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Genetic Variability of Traits Related to Synchronous Maturity in Greengram [*Vigna radiata* (L.) Wilczek]

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A B S T R A C T

The present study was conducted to evaluate 38 greengram genotypes to determinethe nature and extent of variation in the phenological traits related to synchronous maturity. A field trial was laid under a Randomized Block Design (RBD) with three replications; observations were recorded on 17 morphological characters. Analysis of variance revealed significant variation among genotypes for all the characters except for 100 seed weight. Different genotypes were found superior for different characters. Phenotypic coefficient of variation (PCV) was greater than that of Genotypic coefficient of variation (GCV) for all characters studied thereby indicating the influence of environmental effect on the characters. The GCV and PCV estimates were high for number of pods per plant followed by degree of indetermination of plant height from first pod maturity to 90% pod maturity and number of branches per plant respectively. High heritability coupled with high genetic advanced as percent of mean was observed for 13 traits including yield per plant. Based on D^2 values, the genotypes were grouped into eight clusters. Maximum inter cluster distance was observed between clusters III and cluster VI followed by cluster Vand cluster VIII while lowest distance was noticed between cluster I and cluster VII. Days to 90% pod maturity followed by days to first flowering and days to first pod maturity had highest contribution towards genetic divergence.

Introduction

Greengram or Mungbean (*Vigna radiata* L. Wilczek) is a self pollinated diploid (2n = 22) pulse crop native to the Indian subcontinent. It contains about 25 per cent protein, which is almost three times that of cereals. India ranks first both in acreage and production of greengram in the world. During 2017-18, Greengram was sown over an area of 4.26 Mha in (kharif + rabi) and recorded a production of 2.01 Mt at and yield level of 472 kg/ha (Anon., 2018). Rajasthan, MP, Maharashtra, Karnataka, Bihar, AP, Odisha, Tamil Nadu, Gujarat and Telangana have been the major states. But productivity of the crop is very low to meet the requirement of India's ever increasing population.

Greengram shows asynchronous pattern of maturity, which is not desired by farmers as it requires several pickings for harvesting of the crop and make it a labour intensive, costly practice. Moreover, asynchrony in flowering is also attributed to lower productivity due to high harvest index. Therefore, morpho-physiological responses in flower production and flowering pattern that ultimately leads to more mature pods and final yield needs to be properly assessed. A synchronous variety being short duration is suitable to fit in any cropping system without direct competition to the main crops. This suggests that understanding of flowering pattern is useful in the selection of high yielding genotypes. There is however little information on its flowering behaviour.

Pod maturity in mungbean is not synchronous (Yeates *et al.,* 2000) and this is reported to be one of the causes for low yield and low harvest index in mungbean (Bushby and Lawn, 1992; Egli and Bruening, 2006). Asynchrony is linked to indeterminate growth habit resulting in simultaneous transformation of assimilates into both vegetative and reproductive parts which can explain low harvest index in such crops. Again, it is observed that earlier formed pods are heavier than later formed pods indicating inadequate supply of assimilates to later formed pods (Fakir, 1997; Kuroda *et al.,* 1998; Begum *et al.,* 2007). Inverse effects of high leafiness and asynchronous flowering on seed yield were further reported by Bisht *et al.,* (1998 & 2005). Although the new mungbean varieties are not true determinate, technically they are also not indeterminate and the pre and post-flowering plant height variation in Mungbean has been described as the degree of indetermination of plant height (Khattak *et al.,* 2001). Information on the degree of indetermination of growth duration could help in adopting suitable and efficient strategies to develop mungbean genotypes with synchronous growth habit coupled with high yield since time of pod maturation is an important factor in synchronous pod maturity (Sharma-Natu and Ghildiyal, 2005). Moreover, genotype that produces maximum opened flower within 10-15 days and ceases flowering after 15-20 days is desirable. Breeding effort towards the development of synchronous maturity in greengram is limited. For example, out of 40 greengram varieties released of CVRC in 2017-18, only one variety (VBN8) was found to be determinate type (Anon., 2019), indicating limitations in breeding effort. However, these results indicate potentiality of developing such a variety using existing genetic resources and modern tools of crop improvement.

Materials and Methods

The experimental material consisted of 38 green gram genotypes (*Vigna radiata* (L.) Wilczek) obtained from institutes from all over India and was collected from RARS, Shillongoni. The genotypes used were ML 818, KM 2241, MH 2-15, OUM 11-5, HUM 1, COGG 912, Pant M-5, Pusa 0672, Pant M-4, IPM 02-3, BM 4, AKM 8802, IPM 2-14, IPM 312-19, IPM 312-20, IPM 14-7, GGG 1, MH 1142, RMG 1087, RMG 1092, COGG 13-19, PM 14-3, PM 14-11, AKM 12-28, AKM 12-24, TMB 126, SKNM 1502, SKNM 1504, LGG 607, JAUM 0936, NMK 15-08, KM 2355, ML 2479, SML 1808, COGG 13-39, RMG 1097, SGC 16 and SGC 20. Each genotype was sown in rows of 4 metres length, adopting a spacing of 30 x 10 cm in a RBD with three replications. Other recommended packages of practices were followed to raise successful crop of greengram. Five randomly taken plants were considered to record data fordays to first flowering, days to 50% flowering, days to first pod maturity, days to 90% pod maturity, degree of indetermination of pod maturity from first flower to 90% pod maturity (DDd_1), degree of indetermination of pod maturity from first pod maturity to 90% pod maturity (DDd_2), plant height at first flower initiation (cm), plant height at first pod maturity (cm), plant height at 90% pod maturity (cm), degree of indetermination of plant height from first flower to first pod maturity (DDh_1), degree of indetermination of plant height from first flower to 90% pod maturity (DDh_2), degree of indetermination of plant height from first pod maturity to 90% pod maturity (DDh_3), number of pods per plant, number of branches per plant, number of seeds per pod, 100 seed weight (g) and seed yield per plant (g). Degree of indeterminations of pod maturity and plant height were calculated according to the formulae outlined by Khattak *et al.,* (2004). The mean values of five plants were taken for the statistical analysis. Statistical methods suggested by Burton and Devane (1953) for variability, Robinson *et al.,* (1949) for heritability, Johnson *et al.,* (1955) for genetic advance as per cent of mean were adopted to find out the respective estimates. Mahalanobis D^2 (Rao, 1952) analysis was performed in Biotool package of R software (da Silva *et al.,* 2017).

Results and Discussion

Analysis of variance (Table 1) revealed that there were significant variations among the genotypes for all the characters except 100 seed weight. So, this indicated sufficient variations among the genotypes under study for the characters indicating scope for selection. *Per se* performance of different genotypes under study (Table 2) revealed that different genotypes possessed different desirable yield attributes and synchrony related phenological traits. For example, COGG 13-39 was the earliest in days to first flowering (44.00 days), but MH 2-15 was earliest for days to 50% flowering (50.67 days). Similarly, AKM 8802 was the earliest for days to first pod maturity (54.00 days) and AKM 12-28 was earliest for days to 90% pod maturity (64.67 days). Pant M-5 was the shortest in plant stature at first flower initiation (13.50 cm) and at first pod maturity (20.40 cm), but TMB 126 was shortest at 90% pod maturity (30.33 cm). On the other hand, IPM 312-20 had the highest pods per plant (29.87) and branches per plant (7.67) along with IPM 312-19 (7.67). IPM 312-20, COGG 13-39 along with KM 2355 had highest seeds per pods (13.00). KM 2355 further had the highest 100 seed weight (5.40g) and seed yield per plant (10.22g). When different synchrony related attributes were compared, Pant M-4 was the most determinate in terms degree of indetermination of pod maturity from first flower and first pod maturity to 90% pod maturity (30.47; 10.47) but RMG 1092 was the most determinate in terms of degree of indetermination of plant height from first flower to first pod (8.38) and 90% pod maturity (23.96) while RMG 1087 was determinate in terms of degree of indetermination of plant height from first pod maturity to 90% pod maturity (8.28). It was observed that indeterminate behaviour is not directly related to days to first flowering and days to first pod maturity. No varieties possessed all the desirable attributes for synchrony and high yield. The identified genotypes with desirable attributes may carefully be used as parents for hybridization programme to obtain desirable segregant combining better yield with synchronous flowering.

Genetic components

Phenotypic coefficient of variation (PCV) was higher than Genotypic coefficient of variation

(GCV) for all the traits under study (Table 3) which indicated that the variation was not due only to genotypes but also due to the influence of environment. These results are in accordance with Mehandi *et al.,* (2013), Raturi *et al.,* (2015), Hemavathy *et al.,* (2015) and Anand *et al.,* (2015) Venkateswarlu (2001), Dikshit *et al.,* (2002), Reddy *et al.,* (2003) in greengram. In the present study, high GCV, PCV was observed for degree of indetermination of plant height from first flower to first pod maturity (DDh_1), degree of indetermination of plant height from first pod maturity to 90% pod maturity (DDh_3), number of pods per plant and number of branches per plant indicating the predominance of additive gene action. It is expected that the characters exhibiting high GCV would exhibit response to selection in a positive direction.

A high heritability(H^2) in broad sense(bs) was recorded for all the traits except for degree of indetermination of plant height from first flower to first pod maturity which showed moderate heritability. The highest estimate was observed for plant height at 90% pod maturity. The estimates of heritability are environment specific (Shimelis and Rhandzu, 2010). Thus, reliability of selection does not depend upon heritability alone as it is likely to be misleading. Hence, selection of traits based on heritability and genetic advance as percent of mean (GAM) is of great importance Mehandi *et al.,* (2013), Ginwal *et al.,* (2004).High heritability estimates coupled with high or moderate genetic advance was observed for 13 traits including yield per plant. Similar results were reported by (Muthuswamy *et al.,* 2019) for plant height, number of branches per plant, number of pod per plant, 100 seed weight and seed yield per plant. (Baisakh *et al.,* 2016) also reported plant height and pods per plant had high heritability with high genetic advance. Pavan *et al.,* (2019) also reported similar results for pods per plant, seed yield per plant, plant height and number of branches per plant. (Idress *et al.,* 2006) also reported similar results for primary branches, pods per plant, 100 seed weight and seed yield. Similar results for plant height, number of pods per plant and seed yield per plant were reported by (Reddy *et al.,* 2011). Garg *et al.,* (2017) also observed similar results for plant height, number of branches per plant, seed per pod, 100-seed weight, number of pods per plant and seed yield. High heritability coupled with high or moderate genetic advance indicated involvement of additive gene action in the genetic control of these traits suggesting the scope for improvement through simple selection in the present breeding material. High heritability and low genetic advance for characters like days to 50% flowering, days to first pod maturity and days to 90% pod maturity indicated the predominance of non-additive gene action suggesting that these traits could be improved by pedigree method and population approach by breeding. The present findings were not in conformity with (Payasi, 2015) who reported high heritability with low genetic advance for number of pods per cluster, number of seeds per pod, pod length and protein content.

Based on GCV, PCV, H^2(bs) and GAM, degree of indetermination of plant height from first pod maturity to 90% pod maturity, number of pods per plant and number of branches per plant were identified as prominent characters among the genotypes under study to consider in a breeding programme.

Genetic divergence analysis

Mahalonobis D^2 statistics was used to study genetic divergence using 17 quantitative traits since it is hypothesized that divergent parents offer substantial variability in the segregating generations. Significance of Wilk's 'V' statistics revealed that 38 genotypes differed significantly when all the characters were considered simultaneously indicating considerable diversity among the materials. Hence further analysis was done. Tocher's method of classification, (Table 4) based on D^2 estimates grouped the genotypes into eight clusters with a single largest cluster of 23 genotypes of cluster I. It was observed that genotypes originated in same place weren't clustered together indicating lack of association between geographical locations and clustering pattern. The clustering pattern was random and independent with variable number of genotypes. Lack of association between geographical origin and clustering pattern has been reported in greengram and other crops. The results are in agreement with (Singh *et al.,* 2013; Singh *et al.,* 2014). In the present study, clustering pattern might be attributed to their morphological differences and breeding history. Genotypes grouped into the same cluster showed little divergence from one another as the aggregate of characters measured.

Statistical distance as shown with D^2 values represents the index of genetic diversity among the clusters. Maximum intra-cluster distance was observed in cluster IV with two genotypes AKM 8802 and KM 2241, indicating sufficient diversity between two genotypes within this cluster (Table 5). Minimum inter cluster distance between Cluster I and Cluster VII indicating close relationship among the genotypes and similarity for the characters. Maximum inter-cluster distance observed between Cluster III and Cluster VI indicating diverse nature of the genotypes.

In the present study, the existences of higher inter cluster distance than intra cluster distance indicated existence of sufficient genetic variability among the genotypes. (Garg *et al.,* 2017) also reported more inter-cluster distance than intra-cluster distance in their study. Based on inter-cluster distance, careful selection of parents from different clusters may be used in a breeding programme to generate more variability. Careful selection of divergent genotype from these two clusters would produce a broad spectrum of variability in the subsequent generations enabling further selection and improvement.

Cluster mean performance for different characters showed considerable differences between all the clusters for all the characters (Table 6). Cluster II was characterized by earliest days to first flowering and days to first pod maturity. Cluster III was characterized by earliest days to 50% flowering, earliest days to 90% pods maturity, highest number of pods per plant, 100 seed weight and seed yield per plant. Cluster IV was characterized by genotypes having shortest height at 90% pod maturity. Cluster VI was characterized by genotypes exhibiting lowest degree of indetermination of plant height from first flower and first pod maturity to 90% pod maturity. Cluster VII was characterized by genotypes exhibiting lowest degree of indetermination of pod maturity from first flower and first pod maturity to 90% pod maturity and lowest degree of indetermination of plant height from first flower to first pod maturity. Also it had genotypes with the highest number of branches per plant and seeds per pods. Cluster VIII was characterized by genotypes having shortest height at first flower initiation and first pod maturity. The results suggested that intercrossing of carefully chosen genotypes from different cluster showing good mean performance might help in obtaining high yield combining synchronous maturity. According to Mishra *et al.,* (2018), the inclusion of more diverse parents inhybridization is believed to increase the chances of obtaining better heterosis and give broad spectrum of variability insegregating generation.

Table.1 Analysis of variance for yield and its components in greengram

Source of Variations	Df	Mean Squares																
		Days to 1st flowering (D_1)	Days to 50% flowering	Days to 1st pod maturity (D_2)	DDd_1	Days to 90% pod maturity (D_3)	DDd_2	Plant height at 1st flower initiation (H_1)	Plant height at 1st pod maturity (H_2)	DDh_1	Plant height at 90% pods maturity (H_3)	DDh_2	DDh_3	Number of pods per plant	Number of branches per plant	Seeds per pods	100 seed weight (g)	seed yield per plant (g)
Replication	**2**	**0.01**	**0.55**	**0.95**	**0.06**	**0.24**	**1.41**	**1.52**	**1.18**	**9.61 ****	**4.01 ***	**0.08**	**4.55**	**27.29 ****	**1.31**	**0.17**	**0.01**	**0.04**
Genotype	**37**	**18.89 ****	**20.56 ****	**18.80 ****	**24.61 ****	**33.99 ****	**43.21 ****	**41.24 ****	**66.91 ****	**182.21 ****	**121.90 ****	**254.57 ****	**306.18 ****	**116.67 ****	**5.65 ****	**8.40 ****	**1.14**	**3.96 ***
Error	**74**	**0.34**	**0.67**	**0.52**	**1.33**	**0.98**	**2.51**	**2.50**	**3.06**	**37.94 ****	**2.06**	**14.18 ****	**16.88 ****	**7.81 ****	**0.47**	**0.45**	**0.05**	**0.10**

*Significant at 5% level **Significant at 1% level

DDd_1 =Degree of indetermination of pod maturity from 1st flower (D_1) to 90% pod maturity (D_3)

DDd_2= Degree of indetermination of pod maturity from1st pod maturity to 90% pods maturity

DDh_1= Degree of indetermination of plant height from 1st flower to 1st pods maturity

DDh_2= Degree of indetermination of plant height from 1st flower to 90% pods maturity

DDh_3= Degree of indetermination of plant height from 1st pod maturity to 90% pods maturity

Table.2 Performance of greengram genotypes for different quantitative traits

Sl No	Genotypes	Days to 1st flowering (D_1)	days to 50% flowering	Days to 1st pod maturity (D_2)	DDd_1= (D3-D_1)/ D_3*100	Days to 90% pod maturity (D_3)	DDd_2= (D_3-D_2)/ D_3*100	Plant height at 1st flower initiation (H_1)	Plant height at 1st pod maturity (H_2)	DDh_1= (H_2-H_1)/ H_2*100	Plant height at 90% pods maturity (H_3)	DDh_2= (H_3-H_1)/ H_3*100	DDh_3= (H_3-H_2)/ H_3*100	pods plant^{-1}	branches plant^{-1}	seeds pod^{-1}	100 seed weight	seed yield plant^{-1}
1	**ML 818**	44.67	54.33	58.00	36.19	70.00	17.14	20.13	28.33	28.93	48.44	58.43	41.52	4.67	3.33	11.33	3.27	5.79
2	**KM 2241**	45.00	52.33	57.33	33.82	68.00	15.69	18.16	23.72	23.44	35.61	49.00	33.37	13.00	6.67	10.00	4.19	7.35
3	**MH 2-15**	41.33	50.67	55.33	36.72	65.33	15.29	20.29	26.44	23.15	40.68	50.12	34.98	7.00	6.33	9.00	5.15	9.88
4	**OUM 11-5**	46.00	57.33	57.67	34.29	70.00	17.62	20.37	31.98	36.28	43.17	52.78	25.91	19.00	5.33	10.67	4.06	7.17
5	**HUM 1**	41.33	53.33	54.67	39.81	68.67	20.39	24.67	32.52	24.02	49.92	50.58	34.85	15.33	7.33	10.67	4.99	9.12
6	**COGG 912**	44.33	56.33	58.00	39.54	73.33	20.91	23.50	35.17	33.16	50.17	53.15	29.87	7.67	4.33	9.67	4.26	8.59
7	**Pant M-5**	47.00	55.67	59.33	37.61	75.33	21.23	13.50	20.40	33.83	35.67	62.16	42.80	9.00	3.67	8.00	4.33	8.02
8	**Pusa 0672**	48.33	59.67	62.33	33.49	72.67	14.22	17.50	22.83	23.30	38.33	54.32	40.44	4.33	4.33	8.00	3.81	6.31
9	**Pant M-4**	48.67	60.67	62.67	30.48	70.00	10.48	20.50	27.06	24.24	36.00	43.04	24.82	4.56	7.33	12.00	3.79	7.55
10	**IPM 02-3**	44.00	55.67	57.67	38.32	71.33	19.16	17.17	28.67	40.13	48.17	64.37	40.51	8.55	5.33	10.67	4.76	8.62
11	**BM 4**	42.33	54.33	55.67	39.91	70.67	20.98	23.67	36.33	35.00	60.89	61.14	40.34	16.00	6.67	9.67	3.64	7.39
12	**AKM 8802**	41.33	52.67	54.00	43.89	73.67	26.69	16.67	22.33	25.36	33.33	49.95	32.92	11.67	4.33	12.33	3.21	6.72
13	**IPM 2-14**	45.00	55.67	56.67	38.91	73.67	23.07	24.83	32.78	24.28	42.33	41.37	22.59	9.19	4.67	8.33	3.24	7.00
14	**IPM 312-19**	43.00	54.67	55.67	37.38	68.67	18.93	19.33	28.50	32.13	43.44	55.49	34.39	27.78	7.67	11.67	3.67	6.76
15	**IPM 312-20**	42.00	53.33	55.67	39.12	69.00	19.31	22.33	33.33	32.46	49.33	54.72	32.50	29.89	7.67	13.00	4.22	8.20
16	**IPM 14-7**	43.33	56.33	59.67	42.48	75.33	20.80	22.33	34.67	35.57	41.67	46.40	16.82	16.64	5.33	9.33	3.68	7.71
17	**GGG 1**	45.00	56.33	57.33	40.53	75.67	24.23	22.33	30.00	25.50	36.00	37.96	16.60	7.22	4.33	8.33	3.85	7.63
18	**MH 1142**	43.67	55.67	57.33	39.32	72.00	20.33	20.83	29.33	28.95	37.33	44.20	21.39	14.44	3.67	8.33	3.71	7.64
19	**RMG 1087**	41.00	52.67	54.33	40.30	68.67	20.87	21.33	29.67	27.95	32.33	33.98	8.28	14.89	5.67	10.67	4.00	7.88
20	**RMG 1092**	46.33	58.33	61.00	38.77	75.67	19.37	28.33	31.00	8.38	37.33	23.96	16.61	18.67	7.33	10.67	3.32	7.01
21	**COGG 13-19**	44.00	55.33	55.67	41.85	75.67	26.43	22.33	30.20	26.12	37.67	40.79	19.90	13.22	5.33	8.67	4.17	8.68

Sl No	Genotypes	Days to 1st flowering (D_1)	days to 50% flowering	Days to 1st pod maturity(D_2)	DDd_1=(D3-D_1)/D_3*100	Days to 90% pod maturity(D_3)	DDd_2=(D_3-D_2)/ D_3*100	Plant height at 1st flower initiation (H_1)	Plant height at 1st pod maturity (H_2)	DDh_1=(H_2-H_1)/ H_2*100	Plant height at 90% pods maturity (H_3)	DDh_2=(H_3-H_1)/H_3 *100	DDh_3=(H_3-H_2)/H_3 *100	pods $plant^{-1}$	branches $plant^{-1}$	seeds pod^{-1}	100 seed weight	seed yield $plant^{-1}$
22	PM 14-3	42.00	53.67	56.33	40.28	70.33	19.91	17.33	28.00	37.99	38.67	55.36	27.53	10.55	6.33	10.33	4.25	7.84
23	PM 14-11	43.00	55.67	56.67	40.28	72.00	21.30	23.67	34.00	30.07	40.00	40.79	15.07	6.67	4.33	9.67	4.01	8.54
24	AKM 12-28	42.00	53.00	56.67	35.05	64.67	12.37	23.33	38.17	38.89	42.67	45.35	10.53	20.11	7.33	12.67	4.75	9.37
25	AKM 12-24	42.00	53.00	58.33	35.39	65.00	10.26	29.67	36.33	18.21	43.33	31.29	15.85	23.22	7.33	12.67	5.38	9.92
26	TMB 126	45.00	55.33	57.67	37.79	72.33	20.28	13.67	20.67	33.64	30.33	54.85	31.87	9.66	6.33	8.67	3.33	6.05
27	SKNM 1502	47.00	58.67	61.00	38.69	76.67	20.43	20.89	27.83	24.94	34.33	39.18	18.94	8.47	4.33	7.67	3.38	6.05
28	SKNM 1504	47.33	58.67	59.67	34.56	72.33	17.51	20.78	31.40	33.87	39.80	47.80	21.11	7.91	4.00	8.67	4.03	6.83
29	LGG 607	42.33	55.00	56.67	38.35	68.67	17.47	17.87	33.40	46.53	39.80	55.12	16.08	12.07	5.00	9.00	3.93	7.93
30	JAUM 0936	47.33	56.33	59.67	34.86	72.67	17.88	18.00	31.47	42.82	35.87	49.81	12.23	9.93	6.02	8.00	3.22	6.94
31	NMK 15-08	48.67	60.33	62.33	35.40	75.33	17.25	29.00	39.53	26.65	49.10	40.93	19.47	7.67	4.33	8.67	3.75	7.74
32	KM 2355	41.33	53.33	54.67	39.80	68.67	20.39	18.23	32.75	44.39	38.33	52.49	14.47	13.40	7.33	13.00	5.40	10.22
33	ML 2479	47.00	59.33	59.67	34.72	72.00	17.13	19.97	33.20	37.90	47.81	58.15	30.62	6.07	6.00	9.33	3.95	7.94
34	SML 1808	46.33	55.67	56.67	39.30	76.33	25.76	18.53	24.78	24.35	41.67	55.28	40.14	8.60	3.81	9.33	4.10	9.33
35	COGG 13-39	40.67	51.00	55.33	41.34	69.33	20.17	25.13	32.93	23.65	37.07	32.15	11.07	11.00	5.67	13.00	3.78	8.43
36	RMG 1097	47.67	59.67	62.67	34.40	72.67	13.76	22.80	30.20	24.43	36.40	37.36	17.04	6.00	3.67	8.00	3.46	7.00
37	SGC 16	48.00	58.33	61.67	37.39	76.67	19.57	16.87	24.47	30.96	31.27	46.10	21.82	7.53	4.11	8.00	2.93	6.03
38	SGC 20	47.33	58.67	60.33	38.53	77.00	21.65	19.73	24.83	20.48	36.13	45.35	31.26	3.93	3.93	8.67	3.13	6.27
	Mean	44.54	55.71	57.95	37.86	71.74	19.11	20.94	29.98	29.79	40.54	47.77	25.43	11.72	5.44	9.90	3.95	7.72
	C.V.	1.31	1.47	1.24	3.05	1.38	8.29	7.55	5.83	20.68	3.54	7.88	16.16	23.83	12.61	6.74	5.55	4.02
	S.E.	0.34	0.47	0.41	0.67	0.57	0.92	0.91	1.01	3.56	0.83	2.17	2.37	1.61	0.40	0.39	0.13	0.18
	C.D. 5%	0.95	1.33	1.17	1.88	1.61	2.58	2.57	2.84	10.02	2.34	6.13	6.68	4.55	1.12	1.09	0.36	0.51
	Range	40.67-48.67	50.67-60.67	54-62.67	30.48-43.89	64.67-77	10.26-26.69	13.5-29.67	20.4-39.53	8.38-46.53	30.33-60.89	23.96-64.37	8.28-42.8	3.93-29.89	3.33-7.67	7.67-13	2.93-5.4	5.79-10.22

Table.3 Genetic parameters of variations for different traits in greengram

Genetic parameters	Days to 1st flowering (D_1)	Days to 50% flowering	Days to 1st pod maturity (D_2)	DDd_1	Days to 90% pod maturity (D_3)	DDd_2	Plant height at 1st flower initiation (H_1)	Plant height at 1st pod maturity (H_2)	DDh_1	Plant height at 90% pods maturity (H_3)	DDh_2	DDh_3	Number of pods per plant	Number of branches per plant	Seeds per pods	100 seed weight (g)	seed yield per plant (g)
GCV	5.58	4.62	4.26	7.36	4.62	19.27	17.16	15.39	23.28	15.59	18.74	38.61	51.38	24.17	16.44	15.28	14.70
PCV	5.74	4.85	4.44	7.96	4.83	20.98	18.75	16.45	31.14	15.99	20.33	41.85	56.64	27.26	17.77	16.26	15.24
H^2 (bs)	0.95	0.91	0.92	0.85	0.92	0.84	0.84	0.87	0.56	0.95	0.85	0.85	0.82	0.79	0.85	0.88	0.93
GAM	11.19	9.07	8.43	14.00	9.13	36.47	32.37	29.64	35.86	31.32	35.58	73.37	96.02	44.14	31.33	29.58	29.20

Table.4 Cluster composition of Greengram Genotypes (Tocher's Method)

SI. No	Cluster	Number of genotypes	Name of genotypes
1	Cluster I	23	SGC20, SKNM1502, SGC16, RMG1097, Pusa0672 SKNM1504, JAUM0936, TMB126, GGG1, MH1142, IPM2-14, OUM11-5 , IPM14-7, ML2479, RMG1092, PM14-3, PM14-11, LGG607, COGG13-19, COGG912, IPM312-19, ML818, SML1808
2	Cluster II	6	COGG13-39, RMG1087, KM2355 , HUM1, PM312-20, IPM02-3
3	Cluster III	3	AKM12-24, AKM12-28, MH2-15
4	Cluster IV	2	AKM8802, KM2241
5	Cluster V	1	BM4
6	Cluster VI	1	NMK15-08
7	Cluster VII	1	PantM-4
8	Cluster VIII	1	PantM-5

Table.5 Intra- Cluster (Diagonal) And Inter- Cluster Distances for eight clusters in Greengram

	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V	Cluster VI	Cluster VII	Cluster VIII
Cluster I	**201.58**	**322.92**	**761.70**	**265.40**	**608.98**	**277.13**	**255.01**	**278.43**
Cluster II		**194.20**	**445.03**	**296.68**	**417.32**	**523.03**	**430.63**	**502.78**
Cluster III			**186.73**	**561.34**	**840.60**	**1046.15**	**719.35**	**910.01**
Cluster IV				**205.62**	**746.07**	**574.16**	**322.14**	**307.15**
Cluster V					**0.00**	**688.80**	**799.51**	**984.36**
Cluster VI						**0.00**	**294.88**	**346.23**
Cluster VII							**0.00**	**346.11**
Cluster VIII								**0.00**

Table.6 Mean performance of the clusters with respect to different traits

Cluster	Days to 1st flowering (D_1)	Days to 50% flowering	Days to 1st pod maturity (D_2)	DDd_1	Days to 90% pod maturity (D_3)	DDd_2	Plant height at 1st flower initiation (H_1)	Plant height at 1st pod maturity (H_2)	DDh_1	Plant height at 90% pods maturity (H_3)	DDh_2	DDh_3	Number of pods per plant	Number of branches per plant	Seeds per pods	100 seed weight (g)	seed yield per plant (g)
Cluster I	45.39	56.74	58.61	37.91	73.15	19.81	20.52	29.52	30.03	39.48	47.57	24.77	10.45	4.94	9.15	3.69	7.26
ClusterII	41.72	53.22	55.39	39.78	69.28	20.05	21.48	31.65	32.10	42.53	48.05	23.61	13.51	6.50	11.83	4.53	8.74
ClusterIII	41.78	52.22	56.78	35.72	65.00	12.64	24.43	33.65	26.75	42.23	42.25	20.46	16.78	7.00	11.44	5.10	9.72
Cluster IV	43.17	52.50	55.67	38.86	70.83	21.19	17.42	23.03	24.40	34.47	49.47	33.15	12.33	5.50	11.17	3.70	7.04
Cluster V	42.33	54.33	55.67	39.91	70.67	20.98	23.67	36.33	35.00	60.89	61.14	40.34	16.00	6.67	9.67	3.64	7.39
Cluster VI	48.67	60.33	62.33	35.40	75.33	17.25	29.00	39.53	26.65	49.10	40.93	19.47	7.67	4.33	8.67	3.75	7.74
Cluster VII	48.67	60.67	62.67	30.48	70.00	10.48	20.50	27.06	24.24	36.00	43.04	24.82	4.56	7.33	12.00	3.79	7.55
Cluster VIII	47.00	55.67	59.33	37.61	75.33	21.23	13.50	20.40	33.83	35.67	62.16	42.80	9.00	3.67	8.00	4.33	8.02

Table.7 Contribution of different quantitative traits to diversity in greengram following Singh (1981)

	Days to 90% pod maturity (D_3)	Days to 1st flowering (D_1)	Days to 1st pod maturity (D_2)	DDd_2 =(D3-D2)/D3*100	Plant height at 90% pods maturity(H_3)	DDd_1 =$(D_3-D_1)/D_3*100$	yield $plant^{-1}$	DDh_3 =$(H_3-H_2)/H_3*100$	Plant height at 1st pod maturity(H_2)	100 seed weight	DDh_1 =$(H_2-H_1)/H_2*100$	Number of branches per plant	Days to 50% flowering	Number of seeds per pod	Number of pods per plant	DDh_2 =$(H_3-H_1)/H_3*100$	Plant height at 1st flower initiation(H_1)
Singh statistic	406455.083	228067.716	202363.781	133934.342	70557.460	42774.243	24332.463	21713.688	14338.796	12727.118	9220.979	7650.928	4324.299	3930.149	3537.430	234.366	159.715
Proportion	0.343	0.192	0.171	0.113	0.059	0.036	0.021	0.018	0.012	0.011	0.008	0.006	0.004	0.003	0.003	0.000	0.000
Cumulative proportion	0.343	0.535	0.705	0.818	0.878	0.914	0.934	0.953	0.965	0.976	0.983	0.990	0.993	0.997	1.000	1.000	1.000

The better genotypes might be selected for most of characters on the basis of mean performance in the cluster.

Following Singh's (1981) approach used to identify the character contributing the most to the overall divergence, highest contribution was by days to 90% pod maturity followed by days to first flowering and days to first pod maturity (Table 7). Contributions were negligible by degree of indetermination of plant height from first flower to 90% pod maturity and plant height at first flower initiation. No previous reports were seen in relation to present findings for days to maturity towards the contribution of divergence, indicating careful consideration of the present results.

It is concluded from the present study, the best genotypes for yield and yield attributing characters identified were KM 2355, AKM 12-24, AKM 12-28, MH 2-15, IPM 312-20 and HUM 1. Pant M-4 was the most determinate at 90% pod maturity from first flower. RMG 1092 was the most determinate for plant height from first flower to first pod and 90% pod maturity. RMG 1087 was determinate for plant height from first pod maturity to 90% pod maturity. Based on the clustering pattern, cluster distance and cluster mean genotype PantM-4, AKM 12-24, AKM 12-28, MH 2-15, KM 2355, IPM 312-20 and COGG 13-39 could be useful for exploitation of hybrid vigor and for getting good recombinant. Days to 90% pod maturity, days to first flowering and days to first pod maturity showed high contribution toward genetic divergence.Sufficient variation for yield and synchronous maturity was observed which justifies scope for future breeding.

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