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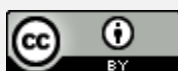
Analysis of Genetic Variability, Correlation and Path Co-efficient in Various Country Bean (*Dolichos lablab* L.) Genotypes

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Abstract

Twenty-six genotypes of Country bean (*Dolichos lablab* L.) were analysed for Genetic Variability, Correlation and Path Co-efficient. The genotypes were collected from Plant Genetic Resources Centre (PGRC) of Bangladesh Agricultural Research Institute (BARI), Gazipur. The study was undertaken at Sher-e-Bangla Agricultural University Farm, Dhaka to select suitable donor parents for improved breeding of Country bean. The objectives of the study were to measure the variability among the genotypes for yield and yield contributing characters, estimate genetic parameters, association among the characters and their contribution to yield. There was a great deal of significant variation for all the characters among the genotypes. High genotypic co-efficient of variation (GCV) was observed for pod width, inflorescence length, pod per inflorescence whereas low genotypic co-efficient of variation (GCV) was observed for seed width, seed length, days to first flowering. In all cases, phenotypic variances were higher than the genotypic variance. Heritability with low genetic advance in percent of mean was observed in seed width which indicated that non-additive gene effects were involved for the expression of this character and selection for such trait might not be rewarding. High heritability with high genetic advance in percent of mean was observed for pod width, inflorescence length indicated that this trait was under additive gene control and selection for genetic improvement for this trait would be effective. Correlation studies revealed that the highest significant association of yield per plant was observed with pod length, pod weight, pods per plant, inflorescence per plant. Path co-efficient analysis revealed the maximum direct contribution towards yield per plant was with pod weight followed by pods per plant, pod width and number of flower per inflorescence. Keyword: Country bean, Genetic Variability, Correlation and Path Co-efficient.

Keywords: Compost tea, lebak swamp soil, NPK fertilizer and rice husk.

Introduction

Dolichos lablab L. (Sweet) also known as country bean/ hyacinth bean, a self-pollinated crop, belongs to the family leguminosae, sub-family papilionaceae. Bangladesh, India, Philippines, Malaysia, Japan, Egypt and Sudan are the main grown region. Katyal and Chadha (1985) and Chowdhury *et al.* (1989) mentioned that India to be the place of its origin from where it is spread to the other parts of the world. This crop is grown worldwide for various purposes. In South and South East Asia, hyacinth bean is traditionally used as a pulse crop and the immature pods serve as a vegetable (Duke *et al.*, 1981). Similarly, in Africa both the grain and the immature pods are a minor human food source (Smartt, 1985) and it has become an important annual forage crop in Australia (English, 1999) and America (Maass *et al.* 2003). Despite its wide distribution in the tropics, its adaptability and diversity, it is considered as a neglected crop with underused potential (NAS, 1979; Smartt, 1985). *Dolichos* bean is mainly grown for its green

Pods, while the dry seeds are used in various vegetables preparation. 100 g of green pods contain 6.7 g carbohydrates, 3.8 g protein, 1.8 g fibre, 210 mg calcium, 68.0 mg phosphorus and 1.7 mg iron. The Lablab purpureus leaf and grain contain 21.38% and 20-28% of crude protein respectively (Norton, 1982). Lablab's protein is low in cereal grains and high in amino acids like lysine (6.2%). Therefore, it has the potential to significantly improve the diets of vulnerable rural communities in developing nations like Bangladesh.

Large-scale production of country beans can meet both the protein and vegetable minimum requirements. In the winter, it is cultivated on about 25910 hectares throughout the nation., yielding an average of 8.85 t of fresh pods per ha for a total yield of about 228000 t (BBS 2023). Low management techniques, the use of low-yielding indigenous cultivars, and the lack of locally created high-yielding varieties are the key causes of its relative lowness compared to other developed nations. So important objective of country beans breeding programs in Bangladesh and other

countries should be to increasing the genetic potential of yield, tolerance to biotic and abiotic stress. Knowledge of genetic diversity within a crop and correlation among the yield contributing characters is essential for the long-term success of a breeding programme and maximizes the exploitation of germplasm resources. These indigenous types of country bean contribute considerable degree of variability in respect to qualitative and quantitative characters. A successful hybridization programme for varietal improvement depends mainly on the selection of the parents having high genetic divergence (Upadhyay and Mehta, 2010).

Knowledge of the structure of genetic diversity within a large germplasm collection is very important in making decisions on germplasm management, as well as in developing breeding strategies. Recently, some attempts have been made to use molecular markers to study genetic diversity in hyacinth bean. For example, Liu (1996) studied genetic variation among 40 accessions of hyacinth bean using random amplified polymorphic DNA. A high level of genetic variation was detected but mainly between cultivated and wild forms and not within cultivated forms. Genetic variation was significantly greater among Asian accessions of the cultivated genotypes than among African accessions. Pengelly and Maass (2001), using morphological and agronomic characters, found greater variation in wild forms from eastern and southern Africa than within cultivated landraces collected from Africa and Asia. They also found that the wild and cultivated forms from the East African highlands, particularly Ethiopia, belonged exclusively to subsp. *uncinatus* and were distinct from the remainder of the collection studied.

Among the quantitative characters, yield is a complex character, which is dependent on a number of yield contributing characters. The knowledge of the association of yield components and their relative contribution shown by path analysis has practical significance in selection (Upadhyay and Mehta, 2010). Since wide genetic diversity exists within the country bean for almost all the characters (Ismunadji and Arsyad, 1990), there is a need of the information on the nature and magnitude of the variation available in the materials and role played by the environment in expression of different characters.

Keeping in view the above facts, the present investigation was therefore undertaken to quantify the genetic divergence and variability in a diverse local collection of *Dolichos lablab* L. (Sweet) genotypes with the following objectives:

To identify the primary yield-contributing features as well as how they affect yield both directly and indirectly.

To investigate the relationships between the traits that contribute to pod and seed yield and identify the key genetic parameters related to pod yield and beneficial traits.

Materials and Methods

The research work was conducted at the Sher-e-Bangla Agricultural University Farm, Dhaka-1207. The experimental area was situated at 23°77'N latitude and 90°33'E longitude at an altitude of 8.6 meter above the sea level. The experimental field belongs to the Agro-ecological zone of "The Modhupur Tract", AEZ-28.

Table 1. Name and origin of twenty six genotypes of country bean used in the present study

Sl.No.	Genotypes No.	BARI ACC Number	Origin
1	G1	BD-8737	PGRC, BARI
2	G2	BD-1816	PGRC, BARI
3	G3	BD-808	PGRC, BARI
4	G4	BD-8312	PGRC, BARI
5	G5	BD-7978	PGRC, BARI
6	G6	BD-7985	PGRC, BARI

7	G7	BD-8832	PGRC, BARI
8	G8	BD-1805	PGRC, BARI
9	G9	BD-7995	PGRC, BARI
10	G10	BD-7977	PGRC, BARI
11	G11	BD-7998	PGRC, BARI
12	G12	BD-113	PGRC, BARI
13	G13	BD-8034	PGRC, BARI
14	G14	BD-130	PGRC, BARI
15	G15	BD-7999	PGRC, BARI
16	G16	BD-8027	PGRC, BARI
17	G17	BD-137	PGRC, BARI
18	G18	BD-8001	PGRC, BARI
19	G19	BD-1830	PGRC, BARI
20	G20	BD-132	PGRC, BARI
21	G21	BD-1809	PGRC, BARI
22	G22	BD-8729	PGRC, BARI
23	G23	BD-8813	PGRC, BARI
24	G24	BD-7988	PGRC, BARI
25	G25	BD-6	PGRC, BARI
26	G26	BD-8816	PGRC, BARI

Here, PGRC = Plant Genetic Resources Centre, BARI = Bangladesh Agricultural Research Institute.

Estimation of genotypic and phenotypic variances

Genotypic and phenotypic variances were estimated according to the formula given by Johnson *et al.* (1955).

Genotypic variance ($\sigma^2 g$) = (GMS-EMS)/r

Where,

GMS = Genotypic mean sum of squares

EMS = Error mean sum of square

r = number of replications

Phenotypic variance ($\sigma^2 ph$) = $\sigma^2 g$ + EMS

Where,

$\sigma^2 g$ = Genotypic variance

EMS = Error mean sum of square

Estimation of genotypic and phenotypic correlation co-efficient

For calculating the genotypic and phenotypic correlation co-efficient for all possible combinations the formula suggested by Miller *et al.* (1958), Johnson *et al.* (1955) and Hanson *et al.* (1956) were adopted.

The genotypic co-variance component between two traits and have the phenotypic co-variance component were derived in the same way as for the corresponding variance components.

Estimation of genotypic and phenotypic co-efficient of variation

Genotypic and phenotypic co-efficient of variation were calculated by the formula suggested by Burton (1952).

Estimation of heritability

Broad sense heritability was estimated (Lush, 1943) by the following formula, suggested by Johnson *et al.* (1955).

Estimation of genetic advance

The expected genetic advance for different characters under selection was estimated using the formula suggested by Lush (1943) and Johnson *et al.* (1955).

Estimation of genetic advance in percent of mean

Genetic advance in percent of mean was calculated from the following formula as proposed by Comstock and Robinson (1952):

$$\text{Genetic advance (\% of mean)} = \frac{\text{Genetic Advance (GA)}}{\text{Population mean } \bar{x}} \times 100$$

Results and Discussions

Variability of country bean based on yield and yield contributing characters

Days to first flowering

Genotypic and phenotypic variance was observed 29.70 and 36.00 respectively for days to first flowering with large environmental influence and difference between the genotypic co-efficient of variation (10.89) and phenotypic co-efficient of variation (11.99) indicating existence of less variation among the genotypes (Table-2). Heritability for this trait was estimated very high (82.48%) and genetic advance in percent of mean (20.37) were found high, indicated that the possibility of predominance of additive gene effect for this characters is in agreement with the findings of earlier workers Singh *et al.* (1979), Mallareddy (1979), Pandita *et al.* (1980), Kabir and Sen (1987) and Basavarajappa and Byre Gowda (2004). However, Muralidharan (1980) reported a high heritability coupled with low genetic advance for this trait.

Days to first fruiting

Highest genotypic and phenotypic variance was observed 61.94 and 71.84 respectively for days to first fruiting with large environmental influence and difference between the genotypic co-efficient of variation (13.11) and phenotypic co-efficient of variation

indicating large environmental influence on these characters. The genotypic co-efficient of variation and phenotypic co-efficient of variation were 31.39 and 32.73 respectively. Heritability (91.96%) estimates for this trait was high and genotypic advance in percent of mean (62.01) was found high, indicate that apparent variation was due to genotypes so selection based on this trait could be effective. Muralidharan (1980) has got same result.

No. of flower per Inflorescence

The differences in magnitudes in between genotypic (7.92) and phenotypic (9.48) variances was relatively high for this trait indicating large environmental influence on these characters. The genotypic co-efficient of variation and phenotypic co-efficient of variation were 25.49 and 27.89 respectively. Heritability (83.54) estimates for this trait was high and genotypic advance in percent of mean (48.00) was found high, revealed that the trait was controlled by additive gene agrees with the finding of Ali *et al.* (2005)..

No. of pod per inflorescence

The differences in magnitudes in between genotypic (5.44) and phenotypic (6.63) variances was relatively high for this trait indicating large environmental influence on these characters. The

Table 2. Genetic parameters of thirteen vegetative and yield contributing characters of 26 country bean genotypes.

Characters	σ^2_g	σ^2_p	σ^2_e	GCV	PCV	h^2_b	GA in % of mean (5%)
DFI	29.70	36.00	6.31	10.89	11.99	82.48	20.37
DFr	61.94	71.84	9.90	13.11	14.12	86.22	25.07
NI/P	84.63	92.04	7.40	31.39	32.73	91.96	62.01
NF/I	7.92	9.48	1.56	25.49	27.89	83.54	48.00
NP/I	5.44	6.63	1.19	31.75	35.05	82.06	59.24
IL (cm)	67.82	72.51	4.69	32.99	34.11	93.53	65.73
PL (cm)	5.23	6.28	1.05	25.50	27.94	83.28	47.94
PWi (cm)	1.54	1.60	0.07	49.50	50.55	95.88	99.85
PWe (g/pod)	1.88	2.37	0.49	20.82	23.40	79.21	38.18
SL (mm)	1.13	1.75	0.61	8.76	10.87	64.92	14.54
SWi (mm)	0.33	0.85	0.53	6.56	10.60	38.29	8.36
NP/P	790.29	1150.70	360.41	20.35	24.56	68.68	34.75
PY/P (g)	57514.32	64023.61	6509.2	26.51	27.97	89.83	51.76

σ^2_e = Environmental variance, σ^2_g = Genotypic variance, σ^2_p = Phenotypic variance, GCV = Genotypic coefficient of variation, PCV = Phenotypic coefficient of variation, h^2_b = Heritability, GA= Genetic advance.

DFI=Days to 1st flowering, DFr= Days to 1st fruiting, NI/P=No. of Inflorescence per plant, NF/I =No. of flower per Inflorescence, NP/I= No. of Pod per inflorescence, IL= Inflorescence length, PL=Pod length, PWi=Pod width, PWe= pod weight, SL= Seed length, SWi= Seed width, NP/P=No. of Pods/plant, PY/P= pod yield/plant.

(14.12) indicating existence of less variation among the genotypes. Heritability for this trait was estimated very high (86.22%) and genetic advance in percent of mean (25.07) were found high, indicated that the possibility of predominance of additive gene effect. Similar findings were recorded by Borah and Shadeque (1992), Basavarajappa and Byre Gowda (2004). In contrast, Mallareddy (1979) indicated higher heritability coupled with high genetic advance for this trait.

No. of inflorescence per plant

The differences in magnitudes in between genotypic (84.63) and phenotypic (92.04) variances was relatively high for this trait

genotypic co-efficient of variation and phenotypic co-efficient of variation were 31.75 and 35.05 respectively. Heritability (82.06) estimates for this trait was high and genotypic advance in percent of mean (59.24) was found high, revealed that the trait was controlled by additive gene. This is in line with the findings of Ali *et al.* (2005).

Inflorescence length (cm)

The genotypic variance and phenotypic variance were 67.82 and 72.51 respectively. The phenotypic variance appeared to be higher than the genotypic variance suggested considerable influence of environment on the expression of the genes controlling this

character. The genotypic co-efficient of variation (32.99) and phenotypic co-efficient of variation (34.11) were close to each other. Heritability (93.53%) estimates for this trait high and genotypic advance in percent of mean (65.73) were found moderately high, indicated that the trait was governed by additive gene and selection for this character would be effective. This finding is similar to that of Borah and Shadeque (1992) who recorded a high heritability value coupled with a high genetic advance for this character.

Pod length (cm)

The genotypic variance and phenotypic variance were 5.23 and 6.28 respectively. The phenotypic variance appeared to be higher than the genotypic variance suggested considerable influence of environment on the expression of the genes controlling this character. The genotypic co-efficient of variation (25.50) and phenotypic co-efficient of variation (27.94) were close to each other. Heritability (83.28%) estimates for this trait high and genotypic advance in percent of mean (47.94) were found moderately high, indicated that the trait was governed by additive gene and selection for this character would be effective. Heritability estimate for this trait was high and agrees with the results obtained by Singh et al. (1979), Pandita et al. (1980), Borah and Shadeque (1992) and Ali et al. (2005). Low genetic advance as percent of mean.

Pod width (cm)

The genotypic variance and phenotypic variance were 1.54 and 1.60 respectively. The genotypic co-efficient of variation and phenotypic co-efficient of variation were 49.50 and 50.55 respectively. Heritability (95.88%) estimates for this trait was high and genetic advance in percent of mean (99.85) indicated that this character was controlled by additive gene effects. Borah and Shadeque (1992) was reported similar result for these characters.

Pod weight (g)

The differences in magnitudes in between genotypic (1.88) and phenotypic (2.37) variances was relatively high for this trait indicating large environmental influence on these characters. The genotypic co-efficient of variation and phenotypic co-efficient of variation were 20.82 and 23.40 respectively for fruit weight which indicating that significant variation exists among different genotypes. Heritability (79.21%) estimates for this trait was high and genetic advance in percent of mean (38.18) indicated that selection for this character would be effective. Similar results were reported by Arunachala (1979), Baswana et al. (1980), Singh et al. (1985), Dahiya and Pandita (1989), Uddin and Newaz (1997) and Basavarajappa and Byre Gowda (2004).

Seed length (mm)

The genotypic variance (1.13) and phenotypic variances (1.75) were close to each other. The phenotypic variance appeared to be higher than the genotypic variance suggested considerable influence of environment on the expression of the genes controlling this character. The genotypic co-efficient of variation was 8.76 and phenotypic co-efficient of variation was 10.87. Heritability (64.92%) estimates for this trait was high and genotypic advance in percent of mean (14.54) were found moderately high, indicated that this trait was controlled by additive gene. Similar finding was reported by Kabir and Sen (1987).

Seed width (mm)

The genotypic variance (0.33) and phenotypic variances (0.85) were close to each other. The phenotypic variance appeared to be higher than the genotypic variance suggested considerable influence of environment on the expression of the genes controlling

this character. The genotypic co-efficient of variation was 6.56 and phenotypic co-efficient of variation was 10.60. Heritability (38.29%) estimates for this trait was high and genotypic advance in percent of mean (8.36) were found moderately high, indicated that this trait was controlled by additive gene. Similar finding was reported by Kabir and Sen (1987)

Number of pod per plant

The genotypic variance (790.29) and phenotypic variance (1150.70) for this trait were very low. The phenotypic variance appeared to be higher than the genotypic variance suggested considerable influence of environment on the expression of the genes controlling this character. The genotypic co-efficient of variation and phenotypic co-efficient of variation were 20.35 and 24.56 respectively which indicated presence of considerable variability among the genotypes. Heritability (68.68%) estimates for this trait was high and genetic advance in percent of mean (51.76) was found moderately high, indicated that the character was controlled by additive gene. Similar result was reported by Muralidharan (1980).

Pod yield per plant (g)

The differences in magnitudes in between genotypic (57514.32) and phenotypic (64023.61) variances was relatively high for this trait indicating large environmental influence on these characters. The genotypic co-efficient of variation and phenotypic co-efficient of variation were 26.51 and 27.97 respectively for yield per plant which indicating that significant variation exists among different genotypes. The heritability value (89.83%) as well as genetic advance in percent of mean (51.76) were observed very high. The very high heritability with moderate genetic advance provided opportunity for selecting high valued genotypes for breeding programme. Nayar (1984) has got same results for this characters.

Correlation co-efficient

Yield is a complex product being influenced by several interdependent quantitative characters. Selection for yield may not be effective unless the directly or indirectly influences of other yield components are taken into consideration. When selection pressure is exercised for improvement of any character highly associated with yield, it simultaneously affects a number of other correlated traits. Hence knowledge regarding association of character with yield and among themselves provides guideline to the plant breeder for making improvement through selection provide a clear understanding about the contribution in respect of establishing the association by genetic and non-genetic factors. Higher genotypic correlations than phenotypic one might be due to modifying or masking effect of environment in the expression of the character under study (Nandpuri et al. 1973). Results of genotypic and phenotypic correlation co-efficient of sixteen yield and its contributing traits of country bean were estimated as vegetative character and reproductive character with yield and shown in Table 3 which discussed character.

Days to first flowering

Significant positive relationships were found in days to first flowering at both genotypic and phenotypic levels (Table 3). Highly significant positive association between days to first flowering indicates that the traits are governed by same gene and simultaneous improvement would be effective. This character showed significant and negative correlation at both genotypic and phenotypic level between other traits like inflorescence per plant, flower per inflorescence, pod per inflorescence, pod length, pod weight, pod per plant and yield. Results indicated that the increasing the correlation of days to first flowering with other traits

Table 3. Genotypic and phenotypic correlation of nine yield contributing characters on yield of twenty six country bean Genotypes

Parameters		DFI	Inflorescence/ plant	Flower/ Inflorescence	Pod/ Inflorescence	Pod length (cm)	Pod width (cm)	Pod Weight (g/pod)	Pods/plant	Pod yield/plant
DFI	r_g	0.969**	-0.078	-0.195	-0.208	-0.262	0.108	-0.173	-0.256	-0.298
	r_p	0.841**	-0.052	-0.191	-0.194	-0.170	0.071	-0.126	-0.125	-0.218
DFr	r_g		-0.170	-0.275	-0.319*	-0.233	0.072	-0.115	-0.066	-0.066
	r_p		-0.150	-0.249	-0.293	-0.164	0.052	-0.049	-0.016	-0.080
NI/P	r_g			-0.144	0.175	0.052	0.167	0.004	0.794	0.612**
	r_p			-0.105	0.169	0.092	0.187	-0.030	0.404**	0.307
NF/I	r_g				0.982**	-0.100	-0.050	-0.536**	0.141	-0.353*
	r_p				0.774**	-0.109	-0.048	-0.150	0.077	-0.059
NP/I	r_g					-0.136	0.049	-0.231	0.301	0.080
	r_p					-0.072	0.055	-0.229	0.250	0.055
PL	r_g						-0.216	0.667**	0.053	0.555**
	r_p						-0.140	0.533**	0.069	0.493
PWi	r_g							-0.385*	0.029	-0.305*
	r_p							-0.346*	-0.007	-0.267
Pwe	r_g								-0.104	0.654**
	r_p								-0.027	0.613
NP/P	r_g									0.698**
	r_p									0.543

** indicates significant at 0.01 level of significance and * indicates significant at 0.05 level of significance

DFI=Days to 1st flowering, DFr= Days to 1st fruiting, NI/P=No. of Inflorescence per plant, NF/I=No. of flower per Inflorescence, NP/I= No. of Pod per inflorescence, PL=Pod length (cm), PWi=Pod width (cm), PWe= pod weight (g/pod), NP/P=No. of Pods/plant, GCY= Genotypic correlation with yield

decreasing the yield in country bean. Basavarajappa and Byre Gowda (2004) also noticed this positive significant association of days to 50 per cent flowering with seed yield.

Days to first fruiting

The days to first fruiting showed highly significant and negative correlation with pods per inflorescence at genotypic level (Table 3). This indicated that if day to first fruiting is delayed, then pod per inflorescence decreased. These results are in contrary with the findings of Mallareddy (1979), Pandey et al. (1980), Kabir and Sen (1987), Uddin and Newaz (1997), Basavarajappa and Byre Gowda (2004). The character showed insignificant and negative correlation at both genotypic and phenotypic level between other traits like, inflorescence per plant, flower per inflorescence, pod length, pod weight, pod per plant and yield. Insignificant association of these traits indicated that the association between these traits is largely influenced by environmental factors. But only positive correlation of days to first fruiting with pod width was observed. These results are in contrary with the findings of Mallareddy (1979), Pandey et al. (1980), Kabir and Sen (1987), Uddin and Newaz (1997), Basavarajappa and Gowda (2004).

Number of inflorescence per plant

The character showed highly significant and positive relationship with pod yield per plant at both genotypic and phenotypic levels (Table 3) indicated that if inflorescence per plant is increased, then yield also increased. This is in line with the findings of Joshi (1971), Uddin and Newaz (1997), Basavarajappa and Byre Gowda (2004) and Ali et al. (2005). The character showed highly significant and positive relationship with pod per plant at phenotypic levels (Table 3) indicated that if inflorescence per plant is increased, then pod per plant also increased. This is in line with the findings of Joshi

(1971), Uddin and Newaz (1997), Basavarajappa and Gowda (2004) and Ali et al. (2005). Negative and insignificant correlation between flowers per inflorescence. The character showed insignificant and positive relationship with pod per inflorescence, pod length, pod width, pods per plant at both genotypic and phenotypic level.

Number of flower per inflorescence

Flower per inflorescence showed positive and significant correlation with pod per inflorescence only at both genotypic and phenotypic level (Table 3). Baswana et al. (1980) agreed with this result. But this character produced insignificant and negative correlation at both genotypic and phenotypic level with pod length and pod width indicated that the association among these traits is largely influenced by environmental factors. This character produced significant and negative correlation at genotypic level with pod weight and pod yield indicated that the association among these traits is largely influenced by environmental factors.

No of pod per inflorescence

Pod per inflorescence showed insignificant and positive correlation with pod width, pod per plant and pod yield at both genotypic and phenotypic level (Table 3). Basavarajappa and Gowda (2004) was reported positive correlation with pod width, pod per plant and pod yield at both genotypic and phenotypic level. But this character produced insignificant and negative correlation at genotypic and phenotypic level with pod length and pod weight indicated that the association among these traits is largely influenced by environmental factors.

Pod length and pod width (cm)

Pod length showed significant and positive correlation with pod weight and pod yield at both genotypic and phenotypic level (Table

3) revealed that if the pod length is increased, then pod weight and pod yield also increased. Nandi *et al.* (1999) and Ali *et al.* (2005) recorded positive significant association of pod length with seed yield per plant. But this character produced insignificant and positive correlation at both genotypic and phenotypic level with pods per plant, negative and insignificant correlation with pod width.

Pod width also showed significant and negative correlation with pod weight at both genotypic and phenotypic level (Table 3) indicated that if the pod breadth is increased, then pod weight

relations observed between the number of pods per plant and seed yield was similar to the results of Gopalan *et al.* (1982). But it contradicts with Rahman (2002) and reported that pod yield/plant was positively and significantly correlated with days to first flowering

Path co-efficient analysis

Partitioning of genotypic correlation of different genotype, yield and its contributing traits in country bean are shown in Table 4.

Table 4. Path analysis of nine vegetative characters on yield of twenty six country bean genotypes.

	DFi	DFr	NI/P	NF/I	NP/I	PL	PWi	PWe	NP/P	GcY
DFi	0.245	-0.175	0.004	-0.064	0.066	0.031	0.005	-0.168	-0.243	-0.2982
DFr	0.238	-0.180	0.009	-0.090	0.101	0.028	0.003	-0.112	-0.063	-0.0656
NI/P	-0.019	0.031	-0.055	-0.047	-0.055	-0.006	0.007	0.004	0.752	0.6123**
NF/I	-0.048	0.050	0.008	0.326	-0.310	0.012	-0.002	-0.522	0.134	-0.3532*
NP/I	-0.051	0.058	-0.010	0.320	-0.316	0.016	0.002	-0.225	0.285	0.0800
PL	-0.064	0.042	-0.003	-0.032	0.043	-0.120	-0.010	0.649	0.050	0.5551**
PWi	0.026	-0.013	-0.009	-0.016	-0.015	0.026	0.044	-0.375	0.027	-0.3049*
PWe	-0.042	0.021	0.000	-0.175	0.073	-0.080	-0.017	0.973	-0.099	0.6536**
NP/P	-0.063	0.012	-0.043	0.046	-0.095	-0.006	0.001	-0.101	0.948	0.6982**

R = 0.132 ** indicates significant at 0.01 level of significance and * indicates significant at 0.05 level of significance

DFi=Days to 1st flowering, DFr= Days to 1st fruiting, NI/P=No. of Inflorescence per plant, NF/I =No. of flower per Inflorescence, NP/I= No. of Pod per inflorescence, PL=Pod length (cm), PWi=Pod width (cm), PWe= pod weight (g/pod), NP/P=No. of Pods/plant, GcY= Genotypic correlation with yield

decreased. On the other hand this character produced insignificant but positive correlation with pod per plant at genotypic level indicated that the association among these traits is largely influenced by environmental factors. Kabir and Sen (1987) reported that pod width was strongly correlated with pod number, pod length. Pod width also showed significant and negative correlation with pod yield per plant at genotypic level that indicated if pod width increase pod yield decreased. Upadhyay *et al.* (2012) founded that Pod yield per plant was exhibited positive correlation with pod length (0.499) and marketable pod weight (0.400). The results are supported by the findings of Baswana *et al.* (1980) and Dahiya *et al.* (1991).

Singh (2000) and Fatema *et al.* 2023; reported pod length showed significant and positive association with plant height, number of pods per plant and Alemu *et al.* (2017) reported that there was negative and significant association between green pod width and green pod length

Pod weight (g/pod)

The trait, pod weight showed highly significant and positive correlation with pod yield per plant at both genotypic and phenotypic level (Table 3) indicated that if the pod weight is increased, then the pod yield are also increased. Baswana *et al.* (1980) indicated positive association of grain yield with weight of pods, pod length, pod width and seeds per pod. The character also showed negative but insignificant correlation with pod per plant at both genotypic and phenotypic level.

Number of pod per plant

Yield highly significant and positively correlated with number of pod per plant at both genotypic and phenotypic level (Table 3) indicating that any increase in number of pod per plant should bring an enhanced in the yield. In present research, the high and positive

Days to first flowering

Days to first flowering showed the positive direct effect (0.245) on yield (Table 4) and agrees with the findings of Basavarajappa and Gowda (2004). The character also showed the maximum positive indirect effect through pod per inflorescence (0.066) followed by pod length (0.031), pod width (0.005), number of inflorescence per plant (0.004). The negative indirect effect of this character on yield via number of flower per inflorescence (- 0.064) was the highest followed by pod weight (-0.168), days to first fruiting (- 0.175) and number of pods per plant (-0.243) which finally made insignificant negative correlation between days to first flowering and yield per plant (-0.2982).

Days to first fruiting

Days to first fruiting showed a negative direct effect (-0.180) on yield (Table 4). Basavarajappa and Gowda (2004) agreed with this result but it contradicted with Shinde and Dumbre (2001), Salim *et al.* 2013. This character, also showed the highest positive indirect effect through days to first flowering (0.238) followed by number of pod per inflorescence (0.101) and pod length (0.028), number of inflorescence per plant (0.009), pod width (0.003) on yield. The character also produced negative indirect effect on yield via number of pods per plant (-0.063), number of flower per inflorescence (- 0.090), pod weight (-0.122). The cumulative effects of these characters produced a negative genotypic correlation on yield (-0.0656).

Number of inflorescence per plant

It was found that internodes distance showed the negative direct effect (-0.055) on yield (Table 4). The character also showed the maximum positive indirect effect through number of pods per plant (0.752) followed by days to first fruiting (0.031), pod width (0.007) and pod weight (0.004). The negative indirect effect of this

character on yield via pod length (-0.006) was the highest followed by days to first flowering (-0.019), number of flower per inflorescence (-0.047) and number of pod per inflorescence (-0.055) which finally made significant positive correlation between number of inflorescence per plant and yield per plant (0.6123).

Number of flower per Inflorescence

Number of flower per Inflorescence showed a positive direct effect (0.326) on yield (Table 4). A path coefficient analysis by Mallareddy (1979) also got the same result. This character also showed the highest positive indirect effect through number of pods per plant (0.134) followed by days to first fruiting (0.050), pod length (0.012), number of inflorescence per plant (0.008). The character also produced the negative indirect effect on yield via pod width (-0.002), days to first flowering (-0.048), number of pod per inflorescence (-0.310), pod weight (-0.522). The cumulative effects of these characters produced a significant and negative genotypic correlation on yield (-0.3532).

Number of pod per Inflorescence

Number of pod per inflorescence showed the negative direct effect (-0.316) on yield (Table 4). A path coefficient analysis by Mallareddy (1979) also got the same result. This character also showed high positive and insignificant genotypic correlation with yield per plant (0.0800) due to moderately high indirect effect through flower per inflorescence (0.320) followed by number of pods per plant (0.285), days to first fruiting (0.058), pod length (0.016), pod width (0.002). Significant genotypic correlation coefficients between number of branches per vine and yield further strengthened their reliability in the process of selection for higher yield. But the negative indirect effect through number of inflorescence per plant (-0.010), days to first flowering (-0.051), pod weight (-0.225).

Pod length (cm)

Pod length showed negatively direct effect (-0.120) on yield (Table 4). However Kabir and Sen (1987) had got highest direct effect on yield. This character, however, showed positive indirect effect through pod weight (0.649), number of pods per plant (0.050), number of pods per inflorescence (0.043), days to first fruiting (0.042). The negative indirect effect via inflorescence per plant (-0.003) followed by pod width (-0.010), number of flower per inflorescence (-0.032), days to first flowering (-0.064) which were contributed to result insignificant positive genotypic correlation with yield per plant (0.5551).

Pod width (cm)

Pod breadth showed a positive direct effect (0.044) on yield (Table 4). This character, however, showed also positive indirect effect through number of pods per plant (0.027), pod length (0.026), days to first flowering (0.026). The negative indirect effects were also observed via number of inflorescence per plant (-0.009) followed by days to first fruiting (-0.013), number of pods per inflorescence (-0.015), number of flower per inflorescence (-0.016) and pod weight (-0.375) which were contributed to result significant negative genotypic correlation with yield per plant (-0.3049).

Pod weight (g/pod)

Pod weight showed a positive direct effect (0.973) on yield (Table 4). Acharya (2013) reported seed weight had negligible positive direct effect on toward the yield, and he also reported high positive indirect effects towards pod yield per hectare via pod weight. This character showed positive indirect effect number of pods per inflorescence (0.073) followed by days to first fruiting (0.021), number of inflorescence per plant (0.000). But the negative indirect

effect through pod width (-0.017), days to first flowering (-0.042), pod length (-0.080), number of pods per plant (-0.099), number of flower per inflorescence (-0.175) which finally made significant positive correlation between pod weight and yield per plant (0.6536).

Number of Pods per plant

Number of pod per plant showed a positive direct effect (0.948) on yield (Table 4). Immaculee (2011) found pods per plant having the highest direct effect on yield per hectare. Positive direct effect on seed yield was also founded by Rahman et al. (1988) and Salim et al 2013 in Lablab purpureus. This character, however, showed also positive indirect effect through number of flower per inflorescence (0.046), days to first fruiting (0.012). The negative indirect effects were also observed via days to first flowering (-0.063), number of inflorescence per plant (-0.043), pod per inflorescence (-0.095), pod length (-0.006), pod weight (-0.101) which were contributed to result highly significant positive genotypic correlation with yield per plant (0.6982).

Conclusion

The present study demonstrated considerable genetic variability among the 26 genotypes of country bean for yield and its contributing characters. Traits such as pod width and inflorescence length showed high heritability with high genetic advance, suggesting that additive gene effects are predominant and direct selection for these traits would be effective for yield improvement. Conversely, seed width exhibited low genetic advance despite moderate heritability, indicating the influence of non-additive gene action and limited potential for selection. Correlation and path coefficient analyses further revealed that pod weight, pods per plant, pod width and number of flowers per inflorescence exerted the greatest direct effects on yield per plant. These findings collectively identify pod-related traits as key selection criteria and provide valuable guidance for the identification of superior donor parents to enhance breeding programs aimed at improving country bean productivity.

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