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Genetic Association of yield and yield attributing characters in cluster bean [*Cyamopsis tetragonoloba* (L.) Taub.]

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Abstract
Fifty numbers of genetically diversed cluster bean genotypes were evaluated for fourteen biometric and two quality traits for estimating the correlation of yield contributing characters. Analysis of variance showed significant variation for all the characters, indicating presence of sufficient variability in the material studied. The study showed that the genotypic correlations were higher than those of their respective phenotypic correlation coefficients in majority of the characters, suggesting that genotypic correlations were stronger, reliable and free from environmental influences. Dry pod yield per plant showed significant positive correlation with plant height, days taken to first flowering, number of pods per cluster, fresh pod yield, seed yield per plant and 100 seed weight.

Keywords: Cluster bean, diverse genotypes, association of characters

Introduction
Cluster bean [*Cyamopsis tetragonoloba* (L.) Taub.] also known as Guar / Gowaar / belongs to the family Fabaceae. It is an annual legume and mainly cultivated in the states of Rajasthan and Maharashtra. Cluster bean is rich in protein and is mainly used for making vegetable curries. It is suitable for the areas with light to medium textured soils, with a rainfall range of 250 - 450 mm and temperature range of 25°C to 40°C. This crop is highly susceptible to water logging conditions. Guar is grown mainly in the *kharif* season. But the crop is being grown during summer season in the arid regions of Haryana. On account of its high protein content, it is used as cattle feed and as green manure.

Mature seeds of cluster beans are dried and powdered to form guar gum which is used as a thickening agent in ice creams. To give economic advantage for the farming community of such areas varieties with earliness, better adaptability, resistance to drought, photo and thermo insensitivity with efficient root system and high level of nodulation will be required. Association of different quantitative characters of a given crop plant provides information on their association and the degree of inter relationship among various characters and to evolve selection criteria for improvement. Therefore, the present investigation was conducted to understand of these inter relation among the characters which form an integral part of a programme for making improvement on yield and its component traits.

Materials and methods
The present investigation was carried out in the college orchard, Department of Horticulture, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, Puducherry (U.T). A total number of 50 cluster bean accessions collected from NBPGR, New Delhi and raised in the main field during *Kharif* season in a Randomized Block Design with three replications at a spacing of 45cm x 15cm. All recommended cultural practices were done periodically to raise a healthy crop. Five uniform size plants per genotype under each replication was selected at random and tagged for recording the observations *viz*., plant height, number of branches per plant, days taken to first flowering, number of clusters per plant, number of pods per cluster, pod length, pod girth, individual pod weight, pod yield per plant, seed yield per plant, number of seeds per pod, 100 seed weight, days taken to maturity and harvest index. Qualitative characters like crude protein content, crude fibre and guar gum content were also analysed. The inter relation and association among traits was estimated in terms of phenotypic (rp) and genotypic (rg) correlation coefficient estimates of component traits with yield were computed according to the method given by Aljibour *et al*. (1958) [1].

Results and Discussion

The genotypic and phenotypic correlation coefficients are presented in Table 1 & 2. The associations of characters were worked out among different characters including pod yield. The study showed that the dry pod yield per plant was found to be significantly and positively correlated with plant height, number of pods per cluster, pod length, fresh pod yield, seed yield per plant, hundred seed weight. This results are in agreement with Singh *et al*. (2001) [12], Singh *et. al*. (2002) [13], Singh *et. al*. (2005) [14], Patel *et al.* (2008) [8], Saini *et.al*., (2010) [9], Girish *et al*. (2012) [5], Vir and Singh (2015) [15] and Boghara *et al*. (2016) [2] also reported positive and significant association for number of seeds per pod, number of pods per plant, number of pods per cluster, number of clusters per plant, days to 50% flowering and days to maturity and dry pod yield per plant.

These results suggested that the genotypes those have more number of seeds per pod, higher number of pods per plant, higher numbers of pods per cluster, increased number of clusters per plant and delayed flowering and maturity have given higher seed yield. While number of seeds per pod and guar gum content showed positive and non significant association with yield. Days taken to first flowering, number of clusters per plant and days taken to maturity recorded negative significant association with dry pod yield per plant. Similar findings were reported by Deepa and Balan (2006) [4] in cowpea Vir and Singh (2015) [15] and Panchta *et al*. (2017) [7] in cluster bean. The characters like number of branches per plant, harvest index, crude fibre and crude protein showed negative non-significant association with pod yield. The findings were in line with the findings of Shridhar (2005) [10] in peas.

Fresh pod yield recorded highest correlation (r = 0.947) with dry pod yield followed by seed yield per plant (r = 0.939), number of pods per cluster (r = 0.834), hundred seed weight (r = 0.420) and plant height (r = 0.367) at genotypic level. The trait fresh pod yield had the highest correlation with dry pod yield per plant, followed by seed yield per plant (r = 0.938), number of pods per cluster (r = 0.803), hundred seed weight (r = 0.420), plant height (r = 0.364) and pod length (r = 0.285) at phenotypic level.

The present study revealed that the traits *viz.*, fresh pod yield per plant, seed yield per plant, number of pods per cluster, hundred seed weight, plant height and pod length showed high positive and significant correlation with dry pod yield per plant. Hence during selection care should be taken to give more weightage on these traits for realizing the highest dry pod yield.

The inter correlation among component characters revealed significant positive correlation of plant height with number of pods per cluster, fresh pod yield, seed yield per plant, number of branches per plant with number of clusters per plant, days taken to first flowering with number of clusters per plant and days taken to maturity, number of clusters per plant with days taken to maturity and crude fibre, number of pods per cluster with pod length, fresh pod yield, seed yield per plant and hundred seed weight, pod length with fresh pod yield, seed yield per plant, hundred seed weight, fresh pod yield with seed yield per plant, hundred seed weight, seed yield per plant with hundred seed weight.

While negative significant correlation was observed for plant height with days taken to first flowering and days to maturity, number of branches per plant with number of pods per cluster, number of seeds per pod, days taken to first flowering with number of pods per cluster, pod length, fresh pod yield, seed yield per plant, hundred seed weight, number of clusters per plant with number of pods per cluster, number of pods per cluster with days taken to maturity, pod length with days taken to maturity, seed yield per plant with days taken to maturity, and hundred seed weight with days taken to maturity. This results are in corroboration with Henry *et al*. (1986) [6] and Brindha *et al*. (1996) [3], Singh *et. al*., (2005) [14] and Saini *et. al*. (2010) [9].

The conclusion that can be reached from the association analysis is that, fresh pod yield, seed yield per plant, number of pods per plant, hundred seed weight, plant height, pod length, number of seeds per pod and gum content may result in simultaneous improvement for pod yield and could be utilized as yield indicator while exercising selection. However, characters like days taken to first flowering, number of clusters per plant, and days taken to maturity, number of branches per plant, harvest index, quality characters like crude fibre and crude protein were negatively associated with dry pod yield per plant. Hence, intensive selection for these traits will however result in the reduction of dry pod yield and so a compromise towards selection is required for these traits.

Table 1: Genotypic correlation coefficient among different characters on dry pod yield.

Traits	NBPP	DTFF	NCPP	NPPC	PL	FPY	NSPP	SYPP	HSW	DTM	HI	CF	CP	GC	DPY
PH	-0.276	-0.321*	-0.150	0.436**	0.234	0.381**	0.089	0.412**	0.228	-0.309*	-0.016	-0.092	-0.045	0.111	0.367**
NBPP	1.000	0.154	0.505**	-0.486**	-0.221	-0.209	-0.286*	-0.248	-0.027	0.144	-0.041	0.239	-0.054	-0.008	-0.188
DTFF		1.000	0.287*	-0.765**	-0.301*	-0.923**	-0.211	-0.917**	-0.419**	1.000**	0.093	0.091	-0.034	-0.085	-0.957**
NCPP			1.000	-0.599**	-0.025	-0.201	-0.113	-0.270	-0.160	0.297*	0.197	0.300*	0.121	0.006	-0.300*
NPPC				1.000	0.302*	0.775**	0.161	0.776**	0.424**	-0.767**	-0.063	-0.148	0.056	0.178	0.834**
PL					1.000	0.362**	0.036	0.339*	0.406**	-0.287*	-0.099	-0.126	0.209	0.081	0.285*
FPY						1.000	0.212	0.913**	0.384**	-0.917**	0.001	-0.126	0.056	0.094	0.947**
NSPP							1.000	0.071	-0.073	-0.183	-0.008	-0.083	-0.084	0.146	0.167
SYPP								1.000	0.412**	-0.913**	-0.079	-0.066	-0.050	0.037	0.939**
HSW									1.000	-0.409**	0.025	-0.095	0.269	0.076	0.420**
DTM										1.000	0.113	0.094	-0.031	-0.090	-0.957**
HI											1.000	-0.056	0.165	0.023	-0.052
CF												1.000	-0.169	-0.156	-0.068
CP													1.000	-0.035	-0.014
GC														1.000	0.112

* Significant at 5 per cent level ** Significant at 1 per cent level.

PH- Plant height, NBPP- Number of branches per plant, DTFF- Days taken to first flowering, NCPP- Number of clusters per plant, NPPC- Number of pods per cluster, PL- Pod length, FPY- Fresh pod yield, DPY- Dry pod yield, NSPP- Number of seeds per pod, SYPP- Seed yield per plant, HSW- Hundred seed weight, DTM- Days to maturity, HI- Harvest index, CF- Crude fibre content, CP- Crude protein content, GC- Gum content.

Table 2: Phenotypic correlation coefficient among different characters on dry pod yield.

Traits	NBPP	DTFF	NCPP	NPPC	PL	FPY	NSPP	SYPP	HSW	DTM	HI	CF	CP	GC	DPY
PH	-0.256	-0.310*	-0.147	0.413**	0.233	0.379**	0.071	0.409**	0.227	-0.296*	-0.016	-0.092	-0.047	0.108	0.364**
NBPP	1.000	0.140	0.473**	-0.456**	-0.209	-0.197	-0.226	-0.232	-0.024	0.131	-0.036	0.225	-0.051	-0.004	-0.177
DTFF		1.000	0.279	-0.722**	-0.294	-0.901**	-0.155	-0.895**	-0.408**	0.993**	0.093	0.089	-0.034	-0.080	-0.935**
NCPP			1.000	-0.577**	-0.025	-0.199	-0.096	-0.269	-0.158	0.287*	0.195	0.297*	0.120	0.004	-0.298*
NPPC				1.000	0.291*	0.748**	0.112	0.747**	0.409**	-0.717**	-0.058	-0.142	0.050	0.166	0.803**
PL					1.000	0.362**	0.030	0.338*	0.406**	-0.278	-0.098	-0.126	0.208	0.080	0.285*
FPY						1.000	0.178	0.912**	0.384**	-0.889**	0.001	-0.126	0.055	0.093	0.947**
NSPP							1.000	0.058	-0.062	-0.130	-0.015	-0.068	-0.062	0.128	0.140
SYPP								1.000	0.412**	-0.885**	-0.078	-0.066	-0.049	0.036	0.938**
HSW									1.000	-0.395**	0.025	-0.095	0.268	0.075	0.420**
DTM										1.000	0.113	0.092	-0.032	-0.084	-0.927**
HI											1.000	-0.056	0.163	0.022	-0.051
CF												1.000	-0.169	-0.154	-0.068
CP													1.000	-0.034	-0.014
GC														1.000	0.11

* Significant at 5 per cent level ** Significant at 1 per cent level.

PH - Plant height, NBPP - Number of branches per plant, DTFF - Days taken to first flowering, NCPP - Number of clusters per plant, NPPC - Number of pods per cluster, PL - Pod length, FPY - Fresh pod yield, DPY - Dry pod yield, NSPP - Number of seeds per pod, SYPP - Seed yield per plant, HSW - Hundred seed weight, DTM - Days to maturity, HI - Harvest index, CF - Crude fibre content, CP - Crude protein content, GC - Gum content.

Conclusion

The residual effect determines how best the causal factor accounts for the variability of the dependent factor *i.e.* dry pod yield per plant in this study. In the present investigation, it was interesting to note that the residual effect was 0.268 which accounted that a high percentage of variability in dry pod yield per plant has been exhibited by the 16 characters included in the study. The findings suggested that days to maturity, number of pods per cluster, fresh pod yield, and seed yield per plant are important characters to bring about overall improvement in dry pod yield per plant. Hence weightage may be given to these characters during selection.

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