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Effect of different Micronutrients on yield and economics of linseed (*Linum usitatissimum* L.) under limited irrigation

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Abstract
A field experiment was conducted to study the effect application methods of micronutrients on yield and Economics of linseed (*Linum usitatissimum* L.), at the Research farm, Bihar Agricultural College, Sabour, Bhagalpur during *rabi*, season of 2020-21. The experiment was laid out in randomized block design with three replications. The treatments consisted of nine micronutrient application practices. Result revels that application of RDF + foliar application of ZnSO4 @ 0.5% + foliar application of Borax @ 0.3% at 45 DAS (T_8) recorded statistically highest capsules plant^{-1},seed capsule^{-1}, test weight (7.03 g), seed yield (1201.6 kg ha^{-1}) and straw yield (2308.6 kg ha^{-1}) which was statistically at par with application of RDF + Soil application of ZnSO4 @ 25 kg ha^{-1} + Foliar application of ZnSO4 @ 0.5% at 45 DAS (T_4), RDF + Soil application of Borax @ 1.5 kg ha^{-1} (T_5), RDF + Foliar application of Borax @ 0.3% at 45 DAS (T_6), RDF+ Soil application of Borax @ 1.5 kg ha^{-1} + Foliar application of Borax @ 0.3% at 45 DAS (T_7) and RDF+ Soil application of ZnSO4 @ 25 kg ha^{-1} + Borax @ 1.5 kg ha-1(T_9). However, none of the micronutrient treatments have significant influence on harvest index (H.I.) of linseed though maximum was recorded in T_8 (34.33%). Analysis of economics revels that highest gross return of Rs. 51474 ha^{-1}, net returns of Rs. 48622 ha^{-1} and benefit-cost ratio was observed when RDF+ Foliar application of ZnSO4 @ 0.5% + Borax @ 0.3% at 45 DAS (T_8).

Keywords: Harvest index, micronutrients, net return, seed yield

Introduction
Oilseed crops are the second most important contributing factor of agricultural economy, next to cereals within the segment of field crops. During early 1990's, the dependent on oilseeds attained through "yellow revolution" could not be sustained beyond a short period. Among the different oilseed crops grown in country, linseed is considered the most important industrial oilseed crop of India and stands next to rapeseed-mustard among *rabi* oilseed crops in context to area and production. Major linseed producing states of India are M.P, Karnataka, Chhattisgarh, Jharkhand, Bihar, Maharashtra, Odisha, Uttar Pradesh, W.B and Assam. Madhya Pradesh and Uttar Pradesh jointly contribute to the national linseed production to the extent of about 70 per cent. In Bihar, it occupies 9.65 thousand ha area with 8.19 metric tonnes production and productivity of 849 kg ha^{-1} (Anonymous 2018-19) [2]. Due to persistently increasing demand of the crop, there is a direct need to increase seed yield potential of linseed crop. Its production can be increased by growing high yielding variety and by the use of macro and micronutrients in balance quantity. Micronutrients mainly zinc and boron play a major and significant role in growth and metabolic operations of plant associated with photosynthesis, cell wall growth and respiration, absorption of water, also xylem permeability, resistance to plant diseases and enzyme activities involved in the synthesis of metabolites. The deficiencies of these two micronutrients in soil adversely influence the growth and development of the crop. Zinc is one of the essential micronutrients require for many enzymes activation and ultimately help in synthesis of certain protein. It also helps in formation of chlorophyll that leads to optimum crop growth and deficiency of it causes various detrimental effects on growth and yield of linseed. It was studied that plant heights, number of branches and number of capsules plant^{-1} were significantly higher with soil application of $ZnSO_4$ & foliar application of zinc in linseed at bud initiation and after capsule filling stage significantly improved in an increase in the seed oil percent by 7.15 percent (Khalifa *et al.*, 2011) [4]. Depletion of B from soils is mainly through leaching to the lower layers and through the uptake by the crops, which removes a significant amount. Globally boron deficiency has been noticed as the second most important micronutrient limitation in crops after that of zinc.

Application of boron assessed a positive trend in production of more dry matter, increase in capsules plant^{-1}, seed yield, oil content, gross returns, net returns and harvest index significantly greater over no spray of boron. Keeping these facts of incredible role of micronutrients on yield and economics, this study was conducted.

Materials and Method

Present field investigation was conducted during *rabi*, season of 2020-21 at the Research farm, Bihar Agricultural College, Sabour, Bhagalpur which is situated at an altitude of 45.75 meters beyond mean sea level, with longitude 870 2' 42" E and latitude of 250 15' 40" N in Gangetic plains of India, Sabour, Bhagalpur comes under sub-tropical area, with average annual rainfall of 1167.0 mm, cool climate in winter and hot and dry weather in summer. The maximum and minimum temperatures recorded were 35 ^{0}C to 18.8 ^{0}C, and average rainfall received was 0.4 mm during the crop growing season. The experiment was laid out in randomized block design with three replications. The treatments consisted of nine micronutrient application practices *viz*, RDF + Control (T_1), RDF + Soil application of $ZnSO_4$ @ 25 kg/ha (T_2), RDF + Foliar application of $ZnSO_4$ @ 0.5% at 45 DAS(T_3), RDF + Soil application of $ZnSO_4$ @ 25 kg/ha + Foliar application of $ZnSO_4$ @ 0.5% at 45 DAS(T_4), RDF + Soil application of Borax @ 1.5 kg/ha(T_5), RDF + Foliar application of Borax @ 0.3% at 45 DAS(T_6), RDF + Soil application of Borax @ 1.5 kg/ha + Foliar application of Boron @ 0.3% at 45 DAS(T_7), RDF + Foliar application of $ZnSO_4$ @ 0.5% + Borax @ 0.3% at 45 DAS(T_8)and RDF + Soil application of $ZnSO_4$ @ 25 kg/ha + Borax @ 1.5 kg/ha(T_9).On 29th November 2020 the linseed variety Sabour Tisi-2 was sown and harvested on 6th April 2021 with a seed rate of 30 kg ha^{-1} with a recommended dose of fertilizers was 80: 40: 40, N: P: K kg ha^{-1}respectively. The yield of linseed was converted into gross return in rupees ha^{-1} based on current price prevailing in the market and approved for the sale of product at research farm of the Institute.

The net return calculated as follows

Net return (Rs.) = Gross return (Rs.) - cost of cultivation (Rs.)
The data taken down regarding different parameters in the present experiment were analysed statistically using fallowing aid procedure for Randomized Complete Block Design. The standard error of means was determined in each item of study. The critical differences (CD) at 5% level of probability were worked out for comparing the treatment means

Result and Discussion

Yield attributes and yield

Yield is the most significant and dynamic trait in crops. Yield is measurement of the amount of a crop grown, or product such as seed, stover produced per unit land area. It reflects the interaction of the environment with all growth and developmental process that occur throughout the life cycle. Analysis of data indicated that significantly highest number of capsules per plant (53.12) were registered with RDF + foliar application of $ZnSO_4$ @ 0.5% + foliar application of Borax @ 0.3% at 45 DAS as compared to control (40.40). This might be due to micronutrient application at vegetative stage, increased the nutrient uptake and chlorophyll content that resulted into production of greater number of branchesplant^{-1} and ultimately greater number of capsules. Similar results on linseed were also reported by Elayaraja (2015) [3]. Number of seeds capsule^{-1} was significantly influenced by micronutrient treatments. It is also influenced by favourable environment particularly that of temperature prevailed during the time of sowing and vegetative and reproductive stages. Availability of theses micronutrients to the crop increases the number of seeds per capsule. Significantly highest numbers of seeds per capsule (7.77) were registered with RDF + foliar application of $ZnSO_4$ @ 0.5% + foliar application of Borax @ 0.3% at 45 DAS as compared to RDF + Control (6.67). Similar results on linseed were also reported by Mousa *et al.* (2010) [7]. Test weight was influenced by micronutrient treatments and favourable environment particularly that of temperature prevailed during the time of vegetative and reproductive stages. This might be due to the fact that the plant of these treatments has got better nutrient availability of specially zinc and boron at branching stage for their growth and development there by increasing the weight of the seed. The significantly highest test weight (7.03) was registered with RDF + foliar application of $ZnSO_4$ @ 0.5% + foliar application of Borax @ 0.3% at 45 DAS as compared to RDF + Control (6.58). Singh *e. al.*, (2020) [8] also reported similar findings. Seed yield (Table -1) of linseed had shown positive response to different micronutrient treatments. Application of RDF + foliar application of $ZnSO_4$ @ 0.5% + borax @ 0.3% at 45 DAS recorded significantly highest seed yield (1201.6 kg ha^{-1}) over RDF + Control (947.3 kg ha^{-1}) in linseed which might have influenced the metabolism of carbohydrate positively leading to increased translocation and partitioning of photosynthates towards growth and yield attributing characters, thereby increasing seed yield of linseed. Mishra *et al.*, (2016) [6] in linseed and Kumar *et al.*, (2014) [5] in mustard had also reported similar results. Application of RDF + foliar application of $ZnSO_4$ @ 0.5% + borax @ 0.3% at 45 DAS recorded significantly highest straw yield (2308.6 kg ha^{-1}) over RDF + Control (1931 kg ha^{-1}) in linseed. These findings are in close conformity to those of Singh and Singh (2017) [9] in linseed. The data on harvest index (HI) under the influence of different micronutrient treatments in linseed showed that there was no significant impact of micronutrient treatments on harvest index. However, maximum HI (34.33%) was recorded with RDF + foliar application of $ZnSO_4$ @ 0.5% + foliar application of Borax @ 0.3% at 45 DAS as compared to RDF + Control (32.74%). Similar results have also been reported by Alam *et al.*, (2021) [1].

Economics

Economic viability is a function of gain and loss. The adoption of any technology in current agriculture can only be viable and acceptable to farmers if it is economically feasible. The data on economics of linseed cultivation was significantly affected by different treatments. The gross return calculated by yield of crop varied significantly due to different treatments, which consequently influenced the net return and benefit: cost ratio. The data on net return (Table-2) revealed that significantly highest of Rs. 48622 ha^{-1} was accrued when RDF + Foliar application of $ZnSO_4$ @ 0.5% + Borax @ 0.3% at 45 DAS (T_8) was applied which was statistically at par with rest of the treatment except T_1 and T_2. The lowest net return of Rs. 34868 ha^{-1} was registered under RDF + Control (T_1). This was mainly due to higher gross returns recorded in these treatments as a consequence of higher economic yield of linseed. These findings are in the agreement with Alam *et al.*, (2021) [1]. Data revealed that the effect of different micronutrient treatments on benefit: cost ratio was found

significant. Highest benefit-cost ratio was found (1.73) under RDF + Foliar application of $ZnSO_4$ @ 0.5% + Borax @ 0.3% at 45 DAS (T_8) which was statistically at par with rest of the treatments except T_2 and T_1. This was largely due to gross return obtained by yield of crop, varied significantly due to different treatments, which ultimately influenced the net return and benefit: cost ratio. Minimum B: C ratio (1.32) was registered with RDF + Soil application of $ZnSO_4$ @ 25 kg ha^{-1} (T_2). These finding are in the close vicinity with those reported Singh *et al.*, (2020) [8].

Table 1: Effect of different micronutrient treatments of linseed on yield attributes, seed yield and harvest index of linseed

S. No.	Treatments	Capsules/ plant	Seeds/ capsule	Test weight (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest Index (%)
T_1	RDF+Control	40.40	6.67	6.58	947.3	1931.0	32.74
T_2	RDF+Soil application of $ZnSO_4$ @ 25 kg ha^{-1}	43.56	7.37	6.71	1008.6	2013.0	33.34
T_3	RDF+Foliar application of $ZnSO_4$ @ 0.5% at 45 DAS	42.86	7.60	6.60	1025.9	2112.3	32.55
T_4	RDF+Soil application of $ZnSO_4$ @ 25 kg ha^{-1} + Foliar application of $ZnSO_4$ @ 0.5% at 45 DAS	47.09	7.67	6.83	1055.5	2176.3	32.73
T_5	RDF+Soil application of Borax @ 1.5 kg ha^{-1}	47.42	7.53	6.72	1053.8	2147.0	33.01
T_6	RDF+Foliar application of Borax @ 0.3% at 45 DAS	50.74	7.73	6.95	1119.7	2282.0	32.94
T_7	RDF+Soil application of Borax @ 1.5 kg ha^{-1} + Foliar application of Borax @ 0.3% at 45 DAS	51.20	7.30	6.99	1130.8	2292.3	32.95
T_8	RDF+Foliar application of $ZnSO_4$ @ 0.5% + Borax @ 0.3% at 45 DAS	53.12	7.77	7.03	1201.6	2308.6	34.33
T_9	RDF+Soil application of $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 1.5 kg ha^{-1}	49.13	7.10	6.90	1150.6	2300.3	33.29
	S.Em (±)	1.83	0.29	0.14	54.7	87.2	1.40
	CD at 5%	5.48	0.86	0.43	164.0	261.5	NS

Table 2: Effect of micronutrient treatments on economics of linseed

S. No.	Treatments	Gross returns (Rs ha^{-1})	Net Return (Rs ha^{-1})	B: C ratio
T_1	RDF+Control	60701	34868	1.35
T_2	RDF+Soil application of $ZnSO_4$ @ 25 kg ha^{-1}	64545	36712	1.32
T_3	RDF+Foliar application of $ZnSO_4$ @ 0.5% at 45 DAS	65780	39547	1.51
T_4	RDF+Soil application of $ZnSO_4$ @ 25 kg ha^{-1} + Foliar application of $ZnSO_4$ @ 0.5% at 45 DAS	67686	39453	1.40
T_5	RDF+Soil application of Borax @ 1.5 kg ha^{-1}	67524	40761	1.52
T_6	RDF+Foliar application of Borax @ 0.3% at 45 DAS	71749	44056	1.59
T_7	RDF+Soil application of Borax @ 1.5 kg ha^{-1} + Foliar application of Borax @ 0.3% at 45 DAS	72437	43814	1.53
T_8	RDF+Foliar application of $ZnSO_4$ @ 0.5% + Borax @ 0.3% at 45 DAS	76715	48622	1.73
T_9	RDF+Soil application of $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 1.5 kg ha^{-1}	73638	44875	1.56
	SE(m)±	3299	3299	0.12
	CD at 5%	9893	9893	0.36

Conclusion

On the basis of the results of present investigation, it may be concluded that application of RDF (80:40:40 NPK kg ha-1) + foliar application of ZnSO4 @ 0.5% + foliar application of Borax @ 0.3% at 45 DAS can be recommended for linseed in enhancing seed yield in terms of yield attributes and achieving more net returns as well as B: C ratio.

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