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Effect of graded levels of potassium on yield and major nutrient uptake of black gram

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Abstract
A field experiment was conducted in *kharif* season 2015-16 using black gram as a test crop to study the response of black gram to graded levels of potassium under drought condition with long dry spell in the Month of July and August. The results emerged out clearly indicated that various growth parameters like plant height, number of pods, number of nodules, fresh weight of nodules, total biomass production and dry matter and seed yield was increased due to application of potassium. It was inferred from the results that application of 25 kg N, 50 kg P2O5, or 30 kg K2O per hectare found superior over only N and P application i.e. RDF (25:50:00 N, P2O5 and K2O kg ha-1). The K application showed synergistic effects on other nutrients (N, P) uptake. Soil fertility was also found to be improved due to application of potassium to black gram.

Keywords: Graded levels of potassium, black gram, N,P, K uptake

Introduction
India is one of the important pulse producing countries in the world. Though India is one of the largest pulse producing countries in the world, about 2-3 million tons of pulses are imported annually to meet the domestic consumption requirement. The current per capita availability of pulses of 80 gm/capita/day as recommended by FAO is very low which could not meet per capita requirement. Therefore, it is necessary that the agricultural scientists should keep the strategy for increasing the production of pulses to meet the protein requirement of increasing population of the country (Subbulakshmi *et al.,* 2009) [8]. They are valued for protein rich food, feed and fodder and therefore, have been rightly described as unique jewels of Indian crop husbandry by Swaminathan (1981) [9].
Potassium is involved in many physiological process such as photosynthesis (Vyas *et al.*, 2001) [10], photosynthetic translocation, protein and starch synthesis, water energy relations and it also improves the water use efficiency (Singh *et al.*,1997) [7] through its influence on maintenance of turgor potential (William, 1999) [11].
Therefore the present study was conducted during 2015-16 to study the effect of application of graded levels of potassium on growth, yield and nutrient uptake by Black gram to achieve balance in the use of N, P and K nutrients.

Material and Methods
The experiment was laid out in Randomised Block Design (RBD) with 6 treatments T_1- Absolute control (No fertilizer), T_2- RDF Only (25:50:00 N,P_2O_5,K_2O 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}) and replicated four times at Experimental farm of College of Agriculture, Badnapur. The black gram (variety BDU-1) was sown on 22th June 2015 by adopting 30 cm X 10 cm spacing and was harvested on 2th september 2015 at maturity.

Soil and plant sample collection: Black gram plant samples (5 plants from each observation unit of treatment plot) were uprooted at crop growth stage i.e. Flowering and harvesting stage for chemical analysis. At the same time, soil samples from each plot were also collected to study the soil nutrient content.

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 $65^0C \pm 2^0C$, and then weight of dry matter was taken and expressed on per plant basis.

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}).

Soil analysis: Surface soil samples (0-30 cm) were collected from different plots of the layout and were thoroughly mixed, air dried and ground with wooden mortar and pestle and passed through 2mm sieve. The sieved sample was stored in bag with proper labelling. The methods given below adopted for analysis of physico-chemical properties of soil.

Soil reaction (pH): It was determined in (1: 2.5) Soil: Water Suspension using digital pH meter (Jackson, 1973) [2]. Electrical conductivity (EC): It was estimated in (1: 2.5) Soil: Water suspension using direct read type conductivity meter (Jackson, 1973) [2]. Organic carbon: Walkley and Black's wet digestion method was used for the determination of organic carbon from soil (Jackson, 1973) [2]. Free calcium carbonate: It was determined by rapid titration method as suggested by Piper (1966). Available soil nitrogen: It was determined by using alkaline potassium permanganate method as described by Available soil phosphorous: Phosphorous from soil was extracted by 0.5 M sodium bicarbonate at a constant pH 8.5 and measured colorimetrically at 420 nm as described by Olsen. Available soil potassium: It was determined by using neutral normal ammonium acetate as an extractant using flame photometer (Jackson, 1973) [2].

Plant analysis: For the determination of nutrient contents in plant samples, the samples were collected at different growth stages of the crop. First of all the fresh plants were washed with tap water and roots were discarded. Preparation of plants samples are carried out first by sun drying and then oven drying. The dried samples were grind in electrically operated stainless steel grinder to maximum fineness. The grind plant materials were stored in the paper bags and used for further chemical analysis. Digestion: 0.5 g of fine powdered plant sample was taken in 100 ml conical flask.5 ml concentrated nitric acid added to it and kept for over night. On the next day, 10 ml of diacid mixture (HNO_3 and $HClO_4$ in 9:4) was added and digested in hot plate as described by Piper (1966). After digestion, known volume was prepared with glass distilled water and filtered. The same extract was used for the estimation of P, K.

Analysis for quality parameters

Protein content: The nitrogen content from the grain samples was estimated by Microkjeldhals method and N content was multiplied by 6.25 to get percent crude protein.

Uptake of nutrients

Nutrient uptake i.e. uptake of N, P, K, was calculated by considering grain and dry matter yield at harvest in particular treatment plot in relation concentration of the particular nutrient in respective treatment plot using the formula.

$$\text{Uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient concentration \% X (dry matter yield (kg ha}^{-1}\text{)}}{} 100$$

Result and Discussion

Effect of graded levels of potassium on soil properties

As per data presented in Table 1, the soil was alkaline in reaction ($pH_{1:2.5}$= 7.82), safe in soluble salt concentration ($EC_{1:2.5}$ =0.286 dSm^{-1}) and medium in organic content (5.3 g kg^{-1}). However, there was increase in organic carbon due to application of the treatment. The free $CaCO_3$ content was 53.40 g per kg. At harvest, pH, EC, and $CaCO_3$ were not influenced significantly due to application of various levels of graded potassium. The organic carbon content was varied inconsistently due to the application of the fertilizers. The mean calcium carbonate after harvest of crop was 52.95 g kg^{-1} which was found to be decreased by 0.84 %, that seems to be very negligible. It was obvious that the primary soil properties like pH, EC, OC, $CaCO_3$, content could not change significantly due to one crop season, as black soils are buffered.

Table 1: Soil Properties of the experimental plot

Treatments	pH	EC (dSm^{-1})	Organic Carbon (g kg^{-1})	$CaCO_3$ (g kg^{-1})
Initial				
Before Sowing	7.82	0.286	5.3	53.40
After harvest				
T_1 Absolute control (No fertilizer)	7.60	0.269	5.45	53.21
T_2 RDF Only(25:50:00 N, P_2O_5 and K_2O kg ha^{-1})	7.61	0.266	5.52	53.20
T_3 RDF+ 15 Kg K_2O ha^{-1}	7.63	0.265	5.74	53.08
T_4 RDF+ 30 Kg K_2O ha^{-1}	7.73	0.266	5.83	52.92
T_5 RDF+ 45 Kg K_2O ha^{-1}	7.72	0.267	5.95	52.69
T_6 RDF+ 60 Kg K_2O ha^{-1})	7.74	0.271	6.01	52.60
Grand Mean	7.69	0.267	5.73	52.95
SEm±	0.06	0.002	0.08	1.01
CD at 5%	NS	NS	0.24	NS

Effect of graded levels of potassium on Dry matter, economic yield and protein content

From the data in Table 2, it is reveled that the highest dry matter, yield and Protein content 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) and RDF + 30 kg K_2O ha^{-1} (T_4) which were at par with each other.

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).

Table 2: Effect of graded levels of potassium on Dry matter, economic yield and protein content

Treatments	Dry matter (kg ha^{-1})	Economic yield (kg ha^{-1})	Protein (%)
T_1 Absolute control (No fertilizer)	1497.02	712.63	18.94
T_2 RDF Only(25:50:00 N, P_2O_5 and K_2O kg ha^{-1})	1604.96	960.86	19.55
T_3 RDF+ 15 Kg K_2O ha^{-1}	1702.71	1005.01	20.09
T_4 RDF+ 30 Kg K_2O ha^{-1}	1811.04	1141.68	20.97
T_5 RDF+ 45 Kg K_2O ha^{-1}	1829.91	1147.89	21.02
T_6 RDF+ 60 Kg K_2O ha^{-1})	1836.44	1156	21.08
Grand Mean	1713.68	1020.68	20.27
SEm ±	62.30	40.24	0.32
CD at 5%	187.76	121.26	0.97
CV %	7.27	7.88	3.17

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. Similar observations were reported by, Patil and Dhonde (2009) [5] in green gram and Asghar (1994) [1] in black gram.

The highest protein content 21.08% was recorded by application of RDF + 60 kg K_2O ha^{-1} (T_6), followed by RDF + 45 kg K_2O ha^{-1} (T_5, 21.02 %) and RDF + 30 kg K_2O ha^{-1} (T_4; 20.97%). Potassium involved in physiological and biochemical functions of plant growth i.e. enzyme activation and protein synthesis and its application in legumes might have improved the nitrogen use efficiency which leads to increase the protein content of the crop. Kurhade *et al.,* (2014) [3] showed that seed protein content was maximum in case of RDF+40 Kg K_2O ha^{-1} (22.16%).

Effect of graded levels of potassium on nutrient uptake by black gram

From the data presented in Table 3, among the treatments, application of RDF + 60 kg K_2O ha^{-1} (T_6) recorded significantly higher uptake of N,P,K in flowering, plant at harvest and seed. This was followed by RDF + 45 kg K_2O ha^{-1} (T_5) and RDF + 30 kg K_2O ha^{-1} (T_4). T_6 treatment were at par with T_5 and T_4 at flowering and at harvesting stage. In presence of potassium, the increase in N, P and K uptake could be attributed to enhanced vigour of crop growth with increased utilization and translocation of N in to plant and synergy between N and K in soil system resulting in the enhancement of yield. Similar trend was also reported by Kurhade *et al.,* (2014) [3] in black gram and Sahay *et al.,* (2013) [6].

Table 3: Effect of graded levels of potassium on N,P,K uptake

Treatments	N Uptake (kg ha^{-1})			P Uptake (kg ha^{-1})			K Uptake (kg ha^{-1})		
	Flowering	Harvest	Seed	Flowering	Harvest	Seed	Flowering	Harvest	Seed
T_1 Absolute control (No fertilizer)	14.85	18.14	21.91	1.73	2.15	3.22	11.48	11.86	5.82
T_2 RDF Only(25:50:00 N, P_2O_5 and K_2O kg ha^{-1})	17.28	18.70	30.03	2.07	2.33	4.44	13.26	12.32	7.97
T_3 RDF+ 15 Kg K_2O ha^{-1}	18.72	20.14	32.29	2.33	2.47	4.72	14.52	13.28	8.46
T_4 RDF+ 30 Kg K_2O ha^{-1}	21.35	21.75	38.35	2.77	2.85	5.49	16.66	14.53	9.84
T_5 RDF+ 45 Kg K_2O ha^{-1}	21.83	22.06	38.52	2.85	2.88	5.51	16.72	14.85	9.87
T_6 RDF+ 60 Kg K_2O ha^{-1})	21.92	22.40	38.98	2.83	3.12	5.69	16.94	14.84	9.95
Grand Mean	19.32	20.53	33.30	2.43	2.63	4.84	14.93	13.61	8.65
SEm ±	0.76	0.94	1.28	0.10	0.09	0.19	0.64	0.60	0.33
CD at 5%	2.30	2.82	3.86	0.31	0.28	0.58	1.94	1.80	1.00
CV %	7.90	9.11	8.33	8.47	7.12	7.98	8.61	8.78	7.67

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