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Research Article

Breeding potential of crosses derived from genetically divergent parents differing for yield and its attributes in cowpea [*Vigna unguiculata* (L.) Walp]

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Abstract
Handling of segregating populations arising from a large number of crosses in Plant Breeding is a challenging and vital task. Identification of potential of the particular cross will aid in the selection of superior segregants. In the present study, four crosses derived from parents contrasting for seed yield and most of its attributing traits was assessed by comparing the 11 quantitative traits, mean values, phenotypic coefficient of variation, standardized range and frequency of transgressive segregants in F_2 and F_3 generations in cowpea. Based on *per se* mean value , variances, standardized range and frequency of transgressive segregants in F_2 and F_3 generations derived from four crosses, PL-2 × NBC-39 was predicted to have better breeding potential followed by PL-5 × EC-402104 in terms of chances of isolating desirable recombinants in advanced generations. Increasing trend in mean values, variances, and frequency of transgressive segregants for most of the traits from F_2 to F_3 generations derived PL-2 × NBC-39 and PL-5 × EC-402104 supported the conclusion, although a decreasing trend was observed for standardized range in all four crosses. Identification of 10 best F_3 plants in PL-2 × NBC-39 indicated the utility of mean values, variances, standardized range and frequency of transgressive segregants in predicting the performance of a cross to maximize the frequency of superior segregants in advanced generations.

Key words: PCV, GCV, Transgressive segregation, Cowpea , *Vigna unguiculata*

INTRODUCTION

Cowpea [*Vigna unguiculata* (L.) Walp] is one of the important protein rich pulse crops that originated in Africa, although West Africa and India are considered to be the centres of diversity (Simmonds,1976). It is a diploid species with chromosome number 2n=2x=22 and its seeds are rich in dietary protein (22 to 27%). Cowpea is a multi-utility crop because of its use as vegetable, pulse, fodder, cover crop, green manure and as an atmospheric nitrogen fixer (Babariya *et. al*., 2016; Manju Devi and Jaymani, 2018). Cowpea is a versatile, drought hardy, herbaceous, warm season annual legume that has a wide range of growth habits and hence fits into a variety of cropping systems (Patel *et al*., 2013). Despite its multiple uses, versatile and hardy nature, the area and production of cowpea have not witnessed any dramatic increase over the years. Also, it qualifies as an increasingly important consumer preferred healthy food in traditional diets because of its low fat, high fibre, and dietary protein. Hence, efforts have to be directed for its genetic improvement and to ensure higher yield from a limited areas. Genetic variability is a basic requirement for any crop improvement. The exploitation of naturally existing genetic variability can serve as a short-term strategy for cultivar development in cowpea. Whereas, genetic variability created through hybridization gives greater scope to select desirable recombinants in later generations. Cowpea being a predominantly self-pollinated crop, plant breeders performs a large number of crosses to combine desirable traits distributed in a large number of parents. Hence, plant breeders often encounter the problem of handling large segregating populations derived from large number of crosses. Predicting the performance of a cross (in terms of recovery of superior recombinants in advanced generations) and early elimination of poor crosses, while forwarding few promising crosses to further generations overcomes the constraints of time, human resource and land (Dudley, 1984; Melchinger, 1987; Krishnappa *et al*., 2009; Suresh *et al*., 2017; Bernardo, 2020).With this idea, a study was carried out to assess the breeding potential of four crosses and to identify promising crosses that are likely to recover superior recombinants in advanced generations.

MATERIALS AND METHODS

The basic experimental material for the study consisted of F_2 and F_3 generations derived from the following four crosses *viz.,* Pant Lobia-5 (PL-5) × IC-27749, Pant Lobia-2 (PL-2) × EC-402104, Pant Lobia-2 (PL-2) × NBC-39 and Pant Lobia-5 (PL-5) × EC-402104 along with their five parents and four checks (AV-6, IT-38956-1, KBC-2 and C-152). The four sets of parents contrasting for seed yield and its attributing traits were crossed to obtain four F_1s [(PL-5 × IC-27749), (PL-2 × EC-402104), (PL-2 × NBC-39) and (PL-5 × EC-402104)] during *kharif*, 2016 (Keerthi, 2017). The four F_1s and their parents were selfed and seeds were collected separately. The four F_2 populations (with a minimum of 200 plants in each F_2) derived from the four crosses were evaluated in contiguous blocks at Main Research Station, Hebbal during summer, 2017. Each entry in each block was planted in a single row of 3 m length following a spacing of 0.15 m between plants and 0.45 m between rows. The 26, 27, 28 and 34 F_3 families derived from 26, 27, 28 and 34 randomly selected F_2 plants in the four crosses along with four checks were evaluated in augmented design during *rabi,* 2017 at the experimental plots of the Department of Genetics and Plant Breeding, College of Agriculture, UAS, GKVK, Bengaluru. Each F_3 progeny was sown in a single row of 3 m length following a spacing of 0.15 m between plants and 0.45 m between rows. Data was recorded on all the F_2 plants, 10 randomly selected plants in each of the checks and parents and on 20 randomly selected plants in each of the F_3 progenies for eleven quantitative traits .The mean value of parents and checks in two replications were computed. Analysis of variance of F_3 progenies derived from all the four crosses was done using the method prescribed for augmented design. The mean values of 20 plants in each F_3 progeny were adjusted to account for the block effect. The values of the individual F_2 plants and adjusted mean values of F_3 progeny plants were used to compute mean, standardized range (SR), phenotypic coefficient of variation (PCV) and frequency of transgressive segregants. The mean, PCV, standardized range and frequency of transgressive segregants were used as the criteria to assess breeding potential of crosses (Roy, 2000). The crosses which had high mean value, PCV, standardized range and frequency of transgressive segregants in F_2 and F_3 generations were predicted to have better breeding potential compared to the other crosses in terms of recovery of superior recombinants in advanced generations (Suresh *et al*., 2017).

RESULTS AND DISCUSSION

Though a breeder performs a large number of crosses, practically it is possible to forward and handle only a few crosses due to constraints in time, land, and human resource. This demands the use of a suitable method to predict the performance of a cross. Comparison of mean value, PCV, standardized range and frequency of transgressive segregants in the early segregating generations derived from crosses, serves as a useful method to assess the relative breeding potential of the crosses to isolate superior segreganats (Anilkumar *et al*., 2021). In this study the mean value, PCV, standardized range and frequency of transgressive segregants of four crosses for 11 traits were assessed and compared in F_2 and F_3 generations derived from four crosses.

In parents, the mean value of yield attributing traits such as clusters per plant, pods per cluster, pods per plant, seeds per pod, pod yield per plant and seed yield per plant were high in the female parents PL-2 and PL-5 (**Table 1**). Among the female parents, mean value of most of the traits was found to be high in PL-2, while among male parents *viz.,* EC-402104, IC-27749 and NBC-39 , the mean values were higher for NBC-39 (**Table 1**).Thus, the crosses with PL-2 and NBC-39 as parents *viz.,* PL-2 × NBC-39 and PL-2 × EC-402104 are likely to be more potent and productive. In the F_2 generation, mean value for branches per plant, clusters per plant, pod length, pods per plant, seeds per pod, pod yield per plant and seed yield per plant were higher in PL-2 × NBC-39. In addition to this, average plant height, pod length, clusters per plant and seeds per pod were lower in PL-2 × EC-402104, compared to other three crosses (**Table 2**). In F_3 generation, pod length, pods per plant, pod yield per plant and seed yield per plant were higher in PL-2 × NBC-39. Seeds per pod were high in PL-2 × NBC-39 and PL-5 × EC-402104. Pod length was high in PL-2 × EC-402104,whereas, plant height and branches per plant were comparable among the F_3 generations of four crosses. Altogether, there was a general increase in trend of mean values from F_2 to F_3 for plant height, clusters per plant, pods per cluster, pod length, seeds per pod, pod yield per plant and seed yield per plant in all the

Table 1. Estimates of mean values of eleven traits in parents of the four crosses of cowpea

Characters	Pant Lobia-5	Pant Lobia-2	IC-27749	EC-402104	NBC-39
Days to first flowering	51 ± 0.52	51 ± 0.55	52 ± 0.61	45 ± 0.53	44 ± 0.38
Plant height (cm)	35.5 ± 0.78	37.5 ± 0.98	43.5 ± 0.51	45.7 ± 0.75	46.5 ± 0.37
Branches per plant	5.5 ± 0.11	4.5 ± 0.12	6.5 ±0.11	6.5 ± 0.09	6 ± 0.09
Clusters per plant	15 ± 0.77	14.5 ± 0.63	13 ± 0.55	12.5 ± 0.37	13 ± 0.32
Pods per cluster	1.75 ±0.04	1.75 ± 0.04	1.5 ± 0.03	1.5 ± 0.04	1.5 ± 0.03
Pod length (cm)	17.5 ± 0.24	18 ± 0.12	17.5 ± 0.15	16.5 ± 0.11	18 ± 0.22
Pods per plant	28 ± 1.57	29 ± 1.23	27 ± 0.62	22 ± 1.13	24 ± 1.22
Seeds per pod	12.5 ±0.34	13.5 ±0.08	11.5 ± 0.25	11 ± 0.18	12 ± 0.13
Pod yield per plant (g)	51.3 ± 2.49	53.3 ± 2.3	47.4 ± 1.91	47.3 ± 2.59	49.7 ± 2.16
Seed yield per plant (g)	31.1 ± 1.31	32.7 ± 1.03	23.9 ± 1.06	22.7 ± 1.46	23.1 ± 1.49
Test weight (g)	12.3 ± 0.04	12.22 ± 0.07	11.7 ± 0.08	12.01 ± 0.08	11.9 ± 0.05

Table 2. Estimates of mean values of quantitative traits in F_2 and F_3 generations of four crosses of cowpea

Characters	PL-5 × IC-27749		PL-2 × EC-402104		PL-2 × NBC-39		PL-5 × EC-402104	
	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3
Days to first flowering	47.32 ± 1.50	46.52 ± 1.19	46.84 ± 1.80	47.49 ± 1.19	46.53 ± 1.50	49.36 ± 1.19	47.41 ± 1.50	48.09 ± 1.19
Plant height (cm)	37.47 ± 0.54	42.65 ± 0.25	33.39 ± 0.39	41.41 ± 2.51	36.29 ± 2.90	41.93 ± 2.51	35.00 ± 2.90	42.49 ± 2.51
Branches per plant	05.19 ± 0.11	04.49 ± 0.03	05.30 ± 0.13	04.47 ± 0.30	05.68 ± 0.10	04.49 ± 0.30	05.14 ± 0.08	04.27 ± 0.30
Clusters per plant	10.93 ± 0.29	13.21 ± 0.76	10.37 ± 0.27	13.48 ± 0.76	12.49 ± 0.31	14.45 ± 0.76	11.67 ± 0.32	14.47 ± 0.76
Pods per cluster	01.56 ± 0.03	01.86 ± 0.24	01.58 ± 0.03	02.00 ± 0.23	01.60 ± 0.02	01.83 ± 0.24	01.68 ± 0.03	01.84 ± 0.24
Pod length (cm)	18.62 ± 0.16	24.36 ± 1.46	16.21 ± 1.60	27.76 ± 1.46	20.22 ± 1.60	26.30 ± 1.46	18.61 ± 1.50	25.97 ± 1.46
Pods per plant	17.14 ± 0.59	16.96 ± 0.47	18.49 ± 0.30	16.38 ± 0.47	18.99 ± 0.40	17.23 ± 0.48	17.62 ± 0.40	16.61 ± 0.48
Seeds per pod	12.08 ± 0.15	12.44 ± 0.58	10.95 ± 0.11	11.18 ± 0.58	12.16 ± 0.16	11.27 ± 0.58	11.20 ± 0.13	11.95 ± 0.58
Pod yield per plant (g)	32.52 ± 2.50	40.09 ± 2.81	33.98 ± 2.30	42.01 ± 2.82	40.16 ± 2.50	46.97 ± 2.82	34.93 ± 2.70	41.74 ± 2.82
Seed yield per plant (g)	23.67 ± 1.70	23.15 ± 1.55	22.93 ± 1.50	24.79 ± 1.55	24.80 ± 1.70	27.11 ± 1.55	23.88 ± 1.70	25.87 ± 1.55
Test weight (g)	12.60 ± 0.30	12.39 ± 0.27	12.37 ± 0.30	12.40 ± 0.27	12.71 ± 0.30	12.32 ± 0.27	12.18 ± 0.30	12.04 ± 0.27

four crosses (**Table 2**). In F_2, the PCV for eight traits such as, days to first flowering, branches per plant, pods per cluster, pod length, seeds per pod, pod yield per plant and seed yield per plant were high in PL-2 × NBC-39 followed by PL-5 × EC-402104. In F_3 generation, the high PCV values for nine traits such as days to first flowering, plant height, branches per plant, clusters per plant, pods per cluster, pod length, pods per plant, pod yield per plant and seed yield per plant were observed in cross PL-2 × NBC-39 followed by PL-5 × EC-402104 (**Table 3**). An increasing trend in PCV from F_2 to F_3 for eight traits such as days to first flowering, plant height, clusters per plant, pods per cluster, pod length, pods per plant, pod yield and seed yield per plant were observed in PL-2 × NBC-39 (**Table 3**). Whereas a decreasing trend from F_2 to F_3 was noticed for all traits except for days to first flowering and pod length in PL-5 × IC-27749 and branches per plant, pods per cluster, pod length and pods per plant in PL-2 × EC-402104. A decreasing trend in PCV for all traits except branches per plant and pod length was noticed in PL-5 × EC402104. In F_2 generation, the standardised range for plant height, secondary branches per plant, clusters per plant, pod length and pods per plant were high in PL-2 × NBC-39 than in other three crosses. But standardised range for days to first flowering was high in PL-5 × EC-402104 and for seeds per pod and test weight it was high in PL-2 × EC-402104 (**Table 4**). In F_3 generation, the standardised range for plant height, pod length, seeds per pod and seed yield per plant were higher in PL-2 × NBC-39 than other three crosses. But for clusters per plant, pods per plant and pod yield per plant the standardised range was higher in PL-5 × IC-27749. For days to first flowering and branches per plant, standardised range was high in PL-2 × EC-402104, and for pods per cluster and for test weight it was high in PL-5 × EC-402104. The frequency of segregants that

Table 3. Estimates of PCV of quantitative traits in F_2 and F_3 generations of four crosses of cowpea (Per cent)

Characters	PL-5 × IC-27749		PL-2 × EC-402104		PL-2 × NBC-39		PL-5 × EC-402104	
	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3
Days to first flowering	04.29	04.68	05.18	05.04	05.57	05.68	05.36	04.28
Plant height	14.63	13.40	20.01	16.08	17.74	18.33	16.36	10.09
Branches per plant	20.53	15.95	24.35	26.13	29.50	26.93	13.76	16.97
Clusters per plant	26.30	20.60	23.55	18.81	28.49	28.83	30.01	25.42
Pods per cluster	22.67	13.41	21.17	24.25	23.15	29.85	21.75	13.66
Pod length	12.12	17.49	12.61	17.89	16.24	23.49	09.51	18.61
Pods per plant	34.08	22.74	33.20	35.34	34.92	35.71	35.74	23.03
Seeds per pod	12.06	04.57	13.05	12.60	14.67	10.20	13.76	06.52
Pod yield per plant	36.51	20.71	36.73	23.05	50.44	52.17	37.82	25.36
Seed yield per plant	38.60	14.57	37.44	28.49	39.67	39.72	34.84	22.22
Test weight	08.44	01.84	05.53	02.32	08.14	2.17	05.82	02.82

Table 4. Estimates of standardised range of quantitative traits in F_2 and F_3 generations of four crosses of cowpea

Characters	PL-5 × IC-27749		PL-2 × EC-402104		PL-2 × NBC-39		PL-5 × EC-402104	
	Standardized Range		Standardized Range		Standardized Range		Standardized Range	
	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3
Days to first flowering	0.21	0.21	0.21	0.29	0.23	0.23	0.24	0.27
Plant height (cm)	1.06	0.35	1.31	0.29	1.14	0.49	0.94	0.47
Branches per plant	1.35	0.56	1.6	0.72	2.45	0.55	1.36	0.58
Clusters per plant	1.83	1.02	2.32	0.82	3.37	0.76	2.67	0.62
Pods per cluster	0.96	0.36	0.94	0.35	0.95	0.43	0.93	0.56
Pod length (cm)	0.84	0.16	0.84	0.34	1.12	0.38	0.91	0.15
Pods per plant	2.8	1.15	2.59	0.91	3.45	0.98	2.94	1
Seeds per pod	1.16	0.11	1.55	0.49	1.06	0.68	1.12	0.37
Pod yield per plant (g)	3.36	1.26	2.79	1.11	3.52	1.1	3.08	1.16
Seed yield per plant(g)	3.21	0.94	2.84	1.1	3.23	1.1	3.09	1.06
Test weight (g)	0.16	0.06	0.72	0.16	0.42	0.12	0.3	0.23

surpassed the higher scoring parent for branches per plant, clusters per plant, pods per plant, pod yield per plant, seed yield per plant and test weight were higher in F_2 derived from PL-2 × NBC-39. For plant height and seeds per pod, the frequency of segregants surpassing the higher performing parent were high in PL-5 × IC-27749, while for pod length, it was high in PL-5 × EC-402104. In F_3 generation, the frequency of segregants that transgressed higher scoring parent for branches per plant, pods per cluster, pods per plant, seeds per pod, pod yield per plant, seed yield per plant and test weight were high in PL-5 × IC-27749 (**Table 5**). While, for days to first flowering, clusters per plant and pod length the frequency was high in PL-5 × EC-402104. But the frequency of transgressive segregants that surpassed the lower performing parent for most of the traits were high in F_2 and F_3 generations derived from PL-2 × EC-402104 and PL-5 × EC-402104 than other two crosses (**Table 5**). In addition to this, the frequency of transgressive segregants surpassing superior parent was showing an increasing trend from F_2 to F_3 for days to first flowering, clusters per plant, plant height, pods per plant, seeds per pod, pod yield per plant, seed yield per plant and test weight across all the four crosses.

Based on *per se* performance, F_2 and F_3 generations for seed and pod yield per plant and most of its attributing traits were higher in PL-2 × NBC-39 followed by

Table 5. Estimates of frequency (%) of transgressive segregants for quantitative traits in F_2 and F_3 generations of four crosses of cowpea

Characters	Progeny	PL-5 × IC-27749		PL-2 × EC-402104		PL-2 × NBC-39		PL-5 × EC-402104	
		> High parent	<Low parent	> High parent	<Low parent	> High parent	<Low parent	> High parent	<Low parent
Days to first flowering	F_2	0	0	0	56.09	0	0	0	31.35
	F_3	10	22.12	14.26	23.7	25.36	10.18	29.85	30.29
Plant height	F_2	18.81	22.28	2.27	50.14	4.33	49.46	0.4	49.6
	F_3	17.31	5	12.78	20.56	2.5	12.32	8.38	3.53
Branches per plant	F_2	6.44	32.67	11.05	20.68	11.19	10.47	3.57	33.73
	F_3	0.58	68.46	0.37	35	1	31.25	0.15	42.5
Clusters per plant	F_2	6.93	33.66	11.9	48.44	12.83	26.71	10.71	29.76
	F_3	26.92	19.42	29.44	19.81	33.04	15.36	36.91	11.76
Pods per cluster	F_2	0	32.67	0	33.43	0	29	0	30.56
	F_3	0.38	14.04	0.37	2.59	4	12	0	11.62
Pod length	F_2	22.77	27.23	3.97	56.94	27.44	29.6	57.94	2.78
	F_3	1.73	38.65	1.11	25.56	1.96	34.11	8.24	2.94
Pods per plant	F_2	3.47	40.59	8.78	26.06	10.47	31.05	8.33	17.46
	F_3	23.08	21.92	38.15	12.04	38.39	17.14	31.03	16.32
Seeds per pod	F_2	12.38	11.39	2.55	22.1	5.54	24.55	2.78	18.65
	F_3	2.58	3.27	0.56	32.59	8.66	44.64	4.85	8.68
Pod yield per plant	F_2	2.97	67.82	5.38	58.36	15.08	46.83	6.14	54.15
	F_3	16.35	48.08	22.04	42.04	31.32	34.85	23.21	40.89
Seed yield per plant	F_2	12.87	31.19	10.2	28.33	30.89	24.6	18.41	20.58
	F_3	10.19	32.5	19.07	19.63	31.35	20.36	28.68	18.38
Test weight	F_2	7.92	0	17.85	6.8	18.61	1.59	6.5	6.86
	F_3	12.69	0	18.15	0	23.73	1.07	15.29	0.59

Table 6. Estimates of means of ten best plants identified in F_3 population derived from PL-2 × NBC-39 in cowpea

Pedigree of the F_3 plants	Days to first flowering	Plant height (cm)	Branches per plant	Clusters per plant	Pods per cluster	Pod length (cm)	Pods per plant	Seeds per pod	Pod yield per plant (g)	Seed yield per plant (g)	Test weight (g)
PL-2NBC-127-18	48.00	42.00	5.00	20.00	1.50	16.2	52.0	10.2	72.30	42.70	12.32
PL-2NBC-284-1	48.00	45.00	5.00	18.00	1.50	16.2	54.0	09.2	65.90	41.60	12.42
PL-2NBC-41-9	51.00	36.00	6.00	17.00	1.75	15.7	40.0	09.6	64.50	41.40	12.39
PL-2NBC-25-15	48.00	44.00	5.00	18.00	1.50	16.8	36.0	10.1	63.19	41.10	12.12
PL-2NBC-25-8	47.00	36.00	4.00	19.00	1.50	16.7	33.0	13.3	59.51	41.07	12.10
PL-2NBC-195-7	47.00	39.00	5.00	16.00	1.50	16.5	36.0	11.3	63.17	40.23	12.22
PL-2NBC-153-5	52.00	39.00	6.00	18.00	2.50	17.4	32.0	12.6	58.20	39.40	12.15
PL-2NBC-17-8	45.00	37.00	4.00	17.00	1.50	17.5	32.0	11.1	59.10	39.20	12.19
PL-2NBC-299-2	55.00	37.00	5.00	16.00	1.50	16.4	31.0	10.4	57.66	38.80	12.21
PL-2NBC-17-9	50.00	41.00	4.00	16.00	2.00	16.1	29.0	09.9	57.04	37.60	12.19
Checks											
AV-6	42.30	51.60	5.20	11.20	2.30	17.5	26.7	12.9	51.69	33.30	12.38
KBC-2	46.60	49.50	4.80	14.20	1.90	16.8	19.6	10.8	42.46	29.26	12.12
SEm±	00.41	00.38	0.09	00.33	0.03	0.15	0.63	0.13	01.91	01.07	00.05
CD @ P=0.05	02.51	02.41	1.16	02.24	0.68	1.49	3.11	1.44	05.42	04.05	00.85

PL-5 × EC-402104. And, there was a general increasing trend of means from F_2 to F_3 for all the 11 traits in all the four crosses. The results of estimates of PCV for most of the traits revealed a high magnitude in F_2 and F_3 generations of PL-2 × NBC-39 followed by PL-5 × EC-402104 suggesting that, cross PL-2 × NBC-39 has a considerably high variation for traits followed by PL-5 × EC-402104 in comparison with other two crosses and hence, providing a scope to practice selection to recover desirable genotypes in the later segregating generations of these crosses. Also, an increasing trend in PCV was observed for more than half of the traits from F_2 to F_3 generation in these two crosses. Similar methods were also used by earlier researchers to predict breeding potential of crosses in finger millet (Krishnappa *et al.,*2009) and dolichos bean (Suresh *et al.,*2017). The higher *per se* estimates of standardised range and high frequency of segregants surpassing the higher scoring parent for seed yield and most of its attributing traits in F_2 and F_3 generations derived from PL-2 × NBC-39 followed by PL-5 × EC-402104 suggested the possibility of recovering desirable extreme phenotypes in later generations.

From the comparison of mean values, PCV, standardized range and frequency of transgressive segregants among four crosses in F_2 and F_3 generations, , it could be opined that cross PL-2 × NBC-39 was predicted to possess high breeding potential in terms of recovery of desirable recombinants in advanced generations, followed by PL-5 × EC-402104, compared to other two crosses. Identification of 10 best F_3 plants that surpassed the checks AV-6 and KBC-2 for seed and pod yield per plant and most of the other yield contributing traits in the F_3 progenies derived from PL-2 × NBC-39 supported the opinion that was drawn regarding the better breeding potential of PL-2 × NBC-39 **(Table 6).** Identification of these 10 best F_3 plants also supported the utility of traits mean values, variances, standardized range and frequency of transgressive segregants in predicting the breeding potential of any cross.

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