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Effect of integrated nutrient management and spacing on seed quality parameters of black gram cv. Lbg-625 (rashmi)

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Abstract: A field experiment was conducted to assess the response of nutrient levels and spacing on seed quality attributes of black gram cv. LBG-625 (Rashmi). Experimental results revealed that fertilizer application of 50:100:100 + Black gram rhizobia (250 g ha^{-1}) + PSB- *Bacillus megaterium* (250 g ha^{-1}) recorded highest test weight (39.27 g), germination (90.60%), root length (15.77 cm), shoot length (13.43cm), mean seedling length (29.20 cm), mean seedling dry weight (57.99 mg), seedling vigour index-I (2656), seedling vigour index-II (525), total dehydrogenase activity (0.998), protein content (23.16%), field emergence (86.56 %) lowest electrical conductivity (0.813 dSm^{-1}) were superior over other fertilizer treatments. Among the planting geometry 60 x 10 cm recorded more germination per cent (90.48 %) compared to 45 x 10 cm (87.64 %) and 30 x 10 cm (86.91 %). Interaction of nutrient levels and spacing through the application of 50:100:100 + black gram rhizobia (250 g ha^{-1}) + PSB- *B. megaterium* (250 g ha^{-1}) with planting geometry 60 x 10 cm recorded more mean seedling length (34.40 cm), mean seedling dry weight (58.30 mg),and field emergence (90.24 %) lowest electrical conductivity (0.776 dSm^{-1}) compared to control. The application of 50:100:100 + Black gram rhizobia (250 g ha^{-1}) + PSB- *B. megaterium* (250 g ha^{-1}) with planting geometry 60 x 10 cm were considered as seed quality improvement approach in blackgram, therefore conjunctive use of inorganic fertilizers and biofertilizer may be suggested for higher seed quality parameters along with overall betterment of crop.

Keywords: Black gram, rhizobia, PSB- *Bacillus megaterium,* nutrient levels

INTRODUCTION

Black gram (*Vigna mungo* L. Hepper) is one of the most important pulse crop among the various grain legumes. According to Vavilov (1951) it is native to India, belong to the family leguminaceae. It contains about 26 percent protein, 1.2 per cent fat and 56.6 per cent carbohydrates on dry weight basis and it is rich source of calcium and iron. The basic concept of integrated nutrient management is the supply of required plant nutrient for sustaining the desired crop productivity with minimum deleterious effect on soil health environment. Integrated nutrient management intended for four major goals to be achieved. They are to maintain soil productivity, to ensure sustainable productivity, to prevent degradation of the environment and to reduce the expenditure on the cost of chemical fertilizers (Balasubramanian, 1999).

However, application of 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 and maintaining seed quality. INM, which entails the maintenance 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 *et al.*, 2009).

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

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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) 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). In view of the above facts the present investigation carried out to study the influence of integrated nutrient management and spacing on growth parameters of black gram cv. LBG 625 (Rashmi).

MATERIALS AND METHODS

The experiment was conducted at plot E-6 of 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- *B. megaterium* (250 g ha^{-1}), T_8 : 37.50:75:37.50 NPK kg ha^{-1} + Black gram rhizobia (250 g ha^{-1}) + PSB- *B. 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- *B. megaterium* (250 g ha^{-1}), T_{10}: 50:100:100 NPK kg ha^{-1} + Black gram rhizobia (250 g ha^{-1}) +PSB- *B. 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 *B. megaterium* and sown on 4th of August 2012 at an inter and intra row spacing of 30x10, 45x10 and 60x10 cm, respectively. For recording seed quality parameters like Test weight (g), Germination (%), mean seedling length (cm), mean seedling dry weight (mg), seedling vigour index [SVI-I and SVI-II], electrical conductivity of seed leachate (dSm^{-1}), total dehydrogenase activity, protein Content (%), field emergence (%) were discussed below,

Test weight (g): Thousand seeds were counted manually from a sample drawn randomly from each treatment in four replications and weighed as per the procedure given by ISTA (Anonymous, 2007). The mean weight of the sample was recorded as thousand seed weight and expressed in grams.

Germination (%): The germination test was conducted in the laboratory by using between paper methods as per ISTA rules (1985). One thousand seeds in four replicates were placed on germination paper and rolled towels were incubated in germination chamber maintained at 25 ± 1°C and 90 per cent relative humidity. The germinated seedlings were evaluated on fourth and eighth day as first and final count, respectively and

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

Nutrient levels	Test weight (g)	Germination (%)	Mean seedling length (cm)	Mean seedling dry weight (mg)	Seedling vigour index-I	Seedling vigour index-II
T_1	35.51	86.60	21.60	50.86	1871	440
T_2	35.67	87.00	22.94	51.71	1996	450
T_3	35.76	87.37	22.50	51.27	1966	448
T_4	36.27	87.40	23.58	52.54	2061	459
T_5	36.02	88.14	23.19	53.73	2045	473
T_6	37.60	88.42	24.15	53.54	2141	473
T_7	37.36	88.80	24.29	53.76	2163	478
T_8	37.87	89.30	26.40	54.70	2364	488
T_9	37.87	89.80	27.43	56.10	2473	504
T_{10}	39.27	90.60	29.20	57.99	2656	525
F test	*	*	*	*	*	*
S. Em±	0.07	0.37	0.13	0.27	8.77	0.85
C.D (P=0.05)	0.20	1.05	0.37	0.78	24.83	2.39
Spacing (cm)						
S_1: (30x10)	35.35	86.91	22.64	53.23	1968	463
S_2: (45x10)	36.03	87.64	23.85	53.28	2091	467
S_3: (60x10)	39.37	90.48	27.11	54.35	2462	492
F test	*	*	*	*	*	*
S. Em±	0.04	0.20	0.07	0.15	6.68	0.46
C.D (P=0.05)	0.11	0.57	0.20	0.42	18.90	1.31

Table 2. Influence of nutrient levels (T) and spacing (S) on seed quality parameters of black gram cv. LBG 625 (Rashmi).

Nutrient levels	Electrical conductivity(dSm^{-1})	Total dehydrogenase activity (A_{480} nm)	Protein content (%)	Field emergence (%)
T_1	0.889	0.983	22.13	82.61
T_2	0.868	0.988	22.38	83.69
T_3	0.860	0.990	22.54	83.71
T_4	0.870	0.991	22.64	83.64
T_5	0.850	0.991	22.72	84.00
T_6	0.844	0.991	22.70	84.10
T_7	0.840	0.992	22.88	84.68
T_8	0.832	0.993	23.03	85.46
T_9	0.822	0.997	23.05	85.83
T_{10}	0.813	0.998	23.16	86.56
F test	*	*	*	*
S. Em±	0.0035	0.0008	0.09	0.39
C.D (P=0.05)	0.0098	0.0024	0.25	1.11
Spacing (cm)				
S_1: (30x10)	0.869	0.987	22.42	83.09
S_2: (45x10)	0.849	0.991	22.63	83.83
S_3: (60x10)	0.829	0.997	23.10	86.36
F test	*	*	*	*
S. Em±	0.0019	0.0005	0.05	0.22
C.D (P=0.05)	0.0054	0.0013	0.14	0.61

percentage germination was expressed based on normal seedlings.

Mean seedling length (cm): Ten seedlings taken at randomly from each treatment and replication were separated carefully from the paper towel of laboratory germination test and total length of seedlings after removing the cotyledons was measured using metric scale on the germination (Table 1). The mean length of ten seedlings in each treatment and replications was calculated and expressed in centimeters.

Mean seedling dry weight (mg): Ten seedlings from each treatment and replication were used for measuring the mean seedling length was kept in the hot air oven at 85±1°C for 24 hours. The dry weight (mg) was measured and expressed as mean dry weight (mg seedling^{-1}).

Seedling vigour index [SVI-I and SVI-II]: The seedling vigour index was calculated as per the formula given by Abdul Baki and Anderson (1973).

SVI-I = Germination (%) × Mean seedling length (cm).

SVI-II= Germination (%) × Mean seedling dry weight (mg).

Electrical conductivity of seed leachate (dSm^{-1}): Twenty five seeds of two replications were taken randomly from each treatment in a beaker. Then the seeds were soaked in 25 ml of distilled water for 24 h at 25±10°C. The steeped water from soaked seeds was collected and the electrical conductivity (EC) of seed leachate was measured in digital conductivity meter (Model: Systronic conductivity meter 306). After subtracting the EC of the distilled water from the value obtained from the seed leachate, the actual EC due to electrolyte was measured and expressed in dSm^{-1} (Anonymous, 2007).

Total dehydrogenase activity : The total dehydrogenase activity was determined by method described by Perl *et al*. (1978).

Protein Content (%): The total soluble protein was estimated as per the method prescribed by Lowry *et al.* (1951).

Field emergence (%): One hundred seeds selected at random from each treatment in three replications were used for the field emergence studies. The seeds were sown in well-prepared soil at 2.50 to 3.00 cm depth and covered with soil. Field emergence count was taken on 8th day after sowing and the emergence percentage was calculated based on the number of seedlings emerged three centimeters above the soil surface.

Field emergence =Number of seedling emergence at 8th day / Total number of seeds sown X 100

RESULTS AND DISCUSSION

Influence of nutrient levels on seed quality parameters in black gram: Seed quality parameters were highly significant over the control. The crop provided with 50:100:100 NPK kg ha^{-1}+ Black gram rhizobia 250 g ha^{-1} + PSB- *B. megaterium* 250 g ha^{-1} recorded more test weight (39.27 g), compared to recommended dose of NPK 25:50:25 kg ha^{-1} (35.51 g) (Table 1).Among the combinations wider spacing of 60×10 cm along with an application of 50:100:100 NPK kg ha^{-1} + Black gram rhizobia 250 g ha^{-1} + PSB- *B. megaterium* 250 g ha^{-1} recorded more 1000 seed weight (41.60 g) compared to closer spacing 30×10 cm along with an application of 25:50:25 RDF NPK kg ha^{-1} (33.53 g) (Table 3).

Significant differences were noticed in germination per cent among the nutrient levels. The highest germination per cent recorded in 50:100:100 NPK kg ha^{-1} + Black gram rhizobia 250 g ha^{-1} + PSB- *B. megaterium*

Table 3. Seed quality parameters of black gram cv. LBG 625 (Rashmi) as influenced by the interaction of nutrient levels (T) and spacing (S).

Nutrient levels	Test weight (g)			Germination (%)			Mean seedling length (cm)			Mean seedling dry weight (mg)			Seedling vigour index-I			Seedling vigour index-II		
	S_1	S_2	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	S_1	S_2	S_3
T_1	33.53	34.73	38.27	86.20	86.40	87.20	21.42	21.51	21.88	50.67	51.30	50.60	1846	1858	1908	437	443	441
T_2	34.20	34.80	38.00	86.40	86.80	87.80	21.30	23.50	24.02	50.50	51.82	52.80	1840	2040	2109	436	450	464
T_3	34.27	34.80	38.20	86.60	87.10	88.40	21.80	22.68	23.03	51.30	51.50	51.00	1888	1975	2036	444	449	451
T_4	34.80	35.40	38.60	86.65	87.35	88.20	22.40	24.06	24.28	51.73	52.00	53.90	1941	2102	2141	448	454	475
T_5	34.47	35.20	38.40	86.72	87.50	90.20	22.36	23.36	23.86	53.80	52.60	54.78	1939	2044	2152	466	460	494
T_6	36.20	36.80	39.80	86.58	87.48	91.20	22.38	22.48	27.60	53.73	52.90	54.00	1938	1967	2517	465	463	492
T_7	35.87	36.60	39.60	86.80	88.00	91.60	21.90	22.06	28.90	53.03	53.24	55.00	1901	1941	2647	460	469	504
T_8	36.40	37.00	40.20	87.20	88.40	92.30	23.80	24.80	30.60	54.00	54.30	55.80	2075	2192	2824	470	480	515
T_9	36.00	36.60	41.00	87.80	88.20	93.40	24.20	25.60	32.50	55.70	55.30	57.30	2125	2258	3036	489	488	535
T_{10}	37.80	38.40	41.60	88.10	89.20	94.50	24.80	28.40	34.40	57.87	57.80	58.30	2185	2533	3251	510	515	551
F test	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
S. Em±	0.12	0.12	0.12	0.64	0.64	0.64	0.22	0.22	0.22	0.47	0.47	0.47	15.19	15.19	15.19	1.46	1.46	1.46
C.D P=(0.05)	0.35	0.35	0.35	1.81	1.81	1.81	0.63	0.63	0.63	1.34	1.34	1.34	43.00	43.00	43.00	4.15	4.15	4.15

250 g ha^{-1} (90.60 %) as compared to 25:50:25 RDF NPK kg ha^{-1} (86.60 %) (Table 1). This may be due to presence of higher amount of metabolites, which helps in resumption of embryonic growth during germination. In addition to these metabolites, release of certain enzymes responsible for degradation of macromolecules into micro molecules within the seed These results are also incongruence with Ajay Gupta *et al.* (2006) in urd bean. Among the combinations wider spacing of 60×10 cm along with an application of 50:100:100 NPK kg ha^{-1} + Black gram rhizobia 250 g ha^{-1} + PSB- *B. megaterium* 250 g ha^{-1}was recorded highest germination per cent 94.50 % compared to closer spacing 30×10 cm along with an application of 25:50:25 RDF NPK kg ha^{-1} (86.20 %) (Table 3).

The significant higher root length (15.77 cm), shoot length (13.43 cm), mean seedling length (29.20 cm), mean seedling dry weight (57.99 mg), seedling vigour index-I and II (2,656 and 525) and lower electrical conductivity of seed leachates (0.813 dSm^{-1}) and higher TDH (0.998 A_{480} nm) were recorded in 50:100:100 NPK kg ha^{-1}+ Black gram rhizobia 250 g ha^{-1} + PSB- *B. megaterium* 250 g ha^{-1} as compared to 25:50:25 RDF NPK kg ha^{-1} (12.30 cm, 9.30 cm, 21.60 cm, 50.86 mg, 1,871 and 440, 0.889 dSm^{-1} and 0.983 A_{480} nm, respectively) (Tables 1 and 2). This might be ascribed to the efficient protein synthesis and better source to sink relationship which resulted in better development of seeds giving rise to higher germination and vigour index. 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.

Among the combinations wider spacing of 60×10 cm along with an application of 50:100:100 NPK kg ha^{-1} + Black gram rhizobia 250 g ha^{-1} + PSB- *B. megaterium* 250 g ha^{-1}was recorded highest root length (17.70 cm), shoot length (16.70 cm), mean seedling length (34.40 cm), mean seedling dry weight (58.30 mg), seedling vigour index-I and II (3251 and 551) and lower electrical conductivity of seed leachates (0.776 dSm^{-1})and higher TDH (1.008) compared to closer spacing 30×10 cm along with an application of 25:50:25 RDF NPK kg ha^{-1} (12.21 cm, 9.21 cm, 21.42 cm, 50.67 mg, 1855, 437, 0.897 dSm^{-1} and 0.976) (Tables 3 and 4).

Maximum protein content (23.16 %) was recorded in 50:100:100 NPK kg ha^{-1} + Black gram rhizobia 250 g ha^{-1} + PSB- *B. megaterium* 250 g ha^{-1} compared to recommended dose of NPK 25:50:25 kg ha^{-1} (22.12 %) (Table 2). Increase in protein content due to high uptake of nitrogen and phosphorous by slow and continuous supply through bio fertilizers. The results are in agreement with Mahesh babu *et al.* (2006) in

Table 4. Seed quality parameters of black gram cv. LBG 625 (Rashmi) as influenced by the interaction of nutrient levels (T) and spacing (S).

Nutrient levels	Electrical conductivity(dSm^{-1})			Total dehydrogenase activity (A_{480} nm)			Protein content (%)			Field emergence (%)		
	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	0.897	0.892	0.878	0.976	0.983	0.991	22.24	22.31	21.80	82.22	82.40	83.20
T_2	0.881	0.868	0.856	0.984	0.988	0.993	22.25	22.28	22.60	82.77	83.50	84.80
T_3	0.873	0.858	0.850	0.987	0.989	0.994	22.37	22.44	22.80	82.78	83.45	84.90
T_4	0.885	0.868	0.856	0.988	0.989	0.995	22.40	22.54	22.98	83.05	83.48	84.40
T_5	0.867	0.848	0.834	0.988	0.990	0.995	22.44	22.60	23.12	82.89	83.50	85.60
T_6	0.864	0.843	0.825	0.988	0.991	0.994	22.39	22.57	23.14	82.69	83.55	86.05
T_7	0.863	0.838	0.818	0.988	0.993	0.995	22.50	22.76	23.38	82.82	84.03	87.20
T_8	0.861	0.832	0.804	0.989	0.994	0.996	22.47	22.83	23.80	83.57	84.73	88.07
T_9	0.855	0.824	0.788	0.990	0.995	1.006	22.56	22.94	23.64	83.98	84.37	89.13
T_{10}	0.844	0.818	0.776	0.990	0.996	1.008	22.60	23.04	23.84	84.17	85.28	90.24
F test	*	*	*	*	*	*	*	*	*	*	*	*
S. Em±	0.006	0.006	0.006	0.001	0.001	0.001	0.16	0.16	0.16	0.68	0.68	0.68
C.D (P=0.05)	0.017	0.017	0.017	0.004	0.004	0.004	0.44	0.44	0.44	1.93	1.93	1.93

Treatment Details: 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: 30x10 cm; S_2: 45x10 cm; S_3: 60x10 cm.

soybean where combined use of organic and inorganic fertilizers provided better seed quality parameters over control. Among the combinations wider spacing of 60×10 cm along with an application of 50:100:100 NPK kg ha^{-1} + Black gram rhizobia 250 g ha^{-1} + PSB- *B. megaterium* 250 g ha^{-1} was recorded highest protein content (23.84 %) compared to closer spacing 30×10 cm along with an application of 25:50:25 RDF NPK kg ha^{-1} (22.24 %) (Table 4).

Maximum field emergence per cent (86.56 %) was noticed in 50:100:100 NPK kg ha^{-1} + Black gram rhizobia 250 g ha^{-1} + PSB- *B. megaterium* 250 g ha^{-1} compared to recommended dose of NPK 25:50:25 kg ha^{-1} (82.61 %) (Table 2).

Among the combinations wider spacing of 60×10 cm along with an application of 50:100:100 NPK kg ha^{-1} + Black gram rhizobia 250 g ha^{-1} + PSB- *B. megaterium* 250 g ha^{-1} was recorded highest field emergence 90.24 % compared to closer spacing 30×10 cm along with an application of 25:50:25 RDF NPK kg ha^{-1} (82.22 %) (Table 4). It might be due to higher food reserves and better source to sink relationship which resulted in better development of seeds giving rise to higher field emergence Similar increased in seed quality parameters with combinations of wider spacing and increased fertilizer levels along with biofertilizers was also reported by Tammanagowda (2002) in green gram.

Spacing differences on seed quality in black gram: Highly significant differences were observed in germination per cent of the spacing. The wider spacing 60×10 cm gave higher germination (90.48 %) than closer spacing 30×10 cm (86.91 %) and other seed quality parameters like 1000 seed weight, root length, shoot length, mean seedling length, mean seedling dry weight, seedling vigour index-I and II were also highest in wider spacing 60×10 cm (39.37 g, 14.90 cm, 12.20 cm, 27.11 cm, 54.35 mg, 2,462 and 492) compared to closer spacing 30×10 cm (35.35 g, 12.82 cm, 9.82 cm, 22.64 cm, 53.23 mg, 1,968 and 463, respectively) (Table 1) the similar results of increased seed quality parameters with wider spacing where may be attributed to better source to sink relationship of the plants which resulted in better accumulation and assimilation of photosynthates into sinks reported by Dhutraj (2011) in soybean, Selvakumar *et al*. (2012)in black gram.

Higher TDH (0.997 A_{480} nm), protein content (23.08 %) and field emergence (86.36 %) and lower electrical conductivity of seed leachate (0.829 dSm^{-1}) were noticed in wider spacing 60×10 cm compared to closer spacing 30×10 cm (0.987 A_{480} nm, 22.42 %, 83.09 % and 0.869 dSm^{-1}, respectively) (Table 2).

The similar superior trend in seed quality parameters under wider spacing was also confirmed by Siddaraju *et al*. (2010) in cluster bean, Dhage shubhangi and Kachhave (2010) in soybean, where in wider spacing may be attributed to better source to sink relationship of the plants which resulted in better accumulation and assimilation of photosynthates into sinks results in higher seed quality parameters.

Conclusion

The study result indicated that interaction of nutrient levels and spacing through the application of 50:100:100 + Black gram rhizobia (250 g ha^{-1}) + PSB-*B. megaterium* (250 g ha^{-1}) with planting geometry 60 x 10 cm recorded highest seed quality parameters over other fertilizer treatments. Therefore conjunctive use of inorganic fertilizers and biofertilizer under wider spacing may be suggested for higher seed quality parameters along with overall betterment of black gram.

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