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EFFECT OF INTEGRATED NUTRIENT MANAGEMENT AND SPACING ON GROWTH AND YIELD PARAMETERS OF BLACK GRAM CV. LBG-625 (RASHMI)

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ABSTRACT
A field experiment was conducted at Department of Seed Science and Technology, GKVK, UAS, Bangalore during kharif 2012 to assess the response of nutrient levels and spacing on growth and yield attributes of Black gram cv. LBG-625 (Rashmi). Experimental results revealed that fertilizer application of 50:100:100 NPK kg ha^{-1} + Black gram *rhizobia* (250 g ha^{-1}) + PSB- *Bacillus megaterium* (250 g ha^{-1}) with the spacing of 60 x 10 cm recorded significantly higher number of branches plant^{-1} (5.60), number of leaves plant^{-1} (29.87), plant spread plant^{-1} (756.00), number of cluster plant^{-1} (14.07), number of pods cluster^{-1} (22.60), number of pods plant^{-1} (54.40), pod weight plant^{-1} (g) (22.60), seed recovery per cent (98.45) and processed seed yield (q ha^{-1}) (15.83) as compared to rest of the treatments. Hence, it can be concluded that the application of 50:100:100 NPK kg ha^{-1} + Black gram *rhizobia* (250 g ha^{-1}) + PSB- *Bacillus megaterium* (250 g ha^{-1}) with the spacing of 60 x 10 cm would be useful to enhance the productivity of black gram. The conjunctive use of inorganic fertilizers and biofertilizer may be suggested for higher productivity along with overall betterment.

INTRODUCTION

Black gram (*Vigna mungo* L. Hepper) is one of the most important pulse crops among the various grain legumes. According to vavilov (1951) it is native to India, belong to the family Leguminaceae. It is a rich protein food, contains about 26% protein, 1.2% fat and 56.6% carbohydrates on dry weight basis and it is rich source of calcium and iron.

One of the most important challenges facing humanity today is to conserve/sustain natural resources, including soil and water, for increasing food production while protecting the environment. As the world population grows, stress on natural resources increases, making it difficult to maintain food security. Long term food security requires a balance between increasing crop production, maintaining soil health and environmental sustainability. In India, effective nutrient management has played a major role in accomplishing the enormous increase in food grain production from 52 million tons in 1951-52 to 230 million tons during 2007-08. However, application of imbalanced and/or excessive nutrients led to declining nutrient-use efficiency making fertilizer consumption uneconomical and producing adverse effects on atmosphere (Aulakh and Adhya, 2005) and groundwater quality (Aulakh *et al.*, 2009) causing health hazards and climate change. On other hand, nutrient mining has occurred in many soils due to lack of affordable fertilizer sources and where fewer or no organic residues are returned to the soils. Soils of Karnataka are inherently poor in organic matter, fertility and water-holding capacity. In these soils, N, P and S deficiencies are principal yield-limiting factors for crop production. INM, which entails the maintenance/adjustment of soil fertility to an optimum level for crop productivity to obtain the maximum benefit from all possible sources of plant nutrients – organics as well as inorganics – in an integrated manner (Aulakh and Grant 2008; Sangeeta *et al.*, 2014), is an essential step to address the twin concerns of nutrient excess and nutrient depletion. INM is also important for marginal farmers who cannot afford to supply crop nutrients through costly chemical fertilizers (Aulakh, 2009). The biofertilizers have shown encouraging results in sustaining the crop productivity and improving the soil fertility (Govindan and Thirumurugan, 2005). Ghosh and Joseph (2008) also reported that pulse crop inoculated with Rhizobium culture significantly recorded higher number of pods, number of seeds, test weight and seed yield. Organic manures, on the other side provide a good substrate for the growth of micro-organisms and maintain a favourable nutrient supply environment and improve soil physical properties.

Therefore, the aforesaid consequences have paved way to increase the productivity of crops using the combination of inorganic sources and biofertilizers. Thus, integrated approach of nutrient supply by chemical fertilizers along with biofertilizers is gaining importance as this system not only reduces the use of excessive use of inorganic fertilizers, but sustaining the crop productivity by improving soil health and is also an environment-friendly approach. Integration of inorganic fertilizers and biofertilizers resulted in better growth, yield and nutrient uptakes in black gram (Kumpawat, 2010), green gram (Mandal and Pramanick, 2014), sesame (Nayek *et al.,* 2014) and rice (Kumar *et al.,* 2014) as compared to sole application of inorganic fertilizers. However, information on the conjunctive use of inorganic fertilizers and biofertilizers is lacking in many crops including black gram. The optimum plant density can provide congenial conditions to have maximum light interruption right from early growth stage to pod filling stage. By changing the plant spacing, it is possible to achieve optimum vegetative and reproductive growth to boost up crop productivity per unit area (Anilkumar, 2004). Hence, keeping above facts in view, the present investigation was carried out to study the effect of integrated nutrient management practices on growth and yield parameters of black gram cv. LBG 625 (Rashmi).

MATERIALS AND METHODS

The experiment was conducted at Department of Seed Science and Technology, Gandhi Krishi Vignana Kendra campus, University of Agricultural Sciences, Bangalore during *Kharif* 2012-13. There were ten treatments with three spacing levels and laid out in factorial randomized block design with three replications. The treatments combinations includes T_1 :25:50:25 RDF NPK kg ha^{-1}, T_2 :31.25:62.50:31.25 NPK kg ha^{-1} (25% enhanced dosage), T_3 :37.50:75:37.50 NPK kg ha^{-1} (50% enhanced dosage), T_4 :43.75:87.50:43.75 NPK kg ha^{-1} (75% enhanced dosage), T_5 :50:100:100 NPK kg ha^{-1} (100% enhanced dosage), T_6 :25:50:25 NPK kg ha^{-1} + Black gram *rhizobia*(250 g ha^{-1}) + PSB- *Bacillus megaterium* (250 g ha^{-1}), T_7 :31.25:62.50:31.25 NPK kg ha^{-1} + Black gram *rhizobia*(250 g ha^{-1}) + PSB- *Bacillus megaterium* (250 g ha^{-1}), T_8 :37.50:75:37.50 NPK kg ha^{-1} + Black gram *rhizobia*(250 g ha^{-1}) + PSB- *Bacillus megaterium* (250 g ha^{-1}), T_9 :43.75:87.50:43.75 NPK kg ha^{-1} + Black gram *rhizobia*(250 g ha^{-1}) + PSB- *Bacillus megaterium* (250 g ha^{-1}), T_{10}:50:100:100 NPK kg ha^{-1} + Black gram *rhizobia*(250 g ha^{-1}) + PSB- *Bacillus megaterium* (250 g ha^{-1}), S_1:30 x 10 cm, S_2:45 x 10 cm and S_3:60 x 10 cm.

The calculated quantity of N, P_2O_5 and K_2O in the form of urea, single super phosphate and muriate of potash, respectively were supplied as per the treatments at the time of sowing. Black gram cv. LBG 625 (Rashmi) seeds were treated with Black gram *rhizobia* and *Bacillus megaterium* and sown on 4th of August 2012 at an inter and intra row spacing of 30x10, 45x10 and 60x10 cm respectively. Five plants per plot were selected randomly in the net plot area and tagged for recording growth and yield parameters. The results were analyzed statistically to draw suitable inference as per standard ANOVA technique described by Gomez and Gomez (1984) and the level of significance used in 'F' and 't' test was five per cent.

RESULTS AND DISCUSSION

Effect of fertilizer

Significant differences were noticed on growth, seed yield and yield attributing characters of Black gram with the application of fertilizers. Significantly highest plant height (42.97cm), number of branches $plant^{-1}$ (5.53), number of leaves per plant (25.91), plant spread $plant^{-1}$ (518.33), number of nodules per plant (5.78) at harvest and days to maturity was recorded with an application of 50:100:100 NPK kg ha^{-1} + Black gram *rhizobia* 250 g ha^{-1} + PSB- *Bacillus megaterium* 250 g ha^{-1} compared to other treatments (Table 1). More number of branches, leaves and plant spread might be due to less internodal elongation and combine application of inorganic nutrients and biofertilizers increase the use efficiency of added nutrients and supply it continuously to the plant throughout the crop growth period and promoted various physiological activities in plant which are consider being indispensable for proper growth and development. The highest number of nodules might be due to increased nitrogenase activity by

Table 1: Influence of nutrient levels (T) and spacing (S) on growth parameters of black gram cv. LBG 625 (Rashmi)

Nutrient levels	Plant height (cm)	Number of branches per plant	Number of leaves per plant	Plant spread $plant^{-1}$	Number of nodules per plant	Days to50% flowering	Days to maturity
T_1	40.20	4.07	19.27	333.78	4.38	44.40	76.13
T_2	40.44	4.60	22.09	357.67	4.73	42.40	75.80
T_3	40.87	4.40	23.67	380.67	4.51	43.40	75.60
T_4	40.92	4.47	23.53	400.00	4.71	43.20	75.40
T_5	41.07	4.73	23.58	415.67	4.73	43.00	75.07
T_6	41.89	5.20	23.76	435.67	4.98	42.80	75.07
T_7	41.87	5.27	24.22	455.67	5.40	42.60	74.80
T_8	42.07	5.33	24.53	475.67	5.53	42.40	74.67
T_9	42.69	5.33	24.96	491.67	5.71	42.20	74.40
T_{10}	42.97	5.53	25.91	518.33	5.78	40.17	73.24
F test	*	*	*	*	*	*	*
S. Em ±	0.04	0.10	0.16	1.94	0.02	0.06	0.13
C.D (P=0.05)	0.10	0.27	0.46	5.49	0.04	0.17	0.36
Spacing (cm)							
S_1:(30x10)	42.93	4.76	20.81	254.87	4.98	43.25	75.23
S_2:(45x10)	42.28	4.90	23.31	397.03	5.15	42.71	75.00
S_3:(60x10)	39.29	5.02	26.53	627.53	5.01	42.01	74.81
F test	*	*	*	*	*	*	*
S. Em ±	0.02	0.05	0.09	1.06	0.01	0.03	0.07
C.D (P=0.05)	0.06	0.15	0.25	3.01	0.02	0.09	0.20

Table 2: Growth parametersof black gram cv. LBG 625 (Rashmi) as influenced by the interaction of nutrient levels (T) and spacing (S)

Nutrient levels	Plant height (cm)			Number of branches plant-1			Number of leaves plant-1		
	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
T_1	41.4	41.53	37.67	3.6	4.6	4	19	19.2	19.6
T_2	41.6	41.73	38	4.4	4.6	4.8	20.33	21.4	24.53
T_3	42.47	41.93	38.2	4.2	4.4	4.6	21.2	23.2	26.6
T_4	42.47	41.7	38.6	4.6	4	4.8	21.33	23.2	26.07
T_5	42.67	42.13	38.4	4.8	4.6	4.8	21.13	23.2	26.4
T_6	43.53	42.33	39.8	5	5.2	5.4	20.73	23.47	27.07
T_7	43.33	42.67	39.6	5.2	5.4	5.2	20.67	24.13	27.87
T_8	43.4	42.6	40.2	5	5.4	5.6	20.8	24.4	28.4
T_9	44.07	43	41	5.4	5.2	5.4	21	24.93	28.93
T_{10}	44.33	43.17	41.4	5.4	5.6	5.6	21.87	26	29.87
F test	*	*	*	*	*	*	*	*	*
S. Em ±	0.06	0.06	0.06	0.16	0.16	0.16	0.28	0.28	0.28
C.D (P=0.05)	0.18	0.18	0.18	0.47	0.47	0.47	0.79	0.79	0.79

Nutrient levels	Plant spread plant-1			Effective nodules			Days to 50 % flowering		
	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
T_1	205.33	304	492	4.4	4.6	4.13	46.8	43.6	42.8
T_2	219.33	334.33	519.33	4.6	4.8	4.8	40.4	43.8	43
T_3	225	357	560	4.4	4.53	4.6	44.2	43.4	42.6
T_4	238	374	588	4.6	4.73	4.8	44	43.2	42.4
T_5	240	391	616	4.6	4.8	4.8	43.8	43	42.2
T_6	255	408	644	5	5.13	4.8	43.6	42.8	42
T_7	270	425	672	5.4	5.6	5.2	43.4	42.6	41.8
T_8	285	442	700	5.4	5.6	5.6	43.2	42.4	41.6
T_9	288	459	728	5.6	5.73	5.8	43	42.2	41.4
T_{10}	323	476	756	5.8	5.93	5.6	40.1	40.14	40.27
F test	*	*	*	*	*	*	*	*	*
S. Em ±	3.36	3.36	3.36	0.03	0.03	0.03	0.11	0.11	0.11
C.D (P=0.05)	9.52	9.52	9.52	0.08	0.08	0.08	0.3	0.3	0.3

Table 3: Yield attributes and seed yield of black gram cv. LBG 625 (Rashmi) as influenced by the interaction of nutrient levels (T) and spacing (S)

Nutrient levels	Number of clusters plant-1	Number of pods plant-1	Pod weight plant-1 (g)	Pod length (cm)	Number of seeds pod-1	Seed recovery per cent	Processed seed yield (q ha-1)
T_1	8.09	33.87	12.20	5.18	5.82	91.54	10.83
T_2	8.60	36.76	12.67	5.38	6.18	91.79	11.11
T_3	8.92	36.24	12.60	5.46	6.09	95.45	10.56
T_4	9.21	35.56	12.78	5.58	6.36	94.56	10.83
T_5	9.35	37.24	13.44	5.63	6.98	95.61	11.39
T_6	9.04	36.84	13.96	5.56	7.09	93.52	13.06
T_7	10.20	41.58	14.53	5.70	7.20	93.04	12.50
T_8	10.41	41.58	15.43	5.75	7.49	92.44	12.78
T_9	10.63	43.11	15.60	5.85	7.71	94.27	12.78
T_{10}	11.00	46.11	15.87	5.97	7.84	97.58	13.61
F test	*	*	*	*	*	*	*
S. Em ±	0.20	0.15	0.03	0.10	0.12	0.09	0.06
C.D (P=0.05)	0.57	0.43	0.09	0.27	0.34	0.24	0.17
Spacing (cm)							
S_1:(30x10)	7.08	23.39	9.48	5.40	5.48	93.36	10.00
S_2:(45x10)	9.08	40.27	13.22	5.52	6.61	93.62	11.39
S_3:(60x10)	12.48	53.01	19.03	5.90	8.54	94.96	14.44
F test	*	*	*	*	*	*	*
S. Em ±	0.11	0.08	0.02	0.05	0.07	0.05	0.03
C.D (P=0.05)	0.31	0.24	0.05	0.15	0.18	0.13	0.09

Rhizobium and PSB produce growth hormones, *i.e.* IAA, auxins, gibberrllins and vitamins which are conductive to better nodulation.Similar finding was reported by Shrikant Vadgave (2010) in green gram, Dusica Delica *et al.* (2011) in mung bean and Anupama kumari *et al.* (2012) in field pea.

The less number of days taken to 50 per cent flowering (40.17 days) was observed with the application of 25:50:25 RDF NPK kg ha-1(Table 1). Induction of early flowering due to application of bio fertilizers was mainly ascribed to the process of bio regulators which have an influence on early flower

Table 4: Yield attributes and seed yield of black gram cv. LBG 625 (Rashmi) as influenced by the interaction of nutrient levels (T) and spacing (S)

Nutrient levels	Number of cluster plant^{-1}			Number of podsplant^{-1}			Number of podsplant^{-1}			Number of seedspod^{-1}			Seed recovery (%)			Processed seed yield (q ha^{-1})		
	S_1	S_1	S_1	S_1	S_1	S_3	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
T_1	5.47	18.00	8.00	8.00	8.00	16.60	8.00	12.00	16.60	4.60	5.47	7.40	91.67	90.91	92.05	9.17	11.11	11.94
T_2	5.99	21.93	9.00	9.00	9.00	16.80	9.00	12.20	16.80	4.80	6.07	7.67	92.67	90.38	92.31	8.33	11.94	13.06
T_3	6.30	20.40	9.40	9.40	9.40	16.60	9.40	11.80	16.60	4.93	5.73	7.60	93.50	95.98	96.88	8.89	9.17	13.89
T_4	7.84	19.07	9.20	9.20	9.20	17.07	9.20	12.07	17.07	4.87	6.20	8.00	95.40	93.75	94.53	9.72	9.17	13.89
T_5	6.57	21.60	9.00	9.00	9.00	17.93	9.00	13.40	17.93	5.53	6.87	8.53	92.00	96.55	98.28	10.83	9.17	14.44
T_6	7.07	20.13	9.60	9.60	9.60	18.67	9.60	13.60	18.67	5.73	6.93	8.60	94.58	91.46	94.51	11.11	13.06	14.72
T_7	7.72	27.40	10.00	10.00	10.00	20.20	10.00	13.40	20.20	5.87	6.87	8.87	92.11	92.67	94.36	8.89	13.06	15.28
T_8	7.83	25.93	10.10	10.10	10.10	21.80	10.10	14.40	21.80	6.00	7.13	9.33	92.00	92.00	93.33	10.56	12.50	15.56
T_9	7.77	26.80	10.20	10.20	10.20	22.00	10.20	14.60	22.00	6.13	7.27	9.73	93.00	94.90	94.90	10.83	11.94	15.83
T_{10}	8.27	32.60	10.30	10.30	10.30	22.60	10.30	14.70	22.60	6.33	7.53	9.67	96.70	97.59	98.45	11.11	13.89	15.83
F test	*	*	*	*	*	*	*	*	*	NS	NS	NS	*	*	*	*	*	*
S. Em ±	0.35	0.26	0.06	0.06	0.06	0.06	0.06	0.06	0.06	-	-	-	0.15	0.15	0.15	0.11	0.11	0.11
C.D (P=0.05)	0.98	0.75	0.16	0.16	0.16	0.16	0.16	0.16	0.16	-	-	-	0.42	0.42	0.42	0.30	0.30	0.30

initiation. The results are in agreement with findings of Mahesh babu *et al.* (2008) in soybean and Kathiravan *et al.* (2008) in lablab.

Application of 50:100:100 NPK kg ha^{-1} + Black gram *rhizobia* 250 g ha^{-1} + PSB- *Bacillusmegaterium* 250 g ha^{-1} recorded significantly more number of clusters plant^{-1} (11.00), number of pods plant^{-1} (46.11), pod weight plant^{-1} (15.87 g), pod length (5.97 cm), Number of seeds pod^{-1}(7.84), seed recovery per cent (97.58 %) and processed seed yield(13.61 q/ha) as compared to 25:50:25 RDF NPK kg ha^{-1} (8.09, 33.87, 12.20 g, 5.18 cm, 5.82, 91.54 % and 10.83 q/ha, respectively) (Table 3). This might be due to enhanced vegetative growth and synergistic effect of combined use of biofertilizers and inorganic manures. Similar results were reported by Dubay (1998) and Dhage Shubhangi and Kachhave (2010) in soybean. The increased seed recovery per cent might be due to influence of nitrogen, the chief constituent of protein, essential for protoplasm which leads to cell division and cell enlargement given to the parent seed exerted a profound influence on seed filling and relatively high percentage of well filled seeds of largest size. Similar results were reported by Vijaya kumar (2007) in black gram.

Effect of spacing

The number of branches plant^{-1}(5.02), number of leaves plant^{-1} (26.53),Plant spread plant^{-1} (627.53) and Number of nodules per plant (5.01)was significantly higher in wider spacing 60×10 cm at harvest compared to closer spacing 30×10 cm (4.76, 20.81, 254.8 and4.98,respectively) (Table 1). Increase of vegetative growth in wider spacing might be due to in wider spacing less competition for space, mutual shading effect, nutrients and moisture due to reduced plant density per unit area. Similar findings were also reported by Asaduzzaman *et al.* (2010) in black gram.

The spacing differed significantly in days to 50 per cent flowering. In wider spacing 60×10 cm flowered earlier (42.01 days) and matured earlier (74.81 days) than in closer spacing 30×10 cm (43.25 days and 75.23 days) (Table 1). It might be related to better vegetative growth, plant canopy area and efficient photosynthetic activity which might have enhanced the reproductive phase in wider spacing compared to closer spacing. These results are in agreement with the findings of Gurusharan and Sharma (2004) in mung bean.

The number of clusters plant^{-1} was significantly higher in wider spacing 60×10 cm (12.48) than in closer spacing 30×10 cm (7.08). Number of pods plant^{-1}(53.01), pod weight (19.03 g), pod length (5.90 cm) and number of seeds pod^{-1}(8.54)were also higher in wider spacing 60×10 cm than in closer spacing 30×10 cm (23.39, 9.483.5.48 and 5.40 cm, respectively). Highly significant differences were observed in number of seeds pod^{-1}, threshing per cent, seed recovery per cent and processed seed yield ha^{-1} were higher in wider spacing 60×10 cm (8.54, 81.30 %, 94.96 % and 14.44 q ha^{-1}) than in closer spacing 30×10 cm (5.48, 72.15 %, 93.36 % and 10.00 q ha^{-1}, respectively)(Table 3). The superior values of seed yield and its components noticed under wider spacing may be attributed to better growth and development of plants under less plant population density and it resulted into better source to sink relationship due to availability of balanced, adequate nutrients, better light, space and moisture unlike in closer spacing. These results were in conformity with those of Subrata Saha *et al.* (2000) in urd bean, Asaduzzaman *etal.* (2010) and Anupama Kumari *et al.* (2012)

Interaction effect

Interactions due to nutrition and plant density differed significantly for growth, seed yield and yield components. Among the combinations wider spacing of 60x10 cmwith an application of 50:100:100 NPK kg ha^{-1}+ Black gram *rhizobia*(250 g ha^{-1}) + PSB- *Bacillus megaterium* (250 g ha^{-1}) recorded highest number of branches $plant^{-1}$ (5.60), number of leaves $plant^{-1}$ (29.87), plant spread $plant^{-1}$ (756.00), number of cluster $plant^{-1}$ (14.07), number of pods cluster (22.60), number of pods $plant^{-1}$ (54.40), pod weight $plant^{-1}$ (g) (22.60), seed recovery per cent (98.45) and processed seed yield (15.83q ha^{-1}) compared to other combinations(Table 2 and 4). These results are in agreement with findings of Anilkumar (2004) in fenugreek, Singh *et al.* (2009) in black gram and Nazir hussain *et al.* (2011) in black gram.

Integration of inorganic fertilizers along with biofertilizers of plant nutrient elements results in more uptake of them as compared to sole use of inorganic ones. This may be due to the fact that the balanced and combined use of various plant nutrient sources results in proper absorption, translocation and assimilation of those nutrients, ultimately increasing the dry-matter accumulation and nutrient contents of plant and thus showing more uptake of elemental nutrients. It is also a fact that improvement of physiological efficiencies of different macro and trace elements resulted from the combined application of organic and inorganic sources of nutrients produces crop with superior quality under investigation. Combined application of inorganic fertilizers with Rhizobium + PSB increased nutrient content in soil and nutrient uptake by plant (Ipsita Das and Singh, 2014). Similar findings were reported by Kumpawat (2010), Vadgave (2010), Anandan and Natarajan (2012). Beneficial effects of integration of chemical fertilizers and organic manures along with biofertilizers on nutrients uptake in wheat, sesame, vegetable soybean and green gram were also noticed by Sharma *et al.* (2013), Nayek *et al.* (2014) , Maruthi *et al.* (2014) and Tyagi *et al.* (2014) respectively.

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