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Genetic variability, character association and path analysis in clusterbean (*Cyamopsis tetragonoloba* (L.) Taub)

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ABSTRACT

Clusterbean (*Cyamopsis tetragonoloba* (L.) Taub) is commonly known as Guar, is a valuable arid legume crop grown for its gum, vegetable and also fodder. Very few efforts have made to understand the association of various yield components and their direct and or indirect influence on yield of clusterbean. In the present study forty two genotypes of clusterbean selected from various genetic backgrounds with diverse geographical origin were used to study the association pattern among morphological traits and direct and indirect effect of these traits on productivity is also discussed. Number of pods per plant, cluster per plant, pods per cluster, and branches per plant had positive and significant correlation with seed yield per plant, whereas, cluster per pod, 100-seed weight, followed by seed per pod had positive and greater direct effects on seed yield per plant and pod length, branches per plant and days to maturity had negative direct effect on seed yield per plant.

Key words: Correlation, Clusterbean, Genetic variability, Path analysis

Clusterbean (*Cyamopsis tetragonoloba* (L.) Taub) is commonly known as Guar. It is a deep rooted annual arid legume crop known for its drought tolerance and suitability for various limited environments. India is the major guar producer accounting for 80% of the world's production followed by Pakistan, USA and South Africa. In India, guar is being grown mainly in arid and semiarid regions of north-western states of Rajasthan, Gujarat, Haryana, Punjab, parts of Uttar Pradesh, Madhya Pradesh and Tamil Nadu covering about 3.34 million hectares with a production of 0.4 million tonnes of guar seed. Rajasthan is the largest producer accounting for 70% of total guar production followed by Gujarat, Haryana and Punjab. The productivity of cluster bean ranges from 474 kg/ha in Rajasthan to 1200 kg/ha in Haryana (Ahlawat *et al.* 2013). Cluster bean known for its endosperm bound polysaccharide gum known as galactomannan, which fetches high value in shale energy production field (fracking in petroleum industries), textile, paper, pharmaceutical, nutraceutical and cosmaceutical industries.

Very limited efforts have been made in cluster bean for genetic improvement of seed yield through systematic breeding programme. Yield is a complex trait influenced by various agro morphological and reproductive traits and hence, there is a need to study the association and their direct and indirect effects on seed yield. Correlation coefficient offers a means of determining the important traits influencing the dependent trait such as yield and it also helps in the determination of the selection criteria for simultaneous improvement of various characters along with economic yield. Cluster bean for gum purpose is being introduced for large scale cultivation in Tamil Nadu recently. It will be more desirable to know the diversity of germplasm which will be suited to climatic condition of Tamil Nadu. In the present study an attempt has been made to assess the factors determining seed yield in cluster bean through association analysis and path coefficient.

MATERIALS AND METHODS

The experimental material consisted of 42 diverse clusterbean genotypes from from CCS HAU, Hisar, Haryana; Rajasthan Agriculture Research Institute, Swami Keshwanand Rajasthan Agricultural University, Durgapur, Rajasthan; Sardarkrushinagar Dantiwada Agricultural University, Krushinagar, Gujarat; Indian Agricultural Research Institute, Pusa, New Delhi, local landraces from Rajasthan and Tamil Nadu which represents eco-geographical diverse areas of India. Out of 42 genotypes, 36 are of grain type (gum purpose), five of vegetable type and only one is of forage type. The material was grown in a randomized block design with two replications with spacing of 45 x 15 at Department of Plant Breeding and Genetics, Agricultural College and Research Institute, Madurai. Each entry was sown in single row with a row length of 3m. Five plants were randomly selected from each entry and replication; and observations were recorded on twelve morphological as well as yield attributes including seed yield as listed in Table 1.

The phenotypic and genotypic variances in terms of their coefficients, heritability, genetic advance as per cent of mean, Correlation and path analysis was calculated following standard methods. The estimates of PCV and GCV were classified as low (<10%), medium (10-20%) and high (>20%) . Correlation coefficient between all possible pairs of characters and path analysis using the seed yield as dependent character were estimated .

RESULTS AND DISCUSSION

The analysis of variance showed that the genotypes differed significantly among themselves for all the characters indicating the presence of adequate variability. The range (Table 1) was maximum for pods per plant followed by plant

Table 1. Estimation of genetic parameters for yield and its component characters in clusterbean.

Characters	Minimum	Maximum	Mean	GCV	PCV	Heritability (%)	GA (% of mean)
Plant height	45.35	94.60	69.76	10.45	16.50	40	13.63
Primary branches per plant	0.00	8.40	4.91	42.74	51.55	69	73.01
Secondary branches per plant	0.00	5.35	4.99	44.55	49.06	79	77.43
Clusters per plant	10.80	32.90	21.81	17.91	32.17	31	20.53
Pods per cluster	2.60	10.70	7.51	16.53	23.67	49	23.78
Pod length	5.26	12.88	6.56	25.30	26.21	93	50.32
Seeds per Pod	6.62	9.20	8.19	4.65	7.59	38	5.87
Pods per plant	21.20	132.10	77.00	19.77	36.25	30	22.22
Days to 50% flowering	23.50	34.50	25.84	11.44	11.72	95	22.98
Days to maturity	87.50	107.00	98.17	5.71	6.23	84	10.78
100-Seed weight	3.32	4.99	3.94	7.95	9.76	66	13.33
Seed yield per plant	5.76	25.95	15.18	18.84	31.71	35	23.06

Table 2. Genotypic and Phenotypic correlation of various agro morphological traits of Clusterbean

		PH	B/P	2B/P	C/P	P/C	PL	S/P	P/P	DFF	DTM	100SW	SPY
PH	rG	1	-0.488**	-0.054	-0.691**	0.340*	-0.027	0.160	-0.062	-0.002	-0.052	0.254	0.156
	rP	1	-0.204	-0.030	0.064	0.405**	0.006	0.184	0.233	-0.029	0.0210	-0.009	0.338*
B/P	rG		1	1.003**	1.07**	0.120	-0.592**	-0.431**	0.893**	-0.310*	-0.180	-0.465**	0.560**
	rP		1	0.528**	0.831**	0.127	-0.433**	-0.142	0.679**	-0.238	-0.167	-0.350*	0.492**
2B/P	rG			1	1.021**	0.418**	-0.666**	0.080	0.652**	-0.135	-0.507**	-0.617**	1.085**
	rP			1	0.642**	0.217	-0.185	-0.119	0.685**	0.012	-0.089	-0.099	0.639**
C/P	rG				1	-0.062	-0.597**	-0.335*	0.838**	-0.239	-0.318*	-0.428**	0.581**
	rP				1	0.108	-0.287	-0.041	0.812**	-0.119	-0.121	-0.192	0.668**
P/C	rG					1	-0.938**	-0.564**	0.558**	-0.345*	0.052	-0.829**	0.532**
	rP					1	-0.638**	-0.205	0.471**	-0.237	0.0230	-0.514**	0.505**
PL	rG						1	0.693**	-0.920**	0.530**	-0.041	0.874**	-0.629**
	rP						1	0.505**	-0.486**	0.502**	-0.047	0.713**	-0.336*
S/P	rG							1	-0.313*	0.274	0.044	0.541**	0.110
	rP							1	-0.138	0.133	0.117	0.403**	0.060
P/P	rG								1	-0.391*	-0.450**	-0.668**	0.823**
	rP								1	-0.203	-0.156	-0.318*	0.793**
DFF	rG									1	0.250	0.366*	-0.233
	rP									1	0.216	0.337*	-0.110
DTM	rG										1	-0.162	-0.127
	rP										1	-0.077	-0.011
100 SW	rG											1	-0.481**
	rP											1	-0.216
SPY	rG												1
	rP												1

* Significant at 0.05 level of probability ** Significance at 0.01 level of probability

rG- Genotypic correlation , rP- Phenotypic correlation

Traits - PH (Plant height), B/P (Branches per plant), 2B/P (Secondary branches per plant), C/P (Clusters per plant), P/C(Pods per cluster), PL (Pod length), S/P (Seeds per pod), P/P (Pods per plant) DFF (Days to fifty percent flowering), DTM (Days to maturity), 100 SW(100 seed weight), SPY (Seed yield per plant)

height, cluster per plant and seed yield per plant. Variances in terms of coefficient of variation indicated that there were little differences between phenotypic and genotypic variance for some of the characters *viz.*, pod length, days to maturity and days to 50% flowering, indicating that these characters were less affected by environment. On the other hand, characters such as seed yield per plant, number of pods per plant and plant height were influenced by the environment.

High heritability and high genetic advance as percent of mean was recorded for primary branches per plant, secondary branches per plant, pod length and days to fifty percent flowering. High heritability and moderate genetic advance as percent of mean was recorded for days to maturity and 100 seed weight. Similar results were obtained by Dass *et al.* (1973), Dabas *et al.* (1982), Singh *et al.* (2001), Saini *et al.* (2010) and Girish *et al.* (2012) for high heritability of branches per plant, days to fifty percent flowering, days to maturity,

Table 3. The direct (diagonal) and indirect effects of some morphological traits on seed yield per plant of Clusterbean

	PH	B/P	2B/P	C/P	P/C	PL	S/P	P/P	DFF	DTM	100SW	Genotypic correlation with SPY
PH	-0.1451	0.5366	-0.0255	-0.7303	0.0570	0.0576	0.1347	0.0313	-0.0004	0.0003	0.2397	0.1560
B/P	0.0708	-1.0995	0.4721	1.1309	0.0200	1.2673	-0.3627	-0.4501	-0.0501	0.0009	-0.4392	0.5600**
2B/P	0.0079	-1.1032	0.4705	1.0785	0.0700	1.4261	0.0669	-0.3289	-0.0218	0.0026	-0.5833	1.0850**
C/P	0.1003	-1.1771	0.4804	1.0564	-0.0104	1.2786	-0.2822	-0.4226	-0.0387	0.0016	-0.4052	0.5810**
P/C	-0.0494	-0.1314	0.1967	-0.0658	0.1674	2.0092	-0.4741	-0.2811	-0.0558	-0.0003	-0.7837	0.5320**
PL	0.0039	0.6507	-0.3133	-0.6307	-0.1570	-2.1416	0.5829	0.4640	0.0856	0.0002	0.8261	-0.6290**
S/P	-0.0232	0.4741	0.0374	-0.3544	-0.0943	-1.4839	0.8412	0.1580	0.0443	-0.0002	0.5114	0.1100
P/P	0.0090	-0.9814	0.3069	0.8853	0.0933	1.9706	-0.2635	-0.5042	-0.0632	0.0023	-0.6320	0.8230**
DFF	0.0003	0.3410	-0.0635	-0.2527	-0.0578	-1.1346	0.2305	0.1972	0.1616	-0.0013	0.3461	-0.2330
DTM	0.0076	0.1984	-0.2385	-0.3361	0.0088	0.0869	0.0368	0.2270	0.0404	-0.0052	-0.1533	-0.1270
100SW	-0.0368	0.5108	-0.2903	-0.4526	-0.1387	-1.8710	0.4550	0.3370	0.0592	0.0008	0.9456	-0.4810*

Residual effect: 0.329

*Significant at 0.05 level of probability ** Significance at 0.01 level of probability

Traits - PH **(Plant height),** B/P **(Branches per plant),** 2B/P **(Secondary branches per plant),** C/P **(Clusters per plant),** P/C**(Pods per cluster),** PL **(Pod length),** S/P **(Seeds per pod),** P/P **(Pods per plant)** DFF **(Days to fifty percent flowering),** DTM **(Days to maturity),** 100 SW**(100 seed weight),** SPY **(Seed yield per plant)**

100 seed weight and pod length. High heritability with high genetic advance showed the preponderance of additive gene effect, hence simple selection for those characters should be rewarding. Moderate heritability and high genetic advance as percent of mean was recorded for cluster per plant, pods per cluster and seed yield per plant. Moderate heritability and low genetic advance as percent of mean was recorded for seed per plant. This showed high magnitude of non-additive gene action with less environmental influence.

Yield is a complex traits controlled by several simply inherited traits. The correlation coefficients highlight the pattern of association among such yield components and helps determine how a complex trait such as yield can be improved. Phenotypic and Genotypic correlations for all possible combinations are presented in Table 2. Seed yield per plant showed positively significant correlation with pods per plant, cluster per plant, pods per cluster, and branches per plant at both genotypic and phenotypic levels, the results obtained from the present investigation are in strong agreement with findings of Shah *et al.* (2000), Ibrahim *et al.* (2013), who reported significantly positive correlation of yield with plant height, pods cluster per plant, pods per plant and pod yield per plant. Pod length and 100 seed weight exhibited significantly negative correlation with seed yield per plant. This implied selection for seed yield may not be desirable if we look for test seed weight. Primary branches per plant showed positive correlation with seed yield per plant, pods per plant and cluster per plant at the same time it had significantly negative correlation with pod length, seeds per pod and 100 seed weight. Profuse branching plant type produced more yields and the same time individual seed parameter got compensated. 100 seed weight showed negative correlation with pods per plant, cluster per plant, pods per cluster and branches per plant in terms of genotypic and phenotypic level, however it had positively significant correlation with pod length, seed per pod and days to fifty percent flowering. It showed that seed weight mostly depends on quantity of seeds only. Plant height showed negatively significant correlation with branches per plant and clusters per plant in terms of genotypic correlation. It suggested taller the plant, lesser the cluster number and minimum number of branches. At the same time, plant height showed positively significant correlation with seed yield plant in terms of phenotypic correlation since number of pods per cluster was positively correlated with plant height. Our results were in accordance with findings of Sanghi and Sharma, (1964). Simply by looking into correlation only we cannot determine the true relationship of plant height and seed yield per plant, it has to be tested further for their direct and indirect effect in path analysis.

The path coefficient analysis revealed direct and indirect effects of twelve characters on seed yield are presented in Table 3. The residual effect was low (0.329), Residual effect which measures the effects of those variables not included in the study was negligible, hence indicating the number of characters chosen for the study were appropriate. The cluster per pod, 100-seed weight, followed by seed per pod had positive and greater direct effects on seed yield per plant at the same time pod length, branches per plant and days to maturity had negative direct effect on seed yield per plant and these were in agreement with findings of Singh *et al.* (2002), Hingane and Navale (2008) and Girish *et al.* (2012). The indirect contribution of 100 seed weight via primary branches per plant, seed per pod, pods per plant were positive and greater in magnitude, however pod length and cluster per plants were negative. Contribution of cluster per plant through pod length, secondary branches per plant were considerably positive values, days to maturity and plant height shown merely positive values and rest of the characters shown negative effect only. The indirect contribution of pods per plant via cluster per plant, pods per cluster and pod length were positive but it was negative in effect through 100 seed weight and branches per plant. Higher order positive and greater contribution of seed per pod through 100 seed weight was observed. 100 seed weight which had negative genotypic correlation with seed yield per plant, however it showed positive direct effect on seed yield per plant in path analysis, this kind of negative correlation arouse because of negative indirect effects of other traits like secondary branches per plant, pods per plant, cluster per plant, pod length through 100 seed weight in path analysis. The same pattern was observed for seeds per pod and cluster per plant in comparison of direct effect and correlation with seed yield per plant. Plant height showed positive and significant phenotypic correlation with seed yield per plant, however, direct effect of plant height to seed yield per plant was negative. Our results were in agreement with previous research findings of shah *et al.* (2000) and Ibrahim *et al.* (2013). The conflict relationship between the correlation and the path coefficient analysis is widely observed among the major crop plants, because correlation simply measures the apparent mutual association between the two traits without regard to the cause, whereas path coefficient specifies the causes and measures their relative importance. So, it may be concluded from these findings that correlation alone may not give complete information but when used in combine with path coefficient analysis will give a better measure of cause and effect relationship existing between different pairs of characters. The results of present investigation on direct effect of 100 seed weight, clusters per plant and seeds per pod on seed yield per plant indicated interesting fact that, traits having high direct effects not always shown higher degree of correlation. Similar conclusions were reported by many researchers *viz.*, Dewey and Lu (1959) in crested wheatgrass, Phadnis *et al.* (1970) in chickpea, Singh and Mehndiratta (1970), Kurer (2007) in cowpea, Bhadru (2011) in pigeonpea and Chaubey *et al.* (2012) in faba bean.

From the above said discussion, it could be deduced that the direct and indirect selection on the basis of traits *viz.*, number of clusters per plant, number of pods per cluster, number of seeds per pod and 100 weight in the genotypes under study would be rewarding in improving the yield.

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