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Management of Germplasm Collections in Chickpea

Kuldip Kumar, S. Sardana, M. Singh, N.K. Gautam

National Bureau of Plant Genetic Resources, Pusa Campus, New Delhi, India

***Abstract*—** *Chickpea (Cicer arietinum L.) is an important pulse crop and ranks second in area and third in production among the pulses in the world.About 150 accessions were desi types and remaining 10 kabuli types. Similarly, kabuli germplasm maintained at International Centre for Agricultural Research in the Dry Areas (ICARDA) was screened for 29 traits including reaction to major biotic and abiotic stresses and promising donor sources have been identified. Collaborative efforts among different research institutes through national network should be made to evaluate chickpea germplasm systematically at several locations. To narrow down the gap between germplasm available and the germplasm utilized in the breeding programmes, it is imperative to document the germplasm providing a complete spectrum of genetic variability in the collection. Efforts should also be made towards germplasm enhancement through incorporation of genes from secondary and tertiary gene pools into a suitable genetic background. A good number of accessions conserved in various genebanks may be duplicates and efforts are required to identify and eliminate them using molecular markers.Over 13,500 accessions were evaluated for resistance to race 1 of Fusarium oxysporum f. sp. ciceri at ICRISAT resulting into identification of 160 accessions with stable resistance (Haware et al., 1992).*

***Keywords*—Chickpea,Cicer arietinum L., Germplasm collection, Germplasm evaluation, Genebanks.**

I. INTRODUCTION

Chickpea (*Cicer arietinum* L.) is an important pulse crop and ranks second in area and third in production among the pulses in the world. It is cultivated from Mediterranean region to the Indian sub-continent, the West Asian and North African (WANA) region and Eastern African highlands. However, it is in the Indian subcontinent, that the crop holds the prime position because bulk of population sustains chiefly on vegetarian diet. Chickpea is a rich source of protein, having crude protein that ranges between 12.6 and 30.5% (Singh 1985). India is a premier chickpea growing country in the world and ranks first in area (8.69 million hectare) and production (7.86 million tonnes). Besides being cheap and rich source of dietary protein and a valuable animal feed, it also improves and restores soil fertility. In spite of these virtues, there is only a marginal increase in its productivity over the years. Genetic variability is immensely valuable to chickpea breeders for its improvement. Owing to rapid agro-ecological changes taking place all over the world, many species, old and primitive cultivars, land races and their wild relatives, endowed with superior gene complexes are being rapidly eroded. It is feared that many of these diverse forms may become extinct in due course if corrective steps are not taken immediately. Therefore, concerted efforts are required both at national and international levels to collect, consolidate and conserve valuable resources of chickpea germplasm.

II. TAXONOMY AND GEOGRAPHIC CENTRES OF DIVERSITY

The name *Cicer* is of Latin origin. The genus *Cicer* belongs to family *Leguminosae*, subfamily *Papilionoideae* and tribe, the *Cicereae* Alef. (Kupicha 1977). Earlier, *Cicer* was considered to belong to tribe, *Viceae* Alef. van der Maesen (1987) dealt with this genus in detail and listed 43 species that included 34 wild perennial, eight wild annual and one cultivated annual species, *C. arietinum* (Table 1). van der Maesen (1972), Ladizinsky and Adler (1976a) and Witcombe and Erskme (1984) earned out detailed taxonomic studies of genus *Cicer*. Ladizinsky and Adler (1976b) studied biosystematics relationships between cultigens and its six annual wild relatives and assigned them into three crossability groups; Group I consisted of *C. arietinum, C. reticulatum* and *C. echinospermum;* Group II consisted of *C. judaicum, C. pinnatifidum* and *C. bijugum* and Group III consisted of only one species, C. *cuneatum.* The chromosome number of all these species was 2n=2x=16. Within the groups, hybridization is possible with variable fertility. However, it was not successful between the members of different groups. The study suggests that there is no apparent barrier to gene flow between *C.*

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arietinum and *C. reticulatum* of Group I while it is much more difficult to produce hybrids with *C. echinospermum.* As per the gene pool scheme of Harlan and de Wet (1971), the primary gene pool comprises *C. arietinum* (GP_1A, the domesticated component) and *C. reticulatum* (GP_1B, the wild component); the secondary gene pool (GP_2) apparently consists of *C. echinospermum*, while the remaining species can be assigned to the tertiary gene pool (GP3).

Table.1: Cicer species and their distribution

S.No.	Species	Distribution
	ANNUAL	
1	*C. arietinum*	Mediterranean region to Myammar, Ethiopia, Mexico, Chile
2	*C. chorassanlcum*	Afghanistan, Iran
3	*C. bijugum*	Turkey, Syria, Iraq
4	*C. cuneatum*	Ethiopia, Egypt, Sudan, Saudi Arabia
5	*C. echinospermum*	Turkey, Anatolia, Iraq
6	*C. judaicum*	Palestine, Lebanon
7	*C. pinnatifidum*	Cyprus, Iraq, Syria, Turkey, Former USSR
8	*C. reticulatum*	Turkey
9	*C. yamashitae*	Afghanistan
	PERENNIAL	
10	*C. acanthophyllum*	Afghanistan, Pakistan, Former USSR
11	*C. anaiolicum*	Turkey, Iran, Iraq, Armenia
12	*C. atlanticum*	Morocco
13	*C. balcaricum*	Caucasus
14	*C. balds huanicum*	Former USSR
15	*C. canariense*	Canary islands, Tenerife and La palma
16	*C. fedtschenkoi*	Former USSR, Afghanistan
17	*C. flexuosum*	Former USSR
18	*C. floribundum*	Turkey
19	*C. graecum*	Greece
20	*C. grande*	Former USSR
21	*C. heterophyllum*	Turkey
22	*C. incanwn*	Former USSR
23	*C. incisum*	Greece, Turkey, Iran, Lebanon, Former USSR
24	*C. isauricum*	Turkey
25	*C. kermanense*	Iran
26	*C. Korshinskyi*	Former USSR
27	*C. laetum*	Former USSR
28	*C. macrocanthum*	Afghanistan, India, Pakistan, Former USSR
29	*C. microphyllum*	Afghanistan, Tibet, India, Pakistan, Former USSR
30	*C. mogoltavicum*	Former USSR
31	*C. montbrettii*	Albania, Bulgaria, Turkey
32	*C. multijugum*	Afghanistan
33	*C. nuristanicum*	Afghanistan, India, Pakistan
34	*C. oxyodon*	Iran, Afghanistan, Iraq
35	*C. paucijugum*	Former USSR
36	*C. pungens*	Afghanistan, Former USSR
37	*C. rassuloviae*	Former USSR
38	*C. rechingeri*	Afghanistan
39	*C. songaricum*	Former USSR
40	*C. spiroceras*	Iran

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41	*C. stapfianum*	Iran
42	*C. subaphyllum*	Iran
43	*C. tragacanthoides*	Iran, Former USSR

Based on morphological resemblance, protein profile and crossability, *C. reticulatum* is regarded as the wild progenitor of *C. arietinum* (Ladizinsky and Adler 1976a). However, van der Maesen (1984) appeared somewhat reluctant to accept *C. reticulatum* as progenitor. In general, morphology, physiology and genetics of *C. reticulatum* are in good approximation of *C. arietinum* and such form may be regarded as the progenitor of *C. arietinum* fSmartt 1990).

III. DOMESTICATION AND EVOLUTION

Chickpea is thought to have originated in Anatolia (Turkey), where three closely related wild species (C. *bijugum* K.H. Rech, *C. echinospermum* PH. Davis, and *C. reticulatum* Ladizinsky) are commonly found in nature (van der Maesen 1984). Chickpea seeds had been occasionally recovered in pre-historic sites in the Near East (Renfrew 1973). However, Ramanujam (1976) reported that remnants of chickpea radiocarbon are dated at 5450 BC and there is evidence for its cultivation in the Mediterranean basin in 3000-4000 BC. The earliest record of chickpea in northern India (Uttar Pradesh) dated at 2000 BC, and from the south India much later (Chowdhury *et al.*, 1971, Vishnu-Mittre 1974). Ramanujam (1976) suggested that northern areas of India received chickpea by land route and south areas probably by sea route. *C. arietinum* is closest to *C. reticulatum* (Ladizinsky and Adler 1976b). The other species, *C. bijugum* and *C. echinospermum* are also as close to *C. arietinum* as is *C. reticulatum* (van der Maesen 1984). Prior to domestication, the isolating mechanisms must have evolved between *C. reticulatum* and other wild species. There are evidences to suggest that chromosome structural changes played a significant role as isolating mechanism between *C. arietinum* and *C. echinospermum* (Smithson *et al.*, 1985). The cultigen differs from its wild relatives principally in its growth habit and pods with reduced dehiscence. Under the process of domestication, two major forms have emerged: *desi* (microsperma) with angular and coloured seeds and *kabuli* (macrosperma) with large, ram shaped and beige coloured seeds.

IV. HISTORICAL OVERVIEW

Collection of plant genetic resources primarily aims at tapping of germplasm and its wild relatives/related species from different agro-ecological/phyto-geographical regions. High genetic diversity for chickpea is available in Gangetic and Indus plains. As early as in 1940, sporadic surveys were undertaken and 85 germplasm accessions were assembled at Imperial Institute of Agricultural Research, Pusa, Bihar (Shaw and Ram 1934, Pal 1938). During the first phase, emphasis was laid on single plant selection from germplasm collections and some of important germplasm were released as varieties including C 235, G 24, S 26, C 104, Type 1, Type 2, Gwalior 21 and Ujjain 21 (Argikar 1970). Systematic plant exploration in India was initiated with the establishment of Plant Introduction Scheme in the erstwhile Botany Division of the Indian Agricultural Research Institute, New Delhi in 1946. Later in 1956, it was elevated to Division of Introduction. A large number of germplasm collections was made from different parts of the country and used for making selections during 1948-1965. This resulted in identification of some of the most popular varieties such as Chaffa, Annegeri 1, Co 1, RS 10, ST 4, BR 75 and Type 3.

With the launch of All India Coordinated Pulses Improvement Project (AICPIP) in 1966-67, several collections of landraces, traditional varieties, and primitive types were made. A collection of 1,353 germplasm accessions was assembled at GBPUA&T, Pantnagar. They were evaluated for different agro-morphological traits as well as for biotic and abiotic stresses. This resulted in identification of a large number of genetic stocks with desirable characters (Pandya and Pandey 1979). Similar efforts under the programme 'Improvement of gram' were initiated in 1971 at HAU, Hisar. Another project on 'Intensification of Research on Improvement of Pulses' was started in 1975. As a result, 6,620 accessions were collected both from within the country and abroad. Evaluation and characterization of these accessions resulted in identification of some useful donors (Lai and Tomar 1979).

The first international effort to improve this crop was initiated in 1962, when the Regional Pulse Improvement Project (RPIP) was taken up in India and Iran. Due to the efforts of RPIP, 7,000 germplasm accessions were assembled. When the RPIP was terminated in 1970, part of this collection was deposited with USDA and the rest

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remained with National Research Programmes in India and Iran. In 1972, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) came into existence at Patancheru in India. It assumed the responsibility of World Repository for chickpea genetic resources.

In view of the importance and growing task of genetic resource activities, Plant Introduction Division of IARI was elevated to an independent organization, National Bureau of Plant Genetic Resources (NBPGR) in 1976. Now, NBPGR with 11 regional stations located in various agro-climatic regions of the country and 30 national active germplasm sites (NAGS) caters to the need of the National Plant Genetic System. The Indian Institute of Pulse Research (IIPR), Kanpur has been identified as NAGS for pulses in the country.

V. ACCOMPLISHMENTS

Plant Exploration and Collection

After the inception of NBPGR in 1976, systematic explorations, both crop-specific and region specific (multi crops), have been conducted to augment chickpea germplasm. Prior to this, the chickpea germplasm collection was undertaken by IARI with the support of PL 480 scheme. Under this scheme, collection of chickpea germplasm was made from Rajasthan, Orissa, northern and eastern Maharashtra, Gujarat (except Kutch and Bharuch regions), eastern part of Arunachal Pradesh, southern districts of Karnataka, Tamil Nadu and some parts of Bihar. A large number of indigenous accessions were collected between 1977 and 1999 (Srivastava and Gautam 1999). The crop specific explorations were earned out in collaborations with different institutes like ICRISAT, IIPR, PAU, NDUA&T and BHU.

Areas surveyed for collection of chickpea include Madhya Pradesh (central and western region); Chattisgarh; Rajasthan (central, western and north-western region); dry, semi-arid and rainfed areas of Haryana and adjoining Punjab; coastal and southern region of Gujarat; Bundelkhand region of Uttar Pradesh; Maharashtra; and Telengana and Rayalseema regions of Andhra Pradesh. *Cicer microphyllum*, which grows well at higher altitudes, has been collected from different ecological habitats including Lari and Tabo areas of Himachal Pradesh and Laddakh area of Jammu & Kashmir (Chandel 1992).

Chickpea collection exhibits variability in foliage colour, plant height, pod bearing habit, pod size, seed colour, seed coat texture, seed coat surface and seed size. Collections from Madhya Pradesh were twin podded, large seeded (*kabuli* type) and tuberculated seed types *(desi)* with short and medium duration (Pundir *et al.*, 1989, 1990). Germplasm collection from Maharashtra showed variability for seed type, seed surface and seed colour (Pundir and Koppar 1996). Local land races namely, Gulabi from Maharashtra and Banda from Uttar Pradesh are popular for roasting and popping qualities.

Plant Introduction

Desirable germplasm material from different agro-ecological regions of the world has been introduced in the country through NBPGR. Some of the promising exotic germplasm of *Cicer arietinum* show high level of resistance to biotic and abiotic stresses. Emphasis has been given on the introduction of wild species of *Cicer (C. canariense, C. anatolicum, C. oxyodon, C. bijugum, C. reticulatum, C. pinnatifidum,* C. *judaicuni)* for their utilization in breeding programmes. About 56,905 accessions were introduced from 56 countries (Gautam *et al.*, 2000). Most of the introductions were made from ICARDA mostly in the form of different nurseries and yield trials. Other major sources of introductions were Spain, Afghanistan, Former USSR, Iran, USA, Morocco and Greece.

Some of the promising introductions of chickpea in the country are P 9847, NEC 206, Rabat, E 100Y, P 827, USA 613, P 9623, P 922, ICC 3935, EC 286030, EC 286031, EC 286032, EC 286033, EC 382413, EC 382414, EC 382438, EC 382439, EC 382448, EC 382450, EC 382451, EC 382495, EC 382496, EC 382497, EC 382498, EC 382499, EC 382754, EC 382755, EC 382756, EC 382757, EC 382758, EC 382759, EC 382760, EC 382761, EC 382762, EC 382763, EC 382764 and EC 244886. Of them, some like P 9847 and NEC 206 from the USSR; Rabat and P 827 from Morocco; E 100Y from Greece; P 922 from Spain, ICC 3935 from Iran; USA 613 and P 9623 from USA contributed immensely in genetic enhancement and pre-breeding particularly for resistance to *Ascochyta* blight, leaf miner, *Fusarium* wilt, cyst nematode, cold and drought besides earliness, tall status and bold seeds. Similarly, wild accessions of C. *canariense, C. anatolicum, C. oxyodon, C. microphyllum* and C. *songaricum* were introduced from Syria, the Netherlands and the USA. While introducing the new germplasm, the imported accessions were screened in the quarantine facility to intercept the associated insect pests, pathogens and nematodes.

Characterization, Evaluation and Utilization

The most important stage in germplasm management is its evaluation and utilization. A large number of germplasm accessions has been evaluated for different agro-morphological traits besides screening against biotic and

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abiotic stresses. The first large-scale evaluation of chickpea germplasm was taken up by Narayan and Macefield (1976) who evaluated 5,477 accessions for yield components. This was followed by a number of studies on evaluation for resistance to major diseases and insect pests in addition to yield components. Promising genetic resources were identified for *Fusarium* wilt, *Ascochyta* blight, collar rot, stunt, root knot nematodes, cyst nematode, bruchids and leaf miner. Evaluation of about 15,000 accessions for 25 morphological and yield attributes at ICRISAT revealed great genetic variability (Table 2).

Table.2: Variability for quantitative traits in chickpea germplasm

Trait		Range	
	Minimum	Maximum	Mean
Days to 50% flowering	33	107	64.2
Flowering duration (days)	13	75	35.9
Plant height (cm)	14.2	96.3	38.3
Days to maturity	84	169	117.5
Pods per plant	3	238	38.9
Seeds per pod	1	3.2	1.2
100-seed mass (g)	3.8	59.1	16.1
Harvest index (%)	21.9	64.8	–
Seed protein (%)	12.1	29.6	19.8
Seed yield (kg per ha)	70	5130	1286.0

Source: Pundir *et al.* (1988)

Over 13,500 accessions were evaluated for resistance to race 1 of *Fusarium oxysporum* f. sp. *ciceri* at ICRISAT resulting into identification of 160 accessions with stable resistance (Haware *et al.*, 1992). About 150 accessions were *desi* types and remaining 10 *kabuli* types. Similarly, *kabuli* germplasm maintained at International Centre for Agricultural Research in the Dry Areas (ICARDA) was screened for 29 traits including reaction to major biotic and abiotic stresses and promising donor sources have been identified (Table 3).

Table.3: Number of chickpea accessions screened and identified as tolerant against major stresses

Stress	Accessions screened (No.)	Accessions showing tolerance (No.)
Ascochyta blight	19370	32
Fusarium wilt	2636	28
Botrytis grey mould	4500	4
Leaf miner	5474	8
Seed beetle	5153	–
Cyst nematode	9257	–
Cold	9095	13
Drought	1000	3

Source: Singh and Singh (1997)

National efforts to evaluate chickpea germplasm systematically started as early as 1972 when 1,353 accessions were evaluated at GBPUAT, Pantnagar for different agro-morphological traits as well as for various biotic and abiotic stresses (Pandya and Pandey 1979). Similarly at CCS HAU (Hisar) and IARI (Delhi), 6,620 accessions comprising 1,803 indigenous and 4,817 exotic stocks from 21 countries were evaluated and promising accessions were identified (Lai and Tomer 1979). Later on, screening of 10,581 accessions at GBPUAT was taken up to identify sources of field resistance against *Botrytis* grey mould. Likewise, about 8,000 accessions were screened at PAU, Ludhiana against *Ascochyta* blight and *Botrytis* grey mould. Under the NBPGR -ICRISAT joint evaluation programme, 1,200 accessions were evaluated at NBPGR Regional Station (Jodhpur) and 6,600 at NBPGR Regional Station (Akola). These efforts have resulted in identifying a large number of promising donors for chickpea improvement programme of the country (Table 4).

Besides cultivated species, screening of the available accessions of wild species has also been taken up at ICRISAT and ICARDA. Valuable sources of resistance for important diseases and pests were identified (Table 5). For example, *C. judaicum*, *C. montbretii* and *C. pinnatifidum* possess genes for resistance to *Ascochyta* blight (Singh *et al* 1981); *C. bijugum* to *Heterodera ciceri* (Singh *et al* 1980); and *C. bijugum*, *C. echinospermum* and *C. reticulatum* to low temperature condition (Singh *et al* 1990).

Some of the desirable genetic stocks evaluated at different locations have been used in various ways in the breeding programmes: direct use as variety for cultivation, sources of resistance to biotic and abiotic stresses, parental material for hybridization in order to improve agronomic traits, base

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material for polyploidy and mutation breeding, sources of new plant types to study physiological and agronomical adaptations, and as genetic material for basic studies to elucidate information on phylogeny and inheritance patterns.

Documentation

Documentation and information dissemination are integral parts of genetic resources management. The first catalogue on world collection of chickpea was published by ICRISAT (Pundir *et al* 1988). This catalogue describes 32 descriptors of 15,000 accessions. Subsequent catalogue on 'Evaluation of Chickpea Germplasm' Part I was published by NBPGR under NBPGR-ICRISAT collaboration programme (Mathur *et al* 1993). It has descriptions for 19 characters on 1,209 accessions. Two catalogues on *kabuli* chickpea were published by ICARDA (Singh *et al* 1983, Singh *et al* 1991).

VI. PRESENT STATUS OF CHICKPEA GERMPLASM

Chickpea has orthodox seeds that can be dried and stored for a long period with minimum loss of viability. About 14,635 accessions have been stored at -18 °C in long-term repository of National Gene Bank, the largest *ex-situ* repository situated at NBPGR. About 151 accessions of wild species are also conserved. The main contributors to gene bank are NBPGR and its regional stations, IIPR, IARI and ICRISAT. Active or working collections are stored under medium term storage condition (4°C) at Akola, a regional station of NBPGR and IIPR. The world germplasm collections of chickpea maintained at ICRISAT contain 17,244 accessions in gene bank (FAO 1998). National Agricultural Technological Project on Biodiversity has been initiated recently at NBPGR to augment germplasm in the country. About 132 accessions of chickpea have been collected from Sikkim, Rajasthan, Uttar Pradesh, Maharashtra, Himachal Pradesh, Bihar and Madhya Pradesh.

Table,4: Chickpea germplasm showing resistance/tolerance to biotic and abiotic stresses

Tolerance to	Genetic stocks	References
Fusarium wilt	GL 86152, ICC 11320, ICC 11322, ICC 14303	Pawar *et al* 1992
	G 24, C 214, H 355, H 208, P 426, P 5054, CPS 1, F61, P 82, P 199, P 1336, P 1447, K 315	Lai and Tomer 1979
	PPK 1, PPK 2, GW 1, GW 3-1, GW 9, GW 6, GW 10, BCP 2-3-4, BCP 2-3-5	Dandnaik and Zote 1988
	ICC 184, ICC 1937, ICC 3099, ICC 3528, ICC 3385, ICC 11322	Karki *et al* 1988
	P 436-2, APS 1, BGM 443, BG 246, WR 315, KW 17, Avrodhi, GNG 426, JG 74, JG 315, GW 6, GW 3-1, GW 8, JG 1265, Phule G 81-1-1, Phule G 87207, Phule G 860185, H 81-7-3, H 86-8, H 86072, PPG 83-34, DCPW 1, DCPW 2, DCPW 3, DCPW 4, DCPW 5, GL 87079, GPP 7035, BDN 9-3, BDNG 77, BCP 4, BCP 72, BCP 87, PPK 1, PPK 2, NEC 206, ILC 191, ILC 202, ILC 1069, ICC 1009, ICC 4846, ICC 6103, ICC 6671, ICC 7002, ICC 10302, GL 84099, GL 84107, GL 86143, GL 91058, GL 91059, GL 91060	Asthana and Chandra 1997
Ascochyta blight	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 83-49 C, FLIP 83-72 C, FLIP 83-97C, FLIP 83-85 C, FLIP 84-93 C, ICC 3932, E lOOy, E lOOy (m), E 101, Gaurav, H 86-18, BG 261, BRG 8, EC 26446, PC 82-1, ILC 200, ILC 6482, ICC 4475, ICC 6328 and ICC 12004	Reddy and Singh 1992
	ILC 3864, ILC 380, ILC 4421	Pal and Singh 1990

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	CP59	Shukla and Pandya 1988
	EC 26446, P 919, P 1252-1, NEC 2451	Tewari and Pandey 1986
Viruses	JG221,Prabhat	Mali 1988
Pod borer	PDE 2, PDG 84-10, ICC 12483, ICC 506, P 202, P 927, DDG 128, ICC 3580, GL 645, Desi 3108, LHR69, P696-1	Lateef *et al* 1985, Asthana and Chandra 1997
Root knot nematode	ICC 4954, ICC 5485, ICC 6444, ICC 7200, ICC 7209, ICC 7578, ICC 8556, ICC 8565, ICC 8739, ICC 8748, ICC 12245, ICC 12255, GL 83011, K 904, BG 217	Mishra and Gaur 1989
	RSG130, RSG 143	Sharma *et al.*1988
	Bold K 999, PDG 85-18, GNG 317	Darekar and Jagdale 1987
Salinity	H 893-84, H 81-69, H 85-05, CSG 8893, CSG 8894, CSG 8862	Asthana and Chandra 1997
Drought	IC4958	Saxena *et al*. 1993

Table.5: Annual wild species of chickpea and their importance as sources of resistance Species.

Species	**Resistance**
C. chorassanicum	Leaf miner
C. cuneatum	Leaf miner, Seed beetle, *Ascochyta* blight
C. judaicum	Leaf miner, Seed beetle, *Ascochyta* blight (EC382438, EC382439), Cold (EC382438, EC382439)
C. pinnatifidum	Leaf miner, Seed beetle, *Ascochyta* blight, Cold (EC382450), Root knot Nematode (EC382450)
C. reticulatum	*Fusarium* wilt, Seed beetle, Cold, *Ascochyta* blight, Cyst nematode (ILWC292)
C. bijugum	*Ascochyta* blight, Cyst nematode, Seed beetle, Cold, *Fusarium* wilt (EC382413), Root knot nematode (EC382413)
C. echinospermum	Leaf miner, Seed beetle, Cold, Drought (EC382414)

VII. GERMPLASM UTILIZATION

Based on evaluation and characterization of germplasm, many varieties were released directly for cultivation in various parts of the country. Many germplasm lines with desirable traits were used in hybridization programmes to develop varieties with high yield and desirable plant types. A large number of germplasm lines utilized as sources of resistance to diseases includes lines with resistance to *Fusarium* wilt, *Ascochyta* blight, and stunt (Lai and Tomar 1979, Tewari and Pandey 1986, Dandnaik and Zote 1988, Karki *et al* 1988, Mali 1988, Shukla and Pandya 1988, Pal and Singh 1990, Pawar *et al* 1992, Reddy and Singh 1992 and Asthana and Chandra 1997). Some of the lines have resistance to more than one isolates/strains and also to more than one disease (Nene *et al* 1989, Asthana and Chandra 1997). However, very few lines of germplasm have been reported as sources of resistance for insect pests and nematodes. Some lines have been identified with resistance to *Helicoverpa* pod borer (Lateef *et al* 1985, Asthana and Chandra 1997) and root-knot nematode (Darekar and Jagdale 1987, Sharma *et al* 1988, Mishra and Gaur 1989). Some of the germplasm accessions were also found to be tolerant to drought (Saxena *Qt al* 1993) and salinity (Asthana and Chandra 1997). The utilization of desirable germplasm either for direct selections or in hybridization and mutation breeding have led to release of about 125 chickpea varieties. Germplasm lines have also been used to generate information on the inheritance of traits and in elucidating phylogenic relationships.

Varietal development Research efforts made in the past through the National Agricultural Research System have led to the release of more than 125 varieties, which are adapted to varying agroclimatic conditions, and have in-built resistance against key biotic stresses prevalent in the chickpea-growing areas. From time- to-time, specific trials under the aegis of the AICRPC were constituted to meet

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specific targets such as bold-seeded desi and kabuli types, adaptation to late-sown condition, high- input condition and salt tolerance, resistance to Fzuarizlm wilt and Ascochyta blight, and so on. Some centres like Indian Agricultural Research Institute (IARI) (1 7), Chandra Shekhar Azad University of Agriculture and Technology (CSAUAT) (IS), Punjab Agricultural University (PAU) (15), Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKW) (1 6), and agricultural universities of Maharashtra (1 8) have contributed as many as 60% of the total varieties released so far, which is testimony of their strong chickpea-breeding programmes. Although chickpea breeders have been successful in improving cultivars, the use of limited germplasm has resulted in a rather narrow genetic base in the released varieties. The genetic base of chickpea is quite narrow as only 95 ancestors are used for development of 86 varieties rhrough hybridization following selection (Kumar et ul. 2004). Moreover, relative contribution of the top 10 ancestors is as high as 35% in the total genetic base ofthe released varieties. The most frequently used ancestors are 'Pb 7', 'IP 58', 'F 8', 'Rabat' and 'S 26'. Based on the performance over years and locations of the varieties identified during different periods and subsequently included as checks in the AICRPC trials, the annual rate of genetic gain is estimated to be 6.5 kglha between 1975 and 2000. During the span of 25 years, a major share of the total genetic gain has occurred as a one-time increase of72% during 1980-1985, with an annual rate of 23 kgka. The genetic gain in yield may be biased by the fact that yield performance was not always the sole criterion for release of the varieties. Quite a large number of varieties are released because chickpea breeders have modified other traits in addition to yield particularly resistance to key diseases, early maturity and large seed size besides specific adaptation to a particular situation. Systematic breeding programmes in India have led to the developnlent of resistant varieties against major diseases particularly Fusariztnz wilt and Ascochyta blight. A major breakthrough has been witnessed in developing bold-seeded Icubuli varieties with high-yield potential such as 'KAK 2', 'BG 1003', 'BG 1053' and 'JKG 1'. Similarly, some of the pron~inent bold-seeded desi varieties developed are 'BG 256', 'Phule G 5', 'BG 39 1 ', 'K 850', 'Radhey', and 'Gujarat Gram 2'. Development of short-duration varieties has led to expansion of chickpea in new niches and non-traditional areas. Short- duration varieties like 'Annegiri', 'ICCV 2', 'JG 74', 'Pusa 372' and 'KAK 2' have been the major catalysts for expansion of chickpea in southern and central India. 'KPG 59', 'Pusa 256', 'PBG 1 ' and 'Pusa 372' have been suitable for late planting after the harvest of rice (Olyza sativa L.) in north India. In spite of reduction in duration, the yield potential of these early-maturing varieties remains almost unaffected thus inlproving per day productivity of the crop. Under excessive moisture and high input conditions, chickpea crop lodges due to excessive vegetative growth. Recently, a variety 'DCP 92-3 ' has been released for cultivation under high fertility and adequate moisture conditions. A salt-tolerant variety 'CSG 8962' ('Karial Chana I ') has been developed for cultivation in irrigated areas having moderate salinity. Success has also been achieved in identifying drought-tolerant genotypes sich as 'ICCV 1 0', 'Phule G 5', 'K KSO', 'Vijay'.

Specific trait Released varieties

Resistance to Fusarium wilt 'KWR log', 'ICCV lo', 'H 82-2', 'CSG 8962', 'DCP 92-3', 'GCP 101', 'GCP 105', 'JG 3 15', 'GPF 2'. 'Vijay', 'KGD 1168', 'JG 74', 'GNG 663', 'K 850', 'Radhey', 'BG 391', 'BG 212', 'KPG 59', 'BG 1003', 'BG 1053', 'Annigeri l', 'Mahamaya l', 'Vikas', 'BGD 72', 'Gaurav', 'PBG 1', 'GNG 469' Tolerance to root-rot 'Alok', 'CO 3', 'KWR 108', 'Pusa 209', 'Pusa 240', 'Pusa 417', 'Pusa 413', 'Pusa 244', 'ICCV 6', 'ICCV lo', 'Pusa 372', 'Vijay', 'Vardan', 'Pusa 362', 'Pusa 391', 'GNG 469', 'CO 4', 'BGD 72', 'JG ll', 'L551' Tolerance to Ascochyta blight 'GNG 469', 'Gaurav', 'PBG l', 'GNG 146', 'C 235', 'BG 261' Tolerance to stunt 'Kiran', 'Pusa 244' Tolerance to Botiytis gray-mold 'Pusa 209', 'ICCV 2', 'Gaurav' Tolerance to root-knot nematode 'Kiran', 'Pusa 362', 'BGD 72' Tolerance to Helicoverpa pod-borer 'Ujjain 24', 'ICCV 6', 'Vijay', 'Vardan', 'Vishal', 'BGD 72' Drought tolerance 'CO l', 'RS lo', 'Pant' 'G 114'. 'Vikas', 'GNG 16', 'RSG 14', 'ICCV lo', 'Vijay' Tolerance to salinlty 'CSG 8962'. 'ICCV 6' Lodging resistant 'DCP 92-3', 'GNG 16', 'Pusa 240' Wide adaptation 'C 235', 'L 550', 'Pusa 203', 'Pusa 209', 'Pusa 256', 'Pusa 372', 'Radhey' Bold-seeded varieties 'BG 256', 'Phule' 'G 5', 'K 850', 'Radhey', 'GNG 469', 'BG 391', 'BGD 72', 'Pusa 362', 'Gaurav', 'Avrodhi', 'Co 3', 'Co 4', 'GG 2', 'ICCV 2', 'KAK 2', 'BG 1003', 'BG 1053', 'JKG l', 'Phule G 953 11. '

H 86- 18 for wilt; and ILC 200, ILC 6482, ICC 4475, ICC 6328, ICC 12004, E 100Y, E 100Y(M), BRG 8, NEC 206, GLG 84099, GLG 84038, ICC 1468 for Ascoci~vta blight have been identified. Use of resistant donors in breeding programmes has resulted in the development of resistant varieties against key pathogens

VIII. PRESENT CONSTRAINTS

Although a large number of accessions has been assembled and conserved in various gene banks, the true diversity in many collections is yet to be assessed. This hinders the

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effective utilization of genetic resources in improvement programmes. Some of the constraints and research gaps encountered in the management of genetic resources of chickpea are:

- Superficial large size of collections at various centres leading to redundancy within and between collections.
- Meagre information on their potential usefulness owing to deficiencies in evaluation and information dissemination.
- Limited activities on germplasm enhancement and pre-breeding.
- Restricted flow of genetic resources among users due to changing scenario of PGR regime and related IPR issues.
- Limited awareness and participation of farmers in areas of genetic diversity.
- Limited use of biotechnological tools for enhancing utility of germplasm. ‘

IX. FUTURE RESEARCH PRIORITIES

It is a need of the hour to give more emphasis on new emerging concepts for better utilization of chickpea germplasm. This requires a proper reorientation of research priorities in the country as follows.

Pre-breeding and Germplasm Enhancement

Pre-breeding and germplasm enhancement involving diverse germplasm and closely related species need to be adequately utilized in breeding programmes. At least, 13 wild *Cicer* species have been reported to have useful characteristics (Mallikarjuna 1999). These species should be utilized in pre-breeding and germplasm enhancement programmes by circumventing the crossing barriers.

Development of Core Collections

For efficient management and utilization of large number of collections, research priority should be to develop core collection, a subset that samples the range of diversity of the entire collection. Establishment of core collection for chickpea germplasm based on origin and morphological traits as selection criteria in USA (Hannan *et al* 1994) and at ICRISAT (Upadhyaya *et al* 2001) is expected to help in efficient utilization of chickpea germplasm.

Finger Printing

In recent years, isozymes, random amplified polymorphic DNA (RAPD), amplified fragment length polymorphism (AFLP), and sequence tagged micro satellite (STMS) markers have helped in developing chickpea genome map. Molecular markers based genetic diversity will help to identify duplicates/redundant accessions and select and utilize the diverse germplasm in chickpea improvement programmes. For some of the major biotic constraints such as *Helicoverpa* pod borer, *Botrytis* grey mould, *Ascochyta* blight and dry root rot, high levels of resistance are not available in existing germplasm. In these cases, there may be an opportunity to introduce resistance genes from related genera. The effectiveness of alternative sources of insecticidal genes including those from *Bacillus thuringiensis (Bt)* are currently being evaluated at ICRISAT and IIPR.

Uncovering Genetic Mechanisms

To improve the efficiency, predictability, and effectiveness of chickpea, efforts should be intensified for identification and proper nomenclature of genes and genetic stocks of chickpea (Kumar and van Rheenen 2000).

FUTURE THRUST

Collaborative efforts among different research institutes through national network should be made to evaluate chickpea germplasm systematically at several locations. To narrow down the gap between germplasm available and the germplasm utilized in the breeding programmes, it is imperative to document the germplasm providing a complete spectrum of genetic variability in the collection. Efforts should also be made towards germplasm enhancement through incorporation of genes from secondary and tertiary gene pools into a suitable genetic background. A good number of accessions conserved in various genebanks may be duplicates and efforts are required to identify and eliminate them using molecular markers.

- There are saline areas in Gujarat and Rajasthan and other important regions viz., central and northern parts of Karnataka and parts of Uttar Pradesh, Madhya Pradesh, Haryana and Punjab, which should be explored on a priority basis.
- Germplasm accessions will have to be additionally screened for response to fertilizers, resistance to lodging, biotic and abiotic stresses, early seedling vigour and for low light interceptions.
- Germplasm accessions should be evaluated under different agro-climatic conditions in order to test stability and adaptability.
- The existing germplasm accessions available at different centres should be pooled and core collection should be developed on priority for effective utilization.

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- Pre-breeding and genetic enhancement work should be taken up to foster germplasm utilization in chickpea improvement programme.
- Techniques should be developed for quick and efficient screening against biotic stresses.
- For speedy transfer of genes conferring resistance to important diseases and pests, biotechnological tools need to be utilized on priority. For example Bt gene in chickpea against pod borer can be taken up on a priority basis.
- In view of the emerging IPR issues, there is a need to develop database of entire germplasm of chickpea in the country. A duplicate set of the germplasm should be kept in the gene bank of NBPGR for future use.
- Farmers participatory breeding should be initiated in areas of rich genetic diversity for higher productivity, stability and value addition while conserving on-farm genetic diversity.
- Multidisciplinary and inter-institutional collaborations are urgently needed to elevate the usefulness of the conserved germplasm.

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