



## Exploring the yield and yield contributing traits variability in dolichos bean (*Lablab purpureus*): A character association and path analysis approach

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### ABSTRACT

An experiment was conducted during 2019–20 and 2020–21 at ICAR-Central Institute for Subtropical Horticulture, Lucknow, Uttar Pradesh to evaluate the magnitude of variability in dolichos bean [*Lablab purpureus* (L.) Sweet] genotypes for important horticultural traits and their associations. The observed range and mean variations of the studied traits revealed a significant genetic diversity among the genotypes. The narrow gap in the genotypic (GCV) and the phenotypic coefficient of variation (PCV) for delineated characters indicated that they are governed by genetic factors, and environmental factors had little or no impact on the phenotypic expression of these traits. The traits including pod yield, days taken to first flowering, weight of pod, plant height, and pod width, showed positive GCV, indicating the presence of additive genes action. Traits such as pod weight, days taken to first flowering, and pod width displayed high heritability and moderate genetic advance, suggesting that the high heritability of these traits is due to the effects of additive genes and that genetic gain can be expected through the phenotypic selection. The higher genotypic correlations revealed an inherent association between the traits. Therefore, the selection criterion for high yield was proposed based on the strong character association between plant height, number of pods/cluster, pod width, and pod weight. The number of pods/plant, followed by the number of clusters/plant had the highest direct positive effect on yield. Consequently, pod yield may be increased through selection of heavier pods, more clusters/plant, and more pods/cluster.

**Keywords:** Correlation, Genetic advance, Heritability, Path analysis

The dolichos bean [*Lablab purpureus* (L.) Sweet] is a prominent leguminous crop. It is praised for its high protein, mineral, and vitamin content and grows throughout the nation due to wide climatic adaptability, high tolerance to drought, and broad consumer acceptability. In the northern plains, it is grown by nutri-gardeners and commercial vegetable growers for green pods, immature fresh seeds as vegetables, as well as dry seeds as pulses. Pods have a protein content of 10–19%, while seeds have a protein content of 15–25%. Dolichos bean contributes as a source of therapeutic constituents used in medicine (Morris 2009). It plays an important role in maintaining agriculture sustainability by fixing atmospheric nitrogen in the soil. Despite being such an important leguminous crop, it remained unutilized due to low productivity and long gestation period.

According to available evidence, India is considered to be one of the primary origin centers for dolichos beans, which exhibit a large degree of variability in plant and pod characteristics. To maximize the benefits of

diversity, it is necessary to genetically restructure dolichos bean to increase productivity and bridge the differences between potential and actual yield. Consumers also have varying preferences, when it comes to pod shapes, sizes, colours, and aromas, which should be taken into account during the improvement. However, the horticultural specifications required for dolichos beans has limitation for improvement in yield as it governed by multiple factors. Therefore, selection based on the yield performance will be ineffective, and the breeder should consider other yield-contributing traits during the improvement programme. Prior knowledge of the nature and quantum of association between yield and other yield contributing characters is mandatory for achieving improvement in the right direction. The effectiveness of crop improvement programme is determined by the extent of genetic variation present in the germplasm. Correlation coefficients help to assess the strength of the relationship between independent and dependent traits. Path coefficient analysis, quantifies the direct impact of one variable on another variable. It breaks the correlation coefficients into direct and indirect effects, making it possible to find specific traits for crop improvement. In this study, we aimed to investigate the genetic traits responsible for variability and to identify the

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key traits for yield and quality improvement in the collected genotypes.

#### MATERIALS AND METHODS

Present study was carried out during 2019–20 and 2020–21 at ICAR-Central Institute for Subtropical Horticulture, Lucknow (26° 45' to 27° 10' N, 80° 30' to 80° 5' E and 123 m amsl), Uttar Pradesh. The experiment comprised 20 diverse genotypes of pole type dolichos bean, viz. CISH-DC-1, CISH-DC-2, CISH-DC-3, CISH-DC-4, CISH-DC-5, CISH-DC-6, CISH-DC-7, CISH-DC-8, CISH-DC-9, CISH-DC-10, CISH-DC-11, CISH-DC-12, CISH-DC-13, CISH-DC-14, CISH-DC-15, CISH-DC-16, CISH-DC-17, CISH-DC-18, CISH-DC-19, CISH-DC-20 collected from different growing regions of Uttar Pradesh. The trial was laid out in a randomized block design (RBD) with three replications. The seeds were directly sown in the first week of July during each experimental year at 1.20 m × 0.90 m in inter and intra-row spacing accommodating 10 plants/line of each genotype in each replication. Plants were staked and trained on the bower training system.

To ensure good expression of phenotypic traits, standardized agronomic cultural practices were followed during both the years of study. Data on various quantitative traits including the plant height (m), primary branches/plant, date of first flowering, number of flowers/cluster, number of clusters/plant, pods/cluster, length of pod (cm), width of pod (cm), weight of pod (g), and yield of pod/plant (kg) were collected from five plants in each replication selected randomly, during both the years study. Pooled mean data from two consecutive years were considered for statistical estimation using the methodology proposed by Gomez and Gomez (1984). The coefficient of variation and variance were estimated with the method developed by Allard (1960), while heritability in broad-sense and expected genetic advance computed by the method of Johnson *et al.* (1955). The genotypic and phenotypic variance was estimated using the formulae provided by Al-Jibouri *et al.* (1955). The determination of correlation and path analysis was done as per methods proposed by Miller *et al.* (1958) and Dewey and Lu (1959).

#### RESULTS AND DISCUSSION

Presence of significance for all the traits except to pod width and weight of pod at 1 and 5 % levels of significance in the mean sum of squares of analysis of variance. It reflected a wide variability in evaluated genotypes for pod yield and yield contributing traits. The highest variability was observed for days taken to first flower, number of clusters/plant, number of flowers/cluster, number of pods/cluster, and yield (kg/plant). The existence of significant genetic variability suggests that selection would be an effective tool for earliness and yield improvement in the dolichos bean. The range, mean and genotypic coefficient of variations are effective means to measure the variability of the characters (Singh *et al.* 2020). The wide range of the mean values reflects the presence of high variability in genotypes. The

expression values of traits include the effect of genotypic, environmental, and their interaction. Hence to initiate any crop improvement programme, determination of heritable and non-heritable components of total variability is a prerequisite. The plant height ranged from 1.70 m–5.90 m. Genotype, CISH-DC-18 recorded the minimum plant height (1.70 m) whereas; maximum plant height was recorded with genotype CISH-DC-16. The variation for primary number of branches/plant range from 5.67 (CISH-DC-5) to 11.00 CISH-DC-13. Days taken to first flowering ranged from 65.00 to 225 days. The genotype CISH-DC-1 took the minimum days to first flower, whereas, genotype CISH-DC-20 took the maximum number of days to first flower (225.00). Number of flowers/cluster ranged from 11.33 (CISH-DC-6) to 28.00 (CISH-DC-3 with a grand mean value of 19.70). The number of clusters/plant ranged from 20.00–70.33. The minimum no. of cluster/plant was found in genotype CISH-DC-20 (20.00), whereas, the maximum number of cluster/plant was observed in genotype CISH-DC-15 (70.33). The no. of pods/cluster varied from 6.67–19.67. The genotype CISH-DC-2 recorded the minimum number of pods/cluster (6.67) whereas; genotype CISH-DC-11 recorded the highest number of pods/cluster (19.67). Length of pod ranged from 8.40 cm to 16.80 cm. The largest length of pod was recorded in genotype CISH-DC-13 (16.80 cm), whereas genotype CISH-DC-3 recorded the shortest length of pod (8.40 cm), width of pod ranged from 1.03 (CISH-DC-3) to 2.25 cm (CISH-DC-13). Pod weight ranged from 2.97–5.97 g. The genotype CISH-DC-1 recorded the minimum average weight of pod, whereas, the highest average pod weight was recorded with genotype CISH-DC-6. Pod yield/plant ranged between 1.90–10.17 kg. The highest pod yield/plant was recorded with genotype CISH-DC-3, whereas, lowest pod yield/plant was recorded with CISH-DC-2. The wide range and mean values revealed the presence of high variability among the genotypes for important traits, which suggests the potential for improving dolichos beans through selective breeding. Similar variability patterns in dolichos beans also previously reported by Chaitanya *et al.* (2011), Dhillon and Kumar (2015), Chauhan *et al.* (2021) and Singh *et al.* (2022). The genotypic and phenotypic coefficients of variation are reliable parameters for measuring the degree of variability demonstrated by different traits. Higher PCV than GCV was found in all the parameters indicating the role of environments on expression of characters but differences were very minor. The slight variation between the genotypic and phenotypic coefficients of variation indicates that expressions of traits are predominately governed by genetic factors. The selections based on these traits are likely to be effective with equal chances of success. The high GCV and PCV were found for the yield of pod/plant (50.89 and 50.53) days taken to first flowering (44.39 and 44.38), pod weight (33.04 and 33.00), plant height (26.82 and 25.19), pod width (23.41 and 23.36), number of clusters/plant (25.80 and 25.20), number of flowers/cluster (24.00 and 23.54) offers good scope of improvement with the selection of these traits. The findings corroborate with findings of

Afsan and Roy (2020) and Singh *et al.* (2022) who have reported high PCV and GCV for pod width, no. of primary branches/plant, pod yield/plant, no. of pods/cluster and the average pod weight.

Heritability helps a breeder to insight into the proportion of inherent variation of specific traits and the quantum of inheritable genetic variation to the total amount of variation, which determines the genetic advance and selection response. High heritability (>78%) for all the traits studied in this research suggested that genetic factors rather than the environment mainly controlled the expression of traits. The yield of pod/plant (99.75 %), days taken to first flower (99.79 %), width of pod (99.58%), were the most heritable traits, whereas, the number of primary branches (78.02%) were the least heritable. Heritability, with genetic advances is more reliable in the estimation of genetic gain in selection breeding as compared to heritability. It is not essential that traits depicting high heritability will exhibit high genetic advances. (Johnson *et al.*1955). Traits such as pod weight, days to first flowering, pod width, pod yield/plant, exhibited high genetic advance, indicating that their heritability is mainly due to additive gene effects and direct selection based on these traits in genetically diverse genotypes could be effective for desired improvement. Bendale *et al.* (2004) reported similar results for these traits in the dolichos bean. Genotypic and phenotypic correlations were used to assess the nature and level of relationships between traits for strategic improvement programmes through selection or hybridization (Table 1).

The ultimate objective of plant breeding is to enhance the yield per unit area. Yield is a complex trait governed by multiple components. Therefore, for yield improvement, selection of multiple components of yield has to be considered, because there may not be single genes for yield itself, per se, but genes /quantitative trait loci for various yield contributing traits. The phenotypic correlation coefficients were lower than genotypic correlation coefficients for traits studied, indicating a strong genetic link. Plant height, pod density, pod width, pod weight, pod length, and cluster density were found to have a positive relationship with yield/plant. Hence, selecting genotypes with higher values of these traits may improve crop yield. Roy *et al.* (2006) and Magalingam *et al.* (2013) also reported positive correlations of pod yield with plant height, number of pods/cluster, pod width, and pod weight.

Inter-correlation among the component characters showed that plant height had a positive correlation with the number of flowers/cluster, number of clusters/plant, and number of pods/cluster. This suggests that plant height plays a role in improving pod yield by increasing the number of clusters/plant and number of pods/cluster. The number of flowers/cluster also had a significant positive effect on the number of pods/cluster. Pod weight exhibited a strong positive correlation with pod length and pod width. Therefore, understanding the inter-correlation association with pod yield can help in precise and accurate selection. These findings are consistent with the results reported by

Table 1 Range, mean, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability and genetic advances (GA) in dolichos bean

Trait	Range		Genotype		Mean	Genotypic variance (%)	Phenotypic variance (%)	Phenotypic coefficient variation (%)	Phenotypic coefficient variation (%)	Genotypic coefficient variation (%)	Heritability in broad sense (%)	Genetic advance (%)	Genetic gain means (%)
	Min	Max	Min	Max									
Plant height (m)	1.70	5.90	CISH-DC-18	CISH-DC-16	3.80	1.26	1.43	26.82	25.19	88.21	15.88	79.41	
Number of primary bsn branches branch/plant	5.67	11.00	CISH-DC-5	CISH-DC-13	8.33	2.62	3.36	23.36	20.64	78.02	14.05	70.24	
Days to first flowering	65.00	225.0	CISH-DC-1	CISH-DC-20	145.00	3269.59	3270.92	44.39	44.38	99.96	18.00	89.99	
No. of flower/cluster	11.33	28.00	CISH-DC-6	CISH-DC-3	19.67	18.90	19.64	24.00	23.54	96.24	17.33	86.64	
No. of cluster/plant	20.0	70.33	CISH-DC-20	CISH-DC-15	45.17	161.11	161.95	25.08	25.02	99.48	17.91	89.55	
No. of pods/cluster	6.67	19.67	CISH-DC-2	CISH-DC-11	13.17	11.11	12.03	25.76	24.75	92.35	16.63	83.14	
Pod length (cm)	8.40	16.80	CISH-DC-3	CISH-DC-13	12.60	8.08	8.15	25.44	25.33	99.14	17.85	89.25	
Pod width (cm)	1.03	2.25	CISH-DC-3	CISH-DC-6	1.64	0.11	0.11	23.41	23.36	99.52	17.92	89.59	
pod weight (g)	2.97	5.97	CISH-DC-1	CISH-DC-6	4.47	5.36	5.37	33.04	33.00	99.75	17.96	89.80	
Pod yield/plant (kg)	1.90	10.17	CISH-DC-20	CISH-DC-7	6.03	5.78	5.91	50.89	50.33	97.79	17.61	88.03	

Magalingam *et al.* (2013). Correlations can help to identify yield components but don't paint a complete picture of how each independent trait contributes. Path coefficient analysis is a useful tool to evaluate the relative importance of the various factors that contribute to a given correlation (Table 2).

Path coefficient analysis (PCA) divides the whole correlation coefficient into indirect and direct effects on yield. The pod weight had the most significant positive direct effect ( $r = 0.7053$ ) on pod yield followed by the number of clusters/plant ( $r = 0.6207$ ) number of pods/plant ( $r = 0.5136$ ), number of flowers/cluster ( $r = 0.1605$ ), width of the pods ( $r = 0.0536$ ), length of the pods ( $r = 0.0404$ ), and the number of primary branches/plant ( $r = 0.0135$ ). Positive correlation was recorded between plant height and yield. These included branch density ( $r = 0.0021$ ), flower density ( $r = 0.0724$ ), cluster density ( $r = 0.3277$ ), pod density ( $r = 0.2279$ ), pod length ( $r = 0.0144$ ), pod width ( $r = 0.006$ ), and pod weight ( $r = 0.1364$ ). The number of primary branches/plant was positively correlated with yield through days to first flowering ( $r = 0.0003$ ), cluster number/plant ( $r = 0.0418$ ), and pod number/cluster ( $r = 0.0537$ ). Days to first flowering positively influenced yield via pod length ( $r = 0.0078$ ), pod width ( $r = 0.0164$ ), and pod weight ( $r = 0.1487$ ). Directly affecting yield was not the number of flowers in a cluster

but rather the number of pods in a cluster ( $r = 0.332$ ) and the length of those pods ( $r = 0.0024$ ). The number of clusters/plant was correlated positively with yield through primary branch count ( $r = 0.0009$ ), days to first flowering ( $r = 0.0001$ ), and pod width ( $r = 0.0091$ ) (Table 3)

Days to first flowering, number of primary branches/plant, number of flowers/cluster, and pod width affected yield positively. A positive correlation between pod length and yield through flower count/cluster ( $r = 0.0097$ ), pod count/cluster ( $r = 0.0962$ ), pod width ( $r = 0.0122$ ), and pod weight ( $r = 0.5423$ ). Pod width had an indirect effect on yield through the number of clusters/plant ( $r = 0.1057$ ), the number of pods/cluster ( $r = 0.0775$ ), the pod length ( $r = 0.0092$ ), and the pod weight ( $r = 0.4028$ ). By increasing cluster size ( $r = 0.1134$ ), pod length ( $r = 0.0311$ ), and pod width ( $r = 0.0306$ ), pod weight was found to have a positive indirect effect on yield. Pod weight, cluster density, pod density, pods/plant, flowers/cluster, pod width, and pod length all directly and positively affect yield. These characteristics were highly heritable, suggesting they are crucial to enhancing dolichos bean yield. Desai *et al.* (2003) and Magalingam *et al.* (2013) reported very similar results. However, some components contributing to yield were not included in the analysis, as indicated by the 0.1293 value for the genotypic path coefficient that could not be explained.

Table 2 Genotypic (G) and phenotypic (P) correlation coefficient estimation among the traits of dolichos genotypes

Trait		Plant height (m)	No. of primary branches/plant	Days to first flowering	No. of flowers/cluster	No. of clusters/plant	No. of pods/cluster	Pod length (cm)	Pod width (cm)	Pod weight (g)	Pod yield/plant (kg)
Plant height (m)	G	1.000	0.156	0.089	0.451*	0.528*	0.444*	0.357	0.112	0.193	0.565**
	P	1.000	0.093	0.083	0.418*	0.497*	0.396*	0.328	0.106	0.185	0.527*
Number of primary branches/plant	G		1.000	-0.249	-0.012	0.067	0.105	-0.154	-0.203	-0.141	-0.044
	P		1.000	-0.223	-0.031	0.063	0.042	-0.145	-0.192	-0.127	-0.064
Days to first flowering	G			1.000	-0.238	-0.102	0.038	0.192	0.306	0.211	0.066
	P			1.000	-0.232	-0.102	0.038	0.191	0.306	0.211	0.067
No. of flowers/cluster	G				1.000	-0.020	0.647**	0.061	-0.093	-0.087	0.316
	P				1.000	-0.022	0.648**	0.060	-0.090	-0.086	0.323
No. of clusters/plant	G					1.000	-0.028	-0.218	0.170	-0.253	0.309
	P					1.000	-0.030	-0.216	0.171	-0.250	0.307
No. of pods/cluster	G						1.000	0.187	0.151	0.221	0.678**
	P						1.000	0.185	0.150	0.210	0.676**
Pod length (cm)	G							1.000	0.227	0.769**	0.484
	P							1.000	0.228	0.765**	0.481
Pod width (cm)	G								1.000	0.571**	0.606**
	P								1.000	0.570**	0.602**
Pod weight (g)	G									1.000	0.664**
	P									1.000	0.658**
Pod yield/plant (kg)	G										1.000
	P										1.000

\*Significant at 5% level; \*\* Significant at 1% level.

Table 3 Estimates of direct (bold) and indirect effect of significant traits on yield of dolichos bean

Character	Plant height (m)	No. of primary branches/plant	Days to first flowering	No. of flowers/cluster	No. of clusters/plant	No. of pods/cluster	Pod length (cm)	Pod width (cm)	Pod weight (g)	Pod yield/plant (kg)
Plant height (m)	<b>-0.2221</b>	0.0021	-0.0001	0.0724	0.3277	0.2279	0.0144	0.006	0.1364	0.5648
Number of primary branches/plant	-0.0346	<b>0.0135</b>	0.0003	-0.002	0.0418	0.0537	-0.0062	-0.0109	-0.0996	-0.0346
Days to first flowering	-0.0197	-0.0034	<b>-0.0012</b>	-0.0382	-0.0634	0.0194	0.0078	0.0164	0.1487	0.0664
No. of flowers/cluster	-0.1002	-0.0002	0.0003	<b>0.1605</b>	-0.0126	0.3322	0.0024	-0.005	-0.0614	0.3161
No. of clusters/plant	-0.1172	0.0009	0.0001	-0.0033	<b>0.6207</b>	-0.0144	-0.0088	0.0091	-0.1781	-0.1172
Number of pods/cluster	-0.0986	0.0014	0.0001	0.1038	-0.0174	<b>0.5136</b>	0.0076	0.0081	0.1557	0.6741
Pod length (cm)	-0.0794	-0.0021	-0.0002	0.0097	-0.135	0.0962	<b>0.0404</b>	0.0122	0.5423	0.4841
Pod width (cm)	-0.0249	-0.0028	-0.0004	-0.015	0.1057	0.0775	0.0092	<b>0.0536</b>	0.4028	-0.0249
Pod weight (g)	-0.043	-0.0019	-0.0003	-0.014	-0.1568	0.1134	0.0311	0.0306	<b>0.7053</b>	0.6644

Residual effect – 0.1293.

Therefore, when selecting genotypes of dolichos beans for higher yield in subtropical regions, it is important to consider some additional traits.

Thus, it can be concluded through findings that there is substantial variability in dolichos bean genotypes for pod yield and yield-related traits. The direct positive effects on yield were observed for the number of clusters/plant and the number of pods/plant, while the number of primary branches/plant, days to first flowering, number of flowers/cluster, and pod width showed a positive correlation with yield. Pod weight, cluster density, pod density, pods per plant, flowers per cluster, length of pod, and width pod have a direct and positive impact on yield and may be used in selection breeding of dolichos.

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