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Performance of nutrient management through exogenous application of water-soluble fertilizers on growth, yield and economics of linseed (*Linum usitatissimum* L.) under utera condition

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ABSTRACT

Field experiment was conducted to find out the performance of exogenous application of water-soluble fertilizers on growth, yield and economics of utera linseed (*Linum usitatissimum* L.) during rabi season of 2020-21 at research farm of Bihar Agricultural University, Sabour, Bhagalpur (Bihar) revealed that two times foliar sprays of NPK 19:19:19 @ 1.0 % + ZnSO4 @ 0.5% at flowering and capsule development stage recorded highest capsules/plant (34.98), seed yield (996.98 kg ha^{-1}), oil content (36.23 %), net return (₹40768 ha^{-1}) whereas stover yield (2080.67 kg ha^{-1}), B:C ratio (1.84) and plant height (56.75 cm) were recorded highest with RDF + two sprays of urea @ 2.0 % + ZnSO4 @ 0.5 % however, primary branches $plant^{-1}$ (4.73), secondary branches $plant^{-1}$ (17.12), dry weight (398.58 g^{-2}) were highest with RDF + two sprays of NPK 13:0:45@1.0 % + ZnSO4 @ 0.5 %.

Key words: *Zinc sulphate, Urea, Linseed, Yield, Agriculture economics*

Introduction

Linseed (*Linum usitatissimum* L.) is a valuable oilseed crop that provides the source of omega-3 fatty acid, which is essential for human beings. It is used in manufacturing the paint, soap, varnish, linoleum pad and printing ink. India's total production of linseed is around 1.49 lakh tons from an area of 2.96 lakh ha with low productivity of 502 kg/ha (Anonymous, 2014). Whereas, in Bihar, linseed is cultivated on about 0.17 lakh hectares with a production of 0.14 lakh tonnes and a productivity of 857 kg ha^{-1} (Annual Report, AICRP on linseed, 2017-18). Linseed is one of the important rabi oilseed crops of India which is cultivated in Bihar, Madhya Pradesh, Chhattisgarh, Uttar Pradesh, Maharashtra, Rajasthan, West Bengal, Karnataka and Orissa. Utera or paira is a system of relay cropping in paddy fields, which is done by broadcasting seeds of linseed in standing paddy at dough stage. After one week or 2-3 leaf stage of linseed, rice crop was harvested. It is a traditional practice of rainfed cultivation. Utera cropping practices is the use of efficient residual moisture in rice field, where tillage is more problem. Growing linseed in utera system is the predominant practice of regions like Bihar, Jharkhand, Orissa, Maharashtra, M.P. Eastern part of Uttar Pradesh and Himachal Pradesh etc.

Plant nutrition is key input to increase the production & productivity. Fertilizer is an important option that should be adopted in order to improve crop yield. Foliar application of urea is very important to increase linseed productivity. Similarly, phosphorus is an important plant nutrient which helps in growth and development of a plant and ultimately improve crop yield. Potassium is a useful nutrient for the synthesis of starch, enzyme activation, protein metabolism, and also provides resistance for disease and pest attack in different crops. Among the micronutrient, zinc deficiency is most widespread on a wide range of soil. The Indian soils are deficient in zinc. Zinc deficiency not only reduces crop yield and production but also reduction of their nutritional value. Besides of integrated nutrient management practices, foliar application response of different nutrient is very important, hence testing of foliar response has been taken under the investigation. Foliar application of nutrients to the plants has been successfully used in correction of nutrient deficiency especially micronutrients and quickly counter a mineral unbalance that would inhibit plant metabolism.

Materials and Methods

The experiment was carried and laid out during rabi season of 2020-21 at K-block of the research farm of Bihar Agricultural University, Sabour, Bhagalpur (Bihar). It is located south of the Ganga River. The experimental plot was provided and has sufficient basic infrastructure facilities, with assured irrigation as well as proper drainage facility with uniform slope. Geologically, the geographical location of Bhagalpur comes under the Middle Gangetic plain region of Agro-climatic Zone III A. It is situated between 25°50' N latitude and 87°19' E longitude at an altitude of 52.73 meters above mean sea level. The soil was clay loam in texture with pH (7.4), organic carbon (0.42%), low in available nitrogen (210 kg/ha), medium in available phosphorous (23.0 kg/ha), and medium in available potassium (166 kg/ha). There were eight (8) treatments combination *viz* T_1 : RDF + two sprays of NPK 19:19:19 @ 1.0 %, T_2 : RDF + two sprays of NPK 13:0:45 @ 1.0%, T_3 : RDF + two sprays of Urea @ 2.0 %, T_4: RDF + two sprays of ZnSO4 @ 0.5%, T_5: RDF + two sprays of NPK 19:19:19 @ 1.0 % + ZnSO4 @ 0.5 %, T_6: RDF + two sprays of NPK 13:0:45 @1.0 % + ZnSO4 @ 0.5 %, T_7: RDF + two sprays of Urea @ 2.0 % + ZnSO4 @ 0.5 % and T_8: RDF + control (water spray) tested in a randomized block design (RBD) with three replications. The following the recommended seed rate i.e. 25 kg ha^{-1}. The size of each plot was 5.0 m x 3.0 m and the no any spacing was adopted i.e. methods of sowing was broadcasting. The estimated quantity of fertilizers was applied plot wise as a basal just after harvest of rice crop. The recommended dose of fertilizer in linseed in utera condition are 40, 20, 20 N, P_2O_5, K_2O kg ha^{-1} respectively through urea, DAP and MOP were applied uniformly to all the plots, all fertilizer were applied in a single dose *i.e.* basal application. Intercultural operations were done as and when required. No any irrigation was given i.e. crop was grown in rainfed utera condition. The mature crop were harvested when crop colour change from green to brown.

Results and Discussion

Growth parameters

The result revealed that the two spray of water-soluble fertilizer at 30 and 60 DAS i.e. at flowering and capsule development stage, the plant height (56.75 cm) (Table 1) at harvest was found statistically maximum with treatments RDF + two sprays of urea @ 2.0 % + $ZnSO_4$ @ 0.5 % (T_7) which was statically at par with RDF + two sprays of urea @ 2.0 % (T_3) (55.34 cm), The application of nitrogen fertilizer through urea results in higher biomass yields and protein yield and concentration in plant tissue is commonly increased as a result increase plant height. Kumar *et al.* (2017) and Jain and Agrawal (1989). The primary branches $plant^{-1}$ (4.73) was found statistically maximum with treatments RDF + two spray of 1.0 % NPK 13:0:45 + 0.5 % $ZnSO_4$ (T_6) which was at par with RDF + two spray of 1.0 % NPK 19:19:19 + 0.5 % $ZnSO_4$(T_5) (4.13) although secondary branches $plant^{-1}$ (17.12) was found statistically maximum with treatments RDF + two spray of 1.0 % NPK 13:0:45 + 0.5 % $ZnSO_4$ (T_6) which was statistically at par with RDF + two sprays of Urea @ 2.0 % + $ZnSO_4$ @ 0.5 % (T_7) (16.30). Zinc is an important component of various enzymes that are responsible for driving many metabolic reactions in all crops and promote growth and development of crop as a result increase the primary and secondary branches per plant. Similar result also reported by Banerjee *et al.* (2001) when foliar application of nitrogen, phosphorus and potassium gave the maximum value of

primary and secondary branches plant^{-1}. Similar findings have also been reported by Khare *et al.* (1996), and Sune *et al.* (2006). The dry matter of linseed (g m^{-2}) was found statistically maximum (398.58 g m^{-2}) with the treatment RDF + two spray of 1.0 % NPK 13:0:45 + 0.5 % $ZnSO_4$ (T_6), which was statistically at par with treatment RDF + two spray of 1.0 % NPK 19:19:19 + 0.5 % $ZnSO_4$ (T_5) (368.62 g m^{-2}) and RDF + two spray 2.0 % Urea + 0.5 % $ZnSO_4$ DAS (T_7) (386.89 g m^{-2}). This result might be obtained due to more amino acid carbohydrate synthesis which ultimately increased the dry matter accumulation under the foliar application of nitrogen, potassium along with basal application of primary nutrients similar result was also collaborated by Singh *et al.* (2013) and Kumar *et al.* (2017), whereas the capsules plant^{-1} of linseed was statistically maximum (34.98) found with the application RDF + two spray of 1.0 % NPK 19:19:19 + 0.5 % $ZnSO_4$ (T_5), which was statistically at par with all treatments except RDF + water spray (control) (28.26) treatment. This variation among treatments might be due to the more number of primary branches per plant and also found less competition of nutrient which full fill the nutrient demand, allows the crops to grow their potential by absorbing sufficient nutrients, light and moisture which facilitate more translocation of photosynthetic towards the reproductive parts as well as presence of favorable agro-climatic condition led to more number of capsules plant^{-1} similar results were obtained by Nandanwar *et al.* (2000), Mishra and Singh (1992).

Yield and Economics

The seed yield of linseed was found significant difference among treatments, the significantly higher seed yield (996.98 kg ha^{-1}) and net return (40768 ha^{-1}) were found under the treatment RDF + two spray

Table 1. Growth and yield attributes of linseed under utera condition as influenced by exogenous application of water-soluble fertilizers

Symbol	Treatments	Plant height (cm)	Primary Branches plant^{-1}	Secondary Branches plant^{-1}	Dry Weight (gm^{-2})	Capsules/ Plant
T_1	RDF + Two sprays of NPK 19:19:19 @ 1.0 %	51.84	3.75	14.97	317.96	33.85
T_2	RDF + Two sprays of NPK 13:0:45 @1.0 %	52.69	3.80	15.73	314.28	33.48
T_3	RDF + Two sprays of Urea @ 2.0 %	55.34	3.78	14.92	327.07	33.11
T_4	RDF + Two sprays of $ZnSO_4$ @ 0.5 %	52.97	3.97	15.40	295.28	32.25
T_5	RDF + Two sprays of NPK 19:19:19 @ 1.0 % + $ZnSO_4$ @ 0.5%	52.90	4.13	16.10	368.62	34.98
T_6	RDF + Two sprays of NPK 13:0:45@1.0 % + $ZnSO_4$ @ 0.5%	54.04	4.73	17.12	398.58	34.22
T_7	RDF + Two sprays of Urea @ 2.0 % + $ZnSO_4$ @ 0.5 %	56.75	3.70	16.30	386.89	33.69
T_8	RDF + Two sprays of water (control)	49.37	3.13	13.90	275.44	28.26
	SEm (±)	0.78	0.20	0.29	15.46	1.73
	CD(P=0.05)	2.36	0.60	0.88	46.89	5.25

Table 2. Seed yield (kg ha^{-1}), stover yield (kg ha^{-1}), oil content (%) and economics of linseed under utera condition as influenced by exogenous application of water-soluble fertilizers

Symbol	Treatments	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Oil content (%)	Net return (₹ha^{-1})	B:C ratio
T_1	RDF + Two sprays of NPK 19:19:19 @ 1.0 %	928.97	1864.00	33.75	37307	1.68
T_2	RDF + Two sprays of NPK 13:0:45 @1.0 %	909.02	1802.00	35.32	32986	1.31
T_3	RDF + Two sprays of Urea @ 2.0 %	884.64	1880.33	33.27	36787	1.83
T_4	RDF + Two sprays of $ZnSO_4$ @ 0.5 %	847.28	1814.00	34.30	33706	1.62
T_5	RDF + Two sprays of NPK 19:19:19 @ 1.0 % + $ZnSO_4$ @ 0.5%	996.98	1954.00	36.23	40768	1.78
T_6	RDF + Two sprays of NPK 13:0:45@1.0 % + $ZnSO_4$ @ 0.5 %	951.28	1851.33	34.80	34821	1.34
T_7	RDF + Two sprays of Urea @ 2.0 % + $ZnSO_4$ @ 0.5 %	924.45	2080.67	33.70	38629	1.84
T_8	RDF + Two sprays of water (control)	749.28	1426.00	31.29	29026	1.55
	SEm (±)	56.26	139.71	0.89	3438	0.17
	CD(P=0.05)	170.66	423.78	2.70	10428	0.50

of 1.0 % NPK 19:19:19 + 0.5 % $ZnSO_4$ (T_5), which was statistically at par with all the treatments except RDF + two spray of water (control) (T_8) (749.28 kg ha^{-1}, 29026 ha^{-1}) respectively (Table 2), the similar result was also reported by Khan *et al.* (1998), the foliar application of N, P, K, along with B enhances seed and seed size development. The similar result was also reported by Debbarma *et al.* (2015). Khan and Khan (2016) also concluded, it might be inferred that the foliar application of water - soluble fertilizer nitrogen, potassium indirectly increased the growth and yield attributes which leads to increase in seed yield per plant and also significantly reported the highest seed yield in the genotype of linseed crop. The statistically maximum stover yield (2080.67 kg ha^{-1}) was found under with the application RDF + two spray of 2.0 % urea + 0.5 % $ZnSO_4$ (T_7), which was at par with all the treatments except RDF + two spray of water (control) (T_8) (1426.00 kg ha^{-1}), The increase in stover yield with increasing nitrogen rates, however, the optimal physical rate might be due to observed in stover yield of linseed. Similar result was also demonstrated by Sanchez and Flores (1999). The statistically maximum oil content of linseed (36.23 %) was found with the treatment RDF + two spray of 1.0 % NPK 19:19:19 + 0.5 % $ZnSO_4$ (T_5), which was statistically at par with RDF + two spray of 1.0 % NPK 19:19:19 (T_1) (33.75 %), RDF + two spray of 1.0 % NPK 13:0:45 (T_2) (35.32 %), RDF + two spray of 0.5 % $ZnSO_4$ (T_4) (34.30 %), RDF + two spray of 1.0 % NPK 13:0:45 + 0.5 % ZnSO4 (T_6) (34.80 %) and RDF + two spray of 2.0 % Urea + 0.5 % $ZnSO_4$ (T_7) (33.70 %), This variation among treatments might be due to the foliar application of water soluble fertilizers direct absorb by plant as a result more bold size seed was produce ultimately oil content more. Kumar *et al.* (2013) [4] reported that the foliar application of soluble starter NPK @ 2 per cent + sulphur spray 2 per cent at 45 DAS and soluble booster NPK 2 per cent + boron spray 0.15 per cent at 65 DAS resulted in significantly higher oil content also similar result was found by Nazim Pasha (2016). The statistically maximum B:C ratio (1.84) was observed with the treatment RDF + two spray 2.0 % urea + 0.5 % $ZnSO_4$ (T_7), which was statistically at par with rest of the treatments except RDF + two sprays of NPK 13:0:45 @ 1.0% (T_2) (1.31), the variation in result is might be due to higher economical yield and lower cost of cultivation in concern treatments similar result was also reported by Kashyap TL (2018), and Husain *et al.* (2009).

Conclusion

On the basis of one season of experiment in linseed it may be concluded that the exogenous application of water-soluble fertilizers under the of treatment RDF + two spray of 1.0 % NPK 19:19:19 + 0.5 % $ZnSO_4$ (T_5), showed superiority in seed yield (996.98 kg ha^{-1}), oil content (36.23 %) as well as economically more profitable such as net return (40768 ha^{-1}), hence it is more desirable and preferable to farmers.

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