Economics of production enhancement of lentil (*Lens culinaris* L.) through micronutrient and bio-inoculants in central plains of U. P.

Comment [p1]: meaning

Abstract:

During the Rabi season respective years 2021-22 and 2022-23, a field experiment was conducted at the student instructional farm of CSAUA&T, Kanpur. Experimental soil had a texture of sandy loam. There are 15 treatment combination involved varying combinations of micronutrients and biofertilizers with three replications of randomized block design. The cultivation of lentil variety Lentil-KLS9-3 (Krish) was carried out in accordance with the suggested agronomic practices. It can be concluded from these findings that the two-year results are consistent with the T_{14}(RDF + $ZnSO_4$ (0.5%) +$FeSO_4$ (0.5%) foliar spray at pre flowering + pod development stage+ *Rhizobium*) showed the highest values economics parameters *i.e.*,maximum cost of cultivation 38131 & 39340 gross returns of ₹ 105689 &115894, net return of ₹ 67156 & 76554of respective both of years followed by treatment 15.

Keywords: Lentil, Zinc, Rhizobium and Net return.

Introduction

A staple food in many cultures, lentil (*Lens culinaris L.*) is one of the oldest domesticated crops in the world. In India, lentils are commonly known as red dhal, masur or split peas, all of which are staple foods. After soybeans, it has the second highest protein to calorie ratio, and it contains an abundance of proteins (20-30%), minerals (2-5%) and carbohydrates micronutrients, especially iron, zinc, and selenium [1]. As a rich source of protein, pulses are considered to be a wonder crop, since they are also capable of fixing nitrogen in a biological way, thereby making them the wonder crop of the future. Different cropping systems use these crops as a means of crop diversification [2]. Furthermore, lentil promotes crop rotation, soil fertility, and sustainable cereal-based production systems, it plays a vital role in making agriculture sustainable. which can be noted from the fact that lentil can fix free nitrogen up to 107 kg/ha.[5]

Micronutrients are also very important in crop growth and development. The mineral zinc plays an important role in the reproductive process, such as the fertilization of the pollen grain and the formation of pollen grains. Pollen grains contain significant amounts of zinc. Seeds are mainly translocated with zinc during fertilization [6]. It is necessary to provide micronutrients in order for soil health to be maintained and also for crops to be more productive [7]. Zinc's role is complexdue to its limited availability due to the interface is complex as well. Plants use it either as a metal component in enzymes or as a cofactor of several enzyme reactions physiologically. A precursor for tryptophan synthesis, zinc is necessary. Increasing zinc levels enhances cell differentiation after flowering [8]. Zinc has a direct effect on auxin production, which in turn accelerates plant growth elongation [10]. Zinc foliar spray results in adequate nutrient availability for lush crop growth as well as efficient assimilation and partitioning from source to sink [11].

Oxidized ferric iron is a poor solubilizer in aerobic environment, limiting plant growth and metabolism[13]. For legumes, iron is essential micronutrient. As an essential component of nucleic acid metabolism, chlorophyll synthesizes and maintains chlorophyll in plants. To produce crops, iron is a vital nutrient. Plants need it for growth, enzyme function, and oxygen transportation throughout roots, leaves, and other parts. In order for crops to receive sufficient oxygen, they must have a sufficient amount of iron in their systems, and without an adequate amount of iron, they cannot produce sufficient chlorophyll.

By applying nutrients at the appropriate dose, you can achieve a profitable as well as economically and environmentally optimal result. Along with enhancing grain yield, microbes may also contribute to reducing chemical fertilizer input by lowering production costs [2]. It has been reported thatseeds and soil become more nutrient-rich when biofertilizers are applied by 10% to 25%, with no harmful effects on the environment or the soil [4].Increasing yield significantly requires biofertilizers. The *Rhizobium* bacteria inoculate legume seeds to form nodules that fix atmospheric nitrogen through a symbiotic process in the roots, making the nutrient available to the plants.

[3]. Biofertilizers are living microorganisms that are bacterial, fungal, or algal in origin. As a result of biofertilizers, atmospheric nitrogen is fixed in the root nodules and made available to plants.

Materials and method

The 15 treatments with three replications of randomized block design were performed. Detailed treatment information is provided in table no.1.:

Table -1: Treatment Details

Treatment Combination	**Stage of Application**
T_1 = Only RDF	
T_2= RDF+ $ZnSO_4$ (0.5%) Foliar spray	***R_1***
T_3= RDF +$FeSO_4$ (0.5%) Foliar spray	***R_1***
T_4= RDF + $ZnSO_4$ (0.5%) + $FeSO_4$(0.5%) Foliar spray	***R_1***
T_5= RDF + $ZnSO_4$ (0.5%) Foliar spray	***R_2***
T_6= RDF + $FeSO_4$ (0.5%) Foliar spray	***R_2***
T_7= RDF + $ZnSO_4$ (0.5%) + $FeSO_4$ (0.5%) Foliar spray	***R_2***
T_8= RDF + $ZnSO_4$+ $FeSO_4$ (0.5%) Foliar spray (Mix tank spray)	***R_2***
T_9= RDF + $ZnSO_4$ (0.5%) Foliar spray + Rhizobium	***R_1***
T_{10}= RDF + $FeSO_4$ (0.5%) Foliar spray + Rhizobium	***R_1***
T_{11}= RDF + $ZnSO_4$+ $FeSO_4$ (0.5%) Foliar spray + Rhizobium	***R_1***
T_{12}= RDF + $ZnSO_4$ (0.5%) Foliar spray + Rhizobium	***R_2***
T_{13}= RDF + $FeSO_4$ (0.5%) Foliar spray + Rhizobium	***R_2***
T_{14}= RDF + $ZnSO_4$(0.5%) + $FeSO_4$ (0.5%) Foliar spray + Rhizobium	***R_2***
T_{15}= RDF + $ZnSO_4$(0.5%) + $FeSO_4$ (0.5%) Foliar spray (Mix tank spray) + Rhizobium	***R_2***

R_1 = Pre flowering stage, ***R_2*** = Pre flowering + Pod development stage

2.1 Economics characters:

Grain and straw yield are based on an average in respective years i.e. 2021-22 and 2022-23, different treatments were analysed economically.

Cost of cultivation: Based on input rates at the farm, we calculated the cost of cultivation. Costs associated with treatments were calculated separately. To obtain the total cost of cultivation, all expenses incurred in cultivation were taken into account, and treating costs (including interest on working capital) were added.

Gross return (₹ ha^{-1}): Market rates were used to calculate the income from grain and straw production. Gross return per hectare were calculated by converting lentil crop yields to current produce prices.

Gross return (₹ ha^{-1}) = Total income from grain and Straw yield

Net return (₹ ha^{-1}): To calculate profit, subtract cultivation cost from gross income (ha-1). Following is the formula used to calculate the net return:

Net return (₹ ha^{-1}) = Gross return (₹ ha^{-1}) - Cost of cultivation (₹ ha^{-1})

Table no.2 Treatment wise grain and straw yield (kg ha^{-1})

S. No.	Treatments	Grain Yield (kg ha^{-1})			Straw Yield (kg ha^{-1})		
		2021	2022	Pooled	2021	2022	Pooled
1.	T_1	1510	1515	1513	2280	2288	2284
2.	T_2	1548	1551	1550	2228	2232	2230
3.	T_3	1556	1560	1558	2230	2236	2233
4.	T_4	1681	1683	1682	2350	2353	2352
5.	T_5	1594	1597	1596	2275	2279	2277
6.	T_6	1612	1616	1614	2291	2297	2294
7.	T_7	1726	1730	1728	2384	2389	2386
8.	T_8	1710	1714	1712	2371	2377	2374
9.	T_9	1632	1637	1635	2315	2322	2318
10.	T_{10}	1649	1654	1652	2334	2341	2338
11.	T_{11}	1705	1711	1708	2374	2382	2378
12.	T_{12}	1658	1664	1661	2337	2346	2341
13.	T_{13}	1674	1680	1677	2350	2358	2354

Comment [p2]: mean

14.	**T_{14}**	**1768**	**1788**	**1778**	**2414**	**2438**	**2426**
15.	**T_{15}**	**1750**	**1772**	**1761**	**2405**	**2430**	**2418**
SE (diff) (Kg/ha)		**30**	**31**	**24**	**48**	**62**	**44**
CD at 5.0 % (Kg/ha)		**62**	**63**	**48**	**98**	**127**	**89**

Table-3: Impact of treatments on Cost of Cultivation (₹), Gross Return (₹) and Net Return (₹)of lentil

S. No.	**Treatments**	**Cost of Cultivation (₹)**			**Gross Return (₹)**			**Net Return (₹)**		
		2021	**2022**	**Pooled**	**2021**	**2022**	**Pooled**	**2021**	**2022**	**Pooled**
1.	**T_1**	**37221**	**38158**	**37689.5**	91030	99310	95170	53809	61152	57480.5
2.	**T_2**	**37536**	**38447**	**37991.5**	92938	101118	97028	55402	62671	59036.5
3.	**T_3**	**37561**	**38472**	**38016.5**	93385	101660	97522.5	55824	63188	59506
4.	**T_4**	**37850**	**38761**	**38305.5**	100680	109379	105029.5	62830	70618	66724
5.	**T_5**	**37825**	**38736**	**38280.5**	95632.5	104021	99826.75	57807.5	65285	61546.25
6.	**T_6**	**37875**	**38786**	**38330.5**	96678.5	105213	100945.8	58803.5	66427	62615.25
7.	**T_7**	**38453**	**39364**	**38908.5**	103274	112285	107779.5	64821	72921	68871
8.	**T_8**	**38051**	**38962**	**38506.5**	102348.5	111297	106822.8	64297.5	72335	68316.25
9.	**T_9**	**37616**	**38527**	**38071.5**	97862.5	106556	102209.3	60246.5	68029	64137.75
10.	**T_{10}**	**37641**	**38552**	**38096.5**	98864	107637	103250.5	61223	69085	65154
11.	**T_{11}**	**37930**	**38841**	**38385.5**	102084	111148	106616	64154	72307	68230.5
12.	**T_{12}**	**37905**	**38816**	**38360.5**	99369.5	108242	103805.8	61464.5	69426	65445.25
13.	**T_{13}**	**37955**	**38866**	**38410.5**	100295	109230	104762.5	62340	70364	66352
14.	**T_{14}**	**38533**	**39340**	**38936.5**	105689	115894	110791.5	67156	76554	71855
15.	**T_{15}**	**38131**	**38939**	**38535**	104667.5	114926	109796.8	66536	75987	71261.75

3. RESULT AND DISCUSSION

The data pertaining to economics of lentil was studies in terms of cost of cultivation, gross return, net return which have been presented in Table no.2, are shown the economics data recorded. Maximum cost of cultivation (₹ 38131 & ₹ 38939), Maximum gross returns (105689 ₹ /ha& 115894 ₹ /ha), and net returns (67156 ₹ /ha& 76554 ₹ /ha) were obtained in treatment T14(RDF + $ZnSO_4$ + $FeSO_4$ (0.5%) Foliar spray (Individual spray) at pre flowering

Comment [p3]: 3

Comment [p4]: T15

and pod formation Stage + Rhizobium) improved gross returns. In order to be economical, unit fertilizers should be applied if their yield increase in excess of their cost is greater than the cost of the fertilizers used. Unless the fertilizer increases if the application does not produce enough income to cover its cost, the application is not economical and will not be benefited, yield increases continuously. It is essential to apply essential elements in the right proportion and quantity to increase profit [2]. Because of the enhanced seed yield, highest net returns, the foliar spray of foliar spray of $ZnSO_4$ @ 0.5% and $FeSO_4$ @ 0.5% (Individual spray) at pre flowering and pod formationStage +rhizobium and along with RDF (20:40:20) appeared to be the most cost-effective for lentil growing farmers [12]. The net return has increased compared to the uninoculated control, and this is due to the low cost of biofertilizers and fixation of atmospheric nitrogen in the roots of leguminous plant, which increase the nitrogen uptake by plant [2]. Extensive analysis of both yeari.e. 2021-22 and 2022-23 has revealed that treatment T14, which includes RDF + $ZnSO_4$ (0.5%) + $FeSO_4$ (0. 5%) foliar spray (individual spray) at Pre flowering and pod formation Stage), + *Rhizobium* achieved remarkable outcomes in terms of, cost of cultivation (38553 ₹ /ha& 39340 ₹ /ha), gross return (₹ 105689₹ /ha &115894 ₹ /ha), net return (67156 ₹ /ha &76554 ₹ /ha), and followed by T_{15} This significant finding is supported by the research conducted by esteemed scholars such **Divya *et al* (2023)[14], Kumar *et al* (2023)[15], Prasad *et al* (2023)[16],Verma et al (2023)[17],Singh *et al* (2023)[18]**

4. Conclusion

In the light of results summarized above in conclusion, the application of T_{14}- RDF + $ZnSO_4$ + $FeSO_4$ (0.5%) Foliar spray (Individual spray) at pre flowering and pod formationStage + rhizobium had maximum cost of cultivation but produced more gross and net returns found more. Hence, we can recommend T_{14} to lentil growing farmers.

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