Plant Archives Vol. 25, No. 1, 2025 pp. 2460-2466 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org

DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2025.v25.no.1.354

EFFECT OF PLANTING GEOMETRY AND FERTILIZER LEVELS ON GROWTH AND YIELD OF GREENGRAM (*VIGNA RADIATA* L.) GENOTYPES DURING SUMMER

Mangala Gouramma Banakar*, M.P. Potdar and M.S. Venkatesh

Department of Agronomy, College of Agriculture, UAS, Dharwad-580005, Karnataka, India.
*Corresponding author E-mail: gouribanakar96@gmail.com
(Date of Receiving-04-02-2025; Date of Acceptance-12-04-2025)

ABSTRACT

A field experiment was conducted during summer 2019 at Indian Institute of Pulses Research (IIPR), Regional Research Centre (RRC), UAS campus, Dharwad on black clay soil. Treatments consisted of two planting geometry (30 cm × 10 cm and 45 cm × 7.5 cm) as main plots, two genotypes (Shreya and Meha) as sub plots and three fertilizer levels {F_1: 25:50:0 kg N: P_2O_5:K_2O ha^{-1} + 20 kg S ha^{-1}, F_2: 25:50:20 kg N:P_2O_5:K_2O ha^{-1} + 20 kg S ha^{-1} and F_3: 31.25:62.5:25 kg N:P_2O_5:K_2O ha^{-1} + 20 kg S ha^{-1}} as sub-sub plots with three replications. Genotype Shreya recorded significantly higher plant height (34.4 cm), number of trifoliate leaves (11.21), number of branches (10.19), leaf area (1.76 dm^2 plant^{-1}), LAI (0.55) and dry matter production (8.71 g) at harvest which in turn recorded higher seed (691 kg ha^{-1}) and haulm yield (2679 kg ha^{-1}) than Meha. Planting geometry had significant effect on growth parameters of greengram during summer. Among fertilizer levels application of 31.25:62.5:25 kg N:P_2O_5:K_2O ha^{-1} + 20 kg S ha^{-1} recorded significantly higher growth parameters, seed yield (743 kg ha^{-1}) and haulm yield (2,784 kg ha^{-1}) as compared to application of 25:50:20 kg N:P_2O_5:K_2O ha^{-1} + 20 kg S ha^{-1} and RDF. There is no interaction effect among greengram genotypes, planting geometry and fertilizer levels.

***Key words*:** Summer greengram, genotypes, planting geometry, fertilizer levels

Introduction

Greengram (*Vigna radiata* L.) is third most important pulse crop in India after chickpea and pigeonpea, it highly valued as a grain legume. Greengram contain 24 -25 per cent protein highly rich in lysine, an amino acid which is deficit in cereals (Anon., 2018a).

In India greengram being grown in an area of 3.5 m ha with total production of 1.6 m tonnes and productivity of 466 kg ha^{-1}. Whereas during *rabi* and summer it is grown in an area of 0.96 m ha with 0.56 m tonnes production and 582 kg ha^{-1} productivity (Anon., 2018b). In Karnataka it is being grown in an area of 0.39 m ha with production of 0.128 m tonnes and productivity of 275 kg ha^{-1}. During summer greengram is grown in an area of 1025 ha (Anon., 2018a). The productivity gap analysis revealed that the national average yield of greengram is 466 kg ha^{-1} as against 275 kg ha^{-1} in Karnataka. This indicates the scope for increasing the productivity of summer greengram by proper best agronomic management practices.

Greengram can be grown twice in a year during *kharif* and summer season. In the recent years with development of improved short duration, high yielding, disease resistant, photo and thermo insensitive greengram varieties, it has got great scope for fitting in rice-wheat and other cereal based cropping systems and can be grown under limited irrigation facility after *rabi* crop or rice-rice, rice-wheat cropping system instead of leaving land fallow.

The productivity of greengram is low because it is grown on marginal and submarginal land during summer with inadequate fertilization and poor management practices. Among various management practices selection of varieties, spacing and nutrient management play vital

Table 1: Plant height (cm) of summer greengram genotypes as influenced by different planting geometry and fertilizer level.

Treatment		25 DAS				50 DAS				At harvest			
		F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
S_1: 30 cm ×10 cm	V_1: Shreya	8.4	8.6	8.8	**8.6**	25.8	26.7	29.4	**27.3**	33.1	34.1	37.7	**35.0**
	V_2: Meha	7.1	7.3	7.6	**7.3**	23.0	23.6	26.8	**24.5**	31.6	32.2	35.3	**33.0**
	Mean	**7.7**	**8.0**	**8.2**	**8.0**	**24.4**	**25.2**	**28.1**	**25.9**	**32.3**	**33.2**	**36.5**	**34.0**
S_2: 45 cm × 7.5 cm	V_1: Shreya	7.7	8.3	8.5	**8.2**	24.2	25.0	27.8	**25.7**	32.5	33.0	36.1	**33.9**
	V_2: Meha	7.0	7.1	7.4	**7.1**	21.8	22.1	25.3	**23.1**	30.5	31.1	33.5	**31.7**
	Mean	**7.3**	**7.7**	**7.9**	**7.7**	**23.0**	**23.5**	**26.6**	**24.4**	**31.5**	**32.1**	**34.8**	**32.8**
	V_1: Shreya	8.1	8.4	8.7	**8.4**	25.0	25.8	28.6	**26.5**	32.8	33.6	36.9	**34.4**
	V_2: Meha	7.0	7.2	7.5	**7.2**	22.4	22.9	26.1	**23.8**	31.0	31.6	34.4	**32.4**
Mean		**7.5**	**7.8**	**8.1**		**23.7**	**24.3**	**27.3**		**31.9**	**32.6**	**35.7**	
For comparison of Means		**S.Em±**		**CD at 5%**		**S.Em±**		**CD at 5%**		**S.Em±**		**CD at 5%**	
S		0.15		NS		0.34		NS		0.22		NS	
V		0.31		NS		0.21		0.81		0.29		1.12	
F		0.18		NS		0.30		0.89		0.26		0.79	
S × V		0.35		NS		0.40		NS		0.36		NS	
S × F		0.30		NS		0.59		NS		0.44		NS	
V × F		0.49		NS		0.45		NS		0.51		NS	
S × V × F		0.39		NS		0.56		NS		0.50		NS	

role in increasing greengram production during summer. Performance of genotypes differs from different regions and season because it is governed by different edaphic and climatic factors. Performance of genotypes is also influenced by crop management practices. Selection of high yielding, disease resistance and multi location suitable varieties is very important. Spacing is low cost monetary input. Providing optimum space to individual plant is important to obtain maximum yield of any crop. Yield potential of genotype is obtained when provided with optimum resources like light, water and nutrient which can be achieved by providing optimum space for individual plants.

Nutrient management plays an important role in maximum production of greengram. Even though greengram can fix atmospheric nitrogen, application of nitrogen fertilizer as starter dose at the time of sowing helps to improve the growth and development of greengram. Phosphorous as major nutrient which is essential for cell formation, root development, grain formation and maturity of the grains. Potassium imparts drought tolerance, hence during summer potassium nutrient plays important role. Sulphur is an essential element in forming proteins, enzymes, vitamins, chlorophyll and photosynthesis in plants.

In Karnataka cultivation of greengram during summer season is not popular it may be due to lack of information on availability of suitable varieties, planting geometry and nutrient management of greengram during summer season. Keeping this in view, a field experiment was conducted to study the effect of planting geometry and fertilizer levels on growth and quality of greengram genotypes.

Materials and Methods

A field experiment was conducted during summer 2019 at IIPR, Regional Research Centre, UAS campus, Dharwad. The geographical co-ordinates of experimental site is 15° 49' North latitude, 74° 98' East longitude and at an altitude of 678 m above mean sea level (MSL). Textural class of experimental site was black clay soil having neutral pH (7.34), medium in EC (0.24 dS m^{-1}), low in organic matter content (5.81 g kg^{-1}) and available nitrogen (260 kg ha^{-1}), medium in phosphorus (30 kg ha^{-1}), available potassium (290 kg ha^{-1}) and available sulphur (19 kg ha^{-1}). During cropping period (February to April) 54.5 mm of rainfall was received. Maximum rainfall received during crop period was 29.2 mm in the first week of April which was at the pod development stage of the crop thus ensured adequate soil moisture for pod development.

The experiment was laid out in split-split plot design with two planting geometry (S_1: 30 cm × 10 cm and S_2: 45 cm × 7.5 cm) in main plot, two genotypes V_1: Shreya (IPM 02-14) and V_2: Meha (IPM 99-125)) in sub plot and three fertilizer levels in sub-sub plot {F_1: RDF (25:50:0 kg N: P_2O_5:K_2O ha^{-1} + 20 kg S) ha^{-1}, F_2: 25:50:20 kg N: P_2O_5:K_2O ha^{-1} + 20 kg S ha^{-1} and F_3: 31.25:62.5:25 kg N:P_2O_5:K_2O ha^{-1} + 20 kg S ha^{-1}}.

The crop was sown on February 7th, 2019 and entire dose of nitrogen, phosphorus (P_2O_5), potassium (K_2O) and sulphur was applied as basal at the time of sowing in

Table 2: Number of trifoliate leaves $plant^{-1}$ and number of branches $plant^{-1}$ of summer greengram genotypes as influenced by different planting geometry and fertilizer levels at 25, 50 DAS and at harvest.

Treatment		Number of trifoliate leaves per plant												Number of branches per plant											
		25 DAS				50 DAS				At harvest				25 DAS				50 DAS				At harvest			
		F_1	F_2	F_3	M.	F_1	F_2	F_3	M.	F_1	F_2	F_3	M.	F_1	F_2	F_3	M.	F_1	F_2	F_3	M.	F_1	F_2	F_3	M.
S_1	V_1	3.6	3.7	4.0	**3.8**	11.2	11.4	12.8	**11.8**	10.50	10.93	12.50	**11.31**	3.6	3.7	4.0	**3.8**	6.63	7.13	8.50	**7.42**	9.87	10.03	11.47	**10.46**
	V_2	3.2	3.6	3.8	**3.5**	10.2	10.5	11.6	**10.8**	10.17	10.50	11.63	**10.77**	3.2	3.6	3.8	**3.5**	6.30	6.40	7.60	**6.77**	9.17	9.27	10.33	**9.59**
	M.	**3.4**	**3.7**	**3.9**	**3.6**	**10.7**	**11.0**	**12.2**	**11.3**	**10.33**	**10.72**	**12.07**	**11.04**	**3.4**	**3.7**	**3.9**	**3.6**	**6.47**	**6.77**	**8.05**	**7.09**	**9.52**	**9.65**	**10.90**	**10.02**
S_2	V_1	3.4	3.6	3.8	**3.6**	10.4	10.8	12.0	**11.1**	10.50	10.87	11.93	**11.10**	3.4	3.6	3.8	**3.6**	6.40	6.67	7.87	**6.98**	9.53	9.77	10.50	**9.93**
	V_2	3.3	3.5	3.7	**3.5**	9.7	9.9	11.0	**10.2**	10.03	10.13	11.00	**10.39**	3.3	3.5	3.7	**3.5**	6.17	6.20	6.93	**6.43**	8.70	9.00	9.93	**9.21**
	M.	**3.4**	**3.5**	**3.8**	**3.6**	**10.0**	**10.4**	**11.5**	**10.6**	**10.27**	**10.50**	**11.47**	**10.74**	**3.4**	**3.5**	**3.8**	**3.6**	**6.28**	**6.43**	**7.40**	**6.71**	**9.12**	**9.38**	**10.22**	**9.57**
	V_1	3.5	3.7	3.9	**3.7**	10.8	11.1	12.4	**11.4**	10.50	10.90	12.22	**11.21**	3.5	3.7	3.9	**3.7**	6.52	6.90	8.18	**7.20**	9.70	9.90	10.98	**10.19**
	V_2	3.3	3.5	3.7	**3.5**	9.9	10.2	11.3	**10.5**	10.10	10.32	11.32	**10.58**	3.3	3.5	3.7	**3.5**	6.23	6.30	7.27	**6.60**	8.93	9.13	10.13	**9.40**
M.		**3.4**	**3.6**	**3.8**		**10.4**	**10.7**	**11.9**		**10.30**	**10.61**	**11.77**		**3.4**	**3.6**	**3.8**		**6.38**	**6.38**	**7.73**		**9.32**	**9.52**	**10.56**	
For comparison of Means		**S.Em±**		**CD at 5%**		**S.Em±**		**CD at 5%**		**S.Em±**		**CD at 5%**		**S.Em±**		**CD at 5%**		**S.Em±**		**CD at 5%**		**S.Em±**		**CD at 5%**	
S		0.10		NS		0.12		NS		0.05		NS		0.10		NS		0.08		NS		0.08		NS	
V		0.06		NS		0.06		0.24		0.07		0.27		0.06		NS		0.07		0.28		0.04		0.14	
F		0.11		NS		0.10		0.29		0.11		0.33		0.11		NS		0.11		0.33		0.06		0.19	
S × V		0.11		NS		0.13		NS		0.08		NS		0.11		NS		0.10		NS		0.09		NS	
S × F		0.19		NS		0.20		NS		0.14		NS		0.19		NS		0.17		NS		0.13		NS	
V × F		0.15		NS		0.14		NS		0.16		NS		0.15		NS		0.16		NS		0.09		NS	
S × V × F		0.20		NS		0.18		NS		0.19		NS		0.20		NS		0.19		NS		0.12		NS	

M.: Mean; S_1: 30 cm ×10 cm; S_2: 45 cm × 7.5cm; V_1: Shreya (IPM 2-14); V_2: Meha (IPM 99-125); F_1: RDF (25:50:0 kg N: P_2O_5 :K_2O ha^{-1} + 20 kg S ha^{-1}); F_2: 25:50:20 kg N: P_2O_5 :K_2O ha^{-1} + 20 kg S ha^{-1}; F_3: 31.25:62.5:25 kg N: P_2O_5 :K_2O ha^{-1} + 20 kg S ha^{-1}

the form of urea, DAP, MOP and gypsum, respectively as per the treatments. Seed rate used was 12 kg ha^{-1} for both planting geometry and seeds were treated with *Rhizobium* and PSB at the rate of 500 g per 12 kg seeds. The crop was grown under protective irrigation with sprinkler system of irrigation and irrigations was given by considering critical crop growth period and climatic conditions that was at establishment stage (10 DAS) at CPE of 58.8, vegetative phase (25 DAS) at CPE of 78.3, flower initiation (40 DAS) at CPE of 99.7 and pod filling stage (57 DAS) at CPE of 41.2 on an average to the depth of 30 cm. Overall five irrigations were provided for successful growth and development of crop. The crop was harvested by picking the pods on 13-04-2019 and 20-04-2019.

Results and Discussions

Performance of greengram genotypes

Greengram genotype Shreya (IPM 02-14) recorded significantly higher plant height (26.5 and 34.4 cm, respectively), number of trifoliate leaves (11.4 and 11.21, respectively) and number of branches (7.2 and 10.19, respectively) at 50 DAS and at harvest than Meha (Table 1 and 2). At 25 DAS plant height, number of trifoliate leaves and number of branches did not varied to the level of significance. This might be attributed to their genetic variance, varietal difference and climatic adaptability. These results are in line with those of Miah *et al.*, (2009). Genotype Shreya produced higher dry matter at all growth stages (Table 4). During the initial days (25 DAS) Shreya produced higher dry matter than Meha but not to the level of significance whereas at 50 DAS and at harvest, Shreya produced significantly higher dry matter per plant (3.53 and 8.71 g, respectively) as compared to Meha (2.9 and 7.91 g, respectively). This might be due to increase in morphological character which are responsible for photosynthetic capacity of plant namely plant height, number of trifoliate leaves, number of branches per plant, leaf area and SPAD value there by increasing the biological yield.. The similar results have been reported by Gorade *et al.*, 2013 and Dash and Rautaray (2017).

Significantly higher SPAD value (47.3 at 50 DAS), leaf area (2.19 and 1.75 dm^2 $plant^{-1}$) and LAI (0.69 and 0.55) at 50 DAS and at harvest,

Table 3: leaf area (dm^2 plant^{-1}) and leaf area index of summer greengram genotypes as influenced by different planting geometry and fertilizer levels at 25, 50 DAS and at harvest.

Treatment		Leaf area (dm^2 plant^{-1}) 25 DAS F$_1$	F$_2$	F$_3$	M.	50 DAS F$_1$	F$_2$	F$_3$	M.	At harvest F$_1$	F$_2$	F$_3$	M.	Leaf area index 25 DAS F$_1$	F$_2$	F$_3$	M.	50 DAS F$_1$	F$_2$	F$_3$	M.	At harvest F$_1$	F$_2$	F$_3$	M.
S$_1$	V$_1$	0.34	0.36	0.42	0.37	2.04	2.16	2.89	2.36	1.66	1.71	2.00	1.79	0.11	0.12	0.14	0.12	0.68	0.72	0.96	0.79	0.55	0.57	0.67	0.60
	V$_2$	0.30	0.35	0.36	0.34	1.65	1.73	2.35	1.91	1.56	1.58	1.73	1.62	0.10	0.12	0.12	0.11	0.55	0.58	0.79	0.64	0.52	0.53	0.58	0.54
	M.	0.32	0.35	0.39	0.35	1.84	1.94	2.62	2.14	1.61	1.65	1.86	1.71	0.11	0.12	0.13	0.12	0.61	0.65	0.87	0.71	0.54	0.55	0.62	0.57
S$_2$	V$_1$	0.33	0.34	0.37	0.34	1.73	1.91	2.42	2.02	1.61	1.67	1.88	1.72	0.10	0.10	0.11	0.10	0.51	0.57	0.72	0.60	0.48	0.50	0.56	0.51
	V$_2$	0.28	0.33	0.35	0.32	1.52	1.60	2.02	1.71	1.51	1.55	1.69	1.58	0.08	0.10	0.10	0.09	0.45	0.47	0.60	0.51	0.45	0.46	0.50	0.47
	M.	0.31	0.33	0.36	0.33	1.62	1.75	2.22	1.86	1.56	1.61	1.79	1.65	0.09	0.10	0.11	0.10	0.48	0.52	0.66	0.55	0.46	0.48	0.53	0.49
	V$_1$	0.33	0.35	0.39	0.36	1.88	2.03	2.66	2.19	1.64	1.69	1.94	1.76	0.10	0.11	0.12	0.11	0.60	0.64	0.84	0.69	0.52	0.53	0.61	0.55
	V$_2$	0.29	0.34	0.35	0.33	1.58	1.66	2.18	1.81	1.54	1.57	1.71	1.60	0.09	0.11	0.11	0.10	0.50	0.53	0.69	0.57	0.48	0.49	0.54	0.51
M.		0.31	0.34	0.37		1.73	1.85	2.42		1.59	1.63	1.82		0.10	0.11	0.12		0.55	0.58	0.77		0.50	0.51	0.58	
For comparison of Means		S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%	
S		0.004		NS		0.05		NS		0.02		NS		0.004		NS		0.011		NS		0.004		NS	
V		0.013		NS		0.03		0.12		0.01		0.05		0.003		NS		0.010		0.038		0.004		0.017	
F		0.016		NS		0.05		0.14		0.02		0.06		0.006		NS		0.014		0.043		0.006		0.019	
S × V		0.013		NS		0.06		NS		0.02		NS		0.005		NS		0.014		NS		0.006		NS	
S × F		0.020		NS		0.08		NS		0.03		NS		0.009		NS		0.022		NS		0.010		NS	
V × F		0.026		NS		0.07		NS		0.03		NS		0.008		NS		0.022		NS		0.010		NS	
S × V × F		0.028		NS		0.09		NS		0.04		NS		0.010		NS		0.026		NS		0.011		NS	

M.: Mean; S$_1$: 30 cm ×10 cm; S$_2$: 45 cm × 7.5cm; V$_1$: Shreya (IPM 2-14); V$_2$: Meha (IPM 99-125); F$_1$: RDF (25:50:0 kg N: P$_2$O$_5$:K$_2$O ha^{-1} + 20 kg S ha^{-1}); F$_2$: 25:50:20 kg N: P$_2$O$_5$:K$_2$O ha^{-1} + 20 kg S ha^{-1}; F$_3$: 31.25:62.5:25 kg N: P$_2$O$_5$:K$_2$O ha^{-1} + 20 kg S ha^{-1}

respectively (Table 3 and 4) were recorded in Shreya as compared to Meha. This might be due to genetic make up of cultivar. The similar differences with respect to LAI and leaf area in greengram varieties were reported by Mondal *et al.* 2012 and Tukaram (2011).

At 50 DAS, number of root nodules (17.06) and nodule dry weight (45.56 mg) were also significantly higher in Shreya than Meha (Table 5) which improve plant growth ultimately dry matter accumulation by increasing nitrogen availability through atmospheric nitrogen fixation. At 25 DAS, number of root nodules and nodule dry weight found non significant. These differences might be due to genetic variability and climatic conditions of the varieties under cultivation. Similar results were reported by Rasul *et al.*, (2012) and Mondal and Sengupta (2019).

Significantly higher seed yield (691 kg ha^{-1}) and haulm yield (2679 kg ha^{-1}) was recorded with genotype Shreya which was 14.6 and 10.1 per cent higher than Meha, respectively (Table 5). This might be attribute to its better growth and yield attributing parameters primarily dry matter production and number of branches per plant. These results are in accordance with findings of Dash and Rautaray (2017) and Singh *et al.*, (2017).

Effect of planting geometry

Greengram sown at 30 cm × 10 cm planting geometry recorded higher growth parameters at 25, 50 and at harvest namely plant height (8, 25.9 and 34 cm, respectively), number of trifoliate leaves (3.6, 11.3 and 11.04, respectively), number of branches (3.6, 7.09 and 10.02, respectively), leaf area (0.35, 2.14 and 1.71 dm^2 plant^{-1}, respectively), LAI (0.12, 0.71 and 0.57, respectively) and SPAD value (31.1 and 46.1 at 25 and 50 DAS, respectively) (Table 1, 2, 3 and 4) which contributes higher dry matter accumulation (0.35, 3.39 and 8.44 g respectively) (Table 4) which in turn recorded higher seed (684 kg ha^{-1}) and haulm yield (2,594 kg ha^{-1}) than 45 cm × 7.5 cm (Table 5) but did not differed to the level of significance. This might be due to plant population remains same in both 30 cm × 10 cm and 45 cm × 7.5 cm. Same results were observed by Bhagwanrao (2011) who reported that 30 cm × 10 cm and

Table 4: Dry matter production (g plant^{-1}) and SPAD value of summer greengram genotypes as influenced by different planting geometry and fertilizer levels at 25, 50 DAS and at harvest

Treatment		Dry matter production (g plant^{-1}) 25 DAS				50 DAS				At harvest				SPAD value 25 DAS				50 DAS			
		F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
S_1	V_1	0.35	0.36	0.41	**0.38**	3.38	3.52	4.39	**3.76**	8.09	8.35	10.17	**8.87**	31	31.3	33.8	**32**	44.7	45.5	56.7	**48.9**
	V_2	0.3	0.33	0.36	**0.33**	2.51	2.79	3.77	**3.02**	7.59	7.73	8.7	**8.01**	28.6	30.2	31.7	**30.1**	40.4	42.4	47.2	**43.3**
	Mean	**0.32**	**0.35**	**0.39**	**0.35**	**2.94**	**3.16**	**4.08**	**3.39**	**7.84**	**8.04**	**9.44**	**8.44**	**29.8**	**30.7**	**32.7**	**31.1**	**42.5**	**44**	**51.9**	**46.1**
S_2	V_1	0.33	0.34	0.37	**0.35**	2.94	3.15	3.79	**3.29**	7.89	8.15	9.6	**8.55**	28.6	29.4	30.3	**29.4**	42.4	44.2	50.2	**45.6**
	V_2	0.29	0.31	0.35	**0.32**	2.44	2.66	3.24	**2.78**	7.48	7.53	8.44	**7.81**	28.1	28.3	30.1	**28.8**	39.7	40.4	45.2	**41.7**
	Mean	**0.31**	**0.33**	**0.36**	**0.33**	**2.69**	**2.91**	**3.51**	**3.04**	**7.68**	**7.84**	**9.02**	**8.18**	**28.4**	**28.9**	**30.2**	**29.1**	**41**	**42.3**	**47.7**	**43.7**
	V_1	0.34	0.35	0.39	**0.36**	3.16	3.34	4.09	**3.53**	7.99	8.25	9.88	**8.71**	29.8	30.3	32	**30.7**	43.5	44.9	53.4	**47.3**
	V_2	0.29	0.32	0.36	**0.32**	2.48	2.73	3.5	**2.9**	7.53	7.63	8.57	**7.91**	28.4	29.2	30.9	**29.5**	40	41.4	46.2	**42.5**
Mean		**0.32**	**0.34**	**0.38**		**2.82**	**3.03**	**3.8**		**7.76**	**7.94**	**9.23**			**29.1**	**29.8**	**31.4**		**41.8**	**43.1**	**49.8**
For comparison of Means		**S.Em±**		**CD at 5%**		**S.Em±**		**CD at 5%**		**S.Em±**		**CD at 5%**		**S.Em±**		**CD at 5%**		**S.Em±**		**CD at 5%**	
S		0.022		NS		0.067		NS		0.07		NS		0.76		NS		0.47		NS	
V		0.011		NS		0.070		0.27		0.08		0.30		0.64		NS		0.67		2.63	
F		0.017		NS		0.078		0.23		0.12		0.36		0.64		NS		0.63		1.89	
S × V		0.024		NS		0.097		NS		0.10		NS		1.00		NS		0.82		NS	
S × F		0.036		NS		0.131		NS		0.17		NS		1.31		NS		0.99		NS	
V × F		0.025		NS		0.134		NS		0.18		NS		1.17		NS		1.19		NS	
S × V × F		0.033		NS		0.145		NS		0.21		NS		1.26		NS		1.18		NS	

S_1: 30 cm ×10 cm; S_2: 45 cm × 7.5cm; V_1: Shreya (IPM 2-14); V_2: Meha (IPM 99-125); F_1: RDF (25:50:0 kg N: P_2O_5:K_2O ha^{-1} + 20 kg S ha^{-1}); F_2: 25:50:20 kg N: P_2O_5:K_2O ha^{-1} + 20 kg S ha^{-1}; F_3: 31.25:62.5:25 kg N: P_2O_5:K_2O ha^{-1} + 20 kg S ha^{-1}

45 cm × 7.5 cm recorded on par plant height, leaf area and dry matter production per plant and Srivastava and Dawson (2017) observed on par yield at 30 cm × 10 cm and 45 cm × 6.5 geometry. Similarly planting geometry had no significant effect on number of root nodules and nodule dry weight.

Effect of fertilizer levels

Fertilizer levels had significant effect on growth parameters of greengram during summer. Application of 31.25:62.5:25 kg N:P_2O_5:K_2O ha^{-1} + 20 kg S ha^{-1} recorded significantly higher plant height (27.3 and 35.7 cm at 50 DAS and at harvest, respectively) as compared to application of 25:50:20 kg N:P_2O_5:K_2O ha^{-1} + 20 kg S ha^{-1} and RDF (Table 1). Significant increase in plant height might be due to adequate and balanced application of nitrogen, phosphorus and potassium at the time of sowing, which has contributed for improved root system thus helped in better nutrient uptake which resulted in accelerating various metabolic processes such as cell division, cell elongation and cell development and thereby enhanced the plant growth. Similarly, same treatment recorded higher number of trifoliate leaves per plant (11.9 and 11.77 at 50 DAS and at harvest, respectively) and branches per plant (7.73 and 10.56 at 50 DAS and at harvest, respectively) (Table 2) due to sufficient supply of nitrogen, phosphorus and potassium thus increased the rate of photosynthesis and efficient utilization of nutrients and solar radiation which resulted in attaining better crop canopy. Leaf area is an important area for photosynthesis where radiant energy intercepts for synthesis of photosynthates. Higher leaf area was recorded with application of 31.25:62.5:25 kg N:P_2O_5:K_2O ha^{-1} + 20 kg S at 25, 50 DAS and at harvest (0.37, 2.42 and 1.82 dm^2 plant^{-1}, respectively) as compared to application of 25:50:20 kg N: P_2O_5:K_2O ha^{-1} + 20 kg S (0.34, 1.85 and 1.63 dm^2 plant^{-1}, respectively) and RDF (0.31, 1.73 and 1.59 dm^2 plant^{-1}, respectively) but at 25 DAS leaf area was found non significant (Table 3). Higher leaf area might be due to expansion of cells. Likewise, significantly higher LAI (0.77 and 0.58 at 50 DAS and at harvest, respectively) was recorded with application of 31.25:62.5:25 kg N:P_2O_5:K_2O ha^{-1} + 20 kg S as compared to application of

Table 5: Number of root nodules and root nodule weight (mg) of summer greengram genotypes as influenced by different planting geometry and fertilizer levels at 25 and 50 DAS.

Treatment		Number of root nodules								Root nodule weight (mg)								Seed yield (kg ha^{-1})				Haulm yield (kg ha^{-1})			
		25 DAS				50 DAS				25 DAS				50 DAS											
		F_1	F_2	F_3	M.	F_1	F_2	F_3	M.	F_1	F_2	F_3	M.	F_1	F_2	F_3	M.	F_1	F_2	F_3	M.	F_1	F_2	F_3	M.
S_1	V_1	8.60	9.27	9.93	**9.27**	15.93	16.60	20.27	**17.60**	22.00	23.50	25.67	**23.72**	41.83	44.33	55.17	**47.11**	670	687	845	**734**	2536	2606	2979	**2707**
	V_2	8.27	8.53	9.33	**8.71**	14.43	14.93	16.40	**15.26**	20.33	21.33	23.50	**21.72**	36.50	39.17	46.17	**40.61**	580	599	726	**635**	2359	2409	2675	**2481**
	Mean	**8.43**	**8.90**	**9.63**	**8.99**	**15.18**	**15.77**	**18.33**	**16.43**	**21.17**	**22.42**	**24.58**	**22.72**	**39.17**	**41.75**	**50.67**	**43.86**	**625**	**643**	**785**	**684**	**2447**	**2507**	**2827**	**2594**
S_2	V_1	8.30	9.13	9.43	**8.96**	15.80	16.17	17.60	**16.52**	21.00	22.67	24.17	**22.61**	40.33	43.00	48.67	**44.00**	592	613	740	**648**	2500	2574	2877	**2650**
	V_2	7.60	7.77	9.00	**8.12**	14.27	14.87	16.23	**15.12**	19.50	20.50	22.50	**20.83**	35.33	37.17	43.17	**38.56**	522	532	662	**572**	2241	2318	2604	**2388**
	Mean	**7.95**	**8.45**	**9.22**	**8.54**	**15.03**	**15.52**	**16.92**	**15.82**	**20.25**	**21.58**	**23.33**	**21.72**	**37.83**	**40.08**	**45.92**	**41.28**	**557**	**573**	**701**	**610**	**2370**	**2446**	**2741**	**2519**
	V_1	8.45	9.20	9.68	**9.11**	15.87	16.38	18.93	**17.06**	21.50	23.08	24.92	**23.17**	41.08	43.67	51.92	**45.56**	631	650	792	**691**	2518	2590	2928	**2679**
	V_2	7.93	8.15	9.17	**8.42**	14.35	14.90	16.32	**15.19**	19.92	20.92	23.00	**21.28**	35.92	38.17	44.67	**39.58**	551	565	694	**603**	2300	2364	2640	**2434**
Mean				**8.19**	**8.68**	**9.43**		**15.11**	**15.64**	**17.63**		**20.71**	**22.00**	**23.96**					**591**	**608**	**743**		**2409**	**2477**	**2784**
For comparison of Means		**S.Em±**		**CD at 5%**		**S.Em±**		**CD at 5%**		**S.Em±**		**CD at 5%**		**S.Em±**		**CD at 5%**		**S.Em±**		**CD at 5%**		**S.Em±**		**CD at 5%**	
S		0.16		NS		0.16		NS		0.66		NS		0.67		NS		15.09		NS		30.51		NS	
V		0.18		NS		0.21		0.81		0.85		NS		0.49		1.91		13.15		51.64		26.89		105.60	
F		0.33		NS		0.19		0.58		0.88		NS		0.84		2.51		17.45		52.30		38.87		116.55	
S × V		0.24		NS		0.26		NS		1.07		NS		0.83		NS		20.01		NS		40.67		NS	
S × F		0.44		NS		0.32		NS		1.38		NS		1.35		NS		29.34		NS		62.27		NS	
V × F		0.46		NS		0.37		NS		1.57		NS		1.19		NS		27.42		NS		58.84		NS	
S × V × F		0.56		NS		0.37		NS		1.63		NS		1.49		NS		31.81		NS		69.69		NS	

S_1: 30 cm ×10 cm; S_2: 45 cm × 7.5cm; V_1: Shreya (IPM 2-14); V_2: Meha (IPM 99-125); F_1: RDF (25:50:0 kg N: P_2O_5 :K_2O ha^{-1} + 20 kg S ha^{-1}); F_2: 25:50:20 kg N: P_2O_5 :K_2O ha^{-1} + 20 kg S ha^{-1}; F_3: 31.25:62.5:25 kg N: P_2O_5 :K_2O ha^{-1} + 20 kg S ha^{-1}

25:50:20 kg N: P_2O_5:K_2O ha^{-1} + 20 kg S and RDF (Table 3). This might be due to nitrogen, as it is a constituent of polynuleotide and also plays important role in auxin synthesis thus helped in cell expansion and cell division which resulted in higher LAI. SPAD value indicates the chlorophyll content in leaves, higher SPAD value (49.8) at 50 DAS whereas during initial days (25 DAS) SPAD value remained unaffected due to nutrient levels. Higher SPAD value might be due to higher photosynthetic rate with increased photosynthates in leaf due to supply of nitrogen in adequate quantity. These results are in line with findings of Patil *et al.*, (2011) and Bairwa *et al.*, (2012).

Number of root nodules per plant and root nodule weight per plant were differed significantly due to application of different fertilizer level. Application of 31.25:62.5:25 kg N:P_2O_5:K_2O ha^{-1} + 20 kg S ha^{-1} recorded significantly higher number of root nodules (17.63 plant^{-1}) and root nodule weight (48.29 mg plant^{-1}) at 50 DAS sowing as compared to application of 25:50:20 kg N:P_2O_5:K_2O ha^{-1} + 20 kg S ha^{-1} and RDF (Table 5). There was no significant difference was observed at 25 DAS.

Significantly higher seed yield (743 kg ha^{-1}) and haulm yield (2784 kg ha^{-1}) were recorded with application of 31.25:62.5:25 kg N:P_2O_5:K_2O ha^{-1} + 20 kg S ha^{-1} as compared to application of 25:50:20 kg N:P_2O_5:K_2O ha^{-1} + 20 kg S ha^{-1} and RDF. This might be attributed to adequate and balanced supply of plant nutrients to the crop during the growth period, which increased the availability of nutrients to plants and favourable increase in plant height, accumulation of dry matter, increased photosynthetic activity due to increased leaf area and SPAD value finally seed and haulm yield. These results are in conformity with the findings of Awomi *et al.*, 2012 and Bairwa *et al.*, 2012

Interaction between planting geometry, genotypes and fertilizer levels

Interaction effects among genotypes, planting geometry and fertilizer levels were non significant. However, genotype Shreya sown at 30 cm × 10 cm planting geometry along with application of 31.25:62.5:25 kg N:P_2O_5:K_2O ha^{-1} + 20 kg S ha^{-1} recorded maximum growth attributes namely plant height (8.8, 29.4 and 37.7 cm, respectively), number of trifoliate leaves (4, 11.8 and 12.5, respectively), number of branches (4, 8.5 and 11.47, respectively), leaf area (0.42, 2.89 and 2, respectively), LAI (0.14, 0.96 and 0.67, respectively), dry matter production (0.41, 4.39 and 10.17 g, respectively), SPAD value (33.8 and 56.7 at 25 and 50 DAS, respectively), number of root nodules (9.93 and 20.27 at 25 and 50 DAS, respectively) and root nodule weight (25.67 and 55.17 mg plant^{-1} at 25 and 50 DAS, respectively) at 25, 50 DAS and at harvest as compared to other treatment combinations. Similarly, same treatment combination recorded maximum seed (845 kg ha^{-1}) and haulm yield (2979 kg ha^{-1}) as compared to other treatment combinations. Increase in seed yield was attributed to increased growth and yield attributes. Increased growth indices were attributed to genetic constituent of genotype, availability of optimum space and nutrients for crop growth and development. The results are in accordance with results reported by Gorakhnath, 2012 and Srivastava and Dawson, 2017. Lower seed yield and haulm yield were recorded with genotype Meha sown at 45 cm × 7.5 cm spacing with application of RDF. This might be due to less availability of nutrients and less intra row spacing which increases competition for solar radiation that ultimately reduces growth of some intra row plants at vegetative phase and they were unable to reach reproductive phase which resulted in low yield. These results are in accordance with findings of Kalsaria *et al.*, 2017.

Conclusion

It was concluded that genotype Shreya recorded significantly higher growth parameters, seed yield (691 kg ha^{-1}) and haulm yield (2,679 kg ha^{-1}) than Meha. Planting geometry had no significant effect on growth parameters and yield. Application of 31.25:62.5:25 kg $N:P_2O_5:K_2O$ ha^{-1} + 20 kg S ha^{-1} recorded significantly higher growth parameters, seed yield (743 kg ha^{-1}) and haulm yield (27,84 kg ha^{-1}) as compared to other fertilizer levels.

Reference

Anonymous (2018a). Pulses in India:Retrospect and Prospects, Directorate of Pulses Development, Ministry of Agriculture and Farmers Welfare, Department of Agriculture, Cooperation and Farmers Welfare. Bhopal, available on the www.nfsm.gov.in.

Anonymous (2018b). Area and Production, Directorate of Economics and Statics, Department of Agriculture and Cooperation report, New Delhi, available on website: www.indiastat.com.

Awomi, T.A., Singh A.K., Manoj K. and Bordoloi L.J. (2012). Effect of phosphorus, molybdenum and cobalt nutrition on yield and quality of mungbean (*Vigna radiata* L.) in acidic soil of Northeast India. *Indian Journal of Hill Farming,* **25(2)**, 22-26.

Bairwa, R.K., Nepalia V., Balai C.M. and Upadhyay B. (2012). Effect of phosphorus and sulphur on yield and economics of summer greengram (*Vigna radiata* L.). *Madras Agriculture Journal,* **99(7-9)**, 523-525.

Bhagwanrao, B.A. (2011). Effect of varieties and plant geometry on growth and yield of summer greengram. *M. Sc. (Agri.) Thesis*, Marathwada Krishi Vidyapeeth, Parbhani, India.

Dash, S.R. and Rautaray B.K. (2017). Growth parameters and yield of greengram varieties (*Vigna radiata* L.) in east and south east coastal plains of Odisha, India. *International Journal of Current Microbiology and Applied Sciences*, **6(10)**, 1517-1523.

Gorade, V.N., Chavan L.S., Jagtap D.N. and Kolekar A.B. (2013). Response of greengram (*Vigna radiata L.*) varieties to integrated nutrient management in summer season. *Agricultural Science Digest*, **34(1)**, 36-40.

Gorakhnath, J.R. (2012). Response of greengram varieties to plant geometries during summer. *M. Sc. (Agri.) Thesis,* Marathwada Krishi Vidyapeeth, Parbhani, India.

Kalsaria, R.N., Vekariya P.D., Hadiyal J.G. and Ichchhuda P.K. (2017). Effect of spacing, fertility levels and bio-fertilizers on growth and yield of summer greengram (*Vignaradiata* L.). *J. of Pharmacognosy & Phytochemistry,* **6(5)**, 934-937.

Khairnar, A.V. and Solanke A.V. (2009). Response of potash levels and foliar spray of vermivash on growth and yield of greengram. *Journal of Maharashtra Agricultural University.*, **34(2)**, 215-216.

Miah, M.A.K., Anwar M.P., Begum M., Juraimi A.S. and Islam M.A. (2009). Influence of sowing date on growth and yield of summer mungbean varieties. *Journal of Agriculture & Social Sciences,* **5**, 73-76.

Mondal, M.M.A., Puteh A.B., Malek M.A. and Ismail M.R. (2012). Determination of optimum seed rate for mungbean based on morpho-physiological criteria. *Legume Reerach.*, **35(2)**, 126-131.

Mondal, R. and Sengupta K. (2019). Study on the performance of mungbean varieties in the New Alluvial Zone of West Bengal. *Journal of Crop and Weed*, **15(1)**, 186-19.

Patil, S.C., Jagtap D.N. and Bhale V.M. (2011). Effect of phosphorus and sulphur on growth and yield of mungbean. *International J. of Agriculture Science,* **7**, 348-351.

Patil, S.M. and Dhonde M.B. (2009). Effect of potash levels and foliar spray of cow urine on growth and yield of summer greengram. *Journal of Maharashtra Agriculture University,* **34(1)**, 106-107.

Rasul, F., Cheema M.A., Sattar A., Saleem M.F. and Wahid M.A. (2012). Evaluating the performance of three mungbean varieties grown under varying inter-row spacing. *The J. of Animal & Plant Sci.*, **22(4)**, 1030-1035.

Singh, M., Deokaran, Mishra J.S. and Bhatt B.P. (2017). Effect of integrated nutrient management on production potential and quality of summer mungbean (*Vigna radia*ta L.). *Journal of Krishi Vigyan*, **5(2)**, 39-45.

Srivastava, N. and Dawson J. (2017). Effect of spacing, source of nutrient and methods of zinc application on yield and yield attributes of summer greengram (*Vigna radiata* L.). *International J. of Chemical Studies*, **5(5)**, 1789-1791.

Tukaram, K.G. (2011). Assessment of fertilizer requirement for greengram (*Phaseolus radiata* L.) varieties in summer season. *M. Sc. (Agri.) Thesis*. Marathawada Krishi Vidyapeeth. Parbhani, India.