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Effect of Priming of Micronutrients on Growth and Yield of Linseed

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The field study took place in *rabi* season 2022 at the CRF, Naini Agricultural Institute, Sam Higgin bottom University of Agriculture, Technology, and Sciences, Prayagraj (U.P.). To ascertain the "Effect of Priming of Micronutrients on Growth and Yield of Linseed." The soil of experimental plot was sandy loamy in texture, nearly neutral in soil reaction (pH 7.8), low in organic carbon (0.35%). The experiment was laid out in Randomized Block Design with ten treatments which are replicated thrice. The treatment combinations are T_1: Iron Sulphate 2500 ppm + Ammonium Molybdenum 3000 ppm T_2: Iron Sulphate 2500 ppm + Ammonium Molybdenum 4000 ppm T_3: Iron Sulphate 2500 ppm + Ammonium Molybdenum 4500 ppm T_4: Iron Sulphate 3000 ppm + Ammonium Molybdenum 3000 ppm T_5: Iron Sulphate 3000 ppm + Ammonium Molybdenum 4000 ppm T_6: Iron Sulphate 3000 ppm + Ammonium Molybdenum 4500 ppm T_7: Iron Sulphate 3500 ppm + Ammonium Molybdenum 3000 ppm T_8: Iron Sulphate 3500 ppm + Ammonium Molybdenum 4000 ppm T_9: Iron Sulphate 3500 ppm + Ammonium Molybdenum 4500 ppm T_{10}: Control (N:P:K-60:40:30 Kg/ha) are used. Results obtained that the higher plant height (55.68 cm), plant dry weight (21.73 g/plant), number of branches (9.44), number of pods/plant (54.61), number of seeds/pod (7.92), test weight (8.57g), seed yield (10.23 q/ha) and stover yield (17.41 q/ha) were significantly influenced with application of

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Iron Sulphate 3500 ppm + Ammonium Molybdenum 4500 ppm. Higher gross return (1,07,800.00 INR/ha), net return (71,766.00 INR/ha) and B:C ratio (1.99) were also recorded in treatment-9 (Iron Sulphate 3500 ppm + Ammonium Molybdenum 4500 ppm).

Keywords: Linseed, micro-nutrients; iron sulphate; ammonium molybdenum; growth parameters; yield attributes; economics.

1. INTRODUCTION

Linseed (*Linum usitatissimum*) is a major *rabi* oilseed crop farmed in India for both seeds and fibers. It belongs to the liniaceae family. *Linum usitatissimum* is the only species that is extensively cultivated and commercially important. Every portion of the linseed plant is used economically, either directly or indirectly. Oil content ranges from 33% to 47% in the seed. About 20% of total oil produced is utilized at the farmer level, and the remaining 80% going to industries in different forms such as Apart from ALA, linseed is widely used as a nutritional and functional food in the Western world due to its high content of therapeutic health-promoting sustains such as omega-3 fatty acid, soluble and insoluble fibers, and lignin, as well as its suitability for use with bread, breakfast cereals, and other food products. Flax was authorized by the Flax Council of Canada in 2014 for a health claim to decrease blood cholesterol, a key risk factor for heart disease, by ingesting ground or whole flax seed. Boiled oil, borated oil, epoxidized oil, aluminated oil, urethane oil, isomerized oil, and so on. Linseed occupies an area of 32.23 lakh ha in the globe, yielding 30.68 lakh tonnes with an average productivity of 952 kg/ha, whereas it occupies an area of 1.7 lakh/ha in India, yielding 1 lakh tonnes and 574 kg/ha, respectively. It is grown on 0.18 million hectares in Uttar Pradesh, produces 0.12 million tonnes, and has a productivity of 671 kg/ha [1].

Iron (Fe) is recognized as a critical element for plant metabolism, life sustenance, and improved agronomic production. Iron deficiency in food crops is prevalent, resulting in production losses and a poor agronomic profile. A significant fraction of the iron content gets entangled with soil particles [2] and is therefore unavailable to plants [3]. In agricultural soils, iron is frequently present in its insoluble ionic form (Fe^{+3}). Aerobic soils with high pH, on the other hand, often lack the soluble form of iron (Fe^{+2}) [4]. Maswada et al. [5].The presence of oxide NPs enhances the water content of the leaves and hence the biomass output of the plant. Molybdenum (Mo) is essential for nitrogen metabolism in plants, particularly legumes. It is a cofactor for nitrogenase enzymes, which catalyzes the redox process that converts atmospheric nitrogen to ammonium [6]. It is also a member of the prosthetic group of nitrate reductase, a critical enzyme in plant nitrogen absorption. As a result, plant nitrogen metabolism, particularly for legumes, is tightly connected to the assimilable percentage of Mo in soil [7].

2. MATERIALSANDMETHODS

The experiment was carried out during *rabi*-2022, Agriculture Research Farm, Naini Agriculture Institute, Sam Higginbottom University of Agriculture Technology And Sciences, Prayagraj, Uttar Pradesh. It is located at 25.24' 42" N latitude, 81.50' 56" E longitude, and 98m above mean sea level (SL). The trial used Randomized Block Design, with 10 treatments replicated three times. Each treatment's plot size was 3m × 3m. Factors are three levels of Iron Sulphate (2500, 3000, 3500 ppm) and three levels of Ammonium Molybdenum (3000, 4000, 4500 ppm). The crop was planted on December-17, 2022, with a spacing of 30cm x 10cm. Harvesting was completed by taking 1m^2 of each plot. Five plants were chosen at random to record growth and yield characteristics. The treatment details are as follows, The treatment combinations are T_1: Iron Sulphate 2500 ppm + Ammonium Molybdenum 3000 ppm T_2: Iron Sulphate 2500 ppm + Ammonium Molybdenum 4000 ppm T_3: Iron Sulphate 2500 ppm + Ammonium Molybdenum 4500 ppm T_4: Iron Sulphate 3000 ppm + Ammonium Molybdenum 3000 ppm T_5: Iron Sulphate 3000 ppm + Ammonium Molybdenum 4000 ppm T_6: Iron Sulphate 3000 ppm + Ammonium Molybdenum 4500 ppm T_7: Iron Sulphate 3500 ppm + Ammonium Molybdenum 3000 ppm T_8: Iron Sulphate 3500 ppm + Ammonium Molybdenum 4000 ppm T_9: Iron Sulphate 3500 ppm + Ammonium Molybdenum 4500 ppm T_{10}: Control (RDF- 60:40:30 Kg/ha) was used. Plant height (cm), plant dry weight (g/plant), number of branches/plant, number of pods/plant, number of seeds/pod, test weight (g), seed yield (q/ha) and stover yield (q/ha) were all measured. The data were statistically analyzed using the analysis of variance approach [8].

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

Plant height: The significantly higher plant height (55.68 cm) was recorded in treatment-9 with the application of Iron Sulphate 3500 ppm and Ammonium Molybdenum 4500 ppm. However, treatment-8 Iron Sulphate 3500 ppm and Ammonium Molybdenum 4000 ppm was statistically at par to treatment-9 in [Table 1].This may be due to availability of the molybdenum to the crop at suitable vegetative stage, which may have increased the nutrient uptake and chlorophyll content and resulted in increased plant height. Similar result was also observed by Mousa et al. [9] and Singh et al. [10]. And also, increased in plant height due to application of Iron Sulphate which helps in increase in cell division, cell differentiation, meristematic activity, rapid expansion of cell and the formation of cellwall, increase in photosynthesis Dandoti et al. [11].

Number of branches: The significantly higher number of branches per plant (9.44) was recorded in treatment-9 with the application of Iron Sulphate 3500 ppm and Ammonium Molybdenum 4500 ppm. However, treatment-8 Iron Sulphate 3500 ppm and Ammonium Molybdenum 4000 ppm was statistically at par with treatment-9 in Table 1. This may be attributable to the administration of iron sulphate and ammonium molybdenum during the vegetative stage, which boosted nutrient intake and chlorophyll content and led to the formation of more branches/plants and, eventually, more branches Elayaraja [12] also observed linseed-related outcomes with a similar pattern.

Dry weight: The significantly higher dry weight (21.73 g/plant) was recorded in treatment 9 with the application of Iron Sulphate 3500 ppmand Ammonium Molybdenum 4500 ppm. However, treatment-8 Iron Sulphate 3500 ppmand Ammonium Molybdenum 4000 ppm was statistically at par with treatment-9 in [Table 1]. This may occur as a result of the administration of iron sulphate, which are essential to plants and enhance leaf area index, which increases light absorption and increases the accumulation of dry matter Dandoti et al. [11].

Crop growth rate: The significantly higher crop growth rate (13.8 $g/m^2/day$) was recorded in treatment 7with the application of Iron Sulphate 3500 ppm and Ammonium Molybdenum 3000 ppm. However, treatment-6 Iron Sulphate 3000 ppm and Ammonium Molybdenum 4500 ppm was statistically at par with treatment-7 [Table 1].The significantly higher crop growth rate was recorded with the application of ammonium molybdenum and iron sulphate. This might be due to prolonged vegetative phase of crop under higher supply of these micro nutrients. These results show close conformity with the results of Katore et al. [13].

3.2 Yield Attributes

Number of pods/plant: The significantly higher number of pods/plant (54.61) was recorded in treatment-9 with the application of Iron Sulphate 3500 ppm and Ammonium Molybdenum 4500 ppm. However, treatment-8 Iron Sulphate 3500 ppmand Ammonium Molybdenum 4000 ppm was statistically at par with treatment-9 in [Table 2]. Linseed plants at the harvest stage produced more pods per plant owing to nutrient priming with Mo and Fe. Linseed growth and yield have been positively impacted by priming with the correct amount of fertilizer and adding micronutrients. Ugile et al. [14] achieved comparable outcomes.

Number of Seeds/pod: The significantly higher number of seeds/pod (7.92) was recorded in treatment-9 with the application of Iron Sulphate 3500 ppm and Ammonium Molybdenum 4500 ppm. However, treatment-8 Iron Sulphate 3500 ppmand Ammonium Molybdenum 4000 ppm was statistically at par with treatment-9 in [Table 2]. It may be due to Fe's critical role in chlorophyll synthesis that stimulates plant structure and improves the functions of chloroplast. Further more, it improves microbial and enzymatic activities that might be reason behind these similar results were reported by Rout and Sahoo, [15].

Test weight (g): The significantly higher test weight (8.57 g) was recorded in treatment-9 with the application of Iron Sulphate 3500 ppm and Ammonium Molybdenum 4500 ppm. However, treatment-8 Iron Sulphate 3500 ppm and Ammonium Molybdenum 4000 ppm was statistically at par with treatment-9 in [Table 2]. This was caused by an increase in seed weight, which may have been brought on by a greater mobilization of photosynthesis by the introduction of micronutrients to the growing seeds. Similar findings that seed priming enhanced thousand grain weights in chickpea were reported by Arif et al. [16].

Table 1. Effect of priming of micronutrients on growth parameters of linseed

S. No.	Treatments	Plant height (cm)	No. of Branches/ plant	Plant Dry weight(g/plant)	Crop Growth Rate (g/m^2day)
1.	Iron Sulphate 2500 ppm +Ammonium Molybdenum 3000 ppm	48.65	6.35	16.31	10.5
2.	Iron Sulphate 2500 ppm +Ammonium Molybdenum 4000 ppm	49.77	6.25	16.45	10.0
3.	Iron Sulphate 2500 ppm +Ammonium Molybdenum 4500 ppm	50.66	6.83	17.14	10.7
4.	Iron Sulphate 3000 ppm +Ammonium Molybdenum 3000 ppm	52.57	6.88	17.47	11.8
5.	Iron Sulphate 3000 ppm +Ammonium Molybdenum 4000 ppm	52.85	7.44	18.56	12.0
6.	Iron Sulphate 3000 ppm +Ammonium Molybdenum 4500 ppm	54.10	7.65	19.29	13.0
7.	Iron Sulphate 3500 ppm +Ammonium Molybdenum 3000 ppm	54.89	8.61	19.14	13.8
8.	Iron Sulphate 3500 ppm +Ammonium Molybdenum 4000 ppm	55.43	8.54	20.11	12.6
9.	Iron Sulphate 3500 ppm +Ammonium Molybdenum 4500 ppm	55.68	9.44	21.73	12.5
10.	Control (R:D:F-60:40:30kg/ha)	49.41	6.52	16.56	11.0
	F test	S	S	S	S
	S Em(±)	0.29	0.36	0.23	0.39
	CD (P=0.05)	0.86	1.09	0.68	1.14

Table 2. Effect of priming of micronutrients on yield and yield attributes of Linseed

S. No.	Treatments	No. of. pods/plant	Seeds/pod	Test weight (g)	Seed yield (q/ha)	Stover yield (q/ha)	Harvest index (%)
1.	Iron Sulphate 2500 ppm +Ammonium Molybdenum 3000 ppm	40.23	5.75	7.08	5.27	12.84	29.08
2.	Iron Sulphate 2500 ppm +Ammonium Molybdenum 4000 ppm	43.55	5.55	7.15	5.62	13.28	29.73
3.	Iron Sulphate 2500 ppm +Ammonium Molybdenum 4500 ppm	45.87	6.17	7.19	6.08	13.65	30.82
4.	Iron Sulphate 3000 ppm +Ammonium Molybdenum 3000 ppm	45.27	6.38	7.45	6.47	14.07	31.50
5.	Iron Sulphate 3000 ppm +Ammonium Molybdenum 4000 ppm	47.17	6.27	7.81	6.99	14.68	32.30
6.	Iron Sulphate 3000 ppm +Ammonium Molybdenum 4500 ppm	48.20	6.49	7.99	7.63	15.66	32.74
7.	Iron Sulphate 3500 ppm +Ammonium Molybdenum 3000 ppm	51.31	6.78	8.10	8.69	16.37	34.69
8.	Iron Sulphate 3500 ppm +Ammonium Molybdenum 4000 ppm	52.89	7.31	8.31	9.37	16.78	35.83
9.	Iron Sulphate 3500 ppm +Ammonium Molybdenum 4500 ppm	54.61	7.92	8.57	10.26	17.41	37.08
10.	Control (R:D:F-60:40:30kg/ha)	41.40	5.78	6.97	4.85	12.76	27.56
	Ftest	S	S	S	S	S	S
	SEm(±)	0.73	0.25	0.18	0.15	0.24	0.61
	CD(P=0.05)	2.18	0.75	0.53	0.44	0.72	1.81

Table 3. Effect of priming of micronutrients on economic analysis of Linseed

S. No.	Treatments	Cost of cultivation (INR/ha)	Gross returns (INR/ha)	Net returns (INR/ha)	B:C ratio
1.	Iron Sulphate 2500 ppm +Ammonium Molybdenum 3000 ppm	35,034.00	54,985.00	19,951.00	0.57
2.	Iron Sulphate 2500 ppm +Ammonium Molybdenum 4000 ppm	35,434.00	58,800.00	23,366.00	0.66
3.	Iron Sulphate 2500 ppm +Ammonium Molybdenum 4500 ppm	35,634.00	63,875.00	28,241.00	0.79
4.	Iron Sulphate 3000 ppm +Ammonium Molybdenum 3000 ppm	35,234.00	67,970.00	32,736.00	0.93
5.	Iron Sulphate 3000 ppm +Ammonium Molybdenum 4000 ppm	35,634.00	73,430.00	37,796.00	1.06
6.	Iron Sulphate 3000 ppm +Ammonium Molybdenum 4500 ppm	35,834.00	80,080.00	44,246.00	1.23
7.	Iron Sulphate 3500 ppm +Ammonium Molybdenum 3000 ppm	35,434.00	91,280.00	55,846.00	1.58
8.	Iron Sulphate 3500 ppm +Ammonium Molybdenum 4000 ppm	35,834.00	98,350.00	62,516.00	1.74
9.	Iron Sulphate 3500 ppm +Ammonium Molybdenum 4500 ppm	36,034.00	1,07,800.00	71,766.00	1.99
10.	Control (R:D:F-60:40:30kg/ha)	31,534.00	50,918.00	19,384.00	0.61

Seedyield (q/ha): The significantly higherseed yield (10.26 q/ha) was recorded in treatment-9 with the application of Iron Sulphate 3500 ppmand Ammonium Molybdenum 4500 ppm. However, treatment-8 Iron Sulphate 3500 ppmand Ammonium Molybdenum 4000 ppm was statistically at par with treatment-9 in Table 2. This might be as a result of the synergistic effects of micronutrients like iron and molybdenum, which when combined, yielded the highest seed yield when compared to all other treatments. Which are the metallic parts of a single or many enzymes engaged in a variety of physiological processes, including growth, development, and agricultural yield. Additionally, these outcomes are consistent with Pawel [17].

Stover yield (q/ha): The significantly higher stover yield (17.41 q/ha) was recorded in treatment-9 with the application of Iron Sulphate 3500 ppmand Ammonium Molybdenum 4500 ppm. However, treatment-8 Iron Sulphate 3500 ppmand Ammonium Molybdenum 4000 ppm was statistically at par with treatment-9 in Table 2. Higher nutrient content in seed and stover, together with higher oil content and its output, may have contributed to the increase in nutrient uptake under foliar application [18]. The findings from Maharnor et al. [19].

3.3 Economic Analysis

Observations regarding economics of different treatments of Linseed are given in Table 3.

Gross Return (INR/ha): Higher gross return (1,07,800.00 INR/ha) was obtained with the application of Iron Sulphate 3500 ppm and Ammonium Molybdenum 4500 ppm as compared to other treatments [20].

Net returns (INR/ha): Net return (71,766.00 INR/ha) was found to be higher with the application of Iron Sulphate 3500 ppm and Ammonium Molybdenum 4500 ppm as compared to other treatments.

Benefit cost ratio (B:C): Benefit Cost ratio (1.99) was found to be higher with the application of Iron Sulphate 3500 ppm and Ammonium Molybdenum 4500 ppm as compared to other treatments.

4. CONCLUSION

It is concluded that with the application of Iron Sulphate 3500 ppm + Ammonium Molybdenum 4500 ppm, has performed positively and improved growth and yield parameters and benefit cost ratio which may be more beneficial for farmers.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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