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GENETIC VARIABILITY AND HERITABILITY FOR SEED YIELD AND WATER USE EFFICIENCY RELATED CHARACTERS IN CLUSTERBEAN [*CYAMOPSIS TETRAGONOLOBA* (L.) TAUB.]

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SUMMARY

The material for present investigation comprised 25 guar genotypes. The experimental material was grown at Research Area, Crop Physiology (Agronomy), CCS Haryana Agricultural University, Hisar during **kharif** 2010 in randomized block design with three replications. The mean sums of squares due to genotypes were recorded to be highly significant for all the 18 characters studied, including morpho-physiological, biochemical characters and yield components and seed yield per plant. The studies revealed prevalence of enough genetic variability in the material under study. Characters like pods per plant, dry weight, plant height and proline content in leaves had high GCV, PCV, heritability and genetic advance as per cent of mean. While harvest index and seed yield per plant had high GCV, PCV and heritability associated with moderate genetic advance as per cent of mean. Likewise germination/survival per cent had moderate GCV, PCV and genetic advance as per cent of mean with high heritability. However, 100 seed weight, branches per plant and leaf area index had high GCV, PCV and heritability associated with low genetic advance as per cent of mean. While gum content, rate of water loss from excised leaf, cell membrane stability and seed per pod had moderate heritability associated with low GCV, PCV and genetic advance as per cent of mean, respectively. However, canopy temperature depression and chlorophyll fluorescence had high heritability associated with low GCV, PCV and heritability, respectively.

Key words : GCV, PCV, heritability and genetic advance as per cent of mean, guar

Clusterbean [*Cyamopsis tetragonoloba* (L.) Taub.] belongs to the family Leguminaceae and sub-family Paplionaceae. It is an annual with long and deep root and well developed laterals, cultivated mainly as rainfed crop in arid and semi-arid regions during rainy (**kharif**) seasons for vegetable, forage and green manure. India is one of the main producers of clusterbean accounting for 80 per cent of the total production of the world, whereas Rajasthan occupies the largest area (82.1%) under guar cultivation in the country. Genetic improvement for quantitative traits depends upon the nature and amount of variability present in the genetic stock and the extent to which the desirable traits are heritable. Assessment of the genetic variability within cultivated crops has a strong impact on plant breeding strategies and conservation of genetic resources. It is particularly useful in the characterization of individuals, accessions, and cultivars in determining duplications in germplasm collections and for the choice of parental genotypes in breeding programmes. Yield is a character determined by several component characters. Hence, selection for yield should take into account the related characters also. Genetic variability exists for stress and related traits in guar and is useful in selection of drought resistance genotypes by an efficient screening technique based on a combination of morpho-physiological parameters.

MATERIALS AND METHODS

The material for the study consisted of 25 genotypes of clusterbean. The experiment was conducted at the Research Area, Crop Physiology, Department of Agronomy, College of Agriculture, Hisar

during **kharif** season in randomized block design with three replications. The plot size was two rows of 3 m length. Spacing was 45 cm between rows and 10 cm between plants in a row. Observations on days to 50 per cent flowering were recorded for each plot. Data on plant height, number of branches, number of pods per plant, number of seeds per pod, 100-seed weight, dry weight, harvest index, yield per plant, chlorophyll fluorescence, canopy temperature depression (CTD), leaf area index (LAI) and rate of water loss from excised leaf (RWL) were recorded from five randomly selected plants from each plot. To estimate the extent or magnitude of variation among these strains, the data were subjected to analysis of variance based on mean values of each replication. Components of variation were used for the estimation of coefficient of variation (PCV and GCV) as described by Singh and Chaudhary (1985).

Phenotypic coefficient of variation (PCV)= $\frac{\sqrt{\sigma^2 p} \times 100}{\overline{X}}$

Genotypic coefficient of variation (GCV)= $\frac{\sqrt{\sigma^2 g} \times 100}{\overline{X}}$

Heritability in broad sense H (bs): V_g/V_p or V_g/V_g+V_e

Genetic advance as per cent of mean (G_S)=[(K) (σ_p) (H) × 100]/mean

Where,

σ^2 p=phenotypic variance

σ^2g= genotypic variance

PCV=phenotypic coefficient of variation

GCV=genotypic coefficient of variation

$\overline{X}$=mean

V_g=genotypic component of variance

V_p=phenotypic component of variance

V_e=environmental component of variance

K=selection differential

σp=phenotypic standard deviation

H=heritability in broad sense

RESULTS AND DISCUSSION

The mean sums of squares due to genotypes were recorded to be highly significant for all the 18 characters studied, including morpho-physiological, biochemical characters and yield components and seed yield per plant (Table 1). This indicated prevalence of enough genetic variability in the material under study for selection and improvement of genotypes. Selection for these characters may, therefore, show the positive impact on genetic improvement.

Comparative performance of the 25 clusterbean genotypes for the 18 characters studied (Table 2) provided a clear indication of the superiority of some of the genotypes over others. Good genetic potential, therefore, existed for cultivars such as HG 875, GG 1, GG 2, RGC 986, HG-2-1, HG-2-20, RGC 1017, HG 100, HG 563, HG 884, HVG 2-30 and FS 277, which performed very well for both yield and yield components. Breeding objectives were mainly based on the types of crop species, commercial value and environment where

TABLE 1

Analysis of variance (mean squares) for different morpho-physiological characters

S. V.	d. f.	Germination	Dry weight	Plant height	Yield/ plant	Harvest index	Branches/ plant	Pods/ plant	100-seed weight	Seeds/ pod
Replication	2	403.0	51.8	28.7	5.8	9.3	2.6	66.2	0.004	1.4
Genotype	24	244.9**	746.3**	1664.6**	83.7**	108.6**	13.0**	578.2**	1.1**	1.2**
Error	48	24.7	2.7	91.4	2.1	5.9	1.5	12.7	0.005	0.3

Contd.

Table 1 contd.

S. V.	d. f.	Relative water content	Rate of water loss from excised leaf	Cell membrane stability	Chlorophyll fluorescence	Canopy temperature depression	Leaf area index	Proline	Crude protein	Gum
Replication	2	0.3	11.0	2.4	0.0005	0.0001	1.01	0.6	1.6	15.3
Genotype	24	29.0**	77.8**	13.8**	0.004**	0.1**	7.0**	1901.7**	5.9**	9.5**
Error	48	4.2	20.1	3.8	0.001	0.001	0.2	11.1	0.4	2.4

*,**Significant at P=0.05 and P=0.01 levels, respectively.

TABLE 2
Mean performance of different guar genotypes for morpho-physiological traits

Genotype	Germination (%)	Seeds/ pod	100-seed weight (g)	Pods/ plant	Yield/ plant (g)	Dry weight (g)	Harvest index (%)	Branches/ plant	Plant height (cm)
RGC-986	87.22	8.56	2.61	76.00*	17.17	59.95*	27.53	8.83	167.83*
HG-9-1	86.67	9.56*	2.72	50.33	14.53	47.88	26.43	7.00	158.33*
HG-3-52	86.39	8.22	3.31*	53.00	14.58	66.47*	21.32	8.50	145.67*
HG-3-2	87.32	8.83	3.03	52.67	13.80	46.38	28.93	6.83	125.17
HG-100	82.22	9.78*	3.21*	59.67	18.84*	52.48	34.32*	14.00*	146.67*
C. seneglensis	67.78	8.44	1.09	43.67	3.96	16.60	21.87	14.00*	79.67*
HG-875	86.39	9.28	3.07*	75.00*	21.55*	55.80*	37.67*	13.50	125.17
GG-1	76.39	8.67	3.07*	76.00*	21.47*	66.46*	30.47	9.67	154.33*
C. serrata	46.72	6.50	0.99	36.33	2.41	15.26	15.10	7.00	51.33*
GG-2	87.22	8.61	2.97	46.67	12.05	34.14	33.13	13.33*	136.00
RGC-1003	77.78	8.39	3.13*	40.67	10.85	37.64	27.31	10.00	124.67
HFG-119	75.28	7.56	3.13*	42.67	10.73	39.66	23.82	10.17	127.83
HG-563	77.78	8.17	3.02	75.33	18.68*	47.14	40.78*	11.17	123.17
RGC-1038	82.36	8.17	3.10*	47.00	11.61	39.99	29.24	11.33	132.83
RGC-1002	88.33	9.17	3.03	63.33	17.27	47.52	35.01*	12.50*	120.83
HG-2-4	85.00	7.83	2.89	58.67	12.98	40.82	31.31	10.83	130.50
HG-2-1	87.50	8.61	3.15*	79.00*	21.55*	65.48*	32.28	10.00	132.67
HG-2-20	89.44	8.78	3.25*	76.00*	22.77*	64.88*	33.83*	11.50	111.17*
HG-365	83.33	8.44	3.07*	65.67	17.19	67.86*	24.49	12.33	128.67
HVG-2-30	85.28	8.61	3.25*	64.00	18.36*	58.02*	30.27	9.83	123.83
HG-884	86.67	8.39	3.15*	85.33*	22.36*	71.80*	31.04	9.00	120.50
RGC-1017	77.08	8.39	3.30*	76.33*	21.37*	61.06*	34.76*	9.33	133.67
HG-75	76.39	8.67	3.72*	55.00	17.20	60.82*	28.93	9.33	122.83
HG-870	82.64	8.50	3.35*	57.33	16.37	43.55	36.33*	10.33	127.50
FS-277	88.19	8.17	3.12*	59.67	15.49	76.17*	19.93	9.33	152.67*
Mean	81.49	8.49	2.95	60.61	15.81	51.35	29.44	10.39	128.14
Range	46.72-89.44	6.50-9.78	0.99-3.72	36.33-85.33	2.41-22.77	15.26-76.17	15.10-40.78	6.83-14	51.33-167.83
C. D.	8.19	0.87	0.11	5.86	2.37	2.69	3.98	2.03	15.74
C.V. (%)	6.10	6.19	2.30	5.87	9.11	3.18	8.22	11.84	7.46

Contd.

Table 2 contd.

Genotype	LAI (cm^2)	CTD (°C)	Chlorophyll fluorescence	Cell membrane stability (%)	Rate of water loss	RWC (%)	Crude protein (%)	Proline content (µg/g)	Gum (%)
RGC-986	6.70*	1.43*	0.79	40.19	76.34	86.60	28.22	138.76*	28.63
HG-9-1	6.08*	1.33*	0.80	39.95	76.90	92.22*	31.96*	43.49	29.25
HG-3-52	5.39	1.20	0.77	37.42	78.48	91.45	28.43	70.40	28.00
HG-3-2	3.43	1.25	0.79	35.39	80.59	95.54*	31.53*	84.40*	27.62
HG-100	5.81*	0.93	0.81	34.48	76.94	87.24	27.78	100.47*	26.70
C. seneglensis	1.62	1.03	0.77	36.05	83.68	85.03	29.04	29.66	26.05
HG-875	6.90*	1.50*	0.80	39.91	80.74	90.98	29.72	52.68	26.21
GG-1	5.49*	1.38*	0.78	40.35	76.70	90.82	30.19*	102.14*	25.05
C, serrata	0.73	0.83	0.71	40.18	94.43*	94.20*	30.38*	83.11	26.85
GG-2	5.48*	1.20	0.81	40.23	78.12	89.20	29.00	105.01*	25.88
RGC-1003	4.67	1.40*	0.78	40.41	86.31	90.02	27.85	76.30	27.75

Contd.

Table 2 contd.

HFG-119	6.31*	1.23	0.79	39.22	80.53	88.12	30.00*	78.71	24.43
HG-563	4.76	1.33*	0.81	38.49	84.55	89.91	28.44	46.46	28.55
RGC-1038	4.57	1.33*	0.72	36.80	84.73	89.47	30.04*	97.31*	28.35
RGC-1002	5.46	1.45	0.69	37.56	87.54	92.29	27.23	67.03	29.09
HG-2-4	3.27	1.25	0.74	39.26	91.17*	90.01	28.22	64.28	26.23
HG-2-1	3.69	1.33*	0.83*	35.80	80.40	92.66	28.77	60.01	28.91
HG-2-20	5.34	1.50*	0.82*	39.27	79.65	91.17	28.22	87.38*	27.02
HG-365	4.53	1.58*	0.81	39.22	87.08	89.20	30.10*	84.16*	26.53
HVG-2-30	4.57	1.28	0.79	42.08*	76.65	85.36	29.75	37.16	24.68
HG-884	3.88	1.23	0.80	43.71*	73.64*	89.95	28.06	59.74	28.35
RGC-1017	3.59	1.20	0.84*	39.62	85.55	87.29	26.91	51.78	22.41
HG-75	6.02*	1.28	0.83*	38.84	81.42	94.97*	27.45	62.39	29.27
HG-870	4.25	1.05	0.82*	37.87	86.91	82.31	26.47	70.72	28.15
FS-277	6.88*	1.32*	0.81	36.52	83.99	89.93	27.34	103.36*	29.50
Mean	4.78	1.27	0.79	38.75	82.12	89.84	28.84	74.28	27.18
Range	0.73-6.9	0.83-1.58	0.71-0.84	34.48-43.71	73.64-94.43	82.31-95.54	27.23-31.96	29.66-138.76	22.44-29.50
C. D.	0.70	0.05	0.03	3.19	7.39	3.36	1.07	5.47	2.57
C.V. (%)	8.93	2.21	2.51	5.00	5.46	2.27	2.24	4.48	5.74

LAI : Leaf area index, CTD : Canopy temperature depression, RWC : Relative water content.
*Significant at P=0.05 level.

crop plant has to be cultivated. Depending on the breeding objectives, there was a wide range of genotypes for breeding purpose. In case of clusterbean, main breeding objective is high yield along with high gum and proline content. Because, clusterbean is mainly grown in semi-arid areas so proline accumulation in plant tissue is a physiological mechanism to withstand water stress and it reflects plant's water stress tolerance capability. Genotypes with more gum and protein content are more desirable and useful for guar gum industries. For instance, if the breeding objective is to produce high yielding, high proline content, high protein content and high gum

TABLE 3
Range, mean, PCV, GCV, heritability (broad sense) and genetic advance for different characters

Character	Range	Mean	Coefficient of variations (%)		Heritability	Genetic advance (%)
			GCV	PCV		
Germination (%)	46.72-89.44	81.49	10.51	12.16	0.75	15.26
Seeds/pod	6.5-9.78	8.49	6.65	9.08	0.54	0.85
100-seed weight (g)	0.99-3.35	2.95	20.68	20.81	0.98	1.25
Pods/plant	36.33-85.33	60.61	22.65	23.4	0.94	27.38
Yield/plant (g)	2.41-22.77	15.81	33.01	34.24	0.98	10.36
Dry weight (g)	15.26-76.17	51.35	30.66	30.82	0.92	32.26
Harvest index (%)	15.10-40.78	29.44	19.87	21.5	0.85	11.14
Branches/plant	6.83-14	10.39	18.8	22.22	0.72	3.41
Plant height (cm)	51.33-167.83	128.14	17.87	19.37	0.85	43.53
Leaf area index (cm^2)	0.7-6.9	4.78	31.49	32.73	0.93	2.98
Canopy temperature depression (^0C)	0.83-1.58	1.27	13.78	14	0.97	0.36
Chlorophyll fluorescence	0.71-0.84	0.79	4.58	4.75	0.93	0.07
Cell membrane stability (%)	34.48-43.71	38.75	4.72	6.87	0.47	2.58
Rate of water loss from excised leaf (%)	73.64-94.43	82.12	5.34	7.64	0.49	6.32
Relative water content (%)	82.31-95.54	89.84	3.2	3.92	0.67	4.83
Crude protein	27.23-31.53	28.84	4.7	5.21	0.81	2.52
Proline (µg/g)	29.66-138.76	74.28	33.8	34.09	0.98	51.27
Gum (%)	22.44-29.50	27.18	5.66	8.06	0.49	2.22

content, then hybridization between FS 277 x HG 884 which are high gum, high proline, high protein content and high yielding genotypes per plant, respectively. These results are in agreement with those of Stafford *et al.* (1991), Singh *et al.* (2001, 2002, 2003, 2005) and Buttar *et al.* (2008).

The range, mean, genotypic coefficient of variability (GCV), phenotypic coefficient of variability (PCV), heritability and genetic advance as per cent of mean were estimated for all the characters (Table 3). Generally, GCV are lower in magnitude than the PCV. High GCV and PCV were also observed for some characters. This reveals that the genotypes will respond positively to selection. Most of the relevant characters like pods per plant, dry weight, plant height and proline content in leaves had high GCV, PCV, heritability and genetic advance as per cent of mean. While harvest index and grain yield per plant had high GCV, PCV and heritability associated with moderate genetic advance as per cent of mean. Likewise, germination/survival per cent had moderate GCV, PCV and genetic advance as per cent of mean with high heritability. This indicates that the presence of additive gene action and for these characters simple selection would be the most appropriate breeding method for their improvement. However, 100-seed weight, branches per plant and leaf area index had high GCV, PCV and heritability associated with low genetic advance as per cent of mean. While gum content, rate of water loss from excised leaf, cell membrane stability and seeds per pod had moderate heritability associated with low GCV, PCV and genetic advance as per cent of mean, respectively. However, canopy temperature depression and chlorophyll fluorescence had high heritability associated with low GCV, PCV and heritability, respectively. This may due to presence of both additive and non-additive gene action. To improve these characters, simple selection as well as exploitation of hybrid breeding would be useful. The similar types of results were found by some researchers (Singh *et al*., 2001; Singh *et al*., 2002; Singh *et al*., 2003; Choudhary *et al*., 2003; Singh *et al.,* 2005; Mahla and Kumar, 2006; Choudhary and Shrimali, 2006).

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