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Character association and discriminant function method of selection in cluster bean [*Cyamopsis tetragonoloba* (L.) Taub.] Genotypes

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Abstract

The study was conducted on 56 cluster bean genotypes to study the linear combination of characters associated with pod yield. Correlation, path analysis and selection index were studied for pod yield using the characters viz., plant height at final harvest (cm), days to 50% flowering, average weight of 50 pods (g), pod length (cm) and protein content of pods. The genotypic correlation coefficients were higher than phenotypic correlation coefficients for all the characters studied. Plant height displayed high positive direct effect on pod yield per plant. Average weight of 50 pods, pod length and protein content of pods exhibited low positive direct effects on pod yield per plant. The index value for each genotype was determined and the genotypes were ranked accordingly. The highest value was recorded in check Pusa Navbahar followed by MDU-1, Chitra Gold, IC-51063 and IC-522421. These genotypes were identified to be genetically superior.

Keywords: Correlation, path analysis, selection index, cluster bean, pod yield

Introduction

Cluster bean [*Cyamopsis tetragonoloba* (L.) Taub] is also known as guar bean, has a chromosome number of $2n=2x=14$. It is an arid legume crop, mostly cultivated in the arid and semi-arid areas as it is drought tolerant. The long deep taproot system enables the plant to grasp maximum water from the soil making it an ultimate drought resistant crop. It has the freedom from serious pests and diseases and long storage life of the harvested pods.

It is a self-pollinated crop belonging to family *leguminosae*. Guar is characterized as a short day erect or bushy annual plant. Cluster bean is rich in dietary fibre, potassium and folate which protect the heart from various cardiovascular complications. It is a reservoir of different amino acids including glutamine, arginine, aspartic acid and leucine. Iron and calcium present in cluster bean helps in strengthening the bones. It also works as a good laxative, stimulating bowel movement, improving digestive system and help in flushing out unwanted chemicals.

Yield is a complex character and is known to be associated with a number of component characters and is highly affected by environmental variations. These characters are themselves interrelated. An understanding of correlation between yield and its attributing characters is essential to formulate guide lines for crop selection. Partitioning of total correlation into direct and indirect effect by path coefficient analysis helps in making the selection more effective. The path coefficient analysis reveals that, whether the association of the component characters with pod yield per plant is due to their direct effect on pod yield per plant, or is a consequence of their indirect effect via some other trait(s).

Breeding and selection programmes often encompass several characters simultaneously (Hill *et al.*, 1998) [6]. When considering several traits, it is desirable to choose individuals with the best combination of characters. The basis for such a selection is selection index, which takes into account a combination of characters according to their relative weight. Thus each individual character has an index value and selection is based on the sum of the scores (values) of the different characters. Gain from selection for any given character is expected to decrease as additional characters are included in the index, so the choice for characters to be included must be done objectively. In cluster bean, selection indices have been effectively used in

identifying some traits as selection criteria to improve seed yield. Elsyed (1999) [4] concluded that maximum efficiency of selection was obtained when all the important yield components were included in the index.

Keeping the above context in view, the present study was carried out to formulate character association and selection strategies for improvement of cluster bean pod yield.

Material and Methods

An investigation comprised of 56 genotypes of cluster bean (Table 1) and it was carried out at College of Horticulture, Dr.

Y. S. R. Horticultural University, Venkataramannagudem, West Godavari district during *kharif* season of 2018. Genotypes were evaluated with two replications with spacing of 45 cm x 15 cm. Optimum management practices were followed uniformly for raising the crop.

Observations were recorded on five competitive and randomly selected plants from each plot in each replication for all the genotypes. There were 6 characters studied viz., plant height at final harvest (cm), days to 50% flowering, average weight of 50 pods (g), pod length (cm), protein content of pods (%) and pod yield per plant (g).

Table 1: List of cluster bean genotypes used in the present study

Treatment	Genotypes	Source	Treatment	Genotypes	Source
T ₁	IC-113272	NBPGR, Jodhpur	T ₂₉	IC-116626	NBPGR, Jodhpur
T ₂	IC-113277	NBPGR, Jodhpur	T ₃₀	IC-116652	NBPGR, Jodhpur
T ₃	IC-113278	NBPGR, Jodhpur	T ₃₁	IC-116660	NBPGR, Jodhpur
T ₄	IC-113281	NBPGR, Jodhpur	T ₃₂	IC-116779	NBPGR, Jodhpur
T ₅	IC-113308	NBPGR, Jodhpur	T ₃₃	IC-116705	NBPGR, Jodhpur
T ₆	IC-113374	NBPGR, Jodhpur	T ₃₄	IC-116825	NBPGR, Jodhpur
T ₇	IC-113376	NBPGR, Jodhpur	T ₃₅	IC-116925	NBPGR, Jodhpur
T ₈	IC-113377	NBPGR, Jodhpur	T ₃₆	IC-116930	NBPGR, Jodhpur
T ₉	IC-113378	NBPGR, Jodhpur	T ₃₇	IC-116932	NBPGR, Jodhpur
T ₁₀	IC-113379	NBPGR, Jodhpur	T ₃₈	IC-384974	NBPGR, Jodhpur
T ₁₁	IC-113380	NBPGR, Jodhpur	T ₃₉	IC-384986	NBPGR, Jodhpur
T ₁₂	IC-113382	NBPGR, Jodhpur	T ₄₀	IC-522399	NBPGR, Jodhpur
T ₁₃	IC-113383	NBPGR, Jodhpur	T ₄₁	IC-522389	NBPGR, Jodhpur
T ₁₄	IC-113390	NBPGR, Jodhpur	T ₄₂	IC-522511	NBPGR, Jodhpur
T ₁₅	IC-113393	NBPGR, Jodhpur	T ₄₃	IC-522421	NBPGR, Jodhpur
T ₁₆	IC-113394	NBPGR, Jodhpur	T ₄₄	IC-522487	NBPGR, Jodhpur
T ₁₇	IC-113395	NBPGR, Jodhpur	T ₄₅	IC-522506	NBPGR, Jodhpur
T ₁₈	IC-113396	NBPGR, Jodhpur	T ₄₆	IC-52249	NBPGR, Jodhpur
T ₁₉	IC-113399	NBPGR, Jodhpur	T ₄₇	RGC-986	NBPGR, Jodhpur
T ₂₀	IC-113503	NBPGR, Jodhpur	T ₄₈	PLG-85	NBPGR, Jodhpur
T ₂₁	IC-113506	NBPGR, Jodhpur	T ₄₉	RGC-1038	NBPGR, Jodhpur
T ₂₂	IC-113523	NBPGR, Jodhpur	T ₅₀	IC-421850	NBPGR, Jodhpur
T ₂₃	IC-113568	NBPGR, Jodhpur	T ₅₁	IC-421855	NBPGR, Jodhpur
T ₂₄	IC-113513	NBPGR, Jodhpur	T ₅₂	IC-51063	NBPGR, Jodhpur
T ₂₅	IC-116569	NBPGR, Jodhpur	T ₅₃	Thar Bhadavi	CIAH, Bikaner, Rajasthan
T ₂₆	IC-116607	NBPGR, Jodhpur	T ₅₄	MDU-1	TNAU, Coimbatore
T ₂₇	IC-116608	NBPGR, Jodhpur	T ₅₅	Chitra Gold	Vagro seeds Pvt. Ltd, Hyderabad
T ₂₈	IC-116619	NBPGR, Jodhpur	T ₅₆	Pusa Navbahar (Check)	IARI, New Delhi

The genotypic and phenotypic correlation coefficients were determined for all possible pairwise combinations between the characters. Path coefficient analysis was calculated, following the procedure suggested by Dewey and Lu (1959) [1]. It was used for partitioning the genotypic correlation between pod yield per plant and five of its components into direct and indirect effects. Different selection indices were formed using the six characters and pod yield per plant was used as the ultimately desired product. Different phenotypic weights (b's) were assigned to the six characters.

These weights were computed according to the method suggested by Robinson *et al.* (1951) [10], in which a set of simultaneous equations, constructed from the genotypic and phenotypic variances and covariance's of the characters involved, was solved, as follows.

$$\begin{aligned}
 b_1P_{11} + b_2P_{12} + \dots + b_nP_{1n} &= g_{1y} \\
 b_1P_{12} + b_2P_{22} + \dots + b_nP_{2n} &= g_{2y} \\
 &\vdots \\
 b_1P_{1n} + b_2P_{2n} + \dots + b_nP_{nn} &= g_{ny}
 \end{aligned}$$

Where: P: is the phenotypic variance or covariance.
g: is the genotypic variance or covariance.

P₁₁: is an estimate of the phenotypic variance of character x₁.
P₁₂: is an estimate of phenotypic covariance between characters x₁ and x₂.

g_{1y}: is an estimate of the genotypic covariance between characters x₁ and y.

(Yield = dependent character).

b: is the selection weight.

b₁: is the selection weight for the character x₁.

b₂: is the selection weight for the character x₂.

The standard formula for selection index is: $I = b_1 X_1 + b_2 X_2 + \dots + b_n X_n$.

A number of selection indices were constructed. They were composed of indices that are based on single character and those based on the possible combinations of the characters. The expected genetic advance of these indices was determined according to the formula suggested by Robinson *et al.* (1951) [10].

$$GA = k \sqrt{b_1 g_{1y} + b_2 g_{2y} + \dots + b_n g_{ny}}$$

Where; k: is the selection differential in standard units, its value is 2.06 when selection intensity is 5%.

b: is the selection weight.
g: is the genotypic variance or covariance.

The estimates of genetic advance from selection were in grams of pod yield per plant. Then they were expressed as percentage of the genetic progress obtained from pod yield per plant alone, which was assumed to be 100%, and it was used to compare the relative efficiencies of the different

selection indices.

Results and Discussion

The genotypic (g) and phenotypic (p) correlation coefficients were worked out for 6 characters in fifty six genotypes of cluster bean and presented in table 2. In general genotypic correlation coefficients were higher than phenotypic correlation coefficients for all the characters studied.

Table 2: Genotypic and phenotypic correlation coefficient for different characters of cluster bean genotypes

Characters		Plant height (cm)	Days to 50% flowering	Average weight of 50 pods (g)	Pod length (cm)	Protein content of pods (%)	Pod yield per plant (g)
Plant height (cm)	R_g	1.000	-0.194*	0.448 **	0.309 **	-0.103	0.477**
	R_p		-0.099	0.382 **	0.233 *	-0.093	0.434**
Days to 50% flowering	R_g		1.000	-0.105	-0.052	-0.173	-0.384**
	R_p			-0.101	-0.090	-0.101	-0.230**
Average weight of 50 pods (g)	R_g			1.000	0.803 **	-0.086	0.479**
	R_p				0.750 **	-0.081	0.347**
Pod length (cm)	R_g				1.000	-0.067	0.425**
	R_p					-0.063	0.357**
Protein content of pods (%)	R_g					1.000	0.169
	R_p						0.139

Plant height recorded significant positive association with average weight of 50 pods ($r_g = 0.448$, $r_p = 0.382$), pod length ($r_g = 0.309$, $r_p = 0.233$) and pod yield per plant ($r_g = 0.477$, $r_p = 0.434$) at both genotypic and phenotypic levels. Average weight of 50 pods showed positive significant association with pod length ($r_g = 0.803$, $r_p = 0.750$) and pod yield per plant ($r_g = 0.479$, $r_p = 0.347$) at both genotypic and phenotypic levels. Pod length displayed positive significant correlation with pod yield per plant ($r_g = 0.425$, $r_p = 0.357$) at genotypic and phenotypic level. Protein content of pods did not show significant correlation with pod yield per plant. Similar result

was found by Singh *et al.* (2005) ^[11], Mahla and Kumar (2006) ^[8] and Divya and Abdul (2016) ^[3].

Days to 50% flowering exhibited significant negative association with pod yield per plant ($r_g = -0.384$, $r_p = -0.230$) at both genotypic and phenotypic levels. These were in agreement with the results reported by Girish *et al.* (2012) ^[5] and Patil *et al.* (2016) ^[9].

Path analysis was carried out at genotypic level considering pod yield per plant as dependent character. Results were presented in table 3 and Fig.1 below.

Table 3: Path analysis for different characters of cluster bean genotypes at genotypic level

Characters	PH	DF	AWF	PL	PC	PYP
PH	0.305	-0.059	0.137	0.094	-0.031	0.477**
DF	0.051	-0.264	0.028	0.014	0.046	-0.384**
AWF	0.084	-0.020	0.187	0.150	-0.016	0.479**
PL	0.055	-0.009	0.143	0.178	-0.012	0.425**
PC	-0.019	-0.032	-0.016	-0.012	0.183	0.169

Fig 1: Diagram of the direct and indirect relationships of pod yield per plant with its components at genotypic level

Plant height displayed high positive direct effect (0.305) and high positive correlation coefficient ($r_g = 0.477$) with pod yield per plant. It exhibited low positive indirect effects via average weight of 50 pods (0.137) while other characters were negligible. Average weight of 50 pods had low positive direct effect (0.187) and high positive correlation coefficient (0.479) with pod yield per plant. Its indirect effect was low via pod length (0.150) whereas other characters were negligible. Pod length displayed low positive direct effect (0.178) and high positive correlation coefficient (0.425) with pod yield per plant. Its indirect effect was low via average weight of 50 pods (0.143) while other characters were negligible.

Protein content of pods exhibited low positive direct effect (0.183) and low positive correlation coefficient (0.169) with pod yield per plant. Its indirect effects were negligible. These results were in accordance with the findings of Singh *et al.* (2005)^[11] and Patil *et al.* (2016)^[9].

Days to 50% flowering showed moderate negative direct effect (-0.264) and high negative correlation coefficient ($r_g = -0.384$) with pod yield per plant. Its indirect effects were negligible.

The expected genetic advances in pod yield per plant and the relative efficiencies of different selection indices, involving the pod yield per plant as an independent variable index and five yield components, singly and in different combinations are shown in table 4. The individual trait indices, *viz.*, average

weight of 50 pods and plant height had the highest relative efficiencies (126.06% and 23.76%). This means that these characters were more efficient in determining the genotypic value of a genotype than selection based on pod yield per plant alone. Also it indicates their importance as yield attributing characters. These results are in line with the findings of Ibrahim *et al.* (2012)^[7].

These findings were further confirmed by the fact that whenever average weight of 50 pods and plant height were added to or replaced with other characters in a selection index, the efficiency of such index was tremendously improved. The minimum genetic advances -0.17% and 0.36% and the minimum relative efficiencies -0.67% and 1.39% were obtained by the indices having single traits, *viz.*, days to 50% flowering and protein content of pods, respectively. This is in accordance with Elsyed (1999)^[4] and Ibrahim *et al.* (2012)^[7].

Furthermore, when days to 50% flowering and protein content of pods were added to or replaced another character in a selection index, the relative efficiency of such an index was drastically reduced. Therefore, it could be concluded that days to 50% flowering and protein content of pods are an inefficient selection criterion for the improvement of pod yield in cluster bean. Similar findings were reported by Ibrahim *et al.* (2012)^[7].

Table 4: Expected genetic advance and relative efficiency in cluster bean genotypes

Character	Genetic advance (%)	Relative efficiency (%)	Character	Genetic advance (%)	Relative efficiency (%)
X6	25.81	100.00	X2, X3, X5	22.68	87.87
X1	6.13	23.76	X2, X3, X6	7.76	30.05
X2	-0.17	-0.67	X2, X4, X5	36.33	140.75
X3	32.54	126.06	X2, X4, X6	20.84	80.76
X4	1.06	4.11	X2, X5, X6	31.23	120.99
X5	0.36	1.39	X3, X4, X5	26.49	102.65
X1, X2	48.00	185.98	X3, X4, X6	7.79	30.20
X1, X3	24.30	94.16	X3, X5, X6	7.41	28.70
X1, X4	33.93	131.45	X4, X5, X6	20.82	80.66
X1, X5	48.49	187.87	X1, X2, X3, X4	20.39	78.99
X1, X6	28.47	110.30	X1, X2, X3, X5	18.78	72.74
X2, X3	23.60	91.44	X1, X2, X3, X6	3.93	15.24
X2, X4	36.45	141.22	X1, X2, X4, X5	29.41	113.97
X2, X5	61.01	236.39	X1, X2, X4, X6	17.33	67.15
X2, X6	31.56	122.27	X1, X2, X5, X6	27.44	106.31
X3, X4	28.69	111.17	X1, X3, X4, X5	20.96	81.19
X3, X5	26.50	102.65	X1, X3, X4, X6	3.86	14.95
X3, X6	7.79	30.20	X1, X3, X5, X6	0.88	3.43
X4, X5	41.79	161.92	X1, X4, X5, X6	17.26	66.86
X4, X6	20.84	80.76	X2, X3, X4, X5	22.60	87.56
X5, X6	31.86	123.45	X2, X3, X4, X6	7.75	30.04
X1, X2, X3	20.62	79.88	X2, X3, X5, X6	7.40	28.66
X1, X2, X4	30.23	117.14	X2, X4, X5, X6	20.81	80.64
X1, X2, X5	47.52	184.10	X3, X4, X5, X6	7.41	28.70
X1, X2, X6	27.44	106.33	X1, X2, X3, X4, X5	18.58	72.00
X1, X3, X4	24.26	93.99	X1, X2, X3, X4, X6	3.85	14.91
X1, X3, X5	21.00	81.37	X1, X2, X3, X5, X6	0.73	2.84
X1, X3, X6	3.94	15.25	X1, X2, X4, X5, X6	17.24	66.78
X1, X4, X5	31.89	123.55	X1, X3, X4, X5, X6	0.37	1.42
X1, X4, X6	17.34	67.18	X2, X3, X4, X5, X6	7.40	28.65
X1, X5, X6	28.40	110.03	X1, X2, X3, X4, X5, 6	65.73	254.66
X2, X3, X4	23.49	91.00			

X1 Plant height at final harvest (cm)

X2 Days to 50% flowering

X3 Average weight of 50 pods (g)

X4 Pod length (cm)

X5 Protein content of pods (%)

X6 Pod yield per plant (g).

In this study, the expected genetic advance and the relative efficiency of the index was increased with the increase in the

number of characters involved. The selection index involving all the six characters exhibited the highest expected genetic

advance (65.73%) and the maximum relative efficiency (254.66%). Similar conclusions were obtained by Elsyed (1999) [4] and Ibrahim *et al.* (2012) [7] in cluster bean. Although this index exceeded the straight selection based on pod yield per plant per se by 154.66% the genetic advance was relatively low.

The selection indices of 56 cluster bean genotypes are

presented in table 5. The index value for each genotype was determined and the genotypes were ranked accordingly. In the present study, the highest value was recorded in check Pusa Navbahar (688.57) followed by MDU-1 (598.556), Chitra Gold (587.482), IC-51063 (470.535) and IC-522421 (448.285). These genotypes were identified to be genetically superior. Similar findings were recorded by Divya (2011) [12].

Table 5: Selection indices arranged in descending order

Rank	Accession no.	Selection index	Rank	Accession no.	Selection index
1	Pusa Navbahar (Check)	688.570	29	IC-113503	386.236
2	MDU-1	598.556	30	IC-113513	386.13
3	Chitra Gold	587.482	31	IC-384974	383.217
4	IC-51063	470.535	32	IC-113272	375.67
5	IC-522421	448.285	33	IC-116569	374.926
6	IC-113399	438.279	34	IC-113379	374.815
7	IC-384986	433.791	35	IC-113523	372.408
8	IC-421855	429.987	36	IC-113376	371.419
9	IC-113506	427.108	37	IC-116607	370.752
10	IC-116932	423.554	38	IC-113374	369.115
11	Thar Bhadavi	422.089	39	IC-113390	367.563
12	IC-116930	421.32	40	IC-116608	363.739
13	IC-116705	417.902	41	IC-522511	361.255
14	IC-113396	417.102	42	IC-421850	360.453
15	IC-113393	417.037	43	IC-113382	360.238
16	IC-522506	414.028	44	IC-116660	359.855
17	IC-113378	412.052	45	IC-116652	358.195
18	IC-522487	411.47	46	IC-522399	357.556
19	PLG-85	408.751	47	IC-113281	352.338
20	IC-113395	403.433	48	RGC-1038	350.696
21	IC-52249	402.073	49	IC-113277	344.76
22	IC-113377	398.972	50	IC-116825	344.014
23	IC-113383	396.962	51	IC-113278	339.23
24	IC-113380	395.097	52	IC-116619	338.39
25	IC-522389	394.321	53	IC-116925	337.034
26	IC-113308	393.507	54	IC-116779	336.979
27	IC-113394	388.685	55	RGC-986	332.018
28	IC-113568	388.656	56	IC-116626	331.214

Conclusion

It could be concluded that, average weight of 50 pods and plant height were the most important yield contributing characters, as pointed out by correlation, path analysis and selection index. These characters were positively associated with each other and with pod yield per plant, suggesting that simultaneous improvement in these characters will be rewarding. Selection index worked out considering several yield related characters would be more efficient in identifying a superior genotype. Use of selection index enables more efficient selection for yield improvement than strait selection for yield alone.

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