	2971
B 87258	3714	1541	2550	2602
B 87259	4497	843	3238	2859
B 87263	3702	1002	2525	2410
L. Small	----	----	3919	3919
L. Small	----	----	4000	4000
Local Check	4343	898	----	2621
SE±	----	----	561.4	----
CV%	11.0	36.1	14.9	----
Mean	4124	1686	3774	

Table 8.2.5. Results of faba bean North Africa regional orobanche nursery-1991.

Entry	Pedigree	No. of shoots per plant				Grain yield (kg/ha)			
		Mor.	Alg.	Tun.		Mor.	Alg.	Tun[1].	
				O.C	O.F.			O.C[2]	O.F[3]
1	Sel. 88.Lat.18009	1.5	0.2	10.5	0.8	609	4058	3.0	5.0
2	Sel. 88.Lat.18025	3.4	0.6	7.5	0.5	535	3800	6.0	1.0
3	Sel. 88.Lat.18035	2.6	0.6	1.5	1.0	538	3600	4.4	4.0
4	Sel. 88.Lat.18054	3.5	0.3	0.8	0.5	385	3808	2.5	3.0
5	Sel. 88.Lat.18105	5.4	0.6	4.5	1.0	692	3630	8.0	4.0
6	Aquadulce	16.0	7.0	15.0	6.5	0	69	5.0	1.0
7	Seville (Algeria)	----	5.7	----	---	---	216	---	---
8	Local Check (Mor)	15.0	---	----	---	4	---	---	---
9	Local Check (Tun)	----	---	12.0	5.0	---	---	5.0	5.5

[1] Grain yield in g per plant.
[2] O.C. = Orobanche crenata.
[3] O.F. = Orobanche foetida.

Table 8.2.6. Results of chickpea North Africa elite yield trial-1991.

Variety	Yield (kg/ha)				
	Morocco	Tunisia		Algeria	Mean
	JS	Beja	Kef	Tessala	
FLIP 83-47C	2190	2157	3200	1368	2229
FLIP 83-48C	1880	2002	3783	1483	2287
FLIP 84-92C	1990	2275	4725	1195	2546
FLIP 84-93C	1890	2215	5175	1373	2663
FLIP 85-17C	1590	1982	4383	1970	2481
FLIP 85-56C	1930	1525	4850	1084	2347
FLIP 83-71C	1800	1907	3941	1147	2199
FLIP 83-46C	1700	1700	4583	1629	2403
FLIP 88-144C	2070	1825	5233	1750	2720
ILC 3279	1850	1715	3725	1489	2195
A.T. 161/14	2140	0	3975	628	1685
PCH 46	1510	0	3066	279	1213
L. AMDOUN	2230	0	4483	394	1777
FLIP 84-164C	2440	2340	4675	1158	2653
ILC 195	2410	1665	5575	1764	2853
SE±		209	937		
CV%	18	13	21	5.8	
Mean	1878	1567	4358	1247	

8.2.3.2.2. Chickpea

Asscochyta blight appeared in a serious form in the Sidi Bel Abbes area during the 1990/91 crop season that affected most chickpea material. However, certain lines showed good tolerance to the disease that included six lines (FLIP 84-92C, -84-93C, -84-99C, 84-133C, -85-94C and ILC 6090) in the CIABN-A-91 and four lines (79TH 101-2, 79TH 101-4, 80TH 177 and ILC 202) in the national Ascochyta blight-screening nursery.

A number of chickpea lines in different yield trials significantly outyielded the standard checks. These included four lines (FLIP 88-22C, -88-82C, 84-15C and -85-42C) in CIYT-W-MR, one line (FLIP 84-102C) in the multilocation yield trial-I, and five lines (FLIP 83-49C, -84-109C, -85-16C, 79TH 101-2 and 80TH 177) in the verification trial at Tessela. Lines FLIP 83-49C, -84-109C and 80TH 177 also provided significant yield advantages over the checks at SBA station and Zidene. In the national yield trial, FLIP 83-71C and -84-145C significantly outyielded the standard check ILC 3279.

In the North Africa chickpea elite yield trial-1991 (NACEYT-91), FLIP 85-17C was the highest yielder (1970 kg/ha) and along with ILC 195, FLIP 84-144C and -83-46C were significantly superior to ILC 3279 (Table 8.2.6).

Four chickpea lines, viz., FLIP 83-49C, -84-109C, 79TH 101-2 and 80TH 177, were identified for preregistration multiplication. Three other lines based on their good performance in yield trials will be multiplied on large plots. It should be noted that the chickpea variety FLIP 84-92C has been released for cultivation in Tiaret province. Another variety, FLIP 84-79C, has been released for cultivation in the eastern parts of Algeria.

8.2.3.2.3. Lentil

The lentil program at Sidi Bel Abbes and Tiaret stations has been strengthened as a result of the ITGC/ICARDA project. Four lentil varieties, viz., Syrie 229, ILL 4400, NEL 2468 and Balkan 755 are already in demonstrations on farmers' fields.

In 1990/91, several lines in different yield trials significantly outyielded the standard check, ILL 4400. These included FLIP 86-10L and -88-10L at Tessela and FLIP 88-11L at SBA station in LIYT-L. In verification trial, two lines (ILL 5700 and -5752) outyielded the standard check ILL 4400 by about 400 kg/ha.

Two lentil varieties, viz., 310C x Eston SBA 1 and 78S 26004 that have done well in different trials were identified for preregistration multiplication.

8.2.3.2.4. Dry pea

It is the smallest component of the food legumes at Sidi Bel Abbes station. The pea international adaptation trial (PIAT) of ICARDA has been serving a useful purpose as several lines from this trial, viz., Syrian local, Century, PS 50699 and Local Sel 1690 have significantly outyielded the local standard check SBA 184. These along with Messire and Terese will be included in the multilocation yield trial-II during the 1991/92 crop season.

8.2.3.3. Pathology

The major portion of the food legume pathology work in Algeria is done at INA-Algiers. The work on food legume nematodes is also done at INA, whereas the work on food legume viruses is done at INPV-Algiers. However, the field work in pathology is done at Sidi Bel Abbes station where an effective field screening for chickpea Ascochyta blight is now done every year. The screening for faba bean Orobanche resistance is done at Oued Smar Research Station. The screening for wilt resistance in chickpea is done in a wilt-sick plot at Guelma Research Station.

Most of the pathology research activities were concentrated on chickpea, which included laboratory screening of chickpeas for Ascochyta blight, identification of races of A. rabiei and Fusarium oxysporum f. sp. ciceri, attempts on integrated control of Ascochyta blight, and survey of food legume diseases in western Algeria. It should be mentioned that several chickpea lines with moderate resistance to Ascochyta blight have been identified for both the isolates of Tessala and SBA station. These include 79TH 101-2, 79TH 101-4, FLIP 83-46C, -83-47C, -83-48C, -84-79C, -84-92C, -84-109C and 80TH 177. Also, the Tessala isolate of A. rabiei has been found to be closely related to the Race 4 of ICARDA.

8.2.3.4. Agronomy

The emphasis in agronomy research has been on weed control in chickpea and lentil. Also, determination of appropriate planting date and optimum plant density has received due attention.

Results of a trial on the control of lentil weeds with herbicides showed a distinct advantage with the use of Igran + Kerb (2 kg + 0.5 kg a.i./ha) over the unweeded plots and the other herbicides tested. A yield increase of 320% was obtained over the unweeded plots.

Results of a date and plant density trial in lentil (with three dates and four densities) were different at the two sites where the trial was conducted. At Zidene, highest grain yield was obtained in Dec 17 planting compared with Nov 20 planting at SBA station. The plant density of 210 plants/m^2 provided highest grain yields in the first two sowing dates at Zidene, whereas the lowest plant density (150 plants/m^2) provided highest grain yield in Nov 20 planting at SBA station.

8.2.3.5. Technology transfer

Demonstrations of two chickpea varieties, viz., ILC 482 and -3279 were carried out in farmers' fields in the three zones of Sidi Bel Abbes province. These were four in Zone 1 (Tessala), one in Zone 2 (SBA station) and one in Zone 3 (Zidene). Variety ILC 482 yielded better (1325 kg) than ILC 3279 (1000 kg/ha) in Zone 1 in spite of the occurrence of Ascochyta blight during the crop season.

Algerian National Scientists and S.P.S. Beniwal

8.2.4. Libya

The 1990/91 season was the second year of LIBYA/ICARDA collaborative program on food legumes in Libya. Food legumes occupy only a very limited hectarage in Libyan agriculture compared with cereals. However, within two years of ARC/ICARDA collaborative program, the priority crops among the four major food legumes in the country, viz., faba bean, chickpea, dry pea and lentil and their priotity areas of research have been identified. Also, a national research team with a national coordinator is now in effective operation.

8.2.4.1. Trial sites and the crop season

Based on the recommendations of the Second Libya/ICARDA Coordination Meeting held at Agricultural Research Center (ARC), Tripoli, Libya, 24-26 September, 1990, a number of nurseries/trials in faba bean, chickpea, lentil and dry pea were conducted. These were conducted at four different locations; Tajoura and Zahra in the western part, Misurata in the central part, and El-Safsaf in the eastern part of Libya.

Like the last crop season, the 1990/91 crop season also received sub-optimal rainfall in the western part which in general adversely affected the crop productivity. This encouraged wilt/root rot diseases in chickpea and virus diseases in faba bean (faba bean yellow mosaic and bean leaf roll). Rust on faba bean and powdery mildew on dry pea were observed. Poor nodulation was observed in chickpea. The eastern part also received suboptimal rainfall (310 mm) most of which was received in January/February. This encouraged Ascochyta blight in winter-sown chickpea and rust in faba bean.

8.2.4.2. Germplasm enhancement

The food legume yield trials and nurseries provided to Libya are listed in Table 8.2.1.

8.2.4.2.1. Faba bean

Three yield trials/nurseries were conducted in faba bean. These included faba bean national yield trial-C, faba bean North Africa regional yield trial-large (FBNARYT-L-91) and -small (FBNARYT-S-91). Of the five lines in the national yield trial, Reina Blanca yielded highest (2350 kg/ha) followed by 79 S4 (2511 kg/ha) whereas FLIP 82-43FB yielded the lowest (2068 kg/ha). In the FBNARYT-L-91, lines 86-36FB, 87-27FB, -87-147FB, -88-1FB and Reina Blanca performed better than others and were selected for further yield testing (Table 8.2.3). Similarly, five lines in FBNARYT-S-91, viz., FLIP 82-9FB, -85-13FB, -85-28FB, -86-80FB and 88-6FB performed better than others and were selected for further yield testing (Table 8.2.4).

8.2.4.2.2. Chickpea

Three yield trials/nurseries were conducted, i.e., chickpea international screening nursery-winter (CISN-W-91), chickpea international yield trial-winter (CIYT-W-91) and chickpea verification trial (CVT). No useful data could be obtained from the first two because of poor and erratic growth and damage by wild animals. In the verification trial at El-Safsaf, four varieties (FLIP 84-79C, -84-93C, -84-144C and ILC 484) were yield-evaluated. Although FLIP 84-93 yielded highest (2347 kg/ha) the difference was statistically nonsignificant from the other three varieties.

8.2.4.2.3. Lentil

Two yield trials/nurseries were conducted. In the lentil verification trial, highest grain yield (2802 kg/ha) was obtained in the variety 'Unknown' followed by 78S 26002 (2729 kg/ha). These two varieties will now go to an adaptation trial for different irrigation projects in Libya.

In the lentil international screening nursery-tall (LISN-T-91), two entries (FLIP 88-10L and -88-31L) were taller (42 and 43 cm, respectively) than others and yielded 2695 and 2035 kg/ha, respectively. This was compared with 2730 kg of the 'Unknown' (37 cm tall) and 2330 kg of 78S 26002 (38 cm tall). Other entries that did well were 78S 26052 (2905 kg/ha; 36 cm tall), FLIP 87-49L (2865 kg/ha; 39 cm tall) and 78S 26013 (2825 kg/ha; 37 cm tall).

8.2.4.2.4. Dry pea

Of the 24 entries in the pea international adaptation trial (PIAT-91) at Tajoura, the best yielder was Local Sel 1690 (2893 kg/ha) followed by Frisson (2399 kg/ha), Syrian Local (2073 kg/ha), Wirrege (1936 kg/ha), PS 210713 (1929 kg/ha) and MG 102369 (1841 kg/ha). The local check yielded only 583 kg/ha. These entries will go to the national pea yield trial-B.

8.2.4.3. Pathology

Work on pathology was done on faba bean and chickpea that included screening of international nurseries from ICARDA to identify sources of resistance, and a limited survey for faba bean diseases. In faba bean, one line (B 88111) showed 6 rating for chocolate spot whereas one line (R 8810) showed 5 rating for rust. Results of survey for faba bean diseases indicated moderate damage in farmers' field by chocolate spot. Also, several virus diseases were observed indicating the need for production of virus-free seeds in faba bean.

In the chickpea international Ascochyta blight nursery-B (CIABN-B-91) grown at El-Safsaf, five lines (FLIP 83-79C, 84-112C, -87-504C, -87-507C and -87-510C) showed rating of 3 or less. In the chickpea international fusarium wilt nursery (CIWN-91) grown in a wilt-sick plot at Tajoura, eight entries, viz., ILC 211, FLIP 84-43C, -84-65C, -85-20C, -85-29C, -85-30C, UC27, FTA (82)29 and ILC 1929 showed a rating of 3 to 5 (1 to 5% plants wilted).

8.2.4.4. Agronomy

Trials on date of planting x row spacing, weed control and Rhizobium inoculation were conducted. In the faba bean sowing date and row spacing trial at Zahra (with four sowing dates and row spacings), sowing on 1 Oct, 15 Oct and 1 Nov with 30-cm row spacing (22.2 plants/m^2) was better than 30 Nov sowing with wider spacing. Diseases such as bean yellow mosaic, chocolate spot and alternaria leaf spot were common especially in the earlier sowings. At Misurata station, all four sowing dates (1 Oct, 15 Oct, 1 Nov, and 15 Nov) with 30 cm row spacing (22.2 plants/m) were better compared with wider spacings.

In the faba bean weed control trial, chlorbromuron (Maloran) + pronamide (Kerb) at 0.5 + 0.5 kg a.i./ha each as pre-emergence application provided a significantly superior weed control over both the weedy and weed-free treatments. The highest grain yield (2294 kg/ha) was also obtained from this treatment followed by the weed-free check (1854 kg/ha).

In chickpea and lentil, the effectiveness of terbutryne (Igran) in controlling weeds in ILC 484 chickpea was verified at El-Safsaf. At El-Marj station, the treatment failed to provide an effective control of Phalaris and mustards.

In faba bean, the exotic Rhizobium strains from ICARDA did not provide any advantage over the untreated check at Tajoura indicating the effectiveness of the native Rhizobium strain in supporting nitrogen fixation.

Libyan National Scientists and S.P.S. Beniwal

8.2.5. Morocco

8.2.5.1. Trial sites and the crop season

The faba bean trials were mainly conducted at Douyet with some trials at Jamaa Shim and Tangier. The major sites for chickpea trials were Merchouch, Douyet, Jamaa Riah and Jamaa Shim whereas for lentil were Merchouch, Sidi El Aidi and Jamaa Shim. Tangier is located in Pre-Rif region, Merchouch and Douyet in Saiss region, and Jamaa Riah, Sidi El Aidi and Jamaa Shim in Chaouia region of the country.

Enough rainfall was received during the 1990/91 crop season in the three regions of the country with fairly good distribution over the crop season. Rainfall during February and March encouraged biotic stresses that included chocolate spot, Ascochyta blight and stem nematodes in faba bean, Aschochyta blight in chickpea, and Ascochyta blight and Botrytis gray mold in lentil. Lentil rust, which was a problem in the last several years, was not a problem in Saiss and Pre-Rif regions whereas it still occurred in serious proportions in the southern parts of the

Chaouia Region.

8.2.5.2. Germplasm enhancement

Germplasm enhancememt continued to be the major objective of the national food legume program in Morocco. The national program received yield trials and nurseries from ICARDA that are listed in Table 8.2.1. Also, it was the second year of the presence of ICARDA's faba bean improvement program at Douyet.

8.2.5.2.1. Faba bean

The major objective continued to develop high and stable yielding faba bean varieties with resistance to Orobanche, chocolate spot, Ascochyta blight and stem nematodes with large pods and seed size. Yield trials, from preliminary to national, were conducted that comprised elite material with desirable characteristics. The trial means ranged from 3117 to 4191 kg/ha and the highest grain yield was 5400 kg/ha. A total of 100 lines outyielded the best check and nine did so significantly. Segregating populations, from F_2 to F_5 for different desirable characteristics were grown and selections were made. The preliminary screening nurseries consisted of closed flower, Botrytis, IVS + Botrytis + Ascochyta, and IVS + Botrytis + rust.

In the FBNARYT-L-91, FLIP 87-140FB was the best yielder (5141 kg/ha) and was significantly superior to Aquadulce (Table 8.2.3). In the FBNARYT-S-91, FLIP 85-28FB was the highest yielder (4835 kg/ha) followed by FLIP 84-59FB (4610 kg/ha) (Table 8.2.4). The former was the best yielder in Tunisia also.

Special emphasis was laid on developing varieties with resistance to Orobanche. Thirty lines were selected during the season that had a lower number of Orobanche shoots per faba bean plant compared with the susceptible Aquadulce. Now the emphasis is to combine Orobanche and chocolate spot resistance into large-seeded background.

8.2.5.2.2. Chickpea

The objective in chickpea continued to develop large-seeded, high and stable yielding varieties with Ascochyta blight resistance for the winter sowing, and also for the dual seasons (winter and spring). From advanced and national yield trials two varieties that did well were identified. These were FLIP 84-145C and -84-182C. These varieties along with FLIP 84-79C will go to the first year national catalogue trial. FLIP 84-93C which was in the first year national catalogue trial last season will now go to the second year of this trial. The verdict of the national catalogue trial committee on two chickpea varieties, FLIP 83-48C and -84-92C which completed two years of testing in the catalogue trials is awaited. Both these varieties yielded well last season compared with five other varieties in the catalogue trial. This was in spite of the serious outbreak of Ascochyta blight in winter chickpea in Saiss and Pre-Rif regions of the country.

In the CNAEYT-91 grown at Jamaa Shim, several entries outyielded the check (Table 8.2.6), however, only one could yield slightly better than the standard check, ILC 195.

Several entries were selected from CISN-91, PYT-91, and CAYT-91 and promoted to the next stage of trials. Ninety-one single plants were selected from CIF_4N-91 at Douyet and Merchouch.

8.2.5.2.3. Lentil

The objective in lentil continued to develop early and erect, medium- to large-seeded varieties with high and stable yields and resistance to rust. From advanced and national yield trials two varieties, FLIP 86-19L and -21L, were selected. These will go to the first year national catalogue trial during the next season. As with chickpea, verdict of the national catalogue trial committee on three lentil varieties, viz., ILL 6200, -6209 and -6212 that completed two years of testing in the national catalogue trial is awaited. ILL 6001 which was in the first year catalogue trial will now go to the second year catalogue trial.

Several good lentil lines were identified in different yield trials and promoted to the next stage of yield testing. Some of these are L 150A, L 151, L 155A, FLIP 84-51L, -87-48L and -87-53L in the small-seeded lentils, and 81S 15 and FLIP 86-18L in the large-seeded lentils.

8.2.5.3. Pathology and entomology

8.2.5.3.1. Faba bean

The major emphasis was on screening faba bean material for Orobanche and chocolate spot. As indicated earlier 211 entries were tested for Orobanche resistance in the Orobanche-sick plot at Douyet. From these, 30 entries were selected. The chocolate spot screening work done at ENA-Meknes consisted of F_2 Botrytis, and F_5 Bortytis + IVS. A total of 1274 single plant selections were made for chocolate spot resistance.

The results from a field trial on the integrated control of Orobanche using resistant varieties, dates of sowing and glyphosate sprays indicated the choices that we could have in controlling this menace. These were one or more of the following: (i) planting resistant varieties slightly late, (ii) delayed planting of the susceptible varieties with glyphosate spray, (iii) early planting of resistant varieties with glyphosate spray.

One hundred and forty-five faba bean lines were field-evaluated for their resistance to the stem nematode under artificial inoculation conditions. Seven lines (1356A, 356, 1752, T 41, -42, -82 and -110) showed resistance (3 rating) and 35 tolerance (5 rating) to the stem nematode. Two resistant lines and six tolerant ones showed no seed infestation with the nematode.

8.2.5.3.2. Chickpea

The emphasis in chickpea pathology was screening for Ascochyta blight resistance. Some very useful chickpea lines were identified from CIABN-A-91 and the national Ascochyta blight screening nursery and yield trials at Merchouch. These included: FLIP 84-48C, -84-79C, -84-144C, -84-145C and -84-148C.

Results of an experiment on an integrated control of Ascochyta blight showed the importance of a resistant variety in the integrated control. A combination of resistant variety and a spray of chlorothalonil (Daconil) provided the best control of the disease. Contrarily, only the seed treatment failed to provide any protection to the susceptible variety against the disease.

Of the 40 chickpea lines screened for resistance to leaf miner, eight (FLIP 82-152C, -83-71C, -83-98C, -84-92C, -84-93C, -84-144C, 84-182C and RH 79-496) showed less than 3 (resistant) rating. From the CIIMN-91, one line (ILC 5901) showed resistance to leaf miner and also Ascochyta blight. These nine lines will be retested for their resistance to leaf miner in the 1991/92 season.

8.2.5.3.3. Lentil

Emphasis on screening for rust resistance continued during the season. Of the 339 lentil accessions/lines screened against rust at Sidi El Aidi, 183 showed 5 or less rating (out of a maximum of 9). These will be retested during the 1991/92 season. Also, lines that showed resistance to rust at Jamaa Shim and resistance/tolerance to Ascochyta blight at Merchouch were identified. Lines L 265, FLIP 86-19L (ILL 6005), FLIP 87-22C (ILL 6212), and 81S 15 (ILL 5883) had good resistance to rust and tolerance to Ascochyta blight.

8.2.5.4. Agronomy and mechanization

Several agronomy trials were conducted on food legumes. In faba bean, the lowest plant density of 5 plants/m^2 resulted in the highest grain yield of 3300 kg/ha. A trial to study the effect of crop rotation and faba bean genotypes on the productivity of the rotation and seed bank of Orobanche was started. A couple of trials to study the effect of plant density and supplementary irrigation on light interception, water use and dry matter production in faba bean were conducted in a semi-arid environment of the country. These provided very useful results and led to the development of a simulation model to determine optimum plant densities in different regions of the country. The model will be tested during the 1991/92 crop season.

In chickpea, important factors for chickpea production were identified through a field trial in Chaouia and Saiss regions. These were Rhizobium inoculation and weed control in Chaouia (Ben Slimane site); weed control at Maaziz site in Saiss; and Ascochyta blight control at Ainshit site in Saiss. The importance of the Rhizobium inoculation in chickpea was also established at Ben Slimane through a need for inoculation trial.

In lentil, results of a weed management trial indicated the possibility of using intercultivation and herbicides in managing lentil weeds.

Work on mechanization of lentil production continued. Results from the use of the animal-drawn seed drill confirmed last year's results. Seed rates of 34, 55 and 70 kg/ha with seed drill provided better grain yields over the 50 kg by hand-sowing behind the plough as per the farmer practice. The conveyor system on the Kubota reaper was further modified to improve crop handling, but not to much advantage. Tall weeds blocked the conveyor system which worked much better in the weed-free crop. The reaper caused 33% yield loss compared with 19% of the hand-harvested crop.

8.2.5.5. Technology transfer

Three Orobanche-resistant faba bean varieties (18009, 18035 and 18105) were verified on farmers' fields for their performance against Aquadulce. The resistant lines outyielded Aquadulce in situations with heavy Orobanche infestation. Over the five sites, the resistant lines outyielded Aquadulce by 46%, and had 64% less Orobanche shoots per faba bean plant compared with Aquadulce.

In chickpea, four varieties in the catalogue trial were tested in farmers' fields in Jamaa Shim and Maaziz-Romani area. FLIP 83-47C provided highest yields (1700 kg/ha) in Jamaa Shim area whereas it was

FLIP 84-92C that provided highest yield of 1800 kg/ha in the Maaziz-Romani area.

In lentil, four varieties that are in the national catalogue trial were verified on farmers' fields in the Jamaa Shim and Maaziz-Romani area. In Jamaa Shim area, ILL 6209 was the highest yielder compared with ILL 6001, -6002, and -6212. In Maaziz-Romani area all the varieties were very heavily infested with Orobanche and as a result were all destroyed.

A number of 0.5 ha demonstrations with winter chickpea ILC 195 were conducted in different parts of Morocco. For comparison purposes farmers' spring-sown chickpea were considered. The winter-planted ILC 195 provided, on an average, 100% yield advantage over the spring-planted ones.

Moroccan National Scientists and S.P.S. Beniwal

8.2.6. Tunisia

The 1990/91 crop season was the 10th year of collaboration between the Tunisian national food legume program and ICARDA. This has lead to establishment and development of a very effective national food legume program in Tunisia.

8.2.6.1. Trial sites and the crop season

Beja, Oued Meliz and El-Kef are the three principal trial sites for conducting food legume research in the country. The first two, located in the higher rainfall zone, are used mainly for faba bean and chickpea, whereas El-Kef, located in the lower rainfall zone, is used mainly for lentil. Screening for faba bean chocolate spot and Ascochyta blight is done at Ras Rajel and for stem nematodes at Fernana. Beja is used for sceening for chickpea Ascochyta blight and wilt.

Rainfall during the crop season was average at Beja whereas it was 130% and 120% of long-term average at Oued Meliz and El-Kef, respectively. Also, it was well distributed over the crop season and combined with mild temperatures in late spring caused 3 weeks delay in crop maturity. It also encouraged development of Ascochyta blight in chickpea and faba bean, chocolate spot and stem nematodes in faba bean. Ascochyta blight was observed for the first time on lentil in Tunisia. Also, the presence of Orobanche foetida was confirmed in the Beja area which is different from O. crenata present in the Cap Bon area of the country.

8.2.6.2. Germplasm enhancement

8.2.6.2.1. Faba bean

Higher faba bean grain yields were obtained compared with the last 3 drier years. The mean for different yield trials for the large-seeded faba bean was 3500 kg/ha for Beja and 4200 kg/ha for Oued Meliz. The highest grain yield of 5900 kg/ha was obtained at Oued Meliz. For the small-seeded faba bean, mean for yield trials was 3300 kg/ha at Beja and 4200 kg/ha for Oued Meliz. The highest grain yield of 6100 kg/ha was obtained at Oued Meliz. This situation was contrary to the last 3 drier years during which faba bean yields in general were lower at Oued Meliz compared with Beja due to occurrence of higher rust infection.

The three large-seeded faba bean varieties, 80S 80028, S 82113-8 and S 82033-3, that provided 18-20% yield advantage over the check during the 3 drier years (1988-90) maintained superiority over the check, especially S 82033-3 and S 82113-8 (Fig. 8.2.1). Variety S 82113-8 was identified for prerelease multiplication. Among the small-seeded lines, FLIP 83-106FB (medium-seeded) that had provided about 8% average yield advantage over the checks during 1987-90 crop seasons yielded as much as the local check during the 1990/91 crop season (Fig. 8.2.2). This makes it a good candidate for release for cultivation. Among the five faba bean local populations (POLs) tested during the 1990/91 crop season, POL 3 was among the two top yielders that looked best in homogeneity.

In the FBNARYT-L-91, line FLIP 84-128FB was the highest yielder (4794 kg/ha) followed by S 82113-8 (4663 kg/ha) (Table 8.2.3). These were higher than 4266 kg/ha of Aquadulce. In the FBNARYT-S-91, FLIP 85-28FB was the highest yielder followed by FLIP 84-59FB (Table 8.2.4).

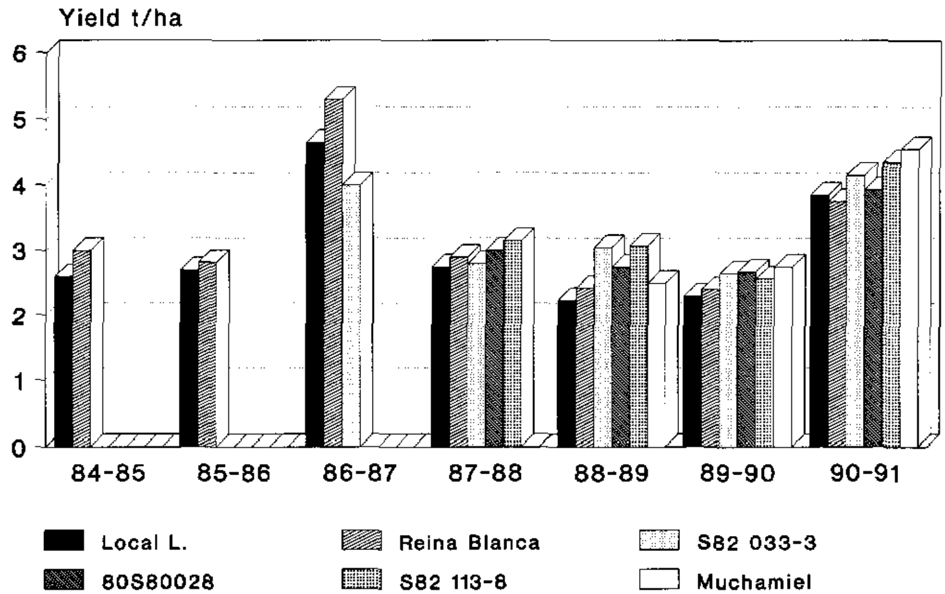


Figure 8.2.1. Yield performance of large faba bean varieties in Tunisia during 1984/85 to 1990/91 crop seasons.

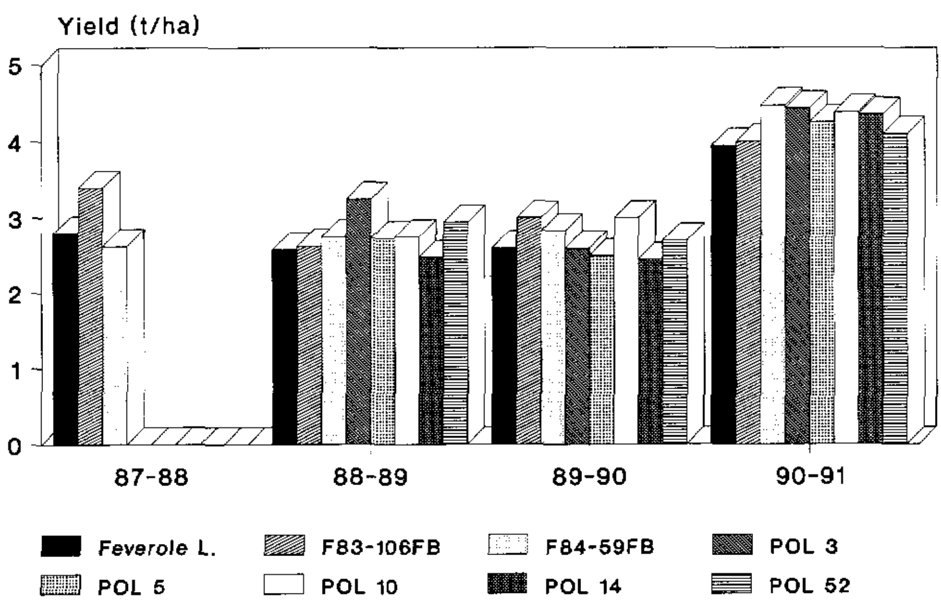


Figure 8.2.2. Yield performance of small faba bean varieties in Tunisia during 1987/88 to 1990/91 crop seasons.

A number of large- and small-seeded lines that outyielded the local and standard checks in different yield trials were selected and advanced to a higher stage of yield testing.

Results of a field study on the rate of out-crossing in faba bean during 1989-90 crop seasons showed 43% out-crossing at Beja, 55% at Oued Meliz and 62% at El-Kef.

Screening for chocolate spot and Ascochyta blight resistance resulted in identification of 12 lines in FBPSN-Bot-91 and six lines in FBICN-91 showing less than 5 rating (out of a maximum of 9). For Ascochyta blight, 14 lines in FBPSN-Asco-91 and one line in FBIABN-91 showed less than 5 rating, and were selected for further use.

Of the 415 faba bean pure lines (BPLs) tested from ICARDA for O. foetida in an infested plot at Beja, 14 were identified as having promising resistance (Table 8.2.7). All the five test lines in FBNARON-91 performed well against O. foetida compared with Aquadulce check (Table 8.2.5). Two of these (18035 and 18054) also did well against O. crenata (Fig. 8.2.3). Of the 493 BPLs tested for stem nematode resistance at Fernana, 15 showed promising resistance (Table 8.2.7). These will be retested during the 1991/92 season.

For chemical control of O. foetida two sprays of imazaquin (15 g a.i./ha) and glyphosate (80 g a.i./ha) at attachment stage proved better than similar sprays at 15-day-intervals after 15 days of flower initiation.

A roving disease survey was conducted in which 47 farmers' faba bean fields were visited in March 1991. The highest percentage of fields (95%) were affected with chocolate spot followed by 45% with viruses, 30% with Ascochyta blight, and 15% each with rust and wilt. Fifty-five percent of the fields were infested with nematodes with the stem nematodes present in 45% of the fields and root-lesion nematode (Pratylenchus spp.) in about 5% of the fields.

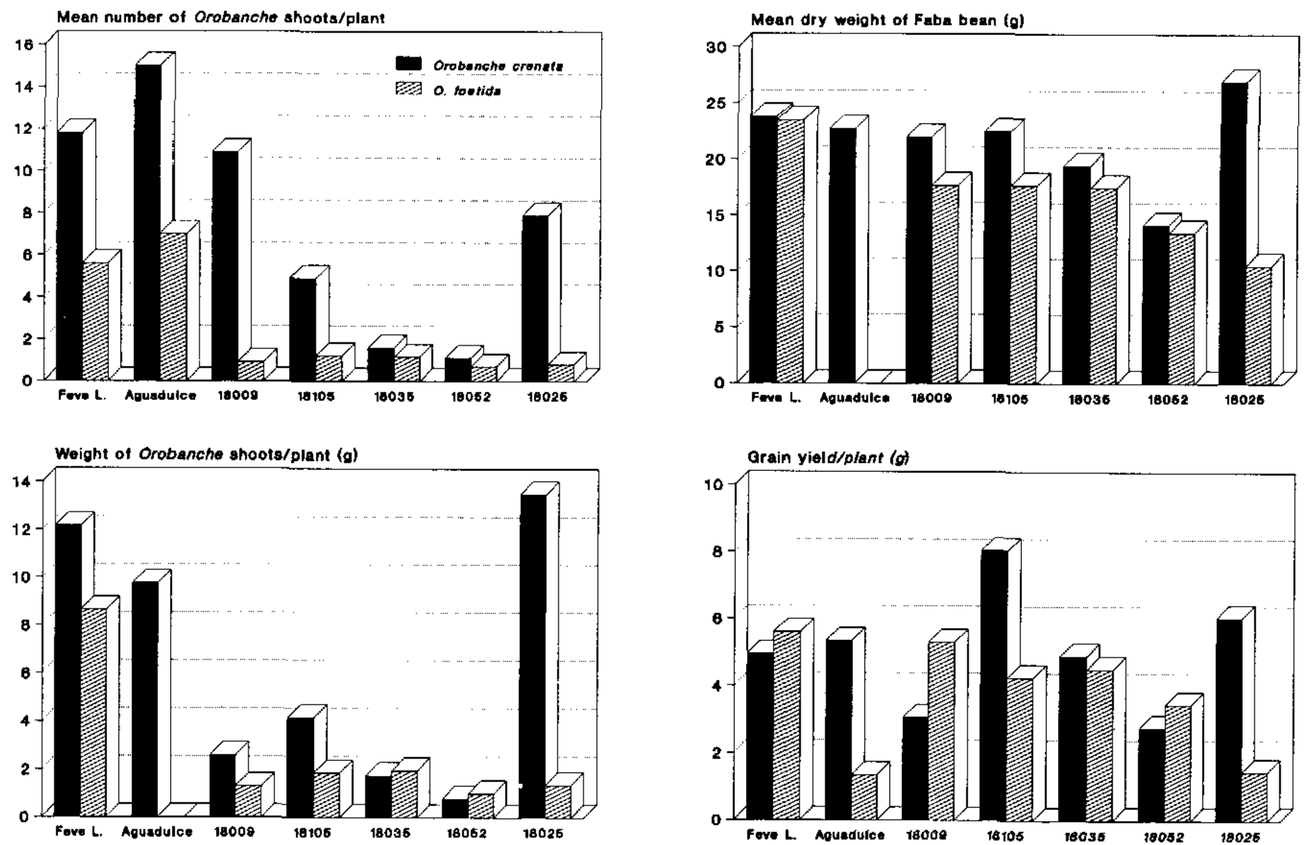


Figure 8.2.3. Comparative parasitism of certain lines of faba bean Orobanche crenata (OC) at Tunis and O. foetida (OF) at Beja, 1990/91 crop season.

Table 8.2.7. Results of screening BPLs for _Orobanche foetida_ at Beja (El-Kefi) and for stem nematodes at Fernana, 1990/91.

	Orobanche foetida at Beja (El-Kefi)	Stem nematodes at Fernana
Number of BPLs tested	415	493
Number of promising lines	14	15
Promising BPLs	BPL 001	BPL 3455
	BPL 017	BPL 3570
	BPL 062	BPL 3572
	BPL 117	BPL 3584
	BPL 166	BPL 3592
	BPL 177	BPL 3594
	BPL 178	BPL 3657
	BPL 182	BPL 3660
	BPL 190	BPL 3735+
	BPL 208	BPL 3782
	BPL 229	BPL 3786
	BPL 248	BPL 3790
	BPL 482	BPL 3794
	BPL 484	BPL 3809
		BPL 3815

+ _Vicia narbonensis_.

8.2.6.2.2. Chickpea

In chickpea also, higher grain yields were obtained compared with the last 3 drier years. The mean for different yield trials was 1800 kg/ha at Beja and 2900 kg/ha at Oued Meliz, where the highest yield of 4600 kg/ha was also obtained. The yield levels at Beja were lower due to much higher severity of Ascochyta blight compared with Oued Meliz.

Of the two new chickpea varieties, INRAT 88 (FLIP 84-92C) yielded higher (2800 kg/ha) than INRAT 87 (FLIP 84-79C) (2600 kg/ha) at Beja which was much better than the best standard check variety Kessab that yielded only 2100 kg/ha (Fig. 8.2.4). At Oued Meliz, ILC 482 was the best yielder (4000 kg/ha) followed by Kessab and INRAT 88 (3800 kg/ha each), and INRAT 87 (3300 kg/ha) (Fig. 8.2.4). In the spring, INRAt 88 was the highest yielder followed by INRAT 87 (Fig. 8.2.5).

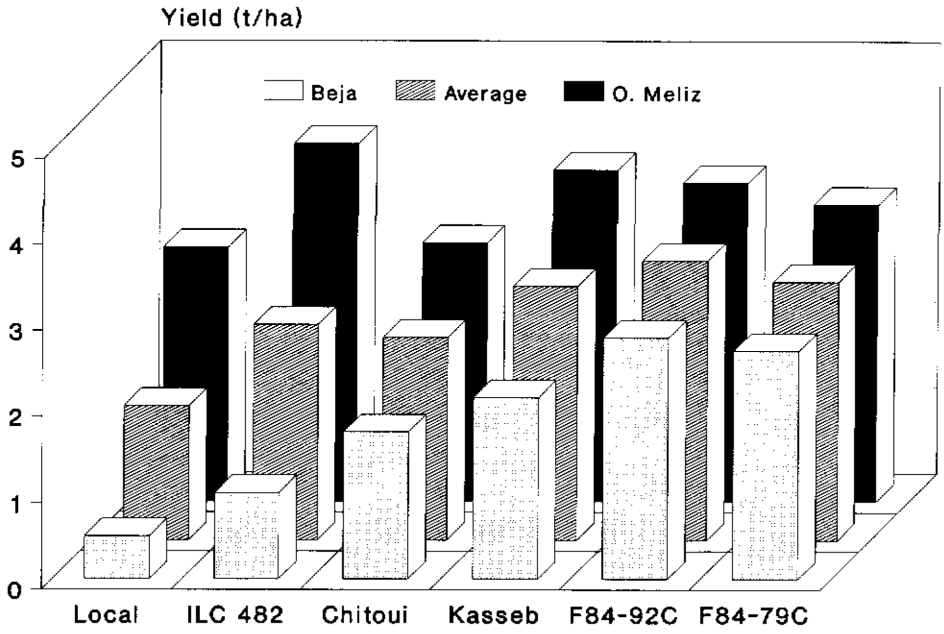


Figure 8.2.4. Mean grain yield of new winter chickpea varieties at Beja and O. Meliz in Tunisia, 1990/91 crop season.

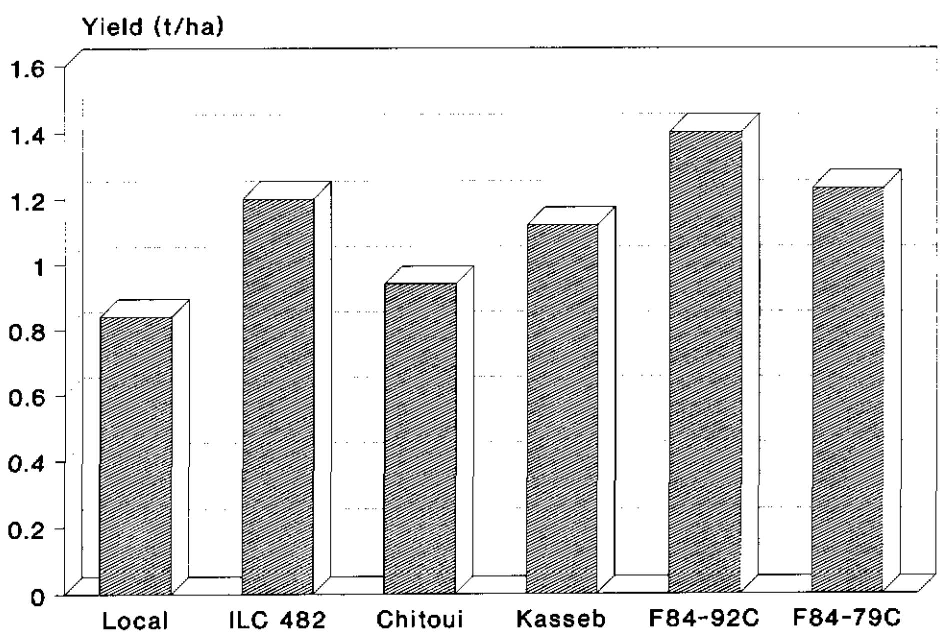


Figure 8.2.5. Mean grain yield of new spring chickpea varieties at Beja in Tunisia, 1990/91 crop season.

In the CNAEYT-91 grown at two locations, FLIP 84-146C was the highest yielder (2340 kg/ha) at Beja whereas ILC 195 was best at El-Kef (5575 kg/ha) (Table 8.2.6). At Beja, lines FLIP 84-92C (2275 kg/ha), -84-93C (2215 kg/ha) and -83-47C (2157 kg/ha) were other good yielders.

Useful results were obtained from the systematic screening of chickpea for Ascochyta blight. Of all the varieties tested, only 1.14% showed less than 3.5 rating (out of a maximum of 9), 10% showed ratings between 3.51 and 4.51, 15% ratings between 4.51 and 5.51, 18% each between 5.51 and 6.51 and 6.51 and 7.50, and 37% more than 7.51 rating. Varieties INRAT 87 and -88 maintained their ratings (Fig. 8.2.6). The 100-seed weight showed inverse relationship with the disease rating; lines with 25-30 g per 100-seed weight showed 4-5 rating, lines with 25-35 g showed 5 rating and lines with 30-50 g showed 7-9 rating. Relationship of 100-seed weight to Ascochyta blight rating on 1-9 scale (X) could be expressed by the equation : Y = 23.0 + 1.58 X.

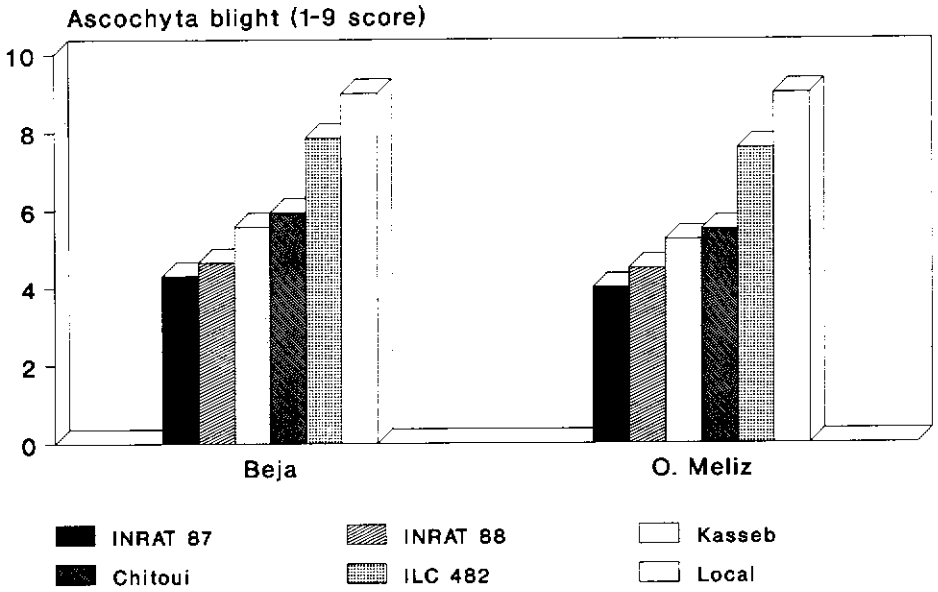


Figure 8.2.6. Reaction of chickpea varieties used as checks in yield trials to Ascochyta blight at Beja and O. Meliz stations in Tunisia, 1990/91 crop season.

Comparative analysis of aggressiveness between the Beja and Oued Meliz isolates of A. rabiei showed the former to be more aggressive than the latter. The relationship in aggressiveness between the two isolates on different genotypes could be shown by the equation : Beja = 0.869 O.M. + 1.56 (r^2 = o.76).

A good progress was achieved in combining Ascochyta blight and wilt resistance in acceptable seed sizes (35-37 g). Ten lines were selected from such material for yield testing through an advanced yield trial during the 1991/92 crop season.

A laboratory technique using isolated chloroplasts and the A. rabiei pathogen toxin has been standardized. The technique could be used for screening chickpeas for resistance to A. rabiei. The two chickpea varieties, viz., INRAT 87 and -88 that have shown good stability in yield and tolerance to Ascochyta blight are serious candidates for registration for release. These will be used for large-scale on-farm demonstrations during the 1991/92 crop season.

8.2.6.2.3. Lentil

In lentil also higher grain yields were obtained compared with the last 3 drier years. The mean for different yield trials was 2200, 2000 and 2200 kg/ha at Beja, Oued Meliz and El-Kef, respectively. The highest grain yield of 4200 kg/ha was obtained at El-Kef.

In lentil advanced yield trial, variety UJ 85-1345 outyielded other varieties at Beja by yielding 2300 kg/ha, whereas at El-Kef Nefza (ILL 4606) was the highest yielder (2300 kg/ha) followed by 78S 26002 (2200 kg/ha). Other varieties that performed well in other trails are shown in Table 8.2.8.

As in the last 3 drier years, lentils again did well in this wet year in the so-called drier areas of the northern part of the country. This strengthens the need to popularize this crop in this zone.

Table 8.2.8. Elite lentil varieties in differents trials and locations in Tunisia, 1990/91.

Station	Trial/Nursery	Variety	Grain yield (kg/ha)
Beja	EAR L2	88-51L	3592
Beja	LISN-S	91-15L	3725
El Kef	IYT-L	4606	3183
El Kef	LISN-E	91-26L	4225
O. Meliz	EAR L1	84-114L	2750

During this crop season, lentils were found to be affected with Ascochyta blight. This forms the first report of this pathogen on lentil in Tunisia. In order to prevent further spread of the disease, all the affected varieties were destroyed.

Variety 78S 26002, which has shown stable yield over the last several years, will be considered for registration for cultivation in the drier areas of El-Kef region.

8.2.6.3. Agronomy

A 3-year study on the yield losses caused by weeds in different food legumes was concluded this year. The yield losses due to weeds in different crops were: 75% in chickpea, 67% in lentil, 60% in dry pea, and 27% in faba bean. These results show the importance of weeds in the successful cultivation of food legumes in the country. As in the past, two hand-weedings provided a good weed control and were superior to the farmers' practice of two intercultivations with animals which was not found effective in controlling weeds.

8.2.6.4. Socio-economic studies

A survey to study socio-economic aspects of the food legume cultivation in northern parts of Tunisia was conducted. The survey was aimed to study (i) production system of food legumes, (ii) constraints to food legume production, (iii) adoption aspects, and (iv) cost of food legume production. The study conducted with two groups of farmers, i.e. those with 30 ha or larger farmers with a tractor and those with less than 30 ha farms without a tractor, provided useful information. Details of the study are published separately and are available in Socio-Eonomics Division of INRAT.

8.2.6.5. Transfer of technology

The on-farm verification trials and demonstrations continued during this year as in the past. Verification trials were done at four sites in the northern parts of the country. The researcher-recommended package consisting of early planting, higher plant density and hand-weeding provided significant yield increases over farmers' practices. The highest yield gains were provided by weeding, followed by plant density and early sowing.

Among the new lentil varieties, Nefza (ILL 4606) continued to be the best yielder followed by FLIP 84-103L although they provided only 6 and 5% yield gains over the farmers' local varieties. Among chickpeas, FLIP 84-92C provided the highest yields both in winter (1769 kg/ha) and spring (1410 kg/ha) situations.

The improved production package for different food legumes demonstrated at 37 farmers' fields once again showed its superiority over the farmers practices. The gains in grain yields were 37% for faba bean, 61% for lentil and 40% for spring chickpea. In the variety demonstrations, FLIP 84-92C chickpea reconfirmed its superiority by yielding 12% more than Kessab. In lentil, Nefza yielded better than 78S 26002.

Tunisian National Program Scientists and S.P.S. Beniwal

8.2.7. Training activities

Training continued to be an important component of collaboration between ICARDA and the four North Africa national programs. The types of training provided to the national scientists/technicians are listed in

Table 8.2.9. Types of training opportunities in food legumes provided by ICARDA to the national programs in North Africa, 1991.

Type of Training	No. of participants				
	Algeria	Morocco	Libya	Tunisia	Total
A. Group Training at ICARDA					
1. Practical Rhizobium Legume Technology	1	1	-	1	3
2. Biology and Control of Orobanche in Legume Crops	1	1	-	-	2
3. Breeding Methods for Food and Feed legumes	-	1	1	-	2
4. Mechnical Harvesting of Food and Feed Legumes	-	1	-	1	2
5. Insect Control in Cereals and Legumes	-	-	-	1	1
B. In-country/Regional Training					
1. Faba Bean Improvement (ENA-Meknes, Morocco)	3	7	1	-	11
2. Winter Chickpea Technology Transfer (INRAT, Tunisia)	3	3	-	16	22
C. **Individual Training**	-	1	1	-	2
D. **Study Visits**	-	1	-	3	4
E. **Specialized Travelling Wokshop** (Morocco)	4	6	1	3	14
TOTAL	12	22	4	26	64

Table 8.2.9. The two training courses in the region, one on faba bean and the other on winter chickpea, were organized based on the needs of the national programs in the region. An excellent opportunity to food legume scientists of the region for interacting with each other, with ICARDA scientists in the region and of the home-base programs at Aleppo and with food legume scientists of the three Nile Valley countries was provided through the Specilized Travelling Workshop that was organized for a week in May in Morocco.

ICARDA and North African Regional Program Scientists

9. TRAINING AND NETWORKING

The purpose of training is to develop or enhance the technical capabilities of NARS scientists and their support staff. It also aims at strengthening networking and to assist in transfer of technologies. Table 9.1.1 summarizes the activities undertaken by LP during 1991 to meet the above objectives. This was done in some cases in collaboration with NARSs and other ICARDA programs. A total of 187 participants received training in the improvement of lentil, kabuli chickpea and faba bean (Table 9.1.1).

9.1. Group Training at ICARDA

Details of group training are summarized in Table 9.1.2.

Table 9.1.1. Summary of training activities in 1991.

Type of training	Participants	Represented countries
I. Training at Aleppo		
1. Group Courses		
1.1. Insect Control	13	10
1.2. Biology & Control of *Orobanche*	6	5
1.3. Breeding Methodologies	14	12
1.4. DNA Molecular Marker Techniques	11	9
1.5 Practical *Rhizobium* Legume Technology	6	5
1.6 Mechanical Harvesting of Legumes	10	7
2. Individual Non-Degree	24	9
3. Graduate Research	3	2
II. In-country\Subregional Training Courses		
1. Faba Bean Improvement, Morocco	14	7
2. Legume Hybridization, Jordan	10	2
3. Winter Chickpea Technology,Tunisia	23	3
4. Winter Chickpea Technology,Turkey	20	1
5. Computer Application and Biometery Ethiopia	20	1
6. Legume Seed Production, Jordan	13	4

Table 9.1.2. Participation in group training by countries.

Type of training	Countries
Short Courses at Aleppo	
1. Insect Control	Ethiopia, Libya, Morocco, Syria, Tunisia, Turkey, Yemen, Jordan, Algeria, Iran
2. Biology & Control of Orobanche	Algeria, Egypt, Morocco, Syria, Tunisia
3. Breeding Methodologies for Food & Feed Legumes	Egypt, Bulgaria, USSR, India, Ethiopia, Libya, Nepal, Morocoo, Pakistan, Syria, Sultanat of Oman, Turkey, Iran, Lebanon
4. DNA Molecular Marker Techniques	China, Egypt, Jordan, Kuwait, Lebanon, Syria, Tunisia, Turkey, Yemen
5. Practical Rhizobium Legume Technology	Egypt, Ethiopia, Lybia, Morooco, Turkey
6. Mechanical Harvesting of Legumes	Algeria, Egypt, Iran, Lebanon, Morocco, Syria, Tunisia
Short Courses-In-country	
1. Faba Bean Improvement, Morocco,	Algeria, Colombia, Egypt, Libya, Morocco, Peru, Tunisia
2. Legume Hybridization	Jordan, Afghanistan
3. Winter Chickpea Technology	Turkey
4. Winter Chckpea Technology	Tunisia, Algeria, Morocco
5. Winter Chickpea Technology	Ethiopia
6. Legume Seed Production	Jordan, Lebanon, Syria, Turkey

9.1.1. Insect Control Course

Food legume crops are attacked by many insect pests which results in sizable yield reduction and post-harvest losses. The same applies for cereal crops as well. Realising the need of NARSs for strengthening the research skills in this field, the Cereals and Food Legume Improvement Programs conducted a joint training course on "Insect Control in Food Legumes and Cereals", 21 April-2 May, 1991 at Aleppo. The course covered topics such as sampling and identification of insects and monitoring of insect populations, collection of insects, screening for host plant resistance, use of pesticides, and application of biological control. The course will continue to be offered in the future with increased time allocated for practical skills such as planning of experiments.

9.1.2. Biology and Control of Orobanche

The parasitic weed Orobanche represents a major constraint to the production of faba bean, lentil, chickpea, peas and forage legumes in the Mediterranean region with yield losses ranging from 5 to 100%. The difficulty in controling this pest is related to the biology of the parasite. To strengthen the research skills of NARSs in this field the course on "Biology and Control of Orobanche" was conducted 22 April-2 May, 1991, at Aleppo. The course was attended by 6 participants from 5 countries and the trainees learned how to explain the biology of parasitic weeds, assess Orobanche damage and infestation in food legume crops, discuss various means of control, apply control measures in an integrated approach, and test germination and viability. The course was conducted in coordination with the University of Hohenheim, Germany.

9.1.3. Breeding Methodologies of Food and Feed Legumes

To promote sound strategies and strengthen the network of collaborators in the improvement of legume germplasm, a training course on "Breeding Methodologies of Food and Feed Legumes" was conducted 5-16 May, 1991 at Aleppo. The course was attended by 14 participants from 12 countries and covered topics such as quantitative genetics as applied to plant breeding, plant genetic resources, breeding methods, mutation breeding, cytogenetic methods, breeding for resistance to environmental stresses, diseases and insects, variety maintenance and experimental design. The course was attended by senior breeders (mostly Ph.D. and M.Sc. holders) and this allowed interaction to discuss breeding strategies in a comparative way. A few of the participants presented the strategies and achievements in their breeding programs as case studies. The participants evaluated the course as highly successful.

9.1.4. Practical Rhizobium Legume Technology

LP and PFLP conducted a course on Rhizobium technology on 3-14 March, 1991, at ICARDA's headquarters, Aleppo. The course was skill oriented and was attended by scientists from five countries in West Asia, North Africa, and Nile Valley. It covered skills in culture collection, cell enumeration, Rhizobium strain identification and selection, inoculum production, assessing needs for inoculation, measurement of nitrogen fixed, and the role of biological nitrogen fixation in the cropping systems.

9.1.5. DNA Molecular Marker Techniques for Germplasm Evaluation and Crop Improvement

Plant biotechnology tools offer innovative approaches in plant improvement research. To increase the awareness of national scientists about the potential of biotechnological tools in facilitating the crop improvement research, ICARDA conducted "DNA Marker Techniques for Germplasm Evaluation and Crop Improvement", 22 September-3 October, 1991 at Aleppo. The course was attended by 11 participants from 9 countries. The course introduced participants to theoretical and practical aspects of DNA marker techniques and covered current and future uses of DNA technology in plant breeding, provided practical experience in some aspects of DNA technology. Two lecture series included gene structure, regulation and transfer, gene identification and marking, genome mapping, application of genetic engineering as well as the use of wide crossing and somaclonal variation. During the practical sessions, each participant successfully extracted DNA from legumes or cereal crops, purified it, digested it by a restriction endonuclease Taq I, electrophoreseed the fragments and probed them with a non-radioactive probe. The practicals focused on RFLP methods, DNA amplification using Polymerase Chain Reaction, and computer-based program for map construction and trait analysis. The trainees evaluated the course as useful and hoped that this interaction will lead to the start of a core network in this upstream research area.

9.1.6. Mechanical Harvesting of Food and Feed Legumes

A legume harvest mechanization short course was run at Tel Hadya from 12 to 23 May 1991 in cooperation with the Pasture, Feed and Livestock Program, and was attended by 10 participants from the following countries: Algeria, Egypt, Iran, Lebanon, Morocco, Syria and Tunisia. The course was to show a range of systems of production and mechanization suited to different conditions to decrease the cost of producing legumes.

The program included both lectures and field demonstrations of a range of equipment, such as mowers (self-propelled and tractor-drawn), combines and the lentil puller. Lectures were on the problems of mechanization, the breeding and agronomy of mechanization for different legumes, seed-bed preparation, economics and techniques for farmer interviews and on-farm trials. In addition, trainees presented the situation of legume production and mechanization in their own countries.

9.2. In-country/Sub regional/Regional Courses

9.2.1. Faba Bean Improvement

A regional course on "Faba Bean Improvement" was held April 21-May 3, 1991 at the facilities of ENA-Meknes in Morocco. There were 14 trainees from 7 countries. The course presented faba bean breeding and pathology in an integrated manner, and aimed at providing an introduction to faba bean improvement with an emphasis on selection for disease resistance. The course brought together breeders and pathologists working on faba bean and provided them an opportunity to learn more on creation of variability, selection techniques, and seed production of the released cultivars.

9.2.2. New Biometrical Tools for Plant Variety Evaluation

A regional course on New Biometrical Tools for Plant Variety Evaluation was held 16-27 September, 1991, at the Mediterranean Agromomic Institute of Zaragoza, Spain. The course was jointly organized by ICARDA, CIHEAM, and CIMMYT. ICARDA supported eight participants from North Africa and West Asia. The course was aimed at plant breeders and agronomists and the course emphasized practical rather than theoretical context. LP and CP programs coordinated the preparation for the course and scientists participated in instruction.

9.2.3. Legume Hybrization Techniques

An in-country course on legume crossing was conducted at the University of Jordan, Amman, during 27 April to 1 May, 1991. The trainees were mainly from Jordan in addition to one trainee from Afghanistan. The course focused on crossing in the field with exposure to information background on hybridization through the auto-tutorial modules developed for the purpose. The use of audio-visuals was given high ratings by the trainees.

9.2.4. Winter Chickpea Technology Transfer

Two courses on transferring winter chickpea technology were conducted: One in Tunisia during 14-17 May, and the other in Dyiarbakr, Turkey, during 23-25 May. The course in Tunisia, jointly with INRAT, was a subregional one hosting candidates from Tunisia (15), Algeria (5), and Morocco (3) while the course in Turkey, jointly with East Anatolian Research Institute, was attended mainly by trainees from the local institutes. In both courses the trainees were a mixture of extension, research, and production staff from the government. A few farmers attended the courses as observers. The emphasis was mainly on transferring winter chickpea techonologies including discussion on adoption aspects. The lectures were augmented by visits to farmers' fields where winter planting was adopted. In both courses audiovisuals and computer-aided instruction (CAI) were demonstrated. The series will continue to enhance training the trainers. Such a course will be our prime candidate for decentralization to NARS.

9.2.5. Biometry and Computer Application

LP and CSU jointly conducted an in-country course in Addis Ababa on experimental design and analysis and biometrical computing in these areas. The course held during 28 March to 4 April was attended by 20 participants from IAR and Alemaya University, Ethiopia. It focused on design and analysis of experiments, and the use of computer software such as: MSTAT, Harvard Graphics, Word Processing. The trainees had a hands-on experience. The level of achievement in skills was high due to motivation of participants.

9.2.6. Legume Seed Production

An in-country course on legume seed production was conducted jointly with ICARDA Seed Unit. The course was conducted in Amman to host trainees from Jordan, Lebanon, Syria, and Turkey. Although the course covered all major aspects of legume seed production, the course focused on seed health. The trainees benefited from the facilities in the seed production unit of the Jordan University. This association will continue in the future and can be used as a model.

9.3. Individual Non-degree Training

As per the request of NARSs, training on an individual basis was offered for 24 participants from nine countries. Skills covered and countries represented are given in Table 9.3.1. The syllabi were tailored to meet the specific needs of NARSs and the academic background and performance objectives of the participants.

Table 9.3.1. Participation in the individual non-degree training, 1991.

Topic	No. of participants	Countries
1. Agronomy & Crop Physiology	2	Syria, Sudan
2. Trial Management	4	Ethiopia
3. Breeding	6	Syria, Iran, Ethiopia, China
4. Insect and Disease Control	10	Algeria, Lybia, Morocco, Syria
5. Legume Mechanization	1	Iran
6. Quality	1	Syria, Tunisia

9.4. Graduate Research Training

As part of the degree-oriented training 3 students joined the program during 1991. The names of the graduate students are given in Table 9.4.1. Six students received their M.Sc. and Ph.D. degrees and a few are writing their thesis at their universities.

Table 9.4.1. Participation in graduate research training in 1991.

Name	Degree	University	Country
Registered in 1991			
1. Immad Mahmoud	M.Sc.	Gezira	Sudan
2. Sara Nour	Ph.D.	INRA	Sudan
3. Mohamed Labdi	Ph.D.	INRA	Algeria
Registration continuing from previous years			
1. Aziza Dibo Ajouri	Ph.D.	Aleppo	Syria
2. Jehad Zaki Abd Al-Raheem Yasin	M.Sc.	Jordan	Jordan
3. Hossam El Din M. El-Sayed Ibrahim	Ph.D.	Alexandria	Egypt
4. Christiane Weigner	Ph.D.	Tübingen	Germany
5. Ahmed Saoud	Ph.D.	Damascus	Syria
6. Heiko Schnell	Ph.D.	Hohenheim	FR Germany
7. Marja van Hezewijk	Ph.D.	Amsterdam	The Netherlands
8. Huda Qawas	Ph.D.	Damascus	Syria
Completed and degree awarded			
1. Ghada Hanti	M.Sc.	Aleppo	Syria
2. Bashir A. Malik	Ph.D.	QaidAzem	Pakistan
3. I. Haq	Ph.D.	Punjab	Pakistan
4. Fatima Mustapha	M.Sc.	Gezira	Sudan
5. El-Nour A. Osman	M.Sc.	Khartoum	Sudan
6. M. Elbashir	M.Sc.	Khartoum	Sudan

9.5. Training Material

LP produced four auto-tutorial modules on hybridization techniques and biological nitrogen fixation designed to meet the needs of the trainees. This is expected to allow NARS reach self-sufficiency in skills such as crossing. The modules are self-learning courseware which are easy to use at trainees' pace thus enhancing language skills. LP also produced two computer prototypes on winter sowing of chickpeas and lentil hybridization. These were based on hypermedia concepts using hypertext-based software. All of these advanced materials were used during in country and headquarter courses and rigorous evaluation was done to get feedback from users.

9.6. Seminar: 'Lentil in South Asia'

A seminar on 'Lentil in South Asia' was held in New Delhi from 11-15 March, 1991 sponsored by the Indian Council for Agricultural Research (ICAR) and ICARDA. The seminar aimed to review research on lentil in South Asia, where about half of the world's lentil is grown, as a base-line for future activity in the region. Invited review papers were presented by key lentil scientists for Bangladesh, India, Nepal, Pakistan, and Sri Lanka. The reviews, together with the ensuing discussion, are being edited for publication by ICARDA.

An additional important aim of the Seminar was to decide collectively the direction of future research on lentil in South Asia. Since many of the problems of lentil are common to the different countries of the region, a major effort was made to identify those areas of research common across countries, which might be assisted by networking. The resulting recommendations for regional activities on research and training may form the technical basis of a sub-regional project on 'Lentil improvement in South Asia'.

M. Habib Ibrahim and other Scientists of Legume Program

10. Publications

10.1. Journal Articles

Ahmed, S. and Beniwal, S.P.S. 1991. Lentil rust and its control in Ethiopia. Tropical Pest Management 36 (3): (In press).

Beck, D.P. 1991. Suitability of charcoal-amended mineral soil as carrier for Rhizobium inoculants. Soil Biology & Biochemistry 23:41-44.

Beck, D.P., Wery, J., Saxena, M.C. and Ayadi, A. 1991. Dinitrogen fixation and nitrogen balance in cool-season food legumes. Agronomy Journal 83:334-341.

Beniwal, S.P.S., Ahmed, S., and Gorfu, D. 1991. Wilt root rot diseases of chickpea in Ethiopia. Tropical Pest Management 36 (3): (In press).

Berhe, A., Beniwal, S.P.S., Ghizaw, A., Telaye, A., Beyene, H., and Saxena, M.C. 1991. On-farm evaluation of four management factors for faba bean production in the Holetta zone, Ethiopia. Ethiopian Journal of Agriculture Science (In press).

Ceccarelli, S., Valkoun, J., Erskine, W., Weigand, S., Miller, R. and van Leur, J. 1991. Plant genetic resources and plant improvement as tools to develop sustainable agriculture. Experimental Agriculture (In press).

Erskine, W., Diekmann, J., Jegatheeswaran, P., Salkini, A., Saxena, M.C., Ghuneim, A., and El-Ashkar, F. 1991. Evaluation of lentil harvest systems for different sowing methods and cultivars in Syria. Journal of Agricultural Science, Cambridge 117 (3): 333-338.

Erskine, W., and Goodrich, W.J. 1991. Variability in lentil growth habit. Crop Science 31(4):1040-1044.

Erskine, W. and Muehlbauer, F.J. 1991. Allozyme and morphological variability, outcrossing rate and core collection formation in lentil germplasm. Theoretical and Applied Genetics 83:119-125.

Erskine, W., Williams, P.C. and Nakkoul, H. 1991. Splitting and dehulling lentil. 1. Effects of seed size and different pre-treatments. Journal of the Science of Food and Agriculture 57:77-84.

Erskine, W., Williams, P.C. and Nakkoul, H. 1991. Splitting and dehulling lentil. 2. Effects of genotype and location. Journal of the Science of Food and Agriculture 57:85-92.

El-Defrawi, G., El-Gantiry, A.M. Weigand, S. and Khalil, S.A. 1991. Screening faba bean (Vicia faba L.) for resistance to Aphis craccivora Koch. Arab Journal of Plant Protection (In press).

Haffar, I., Singh, K.B. and Birbari, W. 1991. Assessment of chickpea (Cicer arietinum) grain quality and losses in direct combine harvesting. Transactions of the ASAE. 34:9-13.

Hamdi, A., Erskine, W. and Gates, P. 1991. Relationships among economic characters in lentil. Euphytica 51(2):109-.

Jimenez-Diaz, R.M., Singh, K.B., Trapero-Casas, A. and Trapero-Casas, J.L. 1991. Resistance in kabuli chickpea to Fusarium wilt. Plant Disease. 75:914-918.

Keatinge, J.D.H., Asghar, A., Roidar Khan, B., Abdel Moneim, A.M. and Ahmd, S. 1991. Germplasm evaluation of annual sown forage legumes under environmental conditions marginal for crop growth in the highlands of West Asia. J. Agronomy & Crop Science 166, 48-57.

Kunisch, M., Linke, K.-H., Richter, O., and Koch, W. 1991. Inclusion of conceptual modelling in studies on the population dynamics of the genus Striga. Angewandte Botanik 5:45-57.

Linke, K.-H., Vorlaender, C. and Saxena, M.C. 1990. Occurence and impact of Phytomyza orobanchia Kalt. on Orobanche crenata in Syria. Entomophaga 35 (4), 116-122.

Linke, K.-H., Sauerborn, J. and Saxena, M.C. 1991. Host-parasite relationhsips: Effect of Orobanche crenata seed banks on development of the parasite and the yield of faba bean. Angewandte Botanik (Applied Botany) 65: 229-238.

Malhotra, R.S. and Singh, K.B. 1991. Gene action for cold tolerance in chickpea. Theoretical and Applied Genetics 82: 598-601.

Malhotra, R.S. and Singh, K.B. 1991. Classification of chickpea growing environments to control genotype by environment interaction. Euphytica (In press).

Matar, A.E., Beck, D.P., Pala, M. and Garabet, S. 1991. Nitrogen mineralization potentials of selected Mediterranean soils. Communications in Soil Science and Plant Analysis 22: 23-36.

Moawad, H. and Beck, D.P. 1991. Some characteristics of Rhizobium leguminosarum isolates from uninoculated field-grown lentil. Soil Biology & Biochemistry 23: 933-937.

Silim, S.N., Saxena, M.C. and Erskine, W. 1991. Effect of sowing date on the growth and yield of lentil in a rainfed Mediterranean environment. Experimental Agriculture 27: 145-154.

Singh, K.B., Malhotra, R.S. and Saxena, M.C. 1991. Registration of ILC 482 chickpea cultivar. Crop Sci. (In press).

Singh, K.B., Malhotra, R.S. and Saxena, M.C. 1991. Registration of ILC 8262, a cold tolerant parental line of chickpea. Crop Sci. (In press).

Singh, K.B. and Bejiga, G. 1991. Evaluation of world collection of chickpea for resistance to pod dehiscence. Journal of Genetics and Breeding. 45: 93-96.

Singh, K.B. and Reddy, M.V. 1991. Advances in disease resistance breeding in chickpea. Advances in Agronomy. 45: 191-222.

Singh, O., Singh, K.B., Jain, K.C., Sethi, S.C., Kumar, J., Gowda, C.L.L., Haware, M.P. and Smithson, J.B. 1991. Registration of ICCV 6 chickpea. Crop Science. 31: 1379.

Vito, M. Di., Greco, N. and Saxena, M.C. 1991. Effectiveness of soil solarization for control of Heterodera ciceri and Pratylenchus thornei on chickpea in Syria. Nematologia Mediterranea 19:109-111.

Weigand, S., Pala, M., Saxena, M.C. 1991. Effect of sowing date, fertilizer and insecticide on nodule damage by Sitona crinitus Herbst (Coleoptera: Curculionidae) and yield of lentil (Lens culinaris Medik) in Northern Syria. Journal of Plant Diseases and Plant Protection. (In press).

Weising, K., Kaemmer, D., Epplen, J.T., Weigand, F., Saxena, M.C., and Kahl, G. 1991. DNA fingerprinting of Ascochyta rabiei with synthetic oligodeoxynucleotides. Current Genetics 19:483-489.

10.2. Conference Papers

Bayaa, B., Erskine, W. and Hamdi, A. 1991. Screening wild lentil for resistance to vascular wilt and Ascochyta blight diseases. Paper presented at Fourth Arab Congress of Plant Protection, Cairo. December 1-5, 1991.

Beniwal, S.P.S. 1991. ICARDA's food legume activities in North Africa with special reference to Algeria. A paper presented at the Regional Seminar on 'Research Achievement of Cereals, Food Legumes and Forages in Sidi Bel Abbes and Saida Provinces', Sidi Bel Abbes, 4-5 March 1991.

Gray, L.N., Pastrana, C., de Delgado, N.G. and Erskine, W. 1991. Un nuevo cultivar de lenteja (Lens culinaris Medik.). National Horticultural Meeting, Mar del Plata, Argentina. September 1991.

Hamdi, A., Erskine, W. and Gates, P. 1990. Heritability and combining ability of yield and its components and earliness in lentil. Pages 511-526 in Proceedings 4th Conference of the Egyptian Society of Crop Science, Cairo, Egypt.

Hezewijk, M.J. van, Linke, K.-H., Pieterse, A. and Verkleij, J.A.C. 1991. The effect of ammonium fertilizer in combination with nitrification inhibitors on Orobanche crenata infestation in faba bean. Pages 470-483 in Proceedings of the 5th Symposium on Parasitic Weeds (J.K. Ransom, L.J. Musselman, A.D. Worsham, and C. Parker, eds.). Nairobi, Kenya, June 1991.

Khoury, W. 1991. Components of resistance to Ascochyta rabiei in chickpea. Poster presented in the American Phytopathological Society Meeting held on 17-21 Aug 1991 in St. Louis, Missouri, USA.

Linke, K.-H., Saxena, M.C., Sauerborn, J. and Masri, H. 1991. Effect of soil solarization on the yield of food legumes and on pest control. Pages 139-154 in Proceedings of the First International Conference on Soil Solarization (J. DeVay, J.J. Stapleton and C.E. Elmore, eds.). Amman, Jordan, 19-25 Feb. 1990. FAO Plant Production and Protection Paper 109.

Linke, K.-H., Schnell, H. and Saxena, M.C. 1991. Factors affecting the seed bank of Orobanche crenata in fields under lentil based cropping system in northern Syria. Pages 321-327 in Proceedings of the 5th Symposium on Parasitic Weeds (J.K. Ranson, L.J. Musselman, A.D. Worsham, and C. Parker, eds.). Nairobi, Kenya, June 1991.

Malhotra, R.S. and Erskine, W. 1991. Breeding lentil for high yield, stability and adaptation. Pages 235-241 in Advances in Pulses Research in Bangladesh: Proceeding of the Second National Workshop on Pulses, 6-8 June, 1989, Joydebpur, Bangladesh. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Malhotra, R.S., Erskine, W., and Saxena, M.C. 1991. Adaptation of improved lentil genptypes to diverse environments. Poster paper presented at the International Golden Jubilee Symposium on Genetic Research and Education: Current Trends and the next Fifty Ye ld at New Delhi, 12-15 March 1991.

Robertson, L.D., Singh, K.B., and Erskine, W. 1991. Evaluation of faba bean, kabuli chickpea, and lentil germplasm collections at ICARDA. Pages 340-350-360 in Legume Genetic Resources for Semi-Arid Temperature Environments (A. Smith and L.D. Robertson, eds). International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria.

Saxena, N.P., Saxena, M.C. and Singh, K.B. 1991. Functional ideotype to increase and stabilize yield of rainfed winter and spring chickpea in West Asia and North Africa. Poster presented in the International Symposium on Physiology and Determination of Crop Yield, University of Florida, Gainsville, Florida, U.S.A., 10-14 June 1991.

Singh, K.B. 1991. The role of wild species in improvement of cool season food legumes. Paper presented at the Golden Jubilee Symposium on Genetic Research and Education: Current Trends and the next Fifty Years, held at New Delhi, 12-15 Feb 1991.

Singh, K.B., Malhotra, R.S. and Saxena, M.C. 1991. Breeding for cold tolerance in chickpea. Poster presented at the Symposium on Plant Breeding in the 1990s, held at the University of North Carolina State University, Raleigh, U.S.A., 10-14 Mar 1991.

10.3. Miscellaneous Publications

Abi Anton, M., Kiwan, P. and Erskine, W. 1990. Talia 2- a lentil cultivar for Lebanon. LENS Newsletter 17(1): 3-4.

Anonymous 1991. International Nursery Report No. 13. Food Legume Nurseries 1988-89. pp 442. ICARDA, P.O. Box 5466, Aleppo, Syria.

Beck, D.P., Tripathi, B.R. and Major, M. 1991. Introduction to Biological Nitrogen Fixation. ICARDA Audiovisual Series, International Center for Agricultural Research in the Dry Areas (ICARDA), P.O. Box 5466, Aleppo, Syria.

Cubro, J.I. and Saxena, M.C. (eds.) 1991. Present Status and Future Prospects of Faba Bean Production and Improvement in the Mediterranean Countries. Proceedings of the Zaragoza/Spain Seminar. Options Mediteraneennes Serie A. No. 10 pp 186.

Erskine, W., Ibrahim, M.E. H., Tripathi, B.R. and Major, M. 1991. Hybridization Techniques in Lentil. ICARDA Audivisual Series. International Center for Agricultural Research in the Dry Areas (ICARDA), P.O. Box 5466, Aleppo, Syria.

Haq, M.A. 1991. Genetic and Physiologic Studies on Induced Mutants of Chickpea (Cicer arietinum L.). Ph.D. thesis. pp 196. University of the Punjab, Lahore, Pakistan.

Ibrahim, M.E.H., Fares, A., Hanati, G. and Erskine, W. 1990. Assessment of lodging resistance in lentil by a lodging instrument. LENS Newsletter 17(1): 15-16.

Kahl, G., Kaemmer, D., Ramser, J., Poulsen, G., Bierwerth, S., Kost, S., Saxena, M.C., Weigand, F., and Weising, K. 1991. Oligonucleotide and DNA amplification fingerprinting of various host plant pathogen systems: The potential of the new technique. Paper presented at 'Simposio Actualidal de la Biotechnologia Vegetal en Mexico, 27-29 Nov. 1991.

Linke, K.-H. and Saxena, M.C. 1991. Study on variability and longevity of Orobanche seed under laboratory conditions. Pages 110-114 in Progress in Orobanche Research (Wegmann, K., and Musselman, L.J.

eds). Eberhard-Karls-Universität, Tübingen, FRG.

Linke, K.-H. and Saxena, M.C. 1991. Towards an integrated control of Orobanche spp. in some legume crops. Pages 248-256 In Progress in Orobanche Research (Wegmann, K., and Musselman, L.J. eds.). Eberhard-Karls-Universität, Tübingen, FRG.

Malik, B.A. 1991. Genetics of resistance to Ascochyta rabiei in chickpea (Cicer arietinum L.). Ph.D. thesis. pp 140. Quaid-i-Azam University, Islamabad, Pakistan.

Robertson, L.D.R., El-Sherbeeny, M., Ibrahim, M.E.H., Tripathi, B.R. and Major, M. 1991. Hybridization Techniques in Faba Bean. ICARDA Audiovisual Series, International Center for Agricultural Research in the Dry Areas, (ICARDA), P.O. Box 5466, Aleppo, Syria.

Sauerborn, J., Wyrwal, G., and Linke, K.-H. 1991. Soil sampling for broom-rape seeds in naturally infested fields. Pages 35-43 in Progress in Orobanche Research (Wegmann, K. and Musselman, L.J. (eds.). Eberhard-Karls-Universität, Tübingen, FRG.

Schlingloff, S. 1991. Einfluss der Unkrautbekaempfung auf den Ertrag und Wasserverbrauch von Kornererbsen im semi-ariden Regenfeldbau Syriens. Pages 112. Inaugural-Dissertation zur Erlangung des Doktorgrades (Dr. agr.) beim Fachbereich Agrarwissenschaften der Justus-Liebig-Universität Giessen.

Singh, K.B., Holly, L. and Bejiga, G. 1991. A Catalog of Kabuli Chickpea Germplasm: An Evaluation Report of winter Sown Kabuli Chickpea Land Races, Breeding Lines and Wild Cicer Species. International Center for Agricultural Research in the Dry Area (ICARDA), P.O. Box 5466, Aleppo, Syria. pp 398.

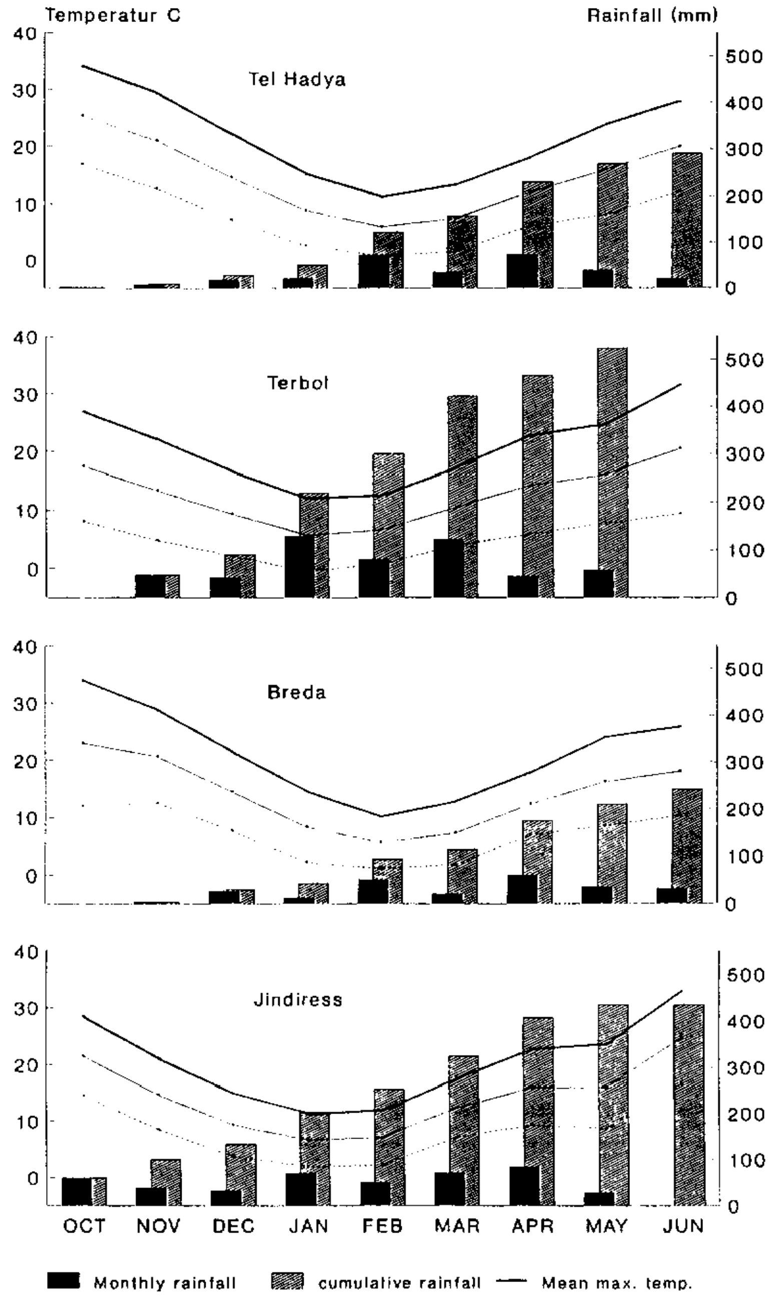
Singh, K.B., Bejiga, G., Saxena, M.C. and Singh, M. 1991. Transferability of selection indices from drought-free to drought-prone environments in chickpea. International Chickpea Newsletter 24:19-22.

Singh, K.B., Ibrahim, M.E.H., Tripathi, B.R. and Major, M. 1991. Hybridization Techniques in Chickpea. ICARDA Audiovisual Series International Center for Agricultural Research in the Dry Areas (ICARDA), P.O. Box 5466, Aleppo, Syria, pp 16.

Telaye, A., Beniwal, S.P.S. and Gates, P. 1991. Faba bean seedling emergence in inbred lines of faba bean in three agroecological zones of Ethiopia. FABIS Newsletter (In press).

Tesfaye, S., Tullu, A. and Beniwal, S.P.S. 1991. Performance of exotic lentils in Ethiopia. LENS Newsleter 17(2): 3-5.

11. **WEATHER DATA 1990/91**



STAFF LIST

M.C. Saxena	Program Leader
Ali Abdel Moneim	Forage Legumes Breeder
D. Beck	Microbiologist
S.P.S. Beniwal	Legume Scientist (Morocco)
W. Erskine	Lentil Breeder
M. Habib Ibrahim	Senior Training Scientist
S.B. Hanounik**	Faba Bean Pathologist (Morocco)
L.D. Robertson**	Faba Bean Breeder (Morocco)
K.B. Singh	Chickpea Breeder (ICRISAT)
S. Weigand	Entomologist
R.S. Malhotra	International Trial Scientist
F. Weigand	Consultant Molecular Biologist
Ahmed Hamdi	Post. Doc. Fellow Lentil Breeding
K.-H. Linke**	Post. Doc. Fellow _Orobanche_ control
W. Khoury**	Visiting Scientist Chickpea Pathology
Mamdouh Omar	Visiting Scientist Chickpea Breeding
Mark Ratinam	Forage Legumes Breeder
N.P. Saxena	Visiting Scientist Crop Physiology (ICRISAT)
Fadel Afandi	Research Associate
Hasan Mashlab	Research Associate
Bruno Ocampo	Research Associate
Nabil Ansari**	Training Assistant
M.Y.N. Agha	Research Assistant
Ibrahim Ammouri	Research Assistant
Suheila Arslan	Research Assistant
Bashar Baker	Research Assistant
Mustafa Bellar	Research Assistant
Samir Hajjar	Research Assistant
Hasan El-Hasan	Research Assistant
Abdulla Joubi	Research Assistant
Gaby Khalaf	Research Assistant
Munzer Kabakibji	Research Assistant
Siham Kabbabeh	Research Assistant
Murhaf Kharboutly	Research Assistant
Hani Nakkoul	Research Assistant
Nabil Trabulsi	Research Assistant
George Zakko	Research Assistant
Riad Ammaneh	Senior Research Technician
Amir Farra	Senior Research Technician
Fadwa Khanji	Senior Research Technician
Pierre Kiwan	Senior Research Technician (Terbol)
Moaiad Lababidi	Senior Research Technician

Raafat Azzo	Research Technician
Abdel K. Bunian	Research Technician
Aida Djanji	Research Technician
Khaled El-Dibl	Research Technician
Hani El-Derbi	Research Technician
Mohammed El-Sayed Hawilo	Research Technician
Mohammed Issa	Research Technician
M.I. El-Jasem	Research Technician
Siham Kabalan	Research Technician
Nidal Kadah	Research Technician
Joseph Karaki	Research Technician (Terbol)
Ghazi Khatib	Research Technician (Terbol)
Omar Labban	Research Technician
Muhammed Maarawi	Research Technician
Aida Naimeh	Research Technician (Terbol)
Abdel Rahim Osman	Research Technician
Diab Ali Raya	Research Technician
Ziad Sayyadi	Research Technician
Hasna Boustani	Secretary
Mary Bogharian	Secretary
Nuha Sadek	Secretary
Namman Ajanji	Driver
Assad Omar El-Darwish	Fieldman
Hussain El-Humeidi	Fieldman
Abdulla El-Khaled	Store Attendant

** Left during the year