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Effect of different varieties, spacing, fertilizer levels and their interactions on grain yield and yield components (*Vigna radiata* L.) in rainfed situation under southern transitional zone of Karnataka

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Abstract
A field experiment was conducted at Agronomy Field unit, College of Agriculture, Shivamogga during *kharif* 2015-2016 and 2016-17 on sandy loamy soils to evaluate performance of promising Greengram varieties (*Vigna radiata* (L.) Wilczek) as influenced by planting density and fertilizer levels under *rain fed* situation in Southern Transitional Zone of Karnataka. Among three different varieties KKM-3 gave significantly higher grain yield (1056.91 kg ha^{-1}) and straw yield (4107.01 kg ha^{-1}) than PDM 84-647.17 178 (kg ha^{-1} and 2438.10 kg ha^{-1}, respectively) and SBM-1 (746.55 kg ha^{-1} and 3097.03 kg ha^{-1}, respectively. KKM-3 sown on 15th July recorded significantly higher grain and straw yield (1252.86kg ha^{-1} and 4912.04 kg ha^{-1} respectively) followed by sowing KKM-3 on 30th of July (878.82 kg $ha^{-1}$and 3286.72 kg ha^{-1}, respectively). Significantly higher grain of greengram was found with the recommended (30 ×10 cm) spacing (925.54 kg ha^{-1}) followed by 45x10 cm spacing (883.42 kg ha^{-1}). The grain and straw yield of greengram nutrition with 25:50:25 N P_205 and K_2O was 855.47 and 3498.70 kg ha^{-1} respectively, which increased to 953.50 and 3768.92 kg ha^{-1} due to125% higher recommended dose *i.e.* 31.25:62.5:31.25 kg N, P_2O_5 and K_2O ha^{-1}.

Keywords: Greengram, KKM-3, PDM 84 -178, SBM-1

Introduction

"*Greengram is considered to be a satvik legume or complete legume"* (Bhishagratna, 1916) [3], alternatively known as the mungbean, provides nourishment to tissues, astringent taste, cooling nature and high fiber content help in aiding proper digestion. It is an ancient and well-known pulse crop that belongs to family *leguminosae* and originated from South East Asia (Mogotsi, 2006) [11]. Amongest the pulses, green gram ranks second in the nutritive value. It contains about 4 to 25 per cent protein, this being about two third of protein content of soybean, twice that of wheat and thrice that of rice. The protein is comparatively rich in lysine, which is deficient in cereal grains. Hence, a diet combining green gram and cereal grains forms a balanced amino acid diet. Every 100 g of green gram seeds contains 56 per cent carbohydrate, 3.5 per cent minerals, 4.1 per cent fibre, 1.3 per cent fat, vitamins like 4.8 mg ascorbic acid, 0.621 mg thiamine, 0.233 mg riboflavin, 2.251 mg niacin, 1.910 mg pantothenic acid and 114 IU vitamin A, 132 mg calcium, 6.74 mg iron, 189 mg magnesium, 367 mg phosphorus and 124 mg potassium and calorific value of 334 its cultivation improves soil fertility by adding about 30 to 40 kg N ha^{-1} after the harvest of the crop.

The important green gram growing states are Rajasthan, Madhya Pradesh, Uttar Pradesh, Odisha, Maharashtra, Karnataka and Bihar. In Karnataka, it occupies 421.04 ha area with a production of 142.57 tonnes with the productivity of 330 kg ha^{-1} (Anon, 2019) [1]. The impending crisis in greengram for India's growing population is obvious. Varieties play an important role in crop production and the potential yield of a variety within the genetic limit as determined by its environment. Hence, combination of genotype and environmental factor can bring about increase in production. Difference in yield of genotypes is attributed to the complex process occurring in various parts of the plant involving many physiological changes. These physiological changes are influenced by environmental factors prevailing at different stages of crop growth. To understand yield variation among greengram varieties in different environments, agronomic practices and yield analysis are required.

The release of high yielding varieties has contributed a great deal towards the improvement of greengram yields.

Many improved varieties *viz*., KKM-3, Pusa Baisaki, PS-16, TAP-7, BGS-9, DGGV-2 and Chaina Mung has been developed and released for general cultivations in Karnataka, The yield potential of these high yielding varieties can be further exploited through better agronomic practices. The gap between potential and existing yield of greengram can be bridged by using optimized spacing of various greengram varieties to improve its production by achieving optimum plant population (Sathyamoorthi *et al.*, 2012) [14]. Optimum spacing requirement depends on type of crop and cultivar, growing season and planting system. Most of short duration pulse varieties need narrow spacing, while long duration varieties perform well under wider spacing. Therefore, there is need to develop integrated crop production, pest and disease management strategies that are cost effective and ecosystem friendly.

However, information about response of newly developed greengram varieties to different dates of sowing and agronomic practices is lacking under Southern Transitional Zone of Karnataka. In the present investigation attempts have been made to identify the suitable variety with suitable agronomic practices *viz.*, time of sowing, optimum spacing with right quantity of fertilizer.

Material and Methods

Experimental Site: A field study was carried out during *Kharif* seasons of agricultural year 2015 and 2016 at College of Agriculture, University of Agricultural and Horticultural Sciences (UAHS), Navile, Shivamogga. The experimental field soil was red sandy loam in texture with lower level organic carbon (0.49%) and available nitrogen (240 kg ha^{-1}), higher level of available phosphorus (79.25 kg ha^{-1}) and medium level of available potassium (139.23 kg ha^{-1}). The area receives an total of 1232.80 mm and 574.40 mm rainfall was received during 2015 and 2016 respectively, as against the normal of 883.30 mm. Rainfall received during 2015 was 349.50 mm in excess whereas, during 2016 the rainfall received was deficit by 308.9 mm over the normal.

Treatments: The treatments included in the experiment were T_1: Variety KKM-3 spacing of 30 × 10 cm with application of 100% RDF NPK kg ha^{-1}, T_2: Variety KKM-3 spacing of 30 × 10 cm with application of 125% RDF NPK kg ha^{-1}, T_3: Variety KKM-3 spacing of 45 × 10 cm with application of 100% RDF NPK kg ha^{-1}, T_4: Variety KKM-3 spacing of 45 × 10 cm with application of 125% RDF NPK kg ha^{-1}, T_5 Variety PDM 84-178 spacing of 30 × 10 cm with application of 100% RDF NPK kg ha^{-1}, T_6: Variety PDM 84-178 spacing of 30 × 10 cm with application of 125% RDF NPK kg ha^{-1}, T_7: Variety PDM 84-178 spacing of 45 × 10 cm with application of 100% RDF NPK kg ha^{-1}, T_8: Variety PDM 84-178 spacing of 45 × 10 cm with application of 125% RDF NPK kg ha^{-1}, T_9: Variety SBM-1 spacing of 30 × 10 cm with application of 100% RDF NPK kg ha^{-1}, T_{10}: Variety SBM-1 spacing of 30 × 10 cm with application of 125% RDF NPK kg ha^{-1}, T_{11}: Variety SBM-1 spacing of 45 × 10 cm with application of 100% RDF NPK kg ha^{-1}, T_{12}: Variety SBM-1 spacing of 45 × 10 cm with application of 125% RDF NPK kg ha^{-1}. The experiment was laid out in randomized block design with factorial concept replicated in to three times.

Results and Discussion

The grain and straw yield of greengram were significantly influenced by varieties (Table 1) variety KKM-3 recorded significantly higher grain and haulm yield (1056.91 kg ha^{-1} and 4107.01 kg ha^{-1}, respectively) compared to PDM 84-178 (909.99 kg ha^{-1} and 3697.39 kg ha^{-1}, respectively) where as significantly lower grain and haulm yield was found with variety SBM-1 (746.55 kg ha^{-1} and 3097.03 kg ha^{-1}, respectively). KKM-3 registered 13.90 per cent and 29.36 per cent higher grain yield over PDM 84-178 and SBM-1 variety. In the similar line Gowda *et al.* (2018) reported that KKM-3 recorded significantly higher grain (1199 kg ha^{-1}) yield compared to other varieties grown under Shivamogga

Significantly higher grain yield in variety KKM-3 was attributed to significantly higher number of clusters per plant^{-1} (14.06) compared to PDM 84-178 (10.48 no.) and SBM-1 (8.68 no.) (Table 2). Higher number of clusters plan^{-1} contributed for higher number of pods and number of seeds per pod (42.94 and 12.16 no., respectively) than PDM 84-178 (28.90 and 8.77 no., respectively) and SBM-1 (20.53 and 6.60) (Table 4.35a) which ultimately contributed for higher grain and straw yield. In other hand pod length (Table 2) and test weight (Table 1) high in SBM-1 (14.12 cm plant^{-1} and 47.73 g plant^{-1}) than PDM 84-178 (10.25 cm plant^{-1} and 44.01 g plant^{-1}) and KKM-3 (7.41 cm plant^{-1} and 35.83 g plant^{-1}). Pod length is totally depend varietal character and test weight is depend on size of the seed.

Higher seed yield with variety KKM-3 was mainly a consequence of more number of pods per plant. Parameswarappa and Kumar, (2003) [12] reported that the performance of SEL-4 was superior over China Mung in growth, yield and yield components. The wide variations in growth and yield attributing parameters persisted among the different varieties obtained from the different parental origin. Attainments of particularly higher or lower yield attributing character among the different varieties are the genetically controlled phenomenon. Such variations in yield attributes among the greengram varieties have also been observed by Bhise *et al*. (2010) [2]. Jnanesha *et al*. (2019) [7] observed performance of different cultivar of greengram in Northern Transitional Zone of Karnataka during the year 2014-15.

Table 1: Grain yield, haulm yield, harvest index and test weight of greengram as influenced by varieties, planting density and fertilizer level

Treatments	Yield											
	Grain yield (kg ha^{-1})			Haulm yield (kg ha^{-1})			Harvest index			Test weight (g)		
Varieties (G)	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
G_1 : KKM-3	1175.76	937.99	1056.91	4438.49	3775.54	4107.01	26.61	23.67	25.51	36.25	35.42	35.83
G_2 : PDM 84-178	1011.92	816.34	909.99	3764.18	3630.60	3697.39	26.94	23.51	25.35	44.42	43.60	44.01
G_3 : SBM-1	830.26	662.83	746.55	3153.46	3040.60	3097.03	26.37	23.03	24.83	48.14	47.31	47.73
S.Em±	5.33	4.83	4.72	29.40	23.68	25.64	1.15	1.10	1.10	0.06	0.06	0.06
C.D. (P=0.05)	15.65	14.17	13.84	86.22	69.45	75.21	NS	NS	NS	0.12	0.12	NS
Planting Density (S)												
S_1 : 30 cm × 10 cm	1029.39	827.17	925.54	3738.53	3538.62	3638.58	27.47	23.86	25.72	42.48	41.65	42.07
S_2 : 45 cm × 10 cm	982.57	784.27	883.42	3832.21	3425.86	3629.04	25.81	22.94	24.74	43.39	42.57	42.98
S.Em±	3.56	3.22	3.15	19.60	15.79	17.10	1.30	1.26	1.28	0.04	0.04	0.04

C.D. (P=0.05)	10.43	9.44	9.22	NS	NS	NS	NS	NS	NS	0.12	0.12	0.12
Fertilizer levels (F)												
F_1 : 25:50:25 NPK kg ha^{-1}	951.35	759.54	855.47	3628.10	3369.30	3498.70	26.40	23.46	25.29	42.75	41.92	42.34
F_2 : 31.25:62.5:31.25 NPK kg ha^{-1}	1060.61	851.90	953.50	3942.65	3595.19	3768.92	26.88	23.35	25.17	43.12	42.30	42.71
S.Em±	3.56	3.22	3.15	19.60	15.79	17.10	1.10	1.06	1.07	0.04	0.04	0.04
C.D. (P=0.05)	10.43	9.44	9.22	57.48	46.30	50.14	NS	NS	NS	0.12	0.12	0.12

Table 2: Number Clusters plant^{-1}, pods plant^{-1}, seeds pod^{-1}and pod length of greengram as influenced by varieties, planting density and fertilizer levels

Treatments	Yield components											
	Number of clusters plant^{-1}			Number of pods plant^{-1}			Number of seeds pod^{-1}			Pod length (cm)		
Varieties (G)	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
G_1 : KKM-3	15.56	12.55	14.06	48.25	37.63	42.94	12.70	11.62	12.16	7.36	7.47	7.41
G_2 : PDM 84-178	11.60	9.36	10.48	32.47	25.33	28.90	9.16	8.38	8.77	10.19	10.31	10.25
G_3 : SBM-1	9.61	7.75	8.68	23.07	17.99	20.53	6.89	6.30	6.60	14.07	14.18	14.12
S.Em±	0.04	0.03	0.03	0.09	0.07	0.08	0.05	0.05	0.05	0.02	0.02	0.02
C.D. (P=0.05)	0.10	0.08	0.09	0.28	0.22	0.25	0.15	0.14	0.14	0.06	0.06	0.06
Planting Density (S)												
S_1 : 30 cm X 10 cm	12.66	10.21	11.43	35.76	27.89	31.83	9.81	8.97	9.39	10.61	10.72	10.66
S_2 : 45 cm X 10 cm	11.86	9.57	10.71	33.43	26.08	29.75	9.36	8.56	8.96	10.47	10.58	10.53
S.Em±	0.02	0.02	0.02	0.06	0.05	0.06	0.03	0.03	0.03	0.01	0.01	0.01
C.D. (P=0.05)	0.07	0.06	0.06	0.19	0.14	0.17	0.10	0.09	0.10	0.04	NS	0.02
Fertilizer levels (F)												
F_1 : 25:50:25 NPK kg ha^{-1}	12.00	9.68	10.84	33.88	26.42	30.15	9.44	8.64	9.04	10.54	10.66	10.60
F_2 : 31.25:62.5:31.25 NPK kg ha^{-1}	12.51	10.09	11.30	35.31	27.55	31.43	9.72	8.90	9.31	10.54	10.65	10.59
S.Em±	0.02	0.02	0.02	0.06	0.05	0.06	0.03	0.03	0.03	0.01	0.01	0.01
C.D. (P=0.05)	0.07	0.06	0.06	0.19	0.14	0.17	0.10	NS	NS	NS	NS	NS

Effect of spacing on crop growth and yield of greengram

Spacing is one of the most important cultural practices to determine the grain yield. Stand density affects architecture, alters growth and development pattern and influence carbohydrate production and partition. Ideally spaced equidistantly from each other competes minimally for nutrients and other growth factors. Narrow rows make more efficient use of available light and also shade the surface soil completely during the early part of the season while the soil is still moist. This results in lower moisture evaporation from the soil surface. With the utilization of higher densities, it soon became clear that distribution within the row could be a limiting factor in wide rows, preventing the full expression of the crop yield potential. Therefore, reducing row width to provide a more equi distancing pattern has the potential to increase crop yield and shift optimum population to a higher value depending on the interactions with management and environmental factors (Malik, 2008) [9].

Grain yield in crop is the results of a number of complex morphological and physiological processes affecting each other and occurring at different growth stages during vegetative period. Significantly higher grain yield of greengram was found with the recommended (30 × 10 cm) spacing (925.54 kg ha^{-1}) followed by 45 × 10 cm spacing (883.42 kg ha^{-1}). Recommended spacing had higher population (3,33,333 ha^{-1}) per unit area. The higher population helps to get more number of clusters per unit area which resulted in higher grain yield of greengram (Table 1). The increase in grain yield due to narrow row spacing was 4.5 percent higher than wider spacing. This might be due to reduction in population per unit area under wider spacing can not compensate for total yield, which result in lower yield. The increased pods per plant production in wider spacing, however, it was not reflected in the total grain production. It may be explained as the increase in number of pods per plant in wider spacing did not compensate for higher population. Similar observation also recorded by Kachare *et al*. (2009) [8].

With respect to haulm yield there is no significance difference with in two spacing levels but higher haulm yield recorded with spacing of 30 × 10 cm (3638.58 kg ha^{-1}) compared with 45 × 10 cm (3629.04 kg ha^{-1}) (Table 4.36a), The increase in biomass production at narrow spacing's might be attributed to the increased population due to many numbers of rows. Higher biomass yield was obtained at the narrower row spacing than wider row spacing this might be due to better resource utilization in narrow rows than wider rows. This finding is in conformity with the finding of Ihsanullah *et al.* (2002) [6] who reported that more biomass was produced at narrow row spacing than wider spacing. Shukla and Dixit (1996) [15] reported that lower population, individual performance is better than that of higher population but within tolerable limit higher population produces higher yield ha^{-1}.

Higher grain and straw yield was obtained with narrow spacing geometry (30 × 10 cm) is directly proportional to yield components and growth components was found better with narrowing geometry (30 × 10 cm). It was mainly because of higher space, moisture, light and nutrient availability in wider planting geometry resulting in higher yield and growth components of greengram.

Narrow spacing (30 × 10 cm) had significantly higher number of clusters^{-1} (11.43), number of pods plant^{-1} (31.83), number of seeds plant^{-1} (9.39), and test weight (10.66 g 100 seeds plant^{-1}) and significantly lower number of number of clusters plant^{-1} (10.71), number of pods plant^{-1} (29.75) and number of seeds plant^{-1} (8.96) were observed with spacing (45 × 10 cm). The difference in the yield components due to variation in planting geometry was mainly due to availability of nutrient, light and moisture. The higher yield components are resultant of higher growth parameters obtained throughout the crop growing period (Table 4.37a). Higher yield attributes like number of pods and seeds per plant with wider row spacing which may be attributed to the less dropping of the flowers and immature fruits. However, 100-seed weight and harvest index did differ significantly with the variation in the plant density. Similar observations were made by Mansur (2003) [10].

Effect of fertilizer levels on crop growth and yield of greengram

With the advancement of high yielding varieties, the era of external application of nutrients or external responsiveness initiated. Thereafter, in agriculture, the practice of mineral nutrition is routinely manipulated to increase the yield. In the list of agro-inputs, plant nutrient takes lion share and adequate supply of essential nutrients in a balanced way has become the talk of an issue for getting not only good yield but also from the point of soil health. The use of inorganic fertilizers is essential to meet the nutrients demand of crop to get maximum yield (Tomar, 1993) [16]. Greengram 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, phosphorus and potassium significantly influence the growth and yield of greengram.

The grain and straw yield (Table 1) of greengram nutrition with 25:50:25 N, P_2O5 and K_2O was 855.47 and 3498.70 kg ha^{-1} respectively, which increased to 953.50 and 3768.92 kg ha^{-1} due to 125 per cent higher recommended dose *i.e.* 31.25:62.5:31.25 kg N, P_2O_5 and K_2O ha^{-1}. These results are in line with Das *et al.* (2002) [4]

Economic yield is expressed as a function of factors that contribute to yield. The variations in yield due to treatments could be attributed to the variations in the yield attributing parameters. The major yield attributes in greengram are number of clusters plant^{-1}, number of pods plant^{-1}, number of seeds per pod and pod length (cm) (Table 2). Higher grain yield was the reflection of improved yield components as evident by number of clusters plant^{-1} and number of pods plant^{-1}, (11.30 and 31.43, respectively) in 125 per cent recommended dose of fertilizer (31.25: 62.5:31.25 kg N, P_2O_5 and K_2O ha^{-1}) as compared to application of recommended dose of fertilizer (25:50:25 kg N, P_2O_5 and K_2O ha^{-1}). These results are in conformity of the findings of Rathore (2010) [13]. The difference in the performance of yield attributes in different nutrient sources was because of higher growth attributes and availability of nutrients to the crop at right time in right proportion. Good crop growth is one of the symbols of higher total dry matter accumulation.

Table 3: Interaction effect of varieties, different planting density and fertilizer levels on grain yield, haulm yield, harvest index and test weight of green gram

Grain yield (kg ha^{-1})	S_1 : 30 × 10 cm						S_2 : 45 × 10 cm					
	F_1 : 25:50:25 NPK kg ha^{-1}			F_2 : 31.25:62.5:31.25 NPK kg ha^{-1}			F_1 : 25:50:25 NPK kg ha^{-1}			F_2 : 31.25:62.5:31.25 NPK kg ha^{-1}		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
G_1 : KKM-3	1045.23	834.71	939.97	1363.65	1086.9	1225.25	1060.33	847.00	953.64	1233.81	983.70	1108.74
G_2 : PDM 84-178	974.00	778.02	876.01	1085.66	866.8	976.24	960.33	766.60	863.44	1027.66	820.80	924.24
G_3 : SBM-1	889.18	709.70	799.44	876.60	700.00	788.32	779.00	621.50	700.27	776.25	620.00	698.14
S.Em±	21.33	16.42	18.87	21.33	16.42	18.87	21.33	16.42	18.87	21.33	16.42	18.87
C.D. (P=0.05)	62.58	48.18	55.34	62.58	48.18	55.34	62.58	48.18	55.34	62.58	48.18	55.34
Haulm yield (kg ha^{-1})	S_1 : 30 × 10 cm						S_2 : 45 × 10 cm					
	F_1 : 25:50:25 NPK kg ha^{-1}			F_2 : 31.25:62.5:31.25 NPK kg ha^{-1}			F_1 : 25:50:25 NPK kg ha^{-1}			F_2 : 31.25:62.5:31.25 NPK kg ha^{-1}		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
G_1 : KKM-3	3742.90	3457.31	3600.10	4838.86	4294.84	4566.85	4228.14	3976.14	4102.14	4581.43	4351.41	4466.42
G_2 : PDM 84-178	3528.68	3227.82	3378.25	3703.31	3416.19	3559.75	3618.55	3329.51	3474.03	3947.64	3673.46	3810.55
G_3 : SBM-1	3262.42	2940.92	3101.67	3190.79	2977.19	3233.99	3122.58	2791.54	2957.06	3045.94	2708.20	2877.07
S.Em±	91.75	106.50	96.01	91.75	106.50	96.01	91.75	106.50	96.01	91.75	106.50	96.01
C.D. (P=0.05)	269.09	312.34	281.59	269.09	312.34	281.59	269.09	312.34	281.59	269.09	312.34	281.59
Harvest index (HI)	S_1 : 30 × 10 cm						S_2 : 45 × 10 cm					
	F_1 : 25:50:25 NPK kg ha^{-1}			F_2 : 31.25:62.5:31.25 NPK kg ha^{-1}			F_1 : 25:50:25 NPK kg ha^{-1}			F_2 : 31.25:62.5:31.25 NPK kg ha^{-1}		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
G_1 : KKM-3	27.92	24.14	26.03	28.27	25.29	26.78	25.45	21.72	23.58	26.93	22.65	24.79
G_2 : PDM 84-178	27.60	24.10	25.85	27.77	24.07	25.92	26.65	23.23	24.94	27.52	23.62	25.57
G_3 : SBM-1	27.27	24.14	25.70	26.67	23.58	25.13	24.97	22.30	23.64	25.60	22.99	24.30
S.Em±	0.63	0.54	0.56	0.63	0.54	0.56	0.63	0.54	0.56	0.63	0.54	0.56
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Test weight (g)	S_1 : 30 × 10 cm						S_2 : 45 × 10 cm					
	F_1 : 25:50:25 NPK kg ha^{-1}			F_2 : 31.25:62.5:31.25 NPK kg ha^{-1}			F_1 : 25:50:25 NPK kg ha^{-1}			F_2 : 31.25:62.5:31.25 NPK kg ha^{-1}		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
G_1 : KKM-3	35.12	34.29	34.71	35.86	35.04	35.45	36.46	35.64	36.05	37.53	36.71	37.12
G_2 : PDM 84-178	43.40	42.57	42.99	44.43	43.61	44.02	44.90	44.07	44.49	44.96	44.13	44.54
G_3 : SBM-1	48.40	47.57	47.99	47.65	46.83	47.24	48.21	47.38	47.80	48.30	47.47	47.88
S.Em±	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
C.D. (P=0.05)	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70

Table 4: Interaction effect of varieties, planting density and fertilizer level on clusters plant^{-1}, pods plant^{-1}, seeds pod^{-1}and pod length in greengram

Number of clusters plant^{-1}	**S_1 : 30 × 10 cm**						**S_2 : 45 × 10 cm**					
	F_1 : 25:50:25 NPK kg ha^{-1}			**F_2 : 31.25:62.5:31.25 NPK kg ha^{-1}**			**F_1 : 25:50:25 NPK kg ha^{-1}**			**F_2 : 31.25:62.5:31.25 NPK kg ha^{-1}**		
	2015	**2016**	**Pooled**	**2015**	**2016**	**Pooled**	**2015**	**2016**	**Pooled**	**2015**	**2016**	**Pooled**
G_1 : KKM-3	15.70	12.67	14.19	16.95	13.68	15.31	14.56	11.74	13.15	15.04	12.13	13.59
G_2 : PDM 84-178	11.61	9.37	10.49	12.04	9.71	10.87	11.45	9.24	10.34	11.29	9.11	10.20
G_3 : SBM-1	9.70	7.82	8.76	9.70	7.82	8.76	9.00	7.26	9.94	9.80	7.91	8.86
S.Em±	0.14	0.11	0.13	0.14	0.11	0.13	0.14	0.11	0.13	0.14	0.11	0.13
C.D. (P=0.05)	0.41	0.33	0.37	0.41	0.33	0.37	0.41	0.33	0.37	0.41	0.33	0.37
Number of pods plant^{-1}	**S_1 : 30 × 10 cm**						**S_2 : 45 × 10 cm**					
	F_1 : 25:50:25 NPK kg ha^{-1}			**F_2 : 31.25:62.5:31.25 NPK kg ha^{-1}**			**F_1 : 25:50:25 NPK kg ha^{-1}**			**F_2 : 31.25:62.5:31.25 NPK kg ha^{-1}**		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
G_1 : KKM-3	48.67	37.97	43.32	52.55	40.99	46.77	45.14	35.21	40.17	46.63	36.37	41.50
G_2 : PDM 84-178	32.51	25.36	28.93	33.70	26.29	30.00	32.06	25.01	28.53	31.62	24.67	28.15
G_3 : SBM-1	23.27	18.15	20.71	23.86	18.61	21.23	19.01	18.98	19.23	23.53	18.35	20.94
S.Em±	0.21	0.19	0.20	0.21	0.19	0.20	0.21	0.19	0.20	0.21	0.19	0.20
C.D. (P=0.05)	0.60	0.55	0.58	0.60	0.55	0.58	0.60	0.55	0.58	0.60	0.55	0.58
Number of seeds pod	**S_1 : 30 × 10 cm**						**S_2 : 45 × 10 cm**					
	F_1 : 25:50:25 NPK kg ha^{-1}			**F_2 : 31.25:62.5:31.25 NPK kg ha^{-1}**			**F_1 : 25:50:25 NPK kg ha^{-1}**			**F_2 : 31.25:62.5:31.25 NPK kg ha^{-1}**		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
G_1 : KKM-3	12.69	11.61	12.15	12.87	11.78	12.33	12.77	11.68	12.23	12.48	11.42	11.95
G_2 : PDM 84-178	9.19	8.41	8.80	9.43	8.63	9.03	8.77	8.02	8.40	9.25	8.46	8.86
G_3 : SBM-1	6.93	6.35	6.64	7.73	7.07	7.40	6.30	5.76	6.03	6.60	6.03	6.31
S.Em±	0.21	0.19	0.20	0.21	0.19	0.20	0.21	0.19	0.20	0.21	0.19	0.20
C.D. (P=0.05)	0.60	0.55	0.58	0.60	0.55	0.58	0.60	0.55	0.58	0.60	0.55	0.58
Pod length	**S_1 : 30 × 10 cm**						**S_2 : 45 × 10 cm**					
	F_1 : 25:50:25 NPK kg ha^{-1}			**F_2 : 31.25:62.5:31.25 NPK kg ha^{-1}**			**F_1 : 25:50:25 NPK kg ha^{-1}**			**F_2 : 31.25:62.5:31.25 NPK kg ha^{-1}**		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
G_1 : KKM-3	7.51	7.62	7.57	7.51	7.62	7.57	7.20	7.22	7.21	7.21	7.32	7.27
G_2 : PDM 84-178	10.08	10.19	10.13	10.34	10.46	10.40	10.18	10.29	10.23	10.18	10.29	10.23
G_3 : SBM-1	14.21	14.32	14.27	13.99	14.11	14.05	14.08	14.19	14.13	13.98	14.09	14.03
S.Em±	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
C.D. (P=0.05)	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22

Interaction between varieties, spacing and fertilizer level (G × S × F) on growth and yield of greengram

The interaction effect of varities, spacing and fertilizer level from pooled data of two years differed significantly. Significantly higher seed yield and haulm yield was noticed with variety KKM-3 sown at spacing of 30 × 10 cm with application of 125 per cent recommended dose of fertilizer (31.25:62.5:31.25 kg N, P_2O_5 and K_2O ha^{-1}) (G1S1F$_2$) (1225.25 and 4566. 85 kg ha^{-1}, respectively) and followed by KKM-3 sown at spacing of 45 ×10 cm with application of 100 per cent recommended dose of fertilizer (25:50:25 kg N, P_2O_5 and K_2O ha^{-1}) ($G_1S_2F_2$) (1108.74 and 4466.42 kg ha^{-1}, respectively) compared to other interactions. Significantly lower seed yield recorded in SBM-1 sowing at 45 × 10 cm spacing with application of 125 per cent recommended dose of fertilizers (31.25:62.5:31.25 kg N, P_2O_5 and K_2O ha^{-1}) ($G_3S_2F_2$) (698.14 and 2877.07 kg ha^{-1}, respectively) which is on par with SBM-1 sown with spacing of 30 x 10 cm with application of 125 per cent recommended dose of fertilizer (31.25:62.5:31.25 kg N, P_2O_5 and K_2O ha^{-1}) ($G_3S_1F_2$) (788.32 and 3233.99 kg ha^{-1}, respectively) (Tables 3).

Interaction effect between varieties, planting geometry and fertilizer level found significant with test weight (Table 3) and pod length plant^{-1} (Table 4). Significantly test weight plant^{-1} and pod length (47.99 g and 14.27 cm) was observed in variety SBM-1 at 30 × 10 cm spacing with application of recommended dose of fertilizers (25:50:25 kg N, P_2O_5 and K_2O ha^{-1}) ($G_3S_1F_1$) which was on par with variety SBM-1 sowing at 30 ×10 cm spacing with application of 125 per cent recommended dose of fertilizers (31.25:62.5:31.25 kg N, P_2O_5 and K_2Oha^{-1}) ($G_3S_1F_2$) (47.24 g and 14.05 cm). Significantly lower pod length (7.21 cm) and test weight (36.05 g) was recorded in KKM-3 sowing at 45 × 10 cm with application of recommended dose of fertilizers (25:50:25 kg N, P_2O_5 and K_2O ha^{-1}) ($G_1S_2F_1$).

Higher grain yield was due to higher number of clusters plant^{-1}, number of pods plant^{-1} and number of seeds (Table 4). Significantly higher clusters plant^{-1} (15.31 no.), number of pods plant^{-1} (46.77) and number of seeds (12.33) recorded in KKM-3 sown at spacing of 30 × 10 cm with application of 125 per cent recommended dose of fertilizer (31.25:62.5:31.25 kg N, P_2O_5 and K_2O ha^{-1}) ($G_1S_1F_2$), which is on par with other early sowing of all varieties significantly lower higher clusters plant^{-1} (9.94), number of pods plant^{-1} (19.23) and number of seeds (6.03) recorded SBM-1 sowing at 45 × 10 cm spacing with application of 100 per cent recommended dose of fertilizers (25:50:25 kg N, P_2O_5 and K_2O ha^{-1}) ($G_3S_2F_1$).

Conclusion

The present study concludes that varieties, spacing and fertilizer level from pooled data of two years differed significantly. Significantly higher seed yield and haulm yield was noticed with variety KKM-3 sown at spacing of 30 × 10 cm with application of 125 per cent recommended dose of fertilizer and followed by KKM-3 sown at spacing of 45 ×10 cm with application of 100 per cent recommended dose of fertilizer compared to other treatments.

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