Biological Forum – An International Journal **13(3): 450-453(2021)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Evaluation of the Performance of Micronutrients on Growth and Quality Parameters of Linseed (*Linum usitatissimum* L.)

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(Received 07 June 2021, Accepted 12 August, 2021)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Oilseed crops are the second most important contributing factor of agricultural economy in the country, next to cereals. Average yield of oilseed *i.e*. linseed in India is very low due to many constraints like poor soil fertility, insufficient application of macro and micronutrients, and traditional crop cultivation practices. Micronutrients mainly zinc and boron play a significant role in the increasing productivity growth and metabolic operations of plant associated with photosynthesis, and enzyme activities involved in synthesis of metabolites. Deficiency of these two micronutrients in soil adversely influences the growth and development of linseed which ultimately abate its oil quality. So, for addressing this issue an experiment was conducted during *rabi*, season of 2020-21 at the Research farm, Bihar Agricultural College, Sabour, Bhagalpur. Nine treatments of application practices of micronutrients were laid out in randomized block design with three replications. Result revels that application of RDF + foliar application of $ZnSO_4$ @ 0.5% + foliar application of Borax @ 0.3% at 45 DAS (T_8) at harvest recorded higher plant height (59.02cm), dry-matter accumulation (717.56 g m^{-2}), and oil content (38.02 %) over RDF + Control. At 60-90 DAS, the application of RDF + Soil application of $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 1.5 kg ha^{-1} (T_9) exhibited maximum CGR (12.46 g m^{-2} day^{-1}) which was at par with other micronutrient treatments. Among micronutrient treatments, application of RDF + foliar application of $ZnSO_4$ @ 0.5% + foliar application of Borax @ 0.3% at 45 DAS (T_8) recorded statistically highest oil yield (456.7 kg ha^{-1}) which was at par with 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 $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 1.5 kg ha^{-1} (T_9). However, none of the micronutrient treatments have significant influence on oil content in seeds though maximum oil content (38.02 %) was recorded with T_8.

Keywords: Dry matter, Linseed growth and development, Micronutrients, Oil yield, Oil content.

INTRODUCTION

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. Linseed or flax (*Linum usitatissimum* L.) is an important oilseed crop in Asia. It is grown for both oil and fibre purpose. Presently linseed is cultivated in 326.01 thousand ha with contributing 173.62 thousand tonnes to the annual oilseed production with the productivity of 545 kg/ha. (Report, 2018-19). The total protein content in linseed seed ranges from 20 to 30 percent composed of basically 80 percent globulins and 20 percent glutelin (Hall *et al.,* 2006). Most of the oil is used in the industry for manufacturing of Industries like paints, varnishes, ink, soaps however small amount is used for edible purposes (Kumar *et al.,* 2016). The average yield of linseed in India is very low due to many constraints like poor soil fertility, insufficient application of macro and micronutrients, dominancy of cereal crop and traditional crop cultivation practices. Due to persistently increasing demand of the crop, there is a direct need to increase seed yield potential of linseed crop (Alam *et al.,* 2020). 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 (Kumar, 2018). The deficiencies of these two micronutrients in soil adversely influence the growth and development of linseed (Kumar, 2017). 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 (Khalifa *et al.,* 2011). 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. The researches were on micronutrients specially zinc and boron application and its effect on growth and development of linseed is very meagre. Keeping these facts of incredible role of micronutrients on quantity and quality of crops, 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°C to 18.8°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 $ZnSO_4$ (21% Zn) @ 25 kg/ha (T_2), RDF + Foliar application of $ZnSO_4$ (33% Zn) @ 0.5% at 45 DAS(T_3), RDF + Soil application of $ZnSO_4$ (21% Zn) @ 25 kg/ha + Foliar application of $ZnSO_4$ (33% Zn) @ 0.5% at 45 DAS(T_4), RDF + Soil application of Borax (11% B) @ 1.5 kg/ha(T_5), RDF + Foliar application of Borax (20% B) @ 0.3% at 45 DAS(T_6), RDF + Soil application of Borax (11% B) @ 1.5 kg/ha + Foliar application of Boron (20% B) @ 0.3% at 45 DAS(T_7), RDF + Foliar application of $ZnSO_4$ (33% Zn) @ 0.5% + Borax (20% B) @ 0.3% at 45 DAS(T_8)and RDF + Soil application of $ZnSO_4$ (21% Zn) @ 25 kg/ha + Borax (20% B) @ 1.5 kg/ha(T_9). The soil of the experimental site was silty loam, low in available nitrogen (186.0 kg ha^{-1}), medium in phosphorus (17.39 kg ha^{-1}) and potassium (126.0 kg ha^{-1}), low in zinc (0.36 mg kg^{-1}) and boron (0.32 mg kg^{-1}) having neutral reaction (pH 7.2). Sabour Tisi-2 variety was sown using seed rate of 30 kg ha^{-1} at a row spacing of 30 cm. A recommended dose of 80 kg N, 40 kg P and 40 kg K ha^{1} were applied to the crop. Nitrogen, phosphorous and potassium were applied through Urea, Di-ammonium Phosphate and Muriate of Potash, respectively. Half dose of N and full dose of P_2O_5 and K_2O was applied as basal and remaining half dose of N was top dressed after first irrigation. The oil content in seed was estimated with the help of *Soxhlet's* apparatus using petroleum ether as extractant (Sankaran, 1966).

Oil yield is calculated by following formulas:

Oil yield= oil content (%) × seed yield (kg ha^{-1})

For determination of protein content in seed, chemical analysis of nitrogen content was done by Micro *Kjeldahl* method, and the value thus obtained were multiplied by a factor 6.25.

RESULT AND DISCUSSION

A. Growth attributes

Plant height is the maximum stature a typical mature individual of a species attains in a given habitat and its growth and development depend on the many biotic and abiotic factors. Among the micronutrients particularly zinc and boron nutrition realized significant effect on plant height of linseed. Initially at 30 DAS, significant differences were reported in plant height (Table 1), the highest i.e. 14.35 cm was observed with the application of RDF + Soil $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 1.5 kg ha^{-1}, similar result was also observed by Katore *et al.*, (2020). However, at 60 DAS, 90 DAS and at harvest, the application of RDF + foliar application of $ZnSO_4$ @ 0.5% + foliar application of Borax @ 0.3% at 45 DAS attained significantly maximum plant height (37.35 cm, 58.23 cm and 59.02 cm) over RDF +Control treatment (30.51 cm, 44.88 cm and 50.21 cm), respectively. This may be due to availability of these micronutrients to the crop at suitable vegetative stage, which may have increased the nutrient uptake and chlorophyll content and resulted in increases plant height. Similar result was also observed by Mousa *et al.*, (2010); Singh *et al.*, (2020). The cumulative amount of dry matter is the biomass produced by the entire plant over a time interval and its distribution to various parts of the plant such as roots, stems, leaves and the economic parts. Initially at 30 DAS, the maximum dry matter accumulation was significantly influenced by different micronutrient treatments, the higher dry matter accumulation (58.27 g m^{-2}) was recorded with RDF + Soil application of $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 1.5 kg ha^{-1} (T_9) while, at 60 DAS, 90 DAS and at harvest stage, the application of RDF + foliar application of $ZnSO_4$ @ 0.5 % + foliar application of Borax @ 0.3 % at 45 DAS attained significantly highest dry matter accumulation (313.98 g m^{-2}, 687.80 g m^{-2} and 717.56 gm^{-2}), respectively (Table 2). The significant increase in dry matter accumulation might be due to availability of these micronutrients to the crop at appropriate vegetative stage, resulted in increase in plant growth and it also might have improvement in photosynthetic area of plant that cumulatively contributed to higher dry matter accumulation. These results are in accordance with Alam *et al.*, (2021) in linseed. The crop growth rate refers to the measurement of overall crop growth in a particular area and is measured as mass increase in crop biomass per unit ground area per unit time. Significantly highest crop growth rate (8.65 g m^{-2} day^{-1}) was recorded with the application of RDF + foliar application of $ZnSO_4$ @ 0.5% + foliar application of Borax @ 0.3% at 45 DAS (Table 3). Similar trend was reported by Alam *et al.*, (2021). Further, it was observed at 60-90 DAS that, the application of RDF + Soil application of $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 1.5 kg ha^{-1} recorded significantly higher crop growth rate (12.46 g m^{-2} day^{-1}). This might be due to prolonged vegetative phase of crop under higher supply of nutrients. This result shows close conformity with the results of Katore *et al.*, (2020).

Table 1: Plant height (cm) of linseed as influenced by different micronutrient treatments.

Sr. No.	Treatments	Plant height (cm)			
		30 DAS	60 DAS	90 DAS	At harvest
T_1	RDF + Control	13.52	30.51	44.88	50.21
T_2	RDF + Soil application of $ZnSO_4$ @ 25 kg ha^{-1}	14.17	34.53	54.25	54.61
T_3	RDF + Foliar application of $ZnSO_4$ @ 0.5% at 45 DAS	13.53	35.07	54.63	55.38
T_4	RDF + Soil application of $ZnSO_4$ @ 25 kg ha^{-1} + Foliar application of $ZnSO_4$ @ 0.5% at 45 DAS	14.07	36.65	55.14	55.25
T_5	RDF + Soil application of Borax @ 1.5 kg ha^{-1}	13.93	35.35	54.18	54.27
T_6	RDF + Foliar application of Borax @ 0.3% at 45 DAS	13.54	35.87	53.31	53.63
T_7	RDF + Soil application of Borax @ 1.5 kg ha^{-1} + Foliar application of Borax @ 0.3% at 45 DAS	13.91	36.95	55.38	55.75
T_8	RDF + Foliar application of $ZnSO_4$ @ 0.5% + Borax @ 0.3% at 45 DAS	13.58	37.35	58.23	59.02
T_9	RDF + Soil application of $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 1.5 kg ha^{-1}	14.35	37.27	56.60	58.01
	SEm (±)	0.22	1.27	1.76	1.60
	CD at 5%	0.67	3.81	5.28	4.80

Table 2: Dry matter accumulation (g m^{-2}) in linseed as influenced by different micronutrient treatments.

Sr. No.	Treatments	Dry matter accumulation (g m^{-2})			
		30 DAS	60 DAS	90 DAS	at harvest
T_1	RDF + Control	47.27	244.62	470.25	489.25
T_2	RDF + Soil application of $ZnSO_4$ @ 25 kg ha^{-1}	57.45	261.55	559.74	597.09
T_3	RDF + Foliar application of $ZnSO_4$ @ 0.5 % at 45 DAS	47.49	267.57	573.52	597.82
T_4	RDF + Soil application of $ZnSO_4$ @ 25 kg ha^{-1} + Foliar application of $ZnSO_4$ @ 0.5 % at 45 DAS	57.43	294.52	617.09	648.49
T_5	RDF + Soil application of Borax @ 1.5 kg ha^{-1}	56.38	272.42	589.94	622.39
T_6	RDF + Foliar application of Borax @ 0.3 % at 45 DAS	47.44	271.03	607.21	629.83
T_7	RDF + Soil application of Borax @ 1.5 kg ha^{-1} + Foliar application of Borax @ 0.3 % at 45 DAS	56.76	299.27	657.13	686.41
T_8	RDF + Foliar application of $ZnSO_4$ @ 0.5 % + Borax @ 0.3% at 45 DAS	47.47	313.98	687.80	717.56
T_9	RDF + Soil application of $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 1.5 kg ha^{-1}	58.27	306.86	675.04	711.63
	SEm (±)	3.18	16.11	41.45	42.89
	CD at 5%	9.54	48.30	124.28	128.59

Table 3: Crop growth rate of linseed at different time intervals as influenced by different treatments.

Sr. No.	Treatments	CGR(gm^{-2} day^{-1})		
		30-60 DAS	60-90 DAS	90-120 DAS
T_1	RDF + Control	6.58	7.52	0.63
T_2	RDF + Soil application of $ZnSO_4$ @ 25 kg ha^{-1}	6.80	9.94	1.24
T_3	RDF + Foliar application of $ZnSO_4$ @ 0.5% at 45 DAS	7.34	10.20	0.81
T_4	RDF + Soil application of $ZnSO_4$ @ 25 kg ha^{-1} + Foliar application of $ZnSO_4$ @ 0.5% at 45 DAS	7.90	10.75	1.05
T_5	RDF + Soil application of Borax @ 1.5 kg ha^{-1}	7.20	10.58	1.08
T_6	RDF + Foliar application of Borax @ 0.3% at 45 DAS	7.45	11.21	0.75
T_7	RDF + Soil application of Borax @ 1.5 kg ha^{-1} + Foliar application of Borax @ 0.3% at 45 DAS	8.08	11.93	0.98
T_8	RDF + Foliar application of $ZnSO_4$ @ 0.5% + Borax @ 0.3% at 45 DAS	8.65	12.27	1.22
T_9	RDF + Soil application of $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 1.5 kg ha^{-1}	8.52	12.46	0.99
	SEm (±)	0.50	1.10	0.21
	CD at 5%	1.51	3.31	NS

B. Quality parameters

The data on oil content revealed that none of the micronutrient treatments have significant influence on oil content in seeds of linseed however, the maximum oil content (38.02 %) was observed with application of RDF + foliar application of $ZnSO_4$ @ 0.5% + foliar application of Borax @ 0.3% at 45 DAS (Table 4). The non significant increment in oil content at higher supply of micronutrients appears to be due to conversion of more carbohydrate into protein and thus the amount of synthesized carbohydrates left for conversion into fats are relatively low (Singh *et al.*, 2013). Significantly highest oil yield (456.7 kg ha^{-1}) was obtained under application of RDF + foliar application of $ZnSO_4$ @ 0.5% + foliar application of Borax @ 0.3% at 45 DAS as compared to RDF + Control (323.46 kg ha^{-1}). Improvement in oil yield with zinc sulphate and borax might be largely due to involvement of sulphur directly in oil synthesis. Further, the increase in absorption of the nutrients under foliar application might be the outcome of increase contents of these nutrients in seed and stover coupled with increased oil content and its yield (Dwivedi and Chaubey 1995). The results reported by Maharnor *et al.*, (2018) are also in close conformity with these findings. The data on seed protein (Table 4) revealed that none of the micronutrient treatments have significant influence on seed protein content of linseed though maximum seed protein content (10.37 %) was recorded with RDF + Foliar application of $ZnSO_4$ @ 0.5% + Borax @0.3% at 45 DAS (T_8). The improvement in protein yield might be due to better translocation of photosynthates leading to more protein yield. The results of the present investigation corroborate the findings of Singh *et al.* (2006).

Table 4: Effect of micronutrients on oil content (%) oil yield (kg ha^{-1}) and Seed protein content (%) of linseed.

Sr. No.	Treatments	Oil content (%)	Oil yield (kg ha^{-1})	Seed protein content (%)
T_1	RDF + Control	34.38	323.4	9.44
T_2	RDF + Soil application of $ZnSO_4$ @ 25 kg ha^{-1}	33.77	338.8	9.71
T_3	RDF + Foliar application of $ZnSO_4$ @ 0.5% at 45 DAS	33.49	338.7	10.17
T_4	RDF + Soil application of $ZnSO_4$ @ 25 kg ha^{-1} + Foliar application of $ZnSO_4$ @ 0.5% at 45 DAS	32.64	340.2	10.00
T_5	RDF + Soil application of Borax @ 1.5 kg ha^{-1}	33.05	349.1	9.81
T_6	RDF + Foliar application of Borax @ 0.3% at 45 DAS	35.55	399.2	9.54
T_7	RDF + Soil application of Borax @ 1.5 kg ha^{-1} + Foliar application of Borax @ 0.3% at 45 DAS	37.28	417.4	9.96
T_8	RDF + Foliar application of $ZnSO_4$ @ 0.5% + Borax @ 0.3% at 45 DAS	38.02	456.7	10.40
T_9	RDF + Soil application of $ZnSO_4$ @ 25 kg ha^{-1}+ Borax @ 1.5 kg ha^{-1}	37.19	430.1	9.48
	SEm (±)	6.16	29.2	0.34
	CD at 5%	NS	87.6	NS

CONCLUSION

Earlier linseed production occurred mainly in rainfed area, since then there has been a continuous decline in linseed area in the country during the last four decades. So, there is need to develop appropriate agronomic practices to increase higher crop yield. Surveys showed that there is an increase of about 50% in food production due to use of chemical fertilisers. Poor management of inputs is one of the limiting factors for low yield of linseed. The amount of fertilizers that a crop needs depends on many factors including climatic conditions, plant species and cultivar, and soil fertility levels. To obtain higher crop yield and quality, suitable agro techniques like judicious use of fertilizers especially micronutrients zinc and boron is the major research threats for agronomic research workers. 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 $ZnSO_4$ @ 0.5 % + foliar application of Borax @ 0.3 % at 45 DAS can be recommended for linseed for enhancing better growth, quality of linseed. However, these results are of one crop season. Hence, further experimentation is required to get the standard recommended dose of micronutrients for linseed for a particular locality.

Acknowledgement. Author is very thankful to AICRP (Linseed), Directorate of Oilseeds Research, Hyderabad and BAU, Sabour for financial support.

Conflict of Interest. Nil.

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How to cite this article: Kumari, S., Kumari, R. and Kumar, S. (2021). Evaluation of the Performance of Micronutrients on Growth and Quality Parameters of Linseed (*Linum usitatissimum* L.). *Biological Forum – An International Journal*, *13*(3): 450-453.