RESEARCH ON FABA BEAN, LENTIL AND KABULI CHICKPEA AT THE INTERNATIONAL CENTER FOR AGRICULTURAL RESEARCH IN THE DRY AREAS (ICARDA)

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ABSTRACT

ICARDA was established in 1977 to conduct research and training relevant to the needs of developing countries and specifically of the rainfed agricultural systems in West Asia and North Africa. It is a world center for improvement of barley, faba bean and lentil and, with ICRISAT and CIMMYT, has regional responsibility for chickpea and wheat. Research and training on faba bean, lentil and kabuli chickpea are conducted by the Food Legume Improvement Program of the Center. The genetic diversity assembled at ICARDA, comprising 3,371 accessions of faba bean populations and 5,000 pure lines, 6,800 accessions of lentil and 6,330 of kabuli chickpea, is being used to develop more productive and stable-yielding genotypes. Breeding efforts are complemented by research on major pests and pathogens and on agronomy to improve crop productivity through better water and nutrient use, symbiotic nitrogen fixation and weed control. The improved genotypes and production practices are shared with the national programs for evaluation under local farming conditions through International Testing Program network. As the national programs become more self-reliant in cultivar development and applied research, ICARDA in future would focus more on basic and strategic research.

Introduction

The International Center for Agricultural Research in the Dry Areas (ICARDA) is one of the youngest agricultural research centers established under the auspices of the Consultative Group on International Agricultural Research (CGIAR). It was formally established in 1977 to undertake research and training activities relevant to the needs of developing countries and specifically, to the rainfed agricultural systems in those areas where limited rainfall is primarily received in winter (CGIAR, 1976). A large proportion of agriculture in West Asia and North Africa (WANA) is practiced in such environments, and so that region (which extends from Pakistan in the East to Morocco in the West, and from Turkey in the North to Sudan and Ethiopia in the South) became one of primary concern to ICARDA. The overall objective of the Center is to contribute towards increased agricultural productivity, thereby also increasing the availability of food and enhancing the economic and social well-being of people. More specifically there are five principal objectives : (1) to serve as a world center for research on improvement of barley (*Hordeum vulgare*), lentil (*Lens culinaris*) and faba bean (*Vicia faba*) ; (2) to act as a regional center, in cooperation with CIMMYT and ICRISAT, for the improvement of bread and durum wheat (*Triticum* spp.) and chickpea (*Cicer arietinum*) ; (3) to develop improved systems of cropping, farming and livestock husbandry ; (4) to foster collaborative networks of scientists in various national, regional and international institutions to promote the evaluation and adoption of improved farming systems ; and (5) to conduct and foster training in research.

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Organization and research strategy of ICARDA

Research at ICARDA has to focus on a wide range of agricultural environments in the region which includes : (1) low elevation (up to 1000 m) littoral areas having a Mediterranean-type climate with cool, moist winters, and hot, dry summers, with an annual precipitation ranging from 200 to 600 mm ; (2) high elevation (1000-2000 m) areas with extremes of winter cold and summer heat, variable periods of snow cover and highly variable precipitation. The work of the Center is organized into four research programs : Farm Resources Management ; Pasture Forage and Livestock Improvement ; Cereal Crop Improvement ; and Food Legume Improvement Program. A genetic Resources Unit works closely with crop improvement programs as the region is full of genetic diversity of the ICARDA mandate crops. The headquarters of the Center are located at Tel Hadya Research Station, 30 km south of Aleppo, in North Syria. But, there is access to a chain of research sites in north Syria and Beka'a valley of Lebanon covering a large range of rainfall isohytes and thermal regimes. Outreach programs are being increasingly developed to decentralize the research efforts to hasten progress in those areas remote from headquarters.

Much of ICARDA's research can be classified as "applied" whereas that conducted in collaboration with national programs is "adaptive". "Strategic" and "basic" research is conducted in collaboration with advanced institutions. With the growing strength of the national programs in future they will assume increased responsibility for applied research and cultivar development so that ICARDA would be able to devote more resources to basic research on strategic issues.

Objectives and research strategy of the food legume improvement program

The food legume crop improvement program (FLIP) at ICARDA is seeking to improve the reliable productivity of crops of each of faba bean, lentil and kabuli chickpea within the WANA region and elsewhere. The objective is to increase total food production and so improve the supply of good quality protein in the diets of people who depend heavily on food legumes, and to encourage the introduction of legumes into new, productive cropping systems with attendant benefits to the soil and reduced dependence on nitrogen fertilizer.

Faba bean, lentil and kabuli chickpea are important components of the daily diet of a large section of population in the developing world. They are used both as pulses and vegetables and are processed in various foods. The by-products of the processing industry and straw of these crops are used as animal feeds.

Many constraints combine to limit the production of these three food legumes : low yield potential of existing cultivars ; variable yields due to susceptibility to elements of environment and depradations by pests, diseases and parasites ; limited use of inputs and inefficient production techniques ; increased cost of hand-harvesting and lack of suitable mechanized harvesting systems. The national programs need support to overcome these constraints, and FLIP can best serve them by developing improved genetic material and alternative production techniques that can be tested locally before making them available to farmers. The major objectives for FLIP are : (1) collection, maintenance and evaluation of diverse germplasm ; (2) development and distribution of advanced lines, segregating populations, and other genetic material for producing cultivars with high yield, yield stability and consumer acceptability ; (3) development of appropriate cultural practices for different agro-ecological conditions ; and (4) training of scientists from national programs ; development of an international network of food legume scientists ; and dissemination of technical information through workshops, conferences, information services, research reports, and other publications.

To achieve the above objectives FLIP has organized an operational structure in which research in specific project areas is carried out by a multidisciplinary team of scientists covering the areas of breeding methods, genetics and cytogenetics, physiology, microbiology, entomology, pathology, weed management, seed quality, production agronomy, mechanization and socio-economics.

Production constraints and research achievements

The world area estimates for chickpea, faba bean and lentil, as per FAO (1988) statistics, are 10.03, 3.24 and 2.8 million ha with a corresponding annual production of 7.09, 4.30 and 2.24 million metric tons and a yield of 705, 1328 and 785 kg/ha, respectively. Thus chickpea ranks third, faba bean fourth and lentil as sixth amongst the food legumes in so far as production and area are concerned. ICARDA region accounts for 27, 18 and 41% of the world's area under faba bean, chickpea and lentil, respectively. Of-course, the importance of these three crops in ICARDA region is evident from the fact that they together account for nearly 70% of the food legume production in the region.

The major factors constraining the production of these crops in ICARDA region and elsewhere and some of the research achievements made at ICARDA are briefly presented in the following section.

Faba bean

Several biotic and abiotic factors constrain productivity of faba bean. Excessive flower and young pod drop, excessive vegetative growth and inadequate autofertility are physiological limitations to high and stable yields in the existing cultivars. Tolerance to heat and cold stress is also inadequate. Depradations by many pests and diseases can also limit productivity and cause yield instability ; notable problems are susceptibility to chocolate spot (*Botrytis fabae*), ascochyta blight (*Ascochyta fabae*), rust (*Uromyces fabae*), broomrape (*Orobanche* spp.), stem nematode (*Ditylenchus dipsaci*) and aphids (*Aphis fabae*). Under some conditions diseases such as leaf spots (*Alternaria* spp. and *Cercospora* spp.), powdery mildew (*Erysiphae polygoni* ; *Leveilulla taurica*), and downy mildew (*Pernospora* spp.) and several viruses (BYMV, CMV, BBMV, PLRV and BBSV) can also cause serious yield losses. Insects such as *Spodoptera exigua*, *Heliothis armigera*, *Liriomyza congesta*, *Lixus algirus*, *Sitona* spp., *Thrips tabaci* and *Bruchus rufimanus* can also be a problem.

The faba bean germplasm collection at ICARDA is world's largest. It is maintained in two different forms. The first is the ILB collection comprising original heterogenous, heterozygous populations and currently stands at 3,371. The other collection is a set of inbred lines developed from ILB collection by a process of repeated selfing and selection in single plant progenies to produce inbred line sources for use in the breeding program. This BPL collection currently holds 5,000 entries. Of these 840 have been evaluated for 43 descriptors and a catalogue published (Robertson and El-Sherbeeny, 1988).

The evaluation of BPL accessions for resistance to common diseases and parasites has revealed several resistant sources each to chocolate spot (Hanounik and Robertson, 1988), ascochyta blight (Hanounik and Robertson, 1989), rust, *Orobanche crenata*, and stem nematodes (Table 1). Some sources of multiple disease resistance have also been identified (ICARDA, 1987). Sources of durable resistance to common diseases have been crossed with locally adapted genotypes from various regions, and segregants have been sent to national programs for selection locally.

Poor partitioning of the assimilates into economic yield is common when the traditional faba bean plant types are grown on fertile soils with assured moisture supply. A project on alternative plant types has now developed determinate lines which promise commercial exploitation in not too distant future. An independent vascular supply (IVS) trait (Gates *et al.*, 1983) is being exploited in an attempt to reduce flower drop. Closed

Table 1 Some of the most important inbred sources of resistance for chocolate spot, ascochyta blight, rust, stem nematode, and *Orobanche in faba bean*

Disease	Sources[1]
Chocolate spot	BPL 110, 112, 261, 266, 710, 1179, 1196, 1278, 1821, ILB 3025, 3026, 2282, 3033, 3034, 3036, 3056, 3106, 3107, 2302, 2320 ; L83114, L82003, L82009
Ascochyta blight	BPL 74, 230, 365, 460, 465, 471, 472, 818, 646, 2485 ; ILB 752 ; L83118, L83124, L83125, L83127, L83129, L83136, L83142, L83149, L83151, L83155, L83156, L82001.
Rust	BPL 7, 8, 260, 261, 263, 309, 406, 417, 427, 484, 490, 524, 533, 539, Sel. 82 Lat. 15563-1, 2, 3, 4
Stem nematode	BPL 1, 10, 11, 12, 21, 23, 26, 27, 40, 63, 88, 183
Orobanche crenata[2]	BPL 2756, 2830, 2916, 3190, 3196, 3205, 3243, 3261, 3312, 3336

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

2) Need reconfirmation.

flower trait is being incorporated for reducing cross-pollination. For vegetable use, large pods and large number of seeds are desirable and these characters are being introduced in appropriate backgrounds.

Using the breeding scheme shown in Fig. 1. materials with improved stress resistance and agronomic characters have been developed with adaptation to different environmental conditions and distributed to the national programs through the International Trials Program. Material supplied from ICARDA has found increasing use in many countries (ICARDA, 1989).

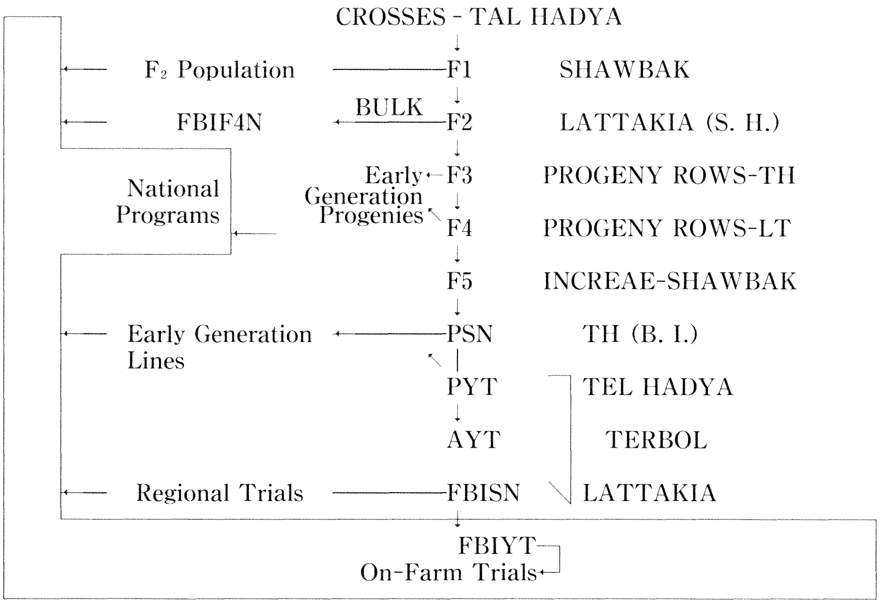

Fig. 1 Breeding scheme for faba bean at ICARDA
Shawbak (Jordan) is used as an off-season (summer) nursery site, Lattakia (screen houses) in Syria for disease screening and Terbol (Lebanon) along with Tel Hadya and Lattakia for yield testing.

One of the most important significant achievements in faba bean improvement has been the results of a special applied research project in the Nile Valley of Egypt, Sudan and Ethiopia, where national scientists have evaluated improved genotypes and production practices in a series of on-farm trials with the participation of local farmers in the systems perspective (Fig. 2). Economic increases in yield, on commercial scales, have been demostrated with the use of improved genotypes, control of weeds and *Orobanche* in Egypt, with the use of improved water management, and insect and weed control in Sudan (Saxena and Stewart, 1983) and improved agronomy in Ethiopia. The project has also conducted studies on the role of vicine, convicine and DOPA in faba bean in causing favism syndrom in susceptible humans, identified genetic differences in their concentration in faba bean, and developed methods for reducing their content through physical treatments.

Lentil

Lentil yields are low because of poor management and low yield potential of land races. There are specific constraints for each of the different agro-geographical areas. For example, in South Asia and East Africa diseases are also a major constraint to production. In West Asia high cost of labour for hand harvest is a serious constraint.

The FLIP objectives for lentil are to develop genetic stocks and cultivars with large and stable yields, with maintained or improved quality and well adapted to the three main regions of production (with specific characters for each region) namely : (1) High altitudes-cold tolerance to allow a winter sowing and attributes for mechanical harvest (tall, non-lodging growth habit and good retention of indehiscent pods) ; (2) Middle to low elevations around the Mediterranean Sea-attributes for mechanical harvest,

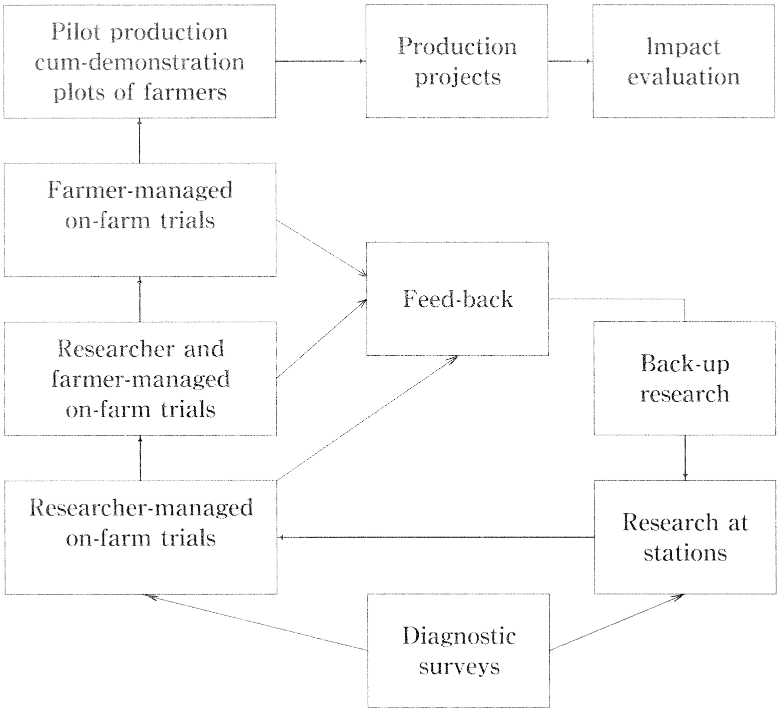

Fig. 2 Research steps in the Nile Valley Regional Project on faba bean in Egypt, Sudan and Ethiopia

maintained straw quality and increased biological yield, tolerance to *Orobanche* spp., cyst nematodes (*Heterodera* sp.), resistance to vascular wilt (*Fusarium oxysporum* f. sp. *lentis*), and drought tolerance during the reproductive phase ; and (3) Lower latitudes (Indian sub-continent, Ethiopia, Sudan)-phenological adaptation to the warm,short-photoperiod environment and resistance to rust (*Uromyces fabae*), vascular wilt and ascochyta blight (*Ascochyta lentis*).

Of the current holding of 6,800 germplasm accessions maintained as International Legume Lentil (ILL), 4,550 accessions from 54 countries have been evaluated for 19 descriptors and a Lentil Germplasm Catalogue has been published (Erskine and Witcombe, 1984). Useful variation has been observed in the germplasm and exploited in crop improvement. This includes characters that affect the success of harvest mechanization such as reduced lodging and pod dehiscence ; resistance to cold, vascular wilt, ascochyta blight and rust (Table 2). Characterization of photothermal requirement for flowering has also been done for some accessions of diverse geographical origin, after developing a model to describe the relationship between the time taken to flower and the mean photoperiod and temperature (Summerfield *et al*., 1985).

Following the breeding scheme shown in Fig. 3, recombination of desirable traits from a wide range of germplasm has led to the development of breeding materials which should meet the needs of the major agro-ecological regions. Distribution of early generation and elite material through the international nursery network is enabling national programs to benefit from these breeding efforts. National programs in Argentina, Canada, Egypt, Equador, Ethiopia, Jordan, Lebanon, Morocco, Nepal, Sudan, Tunisia, and Turkey have selected materials for local trials.

Systems of mechanical harvesting have been developed and tested for different agricultural situations. These are based on improved seed-bed preparation, use of tall non-lodging lines with retentive and indehiscent pods and use of different harvesting machines : angled blades, double knife cutter bar, tractor driven lentil puller and the grain combine. Some of these options have proved superior to the traditional hand harvest.

Agronomic studies have shown advantage of early sowing, phosphate fertilization and weed control. Effective herbicides for wide spectrum weed control have been identified. Control of *Sitona* larvae damage to lentil nodules has resulted in increased economic yield and biological nitrogen fixation (ICARDA, 1989). Effective granular insecticide and insecticide for seed treatment have been identified. Control schedule for reducing the bruchid infestation has been tested and recommended for use (ICARDA, 1989). For the control of *Orobanche*, host resistance has only been partially successful, but integrated control involving tolerant genotype, regulation of sowing date and soil solarization has proved promising (ICARDA, 1989). Collection and evaluation of strains of *Rhizobium* from different production areas has been done and effective host genotype X *Rhizobium* strain combinations have been established.

Table 2 Reaction of some lentil lines to ascochyta blight at NARC, Islamabad, Pakistan and Debre Zeit, Ethiopia and to rust at Debre Zeit and Akaki, Ethiopia on 1-9 scale*

	Ascochyta blight score		Rust score	
ILL	*NARC*	*DZ*	*DZ*	*Akaki*
358	1	5	2	3
5604	2	6	1	1
5748	3	5	3	1
5871	1	—	1	—
6007	3	5	1	1

*1 ; Resistant 9 ; Susceptible

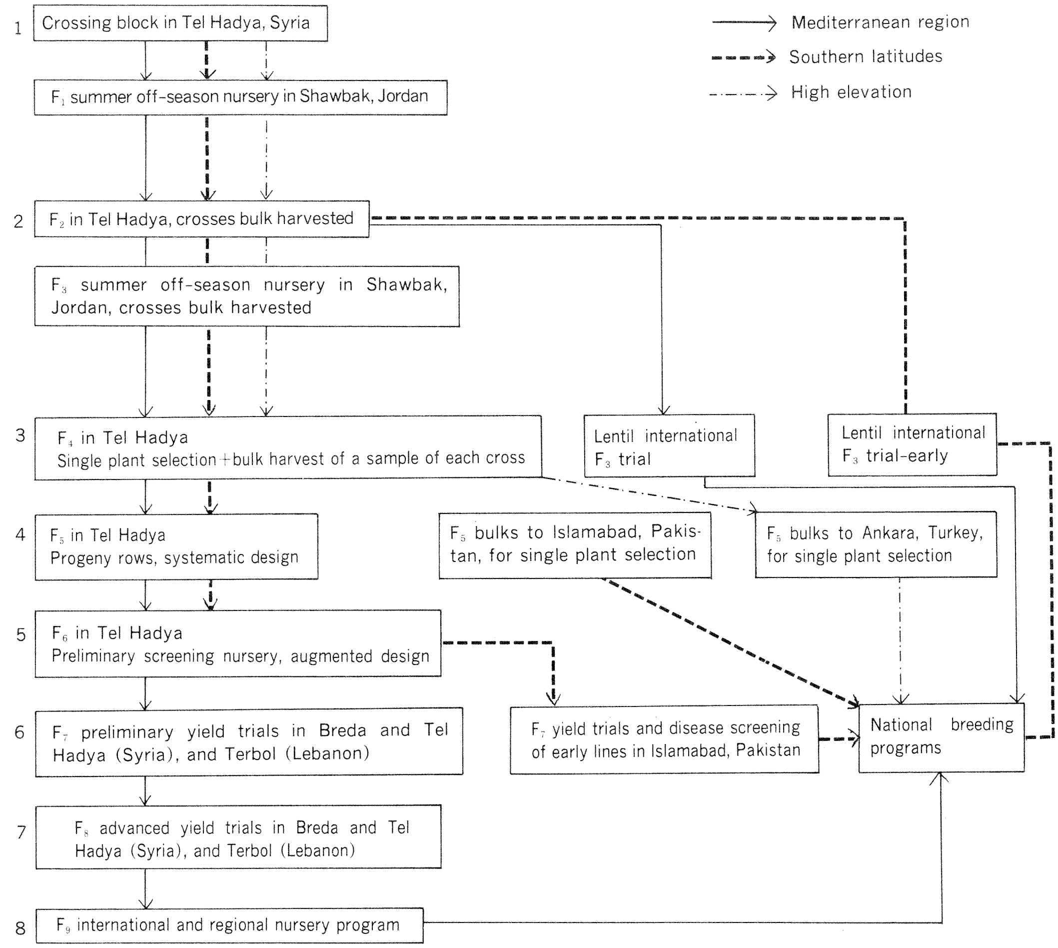

Fig. 3 Breeding scheme for lentil at ICARDA

Kabuli chickpea

Almost 80% of the total chickpea crop grown in WANA is the kabuli type. FLIP's efforts are therefore concentrated on these types in a joint research program with ICRISAT. Existing cultivars, besides being low-yielding, suffer from several constraints which further reduce and destabilize regional yield : susceptibility to ascochyta blight (*Ascochyta rabiei*), to root rot and wilt and stunt virus, to leafminer (*Liriomyza cicerina*) and pod borers (*Helicoverpa armigera* and *Heliothis* spp.), cyst (*Heterodera ciceri*) and root-knot nematode (*Meloidogyne artiellia*), and to frost early in the season and drought and heat stress during the reproductive phase. Farmers sow their crops in spring to avoid losses from frost and ascochyta blight, but the plants are exposed to an increasingly desiccating environment with depleting soil moisture. Inadequate production practices and inputs further reduce yields.

The current holding of kabuli chickpea germplasm at ICARDA now stands at 6,330 and we also have around 137 accessions of 9 wild *Cicer* species. More than 3,300 accessions were evaluated for 27 descriptors in spring sowing and a Germplasm Catalog was published (Singh *et al*., 1983). Recently an evaluation of 6,330 germplasm accessions was done in winter sown crop and a second evaluation catalog is under preparation. Using screening techniques developed by the program for large scale field evaluation for cold and leafminer, greenhouse/laboratory evaluation for cyst nematode, *Orobanche crenata* and seed beetle (*Callosobruchus chinensis*), field and laboratory screening for ascochyta blight and fusarium wilt, available germplasm has been tested for these stress factors and some promising sources identified (Table 3a). Screening for ascochyta blight included both kabuli and desi type chickpea germplasm amounting to 16,000 accessions. No resistance was found for cyst nematode and seed beetle in the cultivated chickpea ; hence the 137 accessions of eight wild annual species were evaluated for these stresses (ICARDA, 1989). High level of resistance was present in wild types for these two stresses as well (Table 3b). Crossability barriers between the wild *Cicer* spp. and cultigen prevent immediate use of this gene pool for breeding.

Using the sources of resistance and other specific traits in a breeding program illustrated in Fig. 4, significant progress has been made in the development of kabuli chickpea genotypes well adapted to different agro-ecological conditions, enabling several national programs to evaluate them under their own farming conditions and releasing them to their farmers (Table 4).

By far the most significant achievement of the FLIP has been to demonstrate that large increases in yield are possible in the Mediterranean basin by sowing chickpea in winter as against the traditional practice of sowing in spring (Hawtin and Singh, 1984). The yield increases in most seasons could be almost linear as sowing is progressively advanced from late spring to winter (Fig. 5). The winter sowing permits matching of the crop phenology with the availability of optimum temperature and moisture regimes so

Table 3a Evaluation of chickpea germplasm for different biotic and abiotic stresses

Stress	Lines screened	Resistance sources
Ascochyta blight	15,000	ILC − 182, − 200, −2506, −2956, −3274, −3856, −3866, −3870, −4421, −5586, −5921, −6188.
Cold	5,200	ILC − 794, −1071, −1251, −1256, −1444, −1455, −1464, −1875, −3465, −3598, −3746, −3747, −3791, −3857, −3861.
Leafminer	6,200	ILC 5901.
Fusarium wilt	2,500	ILC − 857, − 848, − 850, − 851, − 857, − 858, − 860, − 871, − 904, − 911, −5032, −5411.
Cyst nematode	3,800	None
Seed beetle	4,000	None

Table 3b Evaluation of *Cicer* species for biotic and abiotic stresses at Tel Hadya, 1987/88

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

HR Highly resistant ; R Resistant ; S Susceptible.

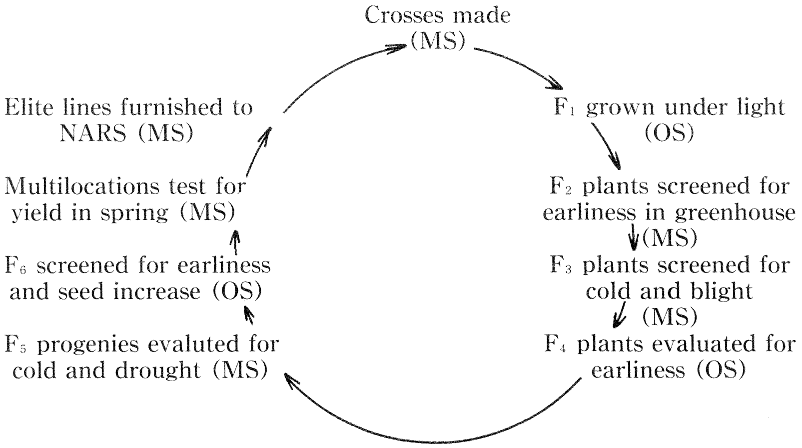

Fig. 4 Breeding scheme for kabuli type chickpea for the development of cold, ascochyta blight and drought-tolerant genetic stocks and cultivars

that adverse effects of environmental conditions are minimized. Since the total water use of the spring and winter sown crops remains nearly the same, there is substantial increase in the water use efficiency (Keatinge and Cooper, 1983). With winter sowing, chickpea cultivation can also be extended into those regions which are too dry for spring-sown crops. Genotypes for winter sowing must be tolerant to cold and resistant to ascochyta blight. A major part of FLIP's research effort is therefore devoted to these two aspects. Resistance to *Orobanche*, fusarium wilt, leafminer, and nematodes, a tall stature, large seed, and early maturity are other important attributes that have been included in the breeding strategy. Significant progress has been made in the development of kabuli chickpea genotypes well adapted to winter sowing in the Mediterranean basin, enabling several national programs to demonstrate to farmers the advantages of winter sowing in their respective countries. Colleagues in Algeria, Cyprus, France, Italy, Morocco, Oman, Spain, Syria, Tunisia and Turkey have released chickpea varieties for winter sowing (Table 4). The technology is spreading fast all over the WANA region.

In order to stabilize the yield gain with the winter sowing, back-up research in the area of epidemiology of *A. rabiei*, variability in the pathogen including the studies on existence of perfect stage of the fungus, genetic control of resistance to the disease and cold, and biochemical basis of resistance has been underway and some interesting results have become available to support the refinement of winter sowing technology.

While efforts have concentrated on developing genotypes and production techniques for winter sowing, the traditional spring crop has not been neglected. Work has been done on developing genotypes with higher yield potential and better tolerance to drought and high temperatures, resistance to root rot and wilt diseases, resistance to leafminer, improved biological nitrogen fixation, responsiveness to supplemental irrigation, tall growth habit, and large seed size with good organoleptic properties. Also research on supplemental irrigation, chemcial weed control, phosphate fertilization and *Rhizobium* inoculation has given valuable results (Saxena, 1987 ; ICARDA 1989).

Table 4 Food-legume cultivars released by different national programs

Country	Cultivars released	Year of release	Specific features
Kabuli chickpea			
Algeria	ILC 482	1988	High yield, wide adaptation
	ILC 3279	1988	Tall, high yield
Cyprus	Yialousa (ILC 3279)	1984	Tall
	Kyrenia (ILC 464)	1987	Large seeds
France	TS1009 (ILC 492)	1988	Released by TOP SEMENCE
	TS1502 (FLIP−81−293)	1988	Released by TOP SEMENCE
Italy	Califfo (ILC 72)	1987	(Verbally informed, details
	Sultano (ILC 3279)	1987	expected)
Morocco	ILC 195	1987	Tall
	ILC 482	1987	High yield, wide adaptation
Oman	ILC 237	1988	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	1987	High yield
Syria	Ghab 1 (ILC 482)	1982	High yield, wide adaptation
	Ghab 2 (ILC 3279)	1986	Tall, cold-tolerant
Tunisia	Chetoui (ILC 3279)	1986	Tall
	Kassab (FLIP 83-46C)	1986	Large seeds, high yield
	Amdoun 1 (Be-sel-81-48)	1986	Large seeds,
Turkey	ILC 195	1986	Tall, medium seed, cold tolerant
	ILC 482	1986	High yield, wide adaptation
Lentil			
Australia	ILL 5750	1989	High yield
Algeria	Syrie 229	1987	High yield, good seed quality
	Balkan 755	1988	High yield, good seed quality
Canada	ILL 4400	1988	High yield, good seed quality
Ecuador	INIAP-406 (FLIP 84-94L)	1987	Rust-resistant, high yield
Ethiopia	ILL 358	1984	Rust-resistant, high yield
Lebanon	Telaya 2 (78S 26002)	1988	High yield, lodging resistance
Syria	Idleb 1 (78 S 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
Faba bean			
Ethiopia	74TA 12050×74 TA 236	1989	High yield, disease resistant
Iran	Barkat (ILB 1269)	1986	Large seeds, long pods, high green-pod and dry-seed yield

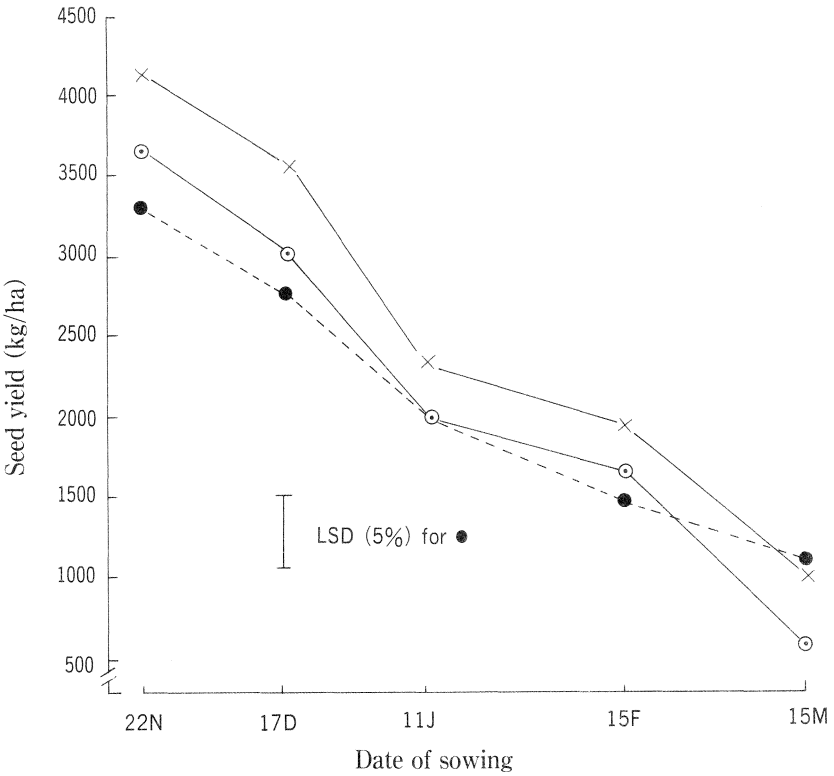

Fig. 5 Effect of date of sowing on the yield of NEC 293 (×—×) and ILC 190(⊙——⊙) chickpea cultivars and the mean yield of 20 cultivars (●------●) at Tel Hadya, northern Syria, 1978/79

International testing programs and information dissemination

In order to assist the national programs is their efforts to develop genotypes and technology appropriate for local production systems, researchers elsewhere are encouraged to participate in FLIP's International Testing Program (ITP), which serves as a major vehicle for the dissemination of improved germplasm. The ITP was initiated in the 1977/78 season with a total of six nurseries for the three legumes distributed to 56 cooperators in 11 countries. The material supplied comprised advanced breeding lines for yield evaluation. Since then, the effort has been substantially expanded and now nurseries containing early generation segregating populations, disease-, insect pest-, and *Orobanche*-resistant material and agronomic, weed control and inoculation response trials have also been provided. In 1988, for example FLIP provided 1,223 sets of 45 different types of nurseries on the three legumes (Table 5). Yet even that supply was smaller than the total demand because of shortage of seed. Clearly, there is increasing interest in the ITP among the national program scientists which reflects the usefulness of the material supplied to them. Indeed, this is reflected in release of large number of cultivars by them as shown already in Table 4.

Improvement of technical skills available in the national programs to strengthen the research base for food legumes necessitates a rapid and efficient dissemination of research information and the specialized training of personnel. FLIP has addressed itself to these needs by : (1) operating information services for faba bean (FABIS) and lentil (LENS)

Table 5 Food Legume International Nurseries supplied for the 1988/89 season

International Trial/Nursery	No. of sets
Faba bean	
Yield Trial, Large-Seed (FBIYT-L-89)	25
Yield Trial, Small-Seed (FBIYT-S-89)	25
Yield Trial, Determinate (FBIYT-D-89)	25
Screening Nursery, Large-Seed (FBISN-L-89)	30
Screening Nursery, Small-Seed (FBISN-S-89)	30
Screening Nursery, Determinate (FBISN-D-89)	30
* F_4 Nursery-A (with Ascochyta Blight Resistance) (FBIF$_4$ NA-89)	5
* F_4 Nursery-B (with Chocolate Spot Resistance) (FBIF$_4$ NB-89)	10
* F_4 Nursery-D (with Determinate Type) (FBIF$_4$ N-D-89)	12
Ascochyta Blight Nursery (FBIABN-89)	8
Chocolate Spot Nursery (FBICSN-89)	8
Rust Nursery (FBIRN-89)	8
Fertility-Rhizobium Evaluation Trial (FBFRT-89)	15
Inoculation Response Trial (FBIRT-89)	10
Weed Control Trial (FBWCT-89)	15
Orobanche Chemical Control Trial (FBOCCT-89)	5
Lentil	
Yield Trial, Large-Seed (LIYT-L-89)	60
Yield Trial, Small-Seed (LIYT-S-89)	35
* Yield Trial, Early (LIYT-E-89)	35
Screening Nursery, Large-Seed (LISN-L-89)	52
Screening Nursery, Small-Seed (LISN-S-89)	30
Screening Nursery, Early (LISN-E-89)	59
Screening Nursery, Tall (LISN-T-89)	52
F_3 Nursery, (LIF$_3$ N-89)	13
F_3 Nursery, Early (LIF$_3$ N-E-89)	26
* Cold Tolerance Nursery (LICTN-89)	17
* Ascochyta Blight Nursery (LIABN-89)	20
Fertility-Rhizobium Evaluation Trial (LFRT-89)	16
Inoculation Response Trial (LIRT-89)	17
Weed Control Trial (LWCT-89)	21
Chickpea	
Yield Trial Spring (CIYT-Sp-89)	42
Yield Trial Winter, Mediterranean Region (CIYT-W-MR-89)	50
Yield Trial Winter, Sub-Tropical Region (CIYT-W-STR-89)	30
Yield Trial Large Seed (CIYT-L-89)	74
Yield Trial Tall (CIYT-T-89)	59
Screening Nursery Winter (CISN-W-89)	55
Screening Nursery Spring (CISN-Sp-89)	46
F_4 Nursery (CIF$_4$ N-89)	18
Ascochyta Blight Nursery : Kabuli (CIABN-A-89)	26
Ascochyta Blight Nursery : Kabuli+Desi (CIABN-B-89)	20
Leaf-miner Nursery (CILN-89)	8
Cold Tolerance Nursery (CICTN-89)	28
Fertility-Rhizobium Evaluation Trial (CFRT-89)	16
Inoculation Response Trial (CIRT-89)	20
Weed Control Trial (CWCT-89)	17

* New Nurseries added for 1988/89.

including the publication and distribution of newsletters and abstract journals ; (2) organizing periodic workshops and conferences ; (3) publishing and distribution of scientific literature, including textbooks (Hawtin and Webb, 1982 ; Saxena and Singh, 1987 ; Webb and Hawtin, 1981) and training manuals ; and conducting residential, specialized, individual and in-country training courses. These activities have combined to create a network of scientists working jointly for the improvement of faba bean, lentil and kabuli chickpea in those many countries where they are important crops.

Looking ahead

FLIP will gradually transfer responsibility of crop improvement research on faba bean to the national programs and will concentrate efforts on lentil and kabuli type chickpea. The first aim will be to consolidate gains made so far in crop improvement research. The strategic research at ICARDA will continue to be directed to (a) increased yield potential, (b) narrow the gap between farm yield and potential yield, (c) improve sustainability of yield, (d) mount a defense against erosion of yields by pests and pathogens, and (e) sustain cereal production in-farming systems by appropriate integration of the food legumes. In breeding, there will be a gradual reduction in the production of finished cultivars at ICARDA : this work will increasingly be done by the national programs as we decentralize our breeding efforts and foster development of sub-regional networks. At ICARDA more emphasis will be put on the development of early-generation segregating populations, more efficient breeding methodologies, and improved screening techniques. Research on abiotic stresses (drought, heat and cold) will increase and will go hand-in-hand with breeding for improved plant architecture and resistance to pests and diseases. Collaboration with centers in the industrialized countries will be used to benefit from the innovations on biotechnology in developing novel crop improvement techniques and a better understanding of the physiological basis of resistance to stresses. Efforts on enhancing biological nitrogen fivation will increase. Effect of new legume technology on the cereal and livestock components will be studied with a view to improving the sustainability of the total farming systems.

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Discussion

Singh, R. B. (FAO RAPA) : Production trends reveal that growth rates for lentil are about the highest among pulses. South Asia also grows a considerable amount of lentil. ICARDA has developed promising breeding materials which have been used for releasing varieties in the Middle East. Would you please comment on ICARDA's support for lentil improvement in South Asia, particularly the Indian sub-continent and specific efforts to maintain the promising growth trend recorded during the past decade.

Answer : South Asia is indeed the major producer of lentil, accounting for approximately 50% of the total world production. ICARDA in the past had not given as much attention to lentil improvement for South Asia as for the Middle East. For the last couple of years, however, increasing attention is being given to the needs of the Indian sub-continent through collaborative research with Pakistan and Indian national programs. The large-seeded characteristics of the Mediterranean lentil have been incorporated in the backgrounds adapted to southern latitudes (short photoperiod environment) and materials selected from such breeding materials are now finding good acceptance in India, Pakistan, Nepal and Bangladesh. Disease-resistant sources have also been identified. Increasing attention will be paid to South Asia in future as our collaborative research in Pakistan and India expands.