International Journal of Agricultural Sciences
Volume 17 | AAEBSSD | 2021 | 297-301
DOI:10.15740/HAS/IJAS/17-AAEBSSD/297-301
ISSN : 0973-130X
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RESEARCH PAPER

Response of micro-nutrients on yield and economics of linseed (*Linum usitatissimum* L.) under limited irrigation

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Abstract : A field experiment was conducted during *Rabi* season of 2019-20 at Oil Seed Research Farm of C S Azad University of Agriculture and Technology, Kanpur. The experiment consisted 9 treatments *viz.,* T_1: Control, T_2: Soil application of $ZnSO_4$ @ 25 kg ha^{-1}, T_3: Foliar application of $ZnSO_4$ @0.5% at 45 DAS, T_4: Soil Application of $ZnSO_4$ @ 25 kg ha^{-1} + Foliar application of $ZnSO_4$ @0.5% at 45 DAS, T_5: Soil application Borax @ 1.5 kg ha^{-1}, T_6: Foliar application of Borax @ 0.3 % at 45 DAS, T_7: Soil application of Borax @ 1.5 kg ha^{-1} Foliar application of Borax @ 0.3 % at 45 DAS, T_8: Foliar application of $ZnSO_4$ @ 0.5% + Borax @ 0.3% at 45 DAS and T_9: Soil application of $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 1.5 kg ha^{-1} in soil assigned in Randomized Block Design with three replication. The Linseed cv Shekhar was used in the experiment. The results in significantly maximum seed yield, oil content, oil yield and stover yield, Root development, minimum water use and ultimately higher seed yield and WUE as compared to other corresponding tested treatments indicated that application of $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 1.5 kg ha^{-1} incorporated in the soil have fetched highest net return of Rs 52050 having B:C ratio of 3.51 would be quite remunerative for higher productivity along with water use efficiency in light textured alluvial soils of Uttar Pradesh.

Key Words : Seed yield, Root development, Water use efficiency and Economics

View Point Article : Verma, Adarsh, Awasthi, U. D., Verma, Amar Kant, Sachan, Kushal and Singh, Avadh Narain (2021). Response of micro-nutrients on yield and economics of linseed (*Linum usitatissimum* L.) under limited irrigation. *Internat. J. agric. Sci.*, **17** (AAEBSSD) : 297-301, **DOI:10.15740/HAS/IJAS/17-AAEBSSD/297-301.** Copyright@2021: Hind Agri-Horticultural Society.

Article History : Received : 01.08.2021; **Accepted :** 04.08.2021

INTRODUCTION

Linseed (*Linum usitatissimum* L.) also known as flaxseed belongs to family Linaceae. It is generally known for seed types and flax is commonly grown for fiber types. Nevertheless, both having 2n=30 chromosomes are perfectly crossable and there is no barrier to the gene flow. Linseed owing to its various uses is considered important in oilseeds economy of the country (Singh and Tewari, 2014). Every part of linseed is used directly or after processing. With a view to have a holistic approach and sound scientific planning for breeding desirable varieties, seed yield and some of the important yield components were considered for their genetic analysis by adopting classical diallel technique (Singh and Tewari, 2016). Oil seeds are rich in fat and in addition they contain a high level of protein, they contribute edible oil (fats) and vanaspati ghee to human diet. Edible oil are concentrated source of energy. The energy content of oil is much higher (39.80 MJ kg^{-1}) than protein (23.88 MJ kg^{-1}) or carbohydrate (16.76 MJ kg^{-1}). They

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contain useful carbohydrates, vitamins and provide essential fatty acids. Edible oil cakes are fed to cattle, while non-edible cakes are used as organic manures and are also a major source of raw material in industries for manufacturing a wide range of products used in life. Oilseeds have also medicinal and therapeutic values.

Globally, linseed is an important oilseed crop grown widely in Asia, Americas and Europe for both seed and fibre and its production is 22.39 lakh tones from 22.07 lakh ha with an average yield of 986 kg ha^{-1}, while our national production is 1.47 lakh tonnes from an area of 3.38 lakh ha with poor productivity of 435 kg ha^{-1} (Anonymous, 2020).

India is the third largest (14.88%) linseed growing countries in the world and production wise it ranks fourth (6.57%) in the world after Canada (31.80%), China (14.74%), and Kazakhstan (13.18%). In India linseed is predominantly grown under rainfed (63%) and *utera* (25%) and irrigated (12%) conditions and the prominent states are Madhaya Pradesh, Maharashtra, Chhattisgarh, Uttar Pradesh, Bihar, Jharkhand, Odissa, Karnataka, West Bengal and Assam. The major impediments for the lower national productivity is due to its continued cultivation under sub-marginal, un-irrigated, input starved and poor crop management conditions coupled with low seed replacement rate. Linseed is basically an industrial oilseed crop and its each and every part is endowed with commercial and medicinal importance. Tolerance to biotic and abiotic stresses is another important characteristics of this crop and because of this property the survival and cultivation of linseed is still prevailing in a wide range of climate conditions and regions. After the inception of AICRP on linseed in late sixties (1967), the organised crop improvement programmes undertaken in the project have culminated in the development of 65 high yielding varieties (56 seed and 9 dual purpose types) mostly of multi regional adaptation with mono/multiple disease resistance. The present yield level is still very low (435 kg ha^{-1}) as compared to the production potential realized in the frontline demonstrations (965 kg ha^{-1}). Hence, in order to bridge this vast gap, I trust and believe that this technology bulletin will be of immense help for researchers, development agencies and extension personnel engaged in the upliftment of this crop.

MATERIAL AND METHODS

The experiment was conducted during *Rabi* season of 2019-20 in Oil Seed Research Farm of C S Azad University of Agriculture and Technology, Kanpur in alluvial soil. Soil of the experimental plot was sandy loam in texture and slightly calcareous having organic carbon 0.33%, total nitrogen 0.034%, available P_2O_5 16.8 Kg ha^{-1}, available K_2O 156.4 kg ha^{-1}, pH 7.7, electrical conductivity 0.38 dS m^{-1}, permanent wilting point 6.3%, field capacity 18.2%, maximum water holding capacity 29.7 %, bulk density 1.45 Mg m^{-3}, particle density 2.57 Mg m^{-3} and porosity 43.57%. The experiment consisted 9 treatments *viz.* T_1: Control, T_2: Soil application of $ZnSO_4$ @ 25 kg ha^{-1}, T_3: Foliar application of $ZnSO_4$ @0.5% at 45 DAS, T_4: Soil Application of $ZnSO_4$ @ 25 kg ha^{-1} + Foliar application of $ZnSO_4$ @0.5% at 45 DAS, T_5: Soil application Borax @ 1.5 kg ha^{-1}, T_6: Foliar application of Borax @ 0.3 % at 45 DAS, T_7: Soil application of Borax @ 1.5 kg ha^{-1} Foliar application of Borax @ 0.3 % at 45 DAS, T_8: Foliar application of $ZnSO_4$ @ 0.5% + Borax @ 0.3% at 45 DAS and T_9: Soil application of $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 1.5 kg ha^{-1} in soil assigned in Randomized Block Design with three replication. The Linseed cv Shekhar was used in the experiment. A uniform dose of 30 kg N + 15 kg P_2O_5 + 15 kg K_2O ha^{-1} was applied as basal at sowing through funnel attached with country plough used for seed sowing. The fertilizer used were urea DAP, Borex, Zinc and muriate of potash. Available moisture at sowing time upto 100 cm soil profile was 307.23 mm. Whereas amount of rainfall received during the crop period was 61.8 mm against the average annual rainfall of about 800 mm. Recommended package of practices were applied in different treatments. Soil moisture was monitored gravimetrically using the sample collected from 0-25, 25-50, 50-75 and 75-100 cm soil depths at regular monthly intervals to quantify the soil moisture content and growth parameters by randomly selecting three plants for each plots till the harvest.

The data collected on growth and yield attributes were statistically analyzed (Fisher and Yates, 1958). Recommended package of practices and fertilizers doses were applied in different treatments.

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Seed yield (q ha^{-1}) and stover yield (q ha^{-1}):

Seed yield (q ha^{-1}) was recorded the highest seed yield (q ha^{-1}) (15.86) was recorded under T_9 (Soil application of $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 1.5 kg ha^{-1}) as compared under T_1 (Control) (12.43 q ha^{-1}). The highest stover yield (q ha^{-1}) (32.04) was recorded under T_9 (Soil application of $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 1.5 kg ha^{-1}) as compared to under T_1 (Control) (26.37 q ha^{-1}). Similar results have also been observed by Rahimi *et al.* (2011), Patel *et al.* (2017) and Verma and Yadav (2017).

Biological yield (q ha^{-1}) and harvest index (%):

The biological yield (q ha^{-1}) was significantly affected by various treatments except T_1 and T_2. The highest biological yield (q ha^{-1}) (47.90) under T_9 (Soil application of $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 1.5 kg ha^{-1}) as compared to under T_1 and T_2 treatments and lowest (38.80 q ha^{-1}) and (40.89 q ha^{-1}). It is evident from data that harvest index (%) was non significantly in various treatments. These findings are in line with those of Verma and Yadav (2017) and Omidbaigi *et al.* (2019).

Oil content (%) and oil yield (kg ha^{-1}):

The oil content (%) and oil yield (Kg ha^{-1}) was recorded. The highest oil content (%) and oil yield (Kg

Table 1: Effect of micro-nutrients on seed yield (q ha^{-1}), oil content (%), oil yield (Kg ha^{-1}), stover yield (q ha^{-1}), biological yield (q ha^{-1}), harvest index (%), zinc concentration (mg kg^{-1}) and boron (mg kg^{-1}) under different treatments

Treatments	Seed yield (q ha^{-1})	Oil content (%)	Oil yield (kg ha^{-1})	Stover yield (q ha^{-1})	Biological yield (q ha^{-1})	Harvest Index (%)	Zinc concentration (mg kg^{-1})	Boron concentration (mg kg^{-1})
T_1	12.43	35.00	435.05	26.37	38.80	32.03	29.73	6.43
T_2	12.87	35.69	459.33	28.02	40.89	31.47	32.65	7.19
T_3	13.05	35.98	469.53	28.76	41.81	31.21	36.32	8.90
T_4	13.11	36.05	472.61	29.15	42.26	31.02	39.98	11.89
T_5	13.08	36.00	470.88	29.05	42.13	31.04	37.85	10.81
T_6	13.56	36.90	500.36	30.00	43.56	31.12	40.73	14.09
T_7	13.43	36.23	486.56	30.48	43.91	30.58	42.09	15.76
T_8	14.75	37.13	547.66	31.81	46.56	31.67	44.21	16.42
T_9	15.86	37.41	593.32	32.04	47.90	33.11	47.30	18.63
S.D. ±	0.61	2.65	3.87	1.31	1.13	1.09	1.28	0.69
C.D. (P=0.05)	1.29	5.87	7.61	2.71	2.37	2.31	2.50	1.72

T_1: Control, T_2: Soil application of $ZnSO_4$ @ 25 kg ha^{-1}, T_3: Foliar application of $ZnSO_4$ @0.5% at 45 DAS, T_4: Soil Application of $ZnSO_4$ @ 25 kg ha^{-1} + Foliar application of $ZnSO_4$ @0.5% at 45 DAS, T_5: Soil application Borax @ 1.5 kg ha^{-1}, T_6: Foliar application of Borax @ 0.3 % at 45 DAS, T_7: Soil application of Borax @ 1.5 kg ha^{-1} Foliar application of Borax @ 0.3 % at 45 DAS, T_8: Foliar application of $ZnSO_4$ @ 0.5% + Borax @ 0.3% at 45 DAS and T_9: Soil application of $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 1.5 kg ha^{-1}

Table 2 : Effect of micro-nutrients on root depth (cm), no. of roots $plant^{-1}$, dry weight of roots $plant^{-1}$ (g), water use (mm), water use efficiency kg seed ha^{-1} mm^{-1} of water) and economics under different treatments

Treatments	Root depth (cm)	No. of roots $plant^{-1}$	Dry weight of roots $plant^{-1}$ (g)	Water use (mm)	Water use efficiency (kg seed ha^{-1} mm^{-1} of water)	Cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C Ratio
T_1	20.03	23.46	2.05	307.23	4.04	18908	55024	36116	2.91
T_2	21.56	23.98	2.07	299.06	4.30	20408	58367	37959	2.86
T_3	21.97	24.65	2.18	301.21	4.33	19308	59078	39770	3.05
T_4	22.14	24.54	2.22	297.97	4.39	20808	64053	43245	3.07
T_5	22.25	24.98	2.34	294.71	4.43	19208	64143	44935	3.33
T_6	22.54	25.07	2.54	295.34	4.59	19458	65582	46124	3.37
T_7	22.67	25.78	2.60	293.14	4.58	19758	67582	47824	3.42
T_8	23.78	25.90	2.65	290.56	5.07	19608	68258	48650	3.48
T_9	24.80	26.12	2.69	287.07	5.52	20708	72758	52050	3.51

T_1: Control, T_2: Soil application of $ZnSO_4$ @ 25 kg ha^{-1}, T_3: Foliar application of $ZnSO_4$ @0.5% at 45 DAS, T_4: Soil Application of $ZnSO_4$ @ 25 kg ha^{-1} + Foliar application of $ZnSO_4$ @0.5% at 45 DAS, T_5: Soil application Borax @ 1.5 kg ha^{-1}, T_6: Foliar application of Borax @ 0.3 % at 45 DAS, T_7: Soil application of Borax @ 1.5 kg ha^{-1} Foliar application of Borax @ 0.3 % at 45 DAS, T_8: Foliar application of $ZnSO_4$ @ 0.5% + Borax @ 0.3% at 45 DAS and T_9: Soil application of $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 1.5 kg ha^{-1}.

ha^{-1}) (37.41 and 593.32) was recorded under T_9 (Soil application of $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 1.5 kg ha^{-1}) as compared to under T_1 (Control) and yield is lowest (35.00 % and 435.05 Kg ha^{-1}). Similar results were reported by Lodhi *et al.* (2007).

Root study:

The highest root depth (cm), No. of roots $plant^{-1}$ and dry weight of roots $plant^{-1}$ (g) (24.80, 26.12 and 2.69) under T_9 (Soil application of $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 1.5 kg ha^{-1}) and lowest under T_1 (20.03, 23.46 and 2.05). Similar results were reported by Gabiana *et al.* (2005).

Zinc and boron concentration in seed:

The zinc and boron concentration (mg kg^{-1}) was significantly affected by various treatments. The highest zinc and boron concentration (47.30 and 18.63 mg kg^{-1}) in all treatments was recorded significantly under T_9 (Soil application of $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 1.5 kg ha^{-1}) as compared to all the treatments. Similar observations have also been reported by Verma and Yadav (2017).

Water use (mm) and water use efficiency (kg seed ha^{-1} mm^{-1} of water):

The highest water use (307.23 mm) under T_1 (Control) as compared to all the treatments and lowest (287.07 mm) under T_9 (Soil application of $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 1.5 kg ha^{-1}). The highest water use efficiency (kg seed ha^{-1} mm^{-1} of water) (5.52 kg seed ha^{-1} mm^{-1} of water under T_9 (Soil application of $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 1.5 kg ha^{-1}) as compared to all the treatments and lowest (4.04 kg seed ha^{-1} mm^{-1} of water) under T_1 (Control). Similar results were reported by Kar *et al.* (2007) and Verma and Yadav (2018).

Economics:

The highest cost of cultivation (20808 Rs. ha^{-1}) in T_4 treatments was recorded as compared to all the treatments and lowest (18908 Rs. ha^{-1}) under T_1 (Control). The highest gross return (72758 Rs. ha^{-1}) in treatments was recorded under (T_9) where use of micronutrients at the time of sowing soil application of $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 1.5 kg ha^{-1} as compared to all the treatments and lowest (55024 Rs. ha^{-1}) under T_1 (Control). The highest net return (52050 Rs. ha^{-1}) in treatments was recorded under (T_9) where use of micronutrients at the time of sowing soil application of $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 1.5 kg ha^{-1} as compared to all the treatments and lowest (36116 Rs ha^{-1}) under T_1 (Control). The highest B:C ratio (3.51) in treatments was recorded under (T_9) where use of micronutrients at the time of sowing soil application of $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 1.5 kg ha^{-1} as compared to all the treatments. Similar results were reported by Sarkar and Sarkar, (2017).

Conclusion:

On the basis of results obtained it can be concluded that application of $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 1.5 kg ha^{-1} incorporated in the soil and seed yield and root study is earlier than other treatments have fetched highest net return and B:C ratio quite remunerative for higher productivity along with water use efficiency in light textured alluvial soil of Uttar Pradesh.

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