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Genetic variability, character association and path analysis for quantitative traits to breed vegetable type cluster bean (*Cyamopsis tetragonoloba*)

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ABSTRACT

The present experiment was conducted during *rabi* 2017 at ICAR- Indian Institute of Horticultural Research, Bengaluru to assess the variability present in the germplasm and their usefulness in breeding of high yielding vegetable type cluster bean (*Cyamopsis tetragonoloba* L.). Total 38 diverse cluster bean germplasm from different sources were used to evaluate the variability, character association and their contribution towards pod yield. Characters like number of pods per plant, pod length, pod weight, plant height, number of clusters per plant, pods per cluster showed high coefficient of variations and high heritability with high genetic gain indicating their suitability for effective selection. Analysis of phenotypic and genotypic correlation co-efficient and path analysis revealed that traits like pod length, pod diameter, pod weight and seeds per pod had significant positive correlation with pod yield. Hence, selection for high pod weight with indirect selection for pod length will bring worthwhile improvement in yield.

Key words: Cluster bean, Correlation coefficient, Path analysis, Quantitative characters, Variability

Cluster bean (*Cyamopsis tetragonoloba* L.) is an important legume vegetable in southern states of India. Besides, providing the nutritious pods rich in protein, fibre, minerals and antioxidants, it also maintains the soil health by fixing atmospheric nitrogen. Moreover, being a drought hardy and low input crop, it fits into various agricultural cropping systems and suitable for small and marginal farmers. But, availability of improved high yielding vegetable type varieties is meagre for this region. Therefore, development of high yielding guar varieties with quality pods is essential.

In self-pollinated crops like cluster bean, germplasm is available in the form of an array of homozygous lines which can be directly released as genetically improved cultivars after selection. For an effective selection, variability for important yield attributing traits is the pre-requisite. Yield is a complex polygenic character, therefore, direct selection for yield improvement may not be effective. Hence, selection should be mediated through yield components for which degree of their association with yield has to be estimated.

Estimation of correlation coefficient aids in identifying the relative contribution of component traits towards yield (Panse 1957). But, the correlation between yield and a contributing trait may be misleading at times due to incorrect estimation of its association with other traits. That means, yield components both directly and indirectly influence the ultimate yield (Tukey 1954). Path analysis is one such method which partitions this correlation into direct and indirect effects (Wright 1921 and Dewey and Lu 1959). Therefore, correlation along with path coefficient analysis will be an important means to bring out the association and quantify the direct and indirect influence of one trait upon another (Dewey and Lu 1959). With the above consideration, a study had been undertaken at ICAR-IIHR, Bengaluru to assess the variability present, character association and contribution of traits towards pod yield within the germplasm and to find out the direct and indirect effect of component traits on pod yield.

MATERIALS AND METHODS

A total of 38 genotypes of cluster bean collected from different sources were evaluated during *rabi* 2017 at ICAR-Indian Institute of Horticultural Research, Bengaluru, situated at latitude: 13°7'N, Longitude: 77°29'E, altitude 890 m amsl. The experiment was laid out in Randomized Block Design (RBD) with two replications. Bunds of size 2 × 1 m were made and the row to plant spacing was maintained at 60 × 20 cm. The crop was raised as per the recommended package of practices for cluster bean in Karnataka (Sadashiva *et al.* 2018). Observations were recorded for days to 1st flowering, number of pods per plant, yield per plant, pod length, pod diameter, single pod weight, number of clusters per plant, number of pods per cluster, plant height and number of seeds per pod. Analysis of variance (ANOVA) for each trait was worked out as per Gomez and Gomez (1984). All the traits showing significant differences among the genotypes were analysed further for

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parameters like coefficients of variability (phenotypic and genotypic) given by Burton and deVane (1953), heritability by Allard (1960), genetic gain by Johnson *et al.* (1955) and correlation studies following Al-Jibouri *et al.* (1958). To find out the direct and indirect effect of the component traits on pod yield path coefficient analysis (Dewey and Lu 1959) was carried out. Statistical analysis was done using OPSTAT, HAU, Hisar by Sheron OP.

RESULTS AND DISCUSSION

The analysis of variance (ANOVA) and mean performance of genotypes (Table 1) in the present investigation revealed significant differences among the genotypes for all the traits in terms of their wide range, higher critical difference and coefficient of variation indicating that the germplasm as a whole offers sufficient opportunity for selecting the genotype(s) with superior horticultural and yield characters under field conditions. Various other workers also reported similar result in cluster bean (Arora *et al.* 2011, Rai *et al.* 2012 and Jukanti *et al.* 2015).

To know the scope of selection for improving a particular trait, various genetic parameters such as variance, coefficient of variability, heritability and expected genetic gain (Table 1) for each trait were estimated. Small difference between the values of Phenotypic coefficient of variability (PCV) and Genotypic coefficient of variability (GCV) indicated lesser influence of environment in traits expression. Wide spectrum of variations along with high (>30%) PCV and GCV were observed for traits like number of pods per plant, pod length, pod weight, plant height, number of clusters per plant and pods per cluster suggesting that there is ample scope for bringing out improvement in these traits. But PCV and GCV were found medium (15–30%) in case of yield per plant, pod diameter, seeds per pod and low (<15%) for days to 1st flowering indicating necessities to generate variation through hybridization.

To predict the success of selection for improvement of the traits, heritability was calculated (Table 1) and estimates of heritability were high (>80 %) for all the traits studied indicating that selection for these traits will be effective as phenotype is a true representative of genotype. Further, Johnson *et al.* (1955) in soybean reported that high heritability estimates along with high genetic gain were more useful than heritability alone for effective selection. The results from present findings also revealed that the traits like number of pods per plant, pod length, pod weight, plant height, number of clusters per plant, pods per cluster had high heritability with high genetic gain (>50%) in accordance with the results of Vijay *et al.* (1988) and Shekhawat and Singhania (2005). This indicates that selection for these traits will be more effective as these are under the control of additive gene action (Panse 1957). Whereas, low values of genetic gain (<25%) was noticed for days to 1st flowering despite high heritability suggesting that improvement in this character through selection is not possible. But for yield per plant, pod diameter and seeds per pod, high heritability with moderate to high (25–50%) genetic gain has been noticed. So, direct selection for these traits may not be recommended.

However, direct selection for complex traits like yield is ineffective as it is polygenic and its expression depend on number of component traits. Correlation coefficients were estimated for pod yield per plant and its attributing traits (Table 2). For all the traits, the magnitude of genotypic correlation coefficients was found higher than the corresponding phenotypic correlation coefficients suggesting that phenotypic correlation coefficient was influenced by environments. Traits like pod length, pod diameter, pod weight and seeds per pod showed significant positive genotypic and phenotypic correlation with pod yield per plant. Pod length, breadth and weight determines the fleshiness of the pods that means fleshier the pod, higher the

Table 1 Analysis of variance, mean performance and estimates of genetic parameters

Trait	ANOVA Replication (df=1)	ANOVA Genotype (df=37)	ANOVA Error (df=37)	Mean performance Mean	Mean performance Range	Mean performance SE (Mean)	Mean performance CD (0.05)	Mean performance CV	PCV	GCV	Heritability %	Genetic gain %
DF	2.22	27.79	0.65	33.87	24.5 - 38.5	0.57	1.63	2.37	11.13	10.88	95.46	21.89
NPP	525.74	3499.46	130.32	105.23	31.3 - 170.1	8.07	23.22	10.85	40.49	39.00	92.82	77.41
YP	517.55	2069.08	206.57	136.17	71.6 - 212.6	10.16	29.24	10.55	24.77	22.41	81.85	41.77
PL	0.16	14.1	0.16	8.24	5.75 -13.95	0.29	0.82	4.9	32.40	32.03	97.71	65.23
PD	0.01	0.5	0.01	0.80	0.55 - 1.10	0.03	0.09	6	20.44	19.65	92.45	38.92
SPW	0.02	1.73	0.02	1.59	0.8 - 4.05	0.09	0.27	8.48	59.38	58.99	98.68	120.71
PH	63.41	3220.13	62.5	82.25	17.0 - 154.5	5.59	16.08	9.61	49.26	48.31	96.19	97.60
NCP	0.05	60.4	4.24	14.56	7.2 - 26.9	1.46	4.2	14.13	39.04	36.39	86.89	69.87
PC	0.26	57.51	5.05	9.08	1.20 - 20.55	1.59	4.57	24.73	60.95	59.17	94.25	118.33
NSP	0.01	2.82	0.07	6.75	3.2 - 8.6	0.19	0.54	3.94	17.81	17.37	95.09	34.89

DF, Days to 1st flowering; NPP, Number of pods per plant; YP, Yield per plant (g); PL, Pod length (cm); PD, Pod diameter (cm); SPW, Single pod weight (g); PH, Plant height (cm); NCP, Number of cluster per plant; PC, Pods per cluster; NSP, Number of seeds per pod.

Table 2 Phenotypic and genotypic correlation coefficients among various traits

Trait	DF	NPP	YP	PL	PD	SPW	PH	NCP	PC	NSP
DF										
NPP	0.640*									
	0.690*									
YP	-0.215^{NS}	0.123^{NS}								
	-0.231*	0.032^{NS}								
PL	-0.678*	-0.868*	0.277*							
	-0.704*	-0.908*	0.306*							
PD	-0.578*	-0.785*	0.250*	0.891*						
	-0.608*	-0.862*	0.265*	0.929*						
SPW	-0.698*	-0.808*	0.420*	0.946*	0.817*					
	-0.713*	-0.845*	0.447*	0.961*	0.858*					
PH	-0.489*	-0.597*	0.202^{NS}	0.710*	0.566*	0.702*				
	-0.522*	-0.620*	0.234*	0.729*	0.600*	0.719*				
NCP	-0.558*	-0.655*	0.069^{NS}	0.650*	0.516*	0.636*	0.595*			
	-0.614*	-0.728*	0.072^{NS}	0.720*	0.592*	0.683*	0.617*			
PC	0.561*	0.831*	-0.039^{NS}	-0.785*	-0.701*	-0.750*	-0.672*	-0.860*		
	0.604*	0.860*	-0.073^{NS}	-0.824*	-0.762*	-0.775*	-0.682*	-0.896*		
NSP	-0.199^{NS}	-0.082^{NS}	0.281*	0.186^{NS}	0.081^{NS}	0.231*	0.471*	0.040^{NS}	-0.162^{NS}	
	-0.208^{NS}	-0.075^{NS}	0.333*	0.191^{NS}	0.088^{NS}	0.229*	0.487*	0.049^{NS}	-0.173^{NS}	

DF, Days to 1st flowering; NPP, Number of pods per plant; YP, Yield per plant (g); PL, Pod length (cm); PD, Pod diameter (cm); SPW, Single pod weight (g); PH, Plant height (cm); NCP, Number of cluster per plant; PC, Pods per cluster; NSP, Number of seeds per pod. For each trait, upper value denotes the phenotypic correlation coefficient and lower value denotes the genotypic correlation coefficient; * denotes significant at 5% level; NS denotes non-significant.

Table 3 Estimates of direct and indirect effect of the characters contributing significantly towards pod yield per plant

Trait	DF	NPP	PL	PD	SPW	PH	NCP	PC	NSP	Genotypic Correlation Coefficient
DF	-0.087	1.137	0.162	-0.316	-1.132	0.140	-0.041	-0.057	-0.038	-0.231*
NPP	-0.060	1.648	0.209	-0.447	-1.341	0.166	-0.048	-0.081	-0.014	0.032^{NS}
PL	0.061	-1.497	-0.230	0.482	1.524	-0.196	0.048	0.077	0.035	0.306*
PD	0.053	-1.421	-0.214	0.519	1.362	-0.161	0.039	0.072	0.016	0.265*
SPW	0.062	-1.393	-0.221	0.445	1.587	-0.193	0.045	0.073	0.042	0.447*
PH	0.045	-1.022	-0.168	0.311	1.140	-0.268	0.041	0.064	0.090	0.234*
NCP	0.053	-1.201	-0.166	0.307	1.083	-0.165	0.067	0.084	0.009	0.072^{NS}
PC	-0.052	1.418	0.190	-0.395	-1.230	0.183	-0.060	-0.094	-0.032	-0.073^{NS}
NSP	0.018	-0.124	-0.044	0.046	0.363	-0.130	0.003	0.016	0.184	0.333*

Residuals = 0.14. Numerical values in bold (phase) denotes the direct effect and others denote indirect effects. DF, Days to 1st flowering; NPP, Number of pods per plant; PL, Pod length (cm); PD, Pod diameter (cm); SPW, Single pod weight (g); PH, Plant height (cm); NCP, Number of cluster per plant; PC, Pods per cluster; NSP, Number of seeds per pod. * denotes Genotypic correlation coefficient significant at 5% level, NS denotes non-significant.

yield. Significant genotypic correlation was found between height of the plant and yield per plant. Further, height showed significant positive correlation with number of clusters per plant. Which indicates height can increase yield by increasing the number of clusters per plant. But number of clusters per plant had significant negative correlation with number of pods per plant and pods per cluster indicating that when the number of clusters increases, number of pods per cluster and per plant as a whole also decreases to balance the source to sink distribution but the length, diameter and weight of single pod increases. Increase in pod weight can be attributed to increase in length, diameter and more number of seeds per pods. Significant negative genotypic correlation was obtained between days to flowering and yield per plant indicating early varieties can be better yielder.

The correlation studies only provide information on associationships and do not give any idea about their direct or indirect contribution toward yield. Consequently, the information is sometimes misleading. Path analysis was carried out to partition this correlation into direct and indirect effects (Table 3). Number of pods per plant showed highest direct effect (1.648) but the non-significant association with yield may be attributed to its considerable negative indirect effect of pod weight (-1.341) and pod diameter (-0.447) via this trait. Single pod weight (1.587) and pod diameter (0.519) showed high positive direct effect which is even higher than the correlation coefficients observed, indicating that these are the real independent character and have maximum contribution towards the increase in green pod yield. Number of seeds per pod (0.184) showed small direct positive contribution for pod yield per plant. Traits like days to 1st flowering, pod length, plant height and pods per cluster showed negative direct effect for pod yield per plant but pod length showed maximum indirect positive effect (1.524) for pod weight.

Selection is the easiest and oldest method of improvement in self - pollinated crops like cluster bean. If sufficient variability is present and character is showing high heritability with high genetic gain, direct selection can be practiced. But for polygenic traits like yield, indirect selection for component traits will be beneficial. Therefore, in the present study, an association between pod yield and component traits were established. After estimating their direct and indirect effect on yield it is concluded that selection for high pod weight with indirect selection for pod length will bring worthwhile improvement in pod yield per plant.

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