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Response of black gram to graded levels of potassium on yield and yield components

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Abstract
The investigation into the response of black gram to graded levels of potassium on the yield and quality characteristics (cv.BDU-1) were carried out on the well drained soil with PH 7.82, EC (0.286 dsm^{-1}),organic carbon 5.3 g Kg^{-1} and $CaCO_3$ 53.40 g Kg^{-1}. A uniform dose of 25 and 50 Kg N and $P_2O_5ha^{-1}$ was used in all treatments. The varying levels of potash were 15,30,45 and 60 kg K_2O ha^{-1}. The results revealed that application (RDF+ 60 kg K_2O ha^{-1}) showed a significant increase in yield and of black gram over control which is at par with the treatments (RDF+ 45 kg K_2O ha^{-1}) and (RDF+ 30 kg K_2O ha^{-1}).

Keywords: Graded levels of potassium, black gram

1. Introduction
Urdbean (*Vigna mungo* (L) Hepper) or black gram is one of the most important cultivated pulse crop of 'Vigna' group. Among pulses, black gram (*Vigna mungo* (L.) Hepper) is one of the most important crop grown in India. It is consumed in the form of 'dal' (whole or split, husked and unhusked) or parched. It is chief constituent of 'papad'. It is used as nutritive fodder specially for milch cattle and also used as green manuring crop and erosion resisting crop. It adds 42 kg N/ha in soil. It posses deep root system which binds soil particles and thus, prevent erosion. Plants require K in large quantities; hence, it is regarded as one of the three major food elements.

Potassium has been described as the "quality element" for crop production. Among pulses, black gram (*Vigna mungo* (L.) Hepper) is one of the most important crop grown in India. It is consumed in the form of 'dal' (whole or split, husked and dehusked) or parched. It is chief constituent of 'papad'. It is used as nutritive fodder specially for milch cattle and also used as green manuring crop and erosion resisting crop. It adds 42 kg N/ha in soil. It posses deep root system which binds soil particles and thus, prevent erosion.

2. Treatments
T1 = Absolute control (No fertilizer)
T2 = RDF Only (25:50:00 N, P2O5, K2O kg ha-1)
T3 = RDF + 15 kg K2O ha-1
T4 = RDF + 30 kg K2O ha-1
T5 = RDF + 45 kg K2O ha-1
T6 = RDF + 60 kg K2O ha-1

3. Material and Methods
3.1 Observations
3.1.1 Height of the plant
It was measured in cm with the help of meter scale from the base of the plant i.e. from ground level to base of the terminal bud of main shoot, and observations were recorded.

3.1.2 Nodulation
Five plants from observation plot were randomly removed with the help of the fork without damaging the roots at flowering and harvesting stage of black gram. The roots were washed carefully to remove the soil stucking to them and nodules were counted.

3.1.3 Dry matter per plant

Five plants uprooted from the observation unit for recording the dry matter weight. After removing the roots, plant samples were kept in well labelled brown paper bag. First the samples are dried in shade and after that kept in oven at 65 ^{0}C±2 ^{0}C, and then weight of dry matter was taken and expressed on per plant basis.

3.1.4 Total number of pods per plant

Number of pods from five selected plants were counted and an average number of pods per plant was worked out.

3.1.5 Seed yield

The plants from each net plot were harvested and seeds were separated by threshing, after sun drying the pods seed yields obtained in each net plot were weighted (kg) and further it was calculated on the hectare basis (kg ha^{-1}).

3.2 Experimental Details

An experiment was laid out in Randomized Block Design with four replication and six treatments. Treatments consisted of T_1 Absolute control (No fertilizer application), T_2 RDF (25:50:00 N, P_2O_5 and K_2O ha^{-1} kg ha^{-1}), T_3 (RDF + 15 kg K_2O ha^{-1}), T_4 (RDF + 30 kg K_2O ha^{-1}), T_5 (RDF + 45 kg K_2O ha^{-1}), T_6 (RDF+ 60 kg K_2O ha^{-1}). The sowing of black gram was taken up on. The sowing was undertaken by dibbling method keeping 30 cm distances between two rows, while plant to plant distance was maintained 10 cm. Recommended package of practices were followed.

Observations were recorded on some important plant parameters like plant height, number of pods per plant, number of nodules per plant, fresh weight of nodules per plant. total biomass production (g $plant^{-1}$),dry matter (kg ha^{-1})., Economic yield of black gram. The data were statistically analyzed.

4. Result and Discussion

4.1 Effect of levels of potassium on plant height.

The height of black gram was monitored throughout the growth period of crop. Periodical observations recorded on various dates under different potassium level treatments are presented in Table 1. It was observed that there was continuous increase in plant height throughout growth period of crop due to each additional nutrients application. Significant variation was observed on the plant height in black gram at all the stages. The plant height was significantly highest in treatment RDF + 60 kg K_2O ha^{-1} (T_6) (25.02 cm) at flowering, whereas at harvesting stage (47.39 cm) over the control (T_1) which is at par with treatment RDF+ 45 Kg K_2O ha^{-1} (T_5) and RDF+ 30 Kg K_2O ha^{-1} (T_4). However, minimum height was observed in controlled treatment at all the growth stages. The increase in plant height could be partly being attributed due to the beneficial effect of potash fertilization. Potash is known to augment cell division and cell expansion resulting in increasing positive effect of growth parameter. The highest plant height may be due to the positive effects of potassium on the vegetative growth and accumulation of metabolic materials. Patil and Dhonde (2009) [9] showed that the maximum height was obtained with the application of 50 kg K_2O ha^{-1} in green gram respectively. Similar findings were obtained by Thesiya *et al.*, (2013) [13] in black gram, Billore *et al*., (2009) [3] in soybean.

Table 1: Effect of levels of potassium on plant height.

Treatments	Plant Height(cm)		
	Flowering	Harvest	Mean
T_1 Absolute control (No fertilizer)	17.49	32.30	24.90
T_2 RDF Only(25:50:00 N, P_2O_5 and K_2O kg ha^{-1})	21.52	39.29	32.32
T_3 RDF+ 15 Kg K_2O ha^{-1}	22.97	42.14	33.31
T_4 RDF+ 30 Kg K_2O ha^{-1}	24.90	46.98	37.47
T_5 RDF+ 45 Kg K_2O ha^{-1}	24.99	47.26	38.50
T_6 RDF+ 60 Kg K_2O ha^{-1}	25.02	47.39	39.67
Grand Mean	22.82	42.56	-
SEm ±	0.988	1.75	-
CD at 5%	2.98	5.28	-
CV %	8.67	8.23	-

4.2 Effect of levels of potassium on number of pods per plant

Table 2. represents the effects of potassium levels on number of pods per plant. The application of RDF + 60 kg K_2O ha^{-1} (T_6) recorded the highest number of pods i.e (14.55 and 13.86) at all the stages followed by application of RDF + 45 kg K_2O ha^{-1} (T_5) (14.46 and 13.63) and RDF + 30 kg K_2O ha^{-1} (T_4) (14.32 and 13.51) at pod development and harvest stage. Improvement of pod bearing capacity of crop could be possibly be because of improved N and P fertilization efficiency in the presence of K. Increase rate of photosynthetic and symbiotic activity following balanced application of NPK stimulated better vegetative and reproductive growth of the crop resulting in higher green pod yield. Asghar *et al.*, (1994) [1] reported that application of 50 kg K_2O ha^{-1} recorded higher pod yield in blackgram. Similar observation was reported by Thesiya *et al.*, (2013) [13] in black gram, Kushwala (2001) [6] in field pea.

Table 2: Effect of levels of potassium on number of pods per plant.

Treatments	Pod development	Harvest
T_1 Absolute control (No fertilizer)	9.41	8.71
T_2 RDF Only(25:50:00 N, P_2O_5 and K_2O kg ha^{-1})	11.02	10.43
T_3 RDF+ 15 Kg K_2O ha^{-1}	12.11	11.40
T_4 RDF+ 30 Kg K_2O ha^{-1}	14.32	13.51
T_5 RDF+ 45 Kg K_2O ha^{-1}	14.46	13.63
T_6 RDF+ 60 Kg K_2O ha^{-1})	14.55	13.86
Grand mean	12.64	11.92
SEm±	0.51	0.42
CD at 5%	1.54	1.28
CV %	8.10	7.12

4.3 Effect of levels of potassium on number of nodules per plant

The data on number of nodules per plant under graded levels of potassium presented in Table No 3. The data on nodulation of black gram revealed that there was significant variation in nodule number at all the stages. Results showed that treatment at RDF + 60 kg K_2O ha^{-1} (T_6) recorded the highest number of nodules (29.04 and 24.48) at all the stages followed by application of RDF + 45 kg K_2O ha^{-1} (T_5) (28.86 and 24.18) RDF + 30 kg K_2O ha^{-1} (T_4) (28.76 and 23.93) at flowering and harvesting stage respectively. This may be due to the application of potassium in various levels. Potassium is required by adenosine S- triphosphate phosphohydrolase (ATP ase) for the movement of sugars from the apoplast between the cells of the phloem. In depth scrutiny of data influenced by growth stages showed that there was continuous decrease in number of nodules per plant from flowering (26.46) to harvest (22.15). The study by on composition of the effects of K and N_2 fixation and photosynthesis in a legume found that potassium was found to have large effect on nodulation and N_2 fixation. Highest number of nodules was observed at 45 kg K_2O ha^{-1} in groundnut by Salve and Gunjal (2011) [12]. Similar findings reported by Patra *et al.,* (1999) [10] in groundnut.

Table 3: Effect of levels of potassium on number of nodules per plant

Treatments	Number of nodules per plant	
	Flowering	Harvest
T_1 Absolute control (No fertilizer)	21.28	18.14
T_2 RDF Only(25:50:00 N, P_2O_5 and K_2O kg ha^{-1})	24.50	20.07
T_3 RDF+ 15 Kg K_2O ha^{-1}	26.31	22.09
T_4 RDF+ 30 Kg K_2O ha^{-1}	28.76	23.93
T_5 RDF+ 45 Kg K_2O ha^{-1}	28.86	24.18
T_6 RDF+ 60 Kg K_2O ha^{-1})	29.04	24.48
Grand Mean	26.46	22.15
SEm ±	1.00	0.79
CD at 5%	3.02	2.39
CV %	7.59	7.51

4.4 Effect of levels of potassium on fresh weight of nodules per plant

Periodical observations recorded for nodules weight on various dates under different potassium level treatments are presented in Table 4.

It was observed that there was continuous decrease in nodules weight throughout growth period of crop (0.21 g to 0.17 g). Over all significant variations were observed for nodules weight at all growth stages. The treatment RDF + 60 kg K_2O ha^{-1} (T_6) (0.25 g and 0.20 g) recorded the highest fresh weight of nodules at all the stages which was statistically at par with application of RDF + 45 kg K_2O ha^{-1} (T_5) (0.24 g and 0.19 g) RDF + 30 kg K_2O ha^{-1} (T_4) (0.23 g and 0.19 g) at flowering and harvesting stage respectively. Similar observations were found by Balai *et al.,* (2005) [2] in cowpea, Kushwala (2001) [6] in field pea.

Table 4: Effect of levels of potassium on fresh weight of nodules per plant

Treatments	Fresh weight of nodules (g $plant^{-1}$)	
	Flowering	Harvest
T_1 Absolute control (No fertilizer)	0.17	0.15
T_2 RDF Only(25:50:00 N, P_2O_5 and K_2O kg ha^{-1})	0.19	0.16
T_3 RDF+ 15 Kg K_2O ha^{-1}	0.21	0.17
T_4 RDF+ 30 Kg K_2O ha^{-1}	0.23	0.19
T_5 RDF+ 45 Kg K_2O ha^{-1}	0.24	0.19
T_6 RDF+ 60 Kg K_2O ha^{-1})	0.25	0.20
Grand Mean	0.21	0.17
SEm ±	0.008	0.0063
CD at 5%	0.025	0.019
CV %	7.93	7.21

4.5 Effect of levels of potassium on total biomass production (g $plant^{-1}$)

The data of total biomass yield per plant of black gram under various potassium levels are presented in Table 5. The data indicated the periodical increase in total biomass of black gram. The average increase in biomass recovery was from 2.90 g $plant^{-1}$ to 7.91 g $plant^{-1}$ from flowering to harvesting stages of the crop. The accumulation of biomass was relatively more at the later part of the crop. This may be attributed to the productive phases of black gram. Results indicate, that the significant increase of biomass was recorded with the application of RDF + 60 kg K_2O ha^{-1} (T_6) (3.52 and 8.59 g $plant^{-1}$) followed by application of RDF + 45 kg K_2O ha^{-1} (T_5) (3.48 and 8.55 g $plant^{-1}$) and RDF + 30 kg K_2O ha^{-1} (T_4) (3.42 and 8.50 g $plant^{-1}$) at flowering and harvesting respectively which were found to be statistically at par with only at flowering and harvest stage with treatment. This may be due to the effect of potassium. Potassium plays a major role in growth as it is involved in assimilation, transport and storage tissue development (Cakmak 2005) [5]. Balai *et al.,* (2005) [2] found that highest dry matter accumulation g $plant^{-1}$ was obtained by 40 kg K_20 ha^{-1} in Cowpea and Salve and Gunjal (2011) [12] found the similar result in groundnut.

Table 5: Effect of levels of potassium on total biomass production (g $plant^{-1}$)

Treatments	Biomass production (g $plant^{-1}$)	
	Flowering	Harvest
T_1 Absolute control (No fertilizer)	1.71	5.06
T_2 RDF Only(25:50:00 N, P_2O_5 and K_2O kg ha^{-1})	2.47	6.79
T_3 RDF+ 15 Kg K_2O ha^{-1}	2.84	7.45
T_4 RDF+ 30 Kg K_2O ha^{-1}	3.42	8.50
T_5 RDF+ 45 Kg K_2O ha^{-1}	3.48	8.55
T_6 RDF+ 60 Kg K_2O ha^{-1})	3.52	8.59
Grand Mean	2.90	7.49
SEm ±	0.11	0.28
CD at 5%	0.33	0.84
CV %	7.71	7.41

4.6 Effect of levels of potassium on dry matter (kg ha^{-1}) production

The data on dry matter production (kg ha^{-1}) at different crop growth stages are presented in Table 6. The results revealed that various levels of potassium application resulted in increase in mean dry matter yield with advancement in crop growth stages i.e. from flowering (1053.18 kg ha^{-1}) to harvest (1713.63 kg ha^{-1}). The mean dry matter was found to be highest due to application of RDF + 60 kg K_2O ha^{-1} (T_6) (1189.12, 1836.44 kg ha^{-1}) which was significantly higher than other treatments at all growth stages. At these stages, RDF + 45 kg K_2O ha^{-1} (T_5) (1185.87, 1829.91 kg ha^{-1}) and RDF + 30 kg K_2O ha^{-1} (T_4) (1178.45, 1811.04 kg ha^{-1}) were found to be at par. This is due to effect of K nutrition on cell elongation, turger potential in leaves. Such results were also observed in soybean plants as by Mengal and Arneke (1982) [8]. Patil and Dhonde (2009) [9] observed that highest dry matter kg ha^{-1} with the application of 50 kg K_2O ha^{-1} in green gram.

Table 6: Effect of levels of potassium on dry matter (kg ha^{-1}) production

Treatments	Dry matter (kg ha^{-1})	
	Flowering	Harvest
T_1 Absolute control (No fertilizer)	851.30	1497.02
T_2 RDF Only(25:50:00 N, P_2O_5 and K_2O kg ha^{-1})	972.39	1604.96
T_3 RDF+ 15 Kg K_2O ha^{-1}	1047.24	1702.71
T_4 RDF+ 30 Kg K_2O ha^{-1}	1178.45	1811.04
T_5 RDF+ 45 Kg K_2O ha^{-1}	1185.87	1829.91
T_6 RDF+ 60 Kg K_2O ha^{-1})	1189.72	1836.44
Grand Mean	1053.18	1713.68
SEm ±	41.47	62.30
CD at 5%	124.96	187.76
CV %	7.87	7.27

4.7 Effect of levels of potassium on economic yield of black gram

Application of RDF + 60 kg K_2O ha^{-1} (T_6) was recorded highest seed yield per plant (3.47 g $plant^{-1}$) which was significant higher over control (T_1; 2.14 g $plant^{-1}$) and application of RDF only (T_2: 2.88 g $plant^{-1}$). Similarly followed by treatment receiving RDF + 45 kg K_2O ha^{-1} (T_5) (3.45 g $plant^{-1}$) and RDF + 30 kg K_2O ha^{-1} (T_4) (3.42 g $plant^{-1}$) also had higher grain yield per plant.

The data on economic yield of black gram (grain yield) under various graded levels of potassium are presented in Table 7. The grain yield was lowest (712.63 kg ha^{-1}) in absolute control (T_1) while yield was improved in nutrient added plots. Potassium application showed significant increase in grain yield of black gram in all the treatments over control (T_1) and RDF (T_2). The highest yield was obtained by the application of RDF + 60 kg K_2O ha^{-1} (T_6) followed by RDF + 45 kg K_2O ha^{-1} (T_5) (3.45 g $plant^{-1}$) and RDF + 30 kg K_2O ha^{-1} (T_4) which were at par with each other. It was observed that, the application of potassium increased the grain yield of black gram with RDF + 60 kg K_2O ha^{-1} (T_6) over control (No fertilizer) by 62.23% and grain yield was increased over RDF only (no application of K) by 20.31%. The positive effect of K on crop yield might also be due to its requirement in carbohydrate synthesis and translocation of photosynthesis and also may be due to improved yield attributing characters, shoot growth and nodulation. Billore *et al.*, (2009) [3] observed seed yield of soybean increase 35.6 % over control with the application of 49.8 kg K ha^{-1}.Similar findings were observed by Thesiya *et al.*, (2013) [13] in lentil, Patil and Dhonde (2009) [9] in green gram, Salve and Gunjal (2011) [12] in groundnut, Balai *et al.*, (2005) [2], Asghar (1994) [1] in black gram.

Table 7: Effect of levels of potassium on economic yield of black gram

Treatments	Economic yield	
	g $plant^{-1}$	(kg ha^{-1}
T_1 Absolute control (No fertilizer)	2.14	712.63
T_2 RDF Only(25:50:00 N, P_2O_5 and K_2O kg ha^{-1})	2.88	960.86
T_3 RDF+ 15 Kg K_2O ha^{-1}	3.01	1005.01
T_4 RDF+ 30 Kg K_2O ha^{-1}	3.42	1141.68
T_5 RDF+ 45 Kg K_2O ha^{-1}	3.45	1147.89
T_6 RDF+ 60 Kg K_2O ha^{-1})	3.47	1156
Grand Mean	3.06	1020.68
SEm ±	0.12	40.24
CD at 5%	0.36	121.26
CV %	7.91	7.88

5. Conclusion
The effect of different levels of graded potassium recorded on growth parameter like plant height showed significant increases with the application of RDF + 60 kg K_2O ha^{-1} and flowering and harvest. The other growth parameters like number of pods (per plant), number of nodules (per plant), fresh weight of nodules (per plant), total biomass production (g $plant^{-1}$), and dry matter (kg ha^{-1}) were at higher magnitude when black gram received RDF + 60 kg K_2O ha^{-1}.Application of RDF + 60 kg K_2O ha^{-1} had recorded highest seed yield per plant which was significantly higher over control and application of RDF i.e. only N and P. The highest grain yield of was 1156 kg ha^{-1} obtained by the application of RDF +60 kg K_2O ha^{-1} which was statistically at par with RDF +45 kg K_2O ha^{-1} RDF +30 kg K_2O ha^{-1} each other. It can be observed that, the application of treatment RDF +60 kg K_2O ha^{-1} increased the grain yield of black gram over control (no application of any fertilizer) by 62.23% and over RDF (no application of K) by 20.23%.

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