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Studies on Phosphorus and Zinc Economy with Phosphate and Zinc Solubilizing Microbes in Lentil

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ABSTRACT

Background: Lentil (*Lens culinaris* Medik) is an important winter pulse crop grown in Indian subcontinent. Lentil like other pulse crops is given secondary importance as far as its growing environment is concerned. Lentil is sown as a cool-season crop and is highly susceptible to rising temperatures. It needs low temperatures at the time of vegetative growth, while maturity requires warm temperatures; the best temperature for its optimum growth has been found to be 18-30°C. It is grown on marginal lands with low fertility and receives sub-optimal fertilizer application. Rhizobium and phosphate solubilizing bacteria help to increase the availability of soil nitrogen and phosphorus and effect of zinc solubilizing microbes in lentil has not been studied earlier.

Methods: An experiment was conducted during *Rabi* 2019-20 and 2020-21 to study the effect of phosphate and zinc solubilizing microbes on growth, yield and economy of lentil at research farm area of Pulses Section Department of Genetics and Plant Breeding, CCS HAU, Hisar. The experiment was laid out in randomized block design with eleven treatments replicated thrice.

Result: Growth as well as yield parameters were significantly affected by different treatments and were significantly higher with application of 50% recommended phosphorus dose application + 12.5 kg $ZnSO_4$ + Biophos + Biozinc. The soil pH did not differ significantly under different treatment. The soil EC under different treatment differed significantly with control. The soil organic carbon was found maximum in T_{10} (50% recommended phosphorus dose application + 12.5 kg $ZnSO_4$ + Biophos + Biozinc) and it was closely followed by T_{11} (recommended phosphorus dose application + nutrient mobilizer {LNm 43a}). Similarly, maximum net return and BC ratio was obtained in T_{10} treatment followed by T_9 (50% recommended phosphorus dose application + Biophos + Biozinc).

Key words: Biophos, Biozinc, Economics, Lentil, Yield.

INTRODUCTION

Globally lentil occupies 5.00 million hectares area with the production of 6.53 million tons (FAOSTAT 2020). Canada has emerged as a lentil bowl in the past decade as it is the largest producer and exporter of lentil in the world.

The leading lentil-producing countries are Canada, India, Australia, Türkiye, USA, Nepal, Syria, Bangladesh and China. In India, lentil is mainly cultivated in rainfed areas of Madhya Pradesh, Uttar Pradesh, West Bengal and Bihar with the national production of 1.49 million tons yielding out of 1.46 million hectares area (INDIASTAT 2021). Although lentil has seen a rise in productivity in the last few years, this increase is not encouraging and has started to stagnate.

India has to lift up pulse productivity with its limited and decreasing land holding to assure food and nutritional security. Sustainable soil nutrient management is one of the ways to increase the pulse production and productivity. The yield level of lentil is generally low because it is less cared crop and mostly grown in poor soil without manures and fertilizers. Regular depletion of nutrient resources of soil has led to emergence of several nutrient deficiencies in many crops including lentil. As a leguminous crop, it utilizes atmospheric nitrogen to meet its partial nitrogen requirement and thus occupies an important place in crop rotation in different part of the country. It is the most suitable crop for rainfed conditions, because of its deep root system and capability to stand in drought condition. In comparison to any other *rabi* crops of similar condition, except gram, it is greatly esteemed for its ability to give satisfactory yield even under sub-optimum condition and less rainfall in winter season.

Biofertilizers are gaining importance as they are ecofriendly, non-hazardous and non-toxic. A substantial number of bacterial species, mostly those associated with the plant rhizosphere, may exert a beneficial effect upon plant growth. Biofertilizers include mainly the nitrogen fixing, phosphate solubilizing and plant growth promoting micro-

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organism. Inoculating pulse crops with rhizobia to add nitrogen is routine for most growers. The presence of efficient and specific strains of Rhizobium in the rhizosphere is one of the most important requirements for proper establishment and growth of grain legume plant. Phosphate solubilizing bacteria partly solubilizes inorganic and insoluble phosphate and improves applied phosphorus use efficiency stimulating plant growth by providing hormone, vitamin and other growth promoting substances (Gyaneshwar *et al.* 2002). Zinc (Zn) is required for the metabolism of plants, enzyme function and ion transport. Consequently, inadequate Zn availability in soil is a main consideration for plant nutrition, resulting in a significant loss in production and grain nutrient content.

MATERIALS AND METHODS

The experiment was conducted during *Rabi* 2019-20 and 2020-21 to study the effect of phosphate and zinc solubilizing microbes on growth, yield and economy of lentil at research farm of Pulses Section Department of Genetics and Plant Breeding, CCS HAU, Hisar. The meteorology of study area indicated that the temperature ranges from freezing point in winter to 48°C in summer with annual rainfall of 429 mm. The soil of experimental site had textural class of 55% sand, 35% silt and 10% clay. The experiment was laid out in randomized block design with the eleven treatments *viz.* T_1 {(absolute Control (Without P)}, T_2 {(recommended phosphorus dose application (Control)}, T_3 (soil application of 25 kg $ZnSO_4$ per ha), T_4 (application of Biophos), T_5 (application of Biozinc), T_6 (application of Biophos + Biozinc), T_7 (50% recommended phosphorus dose application + Biophos), T_8 (12.5 kg $ZnSO_4$+ Biozinc), T_9 (50% recommended phosphorus dose application + Biophos + Biozinc), T_{10} (50 % recommended phosphorus dose application + 12.5 kg Zn SO_4 + Biophos + Biozinc) and T_{11} (recommended phosphorus dose application + nutrient mobilizer {LNm 43a}) replicated thrice. Seeds of HM-1 variety of lentil were treated with Biophos or Biozinc cultures @ 5 ml/kg seed before sowing and were sown at recommended spacing of 22.5 cm × 10 cm on 20th November during both the years.

RESULTS AND DISCUSSION

On the basis of pooled data of two years, the present studies revealed that growth parameters *viz*; plant height and number of branches per plant and yield parameters *i.e.,* Pods/plant, 1000 grain weight and yield/ha were significantly affected by different treatments and were significantly higher at T_{10} treatment (50% recommended phosphorus dose application + 12.5 kg Zn SO_4 + Biophos + Biozinc). The reason for better growth and development in the above treatment might be due to increased availability of zinc and phosphorus to the plant initially through fertilizers, microbial inoculants then through phosphorus, zinc and their liquid bio fertilizer in the cropping season (Sharma *et al.*, 2022). Application of 5% recommended phosphorus dose + 12.5 kg Zn SO_4 + Biophos + Biozinc; recorded maximum and significantly higher pods/ plant (130) and grain yield (1864 kg/ha) over rest of the treatments except application of 50% Recommended phosphorus dose application + Biophos + Biozinc (1782 kg/ha) and 50% Recommended phosphorus dose application + Biophos (1661 kg/ha) were statistically at par (Table 1). Similar trend of getting higher pods per plant and higher yield by the treatment of 50% recommended phosphorus dose + 12.5 kg $ZnSO_4$ + Biophos + Biozinc was observed by Sharma *et al.*, (2022) in lentil, Anant *et al*. (2021) in fieldpea and Navsare *et al*. (2018) in mungbean. Ali *et al*. (2017) found that the application of zinc and phosphorus has a positive effect on yield and attributing traits. The per cent increase in the grain yield was to the tune of 67.5 in T_{10}, 60.0 in T_9 and 49.2% in T_7 over absolute control (Without P), respectively. The increase in yield might have resulted from the growth regulating substances produced by Biofertilizers besides fixation of additional nitrogen from atmosphere thereby increasing nitrogen availability in the soil throughout the crop growth

Table 1: Effects of different phosphate and zinc solubilizing microbes on growth, yield attribute and yield of lentil.

Treatments		Plant height (cm)	Branches/ Plant	Pods/ plant	1000 seed wt. (g)	Seed yield (kg/ha)
T_1	Absolute Control (Without P)	33.10	3.95	74	16.3	1113
T_2	Recommended phosphorus doseapplication (Control)	35.30	5.03	107	17.7	1394
T_3	Soil application of 25 kg Zn SO_4 per ha	34.35	5.29	102	17.9	1577
T_4	Application of Biophos	35.65	4.81	87	17.5	1343
T_5	Application of Biozinc	34.95	4.41	82	17.5	1306
T_6	Application of Biophos + Biozinc	36.55	5.00	94	17.3	1497
T_7	50% Recommended phosphorus doseapplication + Biophos	37.10	5.74	115	17.7	1661
T_8	12.5 kg Zn SO4+ Biozinc	36.30	5.50	102	17.5	1586
T_9	50% Recommended phosphorus doseapplication + Biophos + Biozinc	37.75	5.98	119	17.9	1782
T_{10}	50% Recommended phosphorus doseapplication + 12.5 kg Zn SO_4 + Biophos + Biozinc	39.90	6.53	130	18.4	1864
T_{11}	Recommended phosphorus dose application + nutrient mobilizer (LNm43a)	36.25	5.51	111	17.9	1627
CD (P=0.05)		2.35	0.68	15	NS	231

Table 2: Effects of phosphorus and zinc economy with phosphate and zinc solubilizing microbes on economics of Lentil.

Treatments		Cost of cultivation (Rs./ha)	Gross return (Rs. /ha)	Net return (Rs. /ha)	B:C ratio
T_1	Absolute Control (Without P)	26391	56763	30371	1.15
T_2	Recommended phosphorus dose application (Control)	28455	71094	42638	1.50
T_3	Soil application of 25 kg Z_nSo_4 per ha	27305	80427	53121	1.95
T_4	Application of Biophos	26914	68493	41579	1.54
T_5	Application of Biozinc	26914	66606	39692	1.47
T_6	Application of Biophos + Biozinc	27175	76347	49172	1.81
T_7	50% Recommended P + Biophos	27959	84711	56752	2.03
T_8	12.5 kg Z_nSO_4+ Biozinc	26979	80886	53907	2.00
T_9	50% Recommended P + Biophos + Biozinc	28220	90882	62662	2.22
T_{10}	50% Recommended P + 12.5 kg Z_nSO_4 + Biophos + Biozinc	28547	95064	66517	2.33
T_{11}	Recommended phosphorus dose application + nutrient mobilizer (LNm 43a)	28978	82977	53999	1.86

Table 3: Initial soil properties status.

Soil properties	Values	Category
pH	7.9	Neutral to alkaline
EC (dS/m)	0.57	Non-saline
Organic carbon (%)	0.44	Medium
Available nitrogen (kg/ha)	138.2	Low
Available phosphorus (kg/ha)	14.0	Medium
Available potassium (kg/ha)	262.0	Medium

Table 4: Soil properties after *rabi* 2020-21.

Treatment no.	pH (1:2)	EC (1:2) (dS/m)	Organic carbon (%)	Available nutrients (kg/ha)		
				N	P	K
	7.93	0.54	0.39	117.8	11.2	240.6
T_2	7.82	0.52	0.42	127.6	12.7	251.9
T_3	7.85	0.51	0.43	130.5	13.6	255.0
T_4	7.87	0.50	0.45	133.4	13.8	260.3
T_5	7.83	0.52	0.44	129.7	13.7	255.1
T_6	7.85	0.53	0.45	133.4	13.4	261.8
T_7	7.86	0.52	0.44	130.5	12.8	254.6
T_8	7.85	0.53	0.44	133.1	13.3	261.3
T_9	7.87	0.50	0.43	130.5	13.0	252.6
T_{10}	7.81	0.48	0.47	138.2	14.7	272.1
T_{11}	7.89	0.51	0.46	135.3	14.2	267.3
CD (p=0.05)	NS	0.04	0.03	9.4	1.4	15.7

and this result was reported by Singh and Singh (2017). However, 1000 seed weight did not influence significantly among the treatments and numerically maximum value (18.4 g) was recorded in application of 50% Recommended phosphorus dose application + 12.5 kg $ZnSO_4$ + Biophos + Biozinc in comparison to other treatments (Table 1). Similarly maximum net return (66517 Rs./ha) and BC ratio (2.33) was obtained in T_{10} treatment followed by T_9 as given in Table 2. The soil pH did not differ significantly under different treatments (Table 3 and 4). The Soil EC under different treatment differed significantly with control. The soil organic carbon was found maximum in T_{10} (0.47%) and it was closely followed by T_{11} (0.39%) as observed in Table 4. Organic carbon also differed significantly with control (0.39%); when compared with other treatments. Availability of nutrients (N, P and K) exhibited similar trend under different treatments (Table 4).

CONCLUSION

Application of 50% recommended phosphorus dose along with basal application of 12.5 kg/ha $ZnSO_4$ + seed inoculation with biophos + biozinc @ 5 ml/kg seed was found effective for enhancing grain yield (1864 kg/ha), Net return (Rs. 66517/ha) and B:C ratio (2.33) of lentil. Thus, application of phosphate

and zinc solubilizing microbes in lentil is the cost-effective way of producing food for the undernourished populations.

Conflict of interest: None.

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