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Impact of foliar application of fertilizer and crop biostimulant on yield and yield attributes of linseed (*Linum usitatissimum* L.)

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Abstract
A field investigation was carried out during *rabi* season 2022-23 at Experimental Farm, Department of Agronomy, College of Agriculture, VNMKV, Parbhani to evaluate the impact of foliar application of fertilizer and crop biostimulant on yield and yield attributes of linseed. The field trial was laid out in randomized block design (RBD) with three replications comprising of seven foliar nutrition treatments *viz.*, T_1 - 2% KNO_3, T_2 - 2% DAP, T_3 - 2% urea, T_4 – 0.2% seaweed extract, T_5 – 0.25% fulvic acid, T_6 – 0.2% amino acid and T_7 – control. The foliar application of fertilizers and crop biostimulants were applied at time of flower bud initiation. Foliar application of 2% urea recorded higher number of capsules plant^{-1}, weight of capsules plant^{-1} (g), number of seeds capsule^{-1}, weight of seed plant^{-1} (g), test weight (g), seed yield (kg ha^{-1}), straw yield (kg ha^{-1}), biological yield (kg ha^{-1}) and harvest index (%) and it was found at par with foliar application of 0.2% amino acid (T_6).

Keywords: Foliar, linseed, yield attributes, urea, fertilizer, crop biostimulant

Introduction
Linseed or flax (*Linum usitatissimum* L.) an annual crop that belongs to the family Linaceae and genus Linum. It has its origin in the Middle East or Indian regions. It is an annual, herbaceous, dicotyledonous plant cultivated in *rabi* season. In modern world, people are attracted towards linseed cultivation due to its nutritive and multifarious quality (Dwivedi *et al*., 2021) [3]. It is highly self -pollinated crop and widely adapted in temperate region of the world. Linseed oil is rich source of linolenic acid (40-60%) an omega-3 fatty acid which has anti-inflammatory action in treatment of arthritis. It has also role in lowering down blood cholesterol level. Linseed is mostly grown under conserved moisture and limited nutrient conditions with poor management practices. Linseed production and productivity in India is very low, mainly due to its cultivation on residual moisture during *rabi* season where the crop experiences moisture stress at one or the other stages (Biradar *et al*., 2016) [2]. Efficient and effective use of nutrients is a very important factor which influences crop production. Among agro-techniques that can increase its productivity, judicious application of nutrients, particularly the nitrogen, phosphorus and potash play the important role (Singh *et al*., 2013) [10]. Soil application of nutrients is most common practice, but it has many limitations with respect to availability of nutrients to plants. In the foliar application, the fertilizers are directly applied on leaves to facilitate easier absorption of nutrients which leads to improvement in yield. Foliar nutrition is recognized as an important method of fertilization, since foliar nutrients usually penetrate the leaf cuticle or stomata and enter the cells facilitating easy and rapid utilization of nutrients by the crop. It lowers the cost of cultivation by requiring less fertiliser, decreases crop losses and optimises crop productivity. Foliar application of nutrients can boost photosynthetic efficiency by delaying the start of leaf senescence due to higher absorption efficiency. Foliar spray is much more beneficial than soil application which check losses through leaching and fixation etc. Bio-stimulants are substances or microorganisms which have positive impacts on plant growth, yield, chemical composition, biotic and abiotic stress tolerance. Plant bio-stimulants are capable of inducing an array of anatomical, biochemical, physiological and molecular plant responses such as increasing crop productivity, NUE and tolerance against abiotic stress. There is need to evaluate the performance of linseed under varying foliar fertilization treatments and present investigation addresses this issue. Therefore, an experiment was conducted to find out impact of foliar application of fertilizer and crop biostimulant on yield and yield attributes of linseed.

Materials and Methods

The experiment was conducted at Experimental Farm, Department of Agronomy, College of Agriculture, VNMKV, Parbhani**.** Geographically, Parbhani lies at $19^0$16'east north latitude and $76^0$47'east longitude and at 409 m altitudes above sea level. The climate of experimental site was semi-arid. The soil of experimental site was medium black and clayey in texture. The soil was low in available nitrogen (163 kg ha^{-1}), phosphorous (11 kg ha^{-1}) and medium in available potassium (452 kg ha^{-1}) with pH 7.8. The experiment was consisted of seven treatments *viz.*, T_1 - 2% KNO_3, T_2 - 2% DAP, T_3 - 2% urea, T_4 –0.2% seaweed extract, T_5 – 0.25% fulvic acid, T_6 – 0.2% amino acid and T_7 –control. Linseed variety LSL-93, with duration of 90-95 days was used in the trial. Experiment was set up in randomized block design with three replications and 21-unit plots. The gross and net dimensions of each plot were 5.4 m x 4.5 m and 4.5 m x 3.9 m, respectively. The recommended dose of nitrogen and phosphorous were applied through urea and single super phosphate. The sowing was done by dibbling of seed at the depth of 5 cm. The collected data on various parameters were statistically analyzed using the ''Analysis of variance method. (ANOVA)" (Panse and Sukhatme, 1967) [7].

Results and Discussion

Effect of foliar application of fertilizer and crop biostimulant on yield attributes of linseed.

The mean data on yield attributing characters of linseed *viz.*, number of capsules $plant^{-1}$, weight of seeds $plant^{-1}$(g) number of seeds $capsule^{-1}$, weight of capsule $plant^{-1}$ (g) and test weight (g) as influenced by various treatments are presented in Table 1. The yield attributes of linseed *viz.*, number of capsules $plant^{-1}$, weight of seeds $plant^{-1}$ (g) and weight of capsule $plant^{-1}$ (g) were significantly influenced by various treatments of foliar fertilization.

Number of capsules $plant^{-1}$

Foliar application of 2% urea (T_3) recorded significantly higher number of capsules $plant^{-1}$(68.10) which was found at par with foliar application of 0.2% amino acid (T_6). It was observed that foliar application of 0.2% seaweed extract (T_4), foliar application of 2% KNO_3 (T_1), foliar application of 2% DAP (T_2) and foliar application of 0.25% fulvic acid (T_5) found at par to each other. This might be occurs due to supply of required demand of photosynthates to developing capsule and hence sustains more number of capsules $plant^{-1}$. Foliar application of urea helped in quick absorption of nitrogen at the time of reproductive stage where nutrient demand at its peak. These results are agreement with the findings of Patel *et al.* (2022) [8], Banjara and Porte (2022) [1]. The lowest number of capsules $plant^{-1}$(50.90) was obtained by control treatment (T_7).

Weight of seeds $plant^{-1}$ (g)

Influence of foliar application of fertilizer and crop biostimulant (Table 1) revealed that foliar application of 2% urea (T_3) recorded highest weight of seeds $plant^{-1}$ (5.85 g) which was statistically at par with foliar application of 0.2% amino acid (T_6) and least weight of seeds $plant^{-1}$ (3.34 g) was recorded in control (T_7) treatment.

Weight of capsule $plant^{-1}$ (g)

The data on weight of capsule $plant^{-1}$ as influenced by foliar application of fertilizer and crop biostimulant indicated that all fertilizer and crop biostimulant significantly enhanced this trait as compared to control. Among foliar application of fertilizer and crop biostimulant treatments, foliar application of 2% urea (T_3) recorded significantly highest weight of capsule $plant^{-1}$(7.86 g) and which was at par with foliar application of 0.2% amino acid (T_6). While in control (T_7), least weight of capsule $plant^{-1}$(4.88 g) was noted. This might be occurs due to tendency of nitrogen in accelerating growth, photosynthetic activity and efficient translocation of photosynthates. These results are in accordance with the findings of Kirnapure *et al.* (2020) [4].

Number of seeds $capsule^{-1}$ and test weight (g)

No significant difference was observed with respect to number of seeds $capsule^{-1}$ and test weight (g) of linseed as influenced by different foliar spray of fertilizer and crop biostimulant (Table 1). The mean number of seeds $capsule^{-1}$ and test weight of linseed was 6.64 and 7.63 g respectively. The highest and lowest number of seeds $capsule^{-1}$ and test weight (g) was observed under the foliar application of 2% urea (T_3) and control (T_7) treatment, respectively.

Effect of foliar application of fertilizer and crop biostimulant on yield of linseed

The mean seed, straw and biological of linseed differed significantly due to different treatments of foliar application (Table 2). The highest seed yield (1098 kg ha^{-1}), straw yield (2196 kg ha^{-1}) and biological yield of linseed (3199 kg ha^{-1}) was recorded by foliar application of 2% urea (T_3) and which was statistically comparable with foliar application of 0.2% amino acid (T_6).

The foliar application of 2% urea (T_3) found superior over foliar application of 0.2% seaweed extract (T_4), foliar application of 2% KNO_3 (T_1), foliar application of 2% DAP (T_2) and foliar application of 0.25% fulvic acid (T_5). This might be occurs due to the increased production of dry matter and its efficient translocation to its economic parts ultimately reflected on final seed yield of linseed. The increase in straw yield of linseed might be due to foliar spray of nitrogen, which enhanced source-sink relationship and induced photo-assimilate translocation in the plant. These results are in compliance with the findings of Mahajan *et al.* (2016) [6], Patel *et al.* (2017) [9] and Limba *et al*. (2020) [5]. The data on harvest index of linseed was found to be non-significant but treatment (T_3) *i.e.*, foliar application of 2% urea (T_3) recorded maximum harvest index (33.28%). The lowest seed yield (572 kg ha^{-1}), straw yield (1300 kg ha^{-1}) and biological yield (1872 kg ha^{-1}) was recorded by control treatment (T_7).

Table 1: Yield attributes of linseed as influenced by different treatments

Trt. No.	Treatments	Number of capsules plant^{-1}	Wt. of capsule plant^{-1} (g)	Wt. of seed plant^{-1} (g)	No. of seeds capsule^{-1}	Test wt. (g)
T_1	2% KNO_3	57.93	6.34	4.86	6.80	7.69
T_2	2% DAP	54.53	6.12	4.80	6.56	7.28
T_3	2% Urea	68.10	7.86	5.85	7.41	8.40
T_4	0.2% Seaweed extract	58.00	7.06	5.14	6.88	7.80
T_5	0.25% Fulvic acid	53.63	5.47	3.82	6.24	7.28
T_6	0.2% Amino acid	66.23	7.34	5.59	7.32	8.21
T_7	Control	50.90	4.88	3.34	5.28	6.76
S.E.(m) ±		3.20	0.47	0.30	0.52	2.19
C.D. at 5%		9.88	1.45	0.93	NS	NS
General mean		58.47	6.43	4.77	6.64	7.63

Table 2: Mean seed yield, straw yield, biological yield (kg ha^{-1}) and harvest index of linseed as influenced by different treatments

Trt. No.	Treatments	Yield (kg ha^{-1})		Biological yield	Harvest index %
		Seed	Straw		
T_1	2% KNO_3	835	1767	2602	32.09
T_2	2% DAP	779	1758	2537	30.70
T_3	2% Urea	1098	2196	3199	33.28
T_4	0.2% Seaweed extract	886	1788	2674	33.13
T_5	0.25% Fulvic acid	615	1426	2041	30.13
T_6	0.2% Amino acid	988	1995	2983	33.12
T_7	Control	572	1300	1872	30.55
S.E. (m) ±		59.15	125.30	170.16	--
C.D. at 5%		182.27	386.09	524.27	--
General mean		827	1774	2558	31.85

Conclusion

Conclusively, foliar application of fertilizer and crop biostimulant was found to be superior for enhancing yield and yield attributes of linseed. Among the foliar nutrition treatments, foliar application of 2% urea recorded significantly higher yield and yield attributes *viz.*, number of capsules plant^{-1}, weight of seeds plant^{-1} (g) number of seeds capsule^{-1}, weight of capsule plant^{-1} (g) and test weight (g) and yield of linseed.

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