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Comparison of Backcross and F_2 Populations for Yield Attributes in a Cross between *Cicer arietinum* with *Cicer reticulatum*

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ABSTRACT

Keywords

Chickpea, Wild relative, *Cicer reticulatum*, Yield, Wide hybridization, Introgression

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Availability of variability for yield and related traits is limited in the cultivated germplasm of chickpea. So the evaluation of backcross and F_2 population derived from the cross of chickpea variety GPF2 with 2 accessions of its wild relative *Cicer reticulatum* viz., EC556270 and ILWC21 was done for yield and related traits. A wide variation was observed for all the characters. There were progenies out yielded the parents in most of the characters. A significant increase of number of secondary branches, number of pods, number of seeds per 10 pods and yield per plant was observed in both backcross and F_2 population. The linkage drag was more in F_2 progenies which reduced the 100 seed weight and plant height when compared to cultivated parent. The yield improvement was more in backcross generation with reduced linkage drag when compared to F_2 population in both the crosses.

Introduction

Chickpea (*Cicer arietinum* L.) is one of the earliest cultivated legumes. It is the second important grain legume in globally after pea (FAO 2013). Being a member of Fabaceae family, it is a self pollinated crop with an origin of present day south eastern Turkey and adjoining Syria where several of its natural species are found (Saxena and Singh, 1987). Chickpea is an annual crop that can complete its life cycle in 90 to 180 days depending upon prevailing meteorological conditions (Abdula, 2013). Traditionally, chickpea was of relatively lesser significance in the economy of highly industrialised nations, and as a consequence our understanding of the biological and ecological determinants of yield potential was limited as compared with better studied grain crops like maize (*Zea mays*), rice (*Oryza sativa*), wheat (*Triticum aestivum*) and soybean (*Glycine max*) (Kumar and Abbo, 2001). Chickpea is considered as functional food as it contains 20-22% quality protein and is free from anti-nutritional factors compared to any other dry edible grain legumes. It is rich in fibre and minerals (Phosphorus, Calcium, Magnesium, Iron and Zinc) and its lipid fraction is high in unsaturated fatty acids (Williams and Singh 1987).

Though the world legume production is increasing during last 2 decades, chickpea production has increased only marginally. Non availability of high yielding varieties that are resistant to biotic and abiotic stresses is the major reason for its slow growth. The abiotic stresses includes soil salinity and alkalinity, terminal moisture stress, low and high temperature, foggy weather and lodging under high input conditions are the major problems in achieving higher productivity. Non availability of input responsive varieties remains a major problem in achieving higher productivity level even in high productive environment in North India (Chaturvedi and Nadarajan, 2010). Constraints in breeding of cultivated chickpea include narrow genetic base because of its single domestication event (Zohary, 1996) and very high self pollination rate of 98-100% (Gowda, 1981). This selection of small number of individuals from diverse original population (founder effect), later became widespread as domesticated forms and represent further narrowing of genetic base of chickpea (Abbo *et al.,* 2007).

Adequate sources of resistance to abiotic and biotic stresses and productivity traits are often not available within cultivated germplasms and this has stimulated the interest to use wild species for the improvement of chickpea (Mallikarjuna *et al.,* 2007). There are convincing evidences for the use of wild progenitors as donors of productivity alleles in some crops such as rice (Xiao *et al.,* 1996), tomato (Tanksley *et al.,* 1996) and chickpea (Singh and Ocampo, 1997; Singh *et al.,* 2005). Ladizinsky and Adler (1976 a,b), Jaiswal and Singh (1989) and Verma *et al.,* (1990) exploited the possibilities of introgression of desirable alien genes from wild to cultivated chickpea. Studies have shown that besides disease resistance and drought tolerance, the wild *Cicer* species possess genes for higher number of fruiting branches and pods per plant contributing towards higher productivity (Singh *et al.*, 1994). Among the different wild species available in the *Cicer* genus, *C. reticulatum* is considered to be the wild progenitor as the gene transfer is easier even through the conventional crossing methods (Singh *et al.,* 2008). Even this species was explored for the productivity traits and used for the transfer of productivity alleles in the cultivated *Cicer* species.

So considering the narrow genetic base of cultivated chickpea, inter cross and back cross populations formed with the cultivated chickpea and wild progenitor, *C. reticulatum* were studied for the comparison of yield and related characters in these populations.

Materials and Methods

This study was carried out at Experimental Area of Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana from 2014 during main season. The materials were advanced during 2015 at PAU Off-season Research Station, Keylong. The experimental material consisted of *Cicer arietinum cv.*GPF2 which was used as recurrent parent and wild accessions of *C. reticulatum* EC556270 and ILWC21 as donor parents. The interspecific F_1 plants derived from the two crosses and their recurrent parent formed the base material. F_{1s} derived from two crosses (GPF2 X *C. reticulatum* Acc. EC556270 and GPF2 X *C. reticulatum* Acc. ILWC21) were backcrossed to cultivated recurrent parent to generate BC_1F_1 during rabi 2014-15 in Experimental Area of Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana. The seeds derived from the crosses and the F_2

populations were advanced during off-season (2015) at PAU Off-season Research Station, Keylong. Data was recorded for yield and its component traits of individual plants BC_1F_1 and F_2 generations. The days to first flowering, days to maturity, plant height, number of primary and secondary branches, number of pods, number of seeds per 10 pods, 100 seed weigh and yield per plant were recorded for each plant. The mean, maximum and minimum were calculated and compared with the mean value of the parents.

Results and Discussion

The experiment was conducted during the period of 2014-15 to study the variations in the yield and related characters in BC_1F_1 and F_2 populations made from the cross of cultivated chickpea variety GPF2 with 2 accessions of *C. reticulatum* EC556270 and ILWC21. The data were observed in the individual plant progenies. The observations of different traits of BC_1F_1 progenies of cross using GPF2 as recurrent parent and *C. reticulatum* Acc. EC556270 (cross I) (Table 1) and that of cross with *C. reticulatum* Acc. ILWC21 as donor parent (cross II) (Table 2) were taken.

In cross I, days to first flowering varied from 96 days to 119 days while days to maturity varied from 149 to 161 days. There was an increase in the mean days to first flowering (103.48) and days to maturity (142.00) in comparison with the recurrent parent GPF2 (98, 100). There was no increase in the overall mean of any other character except the number of secondary branches. There were three plants, namely plant no. 6 (22.50 g), 11 (31.00 g) and 15 (27.50 g) which were having yield per plant greater than that of recurrent parent (15.65 g). The superior plants had an increase in yield from 43.70 to 98%. The chance of getting these type of positive transgressive segregants was previously reported by Singh and Ocampo (1997) and considered to be due to the unexpected epistatic effect. In cross II, there was an increase in the mean value of days to first flowering and days to maturity over the mean value of recurrent parent. There was a slight increase in number of secondary branches. The yield per plant varied from 1.02 g to 13.00 g. There was no considerable increase in the yield of any progeny than the recurrent parent, though the yield of a superior progeny in the cross (progeny no.2) was comparable to the mean of per plant yield of the recurrent parent.

As for the F2 progenies (Figure 1 and 2), there was an increase in the average value of days to first flowering (104.00) and days to maturity (155) when compared to the recurrent parent in cross I. The mean of plant height (43.35 cm), number of pods (34.60), number of seeds per 10 pods (11.86), 100-seed weight (8.48 g) and yield (4.05g) of F2s were reduced. The number of primary branches (2.15) was comparable to the parent (2.11). There was about 30% increase in number of secondary branches (15.54) in case of F_2s as compared to recurrent parent. The days to flowering varied from 96-128 days and days to maturity from 149-162 days. The plant nos. 29 (86 cm), 52 (75 cm), 1 (64 cm), 2 (61 cm) and 63 (60 cm) were superior for plant height. The plant nos. 1 (17.20 g), 65(13.90 g) and 40 (11.50 g) were superior for yield with greater number of pods (94, 82 and 83, respectively). Their date of first flowering was comparable with the recurrent parent (98).

In the cross II, there was an increase in days to first flowering (114.13), days to 50% flowering (118.5), days to maturity (155.84), primary branches (2.26) and secondary branches (19.49), while there was a decrease in the value of other characters. The days to first flowering varied from 96-133 days while days to maturity varied from 149-162 days.

There was no considerable increase in the plant height for any progenies except for progeny no. 15 (60 cm). There were six plants namely 2 (152), 75 (104), 24 (100), 73 (100), 85 (80) and 31 (68) were superior for number of pods than the recurrent parent. A wide range of variability for yield was observed in F2 generation which was similar as the reports of Jaiswal *et al.,* (1986). The two plants namely plant nos. 2 (32.80 g) and 24 (20.70 g) were superior for yield per plant. This increase in yield was comparable to the yield increase of F2 in a cross of *C. arietinum* with *C. reticulatum* reported by Singh and Ocampo (1997). They recovered several F2 plants that out yielded the cultigens two to three times.

Table.1 Morphological traits of individual plants of BC_1F_1 of cross I, GPF2 X (GPF2 X *C.reticulatum* Acc. EC556270)

Plant no.	DFF	DM	PH (cm)	NPB	NSB	NP	NSTP	100SW (g)	TYP(g)
1	115	154	38	2	12	32	15	12.82	6.19
2	98	154	52	2	13	43	15	8.69	6
3	100	152	37	2	5	27	16	11.92	5.1
4	103	152	47	3	14	58	18	7.2	7.7
5	98	159	36	2	5	18	17	12.6	3.9
6	104	161	39	2	17	115	14	12.2	22.5
7	96	156	38	2	4	31	18	10.11	6.1
8	96	149	48	2	10	43	17	6.4	4.7
9	97	161	34	3	20	49	13	10.38	7.1
10	96	154	44	2	10	43	18	7.25	5.8
11	98	157	57	2	36	174	14	12.7	31
12	105	151	38	2	17	23	16	8.39	3.7
13	113	155	36	2	11	35	22	9.73	7.8
14	118	154	46	2	13	51	22	10.65	11.4
15	98	156	48	2	23	121	17	13.4	27.5
16	116	155	38	2	10	34	14	9.6	5.3
17	114	156	35	1	7	20	13	16.4	4.4
18	102	154	49	2	20	45	13	9.5	6.5
19	98	154	36	2	15	14	10	9.3	2
20	100	154	37	2	12	27	13	11	4.4
21	117	157	42	2	10	21	17	13.7	5.3
22	96	157	37	2	7	15	12	7	1.6
23	118	158	30	1	2	16	15	14.6	4
24	96	155	38	2	10	51	16	15.2	12.8
25	98	158	41	2	6	39	16	15.2	9.1
26	119	155	30	1	2	12	17	13.5	3
27	96	154	45	2	10	34	21	14.9	10.9
28	96	154	47	2	20	58	16	10.9	10.4
29	100	152	41	2	16	24	16	8	3.5
Mean	**103.48**	**155.1**	**40.83**	**1.97**	**12.31**	**43.9**	**15.9**	**11.15**	**8.27**
MIN	**96**	**149**	**30**	**1**	**2**	**12**	**10**	**6.4**	**1.6**
MAX	**119**	**161**	**57**	**3**	**36**	**174**	**22**	**16.4**	**31**
GPF2	**98**	**140**	**54.83**	**2.11**	**11.23**	**55.2**	**18.25**	**16.11**	**15.65**
EC556270	**110**	**165**	**27**	**5**	**21**	**125**	**21**	**2.8**	**3.8**

DFF-Days to first flowering, DM-Days to maturity, PH-Plant height (cm), NPB- No. of primary branches, NSB-No. of secondary branches, NP-No. of pods, NSTP-No. of seeds/ 10 pods, 100SW-100-seed weight (g), TYP-Total yield/plant (g)

Table.2 Morphological traits of individual plants of BC_1F_1 of cross II, GPF2 X (GPF2 X *C. reticulatum* Acc. ILWC21)

Plant no.	DFF	DM	PH (cm)	NPB	NSB	NP	NSTP	100SW (g)	TYP(g)
1	119	159	41	2	17	62	18	11.6	13
2	99	153	42	2	34	121	17	7.7	15.7
3	120	160	31	2	24	61	13	14.6	11.5
4	112	154	32	2	10	10	5	16	1.02
5	98	153	39	2	14	24	13	8.4	3
6	134	155	28	2	7	7	8	8.8	1.7
7	112	152	34	2	5	4	3	17	2.1
8	120	153	42	2	9	3	10	14.3	2.4
9	126	153	34	2	8	17	22	12.1	4.57
10	111	151	44	2	16	3	30	7.5	1.2
11	115	154	35	2	10	35	15	10.3	5.9
12	114	155	37	2	16	38	16	10.8	6.9
13	116	154	38	2	8	26	17	12.3	6
14	120	159	35	2	6	14	11	13.1	2.7
15	120	153	36	2	10	2	10	21	1.6
MIN	**98**	**151**	**28**	**2**	**5**	**2**	**3**	**7.5**	**1.02**
MAX	**134**	**160**	**44**	**2**	**34**	**121**	**30**	**21**	**15.7**
Mean	**115.73**	**154.53**	**36.53**	**2**	**12.93**	**28.47**	**13.87**	**12.37**	**5.29**
RP-GPF2	**98**	**140**	**54.83**	**2.11**	**11.23**	**55.2**	**18.25**	**16.11**	**15.65**
DP-ILWC21	**114**	**169**	**28**	**6**	**23**	**116**	**26**	**2.35**	**3.4**

Figure.1 Morphological traits of F_2 progenies of cross I, GPF2 X *C. reticulatum* Acc. EC556270

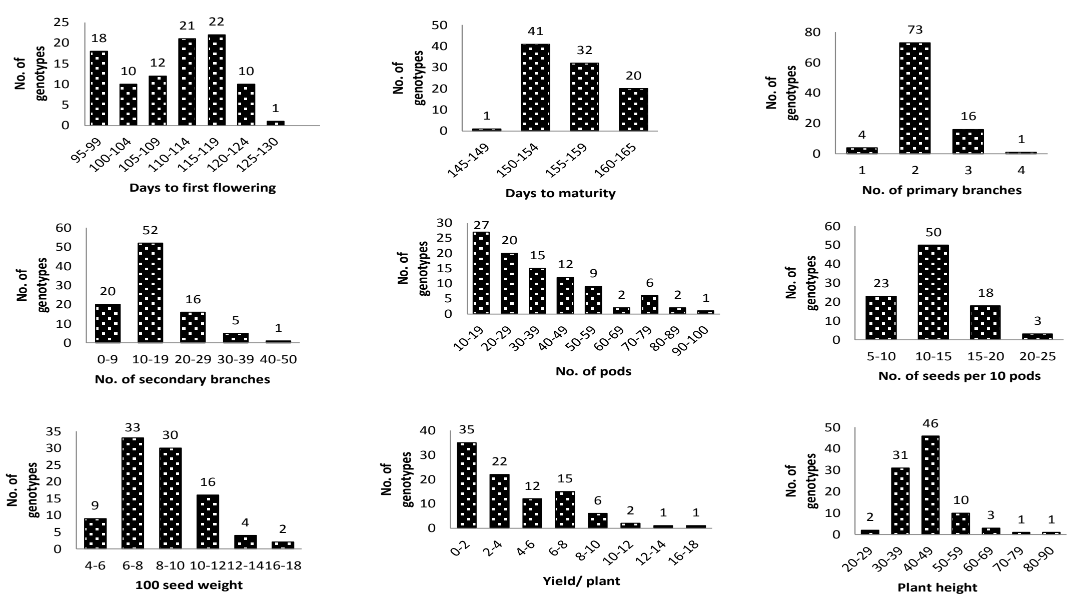
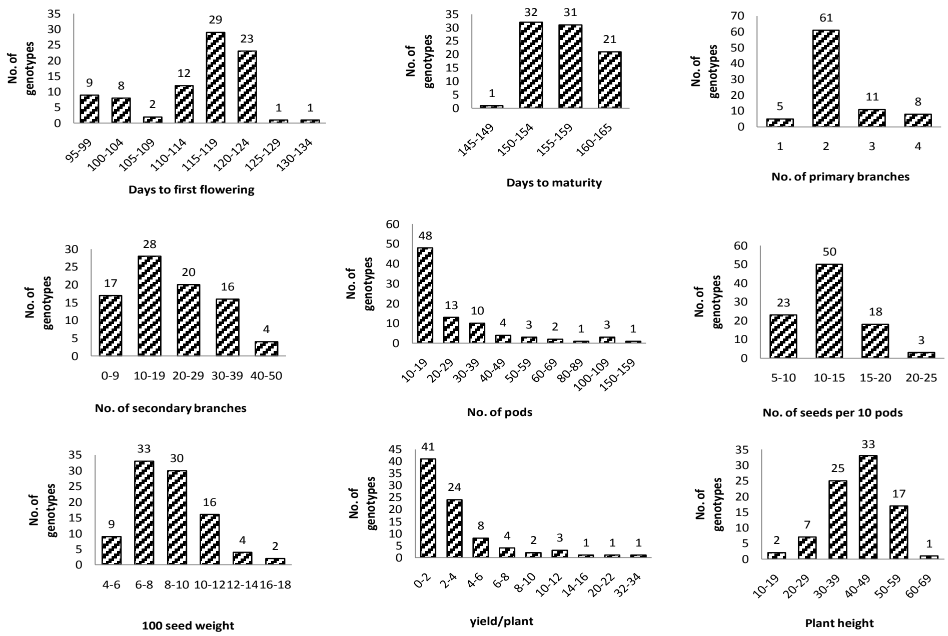


Figure.2 Morphological traits of F_2 progenies of cross II, GPF2 X *C. reticulatum* Acc. ILWC21



The reports of Tanksley and Nelson (1996) that one or two backcrosses are needed to reduce the linkage drag hold true in this case also. Back cross derived lines were superior to F2 generations. There was no improvement in the plant height with backcrossing. Also there was difference in the 100 grain weight of both the populations. The 100 grain weight was slightly increases with the backcross thus resulted in the higher yield per plant. These results were contradictory to the reports of Sharma *et al.*, (2013) as additive gene effects controlling 100-seed weight, there will not be any significant differences across the F1, F2 and backcross generations.

So many yield related traits can be introgressed to the cultivated chickpea from *C. reticulatum*. There was an increase in the days to flowering and days to maturity. There was no considerable difference in the number of primary branches and secondary branches in the population. There was an increase in the number of secondary branches, pods in many progenies of both populations. But the increase in yield was considerably more for the backcross population as it reduced the linkage drag. There was a reduction of 100 seed weight in the progenies when compared to cultivated parent, which can be further improved by backcrossing.

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