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EFFECT OF SOURCES OF PHOSPHORUS AND BIOFERTILIZER ON YIELD, NUTRIENT UPTAKE AND QUALITY OF LENTIL

VINAY SINGH, JAVED ALI, HARVENDRA SINGH[1] AND JAGPAL SINGH

Department of Agricultural Chemistry and Soil Science, Raja Balwant Singh College, (Dr. B.R.A. University), Bichpuri, Agra (U.P.) - 283 105

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ABSTRACT

A filed experiment was conducted during rabi seasons of 2010-11 and 2011-2012 at farmers' field at Panwari (Agra) on a sandy loam soil to assess the effect of single superphosphate and rock phosphate with PSB on yield, nutrient uptake and quality of lentil (Lens culinaris). The experiment was carried out in a randomized block design with nine treatments and three replications. Results revealed that grain and straw yield and uptake of N and P increased significantly with both sources of P over control. Application of single superphosphate proved superior to rock phosphate in respect of yield and uptake of nutrients. There was a significant increase in yield and uptake of nutrients with increase in P application rate from 45 kg P_2O_5 ha^{-1} to 90 kg P_2O_5 ha^{-1} applied either through SSP or RP. Protein content in lentil grain and straw increased significantly with both the sources of P. Application of biofertilizer (PSB) recorded higher yield (grain and straw) and uptake of nutrients over no phosphorus. The maximum grain (17.70 and 18.50 q ha^{-1}) and straw (33.15 and 34.75 q ha^{-1}) yields and protein content were recorded with 90 kg P_2O_5 ha^{-1} as SSP. The amount of available P in post harvest soil increased with increase in P fertilization rates to the crop.

Keywords: Phosphorus sources, PSM, yield, quality, nutrient uptake, lentil

INTRODUCTION

Phosphorus is one the macronutrients for biological growth and development. It is considered to be one of the major nutrient elements limiting agricultural production in India. Phosphorus fertilization to legumes is more important than that of nitrogen. The cultivation of pulses without phosphatic fertilizers is one of the important factors responsible for their low productivity. Phosphorus is an essential nutrient for grain legumes, as it helps in improving nodulation, seed yield and seed protein (Singh *et al.* 2014). A large portion of chemical fertilizers with high P content applied to soil is immobilized rapidly and becomes unavailability to plants. Depending on the soil pH, these soil components react with the P in soil solution, rendering it in to unavailable form, with the formation a wide range of reaction products with varying solubility. This nature of P has resulted in wide spread deficiency. Availability of P to plants is limited due to its conversion in alkali soil as calcium phosphate. Cost of water soluble phosphatic fertilizers has increased tremendously in India in recent times because of importing row materials like high grade rock phosphate and sulphur. Finely ground (100 meshes) low grade Udaipur rock phosphate was procured from Rajasthan state mines and minerals Ltd. Udaipur, Rajasthan. It was alkaline (pH 7.5) with electrical conductivity of 0.80 dSm^{-1}, total P_2O_5 17.5% citrate soluble P_2O_5 0.12% (0.68% of total P_2O_5) and water soluble P_2O_5 in traces. A substantial amount of rock phosphate is available in India, but most of them are low grade and unsuitable for manufacturing of commercial P fertilizers as well as direct use as a source of P to crops, particularly in neutral and alkaline soils. Therefore, there is a need to generate technology for solubilizing P from indigenous low grade rock phosphate to be applied directly in these soils. The concept of P solubilizing biofertilizers is also gaining importance. Phosphate solubilizing microorganisms play an important role in supplementing P to the plants. Inoculation of P-solubilizing microorganisms in the rhizosphere of crop and soil increases the availability of P from insoluble sources of phosphates and also increases the efficiency of phosphate fertilizers (Gaur, 1990). Since, information is lacking on the use of rock phosphate in alluvial soils along with P-solubilizing microorganisms on lentil, a field experiment was conducted to study the effect of rock phosphate and single super phosphate and P-solubilizers on lentil crop in an alluvial soil.

[1]*ZARS, RVSKV, Morena (M.P.)*

METHODS AND MATERIALS

Field experiments were carried out at Panwari, Agra, Uttar Pradesh (27° 14’ N latitude 77° 78’ E longitude and 168m above mean sea level) during rabi seasons of 2010-11 and 2011-12. The mean annual rainfall of Agra is 650mm and more than 80% generally occurs during the monsoon season (July-September). The experimental soil was sandy loam in texture, alkaline in nature (P^H 7.8) low in available N (170 kg ha^{-1}), low in available P (10.2 kg ha^{-1}) and low in available K (108 kg ha^{-1}). The organic carbon content in soil was 2.9 g kg^{-1}. The treatments were namely control (T_0), *Pseudomons striata* inoculation (T_1), 45 kg P_2O_5 ha^{-1} as single superphosphate (T_2), 45 kg P_2O_5 ha^{-1} as single superphosphate + *Pseudomonas striata* inoculation (T_3), 45 kg P_2O_5 ha^{-1} as rock phosphate (T_4) 45 kg P_2O_5 ha^{-1} as rock phosphate + *Pseudomonas striata* inoculation (T_5), 90 kg P_2O_5 ha^{-1} as rock phosphate (T_6), 90 kg P_2O_5 ha^{-1} as rock phosphate + *Pseudomonas striata* inoculation (T_7) and 90 kg P_2O_5 ha^{-1} as single superphosphate (T_8) were tested in randomized block design with three replications. A dose of 20 kg N ha^{-1} and 40 kg K_2O ha^{-1} was applied at the time of sowing through urea and muriate of potash, respectively. Single superphosphate and Mussorie rock phosphate were also applied as basal dose as per treatments. Seeds of lentil (Var. T-36) were treated with *Pseudomonas striata* (5 g kg^{-1} seed) as per treatment. Lentil crop was sown at the rate of 40 kg ha^{-1}. Rest of the management practices were in accordance with the recommended package of practices for the crop. At harvest the grain and straw yields were recorded. Phosphorus content in grain and straw was determined by vanadate molybdate yellow colour method in di-acid mixture ($HClO_4$: HNO_3) digest. Nitrogen content was determined by Kjeldahl method (Jackson, 1973). The soil samples collected after harvest of the crop were analyzed for available P as per procedure suggested by Olsen *et al.* (1954).

RESULTS AND DISCUSSION

Yield

The grain and straw yields of lentil increased significantly by sources and levels of phosphorus (Table 1). Application of 90 kg P_2O_5 ha^{-1} through SSP recorded significantly higher grain and straw yields over no phosphorus. The increases in grain and straw yields with 90 kg P_2O_5 ha^{-1} as SSP were 37.9 and 35.7%, respectively over control. Application of 90 kg P_2O_5 ha^{-1} as RP being at par with 45 kg P_2O_5 ha^{-1} as SSP registered higher yields over no phosphorus and 45 kg P_2O_5 ha^{-1} as RP, Mahanta and Rai (2008) reported similar results. The increase in yield may be attributed to the effective metabolic activities coupled with increased rate of photosynthesis, leading to better translocation of nutrients and expression of development characters. Application of phosphate solubilizing bacteria with P fertilizers increased the grain and straw yield by 8.3 and 5.4% over control. The P solubilizing capacity of PSB is well known fact, which helps in increasing the release of P from RP and thus, maintains a steady P supply to lentil plants under P deficient conditions and subsequently the yield. Similar increase in yield was reported by Singh *et al.* (2014). Percent yield response (Table 1) increased with increasing P levels irrespective of the source. Maximum yield response (37%) was recorded with single superphosphate @ 90 kg P_2O_5 ha^{-1} alone followed by 45 kg P_2O_5 ha^{-1} as SSP + PSB and 90 kg P_2O_5 ha^{-1} as RP + PSB. The response of PSP in improving yield may be attributed to their significant role in regulating root enlargement and better microbial activities (Raj *et al.* 2014).

In general, superphosphate was superior to rock phosphate, but when 45 kg P_2O_5 ha^{-1} as rock phosphate was inoculated with *Pseudomons striata*, it remained at par with 45 kg P_2O_5 ha^{-1} as single superphosphate. The higher grain yield was noted with 45kg P_2O_5 ha^{-1} as single super phosphate due to the easily availability of water soluble P to the crop. The straw yield significantly increased with all the treatments in both the years. Straw yield was further enhanced by single super phosphate (45kg ha^{-1}) with *Pseudomonas striata* and proved superior to superphosphate alone. Rock phosphate with *Pseudomonas striata* also increased the straw yield but the straw yield was lower than that of 45 kg P_2O_5 ha^{-1} as single super phosphate. The increase in straw yield under P sources might be due to increased availability of P that helped in proliferation of root development and hence, better nutrient acquisition and biomass accumulation. Similar results were reported by Deshpande *et al.* (2015) in chickpea.

Table 1: Effect of treatments yield and protein content in lentil crop

Treatments	Grain yield (q ha^{-1})	% response	Straw yield (q ha^{-1})	% response	Protein (%)	
					Grain	Straw
T_0 Control	13.12	-	25.00	-	21.3	3.8
T_1 PSB	14.22	8.3	26.35	5.4	21.6	3.9
T_2 45 kg P_2O_5 ha^{-1} as SSP	15.75	20.0	29.58	18.3	21.9	4.0
T_3 45 kg P_2O_5 ha^{-1} as SSP+PSB	16.74	27.6	31.54	26.1	22.5	4.1
T_4 45 kg P_2O_5 ha^{-1} as RP	13.82	5.3	26.20	4.8	22.3	4.1
T_5 45 kg P_2O_5 ha^{-1} as RP+PSB	14.54	10.8	27.65	10.6	22.4	4.1
T_6 90 kg P_2O_5 ha^{-1} as RP	15.55	18.5	29.75	19.0	22.8	4.2
T_7 90 kg P_2O_5 ha^{-1} as RP+PSB	17.02	29.7	32.75	31.0	23.0	4.2
T_8 90 kg P_2O_5 ha^{-1} as SSP	18.10	37.9	33.92	35.7	23.3	4.4
SEm$\pm$	0.45	-	0.64	-	0.11	0.06
CD (P=0.05)	1.34	-	1.90	-	0.32	0.17

Quality

Different sources and levels of P significantly increased the protein content of lentil grain and straw over control, indicating a favourable effect of P on protein content. There was a significant difference between SSP and RP for protein content in lentil crop. Application of PSB increased the protein content over no PSB. The protein content in grain and straw ranged from 21.3 to 23.0 and 3.8 to 4.4%, respectively. The increase in protein content with P application might be due to higher N uptake as a result of increased nodulation and N fixation by nodules (Singh *et al.* 2014). The maximum protein content in grain (23.3%) and straw (4.4%) was recorded with 90 kg P_2O_5 ha^{-1} as SSP.

Nutrient Content

Nitrogen content in grain and straw increased with all the treatments over control. Application of 45 and 90 kg P_2O_5 ha^{-1} as SSP significantly increased the nitrogen content in lentil crop. Application of rock phosphate alone also improved the N absorption by the crop but it was less effective than that of SSP in improving the N content in lentil crop. Thus, the results showed synergistic effect of applied P on nitrogen content in lentil crop. Inoculation with *Pseudomonas striata* alone or with SSP and RP also improved the nitrogen content in grain and straw. The maximum values of N content in grain (3.58%) and straw (0.64%) were noticed with 90 kg P_2O_5 ha^{-1} as SSP. However, inoculation of PSB + 90 kg P_2O_5 ha^{-1} as RP gave more or less similar values of N content in lentil crop. All the sources and levels of P with or without PSB significantly increased the P content in grain and straw. The P content ranged from 0.3% at control to 0.43% with 90 kg P_2O_5 ha^{-1} as SSP. The corresponding range of P content in straw was from 0.11 to 0.16%. The increase in P content in lentil crop was higher with SSP than that of RP. Inoculation of PSB also improved the P content in lentil grain and straw over control. These effects on the concentration of P in lentil grain and straw were undoubtedly due to the sufficient amount of available P with RP or SSS addition. Similar results were reported by Raj *et al.* (2014) and Singh *et al.* (2015).

Nutrient Uptake

Seed inoculation with *Pseudomonas striata* increased N uptake by lentil crop significantly over control which may be attributed to increased yield of lentil. Application of 60 kg P_2O_5 ha^{-1} as rock phosphate markedly influenced the uptake of nitrogen by lentil crop. Higher values of N uptake with rock phosphate combined with *Pseudomonas striata* inoculation are apparently the results of favourable effect of this treatment of N absorption coupled with greater lentil grain and straw production. Application of 60 kg P_2O_5 ha^{-1} as single superphosphate resulted in significantly higher nitrogen uptake by lentil grain and straw over rock phosphate and control (Nusakho Nyekha *et al.* 2015). Phosphorus uptake by lentil grain and straw increased significantly over control when P was applied as SSP or RP, which further increased when P was applied with PSB. The biofertilizer inoculation also enhanced N and P uptake by lentil as compared to uninoculated plot. This could be possible due to higher biomass production as well as due to more plant accessible phosphate made available by solubilization by PSB from native and applied phosphorus. Similar results and views were also shared by Deshpande *et al.* (2015). Among the sources, SSP was significantly superior to RP for P uptake by lentil grain and straw.

Table 2: Effect of various treatments on content and uptake of nutrients in lintil and soil fertility

Treatments	N content (%)		P content (%)		N uptake (kg ha^{-1})		P uptake (kg ha^{-1})		Available P (kg ha^{-1})
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	
T_0	3.41	0.61	0.30	0.11	44.7	15.2	3.9	2.7	9.0
T_1	3.44	0.62	0.31	0.12	48.9	16.3	4.4	3.1	10.2
T_2	3.47	0.64	0.37	0.14	54.6	18.9	5.8	4.1	12.5
T_3	3.52	0.65	0.39	0.14	58.9	20.5	6.5	4.4	14.0
T_4	3.45	0.62	0.36	0.12	47.6	16.2	4.9	3.1	11.4
T_5	3.49	0.63	0.39	0.14	50.7	17.4	5.6	3.8	12.0
T_6	3.50	0.63	0.38	0.14	54.4	18.7	5.9	4.1	14.0
T_7	3.54	0.64	0.42	0.15	60.2	20.9	7.1	4.9	15.0
T_8	3.58	0.66	0.43	0.16	64.8	22.4	7.8	5.4	16.2
SEm $\pm$	0.05	0.04	0.03	0.02	3.0	1.6	0.24	0.26	0.54
CD (P=0.05)	0.14	0.11	0.08	0.06	8.9	4.7	0.70	0.75	1.63

Available phosphorus

There was a significant build-up of available P in soil with all the treatments over control (Table 2). The available P content in the post-harvest soil after 2 years increased significantly under different sources and levels of P and PSB. The available P content in the soil increased by 6.0 kg ha^{-1} from the initial level with 90 kg P_2O_5 ha^{-1} as SSP. This was also increased when SSP and RP were applied along with PSB over control. This might be because of enhanced activity of PSB for solubilization of P added through SSP or RP (Deshpande *et al.* 2015). Maximum available P (16.2 kg ha^{-1}) was recorded with 90 kg P_2O_5 ha^{-1} as SSP followed by 45 kg P_2O_5 ha^{-1} as SSP + PSB (14.0 kg ha^{-1}) which were significantly superior to all other treatments. Available P showed significant reduction in control plot over the initial value.

Therefore, it can be inferred that the use of rock phosphate at higher dose along with *Pseudomonas striata* can help to meet the P requirement of legume crop by saving 50 percent cost on conventional phosphatic sources. Thus, this method could be adapted as an alternative and cheaper source of P fertilizers by the farmers to replace part of the costly phosphatic fertilizers.

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