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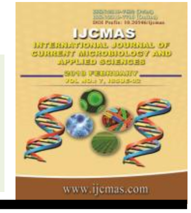

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Effect of Biofertilizers and Micronutrients on Nutrient Uptake, Growth, Yield and Yield Attributes of Lentil (*Lens culinaris* L.)

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A B S T R A C T

A field experiment was conducted to study the effect of biofertilizers (*Rhizobium* and PSB) and micronutrients (Zn and Mo) on nutrient uptake, growth, yield and yield attributing characters of lentil. The experiment was laid out in randomized block design with the eight treatments *viz.* T_1(control), T_2 (Seed inoculation with *Rhizobium* + PSB), T_3 (Seed inoculation with *Rhizobium* + PSB+ 1g Ammonium Molybdate/ kg seed), T_4 (RDF, 20:60:20 kg N, P_2O_5 and K_2O), T_5 (RDF + Seed Inoculation with *Rhizobium* + PSB), T_6 (RDF+ Seed Inoculation with *Rhizobium* + PSB+1 g Ammonium Molybdate/ kg seed), T_7 (RDF + 25 kg $ZnSO_4$/ha) and T_8 (RDF + 25 kg $ZnSO_4$ / ha +Seed inoculation with *Rhizobium* + PSB + 1.0g Ammonium Molybdate/ kg seed)and three replications with lentil variety NDL-1.The soil of experimental field was silt loam in texture, pH: 8.45, EC: 0.34 dSm^{-1}, O.C: 0.31%, Available N 137 kg ha^{-1}, available P 12 kg ha^{-1}, available K 211 kg ha^{-1} and bacterial population (33.0 cfu).The highest uptake of N (91.55 kg ha^{-1}), P (8.57 kg ha^{-1}), Zn (654.66 g ha^{-1}) and Mo (278.69 g ha-1) by lentil crop was found with the treatments T_8, followed by T_6. The maximum growth, yield and yield attributing characters were recorded in T8, which was statistically at par with T6 and significantly superior with rest of the treatments. Whereas maximum 1000 seed weight (26.00) also was recorded in the treatment T_8, which was statistically at par with rest of the treatments. The minimum 1000 seed weight was recorded in control.

Introduction

Lentil (*Lens culinaris* L.) is an important *Rabi* pulse crop extensively grown in India. 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. This is because the greater is the production, the higher and faster are the rate of nutrients exhation from the soil. 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 in year of low winter rainfall.

Lentil seeds contain about 11.20 percent water, 25.0 percent protein, 1.0 percent fat, 55.8 percent carbohydrate, 3.7 percent fiber and 3.3 percent ash. The role of lentil as a legume crop in building up soil fertility is well known.

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-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).

The function of most micronutrients in plants and soils for the most part is widely misunderstood. One example of this is zinc and its relative importance in plants' growth. Zinc plays a vital role in the synthesis of protein and nucleic acid and help in the utilization of nitrogen and phosphorus in plant. It also promotes nodulation and nitrogen fixation of leguminous crops.

Molybdenum is a trace element found in the soil and is required for growth of most biological organisms including plants and animals. Molybdenum plays a vital role in nitrogen fixation through its effect on nitrogenase enzyme of nodule in leguminous plants. The chief role of molybdenum is to activate nitrate reductase enzyme during nitrogen metabolism *(Possinghum, 1956, 57).*

Materials and Methods

The experiment was conducted during Rabi season of 2015-16 at G.P.B. Farm of the Narendra Deva University of Agriculture and technology, Kumarganj, Faizabad U.P. The experiment was laid out in a Randomized Block Design with eight treatment combination *viz.* T_1(control), T_2 (Seed inoculation with *Rhizobium* + PSB), T_3 (Seed inoculation with *Rhizobium* + PSB+ 1g Ammonium Molybdate/ kg seed), T_4 ((RDF, 20:60:20 kg N, P_2O_5 and K_2O), T_5 (RDF + Seed Inoculation with *Rhizobium* + PSB), T_6 (RDF+ Seed Inoculation with *Rhizobium* + PSB+1 g Ammonium Molybdate/ kg seed), T_7 (RDF + 25 kg $ZnSO_4$/ha) and T_8 (RDF + 25 kg $ZnSO_4$ / ha +Seed inoculation with *Rhizobium* + PSB + 1.0g Ammonium Molybdate/ kg seed) with three replications. The soil of experimental field was silt loam in texture, pH: 8.45, EC: 0.34 dSm^{-1}, O.C: 0.31%, Available N 137 kg ha^{-1}, available P 12 kg ha^{-1}, available K 211 kg ha^{-}. The sources of N, P, K, Zn and Mo were urea, single superphosphate, muriate of potash ammonium molybdate andzinc sulphate respectively. The seeds were sown on 29^{th}November 2015 with seed rate of 40 kg/ha and at a distance of 25 cm line to line. Crop management practices were done as perschedule and necessity.

After complete emergence of seed, plant to plant spacing of 10 cm was maintained. There after plant population per square meter was counted. The plant height was measured from the ground level to top position of plant in cm with the help of meter scale based on five randomly selected plants and averaged out for each plant. The observation on plant height was recorded at harvest stages of crop. For counting number of nodules per plant, five plants were selected and up rooted with the help of khurpi and washed without any damage to the root. The number of nodules per plant was counted at 60 DAS. Nodules were carefully detached from the roots of 5 selected plants from each replication and pooled together. The number of nodules per plant was calculated by dividing the total number of nodules with the number of plants. The fresh weight of nodules of five selected plants was recorded at 60 days stage, and their average was calculated. After recording the fresh weight, the nodules were oven dried at 60^0C for 8 hours to a constant weight and dry weight of nodules were recorded. Nitrogen, phosphorus and molybdenum content in seed and stover was determined by micro kjeldahl, vanadomolybdo phosphoric yellow colour, using water and ammonium oxalate extractant method, respectively (Jackson, 1973). The zinc content in the plant was estimated by atomic absorption spectrophotometer using DTPA extractant (Shaw and Dean, 1952). Nutrient uptake (seed and stover) was calculated with the help of following formulae:-

$$\text{Nutrient uptake (kg ha}^{-1}) = \frac{\text{Nutrient content in seed(\%) x Seed yield(Kg /ha)}}{100} + \frac{\text{Nutrient content in straw(\%) x Straw yield(Kg/ha)}}{100}$$

The recovery of seeds from the total dry matter is considered as harvest index, which is expressed in percentage. It was calculated by the following formulae.

Harvest index (%) = (Seed yield / Biological yield) x 100

The total number of pods in 5 randomly selected plants were counted and averaged to get number of pods per pant. The number of pods in randomly selected five plants from each replication was counted for seeds and number of grains per pod was calculated. From each treatment 1000 seed were counted and weighed to express the weight in gram.

Results and Discussion

Growth

Data present in table 1 reveal that seed inoculation with rhizobium, PSB, ammonium molybdate and application of RDF along with zinc sulphate, recorded significant increase all growth parameters (plant height, number of nodules at 60 DAS, fresh and dry weight of nodules at 60 DAS).

It clearly indicates that the treatments had no effect on plant population and statistically they were at par. Maximum plant height (58.24 cm) was recorded with the treatment T_8 which was statistically at par with the treatment T_6 and significantly superior over rest of treatments. The plant height was significantly influenced by various treatments.

The application of biofertilizers, micronutrients and RDF enhanced the plant height appreciably at harvest stages. The maximum plant height was recorded in the T_8 (RDF + 25 kg $ZnSO_4$ / ha +Seed inoculation with *Rhizobium* + PSB + 1.0g Ammonium Molybdate/ kg seed). Increase in plant height might be attributed to the fact that the better nourishment causes beneficial effects such as accelerated rate of photosynthesis, assimilation, cell division and vegetative growth. These results are in agreement with the findings of Singh *et al.,* (2007).

The highest number of nodules (8.80), fresh (25.26 mg) and dry (5.05 mg) weight of nodules plant^{-1}was recorded with the treatment T_8, which statistically at par with the treatment T_6 and significantly superior over rest of the treatments. The highest weight of nodules plant^{-1} was also recorded with the treatment

T_8. It might be due to the enhanced and established good root system by the seed treatment with rhizobium, ammonium molybdate and application of $ZnSO_4$. Favourable responses of Rhizobium, Zn and Mo have also been reported by Johal and Chahal, 1994 and Kumpawat and Manohar, 1994.

Yield

The data (Table 1) on yield and yield attributes of lentil clearly show that all the parameters significantly higher in all the treatments over control.

It was observed that the maximum grain (1457 kg ha^{-1}) yield was recorded with the treatment T_8 (RDF + 25 kg $ZnSO_4$ / ha +Seed inoculation with *Rhizobium* + PSB + 1.0g Ammonium Molybdate/ kg seed) which was statistically at par with treatment T_6 (RDF+ Seed Inoculation with *Rhizobium* + PSB+1 g Ammonium Molybdate/ kg seed) and significantly superior overrest of the treatments.

The minimum grain (860 kg ha^{-1}) yield was obtain in the control. Similarly, maximum straw yield (2365 kg ha^{-1}) was recorded with the treatment T_8, which was statistically at par with the treatments T_6 and significantly superior over the rest of the treatments.

The grain and straw yield of lentil were significantly influenced by various treatments. The maximum increment in grain as well as straw yield were observed with the treatment T_8 (RDF + 25 kg $ZnSO_4$ / ha +Seed inoculation with *Rhizobium* + PSB + 1.0g Ammonium Molybdate/ kg seed) followed by T_6 (RDF+Seed inoculation with *Rhizobium* + PSB + 1.0g Ammonium Molybdate/ kg seed). Grain and straw yield under various treatments (T_8, T_7, T_6, T_5, T_4 and T_3) gave better results over control. The increase in grain and straw yield of lentil might be due to improvement in the efficiency and utilization of native as well as applied nutrients. These results also corroborate with the findings of Kumar *et al.*, (1993), Hafeez *et al.*, (2000) and Shah *et al.*, (2000).

Yield attributes

The data (Table 1) on yield attributing characters of lentil as affected by different treatments clearly show the significant difference for number of pods $plant^{-1}$ and number of seeds pod^{-1}in lentil.

The maximum number of pods (116.40) per plant were recorded with the treatment T_8 (RDF + 25 kg $ZnSO_4$ / ha +Seed inoculation with *Rhizobium* + PSB + 1.0g Ammonium Molybdate/ kg seed), which was statistically at par with the treatment T_6 (RDF+Seed inoculation with *Rhizobium* + PSB + 1.0g Ammonium Molybdate/ kg seed), having 106.40 pods $plant^{-1}$and significantly superior over rest of the treatments.

The minimum number of pods per plant was recorded under control. Similar trend was also recorded with respect to no. of seeds pod^{-1}.

Minimum number of seeds (1.20) per pod recorded under the control.

The maximum test weight (26.00 g) was reccorded in treatment T_8 which was statistically at par with rest of the treatments. The minimum 1000 seed weight was recorded in control.

The increase in yield attributes might be mainly due to increase in photosynthesis activity of leaves, translocation of photosynthates from source to sink and nutrient’s uptake. These results corroborate with the finding of Mishra and Tiwari (2001) and Hossain *et al.*, (2010).

Table.1 Effect of biofertilizers and micronutrients on yield attributes and yield of lentil crop

Si. No.	Initial plant populationm^{-2}	Plant height (cm)	No. of nodules at 60 DAS	Weight of nodules at 60 DAS(mg)		No. of pods plant^{-1}	No. of seeds pod^{-1}	1000 seed weight (g)	Yield (kg ha^{1})	
				Fresh	Dry				Grain	Straw
T_1	84.33	49.36	16.40	19.32	3.87	96.60	1.20	24.00	860	1657
T_2	84.67	50.54	19.00	20.81	4.16	98.60	1.40	24.30	926	1725
T_3	84.67	51.07	20.00	22.09	4.42	100.40	1.40	27.70	988	1789
T_4	85.00	51.37	18.60	20.29	4.06	102.00	1.40	24.80	1168	2068
T_5	85.33	51.74	22.60	23.71	4.54	104.40	1.60	25.20	1226	2125
T_6	85.67	53.56	24.60	23.90	4.78	108.60	1.80	25.70	1330	2236
T_7	85.00	52.04	21.60	22.29	4.46	106.40	1.60	25.50	1275	2175
T_8	85.67	58.24	25.20	25.26	5.05	116.40	1.80	26.00	1457	2365
SEm±	0.50	1.57	1.26	0.26	0.13	3.21	0.05	0.73	44.33	59.28
C.D. (P=0.05)	NS	4.76	3.81	0.79	0.40	9.75	0.14	NS	134.47	179.79

Table.2 Effect of biofertilizers and micronutrients on content and uptake of Nutrients by lentil crop

Si. No.	Total nutrient content				Total nutrient uptake			
	(kg/ha^{-1})		ppm		Kg ha^{-1}		g ha^{-1}	
	N	P	Zn	Mo	N	P	Zn	Mo
T1	5.04	0.36	40.65	16.24	54.81	3.87	406.63	171.10
T2	5.12	0.38	40.65	16.25	59.30	4.40	435.62	182.32
T3	5.13	0.40	40.71	16.28	62.57	4.85	460.98	193.66
T4	5.15	0.41	40.74	16.29	74.83	5.97	541.84	225.37
T5	5.16	0.43	40.78	16.40	76.67	6.43	565.94	234.29
T6	5.27	0.47	41.04	16.67	83.76	7.63	612.62	257.83
T7	5.21	0.45	40.82	16.62	79.98	6.93	586.76	244.01
T8	5.35	0.49	41.48	16.74	91.55	8.57	654.66	278.69
SEm±	0.15	0.01	0.64	0.47	2.23	0.28	20.05	7.01
C.D. (P=0.05)	0.46	0.03	1.94	1.44	6.76	0.86	60.81	20.93

Nutrient content and uptake

The data presented in Table 2 revealed that, the values of total nitrogen, phosphorus, zinc and molybdenum respectively content attain the level of significance with the mean of 5.35%respectively. However highest total N, P, Zn and Mo content were recorded in treatment T_8, this treatment was statistically at par with T_6 and significantly superior with rest of other treatments. The minimum total nitrogen content was recorded in control treatment. Treatment RDF + 25 kg $ZnSO_4$ / ha +Seed inoculation with *Rhizobium* + PSB + 1.0g Ammonium Molybdate/ kg seed recorded significant total N, P, Zn and Mo content over control treatment and was found at par with RDF+Seed inoculation with *Rhizobium* + PSB + 1.0g Ammonium Molybdate/ kg seed.

The data on uptake of nutrients (N, P, Zn and Mo) by lentil crop as influenced by various treatments have been presented in Table 2. It clearly indicates that the maximum uptake of N, P, Zn and Mo (91.55 kg ha^{-1}) was recorded with the treatment T_8 (RDF + 25 kg $ZnSO_4$ / ha +Seed inoculation with *Rhizobium* + PSB + 1.0g Ammonium Molybdate/ kg seed) which was significantly superior over rest of the treatments. The nitrogen uptake increased with the application of fertilizers with or without biofertilizers. It might be due to favorable soil conditions which enhanced nutrient availability and nutrient uptake as well as a better growth and activity of roots. Similar findings were observed byIdris and Snadhu (1979), Jagdale *et al.,* (1980), Bera *et al.,* (2013).

The data in respect of phosphorus uptake by lentil present in the Table 2. The maximum phosphorusuptake (8.57 kg ha^{-1}) was recorded with the treatment T_8 (RDF + 25 kg $ZnSO_4$ / ha +Seed inoculation with *Rhizobium* + PSB + 1.0g Ammonium Molybdate/ kg seed) which was significantly superior over rest of the treatments. The minimum phosphorus uptake (3.87 kg ha^{-1}) was recorded in control. Application of RDF, Zn and Mo with biofertilizers contained highest amount of phosphorus as compared to the control. Similar findings were observed by Singh and Manohar (1982).

The maximum zinc uptake (654.66 g ha^{-1}) was recorded with the treatment of T_8 (RDF + 25 kg $ZnSO_4$ / ha +Seed inoculation with *Rhizobium* + PSB + 1.0g Ammonium Molybdate/ kg seed) which was statistically at par with treatment T_6 (RDF + Seed inoculation with *Rhizobium* + PSB + 1.0g Ammonium Molybdate/ kg seed) having 612.62g ha^{-1} zinc uptake and significantly superior over rest of the treatments. The minimum zinc uptake (406.63 g ha^{-1}) was recorded in control. Addition of biofertilizers, $ZnSO_4$ and ammonium molybdatewith RDF increased zinc uptake. The increase might be due to better crop growth and development. Similar results have been reported by Saber and Kabesh and Malewar *et al.,* (1990).

The data on molybdenum uptake by lentil crop as influenced by various treatments have been presented in Table 2. It clearly indicates that the maximum molybdenum uptake (278.69 g ha^{-1}) was recorded with the treatment (RDF + 25 kg $ZnSO_4$ / ha +Seed inoculation with *Rhizobium* + PSB + 1.0g Ammonium Molybdate/ kg seed) which was statistically at par with treatment (RDF + Seed inoculation with *Rhizobium* + PSB + 1.0g Ammonium Molybdate/ kg seed) having 257.83g ha^{-1} molybdenum uptake and significantly superior over rest of the treatments. The minimum molybdenum uptake (171.10 g ha^{-1}) was recorded in control. Application of RDF, Zn and Mo with biofertilizers contained highest amount of molybdenum as compared to the control. Similar findings were also observed by Kumar and Sharma (2005).

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