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Wide Hybridization in Chickpea for Creating Variability and Increasing Yield via More Number of Primary Branches per Plant

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ABSTRACT

Most of the present day varieties of chickpea (gram) have narrow genetic base because they are developed either through direct selection from germplasm or landraces or intervarietal crosses. Due to this, these varieties are more vulnerable to biotic and abiotic stresses. Wide hybridization plays a crucial role in broadening the genetic base of chickpea. Number of primary branches per plant is an important attribute for improving chickpea yield because most of the pods develop on primary branches in chickpea in comparison to secondary and tertiary branches. The present experiment was conducted at Indian Institute of Pulses Research (IIPR), Kanpur. In this investigation five diverse genotypes of chickpea {two desi, two kabuli and one wild (EC556270)} were utilized to develop eight recombinations. 4 interspecific crosses between *Cicer arietinum* L. x *Cicer reticulatum* viz; (DCP 92-3 x *C. reticulatum*, IPC 98-12 x *C. reticulatum*, IPCK2002-29 x *C. reticulatum* and JGK1 x *C. reticulatum*} and 4 intervarietal crosses between Desi x Kabuli viz; (DCP 92-3 x IPCK 2002-29, IPC 98-12 x IPCK 2002-29, DCP 92-3 x JGK1, IPCK 98-12 x JGK1) crosses were made to create variability and number of primary branches per plant in chickpea. Diallele Selective Mating System (DSMS) or intercrossing between desirable segregants in F_2 can be rewarding in chickpea to increase variability for yield related components through wide hybridization. The aim of this investigation is to provide an update on progress in the development of variable and adaptable genotypes of chickpea, essential for crop improvement.

INTRODUCTION

Production Statistics

Chickpea (*Cicer arietinum L.*), also know an as Gram or Bengal gram is one of the important post-rainy season food legume crops of India. It is the major source of protein for agrarian people. It is grown in more than 55 countries covering 13.2 million ha area and producing about 11.62 million tonnes during 2011 (FAOSTAT 2013). According to 4th advance estimates for 2015-16, the area and production of chickpea in 2015-16 was 8.87 Mha, 7.17 MT, respectively (Source: agricoop.nic.in/imagedefault1/**Pulses**.pdf). Further, the trends in chickpea production has been presented in Fig.1.

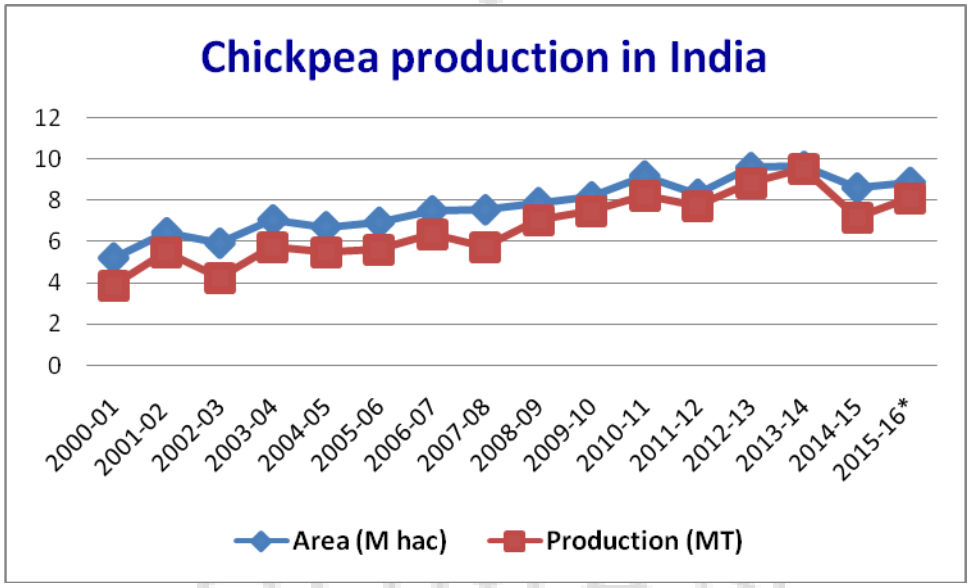

Fig.1. Trends in area and production of chickpea during last fifteen decades.

Nutritional Value

Chickpea also known as garbanzo bean is a self-pollinated diploid crop with chromosome number 2n = 2x = 16, with a relatively small genome size of 740Mb. The seeds of chickpea contain protein (24.6%), carbohydrate (64.6%). Chickpea is also a source of zinc, calcium, iron, and vitamins like B1, B2 and niacin (Abu-Salem and Abou 2011) besides essential amino acids like lysine and tryptophan. Chickpea has low-fat content and most of this is polyunsaturated (Table 1) (Gopalan et al.1971). Chickpea is consumed in different forms like whole seeds, parched seeds, after grinding as flour etc. Green seeds are consumed as salad, curry and after

boiling whole green grains in different parts of the country. The chickpea flour is used to make a large number of sweets and salty snakes.

Table no 1. Nutritional value of chickpea grain (in per 100 g)

Food	Energy (calorie)	Protein (g)	Fat (g)	Calcium (mg)	Iron (mg)	Thiamine (mg)	Riboflavin (mg)	Niacin (mg)	Vitamin C (mg)	Vitamin A (mcg)
Gram (Whole)	360	17.1	5.3	202	10.2	0.30	0.15	2.9	3	189
Gram (Dal)	372	20.8	5.6	56	9.1	0.48	0.18	2.4	1	129

Chickpea Producing Countries

The major chickpea producing countries are Asia, Africa, Europe, India, North and South America and Australia. India ranks first in the production and productivity of chickpea during 2015-16 covering 8.87 Mha and production 7.17 Mt) and contributed more than 43.53% to the total pulses production in India.

Utilization of limited variability in chickpea has resulted in narrow genetic base of present day cultivars (Chaturvedi et al; 2003, Shiv Kumar et al; 2008, Chaturvedi and Nadarajan, 2010) leading to vulnerability in fluctuating environmental conditions. In recent years more emphasis was given to broadening the genetic base of chickpea for reducing its vulnerability and increasing yield. The variability of genotype has been recognized as an important factor influencing the performance of genotypes (Singh and Bejiga, 1990).

In India, ICAR-Indian Institute of Pulses Research (IIPR), Kanpur initiated a three years experiment during 2008-09, 2009-10 and 2010-11. In this experiment interspecific and intervarietal crosses were made using wild *Cicer* species *Cicer reticulatum* (EC556270) to generate new variability for enhancing yield potential, broadening of the genetic base and reduce vulnerability against biotic and abiotic stresses. Thus, present paper deals with the effort made to generate new variability for elite lines development in chickpea through wide hybridization.

MATERIALS AND METHODS

The present experiment was conducted at ICAR-Indian Institute of Pulses Research (IIPR), Kanpur. The experimental material of the present investigation consisted of 5 parents (Table 2) viz; 2 cultivated desi (brown seeded) chickpea variety (DCP 92-3, IPC 98-12), 2 cultivated kabuli (white seeded) chickpea variety (IPCK 2002-29, JGK1) and one wild chickpea accession (*Cicer reticulatum*, EC 556270) (Fig 2). These 5 parents were sown in post rainy (rabi) season under irrigated condition during 2008-09 at IIPR. Eight crosses (4 interspecific and 4 desi x kabuli) were made during winter rabi season 2008-09 (Table 3) and advanced during rabi 2009-10. The best-suited temperature for making crosses is 18-30^{0}C which was observed in February 2009 and pod formation began 5-6 days after fertilization. The experimental material comprising of 8 F_1s, 8 F_2s, and their 5 parents were sown in trial replicated thrice following Completely Randomized Block Design (CRBD) during post rainy season of 2010-11. Standard agronomic practices were followed to raise the experiment. Row to row spacing was kept at 30 cm, whereas plant to plant spacing of 8-10 cm. was maintained. 8 F_1s were planted in a single row and 8 F_2s in 5-row plot whereas all parents were sown in 3-rows plot of 4 cm. long. Observations were recorded on the basis of yield and yield attributes. Treatments mean were subjected to calculate heterosis for primary branches per plant over male, female, mid and best parent.

Fig no 2. *Cicer reticulatum* (EC556270)

Table no 2. Details of parents along with their characteristics

S. No.	Parent	Pedigree	Origin	Special characteristics
1	DCP 92-3	Selection from germplasm (L412)	IIPR, Kanpur	High yielding, wilt resistant, tolerant to lodging, medium yellow seeded desi chickpea variety
2	IPC 98-12	L411 x BG 256	IIPR, Kanpur	High yielding, wilt resistant, large and round seeded desi chickpea genotype
3	IPCK2002-29	L144 x H 82-2	IIPR, Kanpur	Large white-beige colour seeds, wilt resistant, high yielding kabuli chickpea variety
4	JGK1	(ICCV 2 x Surutato 77) x ICC 7344	JNKVV, Jabalpur	Medium large white-beige colour seeds, moderately resistant to wilt, and high yielding Kabuli chickpea variety
5	*C. reticulatum* (EC 556270)	Wild *Cicer*	NBPGR Genebank, New Delhi	Small-seeded, profusely branched wild *Cicer* sps.

Table 3.Detail of 8 crosses made for experiment

	Crosses	Cross type
1	DCP 92-3 x *C. reticulatum* (EC 556270)	Inter-specific cross
2	IPC 98-12 x *C. reticulatum* (EC 556270)	Inter-specific cross
3	IPCK2002-29 x *C. reticulatum* (EC 556270)	Inter-specific cross
4	JGK1 x *C. reticulatum* (EC 556270)	Inter-specific cross
5	DCP 92-3 x IPCK 2002-29	Desi x Kabuli introgression
6	DCP 92-3 x JGK 1	Desi x Kabuli introgression
7	IPC 98-12 x IPCK 2002-29	Desi x Kabuli introgression
8	IPC 98-12 x JGK1	Desi x Kabuli introgression

RESULT

The efforts were made at ICAR-IIPR, Kanpur to study the variability present in chickpea after wide hybridization. Primary branches per plant is an important yield attribute that contributes towards achieving higher yield in chickpea. Any improvement in this character is expected to lead development and isolation of desirable segregants/genotypes through appropriate selection procedures. The Diallele Selective Mating System (DSMS) or inter-mating among superior F_2 plants is likely to result in development of high yielding varieties in chickpea. The mean value of hybrids (Table 4) indicated the presence of large variations among crosses as evident from the coefficient of variations for the traits studied. Among various traits, primary branches per plant exhibited maximum coefficint of variation i.e. 194.14%.

The wild accession i.e. EC556270 (*Cicer reticulatum*) has more number of primary and secondary branches per plant. This genotype belongs to primary gene pool and therefore was easily crossed with both desi and kabuli chickpea types. The segregating generations of interspecific hybrids indicated that intermating in F_2 will be required to recover desirable genotypes possessing more number of primary branches per plant (Table 5 & 6) as heritability of this trait is moderate. JGK1 is a high yielding variety developed through multiple crosses involving parents of diverse origin when crossed with *Cicer reticulatum* produced desirable segregants possessing more number of primary branches per plant. In most of the crosses except (IPC 98-12 x EC556270 and DCP 92-3 x IPCK 2002-29) similar trend was observed for number of primary branches per plant and secondary branches per plant.

Table no 4. Mean values for hybrids

Hybrid	Primary branches per plant	Secondary branches per plant
DCP 92-3 x IPCK 2002-29	2.33	24.00
DCP 92-3 x JGK 1	2.33	14.67
DCP 92-3 x EC556270	5.33	24.00
IPC 98-12 x IPCK 2002-29	2.33	15.67
IPC 98-12 x JGK 1	4.33	18.00
IPC 98-12 x EC556270	5.67	21.33
IPCK 2002-29 x EC556270	5.00	22.00
JGK 1 x EC556270	2.33	13.00
Mean	3.71	19.08
CV %)	194.14	80.98
S.E.(Diff.)	0.69	1.19
C.D.	1.49	2.55

Table 5. Heterosis and inbreeding depression for number of primary branches per plant

Cross	Male (SP)		Mid (MP)		Female (FP)		Best (BP)		I.D.	
DCP 92-3 x IPCK 2002-29	-30.00		-33.33	*	-36.36	*	-41.67	**	0.000	
DCP 92-3 x JGK 1	-22.22		-26.32		-30.00		-40.67	**	0.000	
DCP 92-3 x EC556270	77.78	**	68.42	**	60.00	**	33.33	*	33.333	*
IPC 98-12 x IPCK 2002-29	-36.36	*	-39.13	**	-41.67	**	-41.67	**	12.500	
IPC 98-12 x JGK 1	44.44	*	23.81		8.33		8.33		-85.714	
IPC 98-12 x EC556270	88.89	**	61.90	**	41.67	**	41.67	**	34.615	
IPCK 2002-29 x EC556270	66.67	**	50.00	**	36.36	*	25.00		6.250	
JGK 1 x EC556270	-22.22		-22.22		-22.22		-41.77	**	63.158	**

Table 6. Heterosis and inbreeding depression for secondary branches per plant

Cross	Male (SP)		Mid (MP)		Female (FP)		Best (BP)		I.D.	
DCP 92-3 x IPCK 2002-29	80.00	**	44.00	**	20.00	**	20.00	**	-50.000	*
DCP 92-3 x JGK 1	57.14	**	0.00		-26.67	**	-26.67	**	15.385	
DCP 92-3 x EC556270	28.57	**	24.14	**	20.00	**	20.00	**	13.253	*
IPC 98-12 x IPCK 2002-29	17.50		2.17		-9.62		-21.67	**	21.667	**
IPC 98-12 x JGK 1	92.86	**	35.00	**	3.85		-10.00		-25.581	
IPC 98-12 x EC556270	23.08	**	18.52	**	14.29	*	6.67		-16.364	*
IPCK 2002-29 x EC556270	65.00	**	37.50	**	17.86	*	10.00		-13.793	
JGK 1 x EC556270	39.29	**	-7.14		-30.36	**	-35.00	**	32.759	*

DISCUSSION

In chickpea plant, number of primary branches per plant is an important attribute because most of the pods come on primary branches and/or secondary branches and tertiary branches are known to produce less number of pods. The present investigation suggests that under irrigated condition where yield is directly affected by number of primary branches per plant, improvement in this trait can be achieved desi x kabuli introgression (Bhaduoria and Chaturvedi 2003, Singh 2009). Yield *per se* is a dependent character and is contributed by its various components, therefore, heterotic expression of yield is nothing but the combined heterotic expression of its components. In present investigation, most of the crosses could be handled for developing the better pure lines performing at par or better than the F_1 crosses (Fig 3). Thus in future this study may be useful on the breeding methodology to be employed for varietal improvement in chickpea (Deshmukh and Bhapkar 1982) as through interspecific crosses large amount of variability could be released for important trait like primary branches per plant.

Fig.3 Desirable type of plant obtained by wide hybridization

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