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Short Communication

Biofortification in lentil (*Lens culinaris* Medikus) through improved fertilizer management in Central Zone of India

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ABSTRACT

The present study was conducted under All India Co-ordinated Research project on MULLaRP at R.A.K. College of Agriculture, Sehore (M.P.) during *rabi* seasons of 2016-17, 2017-18 and 2018-19 to investigate productivity enhancement through agronomic management of biofortification in lentil (*Lens culinaris* Medikus). The treatment (RDF + Soil application of $ZnSO_4$ 2.5 kg ha^{-1} + SI with bfr LNm 43a) resulted in significantly higher growth attributes, such as plant height (37.46 cm), number of branches (4.38), yield attributes {viz. no. of pods (105.93) and seed index (2.60 g)} and grain yield (1562 kg ha^{-1}). During *rabi* season 2018-19 the results revealed that treatment of RDF + Soil application of $ZnSO_4$ 2.5 kg ha^{-1} + SI with bfr LNm 43a resulted in significantly higher value of Zn and protein content uptake in seed, and Fe content uptake in seed was significantly higher when treatment with RDF + Seed treatment 2 g $FeSO_4$ kg^{-1} Seed + SI with bfr LNm 43a.

Key words: $FeSO_4$, Lentil, *PGPR, Rhizobium,* $ZnSO_4$

Lentil (*Lens culinaris* Medikus) is a self pollinated and annual winter season legume crop. Lentil is important source of energy, protein, carbohydrate, fiber, mineral, vitamin and antioxidant compound. It is good source of vitamin B complex, potassium, zinc and iron also. Lentil seeds are valued source of food for quality protein and fiber (Tickoo *et al*. 2005). Lentil has an excellent macro and micronutrient profile and favorable levels of mineral bioavailability enhancing factors. Iron deficiency is a common nutritional disorder observed in many crops (Erskine *et al*. 1993) including lentil. Losses in the yield of susceptible genotypes varied between 18 and 25%. The Fe^{2+} concentration of the leaf tissue, compared with the total iron content, was closely correlated with the Fe-deficiency symptoms, and was found to be a useful index to identify soil where response to Fe application can be expected (Sakal *et al*. 1984). Iron is a constituent of the nitrogenase enzyme, leghaemoglobin and ferredoxin. The bacteria use this element during the nitrogen fixation period. Iron deficiency generally decreases nodule formation, leghaemoglobin production and nitrogenase activity; leading to low nitrogen concentrations in the shoots of some legumes.

Poor soil deprived of zinc which can reduce the agricultural productivity and zinc content in agricultural products. Zinc plays fundamental role in various metabolic processes in plants (Dobermann and Fairhurst, 2000). The different approaches for correction of zinc deficiency include supplementation, and biofortification through agronomic and genetic approaches for improving grain zinc concentration. Although, a large number of studies are available on the role of soil and foliar applied Zn fertilizers in correction of Zn deficiency and increasing plant growth and yield (Rengel *et al*. 1999).

Biofortification involves increasing levels of specific, limiting micronutrients in edible tissues of crops by combining crop management. Zn and Fe deficiency in soil is also responsible for reduced crop yield. Biofertilizers like *Rhizobium* and PGPR also have shown beneficial effect on growth and yield of legumes.

The present study was conducted under All India Co-ordinated Research project on MULLaRP at R.A.K. College of Agriculture, Sehore (M.P.). The field experiment was carried out in a randomized block design with 10 treatments and three replications. The gross and net plot size was 5.0 m x 3.0 m and 4.5 m x 2.4 m respectively. The agronomic management of biofortification and control were Absolute control (T_1), Seed inoculation with biofertilizer (bfr) LNm 43a (*Rhizobium* + *PGPR*) (T_2), RDF 20:50:20 kg ha^{-1} ($N:P_2O_5:K_2O$) (T_3), RDF + 0.5% $ZnSO_4$ foliar application + SI with bfr LNm 43a (T_4), RDF + 0.3% $FeSO_4$ foliar application + SI with bfr LNm43a (T_5), RDF + 0.5% $ZnSO_4$ and 0.3% $FeSO_4$ foliar Application + SI with bfr LNm 43a (T_6), RDF + Seed treatment 2 g ZnO kg^{-1} Seed + SI with bfr LNm 43a (T_7), RDF + Seed treatment 2 g $FeSO_4$ kg^{-1} Seed + SI with bfr LNm 43a (T_8), RDF + Seed treatment 2 g ZnO and 2 g $FeSO_4$ kg^{-1} Seed + SI with bfr LNm 43a (T_9), RDF + Soil application of $ZnSO_4$ 2.5 kg ha^{-1} + SI with bfr LNm 43a (T_{10}).

The soil of experimental field was medium black clay loam in texture (vertisol) with pH 7.8, low in organic carbon and available nitrogen, medium in phosphorus, high in potassium, medium in sulphur and low in Zn but normal in Fe. Sowing of lentil was done on 19th November, 2018 with spacing of 30 x 10 cm and harvested on 11th March of October, 2019. To avoid the border effect, border rows were first harvested before the harvest of net plot. The produce of each plot was tied in bundles and weighed with the help of spring balance.

Growth attributes: Plant height and number of branches are an important character of the vegetative phase and indirectly influences the yield components. Application of RDF + Soil application of $ZnSO_4$ 2.5 kg ha^{-1} + SI with bfr LNm 43a has recorded significantly higher plant height (37.46 cm) and number of branches (4.38) over rest of the treatments (Table 1). Increase in growth parameters might be attributed to solubilization of nutrient in soil and higher absorption of nutrient due to soil application of Biofortification. Improvement in different growth attributes due to application of Biofortification in various crop have been reported by Mousavi *et al.* (2013), Kumawat *et al.* (2006) and Pathak *et al.* (2003).

Table 1. Effect of different treatments on average growth and yield attributes during 2016-17, 2017-18 and 2018-19

Treatments	Plant height (cm)	Branches plant^{-1}	Pods plant^{-1}	Seed index (g)
T_1	32.6	2.8	52.0	2.08
T_2	33.4	3.1	62.2	2.18
T_3	33.8	3.2	71.8	2.23
T_4	36.1	4.1	88.0	2.44
T_5	35.4	3.7	77.2	2.39
T_6	36.3	4.2	91.3	2.53
T_7	34.3	3.3	74.4	2.31
T_8	34.9	3.5	76.1	2.36
T_9	35.8	3.7	85.3	2.40
T_{10}	37.4	4.3	105.9	2.60
Sem±	0.5	0.2	5.0	0.04
CD at 5%	1.6	0.6	14.8	0.12

Fe, Zn and Protein content in seed: Significantly higher value of Fe content (59.21 ppm) uptake in seed was recorded under the treatment RDF + Seed treatment 2 g $FeSO_4$ kg^{-1} Seed + SI with bfr LNm 43a (T_8) (Table-2). This might be due to ready availability of this nutrient to root zone of crop by its application under these treatments as compared to those treatments where it was not applied. This result of similar kind has also been reported by Thavarajah *et al.* (2009) and Podder *et al.* (2017). Significantly higher value of Zn (36.65) and protein (24.95) content uptake in seed was recorded under the treatment RDF + soil application of $ZnSO_4$ 2.5 kg ha^{-1} + SI with bfr LNm 43a (T_{10}) (Table 2). This might be due to regular availability of zinc throughout the growth span of crop because of its basal application as Zinc sulphate 2.5 kg ha^{-1}. Better Zinc content and uptake in seed and also its total uptake in lentil was found in all those treatments wherever Zn was applied either as seed application of as foliar spray. The results of similar kind have also been reported by Wani *et al.* (2008) and Hossain and Suman (2005).

Table 2. Effect of different treatments on Fe, Zn and protein content in seed during 2018-19

Treatments	Fe content in seed (ppm)	Zn content in seed (ppm)	Protein content in seed (%)
T_1	56.77	35.23	23.22
T_2	56.92	35.29	23.35
T_3	57.84	35.66	24.6
T_4	58.32	35.93	24.66
T_5	58.85	35.73	24.71
T_6	58.58	36.1	24.7
T_7	57.86	36.23	24.6
T_8	59.21	35.86	24.71
T_9	58.89	36.33	24.72
T_{10}	57.99	36.65	24.95
Sem±	0.24	0.20	0.04
CD at 5%	0.72	0.61	0.12

Yield attributes and yield: Application of RDF + Soil application of $ZnSO_4$ 2.5 kg ha^{-1} + SI with bfr LNm 43a recorded significantly higher number of pods plant^{-1} (105.93), seed index (2.60 g) and grain yield (1562 kg ha^{-1}) over rest of the treatments (Table 1 and Table 3). In the present study, all the yield attributing parameters were significantly higher with Biofortification soil application which might be due to favorable effects of zinc sulphate applied at regular intervals (30 & 60 DAS), it act as a stimulus in the plant system and in turn increase the production of growth regulators in the cell system. This enhancement in yield attributes in T_{10} might be due to adequate supply of Zn throughout the crop growth period by its application in soil before sowing of crop. Fe and Zn are essential nutrient for plant metabolism and several enzymatic activities. The favorable effect of Fe and Zn in promoting yield attributes in legumes was also reported by Pathak *et al.* (2003) and Gupta K (2012).

Table 3. Effect of different treatments on grain yield during 2016-17, 2017-18 and 2018-19

Treatments	2016-17	2017-18	2018-19	Mean
T_1	1010	1397	500	969
T_2	1131	1518	697	1115
T_3	1366	1545	750	1220
T_4	1470	1719	966	1385
T_5	1430	1652	913	1332
T_6	1480	1871	1012	1454
T_7	1390	1554	851	1265
T_8	1409	1590	867	1289
T_9	1432	1660	919	1337
T_{10}	1540	2005	1141	1562
Sem±	21.99	17.96	22.66	
CD at 5%	65.33	53.36	67.33	

Higher gross return was recorded with RDF + Soil application of $ZnSO_4$ @ 2.5 kg ha^{-1} + SI with bfr LNm 43a (T_{10}) (54351 ha^{-1}) followed by RDF + 0.5% $ZnSO_4$ and 0.3% $FeSO_4$ foliar Application + SI with bfr LNm 43a (T_6) (48407 ha^{-1}) (Table4). The higher gross return was mainly due to higher grain yield and straw yield of lentil. While the lower value was recorded under Absolute control (T_1) (24216 ha^{-1}). Similarly, higher net returns (39782 ha^{-1}) and benefit cost ratio (3.73) was recorded with + Soil application of $ZnSO_4$ @ 2.5 kg ha^{-1} + SI with bfr LNm 43a (T_{10}) followed by RDF + 0.5% $ZnSO_4$ and 0.3% $FeSO_4$ foliar Application + SI with bfr LNm 43a (T_6) (34032ha^{-1} and 3.37; respectively) was due to higher gross returns and lower cost of

Table 4. Effect of different treatments on economics during 2018-19

Treatments	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Gross return (ha^{-1})	Cost of cultivation (ha^{-1})	Net profit (ha^{-1})	B:C ratio
T_1	500	858	24216	11260	12956	2.15
T_2	697	978	33345	11290	22055	2.95
T_3	750	1009	35768	14366	22354	2.67
T_4	966	1194	45861	14908	31904	3.29
T_5	913	1407	43925	14814	30063	3.17
T_6	1012	1425	48407	15326	34032	3.37
T_7	851	1154	40641	14412	27181	3.02
T_8	867	1169	41367	14412	27907	3.07
T_9	919	1271	43932	14428	30456	3.26
T_{10}	1141	1481	54351	15521	39782	3.73
Sem±	22.66	86.06	1014.97		1014.97	0.07
CD at 5%	67.33	255.72	3015.74		3015.74	0.22

cultivation. Similar kind of result found in Bahure *et al.* (2013) and Brij Nandan *et al.* (2018).

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