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Effect of spacing, fertility levels and bio-fertilizers on growth and yield of summer greengram (*Vigna radiata* L. Wilczek)

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Abstract
A field experiment was conducted in Factorial Randomized Block Design during summer, 2016 at Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh, to study the "Effect of spacing, fertility levels and bio-fertilizers on growth and yield of summer greengram (*Vigna radiata* L. Wilczek)**".** Twelve treatment combinations comprising of two spacing *viz*., S_1= 30 cm x 10 cm and S_2= 45 cm x 10 cm; three levels of fertilizer *viz*., F_0= control, F_1= 75 % RDF (15-30-00 kg N-P_2O_5-K_2O ha^{-1}) and F_2= 100 % RDF (20-40-00 kg N-P_2O_5-K_2O ha^{-1}) and two levels of bio-fertilizers *viz*., B_0= no inoculation of bio-fertilizers and B_1= inoculation of *Rhizobium* + PSB @ 10 ml per kg seed were evaluated. The results revealed that greengram cultivar GM-4 performed better by recording higher number of branches per plant (3.17), dry matter accumulation per plant at both 30 DAS (7.19 g) and at harvest (14.91 g) and dry weight of root nodules per plant at both 30 DAS (2.25 g) and at harvest (3.41 g), number of pod per plant (26.44), length of pod (6.14 cm) and test weight (38.90 g) when sowing with 45 cm row spacing over 30 cm row spacing but seed yield (930 kg ha^{-1}) and Stover yield (2151 kg ha^{-1}) where recorded with 30 cm row spacing over 45 cm row spacing. Application of 100 % RDF recorded higher values for number of branches per plant (2.83), dry matter accumulation per plant at harvest (14.50 g) and dry weight of root nodules per plant at both 30 DAS (2.21 g) and at harvest (3.39 g), length of pod (6.19 cm) and test weight (39.35 g), seed yield (945 kg ha^{-1}) and stover yield (1900 kg ha^{-1}) over 75 % RDF and control. Inoculation of *Rhizobium* and PSB also improve growth and yield parameters. In general, for obtaining higher yields greengram variety GM-4 to be grown during summer season with 30 cm row spacing and fertilizing the crop with 100 % RDF (20-40-00 kg N-P_2O_5-K_2O ha^{-1}) with inoculation of *Rhizobium* and PSB.

Keywords: Bio-fertilizer, Fertility levels, Growth, Summer greengram, Yield

Introduction
Pulses are important not only for their value as human food, but also because of high protein content for livestock. It has been important component of Indian agriculture enabling the land to restore fertility by fixing atmospheric nitrogen, so as to produce reasonable yields of succeeding crops and to meet out the demand of dietary requirement regarding proteins, carbohydrates and other nutrient sources. On an average, pulses contain 22-24 per cent protein as against 8-10 per cent in cereals. A good amount of lysine is present in the pulses. Pulses vary in maturity periods, hence, are useful in different cropping systems. Greengram locally called as moog or mug (*Vigna radiata* L. Wilczek) belongs to the family Leguminoceae, which fixes atmospheric nitrogen and improves soil fertility by adding 20-25 kg N ha^{-1}. Being a short duration crop and having wider adaptability, it can be grown in summer as well as in *kharif* season. It is an important ruling crop in summer season, locally known as 'Vaishakhi Mug'. The yield of summer greengram is comparatively more than that of *kharif* crop, mainly because the controlled moisture conditions through irrigation, abundant sunshine and less pest and disease infestation. The greengram foliage left over after picking of mature pods can either be fed to livestock or it may ploughed in situ as a green manure to enrich soil with organic matter. Employment is provided to the farmers and the agricultural labours during off season. Greengram is a very short duration crop so it can be grown as catch crop.

In India, it occupied an area of 3.24 million hectares having total production of 1.39 million tons of grain with productivity of 346 kg/ha (Anon., 2015a) [2]. In India, major greengram producing states are Orissa, Madhya Pradesh, Rajasthan, Maharashtra, Gujarat and Bihar. In Gujarat, it is cultivated in about 2.26 lakh hectares with an annual production of 0.97 lakh tones and average productivity of 429 kg/ha (Anon., 2015b) [3]. Greengram crop have direct effect of spacing due to availability of moisture and nutrient depend on spacing.

Greengram [*Vigna radiata* (L.) Wilczek] gives low seed yield and poor growth performance mainly due to poor management and low soil fertility. Nitrogen due to leaching and volatization and phosphorus due to fixation may not be available adequately at flowering and pod formation stages of crop and result in shading of flowers and pods. The crop needs more nitrogen at the reproductive phase, and the nutrient uptake after flowering either becomes slow or stops due to inactivation of roots. The optimum supply of nitrogen and phosphorus significantly influenced on growth and yield of greengram. Yield of summer greengram increases with the application of nitrogenous and phosphatic fertilization. Usually grain legumes are grown on marginal land and poor yield in such soils are partly due to lack of effective and specific strains of *Rhizobium* in rhizosphere. Hence, to evaluate correct spacing, levels of fertilizer and bio-fertilizer on growth and yield of summer greengram the present investigation was undertaken.

Material and methods

A field experiment was conducted during summer 2016 at Instructional farm, College of Agriculture, Junagadh Agricultural University, Junagadh (Gujarat). The soil of experimental plot was medium black calcareous soil with good drainage. The experiment was laid out in Factorial Randomized Block Design with three replications. There were twelve treatment combinations with two spacing (S_1= 30 cm x 10 cm and S_2= 45 cm x 10 cm), three levels of fertilizer [F_0= control, F_1= 75 % RDF (15-30-00 kg N-P_2O_5-K_2O ha^{-1}) and F_2= 100 % RDF (20-40-00 kg N-P_2O_5-K_2O ha^{-1})] and two levels of bio-fertilizers (B_0= no inoculation of bio-fertilizers and B_1= inoculation of *Rhizobium* + PSB @ 10 ml per kg seed). Each experimental unit was replicated thrice with the plot size of 5.0 m × 2.7 m and 4.0 m × 1.8 m as the gross and net plot, respectively. The variety GM-4 was sown 4th February 2016 by drilling. Application of N and P as per RDF 20:40:00 NPK kg ha^{-1}. The complete dose of nitrogen and phosphorus as per treatment was drilled at sowing uniformly in the plots. The fertilizers used were urea (46% N) and di-ammonium phosphate (18% N and 46% P). The seeds were inoculated with culture of *Rhizobium* and phosphorus solubilizing bacteria (PSB) before sowing as per treatments. The biometric observations for growth/ yield attributing characters were taken by randomly selecting five plants per plot. Data obtained on various variables were analyzed by analysis of variance method (Panse and Sukhatme, 1985) [11].

Results and discussion

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads.

Effect of spacing on growth and yield parameters of greengram:

The beneficial effect of different levels of spacing on number of branches, number of root nodules, dry weight of root nodules, dry matter accumulation, number of pods per plant, length of pod and test weight (1000 seed weight), seed yield and stover yield of greengram were evident during active growth and maturity.

Spacing of 45 x 10 cm produced significantly higher number of branches per plant (3.17), dry matter per plant (7.19 g and 14.91 g at 30 DAS and at harvest, respectively) and dry weight of root nodules per plant (2.25 g and 3.41 g at 45 DAS and at harvest, respectively) over 30 x 10 cm spacing (Table 1). Same result was reported by Kotwal and Prakash (2006) [8] and Amruta *et al.* (2015) [1].

Data on yield and yield contributing characters viz., numbers of pods per plant, length of pod, test weight, seed yield (kg ha^{-1}) and stover yield (kg ha^{-1}) as influenced by different levels of fertilizers was found to be significant are presented in Table 2. Spacing of 45 x 10 cm recorded significantly higher number of pods per plant (26.44), length of pod (6.14 cm) and test weight (38.90 g) as compared to 30 x 10 cm spacing. While spacing of 30 x 10 cm recorded significantly higher seed yield (930 kg ha^{-1}) and stover yield (2151 kg ha^{-1}) as compared to 45 x 10 cm spacing. It is may be due to higher number of plants per hectare in case of 30 x 10 cm row spacing. These results are also in agreement with findings of Patel *et al.* (2005) [13], Yadav and Singh (2014) [18], Amruta *et al.* (2015) [1], Kadam and Khanvilkar (2015) [6] and Keerthi *et al.* (2015) [7].

Effect of fertilizer levels on growth and yield parameters of greengram:

The beneficial effect of different levels of fertilizers on plant height, number of branches, dry weight of root nodules, dry matter accumulation, length of pod and test weight (1000 seed weight), seed yield and stover yield of greengram were evident during active growth and maturity.

Application of 100 % RDF resulted in significantly highest number of branches per plant (2.83), dry matter per plant at 45 DAS (14.50 g) and dry weight of root nodules per plant (2.21 g and 3.39 g at 45 DAS and at harvest, respectively) at harvest but it was statistically at par with 75 % RDF (38.58 cm). While application of 75 % RDF produced significantly highest dry matter per plant (6.92 g) at 30 DAS but it was statistically at par with 100 % RDF. These results are also in agreement with findings of Rathod and Gawande (2012) [14], Marimuthu and Surendran (2015) [10] and Twinkle (2016) [16].

The yield attributing characters like length of pod, test weight, seed yield and stover yield were significantly influenced due to various fertilizer treatments. Highest length of pod (6.19 cm), test weight (39.35 g), seed yield (945 kg ha^{-1}) and stover yield (1900 kg ha^{-1}) were recorded under 100 % RDF treatment but it was statistically at par with 75 % RDF. Lowest value of all the characters is found with control treatments. It is may be due to higher dose of fertilizer improves nutrient availability to crop. These results are also in agreement with findings of Kumar *et al*. (2013) [9], Awasarmal *et al.* (2015) [4], Marimuthu and Surendran (2015) [10] and Twinkle (2016) [16].

Effect of bio-fertilizer on growth and yield parameters of greengram:

Various levels of bio-fertilizer application did not exert their significant effect on most of the characters. But it has beneficial effect on number of branches per plant, dry weight of root nodules per plant and stover yield.

Inoculation of seed with *Rhizobium* + PSB gave significantly higher number of branches per plant (2.76), dry weight of root nodules per plant (2.22 g and 3.36 g at 45 DAS and at harvest, respectively) and stover yield (1909 kg ha^{-1}) over control. Similar result was reported by Bhat *et al*. (2010) [5], Patel *et al*. (2016) [12] and Tiwari *et al.* (2016) [15].

Interaction effect

The interaction effect between spacing, fertilizer levels and bio-fertilizer was found to be non-significant for all characters but interaction between spacing and fertilizer levels found significant for number of branches per plant and dry weight of root nodules per plant (Table 3).

Interaction of S_2F_2 (45 x 10 cm row spacing with 100 % RDF)

recorded highest number of branches per plant (3.63) and dry weight of root nodules per plant (2.36 g and 3.61 g at 45 DAS and at harvest, respectively) over all other combinations. Similar result was reported by Uddin *et al.* (2009) [17] and Patel *et al.* (2016) [12].

Table 1: Effect of spacing, fertility levels and bio-fertilizer on growth parameters of summer greengram.

Treatment	Number of branches per plant	Dry matter accumulation (g)		Dry weight of root nodules per plant (g)	
		At 30 DAS	at 45 DAS	at 45 DAS	at harvest
A) Spacing (S)					
S 1 (30 x 10 cm)	2.10	6.25	13.35	2.08	3.16
S 2 (45 x 10 cm)	3.17	7.19	14.91	2.25	3.41
S.Em.±	0.07	0.09	0.21	0.03	0.04
C.D. (P=0.05)	0.19	0.25	0.60	0.08	0.12
B) Fertility levels (F)					
F 0 (Control)	2.31	6.46	13.40	2.10	3.17
F 1 (75 % RDF)	2.75	6.92	14.49	2.19	3.31
F 2 (100 % RDF)	2.83	6.78	14.50	2.21	3.39
S.Em.±	0.08	0.11	0.25	0.03	0.05
C.D. (P=0.05)	0.23	0.31	0.74	0.09	0.14
B 0 (No biofertilizer)	2.51	6.69	14.00	2.11	3.22
B 1 (*Rhizobium*+ PSB)	2.76	6.75	14.27	2.22	3.36
S.Em.±	0.07	0.09	0.21	0.03	0.04
C.D. (P=0.05)	0.19	NS	NS	0.08	0.12
SxF	S	NS	NS	S	S
SxB	NS	NS	NS	NS	NS
FxB	NS	NS	NS	NS	NS
SxFxB	NS	NS	NS	NS	NS
CV%	10.49	5.45	6.18	5.11	5.19

Table 2: Effect of spacing, fertility levels and bio-fertilizer on yield parameters of summer greengram.

Treatment	Number of pods per plant	Length of Pod (cm.)	Test weight (g.)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})
A) Spacing (S)					
S 1 (30 x 10 cm)	24.04	5.84	36.93	930	2151
S 2 (45 x 10 cm)	26.44	6.14	38.90	848	1525
S.Em.±	0.42	0.07	0.65	23	33
C.D. (P=0.05)	1.24	0.21	1.90	66	98
B) Fertility levels (F)					
F 0 (Control)	24.33	5.83	35.37	804	1753
F 1 (75 % RDF)	26.18	5.94	39.02	918	1861
F 2 (100 % RDF)	25.21	6.19	39.35	945	1900
S.Em.±	0.52	0.09	0.80	28	41
C.D. (P=0.05)	NS	0.26	2.33	81	120
B 0 (No biofertilizer)	24.88	5.89	37.17	867	1768
B 1 (*Rhizobium*+ PSB)	25.61	6.08	38.66	911	1909
S.Em.±	0.42	0.07	0.65	23	33
C.D. (P=0.05)	NS	NS	NS	NS	98
SxF	NS	NS	NS	NS	NS
SxB	NS	NS	NS	NS	NS
FxB	NS	NS	NS	NS	NS
SxFxB	NS	NS	NS	NS	NS
CV%	7.09	5.18	7.26	10.77	7.71

Table 3: Interaction effect of spacing and fertilizer levels growth parameters of summer greengram.

S / F	Number of branches per plant		Dry weight of root nodules per plant (g) at 45 DAS		Dry weight of root nodules per plant (g) at harvest	
	S_1	S_2	S_1	S_2	S_1	S_2
F_0	1.96	2.67	2.00	2.19	3.04	3.31
F_1	2.30	3.21	2.18	2.20	3.29	3.32
F_2	2.04	3.63	2.05	2.36	3.16	3.61
S.Em.±	0.11		0.05		0.07	
C.D. (P=0.05)	0.32		0.13		0.20	

Conclusion

Based on the one-year field experimental results, it was concluded that better crop yield and highest net returns could be obtained from summer greengram (cv. GM-4) by sowing the crop with 30 cm x 10 cm spacing and fertilizing the crop with 100 % RDF (20-40-00 kg N-P_2O_5-K_2O ha^{-1}) in the medium black clayey soil under South Saurashtra Agro-climatic Zone of Gujarat.

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