International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(4): 2777-2780
© 2020 IJCS
Received: 01-05-2020
Accepted: 03-06-2020

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Genetic divergence studies in black gram [*Vigna mungo* (L.) Hepper]

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DOI: https://doi.org/10.22271/chemi.2020.v8.i4ag.10063

Abstract
The present investigation entitled "Genetic divergence studies in black gram [*Vigna mungo* (L.) Hepper]" was conducted at the College Farm, Navsari Agricultural University, Navsari, Gujarat with fifty black gram genotypes to assess the extent of genetic diversity by D^2 analysis in a randomized block design during late kharif 2018. Observations were recorded on thirteen characters contributing to yield in black gram which included days to 50% flowering, plant height, branches per plant, clusters per plant, pods per plant, seeds per pod, pod length, 100-seed weight, seed yield per plant, days to maturity, straw yield, harvest index, and protein (%). Based on D^2 values, clustering of fifty genotypes by Tocher's method into six clusters is an indicative of wide diversity. Among thirteen characters studied protein (%), straw yield, plant height, days to maturity, 100-seed weight, harvest index, pod length, days to 50% flowering, pods per plant, clusters per plant, branches per plant and seed yield per plant contributed towards genetic divergence. Cluster means results clearly indicated appreciable difference among cluster means for most of the characters. As far as cluster means are concerned, a greater range of mean values among the clusters was recorded for different traits. From the cluster mean results, it could be concluded that cluster II, III and VI has high amount of variation within population. Hence it can be used for population improvement for further crop improvement.

Keywords: Genetic divergence, black gram, cluster mean

Introduction
Black gram (*Vigna mungo* (L.) Hepper) is an erect, fast-growing annual, herbaceous legume reaching 30-100 cm in height. It has a well-developed taproot and its stems are diffusely branched from the base. Occasionally it has a twining habit and it is generally pubescent. The leaves are trifoliate with ovate leaflets, 4-10 cm long and 2-7 cm wide. The inflorescence is borne at the extremity of a long (up to 18 cm) peduncle and bears yellow, small, papilionaceous flowers. The fruit is a cylindrical, erect pod, 4-7 cm long x 0.5 cm broad. The pod is hairy and has a short hooked beak. It contains 4-10 ellipsoid black or mottled seeds (Jansen, 2006) [1]. Many *Vigna mungo* cultivars exist, each one adapted to specific environmental conditions. Early maturing, disease resistant and easily cultivated cultivars have been obtained (Jansen, 2006) [1]. The Mahalanobis's (1936) D^2 statistics is a powerful tool for quantifying the divergence between two populations. Many studies based on the technique also indicated that geographical isolation is not necessarily related to genetic diversity. It thus gives better idea about the magnitude of divergence and is independent of size of sample and provide the basis for selection of parental lines for further breeding programme.

Materials and Methods
The present investigation was carried out using fifty genotypes of black gram collected from Pulses and Castor research station Navsari Agricultural University, Navsari, Gujarat. The fifty genotypes were sown in randomized block design at the College Farm, Navsari Agricultural University, Navsari, Gujarat during late kharif 2018. A spacing of 45 cm between rows and 10 cm between plants within the row was maintained. A line of 20 plants was sown as gross plot from both side two-two plants excluded to consider middle 16 plants as net plot. Data was collected from five randomly selected plants tagged from each accession.
The genetic divergence in fifty genotypes for thirteen characters were analysed through Mahalanobis (1928) [2] statistic technique. Variances were calculated for all the thirteen characters and test of significance was carried out.

Analysis of covariance (ANCOVA) for the character pairs was estimated on the basis of mean values. From these estimates a dispersion table was prepared. After testing the differences between genotypes for each of the character, a simultaneous test of significance of difference between the mean values of a number of correlated variables was done (Rao, 1952) [5] by using 'V statistic, which in turn utilizes Wilk's criterion (Wilks, 1932) [8]. The sum of squares and sum of products of error and error plus variety, variance - covariance matrix were used for this purpose (Panse and Sukhatme, 1967) [4].

Results and Discussion

The data collected on characters *viz*., days to 50% flowering, plant height, branches per plant, clusters per plant, pods per plant, seeds per pod, pod length, 100-seed weight, seed yield per plant, days to maturity, straw yield, harvest index, and protein (%). were subjected to multivariate analysis using Wilk's criterion for fifty genotypes of black gram. The significant mean squares due to genotypes suggested the presence of sound amount of variability. The D^2 values between all possible pairs indicated the presence of greater diversity among the genotypes for all the traits.

Composition of clusters

Grouping of the genotypes was carried-out by following Tocher's method (Rao, 1952) [5] with the assumption that the genotypes within the cluster have smaller D^2 values among themselves than those from groups belonging to different clusters. In all, six clusters were formed from fifty genotypes. The composition of the cluster is given in Table 4.6. Among the observed six clusters, cluster I was largest having 38 genotypes. Cluster III was the second largest which contained 5 genotypes. Cluster II have 4 genotypes respectively. In clusters IV, V and VI each comprise of one genotype only. Thus, the present results indicated that geographical distribution and genetic divergence did not follow the same pattern. Parallel results findings have been reported by Reni *et al*. (2016) [6] and Mahesha and Garbriel (2017).

Contribution of various characters towards genetic divergence

The analysis on contribution of various characters towards the expression of genetic divergence indicated that the characters *viz.*, protein (%) (38.2%), straw yield (32.41%), plant height (21.96%), days to maturity (1.71%), 100-seed weight (1.63%), harvest index (0.98%), pod length (0.90%), days to 50% flowering (0.80%), pods per plant (0.65%), clusters per plant (0.57%), branches per plant (0.08%) and seed yield per plant (0.08%) contributed towards genetic divergence in variable proportion accounting for 100 per cent of divergence in the material (Table 2 and Fig. 1). Seeds per pod do not contribute to diversity. Therefore while planning breeding programme and selecting parents, importance should be given on protein (%), straw yield and plant height on a priority basis. Parallel results were obtained by Mahesha and Gabriel (2017) [3] for seed yield per plant and pods to maturity; Reddy *et al*. (2017) [7] for days to 50% flowering, clusters per plant, pods per plant days to maturity and harvest index.

Inter and intra cluster distances ($\mathbf{D = \sqrt{D^2}}$)

Inter and intra cluster distance values are given in Table 3 and cluster diagram in Fig. 2. The maximum inter-cluster distance (D=1209.81) was found between clusters II and VI carrying 4 and 1 genotypes followed by that clusters between III and VI (D = 1091.81), II and V (D = 752.64) and indicating that genotypes included in these clusters are genetically diverse and may give rise to high heterotic response. The minimum inter-cluster distance was (D = 73.18) was found between clusters IV and V indicating a close relationship among the genotypes included.

In heterosis breeding, genotypes of diverse clusters are known to play an important role of potential as they are likely to produce heterotic combinations on intercrossing. Hence, for improving any particular trait, breeder should go for parents that are highly divergent with respect to the trait concerned. The most productive divergent lines among themselves may be incorporated in population improvement for future use.

Cluster means for various characters

Cluster means for all the thirteen characters are presented in Table 3. The results clearly indicated appreciable difference among cluster means for most of the characters. As far as cluster means are concerned, a greater range of mean values among the clusters was recorded for different traits. Cluster VI revealed maximum mean values for days to 50% flowering (66.00) and days to maturity (95.67). Cluster II showed maximum mean for plant height (68.80), 100-seed weight (4.69), pod length (4.21) and protein (27.29). Cluster III showed maximum mean for pods per plant (25.60), seeds per pod (6.49), straw yield (12.80) and seed yield per plant (5.41), cluster IV for clusters per plant (6.00), harvest index (44.39) and cluster V for branches per plant (3.33).

Cluster VI had minimum mean value for plant height (31.20), branches per plant (1.40), clusters per plant (1.33), pods per plant (5.73), seeds per pod (3.67), seed yield per plant (1.33), 100-seed weight (3.33), pod length (3.07), straw yield (3.39) and protein (19.24). Cluster IV had minimum mean value for days to maturity (73.67) and Cluster V for harvest index (25.68).

From the cluster mean results, it could be concluded that cluster II, III and VI has high amount of variation within population. Hence it can be used for population improvement for further crop improvement.

Table 1: Distribution of fifty genotypes of black gram into six different clusters on basis of Mahalanobis D^2 statistic

Cluster	No. of genotypes	Name of genotypes
I	38	GP-74, GP-164, GP-157, GP-44, GP-20, GP-13, GP-80, GP-97, GP-17,GP-12, GP-153, GP-26, GP-77, GP-96, GP-47, GP-160, GP-16, GP-14, GP-25, GP-159, GP-156, GP-172, GP-91, GP-108, GP-76,GP-9, GP-46, GP-19, GP-71, GP-41, GP-78, GP-29, GP-73, GP-24, GP-30, GP-60, GP-94, GP-27
II	4	GP-28, GP-120, GP-50, GP-174
III	5	GP-105, GP-146, GP-124, GP-158, GP-177
IV	1	GP-11
V	1	GP-15
VI	1	GP-162

Table 2: Contribution of thirteen characters under study towards total genetic divergence

Sr. No.	Characters	No. of times character ranked first	Per cent contribution (%)
1	Days to 50% flowering	10	0.82
2	Plant height (cm)	269	21.96
3	Branches per plant	1	0.08
4	Clusters per plant	7	0.57
5	Pods per plant	8	0.65
6	Seeds per pod	0	0.00
7	Pod length (cm)	11	0.90
8	100 seed weight (g)	20	1.63
9	Seed yield per plant (g)	1	0.08
10	Days to maturity	21	1.71
11	Straw yield (g)	397	32.41
12	Harvest index (%)	12	0.98
13	Protein (%)	468	38.20
	Total	1225	100

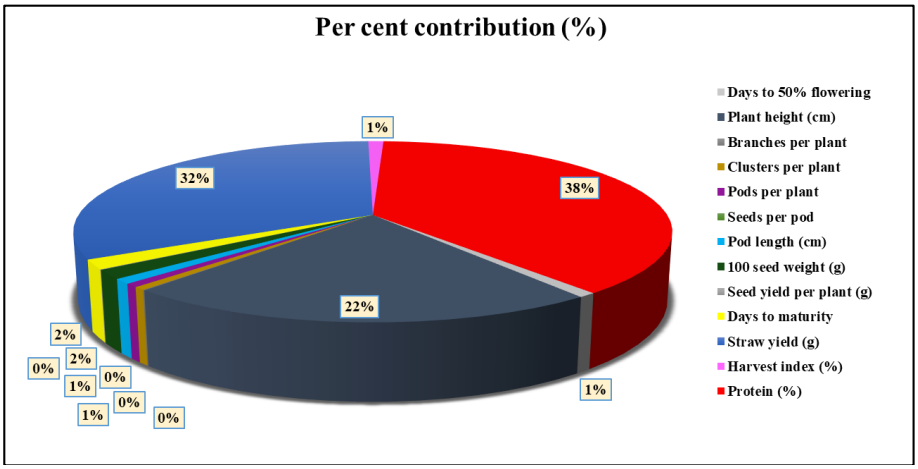

Fig 1: Contribution of thirteen characters under study to the total divergence

Table 3: Average intra and inter cluster ($D = \sqrt{D^2}$) values for fifty genotypes of black gram

Clusters	I	II	III	IV	V	VI
I	123.58	332.53	321.24	190.92	230.25	516.73
II		123.22	317.04	689.83	752.64	1209.81
III			203.78	522.44	554.10	1091.81
IV				0.00	73.18	284.41
V					0.00	188.70
VI						0.00

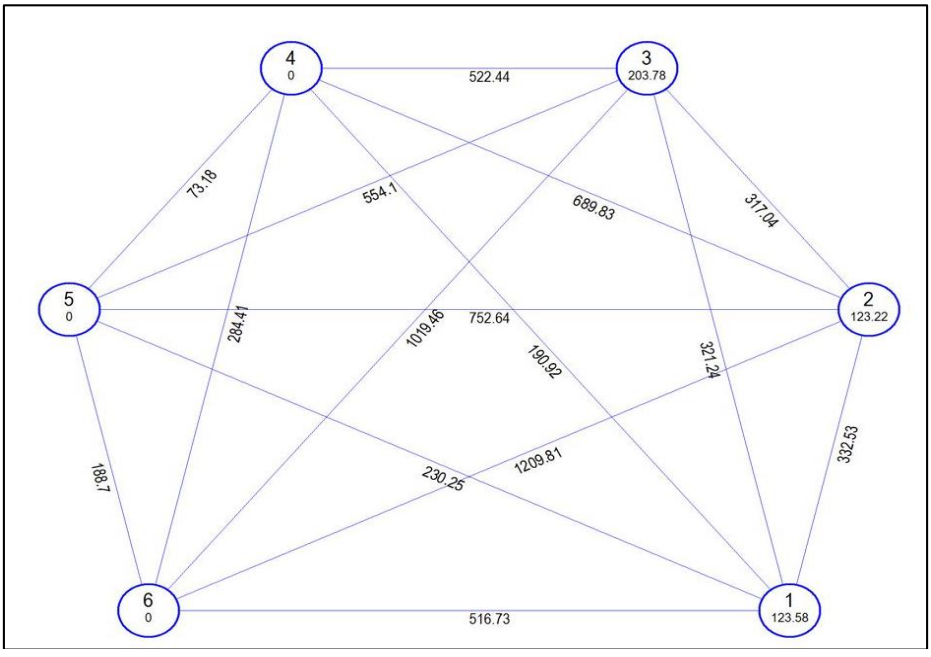

Fig 2: Mahalanobis Euclidian distance

Table 4: Cluster means for thirteen characters in fifty black gram genotypes

Characters / Clusters	DFF	PH	BP	CP	PP	SP	PL	SW	SYP	DM	SY	HI	P
I	48.52	43.97	2.85	3.69	18.28	6.10	3.87	4.26	3.88	79.78	7.06	35.84	24.60
II	46.92	68.80	3.07	3.60	19.01	6.28	4.21	4.69	4.86	77.92	10.29	32.17	27.29
III	51.80	49.09	3.12	5.21	25.60	6.49	3.99	4.27	5.41	85.60	12.80	29.74	24.96
IV	46.33	32.33	2.27	6.00	15.27	6.00	3.80	3.90	3.99	73.67	5.00	44.39	21.38
V	48.67	31.49	3.33	3.93	16.80	5.27	3.36	4.23	2.13	75.00	6.18	25.68	20.54
VI	66.00	31.20	1.40	1.33	5.73	3.67	3.07	3.33	1.37	95.67	3.39	28.72	19.24

DFF	=	Days to 50% flowering	PH	=	Plant height (cm)	BP	=	Branches per plant	CP	=	Cluster per plant
PP	=	Pods per plant	SP	=	Seeds per pod	PL	=	Pod length (cm)	SW	=	100-seed weight(g)
SYP	=	Seed yield per plant(g)	DM	=	Days to maturity	SY	=	Straw yield (g)	HI	=	Harvest index (%)
P	=	Protein (%)									

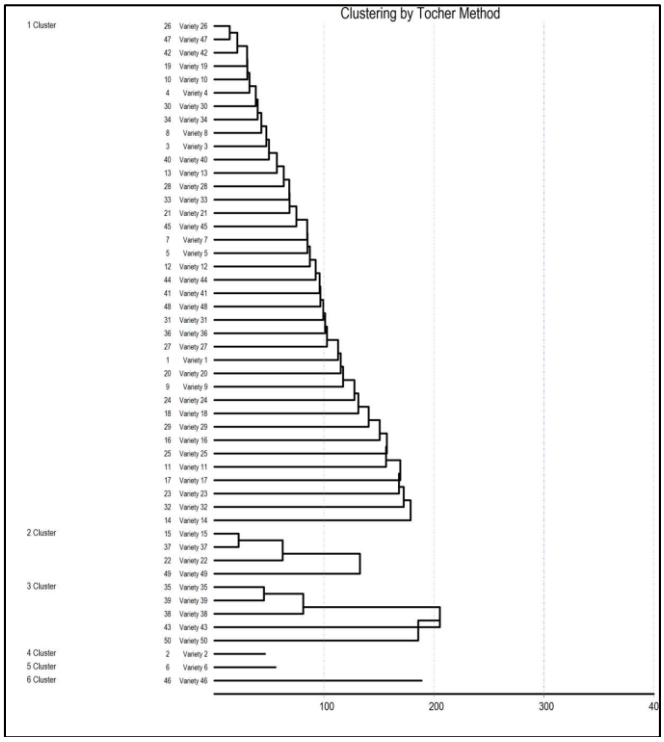

Fig 3: Dendrogram of fifty black gram genotypes based on thirteen traits

Conclusion

The genetic diversity analysis revealed the formation of six clusters suggested the presence of wide genetic diversity among the fifty black gram genotypes studied.

The maximum inter-cluster distance was found between clusters II and VI carrying 4 and 1 genotypes followed by that clusters between III and VI , II and V and indicating that genotypes included in these clusters are genetically diverse and may give rise to high heterotic response. The minimum inter-cluster distance was found between clusters IV and V indicating a close relationship among the genotypes included.

Protein, straw yield and plant height contributed maximum towards divergence in the present study. Cluster VI revealed maximum mean values for days to 50% flowering and days to maturity. Cluster II showed maximum mean for plant height, 100-seed weight, pod length and protein. Cluster III showed maximum mean for pods per plant, seeds per pod, straw yield and seed yield per plant, cluster IV for clusters per plant, harvest index and cluster V for branches per plant. Cluster VI had minimum mean value for plant height, branches per plant, clusters per plant, pods per plant, seeds per pod, seed yield per plant, 100-seed weight, pod length, straw yield and protein. Cluster IV had minimum mean value for days to maturity and Cluster V for harvest index.

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