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Research Note

Spectrum of genetic variation in selection schemes of Desi chickpea (*Cicer arietinum* L.)

M. R . Paneliya Mehta D. R.; Raval Lata J. and Chetariya C. P
Department of Genetics and Plant Breeding, Junagadh Agricultural University
Junagadh-36200, Gujarat
Email: paneliyamehul.mp@gmail.com

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Abstract
An experiment was conducted to study the spectrum of genetic variation for seed yield per plant and its component traits in the four selection procedures [PS(EF), PS(HY), SSD and RBP] each with 20 progenies in GJG 0315 x ICCV 96029 in F_5 generation in Desi chickpea (*Cicer arietinum* L.). Analysis of variance revealed significant genotypic differences for all the characters with wide range of variation. Out of the total 6 cases studied in F_5, PS(EF) in 2 cases; SSD in 3 cases sand PS(HY) in 1 case were better for depicting the widest phenotypic range and maximum coefficient of range, irrespective of characters. Moderate to high heritability and genotypic co-efficient of variation coupled with high expected genetic advance as per cent of mean was observed for number of branches per plant by PS(HY) and RBP and for 100-seed weight in PS(EF), PS(HY) and SSD of this cross which indicated the predominant role of additive gene action in the expression of these traits in respective breeding schemes.

Keywords
Breeding procedures, genetic variability, chickpea

Pulses are the most important source of vegetarian protein, high in fiber content and provide ample quantity of vitamins and minerals. Keeping in view large benefits of pulses for human health, the United Nations has proclaimed 2016 as the International Year of Pulses (Sandhu, 2015). Chickpea (*Cicer arietinum* L.), one of the major pulses cultivated and consumed in India, is also known as Bengal gram and is a major and cheap source of protein as compared to animal protein. In grain legumes, the improvement in seed yield through selection has not been encouraging due to its complex polygenic nature. Various breeding procedures have their own advantages and limitations. The variability of a biological population is an outcome of genetic constitution of the individuals making up of that population in relation to the prevailing environments. An assessment of genetic variation with the help of parameters such as genotypic coefficient of variation, heritability estimates and genetic advance are absolutely necessary to commence an efficient breeding programme. All the attempts about genetic improvement in seed yield and its economic return in chickpea are now directed towards the manipulation of genetic variation through hybridization followed by handling segregating generation with selection schemes.

The comparison of four selection procedures *viz*., pedigree selection for early flowering [PS(EF)], pedigree selection for high yield [PS(HY)], single seed descent (SSD) and random bulk population (RBP) were evaluated in F_5 generations of chickpea cross GJG 0315 x ICCV 96029. A total of 80 progenies (20 progenies in each selection scheme of a cross) were evaluated in F_5 along with original F_2 and two parental lines during *Rabi* 2015-16 in Randomized Block Design (RBD) with three replications.

Initial crosses were made in r*abi* 2010-11 at Pulse Research Station, JAU, Junagadh, F_1 in Rabi 2011-12, F_2 seeds from bulk of F_1 was raised in *rabi* 2012-13 (75% used for selection and rest 25 % reserved for comparison in F_5), F_3 in *rabi* 2013-14, F_4 in *rabi* 2014-15 and F_5 in *rabi* 2015-16 (25% saved F_2 was used.) Upto five years, there is no harm in using old seeds, but viability slightly declines. Observations were recorded on five randomly selected plants in each entry and replication for seed yield per plant and its component traits *viz*., number of branches per plant, number of pods per plant, biological yield per plant, 100-seed weight and harvest index and their mean values were used for the statistical analysis. The genotypic coefficient (GCV) and phenotypic coefficient of variations (PCV) were estimated as per the formulae suggested by Burton (1952), while heritability in broad-sense and genetic advance were calculated by using the formulae suggested by Allard (1960).

The analysis of variance in F_5 generation indicated that all the four selection procedures ([PS(EF)], [PS(HY)], SSD and RBP), two parents and F_2

population differed significantly for all the characters indicating presence of sufficient amount variability among all the four methods including two parents and F_2 population.

A wider phenotypic range and coefficient range was noted among progenies from PS(EF) compared to other selection procedures for number of pods per plant (41.33 – 65.33, 22.50%) and biological yield per plant (19.66 – 32.34, 24.38%). Similarly, wider range was observed among lines derived from SSD for number of branches per plant (2.60 – 6.20, 40.91%), seed yield per plant (9.13 – 13.87, 20.61%) and harvest index (40.97 – 67.26, 24.29%) and PS(HY) for 100-seed weigh (12.43 – 16.30, 13.47%). The variation in phenotypic range for different quantitative characters in F_4 derived lines in F_5 generation could be attributed to the substantial change brought about by selection in genetic makeup of chickpea through different selection procedures.

Among different selection procedures (Table 1), PS(HY) was numerically superior for biological yield per plant (27.12g). However, PS(HY) was found less effective to rest of the selection procedures for number of pod per plant (50.23g), 100-seed weight (14.59g) and seed yield per plant (10.02g). The effectiveness of early generation selection for seed yield was reported by Ivers and Fehr (1978) in soybean which contradictory to the present findings. PS(HY), however, did not turn out to be superior in this cross for seed yield per plant in the present study. Such observations were reported in soybean by Pushpendra and Ram (1987) as well as by Byth *et al*. (1979) in chickpea. From time to time, several reasons have been proposed for failure of isolating high yielding plants in early segregating generations. With the very large genotypic variation available from F_2 populations, segregating generations no longer could be handled *via* pedigree selection.
Significantly better mean performance of SSD over other selection procedures was observed for 100-seed weight per plant (19.40g), seed yield per plant (11.00g) and harvest index (54.00%). For number of pods per plant, SSD (50.72) was found to be superior to PS(HY) (50.23). Thus, SSD seemed to be an effective alternative in case when it is not possible for a breeder to handle large segregating materials with limited resources. The SSD procedure has been shown often superior or at least equally efficient to traditional methods for developing superior lines by Sharma and Chaudhary (1989) in chickpea. RBP was found superior for number of branches per plant (5.13) and number of pods per plant (52.95) and also RBP (15.02) was found superior to PS(HY) (14.59) for 100-seed weight. Under the circumstances, SSD and RBP methods have been found to be useful for carrying such populations (Frey, 1957). If direct selection was not effective in early generations, either SSD or RBP method could be the best alternative for advancing populations in later generations.

Coefficient of variation measures the relative amount of variation for different characters by bringing various measure of dispersion on a uniform scale and are, therefore, comparable. The better index for measuring the genetic variability is genotypic coefficient of variation (GCV%) as described by Burton (1952).The high values of GCV and PCV were observed with PS(EF) for number of pods per plant (10.11%, 13.69%) and seed yield per plant (11.04%, 16.62%); with SSD for harvest index (10.91%, 17.50%) and with RBP for number of branches per plant (20.57%, 24.15%) and biological yield per plant (9.18%, 13.32%), respectively. Irrespective of different selection methods, the cross exhibited high GCV (%) and PCV (%) for number of branches per plant. The high PCV was observed for number of branches per plant in PS(HY) (20.67%), SSD (22.80%) and RBP (24.15%). This suggested that the greater variability for this character among lines had genetic basis and could be improved through selection. Selection based on phenotypic performance would be effective for improvement of seed yield and its component traits by different selection procedures was reported by Mehta and Zaveri, (1994).

In the present investigation, high heritability was recorded for 100-seed weight in PS(EF) (61.09%), PS(HY) (87.80%) and SSD (94.98%). High heritability for 100-seed weight was also reported by Gul *et al*. (2013) and Monpara and Gaikwad (2014). Similarly, high expected genetic advance (per cent of mean) was recorded for number of branches per plant in three selection procedures *viz*., PS(HY) (30.07%), SSD (27.68%) and RBP (36.10%). High heritability (72.54%) along with high genetic advance (36.10%) was noted for number of branches per plant in RBP which indicated the role of additive genetic variance as reported by Kumar *et al*. (2012), Neelu Kumari *et al*. (2013). High estimate of broad sense heritability was observed for most of the characters in different selection procedures of this cross. This indicated that the magnitude of heritability varies more as a function of the genetic variability and of the adaptive or constitutive nature of genetic differences, than as a function of the environment (Ceccarelli, 1989). He also suggested that the magnitude of heritability does not necessarily represent the best criterion to use in deciding the optimal environment for selection.

Overall high heritability coupled with high genetic advance expressed as per cent of mean for most of the characters in different combinations of selection procedures indicated that these characters were under the control of additive gene action. Therefore, different selection procedures were effective in bringing desirable improvement in these characters.

It is concluded from the present study that among different selection procedures, high heritability along with moderate to high genetic advance as per cent of mean was observed for number of branches per plant in PS(HY) and RBP and for 100-seed weight in three selection schemes [PS(EF), PS(HY) and SSD] of this cross.

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Table 1: Phenotypic range, mean and variability parameters for various traits in F_5 generation of desi chickpea

Selection procedure	Phenotypic range	Coefficient of range (%)	Mean ± S.E.	PCV (%)	GCV (%)	h^2 (%)	GA (% mean)
Number of branches per plant							
PS (EF)	3.60-5.93	24.45	4.44 ± 0.43	19.55	9.58	24.00	9.67
PS (HY)	3.00-6.40	36.17	4.63 ± 0.29	20.67	17.37	70.63	30.07
SSD	2.60-6.20	40.91	4.59 ± 0.38	22.80	17.50	58.94	27.68
RBP	3.00-7.00	40.00	5.13 ± 0.37	24.15	20.57	72.54	36.10
F_2	2.00-3.67	29.45	2.73 ± 0.41	-	-	-	-
P_1	3.33-7.00	35.33	5.07 ± 0.71	-	-	-	-
P_2	2.33-5.67	41.75	3.73 ± 0.56	-	-	-	-
Number of pods per plant							
PS (EF)	41.33-65.33	22.50	51.81 ± 2.69	13.69	10.11	54.52	15.38
PS (HY)	43.33-57.33	13.91	50.23 ± 2.95	12.07	6.06	25.20	6.27
SSD	44.33-62.00	16.62	50.72 ± 2.78	13.18	8.89	45.37	12.32
RBP	46.33-68.67	19.43	52.95 ± 2.85	12.25	7.65	38.96	9.84
F_2	31.00-95.00	50.79	51.87 ± 8.08	-	-	-	-
P_1	42.67-57.33	14.66	50.73 ± 4.77	-	-	-	-
P_2	42.33-53.33	11.50	48.47 ± 2.31	-	-	-	-
Biological yield per plant (g)							
PS (EF)	19.66-32.34	24.38	24.59 ± 1.31	13.00	8.92	47.10	12.62
PS (HY)	22.75-31.78	16.56	27.12 ± 1.41	12.26	8.06	43.22	10.91
SSD	19.29-25.54	13.94	22.46 ± 1.19	11.30	6.23	30.39	7.08
RBP	23.07-32.48	16.94	26.82 ± 1.46	13.32	9.18	47.51	13.04
F_2	5.87-51.30	79.46	30.37 ± 3.53	-	-	-	-
P_1	21.40-28.53	14.28	24.20 ± 1.70	-	-	-	-
P_2	20.80-28.07	14.88	24.16 ± 1.93	-	-	-	-
100-seed weight per plant (g)							
PS (EF)	13.80-17.65	12.24	15.56 ± 0.48	8.86	6.92	61.09	11.15
PS (HY)	12.43-16.30	13.47	14.59 ± 0.22	7.76	7.27	87.80	14.03
SSD	16.47-20.93	11.93	19.40 ± 0.15	6.13	5.97	94.98	11.99
RBP	13.78-16.10	7.76	15.02 ± 0.30	5.04	3.57	50.24	5.21
F_2	15.93-18.33	7.01	17.64 ± 1.36	-	-	-	-
P_1	13.57-16.93	11.02	15.20 ± 0.44	-	-	-	-

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P_2	14.60-16.27	5.41	15.25 ± 1.39	-	-	-	-
			Seed yield per plant (g)				
PS(EF)	9.00-12.30	15.49	10.28 ± 0.40	9.73	6.80	48.92	9.80
PS(HY)	9.23-11.40	10.52	10.02 ± 0.28	6.54	4.20	41.20	5.55
SSD	9.13-13.87	20.61	11.00 ± 0.77	16.62	11.04	44.16	15.12
RBP	8.93-12.87	18.07	10.28 ± 0.53	11.00	6.20	31.79	7.21
F_2	5.03-16.73	53.77	10.27 ± 0.98	-	-	-	-
P_1	8.33-11.67	16.70	9.67 ± 0.75	-	-	-	-
P_2	8.67-12.17	16.79	9.30 ± 0.79	-	-	-	-
			Harvest index (%)				
PS (EF)	32.43-50.84	22.11	42.41 ± 2.97	14.66	7.75	27.99	8.45
PS (HY)	30.03-42.94	17.69	37.47 ± 2.40	13.30	6.88	26.79	7.34
SSD	40.97-67.26	24.29	54.00 ± 4.16	17.50	10.91	38.84	14.00
RBP	34.56-43.85	11.85	38.75 ± 2.75	14.59	7.33	25.23	7.58
F_2	27.86-86.23	51.16	40.35 ± 6.58	-	-	-	-
P_1	33.99-48.40	17.49	40.39 ± 3.45	-	-	-	-
P_2	30.41-46.67	21.09	38.58 ± 1.73	-	-	-	-