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Breeding Potential of Crosses in Dolichos Bean (*Lablab purpureus* L. Sweet Var *lignosus*)

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Abstract Breeding potential of three crosses derived from parents contrasting for fresh pod yield plant^{-1} was predicted based on the contribution of 10 quantitative trait means and phenotypic coefficient of variation in F_2 and F_3 generations in dolichos bean. Based on the quantitative traits means *per se in* F_2 and F_3 generations, HA-11-3 × RIL 180 was predicted to have better breeding potential in terms of chances of recovering desirable recombinant inbred lines (RILs) in advanced generations. However, increasing trend in quantitative trait means and phenotypic coefficient of variation (PCV) from F_2 to F_3 generations suggested better breeding potential of HA-10-8×RIL 180 and FPB 21×RIL 180 in advanced generations. Identification of RILs superior to the check HA 4 in F_5 generation derived from HA-10-8 × RIL 180 indicated the utility of quantitative trait means and variances in early segregating generations for predicting the breeding potential of crosses to maximize the frequency of desirable RILs in advanced generations.

Keywords Breeding potential, Dolichos bean, Phenotypic coefficient of variation.

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Introduction

Dolichos bean (*Lablab purpureus* L.) is a bushy semi-erect herb and belongs to family Fabaceae with 2n = 22 chromosomes [1]. It is believed that dolichos bean has originated in Indian sub-continent [2], as it is documented by archaeo-botanical finds in India from 2000 to 1700 BC at Hallur. It is grown for fresh beans used as a vegetable and to a limited extent as split. It is intercropped with finger millet, maize, and sorghum in southern India under rainfed conditions. However, due to the availability of a few photoperiod insensitive determinate cultivars, dolichos bean is being cultivated as a pure crop in irrigated ecosystems in Southern Karnataka and adjoining districts of Andhra Pradesh and Tamil Nadu. In pure crop stands, the productivity of dry seed yield is 1.2 t ha^{-1} (raitamitra.kar.co.in) while it is 0.4 to 0.5 t ha^{-1} in inter - cropping system. In Karnataka, Dolichos bean (*Lablab purpureus* var *lignosus*) is grown in an area of 0.66 lakh hectares with a production of 0.72 lakh t and contributes to nearly 90% of both area and production in India (raitamitra.kar.co.in).

Despite its importance as a multi-purpose crop and ability to with stand drought better than cowpea [3], and adapt to acidic and saline soils, dolichos bean truly qualifies as 'underutilized' crop as evidenced by limited area under the crop and efforts for its genetic improvement.

Exploitation of genetic variability existing in the working germplasm is the first principle in the improvement of any crop (dolichos bean being no exception to this). Analysis and exploitation of existing genetic variability is a short-term strategy for developing improved cultivars for meeting immediate requirement of the farmers and the end-users. Exploitation of variability created by hybridization through recombination breeding is the major approach adopted in dolichos improvement programs [4]. Often, a plant breeder / researcher is confronted with the task of handling segregating populations derived from a large number of crosses. Early elimination of poor crosses helps in efficient utilization of land, time and human resources and allows handling of reasonably large segregating populations derived from a few promising crosses. Under this premise, an investigation was carried out to identify promising crosses that are likely to result in superior recombinant inbred lines in advanced generations.

Materials and Methods

Basic genetic material and development of experimental material

The basic experimental material for the study consisted of three pairs of genotypes P_1 (HA-10-8), P_2 (RIL 180), P_1 (HA-11-3), P_2 (RIL 180), P_1 (FPB 21) and P_2 (RIL 180) contrasting for pod yield and its component traits (Keerthi et al. 2016 b). These were crossed to obtain three F_1s [(HA-10-8 ×RIL 180), (HA-11-3×RIL 180) and (FPB 21 × RIL 180)] during 2013 rainy season.The plants of the three F_1's were grown and selfed during 2014 summer. F_2 population derived from the three F_1's, along with their parents and F_1's were grown in 2014 rainy season.The selfed seeds from the parents and F_1 and F_2 plants were collected, dried, treated and stored in -20°C. The five basic generations (P_1, P_2, F_1, F_2 and F_3) of the three crosses constituted the experimental material. The experimental material was developed in the field plot of the Department of Genetics and Plant Breeding (GPB), University of Agricultural Sciences (UAS), Bengaluru, India.

Evaluation of experimental material

The non-segregating generations P_1, P_2 and F_1 of three crosses were evaluated in a randomized complete block design (RCBD) with two replications in experimental plot of the Department of GPB, UAS, Bengaluru during 2015 rainy season. The seeds of F_2 generation of the three crosses were sown each in 20 rows of 3 m length in separate blocks in field plot of the Department of GPB, UAS, Bengaluru during 2015 rainy season. After 10 days, the seedlings were thinned by maintaining a spacing of 0.45 m between rows and 0.20 m between plants. A total of 200 F_2 plants were maintained in each cross. The F_3 progenies derived from randomly selected 20 different F_2 plants of three crosses along with checks (HA 3 and HA 4) were grown in a single row of 2 m length in separate contiguous blocks following augmented design during 2015 rainy season. A total of 15 plants were maintained in each row. Data were recorded on five plants randomly selected from each of the parents and F_1's, all the 200 F_2 plants and on 10 plants randomly selected from each of the 20 F_3 progenies of each cross on 10 quantitative traits, namely plant height, number of primary branches plant^{-1}, racemes plant^{-1}, raceme length, nodes raceme^{-1}, dry pods raceme^{-1}, dry pods plant^{-1}, dry pod yield plant^{-1}, dry seed yield plant^{-1} and 100 dry seed weight based on descriptors [5].

Statistical analysis

Quantitative traits means over two replications of parents and F_1's were estimated. ANOVA of F_3 progenies were performed following the methods outlined for augmented design. The trait values of 10 plants of each of the F_3 progenies were adjusted for block effect. The adjusted trait values of F_3 progeny plants and individual F_2 plants were used for computing descriptive statistics such as mean, standardized range, and phenotypic coefficient of variation (PCV). Standard error of mean was estimated to assess the precision of trait mean values of F_2 and F_3 generations plants.

Criteria to assess breeding potential of crosses

The quantitative trait means and variances in F_2 and F_3 generations were used as criteria to assess the breeding potential of the crosses. The crosses with high quantitative trait mean and PCV in F_2 and F_3

Table 1. Estimates of mean ± standard error in parents and F_1's derived from the three crosses of dolichos bean.

Traits	Parents HA 10-8	FPB 21	HA 11-3	RIL 180	F_1 HA10-8 × RIL 180	FPB21 × RIL 180	HA11-3 × RIL 180
Plant height (cm)	64.02±3.69	64.38±1.68	62.9 ±3.60	45.10 ±2.60	77.62±1.22	70.10±3.18	68.58±2.56
Primary branches plant^{-1}	03.60±0.32	03.40±0.40	02.20±0.40	02.40±0.24	03.00±0.37	03.20±0.51	03.20±0.32
Racemes plant^{-1}	10.00±0.91	08.60±1.24	08.00±1.82	04.60±0.62	09.80±0.45	07.40±0.67	09.80±0.66
Raceme length (cm)	15.54±0.30	14.34±0.36	11.53±1.90	06.76±0.35	19.46±0.45	19.24±0.60	13.90±0.54
Nodes raceme^{-1}	08.86±0.20	12.97±0.20	06.40±0.53	05.16±0.24	12.78±0.20	11.98±0.20	06.82±0.39
Dry pods raceme^{-1}	04.76±0.55	10.20±0.23	05.00±0.91	03.48±0.14	10.20±0.25	08.56±0.48	07.44±0.45
Dry pods plant^{-1}	48.60±3.52	38.80±2.87	37.40±9.06	18.60±1.57	49.40±3.36	46.80±2.67	47.00±2.98
Dry pod yield plant^{-1} (g)	42.64±3.04	31.24±3.34	35.90±8.45	14.40±1.11	47.22±3.05	42.66±2.62	43.96±2.79
Dry seed yield plant^{-1} (g)	37.34±2.88	24.58±3.45	32.10±5.98	12.62±0.85	40.20±2.94	34.24±2.12	38.90±2.13
100 dry seed weight (g)	19.00±0.24	18.60±0.29	18.10±0.16	16.00±0.16	19.50±0.46	18.90±0.34	18.70±0.22

generations were considered to have better breeding potential to result in high frequency of desirable recombinant inbred lines in advanced generations.

Results and Discussion

A plant breeder attempts a large number of crosses to combine desirable traits spread over a large number of parents to create useful variability in order to isolate superior recombinant inbred lines (RILs) in advanced generations. In practice, it is possible to advance only a few crosses as time, land and human resources are limited. Such circumstances demand an objective method of prediction of potential of crosses from early generation crosses data. Comparison of means and variances in early segregating generations derived from the crosses is a commonly used method to assess the relative potential of cross combinations

Table 2. Estimates of mean±standard error in F_2 and F_3 generations derived from three crosses of dolichos bean.

Traits	HA 10-8 × RIL 180 F_2	F_3	FPB 21 × RIL 180 F_2	F_3	HA 11-3 × RIL 180 F_2	F_3
Plant height (cm)	60.61±1.47	60.85±1.85	60.34±1.99	62.13±3.28	53.97±1.90	53.25±1.77
Primary branches plant^{-1}	02.72±0.07	02.77±0.07	03.02±0.10	02.98±0.09	02.79±0.11	03.08±0.12
Racemes plant^{-1}	06.99±0.42	07.05±0.73	06.79±0.40	07.56±0.27	04.30±0.35	04.41±0.33
Raceme length (cm)	11.61±0.38	10.90±0.20	11.67±0.41	11.48±0.34	15.32±0.49	16.08±0.59
Nodes raceme^{-1}	06.34±0.19	06.22±0.12	06.62±0.16	06.47±0.14	08.41±0.22	08.62±0.19
Dry pods raceme^{-1}	04.78±0.15	04.43±0.14	05.25±0.20	05.84±0.26	05.67±0.22	05.98±0.32
Dry pods plant^{-1}	31.36±1.72	28.90±3.26	32.35±1.60	37.61±3.42	23.39±1.78	24.23±1.84
Dry pod yield plant^{-1} (g)	30.58±1.57	28.49±3.23	32.37±1.48	36.15±3.72	24.06±1.67	25.21±2.16
Dry seed yield plant^{-1} (g)	22.98±1.27	21.94±2.34	23.95±1.14	28.38±3.26	16.91±1.21	18.34±1.55
100 dry seed weight (g)	18.41±0.17	18.87±0.19	18.22±0.18	18.59±0.29	19.66±0.28	20.20±0.48

Table 3. Estimates of standard range in F_2 and F_3 generations derived from three crosses of dolichos bean.

Traits	HA 10–8×RIL 180		FPB 21×RIL 180		HA 11–3×RIL 180	
	F_2	F_3	F_2	F_3	F_2	F_3
Plant height (cm)	1.37	0.57	1.64	0.93	1.76	0.69
Primary branches plant^{-1}	1.01	0.43	1.99	0.47	1.43	0.84
Racemes plant^{-1}	3.00	2.13	3.24	0.59	4.65	1.45
Raceme length (cm)	2.35	0.32	2.41	0.49	1.42	0.60
Nodes raceme^{-1}	2.00	0.46	1.36	0.38	1.43	0.38
Dry pods raceme^{-1}	1.67	0.61	2.05	0.88	2.03	0.94
Dry pods plant^{-1}	2.42	2.04	2.55	1.39	3.55	1.75
Dry pod yield plant^{-1} (g)	2.26	2.07	2.77	1.56	3.26	1.65
Dry seed yield plant^{-1} (g)	2.52	2.00	2.66	1.96	3.31	1.59
100 dry seed weight (g)	0.65	0.21	0.41	0.23	0.58	0.44

to isolate superior RILs. In the present study, the three crosses were compared in terms of mean values, standardized range and PCV for 10 quantitative traits.

The means of non-segregating (P_1, P_2, and F_1) generations in HA 10-8 × RIL 180 cross were higher than those of FPB 21 × RIL 180 and HA 11-3 × RIL 180 crosses for most of the traits investigated (Table 1). F_1 means of the three crosses for most of the traits were slightly higher than their respective parents indicating the presence of an overall heterosis for these traits.

The average plant height, racemes plant^{-1}, dry pods plant^{-1} and dry seed yield plant^{-1} were comparable between HA 10-8 × RIL 180 and FPB 21 × RIL 180 in F_2 generation (Table 2). On the other hand, they were lower in HA11–3 × RIL 180 than those in other two crosses. The mean primary branches plant^{-1}, dry pods raceme^{-1} and 100 dry seed weight were comparable in all the three crosses. The average raceme length and nodes raceme^{-1} in F_2 generation derived from HA11–3× RIL 180 were higher than those derived from other two crosses.

In F_3 generation, mean plant height and racemes plant^{-1} were comparable between HA 10–8 × RIL 180 and FPB 21 × RIL 180 while they were lower in HA 11–3 × RIL 180. The mean raceme length, nodes raceme^{-1} and 100 dry seed weight were higher in HA11-3× RIL 180 than those in other two crosses. On the other hand, dry pods plant^{-1} and dry seed yield plant^{-1} were higher in FPB 21 × RIL 180 compared to other two crosses. The mean primary branches plant^{-1} and dry pods raceme^{-1} were comparable in all three crosses.

The estimates of standardized range which is a reflection of occurrence of extreme phenotypes were higher in HA11-3 × RIL 180 than those in the other two crosses for plant height, racemes plant^{-1}, dry pods plant^{-1}, dry pod yield plant^{-1} and dry seed yield

Table 4. Estimates of phenotypic coefficient of variation in F_2 and F_3 generations derived from three crosses of dolichos bean.

Traits	HA 10–8×RIL 180		FPB 21 × RIL 180		HA 11–3×RIL 180	
	F_2	F_3	F_2	F_3	F_2	F_3
Plant height (cm)	24.64	24.29	32.15	32.99	31.91	21.25
Primary branches plant^{-1}	28.56	22.73	33.79	34.41	35.91	34.54
Racemes plant^{-1}	61.08	63.49	58.75	61.37	73.70	59.75
Raceme length (cm)	33.45	19.89	34.39	23.38	29.48	28.83
Nodes raceme^{-1}	30.45	16.92	24.83	16.95	24.65	21.23
Dry pods raceme^{-1}	32.49	30.72	38.04	39.55	36.05	41.53
Dry pods plant^{-1}	56.83	70.30	53.17	63.29	69.10	61.19
Dry pod yield plant^{-1} (g)	54.90	70.39	51.83	66.92	63.17	60.61
Dry seed yield plant^{-1} (g)	57.95	68.24	52.50	79.60	64.85	60.74
100 dry seed weight (g)	09.46	08.23	09.86	01.95	12.97	14.79

Table 5. The best 10 F_5 plants (derived from HA 10-8 × RIL 180) selected based on fresh pod yield plant^{-1} and their attributing traits in dolichos bean.

Sl. No.	Pedigree of F_5 plants selection	Fresh pod weight plant^{-1}	Plant height (cm)	Primary branches plant^{-1}	Racemes plant^{-1}	Raceme length (cm)	Dry pods raceme^{-1}	Dry pods plant^{-1}	Dry seed yield plant^{-1} (g)	100 Dry seed weight
1	F_5 9-2	85.00	90.00	4.00	7.20	10.60	23.00	74.00	72.30	22.00
2	F_5 51-1	77.00	86.00	3.00	8.00	14.40	21.00	75.80	61.60	21.00
3	F_5 44-4	81.50	69.00	2.67	5.40	11.50	16.00	78.00	60.20	21.50
4	F_5 19-2	93.00	75.00	2.00	6.80	13.50	14.00	82.40	59.80	21.00
5	F_5 71-3	78.74	67.20	3.00	6.16	10.56	15.00	60.08	59.30	21.00
6	F_5 87-4	64.50	63.00	3.00	5.80	13.68	12.00	73.70	57.90	19.50
7	F_5 48-2	70.00	78.00	2.00	6.80	11.80	15.00	61.30	57.40	19.50
8	F_5 19-4	76.00	69.00	3.00	7.40	13.46	17.00	76.50	55.70	18.00
9	F_5 40-1	85.00	72.00	3.00	6.20	12.00	09.00	70.20	54.10	20.50
10	F_5 102-2	83.54	65.00	4.20	6.80	13.15	15.60	66.20	50.38	19.50
Parent	HA 10-8	64.02	45.60	3.60	4.76	15.54	10.00	42.64	37.34	19.00
Parent	RIL 180	45.10	21.60	2.40	4.48	06.76	04.60	18.40	16.62	16.00
Check	HA 4	54.00	43.00	3.00	6.60	20.40	07.00	44.50	39.40	19.00
SE ± m		1.06	1.43	0.05	0.08	0.24	0.40	1.40	1.09	0.13
CD @ p=0.05		2.08	2.81	0.10	0.15	0.48	0.79	2.75	2.13	0.25

plant^{-1} in F_2 generation (Table 3). For primary branches plant^{-1} and raceme length the estimates of standardized range were higher in F_2 generation derived from FPB 21 × RIL 180 than those derived from other two crosses. In F_3 generation, the estimates of standardized range were higher in HA11–3 × RIL 180 than those in other two crosses for primary branches plant^{-1}, raceme length and dry pods raceme^{-1}. The estimates of standardized range were higher in HA10–8 × RIL 180 than those in other two crosses for racemes plant^{-1}, nodes raceme^{-1}, dry pods plant^{-1}, dry pod yield plant^{-1} and dry seed yield plant^{-1} in F_3 generation.

In F_2 generation derived from HA11–3 × RIL 180, the estimates of PCV were higher than those in other two crosses for six traits such as primary branches plant^{-1}, racemes plant^{-1}, dry pods plant^{-1}, dry pod yield plant^{-1}, dry seed yield plant^{-1} and 100 dry seed weight (Table 4). In F_3 generation, the estimates of PCV were higher in HA11-3× RIL 180 than those in other two crosses for primary branches plant^{-1}, raceme length, nodes raceme^{-1}, dry pods raceme^{-1} and 100 dry seed weight.

By and large, the estimates of mean were comparable between F_2 and F_3 generations derived from HA10-8 × RIL 180 for all the traits. While the estimates of mean primary branches plant^{-1}, receme length, nodes raceme^{-1}, dry pods raceme^{-1}, and 100 dry seed weight were comparable, the estimates of mean values for plant height, racemes plant^{-1}, dry pods plant^{-1}, dry pod yield plant^{-1} and dry seed yield plant^{-1} increased from F_2 and F_3 generations derived from FPB 21× RIL 180. However, the means of all the traits marginally increased from F_2 to F_3 generations derived from HA11-3 × RIL 180.

In contrast to estimates of means, those of PCV decreased from F_2 and F_3 generations derived from HA11-3× RIL 180 for most of the traits. The estimates of PCV decreased from F_2 to F_3 generations derived from HA10-8 × RIL 180 for seven traits while they increased for other three traits namely dry pods plant^{-1}, dry pod yield plant^{-1} and dry seed yield plant^{-1}. The decreasing trend in traits variances from F_2 to F_3 is expected (Cornish, 1990). On the other hand, the estimates of PCV increased from F_2 to F_3 for seven of the 10 traits while they decreased from F_2 to F_3 generations derived from HA 10-8× RIL 180 and FPB 21 × RIL 180 for other three traits such as raceme length, nodes raceme^{-1} and 100 dry seed weight in

FPB 21 × RIL 180. The differences in the estimates of quantitative trait means, standardized range and PCV in F_2 and F_3 generations derived from the three crosses could be attributed to differences in the contribution of genes from female parents as male parent is common to all the three crosses.

From the results, it could be opined that based on traits means *per se* in F_2 and F_3 generations, HA11-3 × RIL 180 appeared to have better breeding potential than the other two crosses. However, if the trend in the estimates of quantitative traits means and PCV are considered, HA10-8 × RIL 180 and FPB 21 × RIL 180 appeared to have better potential than that of the other cross. While high mean ensure high *per se* performance in subsequent generations, high variance will result in uncovering the genotypes useful for selection. Following similar procedure, earlier studies also predict the breeding potential of crosses in finger millet [6].

Selecting F_2's and F_3's with higher trait means and higher variances and rejecting F_2's and F_3's with different combinations of means and variances, namely high mean and low variance, low mean and high variance or low mean and low variance has been the common procedure practiced by breeders. Considering better breeding potential, the F_2's of HA 10-8 × RIL 180 were forwarded to F_5 generation using seed-pod-seed method. The F_5 progenies along with checks, HA 3 and HA 4 were grown in plant-to-progenies in a single row of 3 m length. The best 10 plants which surpassed the check HA-4 for fresh pod yield plant^{-1} were selected for further evaluation (Table 5).

Conclusion

The present study indicated the utility of the quantitative traits means and variances in early segregating generations for predicting the breeding potential of crosses to maximize the frequency of desirable recombinant inbred lines in advanced generations.

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