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Effect of phosphorus and molybdenum nutrition on yield and nutrient uptake in lentil (*Lens culinaris* L.)

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ABSTRACT

An experiment was conducted at Jeegani, Morena (M.P.) during rabi seasons of 2010-11 and 2011-12 to study the impact of phosphorus and molybdenum nutrition on yield and nutrient uptake by lentil (Lens culinaris L.). The experiment was laid out in randomized block design with four levels of phosphorus (0, 30, 60 and 90 kg P_2O_5 ha^{-1}) and four levels of molybdenum (0, 1, 2 and 4 kg ha^{-1}).The results revealed that the application of 90 kg P_2O_5 ha^{-1} produced tallest plants (47.6 cm), more pods/plant (94.0) and test weight (29.4 g) of lentil over other levels of phosphorus. The lentil responded significantly up to 90 kg P_2O_5 ha^{-1} and increased the grain and straw yield by 35.6 and 31.6 per cent, respectively, over control. Application of P proved significantly superior to control in terms of content and y ield of protein. Application of 2 kg Mo ha^{1} recorded significantly taller plants (45.8 cm), highest pods/plant (89.7) and test weight (28.9 g). Application of 2 kg M_0 ha^{-1} proved superior to the control with respect to grain and straw yields and increased the grain and straw yields by 22.7 and 19.4 per cent, respectively. Molybdenum application tended to increase the content and yield of protein in lentil over control. The phosphorus levels significantly increased the nitrogen, phosphorus, potassium and molybdenum uptake by lentil over control. Molybdenum application also influenced the utilization of nitrogen, P, K and Mo and the more beneficial effect was observed with highest level of molybdenum (4 kg ha^{-1}).The status of nutrients in post harvest soil improved significantly with P and Mo levels over the control.

Key words: Phosphorus, molybdenum, quality, yield, nutrient uptake, lentil

INTRODUCTION

Lentil (Lens culinaris) is the most important pulse crop of India. It is the most suitable crop for rain fed conditions because its deep roots system. In addition to its use as food for human and livestock, lentil plays a critical role in some agricultural systems due to the ability of the nitrogen-fixing bacteria; it harbors to fix the atmospheric nitrogen under a broad spectrum of environmental conditions. The yield of lentil is poor mainly because of traditional way of cultivation. The yield may be improved through a change in cultural practices. Molybdenum is required for growth of most biological organisms including plants and animals which play an important role in the process of *Rhizobium* symbiosis. Molybdenum is a constituent of the nitrogenase enzyme and every bacterium which fixes nitrogen needs molybdenum during the fixation process. Molybdenum has a positive effect on yield quantity, quality and nodule formating in legume crops (Singh *et al.* 2014). Phosphorus is one of the most important elements significantly affecting plant growth and metabolism. It is, along with N, a major yield limiting nutrient Phosphorus may be a critical constraint of legumes under low nutrient environments because there is a substantial need for P in the N_2 fixation process. However, in legumes, the high requirement for P is consistent with the involvement of P in high rates of energy transfer that take place in the nodule. Under P shortage conditions, legumes may lose the distinct advantage of an unlimited source of symbiotic N. In addition, phosphorus has also an enhancing impact on plant growth and biological yield through its importance as energy storage and transfer necessary for metabolic processes (Singh *et al.,* 2014). Phosphorus addition increased the efficiency of plants to photosynthesis, enhances the activity of rhizobia and increases the number of branches and pod /plants, consequently greater yield of pea, lupine, faba bean and groundnut. Since, no systematic information is yet available on the response of lentil to P and Mo in Morena (M.P.). Hence, the present study was undertaken to evaluate the effect of phosphorus and molybdenum on lentil crop.

MATERIALS AND METHODS

The field experiment was conducted at the farmer field at Jeegani, Mureena (M.P.) during two consecutive rabi seasons of 2010-11 and 2011-12. The experimental soil had EC 0.20 dSm^{-1}, pH 8.0, organic carbon 4.2 g kg^{-1}, available N 170, P 9.5, K 176 kg ha^{-1}, and molybdenum 0.06 mg kg^{-1}. The experiment was laid out in randomised block design with four levels of phosphorus (control, 30, 60 and 90 kg P_2O_5 ha^{-1}) and four levels of molybdenum (control, 1.0, 2.0 and 4.0 kg ha-^{1}) with three replications. The recommended doses of N and K @ 25 and 60 kg K_2O ha^{-1}, respectively were applied as urea and muriate of potash, respectively. Phosphorus and molybdenum were supplied through single super-phosphate and ammonium molybdate as per treatments. The lentil (var. IPL 81) was sown on November 25, in both the years and irrigated at the proper time as judged by the appearance of soil and crop. The weeds were eradicated time to time from the crop. The crop was harvested on maturity. The growth and yield attributes were recorded at harvest. The grain and straw samples were analysed for N content by Kjeldahl method (Jackson 1973). Grain and straw samples were digested in di acid (HNO_3, $HClO_4$) and the digest were analysed for phosphorus by vanado molyblophosphoric acid yellow colour method, K by flame photometer and Mo by thiocyanate method (Jackson 1973). The uptake of nutrients was calculated using the yield data in conjunction with their respective contents. The soil samples collected after harvest were analysed for organic carbon, available N (Subbiah and Asija 1956), P, K and Mo as per procedures suggested by Jackson (1973).

RESULTS AND DISCUSSION

Yield

Application of 90 kg P_2O_5 ha^{-1} resulted in significantly superior plant height at to rest of the levels of phosphorus. The increase in plant height may be owing to the improvement in vigour of the plants possibly by balanced supply and higher uptake of P. Singh and Singh (2014) also reported an improvement in plant height with the application of phosphorus in chickpea. Application of 90 kg P_2O_5 ha^{-1} recorded significantly more pods/plant and higher test weight over lower levels of as reported by Singh and Singh (2014) and Singh *et al.* (2014). The grain and straw yields of lentil increased significantly by levels of phosphorus over control (Table 1).

Table 1: Effect of phosphorus and molybdenum on yield and quality of lentil (mean of 2 years)

Treatment	Plant height (cm)	Pod/Plant	Test weight (g)	Yield (q ha^{-1})		Protein (%)		Protein yield (kg ha^{-1})
				Grain	Straw	Grain	Straw	
Phosphorus (kg ha^{-1})								
0	39.1	76.8	28.0	14.50	27.26	19.0	3.7	275.0
30	42.5	81.8	28.3	16.35	29.22	19.6	3.9	320.5
60	46.0	86.6	29.0	18.47	33.44	20.0	4.2	369.4
90	47.6	94.0	29.4	19.67	35.89	20.4	4.4	401.3
SEm±	0.61	1.34	0.19	0.32	0.44	0.11	0.07	8.52
CD (P=0.05)	1.67	3.68	0.52	0.88	1.21	0.31	0.20	23.43
Molybdenum (kg ha^{-1})								
1	41.5	80.2	28.4	15.48	28.85	19.4	3.9	300.3
1	43.8	85.0	28.6	16.44	30.47	19.7	4.1	323.8
2	45.8	89.7	28.9	19.00	34.47	19.9	4.2	380.0
4	44.1	88.2	28.7	18.12	32.66	20.0	4.2	362.4
SEm±	0.61	1.34	0.19	0.32	0.44	0.11	0.07	8.52
CD (P=0.05)	1.67	3.68	NS	0.88	1.21	0.31	0.20	23.43

Application of 90 kg P_2O_5 ha^{-1} recorded significantly higher yields of grain and straw over control. The increases in grain and straw yields with 90 kg P_2O_5 ha^{-1} were 35.6 and 31.6%, respectively over control. The increase in yield may be attributed to the effective metabolic activities coupled with increased rate of photosynthesis leading to better translocation of nutrients to sink. Similar results were reported by Nusakho Nyekha *et al.* (2015) in green gram and

Singh *et al.* (2016) in lentil. Application of 2 kg Mo ha^{-1} produced significantly taller plants over control. The pods/plant and test weight of lentil were significantly higher with 2 kg Mo ha^{-1} over control. This might be the result of improved supply of Mo with its addition. Singh *et al.* (2014) also reported similar results in lentil. Pooled data showed 22.7 and 19.4% increase in grain and straw yield of lentil (Table 1) with the application of 2 kg Mo ha^{-1} over the control which might be owing to better nutritional environment in term of increased nitrogen fixation and increased plant growth. Molybdenum is known to be essential for N_2-fixation by rhizobia in legumes, being a component of nitrate reductase enzyme which controls the reduction of inorganic NO_3 and helps in fixing nitrogen as NH_3, as a result occurs increased nodulation, growth, grain and straw yield. These results confirm the findings of Singh *et al.* (2014).

Quality

Protein content in lentil grain and straw increased significantly with P application over control and maximum values were recorded with 90 kg P_2O_5 ha^{-1}. This increase is attributed to more fixation of N in soil. Similar results were reported by Singh *et al.* (2016). Increasing dosed of Mo up to 2 kg ha^{-1} resulted in a significant increase in protein content in lentil grain and straw over control. This increase due to Mo addition may be attributed to its involument in N fixation. Similar results were reported by Singh *et al.* (2014). Protein yield in lentil grain increased significantly with increasing levels of P up to 90 kg P_2O_5 ha^{-1} which may be attributed to increased grain production. Similar, application of 2 kg Mo ha^{-1} increased the protein yield significantly over control (Kumawat *et al.* 2009).

Table 2: Effect of phosphorus and molybdenum on uptake of N, P, K, S (kg ha^{-1}) and Mo (g ha^{-1}) by lentil grain and straw (mean of 2 years)

Treatments	Nitrogen		Phosphorus		Potassium		Sulphur		Molybdenum	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Phosphorus (kg ha^{-1})										
0	44.2	16.3	3.0	2.4	11.4	44.4	2.9	3.0	4.6	4.9
30	51.2	18.4	3.9	3.2	13.4	50.0	3.4	3.8	5.4	7.0
60	59.1	22.4	4.8	4.7	15.7	59.2	4.4	4.7	6.2	9.1
90	64.1	25.1	5.9	5.7	16.9	64.2	4.9	5.7	6.7	10.8
SEm±	1.19	0.44	0.14	0.24	0.66	1.40	0.14	0.17	0.23	0.62
CD (P=0.05)	3.27	1.21	0.39	0.67	1.81	3.86	0.39	0.47	0.63	1.71
Molybdenum (kg ha^{-1})										
1	47.9	18.2	3.6	3.2	12.7	48.5	3.2	3.5	3.5	5.2
1	51.7	19.8	3.9	3.6	13.6	51.4	3.6	4.0	4.6	7.0
2	60.6	22.7	4.9	4.5	16.0	59.3	4.4	4.8	6.6	9.4
4	58.0	21.8	5.1	4.6	15.4	55.8	4.2	4.6	8.3	11.1
SEm±	1.19	0.44	0.14	0.20	0.66	1.40	0.14	0.17	0.23	0.62
CD (P=0.05)	3.27	12.1	0.39	0.67	1.81	3.86	0.39	0.47	0.63	1.71

Nutrients Uptake

The uptake of nitrogen by lentil crop increased significantly with increase in the levels of phosphorus compared to control. Application of 90 kg P_2O_5 ha^{-1} resulted in significantly higher nitrogen uptake by the crop which may be attributed to increased N content coupled with higher yield (Singh *et al.* 2016). The uptake of nitrogen was significantly higher with increase in the levels of molybdenum over control and maximum value was recorded with 4 kg Mo ha^{-1}. This increase in N uptake may be attributed to the role of molybdenum in the process of *Rhizobium* symbiosis. Molybdenum, which is a constituent of nitrogenase enzyme, fixes nitrogen during the fixation process. Singh *et al.* (2014) reported similar results. Increase in phosphorus levels significantly increased the phosphorus uptake by the crop over control and lower levels of phosphorus. The maximum enhancement in phosphorus uptake was recorded with 90 Kg P_2O_5 ha^{-1}. Similar findings were also recorded by Singh *et al.* (2016). The utilization of phosphorus by the crop significantly increased with increasing levels of molybdenum compared to control and the maximum value was recorded at 4 Kg ha^{-1}. Similar observations were also recorded by Lal *et al.* (2016).The uptake of potassium by the crop increased significantly with 60 and 90 kg P_2O_5 ha^{-1} compared to control. The uptake of potassium did not show any significant change with 30 kg P_2O_5 ha^{-1}. Comparatively higher potassium utilization was recorded with 90 kg P_2O_5 ha^{-1}. The increase in potassium uptake might be due to increased potassium content and yield of lentil with phosphorus levels. Our findings are in agreement with those of Singh *et al.* (2014). The uptake of potassium increased significantly with increase in the levels of molybdenum in comparison to control. The more beneficial effect on potassium uptake was noted with highest level of molybdenum (4 kg Mo ha^{-1}). Higher values of potassium uptake with molybdenum application are apparently the result of favourable effect on grain and straw production. Similar results were also noted by Alben Awomi *et al.* (2012). The utilization of molybdenum increased with increase in levels of phosphorus over control and the maximum values were recorded with 90 kg P_2O_5 ha^{-1}. This increase is attributed to enhanced lentil production and an increase in molybdenum content. A further study (Table 1), reveals that the molybdenum uptake by the crop increased significantly with increasing levels of molybdenum as compared to control. The maximum enhancement in molybdenum uptake was recorded with highest level of molybdenum (4 kg ha^{-1}). Similar findings were reported by Singh *et al.* (2014).

Table 3: Effect of P and Mo levels on fertility status of post harvest soil (mean of 2 years)

Treatments	Org. C (g kg^{-1})	Avail. N (kg ha^{-1})	Avail. P (kg ha^{-1})	Avail. K (kg ha^{-1})	Avail. Mo (mg kg^{-1})
Phosphorus (kg ha^{-1})					
0	3.1	162.0	8.8	101.0	0.04
30	3.4	163.8	9.1	103.0	0.04
60	3.5	170.1	10.1	105.0	0.05
90	3.6	173.5	11.6	107.0	0.05
SEm±	0.011	0.63	0.32	0.93	0.006
CD (P=0.05)	0.030	1.76	0.64	2.60	NS
Molybdenum (kg ha^{-1})					
1	3.3	163.3	9.1	102.5	0.03
1	3.4	164.5	9.4	103.5	0.04
2	3.4	169.0	10.0	104.4	0.05
4	3.5	171.0	10.3	105.1	0.06
SEm±	0.011	0.63	0.32	0.93	0.006
CD (P=0.05)	0.030	1.76	0.64	NS	0.017

Soil fertility

Organic carbon content in post harvest soil increased from 3.1 g kg^{-1} at control to 3.6 g kg^{-1} with 90 kg P_2O_5 ha^{-1}. Similarly, Mo application also enhanced the organic carbon content in soil. The minimum value of available N content in soil was recorded in control, which may be ascribed to greater utilization of N by lentil. Molybdenum application also improved the status of available N in soil as compared to control (Singh *et al.* 2014). There was a significant build-up of available P in soil with P application and maximum value was recorded with 90 kg P_2O_5 ha^{-1} (Singh *et al.* 2016). The amount of available P in soil was lowest in control, which increased with Mo application. Similar results were reported by Singh *et al.* (2014). At harvest, the amount of available K was depleted from the initiat value of 110 kg ha^{-1} to 101 kg ha^{-1}. Available K content increased with various levels of Mo and maximum value was recorded with 4 kg Mo ha^{-1}. Available Mo was the lowest in the control (Table 3). The concentration of available Mo increased significantly with 4 kg Mo ha^{-1}. This increase may be ascribed to increased concentration of Mo in soil solution as a result of its addition. Application of P also increased the amount of Mo in soil. Similar results were reported by Singh *et al.* (2014).

It could be concluded from the results that the application of 90 kg P_2O_5 ha^{-1} and 3 kg Mo ha^{-1} is beneficial in increasing the status of available N, P, K and Mo in soil besides crop yield and uptake of nutrients by the lentil crop.

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