

Study on Genetic Diversity in Greengram (*Vigna radiata* L.) using Metroglyph Analysis

ABSTRACT

Pulses, such as greengram, blackgram, chickpeas, lentils, dry beans, and peas, are leguminous crops vital for sustainable agriculture and global food security due to their high protein, complex carbohydrates, fiber, vitamins, and minerals, making them essential for balanced diets and vegetarian nutrition. Greengram, a type of pulse, is particularly nutritious with its rich plant-based protein, essential vitamins and minerals, dietary fiber, low fat and calorie content, high antioxidants, and versatile culinary uses. Despite extensive research on greengram, the genetic diversity assessed through Metroglyph analysis remains underexplored. Existing studies primarily focus on conventional methods, lacking comprehensive genetic profiling. This study aims to estimate the variability parameters for 16 quantitative characters of greengram to classify the genotypes using Metroglyph analysis and assess genetic divergence to identify divergent parents for future hybridization programs using 45 greengram genotypes using Randomized Block Design replicated thrice. Among 45 genotypes of greengram on the basis of mean performance MGG-351(12.959) followed by MGG-347(43.16 q/ha), VBN -2 (41.12 q/ha), GM-3(40.8 q/ha) and MGG-385(39.8 q/ha) were found superior for grain yield. High GCV and PCV is recorded for Harvest Index and Number of primary branches. High heritability coupled with genetic advance as percent of mean are recorded for number of primary branches, harvest index (%), number of seeds per pod, biological yield per plant, seed index, number of pods per plant, number of clusters per plant. On the basis of Metroglyph analysis, the total index score was varied from 24 (SHAKTI) to 38 (SIKHA) with a mean of 31.84. Among the 45 germplasm lines, the genotypes GM-3, MGG-385, SML-1663 and MGG-371 were observed as high yielder and identified for higher index score. Scatter diagram plotted with Plant Height and Harvest Index has revealed that 5 clusters could be distinguished on the basis of morphological variation. Cluster -1 was represented by 24 genotypes, Cluster -2 was represented by 10 genotypes, Cluster-3 was represented by 7 genotypes, Cluster-4 was represented by 3 genotype, Cluster -5 was represented by 1 genotype. From those complexes, the germplasm lines, SIKHA and MGG-371 recorded high index score and fell into different cluster, hence used as parents in hybridization for getting desirable transgressive segregants.

Keywords: Greengram, GCV, PCV, Heritability, Genetic Advance, Metroglyph Analysis

INTRODUCTION

Pulses, including crops like chickpeas, lentils, dry beans, and peas, are essential for sustainable agriculture and food security due to their high protein content and nutritional benefits (Bhatty, 2016). They improve soil fertility through nitrogen fixation, reducing the need for synthetic fertilizers and enhancing soil health (Dwivedi *et al.*, 2020). Pulses also serve as valuable rotation crops, boosting productivity, suppressing weeds, and mitigating pest pressures (McGee *et al.*, 2019). Their deep roots aid nutrient cycling and water management, contributing to agroecosystem efficiency (McGee *et al.*, 2019). Pulses are vital for global food security, offering affordable nutrition and fostering sustainability.

Green gram (*Vigna radiata* L.) is grown for its edible seeds, especially in Asia, Africa, and the Americas. It holds agricultural importance due to its high nutritional content, adaptability to diverse climates, and role in sustainable farming (Singh *et al.*, 2019). Rich in protein, essential amino acids, vitamins, and minerals, green gram supports food security and nutrition (Bhardwaj *et al.*, 2020). It thrives in tropical and subtropical regions with warm, humid climates and well-drained soil (Singh *et al.*, 2019). Its short growth cycle and nitrogen-fixing ability enhance soil fertility and productivity, making it ideal for intercropping and crop rotation (Bhardwaj *et al.*, 2020).

India is the world's largest producer of green gram, with cultivation across all states. In 2021-22, green gram was grown on approximately 40.38 lakh hectares, yielding 31.5 lakh tonnes, with a productivity rate of 783 kg/ha, contributing 11% to the country's total pulse production. In the Kharif season of 2022-23, production reached 17.5 lakh tonnes from 33.37 lakh hectares (1st advance estimates). Andhra Pradesh contributed 4.74% of national production, cultivating 0.97 lakh hectares and producing 0.83 lakh tonnes in 2021-22. For 2022-23, cultivation covered 0.08 lakh hectares, yielding 0.04 lakh tonnes with a productivity of 493 kg/ha.

Green gram displays significant genetic diversity, crucial for breeding programs aimed at improving traits like yield, disease resistance, and stress tolerance (Singh *et al.*, 2019). Research focuses on utilizing molecular markers, morphological analysis, and multivariate techniques to develop cultivars suited to specific agro-ecological conditions. This legume enhances soil fertility through nitrogen fixation, reducing the need for synthetic fertilizers, and serves as an excellent rotational crop in tropical and subtropical regions (Bhardwaj *et al.*,

2020). Its short growth cycle and adaptability to diverse soils optimize land use, improve productivity, and help break pest cycles, reducing pesticide reliance. Additionally, green gram is rich in protein, fiber, vitamins, and minerals, promoting digestive health and offering numerous health benefits, including anti-inflammatory and antioxidant effects (Satheesh & Chidambara Murthy, 2019). It's a versatile, nutritious food option in both traditional and modern diets.

Genetic variability is crucial for crop improvement programs, providing the basis for selecting and breeding varieties with desirable traits. It can be analyzed through statistical parameters like Genotypic Coefficient of Variation (GCV), Phenotypic Coefficient of Variation (PCV), heritability, and genetic advance. GCV represents genetic variability, while PCV includes environmental factors, with high values indicating greater potential for genetic improvement. Heritability measures the extent of genetic influence on traits, and genetic advance estimates the expected gain from selection. Metroglyph analysis is a graphical method for visualizing genetic diversity, helping to classify genotypes and select diverse parents for breeding programs. This study aims to estimate variability parameters, classify genotypes, and identify divergent parents for hybridization using 45 genotypes of Green gram.

MATERIALS AND METHODS

The investigation was carried out during *Kharif* 2023 at the Field Experimentation Center of the Department of Genetics and Plant Breeding, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh. A total of 45 green gram genotypes were sown in July using a Randomized Block Design with three replications, maintaining a row spacing of 30 cm and plant spacing of 10 cm. The recommended agricultural practices were followed throughout the experiment. The study focused on assessing key genetic parameters such as heritability, correlation, path analysis, and genetic diversity, all aimed at improving seed yield in green gram.

List 1 : List of chosen genotypes

NO.	GENOTYPES LIST	NO.	GENOTYPES LIST
1	MGG-347	24	MGG-295
2	VBN -2	25	PUSHA-105
3	GM-3	26	CO-8

4	MGG-385	27	VBN-3
5	MGG-351	28	SML-1663
6	MGG-348	29	LGG-460
7	KM-2	30	SM-02-103
8	RM-12-11	31	LGG-407
9	MGG-2	32	TM-96-2
10	KM-11-564	33	IPM-2-3
11	VEENA	34	WGG-42
12	IPM-205-7	35	PUSA BAISAKI
13	MGG-371	36	JALGAON781
14	Su-Urd-113	37	WGG37
15	ML-131	38	LGG-450
16	R-288-8	39	ML-131
17	SIKHA	40	SM2029
18	AMULYA	41	BM2002-4
19	SHAKTI	42	SPM 2040
20	MH421	43	RM 12-13
21	IPM-2-14	44	K-851
22	CO-7	45	SAMRAT-CHECK
23	VIRAT		

RESULTS AND DISCUSSION

The analysis of variance revealed the existence of significant differences among the genotypes for all the characters studied. Hence, the data of all the 16 characters which showed significant differences among the entries were subjected to further statistical analysis.

Out of 45 genotypes of Greengram evaluated for various characters, all genotypes found to be superior for seed yield per plant in MGG-347 (43.15 g), VBN -2 (41.12 g), GM-3 (40.83 g), MGG-385 (39.86 g), MGG-351 (38.90 g), MGG-348 (38.32 g), KM-2 (38.03 g), RM-12-11

(37.18 g), MGG-2 (36.61 g), KM-11-564 (36.12 g), VEENA (34.63 g), IPM-205-7 (34.40 g) exhibited highest seed yield per plant. And the genotypes SML-1663 (62 days) followed by VBN -2 (63.37 days), KM-11-564 (63.67 days), LGG-407 (64 days), MH421 (64.33 days), LGG-460 (65.17 days), MGG-351 (65.26 days), RM-12-11 (65.28 days), BM2002-4 (65.63 days), SAMRAT-CHECK (65.72 days), VEENA (66.16 days) and GM-3 (66.48 days) have shown early maturity among 45 Greengram genotypes. The genotypes BM2002-4, RM-12-11, MGG-351, LGG-460, MH421, LGG-407, KM-11-564, VBN -2 and SML-1663 have shown minimum days to maturity and all the genotypes have shown maximum seed yield per plant than Check variety (SAMRAT) used in this study. Therefore, these genotypes may be used in future breeding programme to develop superior varieties with desirable economic traits beneficial for mankind by creating variability by hybridization followed by selection.

A wide range of phenotypic coefficient of variation (PCV) was observed for all the traits ranged from days to maturity (7.585) to harvest index (23.437). Higher magnitude of PCV was recorded for harvest index (23.437), number of primary branches (22.802), while medium magnitude of PCV is recorded for number of seeds per pod (19.396), biological yield per plant (18.641), seed index (17.388), number of pods per plant (15.733), seed yield per plant (15.426), number of clusters per plant (15.265), number of seeds per plant (14.367), pod length (14.26), number of secondary branches (12.321), plant height (10.099). Lower magnitude of PCV is recorded for number of pods per cluster (8.591), days to 50% pod setting (7.695), days to 50% flowering (7.632), days to maturity (7.585).

A wide range of genotypic coefficient of variation (GCV) was observed for all the traits ranged from days to maturity (4.386) to harvest index (22.234). Higher magnitude of GCV was recorded for harvest index (22.234), number of primary branches (21.937), while medium magnitude of GCV is recorded for number of seeds per pod (17.516), biological yield per plant (16.201), seed index (14.932), number of pods per plant (13.87), number of clusters per plant (13.655), seed yield per plant (11.839), number of seeds per plant (11.776), pod length (11.643), number of secondary branches (10.582). Lower magnitude of GCV is recorded for number of pods per cluster (8.492), plant height (8.245), days to 50% flowering (5.135), days to 50% pod setting (5.045), days to maturity (4.386).

In light of recent advancements, the results of this study align closely with previous research findings of **Sreethy *et al.*, 2017, Yadav *et al.*, 2017, Sandhiya *et al.*, 2018, Susmitha *et al.*, 2018, Mariyammal *et al.*, 2019, Anuradha *et al.*, 2019, Vadivel *et al.*, 2020, Tamalapakula *et al.*, 2021.**

The perusal of the table 2 revealed the estimates of heritability (%) in broad sense for 14 characters studied, which range from days to maturity (33.435) to number of pods per cluster (97.716). Heritability was recorded for number of pods per cluster (97.716), number of primary branches (92.559), harvest index (90), number of seeds per pod (81.557), number of clusters per plant (80.012), number of pods per plant (77.718), biological yield per plant (75.536), number of secondary branches (73.772), seed index (73.742), number of seeds per plant (67.184), pod length (66.671), plant height (66.651). Medium heritability was recorded for seed yield per plant (58.901), days to 50% flowering (45.282), days to 50% pod setting (42.989). Low heritability was recorded for days to maturity (33.435).

A perusal of genetic advance (table 2) revealed that it was Medium in harvest index (16.852). Low estimate of genetic advance as percent of mean was recorded for plant height (9.782), biological yield per plant (8.749), number of seeds per plant (4.063), number of primary branches (3.758), days to maturity (3.66), days to 50% pod setting (3.147), number of secondary branches (2.958), number of pods per plant (2.923), days to 50% flowering (2.542), number of seeds per pod (2.428), seed yield per plant (1.831), number of clusters per plant (1.764), pod length (1.449), number of pods per cluster (1.215), seed index (1.006).

High estimate of genetic advance as percent of mean was recorded for number of primary branches (43.477), harvest index (43.452), number of seeds per pod (32.587), biological yield per plant (29.006), seed index (26.414), number of pods per plant (25.189), number of clusters per plant (25.161). Medium estimate of genetic advance as percent of mean was recorded for number of seeds per plant (19.883), pod length (19.585), number of secondary branches (18.724), seed yield per plant (18.717), number of pods per cluster (17.293), plant height (13.866). Low estimate of genetic advance as percent of mean was recorded for days to 50% flowering (7.119), days to 50% pod setting (6.814), days to maturity (5.224).

High heritability coupled with genetic advance as percent of mean are recorded for number of primary branches, harvest index (%), number of seeds per pod, biological yield per plant, seed index, number of pods per plant and number of clusters per plant, indicated that most likely the heritability might be due to additive gene effect and selection may be effective in segregating generation's improvement of these traits.

In light of recent advancements, the results of this study align closely with previous research findings of **Patel *et al.*, 2011, Das *et al.*, 2015, Baishak *et al.*, 2016, Sreethy *et al.*, 2017, Ramchandra *et al.*, 2017, Chandra *et al.*, 2017, Sandhiya *et al.*, 2018, Susmitha *et al.*,**

2018, Mariyammal *et al.*, 2019, Anuradha *et al.*, 2019, Vadivel *et al.*, 2020, Sineka *et al.*, 2021, Tamalapakula *et al.*, 2021, Dhunde *et al.*, 2021.

From the Metroglyph Analysis, it is revealed that maximum variability was in Plant height (59.78-81.83) followed by Days to maturity (62-76.59), Days to 50% Flowering (31.43-39.88) and Harvest Index (16.77-54.79). These traits thus were most variable for classificatory analysis in Greengram.

The total index score was varied from 24 (SHAKTI) to 38 (SIKHA) with a mean of 31.84. It indicates that germplasm lines were having variations. In the present investigation, it is interesting to note that high seed yielding genotypes were found with highest index score. Among the 45 germplasm lines, the genotypes GM-3, MGG-385, SML-1663 and MGG-371, were observed as high yielder and identified for higher index score.

In light of recent advancements, the results of this study align closely with previous research findings of Abbas *et al.*, 2010, Ghulam Abbas *et al.*, 2011, Jha *et al.*, 2011, Sahu *et al.*, 2014, Hemant Sahu *et al.*, 2014, Ahmad *et al.*, 2019, Win *et al.*, 2020, Lal *et al.*, 2022.

The Frequency Diagram of Index Score for 45 Greengram genotypes revealed that, Index Score 38 and 24 has shown by only 1 genotype respectively. Index Score 32 has shown by 8 genotypes, 30 by 7 genotypes. The scatter diagram revealed that 5 clusters could be distinguished on the basis of morphological variation.

Cluster -1 was represented by 24 genotypes with Plant Height and Harvest Index

Cluster -2 was represented by 10 genotypes with Plant Height and Harvest Index

Cluster-3 was represented by 7 genotypes with Plant Height and Harvest Index

Cluster-4 was represented by 3 genotypes with Plant Height and Harvest Index

Cluster-5 was represented by 1 genotype with Plant Height and Harvest Index

List 2 : Analysis of Variance for 16 quantitative characters of Greengram (*Vigna radiata* L.) genotypes

Sl.No.	Source	Mean Sum of Squares (MSS)		
		Replication	Treatment	Error
	Degrees of freedom	2	44	88
1	Days to 50% flowering	12.1550	14.154**	4.064

2	Days to 50% pod setting	10.2840	23.485**	7.199
3	Days to maturity	40.470	47.115**	18.794
4	Plant height	36.9720	118.432**	16.929
5	Number of primary branches per plant	0.2420	11.076**	0.289
6	Number of secondary branches per plant	2.6850	9.379**	0.994
7	Number of clusters per plant	0.6850	2.978**	0.229
8	Number of pods per plant	0.8690	8.517**	0.743
9	Pod length	0.7550	2.597**	0.371
10	Number of seeds per pod	0.4830	5.494**	0.385
11	Number of pods per cluster	0.629**	1.076**	0.008
12	Number of seeds per plant	0.8960	20.199**	2.828
13	Biological yield per plant	18.7360	79.368**	7.734
14	Seed Index	0.2460	1.086**	0.115
15	Harvest Index	17.9550	231.329**	8.261
16	Seed yield per plant (q/ha)	2.5140	4.961**	0.936

*and ** are Significant at 5 percent and 1 percent level of significance respectively

Table 1 Mean Performance of 45 genotypes of Greengram for 16 characters during *Kharif* – 2023

S No.	Genotypes	DFE	D50%PS	DM	PH	NPB	NSB	NCP	NPP	PL	NSP _o	NPC	NSPI	BYP	SI	HI	SYP
1	MGG-347	33.25	49.42	72.73	61	8.2	13.98	5.18	10.21	7.73	7.51	7.65	19.11	24.06	3.76	35.03	43.15
2	VBN -2	34.44	45.36	63.37	74.1	12.2	17.7	7.79	11.25	8.33	8.89	7.4	17.29	26.92	4.74	37.63	41.13
3	GM-3	38.5	50.76	66.48	79.6	11.8	16.95	6.03	14.57	7.01	5.07	6.27	20.61	38.98	3.6	44.34	40.84
4	MGG-385	38.25	47.01	75.08	75.5	10.1	14.96	6.32	10.46	6.94	6.36	7.6	21.81	31.13	3.93	38.48	39.87
5	MGG-351	36.33	43.28	65.26	74.5	8.9	15.27	5.95	8.07	7.95	6	7.42	17.42	23.04	3.5	41.27	38.91
6	MGG-348	36.77	45.99	75.14	81.3	12.1	14.82	7.89	8.96	8.09	5.11	6.99	20	32.4	4.81	47.99	38.32
7	KM-2	39.66	46.96	74.41	60.6	8.4	14.72	5.66	13.17	7.81	8.14	7.75	21.9	29.6	3.71	46.66	38.04
8	RM-12-11	37.25	49.82	65.28	76.1	7.8	14.13	7.22	10.47	8.25	6.83	6.11	21.76	39.09	4.35	42.08	37.19
9	MGG-2	35.1	45.9	69.42	76.7	5.5	17.63	5.27	10.67	5.97	7.9	6.79	16.92	27.17	3.45	35.63	36.61
10	KM-11-564	34.6	50.57	63.67	72.5	12	13.21	5.37	8.45	8.02	5.27	7.03	22.91	26.28	5	48.32	36.12
11	VEENA	33.9	46.15	66.16	75.3	5.2	15.29	6.35	10.79	8.74	5.94	6.63	19.49	29.81	4.06	54.79	34.63
12	IPM-205-7	35.5	43.72	71.7	79.4	11.4	18.9	8.7	8.26	8.66	6.29	7.92	20.92	30.58	4.1	46.1	34.4
13	MGG-371	37.66	48.14	68.66	66.4	10.6	14.95	7.14	14.98	5.69	8.04	7.43	24.62	34.6	4.54	50.27	33.92
14	Su-Urd-113	34.22	43.9	73.5	66.6	12	16.31	7.22	8.97	5.79	6.45	7.5	18.08	28.98	4.12	44.11	33.73
15	ML-131	33.33	49.73	73.16	67.7	7.7	17.85	7.52	9.41	5.62	6.5	6.19	17.32	34.89	3.15	49.49	33.36
16	R-288-8	36.75	52.2	72.75	72.8	6.2	15.61	7.81	10.52	7.36	7.28	7.22	17.54	26.4	3.1	49.15	33.3
17	SIKHA	39.88	49.87	76.59	81.61	9.33	17.13	8.01	14.6	7.92	9.1	6.27	19.11	30.27	4.13	33.45	33.08

18	AMULYA	37.44	46.67	71	63.63	8.2	17.77	6.47	11.87	6.99	7.7	7.74	21.1	29.8	3	27.83	33.07
19	SHAKTI	38.44	47.34	72	60.9	5.34	16.32	5.93	10.53	6.57	7.1	6.22	17.77	22.87	2.9	20.22	33.07
20	MH421	31.43	42	64.33	75.14	8.6	13.26	7.6	12.93	7.16	8.07	7.91	20.81	20.6	4.06	35.98	32.87
21	IPM-2-14	33.44	42.67	70.67	64.18	8.33	13.85	7.87	13	7.22	8.8	7.6	22.03	27.47	4.56	40.16	32.63
22	CO-7	38.11	47.33	70.67	67.45	8.07	18.44	6.53	11.73	5.98	9	7.77	18.68	24.53	2.8	30.31	32.4
23	VIRAT	34.77	45	69	71.84	7.8	15.62	7.4	12.73	6.33	8.03	6.19	17.42	26.93	3.6	22.08	32.3
24	MGG-295	34.62	45.33	68.33	74.05	8.6	15.14	7.13	13.2	7.18	9.34	6.47	20.9	20.13	3.56	37.88	32.04
25	PUSHA-105	37.44	47.33	71.67	67.01	8.46	16.43	7.4	12.27	7.22	8.2	6.59	21.49	26.4	4.3	37.92	31.85
26	CO-8	37.1	46.66	71.33	59.78	5.53	13.98	6.53	11.47	5.76	6.77	7.64	16.06	29.33	3.9	20.31	31.83
27	VBN-3	39.43	48	71.33	69.77	8	18.12	5.87	11.67	7.33	7.39	7.06	24.58	33.73	2.83	16.77	31.73
28	SML-1663	35.1	42	62	74.62	9.2	17.78	8.2	13.93	7.45	9.45	7.35	24.05	27.13	4.33	43.76	31.67
29	LGG-460	32.86	41	65.17	70.97	8.73	18.27	8	12.87	7.58	9.13	7.69	22.11	24.07	4.1	38.71	31.64
30	SM-02-103	34.44	42.67	67.83	72.42	8.07	18.2	6.47	11.73	6.56	8.57	6.92	21.63	28.13	3.2	29.13	31.24
31	LGG-407	34.1	44.33	64	81.83	11.33	13.99	8.4	13.07	7.33	9.67	7.46	16.82	33	4.46	38.98	29.75
32	TM-96-2	34.77	44.67	69.5	64.82	6.8	16.91	6.07	10.13	6.56	7.77	6.16	23.93	27.47	2.76	22.7	29.6
33	IPM-2-3	37.11	43	69.33	65.89	8.07	13.12	7.93	12.87	7.43	9.49	7.29	17.08	32	4.16	37.24	29.59
34	WGG-42	35.1	44.67	68.33	71.17	8.93	14.09	8.2	14.33	7.59	9.67	6.8	16.65	29.67	4.1	37.8	29.3
35	PUSA BAISAKI	38.77	50.27	74.67	74.88	8.94	14.97	6.73	11.78	8.57	7.68	6.59	24.93	33.42	3.2	35.91	28.64
36	JALGAON78 1	36.23	43.71	72.1	78.9	9.2	15.12	8.07	11.37	5.72	5.83	6.1	20.13	36.52	4.6	46.21	28.64
37	WGG37	34.44	46.05	75.24	70.6	5.4	13.45	7.98	12.42	8.73	7.02	7.37	22.5	31.77	4.04	44.01	28.37
38	LGG-450	35.42	47.41	75.13	69.86	6.84	13.67	8.21	11.41	8.36	6.47	7.02	22.68	30.49	3.75	41.17	28.21
39	ML-131	31.43	46.22	75.35	76.3	10.4	14.55	6.89	10.89	8.35	8.26	7.74	22.22	32.22	3.01	38.23	28.21

40	SM2029	34.25	43.63	69.56	69.4	10	13.16	8.63	10.87	8.37	6.51	7.19	22.67	29.12	4.26	37.93	27.86
41	BM2002-4	35.15	51.24	65.63	62.8	9.9	16.28	7.65	11.29	8.54	5.29	7.75	23.77	40.06	3.86	38.45	27.44
42	SPM 2040	38.6	48.15	74.93	62.2	7.4	15.08	6.23	11.9	8.25	5.12	6.44	21.88	38.1	3.09	44.23	27.31
43	RM 12-13	32.7	45.04	75.16	68.1	6.7	18.36	6.13	11.18	8.06	8.56	6.29	16.04	40.04	4.4	43.31	26.99
44	K-851	33.44	44.5	69	61.3	9.2	18	5.69	12.28	8.23	7.22	6.43	23.23	40.39	3.35	41.19	26.64
45	SAMRAT-CHECK	35.5	42.5	65.72	63.3	7.5	17.6	5.83	12.75	7.66	6.47	6.22	19.64	27.69	3.2	52.02	24.64
Mean		35.71	46.18	70.05	70.55	8.64	15.8	7.01	11.61	7.4	7.45	7.03	20.43	30.16	3.81	38.78	9.78
Range	Minimum	31.43	41	62	59.78	5.2	13.12	5.18	8.07	5.62	5.07	6.1	16.04	20.13	2.76	16.77	24.64
	Maximum	39.88	52.2	76.59	81.83	12.2	18.9	8.7	14.98	8.74	9.67	7.92	24.93	40.39	5	54.79	43.15
CV		5.65	5.81	6.19	5.83	6.22	6.31	6.82	7.43	8.23	8.33	1.3	8.23	9.22	8.91	7.41	9.89
SEm		1.16	1.55	2.5	2.38	0.31	0.58	0.28	0.5	0.35	0.36	0.05	0.97	1.61	0.2	1.66	0.56
CD at 5%		3.27	4.35	7.03	6.68	0.87	1.62	0.78	1.4	0.99	1.01	0.15	2.73	4.51	0.55	4.66	1.57
CD at 1%		4.33	5.77	9.32	8.85	1.16	2.14	1.03	1.85	1.31	1.33	0.2	3.62	5.98	0.73	6.18	2.08
Replication		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	S	NS	NS	NS	NS	NS
Treatment		S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S

DFF- Days to 50% Flowering, **D50%PS** – Days to 50% Pod Setting, **DM** – Days to Maturity, **PH** – Plant Height, **NPB** – Number of Primary Branches, **NSB** – Number of Secondary Branches, **NCP** – Number of Clusters per Plant, **NPP** – Number of Pods per Plant, **PL** - Pod Length, **NSPo** – Number of Seeds per Pod, **NPC** – Number of Pods per Cluster, **NSPI** – Number of Seeds per Plant, **BYP** – Biological Yield per Plant, **SI** - Seed Index, **HI** – Harvest Index, **SYP** – Seed Yield per Plant

Table 2 Estimates of genetic parameters for 14 quantitative characters in Greengram

Sl.No.	Characters	GCV	PCV	h^2 (Broad Sense)	Genetic Advance 5%	Genetic Advance as % of Mean 5%
1	Days to 50% flowering	5.14	7.63	45.28	2.54	7.12
2	Days to 50% pod setting	5.05	7.70	42.99	3.15	6.81
3	Days to maturity	4.39	7.59	33.44	3.66	5.22
4	Plant height	8.25	10.10	66.65	9.78	13.87
5	Number of primary branches per plant	21.94	22.80	92.56	3.76	43.48
6	Number of secondary branches per plant	10.58	12.32	73.77	2.96	18.72
7	Number of clusters per plant	13.66	15.27	80.01	1.76	25.16
8	Number of pods per plant	13.87	15.73	77.72	2.92	25.19
9	Pod length	11.64	14.26	66.67	1.45	19.59
10	Number of seeds per pod	17.52	19.40	81.56	2.43	32.59
11	Number of pods per cluster	8.49	8.59	97.72	1.22	17.29
12	Number of seeds per plant	11.78	14.37	67.18	4.06	19.88
13	Biological yield per plant	16.20	18.64	75.54	8.75	29.01
14	Seed Index	14.93	17.39	73.74	1.01	26.41
15	Harvest Index	22.23	23.44	90.00	16.85	43.45
16	Seed yield per plant (q/ha)	11.84	15.43	58.90	1.83	18.72

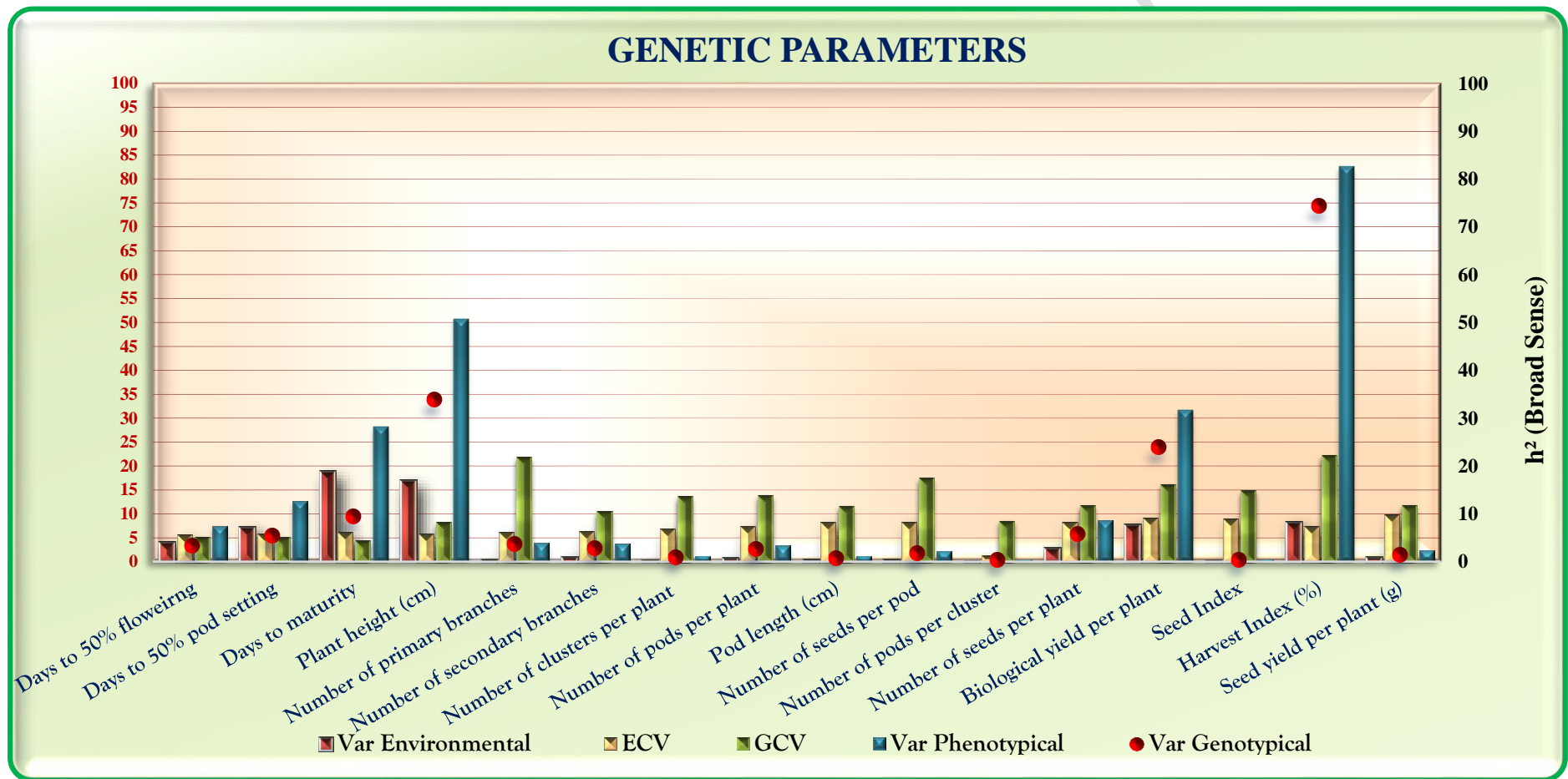


Fig 1 Bar diagram depicting GCV, PCV, heritability and genetic advance for 16 quantitative characters of Greengram

Table 3 The range variability and class intervals of various characters

S No.	Character	Range of Mean	Score 1	Sign	Score 2	Sign	Score 3	Sign
			Value <		Value from - to		Value >	
1	Days to 50% flowering	31.43-39.88	33.54	○	33.54-37.88	○	37.88	○
2	Days to 50% pod setting	41-52.2	43.38	○	43.38-48.98	○	48.98	○
3	Days to maturity	62-76.59	66.09	○	66.09-74.01	○	74.01	○
4	Plant height	59.78-81.83	64.27	○	64.27-76.83	○	76.83	○
5	Number of primary branches	5.2-12.2	6.72	○	6.72-10.57	○	10.57	○
6	Number of secondary branches	13.12-18.9	14.03	○	14.03-17.57	○	17.57	○
7	Number of clusters per plant	5.18-8.7	6.01	○	6.01-8.01	○	8.01	○
8	Number of pods per plant	8.07-14.98	9.92	○	9.92-13.29	○	13.29	○
9	Pod length	5.62-8.74	6.47	○	6.47-8.33	○	8.33	○
10	Number of seeds per pod	5.07-9.67	6.10	○	6.1-8.8	○	8.80	○
11	Number of pods per cluster	6.1-7.92	6.43	○	6.43-7.62	○	7.62	○
12	Number of seeds per plant	16.04-24.93	17.84	○	17.84-23.03	○	23.03	○
13	Biological yield per plant	20.13-40.39	25.02	○	25.02-35.31	○	35.31	○
14	Seed Index	2.76-5	3.21	○	3.21-4.41	○	4.41	○

15	Harvest Index	16.77-54.79	30.00	<input type="radio"/>	30-47.56	<input type="radio"/>	47.56	<input type="radio"/>
16	Seed yield per plant	7.4-12.96	8.50	<input type="radio"/>	8.5-11.07	<input checked="" type="radio"/>	11.07	<input checked="" type="radio"/>

UNDER PEER REVIEW

Table 4 Mean and index scores for yield and yield contributing characters in Greengram

S No.	Genotypes	DFP	D50%PS	DM	PH	NPB	NSB	NCP	NPP	PL	NSPo	NPC	NSPI	BYP	SI	HI	SYP	Total Index Score
1	MGG-347	1	3	2	1	2	1	1	2	2	2	3	2	1	2	2	3	30
2	VBN -2	2	2	1	2	3	3	2	2	3	3	2	1	2	3	2	2	35
3	GM-3	3	3	2	3	3	2	2	3	2	1	1	2	3	2	2	3	37
4	MGG-385	3	2	3	2	2	2	2	2	2	2	2	2	2	2	2	3	35
5	MGG-351	2	1	1	2	2	2	1	1	2	1	2	1	1	2	2	3	26
6	MGG-348	2	2	3	3	3	2	2	1	2	1	2	2	2	3	3	2	35
7	KM-2	3	2	3	1	2	2	1	2	2	2	3	2	2	2	2	2	33
8	RM-12-11	2	3	1	2	2	2	2	2	2	2	1	2	3	2	2	2	32
9	MGG-2	2	2	2	2	1	3	1	2	1	2	2	1	2	2	2	3	30
10	KM-11-564	2	3	1	2	3	1	1	1	2	1	2	2	2	3	3	1	30
11	VEENA	2	2	2	2	1	2	2	2	3	1	2	2	2	2	3	1	31
12	IPM-205-7	2	2	2	3	3	3	3	1	3	2	3	2	2	2	2	2	37
13	MGG-371	2	2	2	2	3	2	2	3	1	2	2	3	2	3	3	2	36
14	Su-Urd-113	2	2	2	2	3	2	2	1	1	2	2	2	2	2	2	2	31
15	ML-131	1	3	2	2	2	3	2	1	1	2	1	1	2	1	3	2	29
16	R-288-8	2	3	2	2	1	2	2	2	2	2	2	1	2	1	3	2	31
17	SIKHA	3	3	3	3	2	2	3	3	2	3	1	2	2	2	2	2	38
18	AMULYA	2	2	2	1	2	3	2	2	2	2	3	2	2	1	1	1	30
19	SHAKTI	3	2	2	1	1	2	1	2	2	2	1	1	1	1	1	1	24
20	MH421	1	1	1	2	2	1	2	2	2	2	3	2	1	2	2	1	27
21	IPM-2-14	1	1	2	1	2	1	2	2	2	3	2	2	2	3	2	2	30
22	CO-7	3	2	2	2	2	3	2	2	1	3	3	2	1	1	2	2	33
23	VIRAT	2	2	2	2	2	2	2	2	1	2	1	1	2	2	1	2	28

24	MGG-295	2	2	2	2	2	2	2	2	2	2	3	2	2	1	2	2	2	32
25	PUSHA-105	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	32
26	CO-8	2	2	2	1	1	1	2	2	1	2	3	1	2	2	1	1	26	
27	VBN-3	3	2	2	2	2	3	1	2	2	2	2	3	2	1	1	2	32	
28	SML-1663	2	1	1	2	2	3	3	3	2	3	2	3	2	2	2	2	35	
29	LGG-460	1	1	1	2	2	3	2	2	2	3	3	2	1	2	2	2	31	
30	SM-02-103	2	1	2	2	2	3	2	2	2	2	2	2	2	1	1	1	29	
31	LGG-407	2	2	1	3	3	1	3	2	2	3	2	1	2	3	2	2	34	
32	TM-96-2	2	2	2	2	2	2	2	2	2	2	1	3	2	1	1	2	30	
33	IPM-2-3	2	1	2	2	2	1	2	2	2	3	2	1	2	2	2	2	30	
34	WGG-42	2	2	2	2	2	2	3	3	2	3	2	1	2	2	2	2	34	
35	PUSA BAISAKI	3	3	3	2	2	2	2	2	3	2	2	3	2	1	2	2	36	
36	JALGAON781	2	2	2	3	2	2	3	2	1	1	1	2	3	3	2	2	33	
37	WGG37	2	2	3	2	1	1	2	2	3	2	2	2	2	2	2	2	32	
38	LGG-450	2	2	3	2	2	1	3	2	3	2	2	2	2	2	2	2	34	
39	ML-131	1	2	3	2	2	2	2	2	3	2	3	2	2	1	2	1	32	
40	SM2029	2	2	2	2	2	1	3	2	3	2	2	2	2	2	2	2	33	
41	BM2002-4	2	3	1	1	2	2	2	2	3	1	3	3	3	2	2	2	34	
42	SPM 2040	3	2	3	1	2	2	2	2	2	1	2	2	3	1	2	3	33	
43	RM 12-13	1	2	3	2	1	3	2	2	2	2	1	1	3	2	2	3	32	
44	K-851	1	2	2	1	2	3	1	2	2	2	2	2	3	3	2	2	32	
45	SAMRAT-CHECK	2	1	1	1	2	3	1	2	2	2	1	2	2	1	3	3	29	

Table 5 45 genotypes into different complexes in scattered diagram

Complex	Name of complex	No. of lines	Name of lines	Range and average score
I	Higher plant height with higher harvest index	24	VBN -2, GM-3, MGG-385, MGG-351, MGG-348, RM -12-11, MGG-2, KM-11-564, IPM-205-7, R-288-8, SIKHA, MH421, CO-7, MGG-295, SML-1663, LGG-460, LGG-407, WGG-42, PUSA BAISAKI, JALGAON781, WGG37, LGG-450, ML-131 and SM2029	26.00-38.00 (33.00)
II	Lower plant height with lower harvest index	10	MGG-347, KM-2, Su-Urd-113, IPM-2-14, PUSHA-105, IPM-2-3, BM2002-4, SPM 2040, RM 12-13 and K-851	30.00-34.00 (31.70)
III	Lower plant height with moderate harvest index	7	AMULYA, SHAKTI, VIRAT, CO-8, VBN-3, SM-02-103 and TM-96-2	24.00-32.00 (28.42)
IV	Lower plant height with higher harvest index	3	MGG-371, ML-131 and SAMRAT-CHECK	29.00-36.00 (31.33)
V	Higher plant height with very high harvest index	1	VEENA	31.00

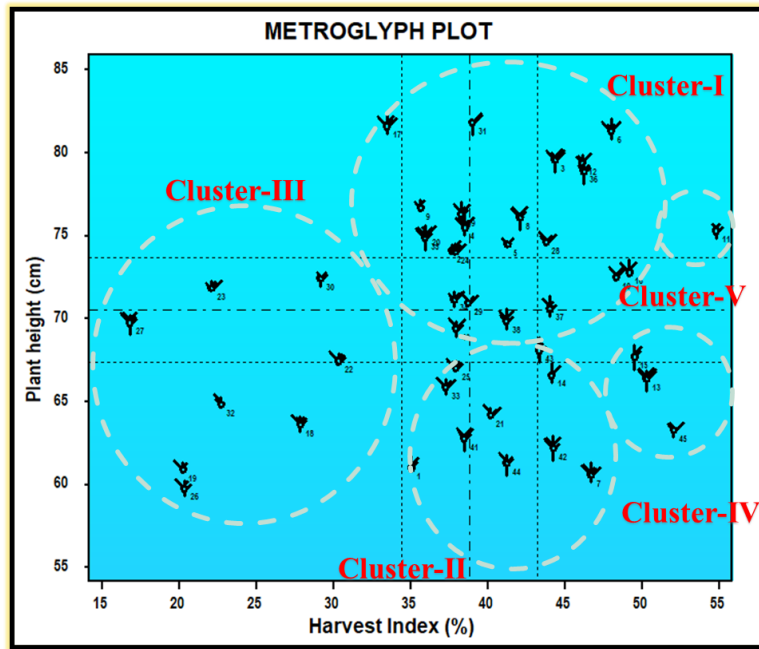


Fig. 2 Scatter diagram of Metroglyph Analysis

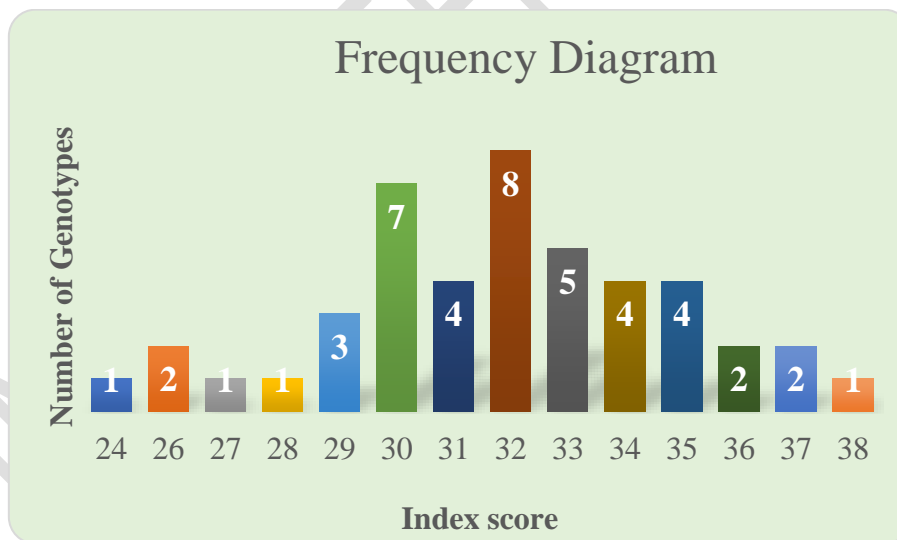


Fig. 3 Frequency Diagram of Index Score for 45 Greengram genotypes

CONCLUSION

From present investigation, it is concluded that among 45 genotypes of Greengram on the basis of mean performance MGG-351(12.959) followed by MGG-347(43.16 q/ha), VBN -2 (41.12 q/ha), GM-3(40.8 q/ha) and MGG-385(39.8 q/ha) were found superior for grain yield. High GCV and PCV is recorded for Harvest Index and Number of primary branches. High heritability coupled with genetic advance as percent of mean are recorded for number of primary branches, harvest index (%), number of seeds per pod, biological yield per plant, seed index, number of pods per plant, number of clusters per plant. On the basis of Metroglyph analysis, the total index score was varied from 24 (SHAKTI) to 38 (SIKHA) with a mean of 31.84. Among the 45 germplasm lines, the genotypes GM-3, MGG-385, SML-1663 and MGG-371 were observed as high yielder and identified for higher index score. Scatter diagram plotted with Plant Height and Harvest Index has revealed that 5 clusters could be distinguished on the basis of morphological variation. Cluster -1 was represented by 24 genotypes, Cluster -2 was represented by 10 genotypes, Cluster-3 was represented by 7 genotypes, Cluster-4 was represented by 3 genotype, Cluster -5 was represented by 1 genotype. From those complexes, the germplasm lines, SIKHA and MGG-371 recorded high index score and fell into different cluster, hence used as parents in hybridization for getting desirable transgressive segregants.

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