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Optimizing planting geometry and fertilizer levels for enhanced yield and economics of greengram (*Vigna radiata* L.) genotypes in summer

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Abstract

A field experiment was conducted during summer 2019 at the Indian Institute of Pulses Research (IIPR), Regional Research Centre (RRC), UAS, Dharwad, on black clayey soil to study the effects of planting geometry, variety and fertilizer levels. Treatments included two planting geometries (30 cm × 10 cm and 45 cm × 7.5 cm), two varieties (Shreya and Meha) and three fertilizer levels: F₁ (25:50:0 N:P₂O₅:K₂O + 20 kg S ha⁻¹), F₂ (25:50:20 + 20 kg S ha⁻¹) and F₃ (31.25:62.5:25 + 20 kg S ha⁻¹). Genotype Shreya recorded significantly higher seed yield (691 kg ha⁻¹), haulm yield (2,679 kg ha⁻¹), gross return (₹52,408 ha⁻¹), net return (₹11,342 ha⁻¹) and B:C ratio (1.27) than Meha. Though planting geometry effects were non-significant, 30 cm × 10 cm gave higher yields and returns than 45 cm × 7.5 cm. the treatment F₃ significantly outperformed F₁ and F₂ in yield (22.2% and 25.7% higher) and economics (₹56,350 gross, ₹13,850 net return; B:C ratio 1.33). Interaction effects among factors were non-significant.

Keywords: Fertilizer levels, genotypes, greengram, planting geometry

Introduction

Pulse crops are usually referred to as soil fertility restorer. They have been neglected in diversified cropping systems in previous decades which lead to the loss of biodiversity and soil fertility. Inclusion of pulses in the cropping system provides a better optioning restoration of soil fertility, achieving production sustainability and obtaining economic gain in the intensified agricultural production. Pulses need less nitrogen as external input as nitrogen requirement is met through biological N-fixation to an extent of 25 to 30 kg ha⁻¹ (Kalsaria *et al.*, 2017) [10] and improve organic matter status of the soils, thus playing an important role in sustainable agriculture. Pulses are considered the most economical source of dietary protein, supplementing approximately 20-30 per cent of the protein requirements of the Indian population (Grover and Singh, 2015) [19].

Greengram (*Vigna radiata* L.) is one of the important pulse crops in India containing high quality vegetable protein and satisfactory amounts of minerals and vitamins. In India, greengram is cultivated over an area of 4.3 million hectares, with a total production of 2.0 million tonnes and an average productivity of 472 kg ha⁻¹. During the rabi and summer seasons, it occupies 0.96 million hectares, producing 0.56 million tonnes with an improved productivity of 582 kg ha⁻¹. In Karnataka it is grown in an area of 0.42 m ha with production of 0.142 m tonnes and productivity of 339 kg ha⁻¹. During summer, it is being grown in an area of 1,025 ha, (Anon., 2018) [1]. The productivity gap analysis revealed that the national average yield of greengram is 472 kg ha⁻¹ as against 339 kg ha⁻¹ in Karnataka. This indicates the scope for increasing the productivity of summer greengram by best agronomic management practices.

The low yield in greengram is attributed to several reasons. The main reason includes low plant population, poor nutrient management and selection of varieties suitable for the given region. In recent decades with development of short duration, photo and thermo insensitive as well as yellow vein mosaic resistant varieties provided excellent opportunity for greengram cultivation during summer.

Plant geometry plays an important role in the dominance and suppression during the process of

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competition. Ideal plant geometry is precious and important for better and efficient utilization of available plant growth resources in order to get maximum productivity in crops. Nutrient management is one more agronomic manipulation, plays an important role in yield maximization in 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. It is also essential constituent of protoplasm, chlorophyll, coenzyme and protein. Phosphorus as major nutrient essential for cell formation, root development, photosynthesis, nucleic acid, sugar and starch transformation, grain formation, uniform and early maturity of the grains. Application of another major nutrient *i.e.* potassium is again neglected, but its application plays an important role in growth and development of crop as it helps in maintaining turgor pressure of cell which is necessary for the cell expansion and also helps in plant cell osmo-regulation. Sulphur is an essential element in forming proteins, enzymes, vitamins, chlorophyll and photosynthesis in plants. It is crucial in nodule development and caused for efficient nitrogen fixation in legumes. Sulphur increases crop yield and improves quality of the produce thus determining the market price a farmer would get for his produce. Keeping all these points in view, the experiments were conducted to find out the effect of different fertilizer levels, genotypes and spacing on yield attributes, yield and economics of greengram during summer seasons.

Materials and Methods

A field experiment was conducted during summer season of 2019 at Regional Research Centre (RRC), UAS Dharwad. The experiment was laid out in split-split plot design with two planting geometry (S_1 : 30 cm $\times$ 10 cm and S_2 : 45 cm $\times$ 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 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. Seeds were treated with *Rhizobium* and Phosphorus Solubilizing Bacteria (PSB) each at the rate of 500 g ha $^{-1}$. The crop was grown under protective irrigation. Overall, five irrigations were provided with sprinklers for the successful growth and development of the crop. The crop was harvested by picking the pods on 13-04-2019 and 20-04-2019.

Result and Discussion

Performance of genotypes

Genotype Shreya recorded 14.6 and 10.1 percent higher seed yield and haulm yield, respectively, as compared to genotype Meha. This might be due to its better growth and yield attributing parameters, primarily dry matter production, number of pods per plant and number of seeds per pod. These results are in accordance with the findings of Begum *et al.* (2009)^[4], Dash and Rautaray (2017)^[6] and Singh *et al.* (2017a)^[19].

The genotype Shreya recorded significantly higher number of pods per plant, pod weight per plant, number of seed per pod and thousand seed weight per plant (23.74, 9.87, 10.46 and 44.74 g, respectively) (21.70, 8.56, 9.49 and 42.37 g, respectively). This might be due to genetic make-up of the cultivar. These results

are in-line with those of Khan and Malik (2001)^[13], who observed that genotypes differ significantly in number of pods per plant and number of seed per pod in greengram. Similar results were observed by Miah *et al.* (2009)^[14] and Bhagwanrao (2011)^[5].

Another important parameter to evaluate the translocation efficiency is harvest index (HI). Further it has been stated that the yielding capacity of genotype is correlated with increased seed to stalk ratio (HI). Total dry matter was the sole determinant of yield, whereas the harvest index of genotypes determines the efficiency of dry matter utilization. In the present study, genotype Shreya recorded a maximum harvest index (25.67%) than Meha (24.88%), attributing to greater dry matter accumulation towards seed development and these results are in line with findings of Miah *et al.* (2009)^[14], Bhagwanrao (2011)^[5] and Singh *et al.* (2017a)^[19].

Effect of planting geometry on yield and yield components

The yield potential of a particular genotype can be exploited under optimal planting geometry in a given environment where competition between plants is minimum. Optimum planting geometry leads to efficient utilization of soil moisture and nutrients and also avoids competition among the plants. In the present study effect of planting geometry on yield components were found to be non significant. This might be due to plant population remains same in both 30 cm $\times$ 10 cm and 45 cm $\times$ 7.5 cm. However, numerically 30 cm $\times$ 10 cm recorded higher seed (684 kg ha $^{-1}$) and haulm yield (2,594 kg ha $^{-1}$) than 45 cm $\times$ 7.5 cm (610 and 2,519 kg ha $^{-1}$, respectively). Higher yield in 30 cm $\times$ 10 cm was due to efficient utilization of natural resources than 45 cm $\times$ 7.5 cm as a result of optimum spacing. These results are in accordance with findings of Srivastava and Dawson (2017)^[20], who found on par yield and harvest index at 30 cm $\times$ 10 cm and 45 cm $\times$ 6.5 geometry, similar results were found by Ihsanullah *et al.* (2002)^[9].

Effect of nutrient management on growth and yield

Application of 31.25:62.5:25 kg N: P_2O_5 : K_2O ha $^{-1}$ + 20 kg S recorded significantly higher seed (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 (608 and 2,477 kg ha $^{-1}$, respectively) and RDF (591 and 2409 kg ha $^{-1}$, respectively). The increase in yield may 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, higher number of pods, 1000 seed weight and finally seed and haulm yield. These results are in conformity with the findings of Awomiet *et al.*, 2012^[2], Bairwa *et al.*, 2012^[3] and Suryavanshi *et al.*, 2017^[21]. The increased yield was also due to higher harvest index with application of 31.25:62.5:25 kg N: P_2O_5 : K_2O ha $^{-1}$ + 20 kg S (26.73%) as compared to application of 25:50:20 kg N: P_2O_5 : K_2O ha $^{-1}$ + 20 kg S (24.64%) and RDF (24.46%). This was due to efficient translocation of photosynthates from source to sink (leaf and stem to pods). These results confirm the findings of Rajput and Rajput (2017)^[18].

Application of 31.25:62.5:25 kg N: P_2O_5 : K_2O ha $^{-1}$ + 20 kg S recorded significantly higher number of pods per plant (24.72), number of seeds per pod (10.98), pod weight per plant (10.50 g), thousand seed weight (45.54 g) and harvest index (26.73%) as compared to 25:50:20 kg N: P_2O_5 : K_2O ha $^{-1}$ + 20 kg S and RDF (Table 1, 2 and 3). The increase in number of seeds per pod may be due to adequate availability of nutrients during crop growth

period and the important role played by potassium in energy transformation, enzyme activation, which are involved in carbohydrate metabolism and simultaneously higher transformation of photosynthates into reproductive parts which resulted in increased number of seeds per pod. Higher pod weight per plant is mainly due to increased number of pods per plant. Increased thousand seed weight can be attributed to the enhanced photosynthetic capacity resulting from greater number of leaves, increased leaf area and chlorophyll content. This led to higher rate of photosynthesis providing a greater supply of photosynthates to sink, which could have enabled the seeds to grow to full size, contributing to a significant increase in thousand seed weight. Similar findings were reported by Mondal *et al.* (2003) ^[15], Oad *et al.* (2003) ^[16] and Rajput and Rajput (2017) ^[18].

Interaction effect of genotypes, planting geometry and nutrient management on growth and yield of greengram

In the present investigation interaction effects between genotypes, planting geometry and nutrient management 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:P₂O₅:K₂O ha⁻¹ + 20 kg S ha⁻¹ recorded higher seed (845 kg ha⁻¹) and haulm yield (2979 kg ha⁻¹) as compared to other treatment combinations (Table 3). Increase in seed yield was attributed to increased growth and yield attributes. Increased yield parameters attributed to higher harvest index (28.72%) over other treatment combinations. The results are in accordance with results reported by Hussain *et al.*, 2011 ^[8], Gorakhnath, 2012 ^[7] and Srivastava and Dawson, 2017 ^[20]. Lower seed yield and haulm yield were recorded with genotype Meha sown at 45 cm × 7.5 cm spacing with application of RDF (551 and 2300 kg ha⁻¹, respectively). 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 results in low yield. These results are

in accordance with findings of Kalsaria *et al.*, 2017 ^[10].

Economics

Economics is the primary criterion for assessing the best treatment in terms of efficient utilization of growth resources, namely solar radiation, water and nutrients. Genotypes and nutrient levels have a significant effect on economics. Genotype Shreya recorded significantly higher gross return, net return and B: C ratio than Meha (Table 4). Variation in all economic constituents among genotypes was a result of higher yield. Similar findings were reported by Gorakhnath (2012) ^[7], Rajput and Rajput (2017) ^[18] and Kartik *et al.* (2020) ^[11]. Greengram sown with 30 cm × 10 cm recorded significantly higher gross return (₹51,967 ha⁻¹), net return (₹10,867 ha⁻¹) and B: C ratio (1.26) as compared to greengram sown at 45 cm × 7.5 cm (₹46,297 ha⁻¹, ₹10,625 ha⁻¹ and 1.13, respectively). This is attributed to higher yield and high market price during the cropping period. These results are in line with findings of Chetan (2015) and Rohidas, (2015). Among nutrient levels, application of 31.25:62.5:25 Kg N: P₂O₅: K₂O ha⁻¹ + 20 kg S ha⁻¹ recorded significantly higher gross return (₹56,350 ha⁻¹), net return (₹13,850 ha⁻¹) and B: C ratio (1.33) as compared to application of 25:50:20 Kg N: P₂O₅:K₂O ha⁻¹ + 20 kg S (₹46,146 ha⁻¹, ₹5,784 ha⁻¹ and 1.14, respectively) and RDF (₹44,900 ha⁻¹, ₹4,961 ha⁻¹ and 1.12, respectively). This might be due to higher yield. These results are in confirmation with findings of Khairnar and Solanke (2009) ^[12] and Patil and Dhonde (2009) ^[17].

Among the treatment combinations genotype Shreya sown at 30 cm × 10 cm spacing along with application of 31.25:62.5:25 kg N: P₂O₅: K₂O ha⁻¹ + 20 kg S ha⁻¹ recorded higher gross return (₹64,000 ha⁻¹), net return (₹21,500 ha⁻¹) and B: C ratio (1.51) as compared to other combinations. The lower gross return (₹39,700 ha⁻¹), net return (₹492 ha⁻¹) and B:C ratio (1.01) were recorded in genotype Meha sown at 45 cm × 7.5 cm with application of RDF. This is attributed to lower yield and higher cost of inputs.

Table 1: Number of pods per plant and pod weight plant⁻¹(g) of greengram genotypes as influenced by different planting geometry and nutrient management during summer

Treatment		Number of pod plant ⁻¹				Pod weight plant ⁻¹ (g)			
		F ₁	F ₁	F ₂	F ₁	F ₁	F ₂	F ₃	Mean
S ₁ : 30 cm × 10 cm	V ₁ : Shreya	22.50	23.07	26.40	23.99	9.33	9.50	11.67	10.17
	V ₂ : Meha	20.67	21.50	23.83	22.00	8.25	8.37	9.97	8.86
	Mean	21.58	22.28	25.12	22.99	8.79	8.94	10.82	9.52
S ₂ : 45 cm × 7.5 cm	V ₁ : Shreya	22.00	22.93	25.57	23.50	8.54	9.12	11.03	9.56
	V ₂ : Meha	20.13	21.00	23.07	21.40	7.40	8.06	9.31	8.26
	Mean	21.07	21.97	24.32	22.45	7.97	8.59	10.17	8.91
	V ₁ : Shreya	22.25	23.00	25.98	23.74	8.94	9.31	11.35	9.87
	V ₂ : Meha	20.40	21.25	23.45	21.70	7.83	8.22	9.64	8.56
Mean		21.33	22.13	24.72		8.38	8.76	10.50	
For comparison of Means		S.E.m±		CD at 5%		S.E.m±		CD at 5%	
S		0.21		NS		0.15		NS	
V		0.20		0.78		0.21		0.83	
F		0.28		0.83		0.14		0.42	
S x V		0.29		NS		0.26		NS	
S x F		0.44		NS		0.27		NS	
V x F		0.43		NS		0.34		NS	
S x V x F		0.50		NS		0.29		NS	

Table 2: Number of seeds per pod and thousand seed weight (g) of greengram genotypes as influenced by different planting geometry and nutrient management during summer

Treatment		Number of seeds pod ⁻¹				Thousand seed weight (g)			
		F ₁	F ₂	F ₃	Mean	F ₁	F ₂	F ₃	Mean
S ₁ : 30 cm × 10 cm	V ₁ : Shreya	9.97	10.23	12.00	10.74	43.73	44.67	47.27	45.22
	V ₂ : Meha	9.17	9.47	10.73	9.79	41.37	42.50	44.77	42.88
	Mean	9.57	9.85	11.37	10.26	42.55	43.58	46.02	44.05
S ₂ : 45 cm × 7.5 cm	V ₁ : Shreya	9.60	9.80	11.17	10.19	42.93	43.60	46.23	44.26
	V ₂ : Meha	8.67	8.90	10.03	9.20	40.50	41.17	43.90	41.86
	Mean	9.13	9.35	10.60	9.69	41.72	42.38	45.07	43.06
	V ₁ : Shreya	9.79	10.02	11.58	10.46	43.33	44.13	46.75	44.74
	V ₂ : Meha	8.92	9.18	10.38	9.49	40.93	41.83	44.33	42.37
Mean		9.35	9.60	10.98		42.13	42.98	45.54	
For comparison of Means		S.E.m±		CD at 5%		S.E.m±		CD at 5%	
S		0.13		NS		0.26		NS	
V		0.11		0.42		0.07		0.29	
F		0.15		0.45		0.35		1.04	
S × V		0.17		NS		0.27		NS	
S × F		0.25		NS		0.54		NS	
V × F		0.23		NS		0.41		NS	
S × V × F		0.27		NS		0.60		NS	

Table 3: Seed yield (kg ha⁻¹), haulm yield (kg ha⁻¹) and harvest index (%) of greengram genotypes as influenced by different planting geometry and nutrient management during summer

Treatment		Seed yield (kg ha ⁻¹)				Haulm yield (kg ha ⁻¹)				Harvest index (%)			
		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	670	687	845	734	2536	2606	2979	2707	26.43	26.54	28.72	27.23
	V ₂ : Meha	580	599	726	635	2359	2409	2675	2481	24.75	24.80	27.15	25.57
	Mean	625	643	785	684	2447	2507	2827	2594	25.59	25.67	27.93	26.40
S ₂ : 45 cm × 7.5 cm	V ₁ : Shreya	592	613	740	648	2500	2574	2877	2650	23.23	23.42	25.68	24.11
	V ₂ : Meha	522	532	662	572	2241	2318	2604	2388	23.42	23.79	25.38	24.20
	Mean	557	573	701	610	2370	2446	2741	2519	23.32	23.61	25.53	24.15
	V ₁ : Shreya	631	650	792	691	2518	2590	2928	2679	24.83	24.98	27.20	25.67
	V ₂ : Meha	551	565	694	603	2300	2364	2640	2434	24.08	24.30	26.27	24.88
Mean		591	608	743		2409	2477	2784		24.46	24.64	26.73	
For comparison of Means		S.E.m±		CD at 5%		S.E.m±		CD at 5%		S.E.m±		CD at 5%	
S		15.09		NS		30.51		NS		0.32		1.94	
V		13.15		51.64		26.89		105.60		0.42		NS	
F		17.45		52.30		38.87		116.55		0.58		1.75	
S × V		20.01		NS		40.67		NS		0.53		NS	
S × F		29.34		NS		62.27		NS		0.81		NS	
V × F		27.42		NS		58.84		NS		0.90		NS	
S × V × F		31.81		NS		69.69		NS		1.02		NS	

Table 4: Gross return, net return and B:C ratio of greengram genotypes as influenced by planting geometry and nutrient management

Treatment		Gross return (₹ ha ⁻¹)				Net return (₹ ha ⁻¹)				B:C ratio			
		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	50650	52200	64000	55617	10467	11584	21500	14517	1.26	1.29	1.51	1.35
	V ₂ : Meha	44200	45600	55150	48317	4017	4984	12650	7217	1.10	1.12	1.30	1.17
	Mean	47425	48900	59575	51967	7242	8284	17075	10867	1.18	1.20	1.40	1.26
S ₂ : 45 cm × 7.5cm	V ₁ : Shreya	45050	46400	56150	49200	4867	5984	13650	8167	1.12	1.15	1.32	1.20
	V ₂ : Meha	39700	40383	50100	43394	492	584	7600	2892	1.01	1.01	1.18	1.07
	Mean	42375	43392	53125	46297	2680	3284	10625	5529	1.07	1.08	1.25	1.13
	V ₁ : Shreya	47850	49300	60075	52408	7667	8784	17575	11342	1.19	1.22	1.41	1.27
	V ₂ : Meha	41950	42992	52625	45856	2255	2784	10125	5054	1.06	1.07	1.24	1.12
Mean		44900	46146	56350		4961	5784	13850		1.12	1.14	1.33	
For comparison of Means		S.E.m±		CD at 5%		S.E.m±		CD at 5%		S.E.m±		CD at 5%	
S		645		3925		766		4659		0.01		0.06	
V		353		1387		640		2512		0.02		0.09	
F		914		2740		777		2329		0.02		0.05	
S × V		735		NS		998		NS		0.02		NS	
S × F		1395		NS		1406		NS		0.03		NS	
V × F		1167		NS		1274		NS		0.04		NS	
S × V × F		1580		NS		1452		NS		0.03		NS	

Conclusion

Based on the results of the experiment, it is concluded that genotype Shreya exhibited superior performance in terms of seed yield, haulm yield, gross return, net return and B:Cratio. The application of 31.25:62.5:25 kg N:P₂O₅:K₂O per hectare, along with 20 kg sulphur per hectare, further enhanced these parameters. However, planting geometry did not significantly affect yield and economic outcomes.

References

1. Anonymous. Area and Production. Directorate of Economics and Statistics, Department of Agriculture and Cooperation, New Delhi; 2018. Available from: www.indiastat.com
2. Awomi TA, Singh AK, Manoj K, Bordoloi LJ. Effect of phosphorus, molybdenum and cobalt nutrition on yield and quality of mungbean (*Vigna radiata* L.) in acidic soil of Northeast India. -Indian J Hill Farming. 2012;25(2):22-6.
3. Bairwa RK, Nepalia V, Balai CM, Upadhyay B. Effect of phosphorus and sulphur on yield and economics of summer greengram (*Vigna radiata* L.). Madras Agric J. 2012;99(7-9):523-5.
4. Begum MST, Begum M, Anwar PMD, Juraimi AS. Optimizing seed rate for summer mungbean varieties. J Agric Soc Sci. 2009;5:114-8.
5. Bhagwanrao BA. Effect of varieties and plant geometry on growth and yield of summer greengram [MSc (Agri.) thesis]. Parbhani: Marathwada Krishi Vidyapeeth; 2011.
6. Dash SR, Rautaray BK. Growth parameters and yield of greengram varieties (*Vigna radiata* L.) in east and south east coastal plains of Odisha, India. Int J Curr Microbiol Appl Sci. 2017;6(10):1517-23.
7. Gorakhnath JR. Response of greengram varieties to plant geometries during summer [MSc (Agri.) thesis]. Parbhani: Marathwada Krishi Vidyapeeth; 2012.
8. Hussain MS, Karim MF, Biswas PK, Kawochar MA, Islam MS. Effect of rhizobium inoculation and chemical fertilization on the yield and yield components of mungbean. J Expt Biosci. 2011;2(1):69-74.
9. Ihsanullah, Taj FH, Akbar H, Basir A, Ullah N. Effect of row spacing on agronomic traits and yield of mungbean (*Vigna radiata* L. Wilczek). Asian J Plant Sci. 2002;1(4):328-9.
10. Kalsaria RN, Vekariya PD, Hadiyal JG, Ichchhuda PK. Effect of spacing, fertility levels and bio-fertilizers on growth and yield of summer greengram (*Vigna radiata* L.). J Pharmacogn Phytochem. 2017;6(5):934-7.
11. Kartik HP, Shah KA, Patel HB. Response of summer greengram [*Vigna radiata* (L.) Wilczek] varieties to different nutrient management under South Gujarat condition. Int J Curr Microbiol Appl Sci. 2020;9(5):1043-50.
12. Khairnar AV, Solanke AV. Response of potash levels and foliar spray of vermiwash on growth and yield of greengram. J Maharashtra Agric Univ. 2009;34(2):215-6.
13. Khan A, Malik MA. Determining biological yield potential of different mungbean cultivars. Online J Biol Sci. 2001;1(7):575-6.
14. Miah MAK, Anwar MP, Begum M, Juraimi AS, Islam MA. Influence of sowing date on growth and yield of summer mungbean varieties. J Agric Soc Sci. 2009;5:73-6.
15. Mondal SS, Chettri M, Sarkar M, Nita C. Growth and productivity of greengram as influenced by levels of potassium and sulphur under irrigated and unirrigated condition. J Potassium Res. 2003;19:107-10.
16. Oad FC, Nadi A, Shah GH, Galoo SH. Phosphorus and potassium requirement of mungbean (*Vigna radiata* L.). Pak J Appl Sci. 2003;3(6):428-31.
17. Patil SM, Dhonde MB. Effect of potash levels and foliar spray of cow urine on growth and yield of summer greengram. J Maharashtra Agric Univ. 2009;34(1):106-7.
18. Rajput BS, Rajput RL. Response of promising rainy summer season greengram (*Vigna radiata* L.) genotypes to phosphorus fertilization. Legume Res. 2017;40(1):170-2.
19. Singh V, Sharma SK, Thakral SK, Sharma MK. Effect of phosphorus on the performance of greengram (*Vigna radiata* L.) varieties during summer. Legume Res. 2017a;1-3.
20. Srivastava N, Dawson J. Effect of spacing, source of nutrient and methods of zinc application on yield and yield attributes of summer greengram (*Vigna radiata* L.). Int J Chem Stud. 2017;5(5):1789-91.
21. Suryavanshi BR, Bhosale AS, Jadhav YR, Kurne RA. Effect of fertilizer levels and plant densities on growth and yield of summer greengram (*Vigna radiata* L.). Trends Biosci. 2017;10(26):5577-80.