Legume Research, 40 (1) 2017 : 22-26
Print ISSN:0250-5371 / Online ISSN:0976-0571

AGRICULTURAL RESEARCH COMMUNICATION CENTRE
www.arccjournals.com/www.legumeresearch.in

Genetic base of Indian chickpea (*Cicer arietinum* L.) varieties revealed by pedigree analysis

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Received: 08-05-2016 Accepted: 29-07-2016 DOI:10.18805/lr.v0iOF.3550

ABSTRACT

In the present study an attempt has been made to determine the genetic base of 138 Indian chickpea varieties through pedigree analysis. The genetic base of 138 varieties can be traced to 160 ancestors utilised to bring genes in development of varieties. Among these, 118 ancestors were used only once or twice. The most frequently used parent included Rabat (37), Pb 7 (36), IP 58 (32), C 1234 (32) and S 26 (27). Rabat and Pb7 are present in the pedigree of more than 26% of varieties followed by C 1234 (23.29%), IP 58 (23.29%) and S 26 (19.57%). Most of the frequently used parents have been used indirectly in the crossing programme. Only 28 parents could represent 50% of total genetic base of chickpea varieties developed in the country. Although conscious efforts have been made to include diverse parents in the chickpea breeding leading to broad genetic base of the varieties yet a huge arsenal of germplasm lines remains unutilised or not resulted in varieties. There is a need to utilise the germplasm resources as well as modern techniques of breeding to incorporate multiple biotic and abiotic stress resistance for yield improvement and stabilization as well as improvement in market driven traits like extra-large seed sized *kabuli* lines. The present article describes the results of pedigree analyses to determine the genetic base of the released cultivars, reasons for narrow genetic base and possible approaches and strategies for its widening in chickpea.

Key words: Chickpea, Genetic base, Pedigree analysis.

INTRODUCTION

Chickpea is being cultivated in more than 50 countries spread over Asia, Africa, Americas, Oceania and Europe (Gaur *et al.*, 2014). It is the most important pulse crop in India accounting for more than 48% of the total pulse production and 97% of total pulse export during 2013-14 (Anonymous, 2015). Madhya Pradesh, Rajasthan, Maharashtra, Karnataka, Uttar Pradesh and Andhra Pradesh are the major chickpea producing states sharing over 80% area (DAC, 2015). The productivity also varies between states indicating need for developing suitable high yielding varieties and matching crop production and protection technologies (Chaturvedi and Nandarajan, 2010).

Among pulses, chickpea has the longest history of breeding in India. Initially major emphasis was laid on increasing yield potential over landraces through selection and purifying existing landraces. This was followed by systematic breeding programme through hybridization with the aim of incorporating disease resistance, development of short duration, suitability for late sowing condition and high input responsive varieties. With change in market demand, effort has been made for export oriented breeding for large and extra-large seeded *kabuli* type varieties (Singh *et al.*, 2009).

Despite these advancements, the productivity of chickpea in the country still remains relatively low and vulnerable to unfavourable weather condition and various biotic stresses. The narrow genetic base of current day cultivars is mainly responsible for unstable yield of chickpea over years and locations. These varieties though possess resistance to many diseases but are highly vulnerable to varying climatic condition. The adverse weather causing untimely rains and hailstorms during February and March in 2014 and 2015 (Bhat, 2014; ICAR, 2015) have caused heavy damage to the standing *rabi* crops including chickpea in many parts of the country. This further accentuates the need to broaden the genetic base so that the much needed stability can be ensured in chickpea yields. A huge diversity of germplasm is available with three centres, namely, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India (19187 accessions), International Center for Agricultural Research in the Dry Areas (ICARDA), Lebanon (12647 accessions) and National Bureau of Plant Genetic Resources (NBPGR), India (14566 accessions). Need based inclusion of diverse parents can help in broadening the genetic base of the present day varieties.

The relative genetic contribution can be used in studying the changes of genetic diversity during the course

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of cultivars improvement (Lin, 1991). It has been used as an indicator of genetic base in cereals (Cox, 1986; Lin, 1991), pulses (Dixit and Katiyar, 2005; Katiyar *et al.*, 2008), oilseeds (Knauft and Gorbet, 1989; Lin and Lin, 1994) and vegetable crops (Gopal and Oyama, 2005).

In the present study an attempt has been made to assess the genetic base of chickpea varieties released in India following pedigree analysis.

MATERIALS AND METHODS

The pedigree analysis was performed on 138 chickpea varieties developed through hybridization and released through Central Variety Release Committee (CVRC) or State Variety Release Committee (SVRC) till 2013 for cultivation in different parts of the country. Pedigrees of these varieties were obtained from the available records maintained at ICAR-Indian Institute of Pulses Research, Kanpur or Department of Agriculture, Co-operation and Farmers Welfare (DAC&FW), New Delhi. The pedigrees could be traced from one to seven generations involving two to fifteen parents. The number of times (frequency) an ancestor appeared in the pedigree of various varieties were counted. The relative genetic contribution (RGC) of different ancestors to a given variety was computed by partitioning the genetic constitution of a cross into theoretical percentage attributable to different ancestors assuming that every time a cross is made each parent transmits 50% of its genes to the progeny with equal probability (Lin, 1991). The mean genetic contribution of a given ancestor was estimated by the means of RGC's of this ancestor to all the varieties developed through hybridization.

RESULTS AND DISCUSSION

Among 190 chickpea varieties released in India till 2013 (Project Coordinator Report, 2015, nearly 22% (41) were developed through direct selection from germplasm material, only about 6% were developed through mutation breeding and the rest were developed through hybridization (Table 1).

During initial years of chickpea improvement major emphasis was laid on collection of germplasm from different part of the country and selecting desirable single plants from them. This has led to release of some important germplasm as varieties including C 235, G 24, S 26, C 104, Type 1, Type 2, Gwalior 21, Ujjain 21, Chaffa, Annegeri 1, RS 10, ST 4, BR 75 and Type 3 (Argikar, 1970).

Simultaneously, desirable germplasm material from different agro-ecological regions of the world has been introduced in the country through NBPGR with emphasis on import of wild species of *Cicer* (*C. canariense, C. anatolicum, C. oxyodon, C. bijugum, C. reticulatum, C. pinnatifidum, C. judaicum*) (Gautam *et al.*, 2000). Some of the promising accessions included 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 from USA *etc*. These accessions have been used as donor for different agronomic traits and biotic and abiotic stresses resistance.

In India, 138 chickpea varieties have been released for cultivation in different zones that have been developed through hybridization. A pedigree analysis of these chickpea varieties revealed that their origin can be traced to 160 parents (Table 2). Among these, 99 ancestors have been used only once while 19 parents have been used twice in all the pedigrees of varieties studied. The most frequent parent utilised in the development of chickpea varieties was Rabat (37) followed closely by Pb 7 (36), IP 58 (32), C 1234 (32) and S 26 (27).Rabat and Pb7 led to development of more than 26% of varieties followed by C 1234 (23.29%), IP 58 (23.29%) and S 26 (19.57%). In an earlier study on the pedigrees of 86 chickpea cultivars developed through hybridization, Kumar *et al.* (2004) have reported the same parents to be the most utilised in chickpea breeding where 95 ancestors were used with Pb 7 being a common ancestor in 41% of the varieties developed. Thus, our study indicates that there has been a sharp decline in the use of known parents in hybridization programmes and a conscious effort has been made to involve new donors for different traits.

Most of the frequently used parents have been used indirectly in the crossing programme. This is the outcome of step wise improvement in performance of the genotype where in the advanced lines are used time and again in making future crosses. Thus, the original parents come in the pedigree of the line although they are not used directly. Another interesting fact observed in the pedigree of varieties was that as the decades passed by, the crosses became more complex. Initially the varieties were developed either through selection from germplasm, mutation breeding or by following single, three way or double crosses. With passage of time, more diverse parents and more round of hybridization have

Table 1: Breeding methodology for varietal development of chickpea varieties in India

Breeding Methodology	State release		Central Release		Total
	Frequency	%	Frequency	%	
Selection	27	24.77	14	17.28	41
Mutation	6	5.50	5	6.17	11
Hybridization	76	69.72	62	76.54	138
Total	109		81		190

Table 2: Parents and their frequency in pedigree of chickpea varieties in India

S. No	Parents	S. No	Parents	S. No	Parents	S. No	Parents
1	Rabat (37)	42	BHEEMA (2)	84	P 127 (1)	122	CSJ 146 (1)
2	Pb 7 (36)	43	Annigeri 1 (2)	85	P 1353 (1)	123	GLK 88016 (1)
3	JG 62 (21)	44	PHULE G 91028 (2)	86	ICC 3935 (1)	124	FLIP 88-34C (1)
4	S 26 (27)	45	P 481 (6)	87	Ilg 613 (1)	125	CSJK 2 (1)
5	E 100 Ym (10)	46	USA 613 (3)	88	BG 1 (1)	126	SBD 377 (1)
6	IP 58 (32)	47	G 1540 (3)	89	ICC 12237 (1)	127	BDG 2048 (1)
7	C 1234 (32)	48	Narsinghpur Bold (4)	90	GCP 2 (1)	128	ICC 118 (1)
8	Chaffa (15)	49	GNR 14 (2)	91	ICCX860263-BG-BP-91-BP (1)	129	ICCV 933001 (1)
9	B 75 (11)	50	P 327 (2)	92	ICC7344-ICCX870026-PB-PB-14B-63AK-7AK-BAK (1)	130	PG 5 (1)
10	M 546 W (12)	51	BEG 482 (2)	93	JG 1258 (1)	131	ICC 4958 (1)
11	F 496 (8)	52	BG 303 (2)	94	BDN 9-3 (1)	132	FLIP 82-1C (2)
12	P 1231 (9)	53	ICC 32 (2)	95	ICCX76581BRH-10H-BH (1)	133	P 922 (1)
13	P 1265 (9)	54	GW 5/6 15)	96	ICCL8424 (1)	134	P 436 (1)
14	Banda Local (23)	55	ICCC 49 (4)	97	GF 8976 (1)	135	F 378 (1)
15	Etah Bold (23)	56	P 179 (3)	98	GNG 149 (1)	136	IG 9216 (1)
16	RSG 515 (4)	57	BG 203 (3)	99	BG 257 (1)	137	GF 88421 (1)
17	G 24 (21)	58	Surutoto 77 (3)	100	H 89-78 (1)	138	ICC 7676 (1)
18	T 3 (6)	59	BG 1048 (2)	101	H 89-84 (1)	139	Surutoto (1)
19	L 2 (9)	60	K 607 (1)	102	BHIM (1)	140	FLIP 82-886 (1)
20	708 (8)	61	195 (1)	103	ICC 10301 (1)	141	C reticulatum (1)
21	Guamchil 2 (16)	62	GG Bijapuri (1)	104	BHARMA (1)	142	H 82-5 (1)
22	P 458 (16)	63	G 140 (1)	105	RSG 255 (1)	143	BG 1003 (1)
23	197 (4)	64	C 168 (1)	106	RSG 668 (1)	144	CPS 1 (1)
24	H 75-35 (4)	65	Pink 2 (1)	107	RSG 817 (1)	145	RS 11 (1)
25	Annigeri (5)	66	GC 654 (1)	108	JG 315 (1)	146	JAKI 92-26 (1)
26	GW 5/7 (6)	67	G 549 (1)	109	RSG 289 (1)	147	DCP 20 (1)
27	850-3/27 (9)	68	Khanur 6 (1)	110	RSG 538 (1)	148	ICCV 91902 (1)
28	H 233 (5)	69	AF 7-10 (1)	111	GNG 421 (1)	149	BG 364 (1)
29	L 168 (5)	70	P 340 (1)	112	KPG 279-3 (1)	150	ICC7344-ICCX870026-PB-PB-14B-BP-62-AK-7AK-BAK (1)
30	P 1630 (6)	71	P 556 (1)	113	RSG 581 (1)	151	BG 1083 (1)
31	76 (3)	72	ST 4 (1)	114	HK 92-94 (1)	152	F 370 (2) FLIP 82-16C (1)
32	F 61 (3)	73	RS 10 (1)	115	ICCV 89230 (1)	153	BG 315 (1)
33	FLIP 88-20 (3)	74	K 315 (1)	116	GNG 1365 (1)	154	ILC 72 (1)
34	P 827 (2)	75	GG 578 (1)	117	ICCV 95412 (1)	155	ICCV 13 (1)
35	P 9847 (2)	76	NEC 206 (1)	118	PHULE G 92307 (1)	156	FLIP 85-11 (1)
36	GNG 146 (2)	77	P 6613 (1)	119	GNG 1382 (1)	157	ICCV 88507 (1)
37	ICC 7344 (2)	78	Ceylon 2 (1)	120	GJG 9707 (1)	158	NP 34 (1)
38	JG 74 (2)	79	K 468 (1)	121	FG 712 (1)	159	ICCL 8100 (1)
39	RSGK 628 (2)	80	Hima (1)			160	ICC 8923 (1)
40	RSG 524 (2)	81	L 245 (1)				
41	PDG 84-10 (2)	82	P 176 (1)				

become a norm in developing chickpea varieties. For example the pedigree of recently released *kabuli* variety Ujjwal (IPCK 2004-29) involves 15 different parents extending to 7 generations.

The perusal of Table 3 clearly indicates that 50% of total genetic base of 138 varieties developed through hybridization in the country can be attributed to only 28 parents. The top three parents Rabat, Pb 7 and JG 62 have contributed over 10% of the genes in pedigree of all the chickpea varieties released in India. Repeated use of these parents led to narrow genetic base of the recently developed varieties in India that has increased its vulnerability to the changing climate. Further, limited utilization of variability led to reduction in pace of development of widely adapted cultivars with resistance to biotic and abiotic stresses (Ladizinski and Adler, 1975; Kazan and Muelbauer, 1991; Ahmad and Slinkard, 1992; Tayyar and Waines, 1996; Siddique *et al.*, 2000). In a separate study, Upadhyaya *et al.* (2006) have reported that the chickpea breeding at ICRISAT and ICARDA also suffers from reduced genetic variability owing to use of fewer germplasm lines. During the period 1978 to 2004 only 83 and 250 germplasm lines were utilised

Table 3: Frequency of direct and indirect occurrence of ancestors in pedigree and their genetic contribution in chickpea varieties in India

Parents	Appearance in pedigree			Relative Genetic Contribution	Mean Genetic Contribution	Cumulative genetic Contribution	Occurrence (%)
	Direct	Indirect	Total				
Rabat	3	34	37	5.94	0.0430	0.0430	26.81
Pb 7	2	34	36	4.94	0.0358	0.0788	26.09
JG 62	1	20	21	4.00	0.0290	0.1078	15.22
S 26	4	23	27	3.89	0.0282	0.1360	19.57
E 100 Ym	5	5	10	3.63	0.0263	0.1623	7.25
IP 58	1	31	32	3.39	0.0246	0.1868	23.19
C 1234	1	31	32	3.39	0.0246	0.2114	23.19
Chaffa	2	13	15	3.34	0.0242	0.2356	10.87
B 75	4	7	11	2.75	0.0199	0.2555	7.97
M 546 W	1	11	12	2.31	0.0168	0.2723	8.70
F 496	1	7	8	2.25	0.0163	0.2886	5.80
P 1231	2	7	9	2.13	0.0154	0.3040	6.52
P 1265	2	7	9	2.13	0.0154	0.3194	6.52
Banda Local	1	22	23	2.11	0.0153	0.3347	16.67
Etah Bold	1	22	23	2.11	0.0153	0.3500	16.67
RSG 515	4	0	4	2.00	0.0145	0.3645	2.90
G 24	1	20	21	1.89	0.0137	0.3782	15.22
T 3	2	4	6	1.88	0.0136	0.3918	4.35
L 2	1	8	9	1.75	0.0127	0.4044	6.52
708	1	7	8	1.75	0.0127	0.4171	5.80
Guamchil 2	0	16	16	1.56	0.0113	0.4284	11.59
P 458	0	16	16	1.56	0.0113	0.4398	11.59
197	2	2	4	1.50	0.0109	0.4506	2.90
H 75-35	2	2	4	1.50	0.0109	0.4615	2.90
Annigeri	2	3	5	1.44	0.0104	0.4719	3.62
GW 5/7	1	5	6	1.38	0.0100	0.4819	4.35
850-3/27	0	9	9	1.31	0.0095	0.4914	6.52
H 233	1	4	5	1.25	0.0091	0.5005	3.62

at ICRISAT and ICARDA, respectively. Thus there is ample variability existing in the chickpea germplasm for utilization in improvement programmes.

Accordingly, breeders have made efforts to include diverse parents in the hybridization to develop high yielding varieties with broad genetic base so that vulnerability to emerging biotic and abiotic stresses can be minimized. The effectiveness of selection in any crop depends upon the extent and nature of phenotypic and genotypic variability present in different traits of the population (Arora, 1991). With the advent of modern breeding tools and techniques including various molecular biology tools it has become possible to incorporate genes from various divergent sources systematically in less time and with less financial resources. The utilization of wild *Cicer* species and primitive land races from centre of origin or centre of diversity will lead to broadening of genetic base thus increasing crop resilience towards various biotic and abiotic stresses.

REFERENCES

Ahmad, F. and Slinkard, A.E. (1992). Genetic relationships in the genus *Cicer* L as revealed by polyacrylamide gel electrophoresis of seed storage proteins. *Theor. Appl. Genet.*, **84:** 688-692.

Anonymous. (2015). Commodity profile of pulses – March 2015. Department of Agriculture and Co-operation, Ministry of Agriculture, Government of India.

Argikar, G.P. (1970). Pulse crops of India. *In* Gram (Ed P. Kachroo), Indian Council of Agricultural Research, New Delhi, India. pp 54-135.

Arora, P.P. (1991). Genetic variability and its relevance in chickpea improvement. *International Chickpea Newsletter,* **25:** 9-10.

Bhat, S. (2014). Impact of untimely rains and hailstorms on prices of chickpea. *Pulses Newsletter*, Indian Institute of Pulses Research, **25:** 6.

Chaturvedi, S.K. and Nadarajan, N. (2010). Genetic enhancement for grain yield in chickpea – accomplishments and resetting research agenda. *Electron J. Plant Breeding*,**1:** 611-615.

Cox, T.S., Murpy, J.P. and Rodgers, D.M. (1986). Changes in genetic diversity in the red winter wheat regions of the United Sates. *P. Natl. Acad. Sci. USA*, **83:** 5583-6.

DAC. (2015). Agricultural Statistics at a Glance – 2014. Department of Agriculture and Co-operation, Ministry of Agriculture, Government of India.

Dixit, G.P. and Katiyar, P.K. (2005). Genetic base of lentil varieties and breeding lines developed in India. *Indian J. Agric. Sci.*, **77:** 585-589.

Gaur, P.M., Jukanti, A.K., Samineni, S., Chaturvedi, S.K., Basu, P.S., Babbar, A., Jayalakshmi, V., Nayyar, H., Devasirvatham, V., Mallikarjuna, N., Krishnamurthy, L. and Gowda, C.L.L. (2014). *Climate Change and Heat Stress Tolerance in Chickpea*. In: Climate Change and Plant Abiotic Stress Tolerance, Vol. 2 (Tuteja, N. and Gill, S.S. Eds.). Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, Germany, pp 839-855.

Gautam, P.L., Sharma, G.D., Srivastava, U., Singh, B.B., Kumar, A., Saxena, R.K. and Srinivasan, K. (2000). *20 glorious years of NBPGR (1976-1996).* National Bureau of Plant Genetic Resources, New Delhi, India.

Gopal, J. and Oyama, K. (2005). Genetic base of Indian potato selections as revealed by pedigree analysis. *Euphytica*, **142:** 23–31.

ICAR. (2015). http://www.icar.org.in/files/Contingency-Unseasonal-Rainfall-2015.pdf.

Katiyar, P.K., Dixit, G.P. and Singh, B.B. (2008). Genetic base of advanced urdbean breeding lines developed in India as revealed by pedigree analysis. *Indian J. Genet*., **68:** 324-326.

Kazan, K., Muehlbauer, F.J. (1991). Allozyme variation and phylogeny in annual species of Cicer (Leguminosae). *Plant Syst. Evol.*,175: 11-21.

Knauft, D.A. and Gorbet, D.W. (1989). Genetic diversity among peanut cultivars. *Crop Sci.*, **29:** 1417-1422.

Kumar, S., Gupta, S., Chandra, S. and Singh, B.B. (2004).*How wide is the genetic base of pulse crops*? In: Pulses in New Perspective. Proceedings of the National Symposium on Crop Diversification and Natural Resources Management, 20– 22 December 2003. Kanpur: Indian Society of Pulses Research and Development, Indian Institute of Pulses Research (Eds. Masood Ali *et al.*) pp. 211–221.

Ladizinsky, G. and Adler, A. (1975). The origin of chickpea as indicated by seed proyein electrophoresis. *Israel Journal of Botany*,**24:** 183-189.

Lin, M.S. and Lin, S.F. (1994). Pedigree analysis of soybean varieties. *Botanical Bulletin Academy*,**35:** 87-93.

Lin, M.S.Z. (1991). Genetic base of *japonica* rice varieties released in Taiwan. *Euphytica*, **56:** 43-46.

Project Coordinator Report (2015). All India Coordinated Research Project on Chickpea. pp 36-52. (http://www.aicrpchickpea.res.in/project_coordinators_report.htm)

Siddique, K.H.M., Brindsmead, R.B., Knight, R., Knights, E.J., Paull, J.G. and Rose, I.A. (2000). *Adaptation of chickpea (Cicer arietinum L) and faba bean (Vicia faba L) to Australia*. In: Linking Research and Marketing Opportunities for pulses in the 21st century. (R Knight ed.) Kluwer Academic Publishers: Dordrecht, the Netherlands pp. 289-303.

Singh, N.P., Sevak, S., Iquebal, M.A., Chaturvedi, S.K. and Nath, Omkar. (2009). *Improved varieties of chickpea in India*. Technical Bulletin, Indian Institute of Pulses Research, Kanpur.

Tayyar, R.I. and Wainws, J.G. (1996). Genetic relationships among natural species of Cicer (Fabaceae) using isozyme variation. *Theor. Appl. Genet.*, **92:** 245-254.

Upadhyaya, H.D., Furman, B.J., Dwivedi, S.L., Udupa, S.M., Gowda, C.L.L., Baum, M., Crouch, J.H., Buhariwalla, H.K. and Singh, S. (2006). Development of a composite collection for mining germplasm possessing allelic variation for beneficial traits in chickpea. *Plant Genetic Resources* **4:** 13–19.