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Variability and correlation analysis in the germplasm of cluster bean [*Cyamopsis tetragonoloba* (L.) Taub.] in hyper hot arid climate of Western India

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ABSTRACT

The 44 accessions of cluster bean collected from Rajasthan, Gujarat and Maharashtra were evaluated in a randomized complete block design with three replicates during *summer* and *kharif* seasons of hyper hot and dry climate of Rajasthan to estimate the presence of genetic variability, inter-characters associations, to identify a suitable high yielding with short duration accession of guar for cultivation during *summer* and to compare the relative performance of the genotypes in two seasons. The high degree of genetic variability was estimated during both seasons for seed yield per plant (g), 100-seed weight (g.), number of seeds per pod, number of pods per plant, number of pods per cluster, number of branches per plant, number of clusters per plant, plant height (cm.), number of days to 50% flowering and number of days to maturity. The moderate to high heritabilities coupled with moderate to high expected genetic advance were observed for all studied traits. 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 had positive and significant correlations with seed yield per plant. A promising unbranched with determinate growth habit genotype IC 421811-P6, developed through single plant selection yielded 20.6 gm seed per plant.The accessions IC 415109, IC 28272, IC 329036, IC 373427, IC 370490 during *summer* season and during *kharif* season IC 370478, IC 370481, IC 421811, IC 421817 and IC 402303 during *kharif*season exhibitedsuperiority in terms of seed yield over best check.

Key words: Cluster bean, Correlation, Genetic variability, *Kharif, Summer*.

INTRODUCTION

Cluster bean[*Cyamopsis tetragonoloba* (L.) Taub]is one of the important arid legume and versatile crop cultivated mainly in India and Pakistan. The 80% of the world's production of cluster bean is in India with smaller crops grown in the semi-arid areas of the high plains of Texas in the USA, Australia, and Africa. The most important growing areas of this crop is Jodhpur in Rajasthan. The bean is the important source of guar gum. Guar beans have a large endosperm that contains galactomannan gum, a substance that forms a gel in water. This is commonly known as guar gum and is used in dairy products like ice cream and as a stabilizer in cheese and cold meet processing. The derivatives of guar gum after being reacted is also used in industrial applications such as the paper and textile industry, ore flotation, the manufacture of explosives and hydraulic fracturing of oil and gas formations.Being a drought tolerant crop with a better growth in warm climate, cluster bean is more popular in semi- arid and arid regions of the tropics where other food legumes do not perform as well. Cluster bean can be grown in very poor soil. It has strong tap root system to cope up with low moisture- stress and nodulation in roots to fix atmospheric nitrogen in the soil. In India cluster bean is grown on 34 lakh hectares with the production and productivity of 12 lakhs tonnes and 400 kg/ha. respectively. Low national productivity of cluster bean is because it is grown on poor and marginal soils without applying required inputs. Western Rajasthan, experiences hot and arid climate with poor rainfall, produces the 80% guar of total India's production. To increase the productivity of guar there is an urgent need to develop high yielding disease resistant varieties of guar that can cope up with vagaries of climate fluctuations. In the past not much effortshave been made for the genetic improvement of the crop however, a lot of variability exists in the germplasm for useful traits. Traditionally, cluster bean is grown during *kharif* seasons. A number of varieties have been developed and released for *kharif* season for its commercial cultivation but not much work has been done for *summer* season.

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Therefore, in the present study efforts have been made to evaluate germplasm during *summer* for morphological traits and for the identification of genotype(s) that can be used to release directly as a variety for *summer* season or may be used in the breeding programme for the development of variety for *summer* season that can fit well between the harvest of *rabi*crops like cumin, wheat and mustard and sowing of *kharif* crops like bajra, rice and pulses. Also so far no sincere efforts have been made to screen germplasm during *summer* season and consequently no variety is released for *summer* cultivation of cluster bean. The cultivation of cluster bean in *summer* can benefit farmers in two ways, i) extra income can be generated by the *summer* crop as fields lie vacant during *summer* and ii) by improving soil fertility for the next *kharif* crop as cluster bean is a leguminous crop and it fixes atmospheric nitrogen in the soils through the swellings in its roots. The other objectives of the study were to generate basic information like to detect the presence and magnitude of genetic variability and inter-characters associations in the fragile climate of Rajasthan during both *summer* and *kharif* seasons.

MATERIALS AND METHODS

The 44 accessions of cluster bean collected from Rajasthan, Gujarat and Maharashtra were evaluated during *summer* and *kharif* 2012 at the Experimental Farm of National Bureau of Plant Genetic Resources, Jodhpur. The soil of the experiment site was sandy loam with a pH 7.86 having 0.19 percent organic carbon and 125.0, 13.5 and 255 kg/ha available N, P_2O_5 and K_2O, respectively. The experiments were laid out in randomized complete block design with three replicates during *summer* and *kharif* seasons keeping line to line distance of 45 cm. and plant to plant distance of 15 cm. Plot size was consisted of three rows of 2 meters length each. In the *summer* four sprinkler irrigations were given uniformly at the interval of 20 days including pre-sowing irrigation. Only pre-sowing irrigation was given to *kharif* experiments as rains were sufficient after sowing of the experiments during the season. *Summer* experiments were sown on March 4, 2012 whereas; *kharif* experiments were sown on July26, 2012.At maturity five plants were selected randomly from each plot and tagged. The data of selected plants were recorded on seed yield per plant (gm), 100- seed weight (gm.), pod length (cm.), number of seeds per pod, number of pods per plant, number of pods per cluster, number of branches per plant, number of clusters per plant, plant height(cm.), number of days to 50% flowering and number of days to maturity. The mean values of these observations were statistically analysed separately for each season. The analysis of variance, heritability, genetic advance and inter-character associations were carried out by using Windostate software following the methods given by Singh and Chaudhary (1985).

RESULTS AND DISCUSSIONS

Analysis of variance on the studied traits presented in the Table 1. revealed significant differences among accessionsfor all the charactersduring both *summer* and *kharif* seasons. Shanmugam (1983), Singh *et. al.*,(2001), Kumar and Singh (2002), Singh *et. al.*, (2003), Singh *et al.*, (2005), Saini *et. al.*, (2006), Anandhi and Oommen (2007), Dwivedi (2009), Pathak *et. al.*, (2009), Saini *et.al.* (2010) and Shabarishrai *et.al.*, (2012) studied the cluster bean genotypes and reported higher genetic variability for yield and its attributing traits. The effect of seasons on the expression of various traits indicated the influence of climatic conditions attributed towards climatic data during two seasons. Imrie and Butler (2005) studied the adaptability and performance of mung bean genotypes in different environments and observed the presence of genotype x environment interaction of higher magnitude for seed yield and yield components. The Mean of the recorded data revealed the high range of most of the studied traits (Table2). Seed yield per plant ranged from 3.89 to 27.62 gm. per plant during *summer* and 5.51 to 31.95 gm. during *kharif*, 100-seed weight 2.12 to 3.90 in *summer* and 1.85 to 4.02 in *kharif*, number of seeds per pod 5.60 to 9.0 in *summer* and 6.0to 10.0 in *kharif*, number of pods per plant 8.0 to 102 in *summer* and 16.0 to 188.0in *kharif*, number of pods per cluster 2.80 to 13.80in *summer* and 3 to 16.5 in *kharif*, number of branches per plant 0.00 to 10.0during *summer* and 0.00 to 11.4 during *kharif*, number of clusters per plant3.80 to 24.0 in *summer* and 4.0 to 28.0 in *kharif*, plant height (cm.) 18.24 to 60.0 in *summer* and 20.80to 78.44 in *kharif*, days to 50 % flowering 29.0 to 57.0 in *summer* and 32 to 58 in *kharif* and days to maturity 63 to 98 in *summer* and 69 to 120in *kharif*. Singh *et. al.*, (2005), Anandhi and Oommen (2007), Saini *et.al.*, (2010) and Shabarishrai *et.al.*, (2012) also observed a wide range in the mean values of the morphological characters including seed yield of cluster bean. The best five accessions that exhibited higher seed yield per plant were IC 415109, IC 28272, IC 329036, IC 373427, IC 370490 during *summer* season and during *kharif* season IC 370478, IC 370481, IC 421811, IC 421817 and IC 402303 were the highest yielding accessions.The *summer* of western Rajasthan are very hot and dry therefore, there is a need to identify a suitable genotype for *summer* guar cultivation and to architect a suitable ideal plant ideotype of guar that can cope up with the vagaries of climate of summer. Therefore, on the basis of *summer* experiments results a new *summer* plant ideotype was postulated as- i) plant should be photo-insensitive with determinate growth habit (Picture), ii) plant

TABLE 1: Mean squares of morphological traits of cluster bean in *summer* and *Kharif* season.

Source of Variation	Degree of freedom	Season	Seed yield/ Plant (gm.)	100-seed weight (gm.)	Pod length (cm.)	Seeds/ pos (Nos.)	Pods per plant (Nos.)	Pods per cluster (Nos.)	Branches per plant (Nos.)	Cluster per plant (Nos.)	Plant height (cm.)	Days to 50% Flowering (Nos.)	Days to Maturity (Nos.)
Genotypes	43	*Summer*	69.89*	86.36*	102.85*	0.98*	1184.73*	419.13*	92.79*	128.22*	189.74*	1178.28*	950.28*
		Kharif	122.92*	75.28*	117.43*	29.23*	1248.65*	306.21*	76.08*	118.07*	134.24*	1001.04*	824.46*
Replications	02	*Summer*	36.44	14.54	23.18	0.18	108.32	140.67	14.21	20.36	19.74	874.47	241.37
		Kharif	71.64	10.74	20.76	5.57	98.76	65.52	11.17	16.54	12.11	634.82	201.94
Error	86	*Summer*	11.35	13.06	06.48	0.16	11.51	16.29	7.73	5.31	16.85	33.62	50.67
		Kharif	22.16	8.32	10.04	0.88	9.60	12.17	5.68	2.78	9.15	27.51	41.19

Significant at 5% level of significance

TABLE 2: Estimation of basic genetic parameters for quantitative traits in the germplasm of cluster bean is *Summer* and *Kharif* seasons.

Characters	Range		Mean±SE		PCV(%)		GCV(%)		Heritability(%)		Genetic Advance (% of mean)	
	Summer	*Kharif*	*Summer*	*Kharif*	*Summer*	*Kharif*	*Summer*	*Kharif*	*Summer*	*Kharif*	*Summer*	*Kharif*
Seed yield/plant (g)	3.89-27.62	5.51-31.95	19.63+1.38	21.42+1.87	67.58	61.25	60.47	59.50	51.12	55.76	33.45	27.77
100-seed weight (g.)	2.12-3.90	1.85-4.02	2.62+0.43	2.66+0.32	19.83	23.07	14.79	18.63	67.31	56.24	23.56	29.51
No. of seeds/pod	5.60-9.00	6.00-10.00	7.53+0.82	7.75+0.52	17.62	22.84	16.88	22.08	51.64	62.49	13.23	12.35
No. pods/plant	8.00-102.0	16.0-188.0	62.50+5.24	112.45+9.18	86.82	82.76	78.28	80.27	65.73	66.35	42.43	37.64
No. of pods/cluster	2.80-13.80	3.00-16.5	5.45+0.37	6.0+0.45	22.11	26.43	18.62	19.74	71.25	76.58	32.78	35.02
No. branches/plant	0.00-10.0	0.00-11.4	4.05+0.13	4.40+0.54	17.93	23.15	16.45	18.45	49.40	53.48	27.72	31.27
No. of cluster/plant	3.80-24.0	4.0-28.0	12.64+2.33	13.98+2.81	32.24	34.53	27.15	25.37	60.48	55.92	34.19	30.83
Plant Height (cm.)	18.24-60.00	20.80-78.44	39.70+4.5	50.57+4.07	75.70	78.64	65.55	68.48	58.31	59.21	25.74	21.62
Days to 50% flowering	29.00-57.0	32.00-58.00	46.00+4.65	47.00+4.35	56.15	49.17	38.99	43.18	54.87	74.64	55.84	50.46
Days to maturity	63.00-98.00	69.00-120.	78.00+6.31	88.00+4.18	51.24	54.60	47354	48.65	56.37	59.86	50.22	57.81

height should be 50-60 cm., iii) all nodes of stem should bear pods, iv) plant should have deep root system with fast growth, v) plant should mature in 65-70 days, vi) plant should bear less foliage, vii) plant should be unbranched, sturdy with erect growth habit, vii) number of pods per plant should be more than eighty, viii) pods may have more than 8-10 seeds per pod, xii) the test weight (100 grain weight) may be more than 3.5 gm. This type of plant may produce 2-3 times more seed yield than the present type of cultivars of guar if plant population of 5 lakhs per hectare with uniform distances around plants in the field are maintained.The short duration variety that matures in less than seventy days with good plant ideotype and seed yield is preferred during *summer* as it fits well in between the harvest of *rabi* crops and sowing of *kharif* crops and also save a irrigation. During the present investigation in *summer* season an unbranched genotype IC 421811-P6,with determinate growth habit (see picture) and matured in 78 days,developed through single plant selection hadshown very high yield 20.6 gm per plant. The yield potential of this genotype could be upto 35-40 quintal per hectare under good management conditions.

The estimates of phenotypic coefficients of variation (PCV), genotypic coefficients of variation (GCV), heritability and genetic advance(expressed as percentage of mean) for all studied traits are also given in Table 2. In most of the cases phenotypic coefficients of variationwere higher than genotypic ones thus, indicating the presence of environmental influence in the expression of these traits (Imrie and Butler, 2005). The highest genotypic coefficient of variation was estimated fornumber of pods per plant followed by plant height, seed yield per plant, days to maturity, days to 50% flowering, number of clusters per plant, number of branches per plant, number of pods per cluster, number of seeds per pod and 100-seed weight during both *summer* and *kharif* seasons thereby indicating the presence of higher degree of genetic variability for these traits (Arumugarangarajan *et.al*., 2000; Singh *et. al.*, 2001; Singh *et. al.*, 2003; Singh *et. al.*, 2005; Saini *et. al.*, 2006; Anandhi and Oommen, 2007; Dwivedi, 2009; Pathak *et. al.*,2009; Saini *et.al.*,2010 and Shabarishrai *et.al.*, 2012). A higher heritability (broad sense) estimate associated with estimate of high expected genetic advance for number of pods per cluster, number of pods per plant, 100-seed weight, number of clusters per plant, and plant height suggest that these characters are governed by additive genetic effect to a large extent (Empig *et. al*., 1970), Omoigui *et al*., 2006) and thus, improvement of these characters would be effective through phenotypic selection.Singh *et. al.*, (2001), Singh *et. al*., (2005), Anandhi and Oommen (2007), Saini *et al*., (2010) also have also reported similar results in cluster bean thus our results of fragile environment are in confirmation of that of others. The other characters that exhibited moderate heritability and moderate expected genetic advance were number of branches per pant and number of seed per pod. These characters are also governed by additive type of gene(s) action and thus, amenable to phenotypic selection and thereby can be improved through simple phenotypic selection.

Picture (left). Two guar plants from left side are photo insensitive with determinate growth habit, matured in 65 days –an ideal plant ideotype for *summer* cultivation whereas third plant is photo-sensitive with indeterminate growth habit not suitable for *summer* cultivation.**Picture (Right).** A plant of unbranched with determinate growth habit genotype IC 421811-P6 of guar having high yield potential.

Phenotypic correlation coefficients and genotypic correlation coefficients estimate for both *summer* and *kharif* seasons for the studied traits are given in Table 3. In most of the cases genotypic correlations coefficientswere higher in magnitude than their corresponding phenotypic correlation coefficients. 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 had positive and significant correlations with seed yield per plant in both seasons.Arumugarangarajan *et.al.*, (2000), Patel and Chaudhary (2001), Singh *et al*., (2001), Singh *et. al.*, (2002), Singh *et. al*., (2004), Singh *et. al*., (2005) and Saini *et.al*., (2010) also reported positive and significant associations of 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 maturitywith seed yield per plant. These results suggest that 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.Number of seeds per pod and number of clusters per plant had negative associations with 100- seed weight in both *summer* and *kharif* seasons. Number of seeds per pod was negatively and significantly associated with

TABLE 3: Estimates of Phenotypic (above diagonal) and genotypic (below diagonal) correlation coefficients for morphological traits in cluster bean germplasm in *summer* (S) and *Kharif* (K) seasons.

Characters		Seed yield	100-seed	No. seeds /pod	No. of pods/ plant	No. of pods per cluster	No. of Branches per plant	No. of cluster per plant	Plant height	No. of days to 50% flowering	No. of Days to maturity
Seeds yield	(S)	1.00	0.13	0.65*	0.72*	0.51*	0.22	0.41*	-0.03	0.43*	0.37*
	(K)	1.00	0.17	0.57*	0.69*	0.50*	0.13	0.37*	-0.20	0.47*	0.45*
100-seed weight	(S)	0.20	1.00	-0.80*	-0.04	0.24	-0.17	-0.33*	-0.14	-0.06	0.11
	(K)	0.11	1.00	-0.67*	-0.01	0.27	-0.14	-0.30*	0.22	-010	0.07
No. of seeds Per pod	(S)	0.70	-0.48	1.00	-0.31*	-0.28	0.11	-0.14	0.20	-0.07	0.17
	(K)	0.62	-0.53	1.00	-0.24	-0.27	0.07	-0.17	0.10	-0.03	0.15
No. of Pods Per plant	(S)	0.76	-0.01	-0.26	1.00	0.34*	0.34*	0.32*	0.43*	0.02	0.08
	(K)	0.70	-0.02	-0.24	1.00	0.42*	0.37*	0.30*	0.25	-0.11	0.06
No. of Pods Per Cluster	(S)	0.56	0.26	-0.19	0.54	1.00	0.08	-0.47	-0.01	0.21	-0.12
	(K)	0.52	0.26	0.14	0.62	1.00	0.13	-0.37*	-0.03	0.14	-0.15
No. of Branches Per Plant	(S)	0.25	0.19	0.21	0.43	0.21	1.00	0.36*	0.31*	-0.16	0.14
	(K)	0.20	0.11	0.25	0.42	0.10	1.00	0.40*	0.58*	-0.10	0.11
No. of cluster Per Plant	(S)	0.43	-0.23	-0.01	0.36	-0.36	0.43	1.00	0.15	-0.04	-0.04
	(K)	0.44	-0.18	-0.06	0.44	-0.31	0.55	1.00	0.03	-0.01	0.22
Plant height	(S)	-0.02	0.25	0.26	0.43	0.11	0.47	0.14	1.00	0.32*	0.58*
	(K)	-0.18	0.31	0.20	0.34	0.11	0.58	0.09	1.00	0.43	0.54*
Days to 50% flowering	(S)	0.46	0.20	0.06	0.14	0.25	0.11	-0.01	0.37	1.00	0.81*
	(K)	0.53	0.22	0.09	0.07	0.21	0.11	-0.01	0.37	1.00	0.81*
Days to maturity	(S)	0.42	0.18	0.24	0.17	-0.02	0.15	0.10	0.66	0.88	1.00
	(K)	0.47	0.21	0.21	0.16	0.17	0.14	0.13	0.69	0.88	1.00

Significant @ 5% level of significance.

number of pods per plant in *summer* season only. However, number of pods per cluster, number of branches per plant, number of clusters per plant, and plant height had contributed positively to number of pods per plant. Number of pods per cluster with number of clusters per plant had negative and significant association in both seasons. Number of branches per plant had positive associations with number of clusters per plant and plant height. Delayed days to 50 % flowering and maturity resulted into increased plant height. Days to 50% flowering had strong positive and significant correlation with days to maturityin both *summer* and *kharif* seasons.Singh *et. al.*, (2001), Singh *et. al.*, (2005) and Saini *et.al.*, (2010) also observed more or less similar results in cluster bean thus, our results of fragile environment are in line with that of others. In general, it has been observed that inter-characters associations are of variable magnitude but in same direction in most of the cases during two differentseasons. The variation observed in the magnitude of correlation coefficients between two seasons could be due to the presence of genotype x environment interaction for the traits (Imrie and Butler, 2005).

On the basis of present study it may be concluded thatcluster beancan be cultivated during *summer* season in the hot and arid climate of Rajasthan provided 3-4 sprinkler irrigations are given to the crop. There is not much difference in the performance of *summer*and *kharif* crops of cluster bean. However, gxe interaction doesexists for all characters. The accessions gave higher yield during *summer* may further be tested for their performance during *summer* seasons and after validation of its promising performance they may be recommended for commercial cultivation. The identified high yielding genotypecan fit in the crop rotation of wheat/cumin/mustard in the *rabi* - cluster bean (*summer)*- bajra/rice/pulses in the *kharif*. This genotype should also be used in breeding programme of cluster bean to enhanced the yield of the this crop.

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