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EFFECTS OF POTASSIUM APPLICATION ON YIELD ATTRIBUTES, YIELD AND GRAIN QUALITY OF LENTIL IN TERRACE SOIL OF JOYDEBPUR

M. A. QUDDUS[1], M. A. HOSSAIN[2], H. M. NASER[3] AND S. AKTAR[4]

Abstract

An experiment was conducted in the research field of Pulses Research Sub-Station, BARI, Gazipur during two consecutive years of 2015-16 and 2016-17 to determine the suitable dose of potassium for achieving higher yield attributes, nodulation, nutrient concentration and yield maximization of lentil. There were 5 treatments viz. T_1 = Control, T_2 = 30 kg K ha^{-1}, T_3= 40 kg K ha^{-1}, T_4= 50 kg K ha^{-1} and T_5= 60 kg K ha^{-1} along with the blanket dose of fertilizers of N, P, S, Zn and B @ 15, 20, 10, 2 and 1.5 kg ha^{-1}, respectively for all treatments. The experiment was laid out in randomized complete block design (RCBD) with three replications. Results revealed that the highest seed yield (1092 kg ha^{-1}) of lentil (mean of two years) was found in T_4 followed by T_5 treatment and the lowest (736 kg ha^{-1}) was noted in K control (T_1) treatment. The highest % yield increase over control (48.3%) was recorded from T_4 treatment. The maximum nodulation was found in T_5 followed by T_4 treatment. The highest protein (26.9%), N, P, K, S, Zn and B concentrations of lentil seed were recorded in T_4 treatment. Therefore, the results suggest that the appliction of 50 kg K ha^{-1} along with $N_{15}P_{20}S_{10}Zn_2B_{1.5}$ kg ha^{-1} are optimum for achieving higher yield potential of lentil in terrace soils of Bangladesh.

Keywords: Potassium, lentil yield, nodulation, nutrient content, terrace soil

Introduction

Improved variety and intensive cropping followed by imbalanced use of fertilizers make the soils deficient in nutrients and thus the crops grown on such soils show mineral deficiencies. Deficiency of several major and minor nutrients such as K, S, Ca, Zn, Fe and B are increasing with time (Kurhade *et al*., 2015; Rao and Vittal, 2007). Lentil (*Lens culinaris* Medic) is an edible and popular pulse crop that belongs to the family *Fabaceae*. Lentil seed contains 25% protein, 1.1% fat, 59% carbohydrate, and is also rich in important vitamins, minerals, and soluble and insoluble dietary fiber (Islam *et al*., 2018). It helps to improve the soil fertility through biological nitrogen fixation (Quddus *et al*., 2014). The average yield of lentil in Bangladesh is low (752 kg ha^{-1}) due to non-judicious use of manures and fertilizers (Zahan *et al.*, 2009).

Potassium (K), as a plant nutrient, is becoming increasingly important in Bangladesh and shows a good response to pulse crop. Potassium improves

[1]Senior Scientific Officer, Soil and Water Management Section, HRC, Bangladesh Agricultural Research Institute (BARI), Gazipur, [2]Chief Scientific Officer, Soil Science Division, BARI, Gazipur, [3]Principal Scientific Officer, Soil Science Division, BARI, Gazipur, [4]Scientific Officer, Pulses Research Sub-Station, BARI, Gazipur, Bangladesh.

plant water relationship and improves shoot growth of pulse crop (Kabir *et al*., 2004). It maintains turgor pressure of cell which is necessary for cell expansion. It helps in osmo-regulation of plant cell, assists in opening and closing of stomata (Yang *et al*., 2004). Potassium nutrition is associated with the nodulation and grain quality and protein content (Srinivasarao *et al*., 2003). It also helps improve disease resistance, drought stress, tolerance to water stress, winter hardiness, tolerance to plant pests and uptake efficiency of other nutrients (Gupta *et al*., 2013). Considering its nutritional value; it is necessary to uplift the production level and nutritional quality of lentil. Therefore, the present study was undertaken to find out the suitable dose of K for yield maximization of lentil.

Materials and Methods

Field experiment was conducted in Rabi season of 2015-16 and 2016-17 in the research field of Pulses Research Sub-Station, Bangladesh Agricultural Research Institute (BARI), Gazipur (24° 0′ 13″ N latitude and 90° 25′ 0″ E longitude). Gazipur is medium high land with fine-textured (clay loam) terrace soils. It belongs to Chhiata series (Soil taxonomy: Udic Rhodustalf) under the agroecological zone - Madhupur Tract (AEZ-28). The Gazipur area received average rainfall from 1.40 to 118 mm during October to March. The mean minimum and maximum air temperatures during October to March of the experiment were 12.2 & 33.1°C during 2015-16 and 13.6 & 33.1°C, respectively during 2016-17. The average minimum and maximum humidity (%) were 51 and 88 during October to March (Table 1). Before starting the experiment, initial soil (0-15 cm) sample was analyzed as outlined by Page *et al*. (1982) and standard method. The chemical properties are shown in Table 2.

Table 1. Weather data during the experimental period at Gazipur

Months	Avg. Temperature (°C)				Avg. Humidity (%)				Rainfall (mm)	
	2015-16		2016-17		2015-16		2016-17		2015-16	2016-17
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	-	-
October	24.0	33.1	24.8	33.1	76	83	67	79	14	13.7
November	18.2	30.7	19.4	30.1	84	88	61	72	0	1.40
December	16.5	26.2	15.5	28.2	74	82	53	80	0	0
January	12.2	25.2	13.6	27.0	67	80	51	81	0	0
February	17.0	29.6	16.3	30.4	57	74	46	73	0	0
March	19.9	33.1	19.4	30.9	53	73	56	75	118	8.02

Source: Weather centre, BARI, Gazipur, Bangladesh

Table 2. Fertility status of initial soil sample of the experimental field at Gazipur

Location	pH	OM (%)	Total N (%)	Ca	K	P	S	Zn	B
				meq. 100 g^{-1}		mg kg^{-1}			
Gazipur (result)	6.2	1.30	0.061	6.55	0.11	13	13.5	0.65	**0.16**
Critical level	-	-	0.12	2.0	0.12	7	10	0.60	0.20
Interpretation*	acidic	low	very low	high	low	medium	medium	low	low

*FRG, (2012)

The land was firstly opened by a tractor operated chisel plough and then prepared thoroughly by ploughing with a power tillerfollowed by laddering and leveling. There were 5 treatments consisting of different levels of potassium (0, 30, 40, 50 & 60 kg K ha^{-1}) including control such as T_1 = Control, T_2 = 30 kg K ha^{-1}, T_3= 40 kg K ha^{-1}, T_4= 50 kg K ha^{-1}, T_5= 60 kg K ha^{-1} along with the blanket dose of other nutrients N, P, S, Zn and B @ 15, 20, 10, 2 and 1.5 kg ha^{-1}, respectively.The experiment was laid out in randomized complete block design (RCBD) with three replications. The unit plot size was 12 m^2 (4 m x 3 m). Nutrients N, P, K, S, Zn and B were applied as urea, TSP, MoP, gypsum, zinc sulphate and boric acid, respectively during final plot preparation. Seeds of lentil (cv. BARI Masur-7) were treated using the fungicide Provex 200 (at 2.5 g kg^{-1} seeds) before sowing for controlling of root rot disease. Treated seeds (@ 30 kg ha^{-1}) were sown on 09 November, 2015 and 16 November, 2016. Seeds were sown continuously in rows (10 rows/plot) maintaining row to row spacing of 30 cm. Hand weeding as well as thining of seedlings were done at 25 days after sowing (DAS) maintaining the distance of plant to plant 05 cm by making a total of 800 plants per plot (12 m^2). Again, hand weeding was done at 50 DAS. Three sprays were done with fungicide of Rovral starting from 55 DAS to control *Stemphylium* disease and two times insecticide (Karate @ 2 ml L^{-1} of water) sprayed at 10 days interval starting from 60 DAS to overcome insect infestation. The crop was harvested at maturity. Data on seed yield (kg ha^{-1}) at around 10% moisture basis were recorded from the whole plot technique. For stover yield (kg ha^{-1}), mature plants were collected from two 1m^2 quadrates in each plot at harvest time. The yield contributing characters namely: plant height and number of pods $plant^{-1}$ were recorded from ten plants selected randomly from each unit plot. Pods were detached from every plant and the number of pods per plant was counted and averaged. Thousand seed weight (g) was determined by the counting of 500 seeds randomly from each plot and weighing through electronic balance and converting it into 1000-seed weight. For nodule counting per plant, 5 plants from each plot were selected randomly at seedling, vegetative, flowering and podding stages. Plants were smoothly uprooted and the soil from roots was removed carefully using tap water. Separated nodules were sliced into two pieces to observe the inside color for nodules activity. The light-pink or red coloured nodules were considered as active.

Stover and seed samples were digested with di-acid mixture (HNO_3-$HClO_4$) (5: 1) as described by Piper (1966) for determination of P (spectrophotometer method), K (atomic absorption spectrophotometer method), S (turbidity method using $BaCl_2$ by spectrophotometer), Zn (atomic absorption spectrophotometer method, VARIAN SpectrAA 55B, Australia) and B (spectrophotometer following azomethine-H method) concentration. The N concentration was determined by Micro-Kjeldahl method. Protein content was calculated multiplying the N value by 6.25 (Hiller *et al*., 1948).

Data on yield attributes, number of nodules per plant, protein content and N, P, K, S, Zn, B content were computed on average of two study years. Data of all parameters were statistically analysed by ANOVA procedure. Then, multiple comparisons were done by LSD at 5% level (Statistix 10., 1985).

Results and Discussion

Effects of K application on yield attributes of lentil

The yield attributes of lentil such as plant height, pods per plant and seed weight responded significantly to application of different rates of potassium (Table 3). In the present experiment, plant height varied from 27.2 to 30.7 cm. The tallest plant (30.7 cm) was recorded from the treatment T_5 which was statistically identical with T_4 and T_3 treatments. The dwarf plant (27.2 cm) was noted for K control (T_1) treatment. The result is in agreement with the findings of Sahay *et al*. (2013) who observed the maximum plant height of lentil (43.5 cm) due to application of 90 kg K_2O ha^{-1}. Optimum dose of K can increase flowering, pod formation, grain set and early physiological maturity (Hasanuzzaman *et al*., 2018). Different levels of K showed significant effect on the number of pods per plant (Table 3). The maximum number of pods per plant (48.4) was found in the treatment T_4 followed by T_5 treatment and the minimum number of pods per plant (30.0) was observed in K control (T_1) treatment (Table 3). Ali *et al*. (2007) reported on chickpea that application of 150 kg K_2O ha^{-1} produced significantly maximum number of pods $plant^{-1}$ (61.9). The K application contributed significantly to the seed weight of lentil. The 1000- seed weight varied from 17.2 to 19.9 g, the highest seed weight being recorded for treatment T_5 which was significantly higher than the other treatments. The lowest 1000- seed weight was recorded in K control treatment (Table 3). Higher K levels resulted in higher seed weight probably due to role of potash in translocation of photosynthates and its ability to develop bold seeds (Ali *et al*., 2007). Islam and Muttaleb (2016) reported that the higher amount of K helps transfer food material to develop grains.

Table 3. Effects of different levels of K on yield attributes of lentil (pooled data of two years)

Treatment	Plant height (cm)	No. of pods plant^{-1}	1000- seed wt. (g)
T_1 (Control)	27.2	30.0	17.2
T_2 (30 kg K ha^{-1})	29.0	38.4	18.6
T_3 (40 kg K ha^{-1})	29.5	39.7	19.0
T_4 (50 kg K ha^{-1})	29.6	48.4	19.2
T_5 (60 kg K ha^{-1})	30.7	44.7	19.9
CV (%)	2.84	3.14	1.71
LSD (0.05)	1.56	2.38	0.60

Effects of K application on yield of lentil

The seed yield of lentil responded significantly to the application of potassium (Table 4). Potassium involves increasing the utilization of carbohydrates, enhances the dry matter accumulation and ultimately increases the yields of crop (Cheema *et al*., 2012). The highest seed yield of 1015 kg ha^{-1} in the 1st year was recorded from T_4 which was significantly higher than other treatments except T_5 treatment (994 kg ha^{-1}). The lowest seed yield value (722 kg ha^{-1}) being noted in the K control (T_1) treatment. Smilarly in the 2nd year, the significantly highest seed yield (1168 kg ha^{-1}) was recorded in T_4 treatment. The lowest seed yield was observed in K control treatment (Table 4). Potassium might have regulated the biosynthesis, conversion, and allocation of metabolites that ultimately increased the yield. Many research works support the idea that K is directly or indirectly responsible for higher yield of crops (Hasanuzzaman *et al*., 2018). Sahay *et al*. (2013) reported that grain yield of lentil increased with increase in K level up to 90 kg K_2O ha^{-1}. Regarding stover yield of lentil, the trend was similar to that of seed yield. The mean stover yield (average of two years) of lentil varied from 1669 to 2542 kg ha^{-1}. The percent seed yield increase over control varied from 20.8 to 48.3%. The highest seed yield increase noted from T_4 treatment was followed by T_5 treatment and the lowest from T_2 treatment (Table 4). Jahan *et al*. (2009) reported that 34.2% grain yield increase of lentil over control was obtained by the application of 42 kg K_2O ha^{-1}.

Table 4. Effects of different levels of K on seed and stover yield of lentil

Treatment	Seed yield (kg ha^{-1})			% yield increase over control	Stover yield (kg ha^{-1})		
	1st Yr.	2nd Yr.	mean		1st Yr.	2nd Yr.	Mean
T_1 (Control)	722	750	736	-	1793	1544	1669
T_2 (30 kg K ha^{-1})	879	899	889	20.8	2233	1809	2021
T_3 (40 kg K ha^{-1})	949	932	941	27.9	2538	1871	2205
T_4 (50 kg K ha^{-1})	1015	1168	1092	48.3	2816	2267	2542
T_5 (60 kg K ha^{-1})	994	1022	1008	36.9	2628	2073	2351
CV (%)	2.03	4.74	-	-	2.25	2.81	-
LSD (0.05)	34.9	85.0	-	-	102	101	-

Effects of K application on nodulation and protein content of lentil

Adequate K supply enhances the biological nitrogen (N) fixation (Srinivasarao *et al*., 2003). Table 5 shows that the number of nodules per plant increased from 32 days after sowing (DAS) to 62 DAS, and then it decreased. Nodulation was influenced significantly due to application of of potassium. At 32 days after sowing, the number of nodules per plant varied from 6.30 to 9.33, at 47 DAS it ranged from 15.4 to 26.7, at 62 DAS it was from 15.7 to 27.3 and at 77 DAS, this range varied from 11.1 to 16.9 (Table 5). The maximum number of nodules per plant was recorded from the treatment T_5 in all the dates of nodule collection followed by T_4 treatment except the collection date 47 (DAS) it was highest in T_4 treatment followed by T_5 treatment. The lowest number of nodules was found in the K control treatment (Table 5). The experimental results show that the maximum nodule formation occured during early to mid flowering. After flowering, nodule efficiency was reduced. The result of this study indicates that the different rates of K application contributed for higher seed protein content in lentil (Table 5). The maximum seed protein (26.9%) of lentil was found in T_4 treatment followed by T_5, T_3 and T_2 treatments. The lowest amount (24.3%) was found in K control (T_1) treatment (Table 5). Similar result was observed by Sahay *et al*. (2013) who noted that the highest protein content (22.01%) in lentil grain was obtained by fertilization of 90 kg K_2O ha^{-1}.

Table 5. Effects of different levels of K application on number of nodules per plant and on protein concentration of lentil seed (pooled data of two years)

Treatment	No. of nodules 32 DAS	No. of nodules 47 DAS	No. of nodules 62 DAS	No. of nodules 77 DAS	Protein (%)
T_1 (Control)	6.30	15.4	15.7	11.1	24.3
T_2 (30 kg K ha^{-1})	7.98	23.3	23.7	15.4	26.2
T_3 (40 kg K ha^{-1})	8.43	24.1	24.4	15.5	26.6
T_4 (50 kg K ha^{-1})	8.83	26.7	25.8	15.3	26.9
T_5 (60 kg K ha^{-1})	9.33	25.6	27.3	16.9	26.8
CV (%)	1.62	2.90	3.35	5.28	3.09
LSD (0.05)	0.25	1.26	1.47	1.48	1.53

Effects of K application on nutrient concentration of lentil seed

Potassium plays a significant regulatory role in numerous plants' physiological processes- seed germination and emergence, protein synthesis, nutrient content and nutrient balance (Marschner, 2012). The N, P, K, S, Zn, and B concentration of lentil (seed) was markedly influenced by the K application (Tables 6). The highest N concentration in lentil seed (4.31%) was found in the T_4 treatment, which was statistically identical to T_5, T_3 and T_2 treatments. The lowest seed N concentration (3.88%) was noted from the K control (T_1) treatment. In case of P concentration, the highest P content in seed (0.45%) was recorded in T_5 treatment followed by T_4 treatment. The lowest P concentration (0.31%) in seed was found in K control treatment (Table 6). The highest K concentration in lentil seed (0.66%) was recorded from the T_4 treatment, which was statistically similar to T_5, T_3 and T_2 treatments. The lowest seed K concentration (0.57%) was found in control (T_1) treatment (Table 6). Regarding S concentration, the highest S concentration in lentil seed (0.37%) was recorded in T_5 treatment followed by T_4 treatment. The lowest S concentration in seed was found in control (T_1) treatment (Table 6). The highest Zn concentration in lentil seed (75.7 ppm) was noted from the T_4 treatment. The lowest seed Zn concentration was noted in the control (T_1) treatment. The highest B concentration (46.4 ppm) in lentil seed was observed in the T_4 treatment, which was statistically similar to T_5 treatment. The lowest seed B concentration was estimated from K control (T_1) treatment (Table 6). Similar results were reported earlier that the K application influenced the uptake of N, P, K, S, Zn, and B (Kurhade *et al*., 2015; Chaudhari *et al*., 2018).

Table 6. Effects of different levels of K on nutrient concentration of lentil seed (Pooled data of two years)

Treatment	N (%)	P (%)	K (%)	S (%)	Zn (ppm)	B (ppm)
T_1 (Control)	3.88	0.31	0.57	0.28	74.1	40.2
T_2 (30 kg K ha^{-1})	4.20	0.38	0.62	0.31	74.5	42.0
T_3 (40 kg K ha^{-1})	4.26	0.40	0.63	0.33	74.8	44.3
T_4 (50 kg K ha^{-1})	4.31	0.44	0.66	0.36	75.7	46.4
T_5 (60 kg K ha^{-1})	4.28	0.45	0.64	0.37	74.9	46.2
CV (%)	3.04	4.72	4.18	3.03	1.34	2.08
LSD (0.05)	0.24	0.04	0.05	0.02	ns	1.72

Conclusion

Application 50 kg K ha^{-1} gave the highest seed yield of lentil. The K application contributed to pod setting, which finally increased the seed yield. The same K rate also showed the highest nutrient and protein content in lentil. Application of 50 kg K ha^{-1} along with $N_{15}P_{20}S_{10}Zn_2B_{1.5}$ kg ha^{-1} can be recommended for lentil cultivation in terrace soils of Bangladesh.

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