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Effect of Plant Density on Performance of Summer Green Gram (*Vigna radiata* L. Wilczek) Varieties

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Abstract: ***A field experiment was conducted during summer, 2016 at Agronomy Instructional Farm, C.P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat to study the "Response of different greengram (Vigna radiata L. Wilczek) cultivars to varying plant populations" Nine treatment combinations comprising of three plant densities (main plot)viz., 4.44 lakh plants/ha (P_1) (22.5 cm × 10 cm), 3.33 lakh plants/ha (P_2) (30 cm × 10 cm) and 2.22 lakh plants/ha (P_3) (45 cm × 10 cm) and three varieties (sub plot) viz., Meha (V_1), GM 4 (V_2) and GAM 5 (V_3) were evaluated in split plot design with four replications. Results revealed that greater plant height was obtained from plant density of 3.33 lakh plants/ha, which was closely followed by plant density of 4.44 lakh plants/ha. Number of branches/plant, pod length and number of seeds/pod were significantly higher under plant density of 2.22 lakh plants/ha followed by plant density of 3.33 lakh plants/ha. Number of pods/plant was significantly higher under plant density of 2.22 lakh plants/ha. Highest seed and stover yield were recorded under plant density of 3.33 lakh plants/ha whereas stover yield was at par with plant density of 4.44 lakh plants/ha. Higher protein yield was found under plant density of 3.33 lakh plants/ha which was at par with planting density of 4.44 lakh plants/ha. Effect of the plant density levels were not significant with respect to nitrogen, phosphorus and potassium contents (%) in seed and stover where as uptake of nitrogen, phosphorus and potassium in seed, stover and total plant was noted with plant density of 3.33 lakh plants/ha, which however was statistically at par with plant density of 2.22 lakh plants/ha. The variety GM 4 registered significantly taller plants at harvest, as also greater pod length and number of seeds/pod followed by GAM 5. Significantly higher number of branches/plant was recorded in variety GAM 5. The variety GM 4 took significantly lower number of days to 50 per cent flowering and physiological maturity and produced highest number of pods/plant, seed index, seed yield and stover yield. The highest protein content was recorded in variety Meha which was at par with variety GAM 5 where as variety GM 4 gave significantly higher protein yield which was statistically at par with variety GAM 5. Variety Meha recorded significantly higher nitrogen, phosphorus and potassium content in seed and stover, being statistically at par with variety GAM 5. Variety GM 4 significantly higher nitrogen, phosphorus and potassium uptake by seed, stover and total plant was observed which was at par with variety GAM 5. Maximum gross income and net income along with higher BCR value were recorded with plant density of 3.33 lakh plants/ha and variety GM 4.***

Keywords: greengram, plant density, cultivars, growth and yield, quality parameters

1. Introduction

Greengram (*Vigna radiata*) is commonly known as moong, golden gram, mung and is one of the most important pulse crop, grown in almost all parts of the country over a wide range of agro-climatic conditions. India is the largest producer of green gram in the world. The average productivity of green gram is very less as compared to its genetic potential (1000 to 1500 kg/ha). Though, in India area and production has increased from 1.99 to 3.43 m ha and 0.60 to 1.06 million tonnes (1964-65 to 2004-05), respectively, there are possibilities of increase in production and area because the crop (Singh, 2005). The yield level of green gram in India especially region of Gujarat is low.

Legumes constitute an important dietary ingredient of India diet as they supply protein and essential amino acids and play significant role in Indian farming. Protein hunger is the major problem in the country, where majority of the population adopt cereal and millet based dietary habits. Another interesting aspect of grain legumes is their unique ability in building-up their own nitrogen supply. Having quick maturity, versatile nature in different agro-climatic and soil situations, and capable of providing crop cover for soil conservation, the broad spectrum of pulses including green gram, black gram, cowpea, pigeon pea, chickpea and lentil, make them the linchpin of cropping systems in India.

Among crop management practices seeding densities or plant population greatly affect crop growth and finally yield. Therefore the flexibility and yielding ability of the cultivars can be assessed by using different seed densities. Using high seed rate on dry land leads to total failure of the crop because it imposes further stress of moisture due to dense population just at germination or emergence stage, while in case of lower seed rate, substandard population is the major cause of low yield, although all other yield components or characters favour high yield. Recently, many high yielding, early maturing and disease resistant varieties suitable for spring or summer cultivation have been evolved, which have to be evaluated for different agro-climatic regions. Singh *et al.* (2007) studied the response of mungbean varieties to plant populations in summer season and observed significant influence in terms of growth and yield.

The yield level of greengram in India especially region of Gujarat is low. Plant population plays an important role in growth, development and production by affecting plant

density and in turn, moisture, nutrient and space availability (Panwar and Sharma, 2004). The genetic variability and correlation for quantitative characters are of almost importance in selecting suitable genotypes and reliable yield component for efficient yield improvement (Mensah and Olukoya, 2007).

Optimum plant density mainly depends on the plants growth habits; however magnitude of growth is governed by edaphic and climatic factors. It is a low cost monetary input. Plant density plays significant role in providing the optimum space to individual plant, which is the main pre-requisite to obtain maximum yield for any crop. Plant densities are known as the growth modifiers of individual plant. Increase in yield with increase in plant population from 200,000 to 800,000/ha but decrease in number of pod/plant in wet season has been reported by Singh and Singh (1990). Hence an experiment was conducted study the effect of effect of plant density on performance of summer green gram varieties.

2. Materials and Methods

A field experiment was conducted during summer season of 2016 at Agronomy Instructional Farm, Department of Agronomy, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar situated at 24° 19' North latitude and 72° 19' East longitude with an elevation of 154.52 metre above the mean sea level. The climate of this region is sub-tropical monsoon type and falls under semi-arid region. The soil of the experimental field was loamy sand, low in organic carbon (0.22 %) and available nitrogen (160.7 kg/ha), medium in available phosphorus (38.79 kg/ha) and available potash (286.12 kg/ha) and with a soil pH of 7.56. Nine treatment combinations comprising of three plant densities *viz.*, 4.44 lakh plants/ha (P_1) (22.5 cm × 10 cm), 3.33 lakh plants/ha (P_2) (30 cm × 10 cm) and 2.22 lakh plants/ha (P_3) (45 cm × 10 cm) and three varieties *viz.*, Meha (V_1), GM 4 (V_2) and GAM 5 (V_3) were evaluated in split plot design with four replications by keeping plant density as main plot and variety as sub-plots. Size of gross plot was 6 m × 4.5 m. A fertilizer dose of 20 kg/ha N and 40 kg/ha P_2O_5 in the form of urea and DAP respectively was given to all the treatments at the time of preparation of field. All other cultural practices were performed uniformly for all treatments. Green gram varieties were dibbled on 6th March, 2016 using different seed rates as per treatments. Intercultural operations like irrigation, weeding, mulching and pest control were done as and when necessary for healthy plant growth and development. The crop was harvested at different dates as per maturity of different varieties when 90% pods were matured. Observations on different growth and yield parameters were recorded from five randomly selected plants in each net plot and seed yield was recorded. Then harvested crop was properly dried in the sun before threshing. The data recorded were tabulated and analyzed statistically using Fishers' analysis of variance (ANOVA) technique and the treatments were compared at 5% level of significance.

3. Results and Discussion

3.1 Effect of plant densities

Plant height at 45 DAS, harvest and number of branches/plant of all varieties were influenced significantly by spacing but not at 30 DAS (Table 1). A 45 DAS and at harvest, significantly greater plant heights 37.1 cm and 60.4 cm respectively have produced under plant density of 3.33 lakh plants/ha (P_2) which were at par with plant density of 4.44 lakh plants/ha (34.9 cm and 55.4 cm, respectively). This was apparently because individual plant from the plots with the highest plant population did not get opportunity to proliferate laterally due to closer spacing. Hence, plants were compelled to grow more in upward direction for the fulfillment of light requirement for photosynthesis. Plant density of 2.22 lakh plants/ha recorded significantly higher number of branches/plant (6.11) and was at par with plant density of 3.33 lakh plants/ha. Number of root nodules/plant, dry weight of root nodules/plant, days to 50 per cent flowering, days to physiological maturity and seed index were not influenced by plant density.

All yield attributing parameters like pod length, pods/ plant and number of seeds/pod were significantly influenced by different plant densities (Table 2). Number of pods/plant was significantly higher under plant density of 2.22 lakh plants/ha as compared to plant densities of 3.33 lakh plants/ha and 4.44 lakh plants/ha. The pod length (8.00 cm) and number of seeds/pod were also found significantly higher under the lowest plant density of 2.22 lakh plants/ha (P_3), but was statistically at par with plant density of 3.33 lakh plants/ha.

It is evident from the results presented in Table 2 that there was a significant difference in seed and stover yield of greengram due to plant densities but not harvest index. Plant density of 3.33 lakh plants/ha (P_2) recorded significantly higher seed yield (1185 kg/ha) as compared to plant density levels of 4.44 lakh plants/ha and 2.22 lakh plants/ha. The magnitude of increase in seed yield under treatments P_2 and P_1 was to the extent of 25.93 and 12.22 per cent, respectively over P_3. Stover yield was significantly higher under plant density of 3.33 lakh plants/ha (1994 kg/ha) followed by 4.44 lakh plants/ha. This is due to reduction in plant population per unit area under lower plant density. Increase in plant population resulted in sharp decline in the seed yield due to severe inter-plant competition which resulted in vegetative growth. The results were in line of those reported by Chaudhary *et al.* (2014), Singh and Singh (2014), Kadam and Khanvilkar (2015) and Sonani *et al.* (2016).

The quality parameter revealed that plant density levels did not affect the protein content of the greengram varieties. (Table 2)

N, P and K content in seed and stover were not significantly influenced due to different plant density levels but nutrient uptake by seed, stover and total uptake were significantly influenced due to planting density levels. Higher uptake recorded under medium plant density level because of higher seed and stover yield (Table 3).

Plant densities did not produce any significant influence on available N, P_2O_5 and K_2O in soil after harvest of the crop. (Table 4)

The plant density of 3.33 lakh plants/ha secured the highest gross income (`45463/ha) and net income (`21771/ha) with BCR value of 1.92.

3.2 Effect of varieties

Growth and yield attributes of green gram were significantly influenced due to different varieties (Table 1). Variety GM 4 recorded significantly higher plant height at harvest (58.1 cm), which was remained at par with variety GAM 5. Significantly higher number of branches/plant (5.97) was observed in variety GAM 5 over variety GM 4 and Meha. This can be attributed to their genetical difference in growth habit. There was no significant difference among varieties in number of root nodules/plant and dry weight of root nodules/plant at 45 DAS. Significantly less number of days to 50 per cent flowering and physiological maturity were observed with variety GM 4 (V_2) as compared to variety Meha (V_1) and GAM 5 (V_3). The variety GM 4 (V_2) had the highest pod length (7.46 cm), number of pods/plant and seed index. However varieties GM 4 & GAM 5 were comparable in the case of number of seeds/pod.

Seed yield of summer greengram varied significantly due to treatments (Table 2). Variety GM 4 (V_2) recorded higher (1126 kg/ha) seed yield as compared to variety GAM 5 (V_3) and Meha (V_1). The magnitude of increase in seed yield under treatments V_2 and V_3 was to the extent of 12.93 and 6.31 per cent, respectively over V_1. Variety GM 4 (V_2) gave significantly higher stover yield (1933 kg/ha) which was statistically at par with variety GAM 5 (V_3). This might be due to difference in number of pods/plant and seed yield/plant. The above findings are in complete agreement with earlier work of Tekale *et al.* (2011), Gorade *et al.* (2014), Rathod and Gawande (2014), Solunke *et al.* (2015) and Patel *et al.* (2016).

The highest protein content (22.22 %) was recorded in variety Meha (V_1) which was at par with variety GAM 5 (V_3) (21.98 %), but significantly better than variety GM 4 (V_2) (21.66 %). The magnitude of increase in protein content in treatments V_1 and V_3 was to the extent of 2.58 and 1.48 per cent, respectively over V_2. Increase in protein content might be due to increased N concentration in grain. Protein yield showed a different tread, as it was dependent on seed yield. Variety GM 4 (V_2) produced significantly higher protein yield (243.20 kg/ha) which was statistically at par with variety GAM 5 (V_3) (232.60 kg/ha). The lowest protein yield was observed in variety Meha (V_1) (221.18 kg/ha) (Table 2).

Significantly higher N, P and K content in seed and stover was registered with variety Meha which was statistically at par with variety GAM 5, while variety GM 4 recorded significantly lower N, P and K content in seed and stover. Seed, stover and total nutrient uptake by the variety GM 4 was higher, but statistically at par with variety GAM 5. Significantly lower uptake of all nutrients was recorded in variety Meha (Table 3).

The available N and P_2O_5 content of soil after harvest of greengram varieties were influenced significantly (Table 3). Variety Meha recorded significantly higher value of available N (186.80 kg/ha) and P_2O_5 (41.89 kg/ha), which was at par with variety GAM 5.Available K_2O did not vary significantly in respect of varieties. However, there was, in general, improvement in available status of N and P under all the varieties after harvest over their initial levels, indicating the overall improvement in soil fertility after harvest of greengram varieties.

Economic analysis of the data revealed that the highest gross realization (`43276/ha), net realization (`19584/ha) and BCR (1.83) were accrued under variety GM 4 (V_2). (Table 2)

4. Conclusion

Results of the field experiment conducted during summer-2016, recorded that summer greengram cultivation could provide quality and profitable yield with variety GM 4, under plant density of 3.33 lakh plants/ha (30 cm × 10 cm spacing) in loamy sand soil under North Gujarat agro-climatic conditions**.**

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Table 1: Growth and yield parameters of summer greengram with different cultivars and plant densities

Treatments	Plant height (cm)			Number of branches/ plant	Number of root nodules/ plant	Dry weight of root nodules/ plant (mg)	Days to 50 per cent flowering	Days to physiological maturity	Pod Length (cm)	Number of pods/ plant	Number of seeds/ pod	Seed index (g)
	30 DAS	45 DAS	At harvest									
A] Main plot treatments (Plant Densities : P) :												
P_1: 4.44 lakh plants/ha (22.5 × 10 cm)	21.6	34.9	55.4	5.19	22.77	15.91	41	70	6.33	19.40	8.39	3.72
P_2: 3.33 lakh plants/ha (30 × 10 cm)	22.7	37.1	60.4	5.70	23.98	16.59	41	70	7.30	23.62	9.28	3.78
P_3: 2.22 lakh plants/ha (45 × 10 cm)	21.1	32.3	51.8	6.11	24.83	17.47	40	69	8.00	25.62	9.97	4.00
S.Em. ±	0.83	1.01	1.51	0.18	0.70	0.36	0.47	0.53	0.20	0.55	0.27	0.09
C.D. at 5 %	NS	3.51	5.22	0.61	NS	NS	NS	NS	0.70	1.90	0.93	NS
C.V. %	13.15	10.10	9.36	10.82	10.13	7.54	4.00	2.66	9.66	8.30	10.13	7.81
B] Sub plot treatments (Varieties : V) :												
V_1 : Meha	21.5	32.9	53.2	5.45	23.45	16.23	44	76	6.84	21.73	8.83	3.58
V_2: GM 4	22.1	36.3	58.1	5.58	24.25	17.04	37	63	7.46	24.15	9.78	4.19
V_3:GAM 5	21.9	35.1	56.3	5.97	23.88	16.70	40	69	7.33	22.75	9.03	3.73
S.Em. ±	0.66	0.83	1.31	0.13	0.65	0.30	0.43	0.22	0.17	0.46	0.26	0.07
C.D. at 5 %	NS	2.47	3.88	0.37	NS	NS	1.27	0.67	0.50	1.37	0.77	0.21
P × V Interaction :												
S.Em. ±	1.15	1.44	2.26	0.22	1.13	0.52	0.74	0.39	0.29	0.80	0.45	0.12
C.D. at 5 %	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V. %	10.52	8.29	8.09	7.62	9.50	6.28	3.65	1.12	8.00	7.00	9.73	6.44

Table 2: Quality parameters, yield and economics of summer greengram by different plant densities and cultivars

Treatments	Protein content (%)	Protein yield (kg/ha)	Seed yield (kg/ha)	Stover yield (kg/ha)	HI (%)	Gross realization (`/ha)	Net realization (`/ha)	BCR
A] Main plot treatments (Plant Densities : P) :								
P_1 : 4.44 lakh plants/ha (22.5 × 10 cm)	22.00	232.22	1056	1863	36.18	40686	16154	1.66
P_2 : 3.33 lakh plants/ha (30 × 10 cm)	21.42	253.62	1185	1994	37.33	45463	21771	1.92
P_3 : 2.22 lakh plants/ha (45 × 10 cm)	22.45	211.15	941	1699	35.66	36333	13481	1.59
S.Em. ±	0.25	7.06	30.46	62.95	0.71	-	-	-
C.D. at 5 %	NS	24.44	105.41	217.83	NS	-	-	-
C.V. %	3.92	10.53	9.95	11.77	6.78	-	-	-
B] Sub plot treatments (Varieties : V) :								
V_1 : Meha	22.22	221.18	997	1762	36.12	38419	14727	1.62
V_2 : GM 4	21.66	243.20	1126	1933	36.81	43276	19584	1.83
V_3 : GAM 5	21.98	232.60	1060	1861	36.24	40822	17130	1.72
S.Em. ±	0.14	4.73	19.49	44.07	0.65	-	-	-
C.D. at 5 %	0.42	14.04	57.92	130.95	NS	-	-	-
P × V Interaction :								
S.Em. ±	0.24	8.19	33.76	76.33	1.13	-	-	-
C.D. at 5 %	NS	NS	NS	NS	NS	-	-	-
C.V. %	2.22	7.05	6.37	8.24	6.20			

Table 3: Yield and nutrient content of summer greengram by different plant densities and cultivars

Treatments		Seed yield (kg/ha)	Stover yield (kg/ha)	Nutrient content (%)					
				N		P		K	
				Seed	Stover	Seed	Stover	Seed	Stover
A]	Main plot treatments (Plant Densities : P) :								
	P_1: 4.44 lakh plants/ha (22.5 × 10 cm)	1056	1863	3.52	1.06	1.01	0.53	0.33	0.63
	P_2 : 3.33 lakh plants/ha (30 × 10 cm)	1185	1994	3.43	1.03	1.00	0.52	0.32	0.62
	P_3: 2.22 lakh plants/ha (45 × 10 cm)	941	1699	3.59	1.09	1.03	0.54	0.34	0.64
S.Em. ±		30.46	62.95	0.04	0.01	0.01	0.01	0.004	0.01
C.D. at 5 %		105.41	217.83	NS	NS	NS	NS	NS	NS
C.V. %		9.95	11.77	3.92	4.71	2.47	4.18	3.94	3.52
B]	Sub plot treatments (Varieties : V) :								
	V_1 : Meha	997	1762	3.56	1.07	1.04	0.54	0.34	0.64
	V_2: GM 4	1126	1933	3.47	1.04	1.00	0.52	0.32	0.62
	V_3 : GAM 5	1060	1861	3.52	1.06	1.02	0.53	0.33	0.63
S.Em. ±		19.49	44.07	0.02	0.01	0.01	0.004	0.002	0.004
C.D. at 5 %		57.92	130.95	0.07	0.02	0.02	0.01	0.01	0.01
P × V Interaction :									
S.Em. ±		33.76	76.33	0.04	0.01	0.01	0.01	0.004	0.01
C.D. at 5 %		NS	NS	NS	NS	NS	NS	NS	NS
C.V. %		6.37	8.24	2.22	2.55	1.94	2.4	2.10	2.02

Table 4: Nutrient uptake and availability of nutrients in the soil after harvest of summer greengram by different plant densities and cultivars

Treatments		Nutrient uptake (kg/ha)									Available Nutrients in the soil after harvest (kg/ha)		
		N			P			K					
		Seed	Stover	Total	Seed	Stover	Total	Seed	Stover	Total	N	P_2O_5	K_2O
A]	Main plot treatments (Plant Densities : P) :												
	P_1 : 4.44 lakh plants/ha (22.5 × 10 cm)	37.15	19.72	54.85	10.71	9.84	20.55	3.51	11.70	15.21	189.45	40.97	275.93
	P_2 : 3.33 lakh plants/ha (30 × 10 cm)	40.58	20.58	58.89	11.88	10.33	22.21	3.82	12.32	16.16	184.25	39.42	273.01
	P_3 : 2.22 lakh plants/ha (45 × 10 cm)	33.78	18.40	50.30	9.64	9.20	18.84	3.19	10.90	14.10	179.18	42.56	278.15
S.Em. ±		1.13	0.48	1.34	0.31	0.24	0.50	0.12	0.30	0.36	2.32	0.69	2.52
C.D. at 5 %		3.91	1.64	4.64	1.07	0.84	1.74	0.40	1.05	1.24	NS	NS	NS
C.V. %		10.53	8.41	8.49	9.92	8.58	8.48	11.55	9.03	8.21	4.35	5.86	3.17
B]	**Sub plot treatments (Varieties : V) :**												
	V_1: Meha	35.39	18.85	52.25	10.32	9.43	19.75	3.35	11.19	14.54	186.80	41.89	277.34
	V_2 : GM 4	38.91	20.10	56.86	11.18	10.07	21.25	3.64	12.00	15.68	181.53	40.21	274.22
	V_3: GAM 5	37.22	19.74	54.93	10.74	9.87	20.61	3.52	11.73	15.25	184.54	40.85	275.54
S.Em. ±		0.76	0.34	0.88	0.20	0.17	0.29	0.07	0.22	0.25	1.31	0.45	0.83
C.D. at 5 %		2.25	1.01	2.61	0.59	0.52	0.87	0.22	0.65	0.73	3.89	1.34	NS
P × V Interaction :													
S.Em. ±		1.31	0.59	1.52	0.34	0.30	0.51	0.13	0.38	0.42	2.27	0.78	1.44
C.D. at 5 %		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V. %		7.05	6.00	5.56	6.39	6.14	4.96	7.41	6.46	5.59	2.46	3.80	1.04