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RESEARCH ARTICLE

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Construction of Selection Indices by using Different Economic Coefficients in Indian Bean [*Lablab purpureus* (L.) Sweet]

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ABSTRACT

Background: Most of the plant characters are governed by polygenes and greatly influenced by environmental conditions. The progress of breeding is conditioned by the magnitude, nature and interrelationship of genotypic and non-genotypic variation. In most of the crop improvement programs, the improvement of one trait may cause advancement or deterioration in associated traits serves to emphasize the need for simultaneous consideration of all traits which determine the economic value of a genotype.

Methods: The present investigation was undertaken for Indian bean [*Lablab purpureus* (L.) Sweet] to construct efficient selection indices for selecting best progenies. The experiment was conducted with 55 progenies with checks GNIB-21 and GNIB-22 in randomized block design (RBD) with 3 replications. An attempt was made to build a selection index by taking 3 different type of economic weights *viz.* equal weight [W_1], genotypic correlation coefficients [W_2] and genotypic path coefficients (Direct effect) [W_3].

Result: It has been seen that genetic gain of Indian bean of selected progenies observed higher with equal weight method as compared to weight assigned method with genotypic correlation coefficients and genotypic path coefficients (Direct effect). It has been concluded that the selection of progeny based on seed yield per plant, plant height, pod width and days to maturity provide higher genetic gain in Indian bean.

Key words: Genetic gain, Genotypic correlation coefficients, Indian bean, Path coefficients, Selection indices.

INTRODUCTION

Indian bean (*Lablab purpureus* L. Syn. *Dolichos lablab* L., 2n = 22) is a well-known vegetable crop of India and South-East Asia. It is an important subsistence crop in many countries, especially Sudan (George, 2011). In India, vegetables are important crop in the horticulture sector, occupying 10.32 million hectare of area with average productivity of 18.4 tonnes/hectare for the year 2020-21. Indian bean is one of the perennial vegetable crop in India which is consumed as vegetable, pulse and forage.

The variability present in a population can be partitioned into heritable and non-heritable parts with the aid of genetic parameters such as genetic coefficient of variation, heritability and genetic advance (Miller *et al*., 1958). Yield is a complex character of any crop governed by quantitative traits and its grown environment, thus, selection for grain yield becomes difficult unless the association between the yield contributing characters are known. Genetic variability (Sivasubramanian and Madhavamenon, 1973), heritability along with genetic advance (Johnson *et al*., 1955) of traits, path analysis (Wright, 1923), allows unfolding coefficients of correlations into direct and indirect effects on yield are essential criteria for crop improvement (Alcantara Neto *et al.,* 2011).

The selection indices based on yield attributing characters *viz.* pods per plant, plant spread and green-pod yield was considered more effective than selection based on green-pod yield alone (Rathnaiah, 1986). Hadavani *et al.* (2018) and Rukhsar *et al.* (2021) constructed selection indices in the Indian bean and cowpea respectively on different characters using a discriminant function analysis. Lima *et al.* (2015) evaluated selection efficiency of plant architecture, plant disease, grain type and yield by means of a selection index in order to obtain superior progenies for traits. Singh and Ramgiry (2018) computed selection indices on the basis of linear combination of 40 soybean germplasm based on nodulation, yield and quality traits. Choudhary *et al.* (2017) studied Mungbean genotypes to assess the magnitude of genotypic variability, heritability and selection indices among the yield components and their direct and indirect effects on grain yield. The method of selection indices adopted by Nyo *et al.* (2020) to regularized indices for breeding value prediction using fifty improved rice genotypes. Yang *et al.* (2021) developed an optimized protocol for selection of sugarcane seedlings that balances the desire to maximize genetic gains but also be cost and labor efficient.

The main aim of breeding program is the improvement of the economic value of an individual through selection

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which is applied to the several traits simultaneously because economic value depends on more than one trait (Lynch and Walsh, 1998; Bernardo, 2002). Appropriate weights will be allocated to each character following their relative economic importance. There is no standard strategy to assign weights to the biometrical characters in the selection indices method. Hence, the current study has been carried out for construction of selection indices by taking different weights.

MATERIALS AND METHODS

The study was carried out at College farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari, India during late *Kharif,* 2018-2019. The experimental material consisted of fifty five F_4 progenies and two check varieties (GNIB-21 and GNIB-22) of Indian bean [*Lablab purpureus* (L.) Sweet]. These F_4 progenies were obtained from four crosses *viz.*, GNIB-21 × GP-1 (2 progenies), GNIB-21 × GP-167 (14 progenies), GNIB-21 × GP-189 (22 progenies) and GNIB-21 × GPKH-120 (17 progenies). The field experiment was conducted in RBD with three replications. The observations on seed yield per plant and its component characters were recorded from five randomly selected competitive plants for each treatment in each replication. Average values per plant were computed for different yield contributing characters *viz.* X_1 = Seed yield per plant (g), X_2 = Plant height (cm), X_3 = Pods per plant, X_4 = Pod width (cm) and X_5 = Days to maturity. Data recorded for yield contributing characters were subjected to analysis of variance (Panse and Sukhatme, 1978).

Selection index

Selection index (Smith, 1937) based on 'Discriminant function' which was given by Fisher (1936). Further Hazel (1943) developed a method of selection index based on the path coefficients. Appropriate weights was assigned to each character according to their relative economic importance. An attempt has been made by assigning different type of economic weights *viz.* equal weight [W_1], genotypic correlation coefficients [W_2] and genotypic path coefficients (Direct effect) [W_3]. Total 31 selection indices were constructed by taking five single characters as well as all possible combinations of these five characters.

Economic coefficients (Weights)

In the present study, different economic coefficients were obtained as weights and these weights has been used for the construction of selection indices.

Equal weight [W_1]

In equal weight method, a value of 1 was assigned to all characters to construct selection indices *i.e.* $a_1 = a_2 = a_3 = a_4 = a_5$.

Genotypic correlation coefficient [W_2]

The genotypic correlation coefficient was calculated between seed yield per plant (X_1) and different yield contributing characters (X_2, X_3, ...X_5) as per the formula given below:

$$r_g(x_i, x_1) = \frac{\sigma_g(x_i, x_1)}{\sqrt{\sigma^2_g(x_i) \times \sigma^2_g(x_1)}} \quad [1]$$

Where,

$r_g(x_i, x_1)$ = Genotypic correlation coefficient between X_i and X_1 (i = 2, 3,…,5).

$\sigma_g(x_i, y)$ = Covariance between X_i and X_1.

$\sigma^2_g(x_i)$ = Genotypic variance of the variable X_i.

$\sigma^2_g(x_1)$ = Genotypic variance of the variable X_1.

Genotypic path coefficients (Direct effect) [W_3]

Correlation coefficient was computed from variance and covariance components as suggested by Burton, (1952), Wright, (1968) and Singh and Chaudhary, (1985). The correlation coefficient was further partitioned into direct and indirect causes according to Dewey and Lu, (1959). The path coefficients (P_{ij}) are obtained as follow:

$$P_{ij} = B^{-1} A \quad [2]$$

Where,

P_{ij} = Path coefficient.

B^{-1} = Inverse of correlation matrix of character X_i and X_1.

A = Correlation matrix between character X_i and X_1.

Expected genetic advance/gain

Genetic advance explains the degree of gain obtained in a character under a particular selection pressure. High genetic advance coupled with high heritability estimates offers the most suitable condition for selection which indicates the presence of additive genes in the trait and further suggest reliable crop improvement through selection of traits (Ogunniyan and Olakojo, 2014). The expected genetic advance/gain is calculated as (Dabholkar, 1992).

$$GA = \frac{Z}{P}\left(\frac{\sum_{i=1}^{p}\sum_{j=1}^{p} a_i b_j G_{ij}}{\sum_{i=1}^{p}\sum_{j=1}^{p} a_i b_j P_{ij}}\right)$$

where,

Z / P = Selection intensity *i.e.* 2.06 at 5% level of significance.

G_{ij} = Genotypic variance and covariance of the different component characters (i=j=1,2,…p characters).

P_{ij} = Phenotypic variance and covariance of the different component characters.

a_i = Weight assigned to ith character.

b_i = Coefficient of i^{th} character.

b_j = Transpose of b_i.

Per cent relative efficiency (PRE)

The relative efficiency of each index has been calculated using genetic gain of seed yield as standard.

$$PRE = \frac{\text{Genetic gain of selection index}}{\text{Genetic gain of seed yield}} \times 100$$

Selection score

The value of the progeny was measured using selection score (H) which is calculated as under:

$$H = \sum_{i=1}^{n} b_i X_i$$

Where,

X_i = Value of ith character (i = 1 to 5).

b_i = Coefficient of ith character.

The best five progenies were selected on the basis of highest score from all the methods (W_1, W_2 and W_3).

Spearman rank correlation

The method-wise ranking was done based on selection score to identify the progenies with their value. The Spearman rank correlation analysis (1904) was employed to find out the degree of association between different weight methods.

RESULTS AND DISCUSSION

Mean performance of progenies

The data were recorded on different quantitative traits has been taken for the analysis of variance (Table 1). Significant variation existed in all the selected traits studied except days to maturity. The seed yield per plant was found significantly higher in progeny F_3B144-2 (17.18 g) and statistically at par with F_3D214-6*1 (13.86 g). The maximum plant height was observed in F_3C246-2 (58.95 cm) followed by F_3C246-3*2 (58.79 cm). The progeny F_3D269-10*2 (32.96) had maximum pods per plant followed by F3D214-6*1 (31.25). The pod width was found maximum in progeny F3B144-4 (1.64 cm) followed by F3B144-8a (1.63 cm). The presence of sufficient variability in all the progenies for all selected characters indicates that selection can be made among the progenies for further improvement.

Genotypic correlation coefficients and path coefficients analysis

The genotypic correlation coefficients between seed yield per plant and its different selected traits is presented in Table 2 along with path coefficients which estimated through path analysis at genotypic level. Correlation study revealed that all the traits showing high positive significant genotypic

Table 1: Mean performance of progenies in Indian bean.

Progenies	Seed yield per plant (g)	Plant height (cm)	Pods per plant	Pod width (cm)	Days to maturity
F_3A1781-4*2	10.93	38.50	18.37	1.58	110.67
F_3B2951-1*3	6.11	43.68	15.58	1.23	109.33
F_3B106-7*3	3.72	25.15	7.92	1.20	114.67
F_3B295II-6*3	7.48	49.43	18.61	1.23	108.00
F_3B269II-2	8.01	43.05	21.04	0.93	110.33
F_3B144-2	17.18	54.39	25.90	1.55	114.33
F_3B295II-9*1	10.68	46.81	21.11	1.05	110.67
F_3B144-8a	9.01	50.70	14.35	1.63	108.00
F_3B144-16	13.12	52.75	18.64	1.48	112.33
F_3B144-6	12.79	52.75	20.88	1.54	116.00
F_3B144-3	11.18	49.79	16.84	1.45	112.67
F_3B144-8b	10.76	45.00	16.50	1.25	111.33
F_3B144-1	9.68	53.96	16.38	1.55	111.33
F_3B144-4	10.90	50.73	14.50	1.64	110.33
F_3B144-15	10.26	51.56	16.54	1.62	110.33
F_3C163-4	6.23	43.08	12.17	1.20	110.00
F_3C163-3	5.91	36.43	9.99	1.09	110.00
F_3C246-3*2	12.06	58.79	15.71	0.93	114.33
F_3C246-2	11.83	58.95	19.22	0.91	114.67
F_3C83-5*4	6.15	41.75	12.45	1.02	110.00
F_3C253-12*4	5.91	50.84	11.13	1.19	109.00
F_3C253-2*2	5.86	56.38	9.96	0.93	113.67
F_3C163-8	7.17	46.09	14.63	1.08	108.00
F_3C163-5	8.34	50.96	15.36	1.49	109.33
F_3C181-8*1	9.87	55.97	15.60	1.40	110.67
F_3C246-6	7.23	57.79	11.67	1.04	112.33
F_3C163-13*3	9.14	58.13	16.38	1.06	109.00
F_3C163-5	7.83	51.78	13.82	0.91	114.67
F_3C163-3	10.63	52.50	19.80	1.35	117.00
F_3C246-12	9.23	57.90	12.63	1.03	113.33
F_3C163-3	9.81	57.38	18.76	1.22	110.67

Table 1: Continue...

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F_3C163-4	9.25	46.73	16.23	0.86	109.00
F_3C163-6	8.01	46.08	14.58	1.25	110.33
F_3C163-16	9.71	50.53	16.61	0.95	111.67
F_3C163-2	6.50	52.08	11.67	0.71	108.00
F_3C163-7*2-1*1	8.88	48.18	16.41	0.95	111.33
F_3D136II	11.37	46.92	26.24	1.46	112.33
F_3D214-6*1	13.86	49.67	31.25	1.02	116.00
F_3D3-1*1	8.26	44.38	23.01	0.81	109.33
F_3D136II-10	9.19	43.80	24.61	1.25	112.67
F_3D64-5	5.75	39.08	20.30	0.82	109.33
F_3D135-11*1	3.92	40.73	16.23	0.94	117.00
F_3D44-3*2	6.51	35.73	19.63	0.92	113.00
F_3D136II-13	5.27	40.92	14.88	0.93	110.67
F_3D269-10*2	10.83	49.63	32.96	0.91	109.00
F_3D85II-13*2	8.78	48.96	21.79	0.89	109.33
F_3D43-8*2	9.21	46.58	21.06	0.91	112.67
F_3D214-11*3	7.71	38.63	19.57	0.92	110.33
F_3D72II-5*1	3.70	33.52	9.78	0.89	117.00
$F_{2:3}$D135I	8.37	45.34	21.56	0.95	109.33
$F_{2:3}$D124II	9.01	47.69	21.66	0.92	113.67
$F_{2:3}$D-11	7.36	48.46	19.63	0.88	111.67
$F_{2:3}$D222II	5.57	36.73	14.62	0.97	109.00
$F_{2:3}$119(A)	7.03	38.52	15.69	1.60	108.00
$F_{2:3}$111(C)	5.36	40.02	11.33	0.92	116.67
Check1:GNIB22	6.59	42.21	21.75	0.94	108.67
Check2:GNIB21	6.99	41.75	21.50	0.76	113.33
Mean	8.56	47.12	17.49	1.12	111.51
SEm±	1.48	3.46	2.81	0.07	2.47
CD ($P \leq 0.05$)	4.19	9.79	7.94	0.19	NS
CV (%)	30.02	12.73	27.80	10.53	3.83

relationship with seed yield per plant. Days to maturity showed highest value of association with seed yield per plant (0.65) followed by pod width (0.55), plant height (0.53) and pods per plant (0.44).

Path coefficient analysis has been used to determine the nature of relationships between seed yield per plant and its contributing components. It has been seen that yield attributing characters have significant positive direct effect (rg) on seed yield per plant therefore it has been used in crop breeding programs. The days to maturity showed highest direct effect (0.68) followed by pod width (0.65), pods per plant (0.41) and plant height (0.23).

Table 2: Association and direct effect between selected trait and seed yield per plant of Indian bean.

Yield contributing characters	Plant height (cm)	Pods per plant	Pod width (cm)	Days to maturity	r_g
Plant height (cm)	0.23	-0.04	0.14	0.20	0.53**
Pods per plant	-0.02	0.41	-0.02	0.07	0.44**
Pod width (cm)	0.05	-0.01	0.65	-0.14	0.55**
Days to maturity	0.07	0.04	-0.14	0.68	0.65**

*Significant at $P \leq 0.05$, **Significant at P = 0.01.

Selection indices for individual and all combination of yield contributing character

Selection indices has been constructed by taking different weight (*Wi*) for all selected individual and all possible combinations of the characters. Among all possible combinations, the top two selection indices with respect to their Percent relative efficiency (PRE) and genetic gain in different methods are presented in Table 3. It has been observed that PRE and genetic gain is higher in equal weight method (W_1) as compared to remaining methods (W_2 and W_3). It has been also found that selection index (I_{1245}) *i.e.* combinations of four characters *viz.* seed yield per plant, plant height, pod width and days to maturity, showed high PRE and genetic gain *w.r.t.* remaining selection index obtained by all combinations of characters.

The current study also reveals that the selection index which includes more than one characters, gave high genetic advance, which suggest the utility of constructing of selection indices for effective simultaneous improvement in several characters and achieving higher genetic gain in late *kharif* season. Overall it observed that equal weight

Table 3: Performance of different weight methods in selection indices.

Combination of character	Selection index	Equations	Genetic gain	PRE
		Equal weight (W_1)		
Individual	I_2	$I=0.519X_2$	9.24	316.98
	I_3	$I=0.422X_3$	5.56	190.74
Two	I_{12}	$I=0.024X_1+0.609X_2$	10.95	375.67
	I_{25}	$I=0.540X_2+0.137X_5$	9.65	331.16
Three	I_{124}	$I=-0.176X_1+0.632X_2+6.724X_4$	11.62	398.72
	I_{125}	$I=0.096X_1+0.612X_2+0.193X_5$	11.44	392.36
Four	I_{1235}	$I=0.939X_1+0.377X_2-0.070X_3+0.151X_5$	11.66	400.00
	I_{1245}	$I=-0.087X_1+0.635X_2+6.034X_4+0.224X_5$	11.97	410.82
Five	I_{12345}	$I=0.763X_1+0.396X_2-0.01X_3+3.233X_4+0.17X_5$	11.91	408.79
		Genotypic correlation coefficients (W_2)		
Individual	I_2	$I=0.419X_1$	2.91	100.00
	I_3	$I=0.275X_2$	4.90	168.00
Two	I_{12}	$I=0.226X_1+0.313X_2$	6.71	230.28
	I_{25}	$I=0.288X_2+0.077X_5$	5.16	177.03
Three	I_{124}	$I=0.08X_1+0.33X_2+4.73X_4$	7.24	248.54
	I_{125}	$I=0.274X_1+0.315X_2+0.120X_5$	7.08	242.98
Four	I_{1235}	$I=0.841X_1+0.193X_2-0.153X_3+0.093X_5$	7.49	256.85
	I_{1245}	$I=0.139X_1+0.332X_2+4.277X_4+0.142X_5$	7.51	257.61
Five	I_{12345}	$I=0.703X_1+0.208X_2-0.107X_3+2.296X_4+0.107X_5$	7.67	263.15
		Genotypic path coefficients (Direct effect) (W_3)		
Individual	I_2	$I=0.419X_1$	2.91	100.00
	I_3	$I=0.173X_3$	2.28	78.20
Two	I_{12}	$I=0.355X_1+0.124X_2$	4.26	146.22
	I_{25}	$I=0.401X_1+0.121X_3$	4.07	139.73
Three	I_{124}	$I=0.663X_1+0.032X_2-0.007X_3$	4.94	169.54
	I_{125}	$I=0.246X_1+0.137X_2+3.768X_4$	4.82	165.26
Four	I_{1235}	$I=0.478X_1+0.052X_2+0.056X_3+3.084X_4$	5.29	181.34
	I_{1245}	$I=0.786X_1+0.024X_2-0.044X_3+0.061X_5$	5.43	186.22
Five	I_{12345}	$I=0.676X_1+0.036X_2-0.008X_3+2.038X_4+0.072X_5$	5.64	193.64

Note: I_1, I_2,…., I_6, I_{12}, I_{13},….., I_{45}, I_{123}, I_{124},…, I_{345}, I_{1234}, I_{1235},….., I_{2345} are selection indices.

Table 4: Selection score values of Indian bean progenies.

	Selection score value					
Rank	Progenies	EW [W_1]	Progenies	GCC [W_2]	Progenies	GPC [W_3]
1	F_3B144-2	68.01	F_3B144-2	43.31	F_3B144-2	20.64
2	F_3C181-8*1	67.92	F_3B144-6	42.35	F_3D214-6*1	17.79
3	F_3C163-3	67.73	F_3B144-1	41.70	F_3B144-16	17.61
4	F_3B144-1	67.71	F_3C181-8*1	41.66	F_3B144-6	17.48
5	F_3B144-6	67.66	F_3B144-16	41.62	F_3C246-3*2	17.17

Note: EW = Equal weight, GCC = Genotypic correlation coefficients, GPC = Genotypic path coefficients (Direct effect).

method provide more PRE and high genetic gain as compared to other weight methods. It has been also observed that in construction of selection indices the addition of X3 (Pods per plant) character in I1245 which resulted reduction of PRE from 410.82 to 408.79% in **W_1** weight methods. Ranking of Indian bean progenies based on selection scores The selection score has been calculated for each progenies of Indian bean based on best selection index *i.e.* I1245 for all weight methods. The progenies were ranked based on their selection score and top first 5 rank is presented in Table 4. It has been observed that selection scores obtained through equal weight (W_1) found apparently higher followed by W_2 and W_3 weight methods. It reveals that equal weight method performed better than other two methods. The ranking of progenies moderately similar for all the three weight methods (Fig 1).

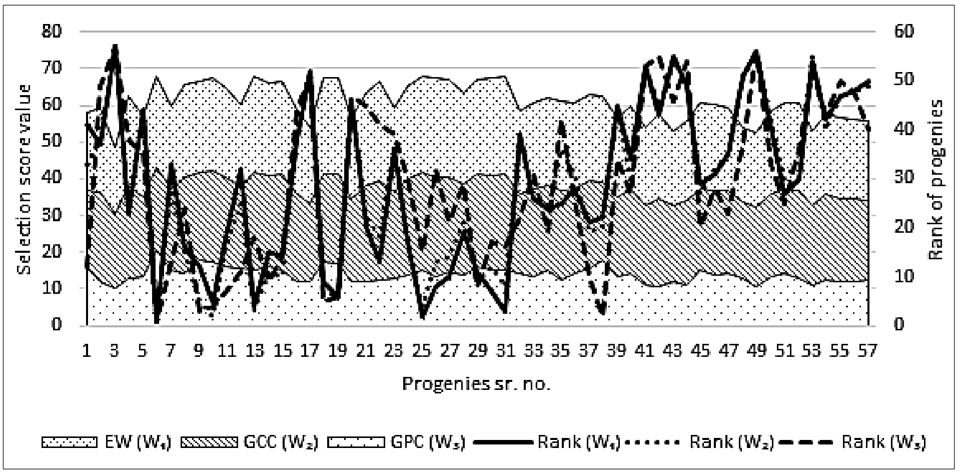

Fig 1: Selection score values and rank of progenies under different weight methods.

Table 5: Rank correlations coefficients between different weight methods.

Weight methods	Rank based on seed yield/plant	EW [W_1]	GCC [W_2]	GPC [W_3]
Rank based on seed yield/plant	1.00	0.67**	0.76**	0.99**
EW [W_1]		1.00	0.98**	0.75**
GCC [W_2]			1.000	0.83**
GPC [W_3]				1.000

** Significant at P≤0.01; n=57.

Further it has been seen that progeny F_3B144-2 possessed 1st rank under all the weight methods and thus recommended for future breeding programme. It was perceived that Progeny F3C181-8*1 and F3B144-6 possessed 2nd rank in W_1 and W_2 weight methods respectively while 4th under W_2 and W_3 weight method respectively.

Rank correlation between different weight (Wi) methods

Rank correlation has been calculated between assigned ranks to progenies based on selection scores and seed yield per plant (Table 5). The results designated that all correlation coefficients among different weight methods were more than 0.75 and highly significant which indicated the ranking of progenies based on the selection index I_{1245} with highest PRE under different weights method and comparatively similar for all the progenies. It has been seen that there is highly positive correlation which explained closed association with W_3 method (rs=0.99) followed by W_1 and W_2 weight method.

CONCLUSION

The genetic gain and PRE was observed higher in equal weight method than other two methods, therefore one can use equal weight to achieve higher genetic gain in Indian bean for purpose of breeding improvement programs. The study also determined PRE further increased with the inclusion of two or more characters. The best PRE was obtained with four character combinations (I_{1245}). Looking towards the simplicity of assigning weight and achieving highest genetic gain and PRE, the selection index, combinations of seed yield per plant, plant height, pod width and days to maturity was suggested to select the progenies for Indian bean seed yield improvement with equal weight method.

Conflict of interest: none.

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