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Effectiveness of Water-soluble Fertilizers Sprays on Productivity and Profitability of *Utera* Linseed (*Linum usitatissimum*) in Assam

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ABSTRACT

Background: Linseed or flax is popularly called "*Tissi*" in Assam. The crop is considered as an oilseed crop in the state where some parts people used the raw seeds in their various cuisines. The crop has tremendously grown for a variety of purposes; food, fibre and medicine worldwide. The area under linseed has been decreasing day by day due to its low productivity. Enhancement of the crop yield can be achieved either by increasing the cropping area under this crop or by using improved agronomic intervention. Basically, the present investigation was designed to increase the crop yield by means of application of water-soluble fertilizers.

Methods: During the *rabi* season of 2022-23 and 2023-24 at the Experimental Farm Unit, Zonal Research Station, Shillongani, Nagaon, Assam, an experiment was conducted to enhance the yield potentiality of *utera* linseed. The experiment was laid out in Randomized Block Design with three replications and comprised of eight treatment combinations of water- soluble fertilizers, viz., F_1: 19:19:19 @ 1.0%, F_2: 13:0:45 @1.0%, F_3: Urea @2%, F_4: $ZnSO_4$ @0.5%, F_5: 19:19:19 @1.0% + $ZnSO_4$ @0.5%, F_6: 13:0:45 @1.0% + $ZnSO_4$@0.5%, F_7: Urea 2% + $ZnSO_4$@0.5% and F_8: Control (Water spray).

Result: Consecutive two years of Experimentation revealed that foliar spraying of 2% urea and 0.5% zinc sulphate separately one at vegetative stage and another at capsule development stage significantly improved the *utera* linseed productivity and profitability, yielding higher grain yield (520.5 kg/ha) and net returns (Rs. 20230/ha). Crop growth rate and relative growth rate were shown significant variation. The study affirmed the suitability of foliage application of water-soluble fertilizers for obtaining higher grain yield of linseed under utera ecology.

Key words: Crop growth rate, Harvest index, Relative growth rate, *Utera*, Zinc sulphate.

INTRODUCTION

Linseed (*Linum usitatissimum*) has a greater importance among oilseeds; owing to its various uses and special qualities. In India, it is grown mainly for seeds, used for extracting oil. It is a source of complete protein, high order linolenic acid (an essential polyunsaturated omega-3 fatty acid), complex carbohydrates, vitamins, minerals and lignans (Chopra, 2016) and becoming increasingly popular as a nutritional and functional food especially for vegetarians. In India, Linseed occupies second position after Rapeseed and Mustard in terms of area and production among the rabi oilseed crops. It grown on 2.98 lakh hectare with a production of 1.32 lakh tonnes culminating productivity of 591 kg/ha during 2019-20 (Annual Report, 2019). Major linseed producing states of India are M.P, Karnataka, Chhattisgarh, Jharkhand, Bihar, Maharashtra, Odisha, Uttar Pradesh, W.B and Assam. In Assam, linseed grown on 4900 ha and production of 5323 mt and the productivity was 615 kg/ha (Directorate of Economics and Statistics, 2021).

Linseed is an important rabi oilseed crop predominantly grown under three ecology namely rainfed, irrigated and utera condition. In Assam, 18 lakh hectares of area occupied

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by sali/winter rice. During *rabi* season approximately 8-10 lakh hectares remain fallow through out the season after winter paddy. Which can be utilized by cultivating *rabi* crops under Relay/Utera condition (Directorate of Economics and Statistics, 2021).

Relay/Utera cultivation is a system of cropping in paddy fields, which is done by broadcasting seeds of linseed in standing paddy crops at dough stage. It is a traditional practice of rainfed cultivation. Growing of linseed in Utera system is the most common practice of regions like Bihar, Jharkhand, Orissa, Maharashtra, M.P. Eastern part of Uttar Pradesh, Himachal Pradesh and Assam. Linseed can be grown very well in rice fallows and productivity can be increased by adoption of improved practices such as, proper cutting height of rice stubbles and tillage practice as well as application of fertilizers are considered important for linseed cultivation in rice fallows (Saud *et al.,* 2018).

Due to increasing demand of the crop, there is a direct need to increase seed yield potential of the crop. The national average productivity of the crop is very low as compared to that of world average. Low productivity of linseed in India can be ascribed by many reasons but inadequate and imbalanced fertilization are the major factor. Balanced fertilization by the application of chemical fertilizer along with foliar application of water-soluble fertilizers are of great importance to enhance the productivity of linseed. Nitrogen, phosphorus and potassium are all important nutrients in increasing the quality of linseed. Nitrogen is known to activate most metabolic activities and energy transformations. Phosphorus is required for cell division and tissue meristematic growth. It also aids in the development of seeds and fruits, as well as the stimulation of flowering. Zinc plays 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, which in turn increases the crop growth and yield. Among agro-techniques, judicious application of nutrients, particularly nitrogen, phosphorus and potash, is crucial for increasing linseed productivity (Singh *et al.,* 2013). Fertilizer application is considered necessary for increasing crop production. Long-term studies conducted in several locations across India revealed that applying all necessary nutrients through chemical fertilizers has a negative impact on soil health, resulting in unsustainable yields (Jaga and Upadhyay, 2013). It is necessary to increase flaxseed productivity per unit area, which can be accomplished by using high yielding cultivars and improving cultural practices such as balanced fertilization, foliar spray of urea and micronutrient zinc. Foliar application of urea as a supplement to soil applied nitrogen is critical for lowering costs and pollution. It also increases flax productivity.

Besides of soil applied chemical fertilizers, foliar application response of different nutrient is very essential in case of utera cropping, hence testing of foliar response has been taken under the investigation.

MATERIALS AND METHODS

The experiment was conducted during two consecutive rabi season of 2022-23 and 2023-24 at Research Farm, Zonal Research Station, Shillongani, Assam, which is situated at an altitude of 50.2 meters above mean sea level, with longitude 90°45′E and latitude of 26°21′N with an average annual rainfall of 2500 mm. The maximum and minimum temperatures recorded during 2022-23 28.4°C to 8.4°C and total rainfall received was 58 mm and during 2023-24 maximum and minimum temperatures recorded were 28.8°C and 8.7°C and average rainfall received was 67 mm during the crop growing season (Fig 1).

The soil of the experimental area was sandy loam in nature with pH of 5.3 (Glass electrode digital pH meter, Jackson, 1973), available nitrogen was 259.6 kg/ha (Alkaline permanganate method, Subbaiah and Asija, 1956),

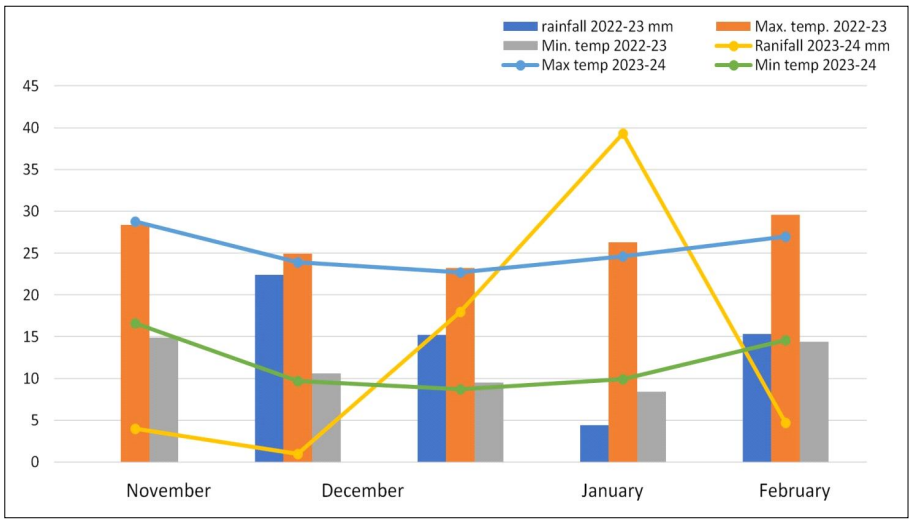


Fig 1: Monthly weather parameters of two consecutive crop season.

available phosphorous was 21.4 kg/ha (Olsen's colorimetric method, Jackson, 1973), available potash was 133.1 kg/ha (Flame photometer method Jackson, 1973) and organic matter was 0.88% (Walkley and black rapid titration method Jackson, 1973). The experiment was laid out in randomized block design with three replications and comprised of eight different treatment combinations of water-soluble fertilizers, *viz*., F_1: 19:19:19 @ 1.0%, F_2: 13:0:45 @1.0%, F_3: Urea @2%, F_4: $ZnSO_4$ @0.5%, F_5: 19:19:19 @1.0% + $ZnSO_4$ @0.5%, F_6: 13:0:45 @1.0% + $ZnSO_4$@0.5%, F_7: Urea 2% + $ZnSO_4$@0.5% and F_8: Control (Water spray).

Linseed variety Shekhar was sown on 10th November'22 and harvested on 26th March'23 during *Rabi*, 2022-23. Second year sowing was done on 12th Novemeber'23 and harvested on 2nd April'24. Seeds were sown by broadcasting method using seed rate of 30 kg/ha. Intercultural operations like one hand weeding was given at 25 DAS. As the crop was grown in rainfed utera condition no supplementary irrigation was provided. Various concentrations of soluble fertilizers were prepared with distilled water and applied foliarly at vegetative and capsule development stages. Control plants were given water spray. Observations of growth and yield attributes were recorded at periodic intervals from five randomly selected plants from each treatment demarcated with proper tagging and the mature crop were harvested when the crop attains physiological maturity. All the recorded data were analysed using method of analysis of variance as described by Gomez and Gomez, (1984).

RESULTS AND DISCUSSION

Growth parameters

The foliar application of urea and zinc sulphate treatments shows positive affect on the plant height, fruiting branches, plant population, capsule number, seed per capsule, 1000 -seed weight and seed yield. Plant height is the ultimate structure of a typical mature individual can attain in their life cycle. Foliar application of water-soluble fertilizers make a significant difference in the present investigation. Treatment receiving foliar spraying of 2% Urea and 0.5% zinc sulphate separately one at vegetative stage and another at capsule development stage recorded maximum plant height at maturity during both the years as well as in pooled analysis (55 cm, 47 cm, 51 cm) respectively (Table 1). In case of plant population and number of primary fruiting branches per plant, there were no significant variation shown however, the maximum was recorded in foliar spraying of 2% Urea and 0.5% zinc sulphate during both the years as well as in pooled analysis. The maximum number of capsules per plant differs significantly among the treatments in both the years and found highest under treatment receiving foliar spraying of 2% Urea and 0.5% zinc sulphate separately which however found statistically at par with two spray of 1.0% NPK 19:19:19 + 0.5% $ZnSO_4$ and two spray of NPK 19:19:19 @ 1.0% (Table 1). However, the maximum seed per capsule of linseed was found statistically maximum with treatment receiving foliar spraying of 2% Urea and

Table 1: Effect of water-soluble fertilizers on growth characters of *Utera* linseed.

Treatment	Plant height (cm)			Primary branches/plant			No. of capsules/Plant			Plant population'000/ha			No. of seed/Capsule		
	2022-23	2023-2024	Pooled	2022-23	2023-2024	Pooled	2022-23	2023-2024	Pooled	2022-23	2023-2024	Pooled	2022-23	2023-2024	Pooled
F_1: 19:19:19 @ 1.0%	48.6	45	46.8	2.00	1.73	1.9	39.8	40.8	40.3	517	453	485.0	8.20	8.93	8.6
F_2: 13:0:45 @1.0%	44.9	44	44.5	1.83	1.80	1.82	29.5	30.5	30.0	471	434	452.5	8.33	8.80	8.6
F_3: Urea @2%	44.7	47	45.9	1.93	1.9	1.92	39.1	40.1	39.6	481	470	475.5	8.33	8.93	8.6
F_4: $ZnSO_4$ @0.5%	43.1	46	44.6	1.93	1.80	1.9	32.5	30.5	31.5	478	433	455.5	8.13	9.07	8.6
F_5: 19:19:19 @1.0% + $ZnSO_4$ @0.5%	44.1	50	47.05	2.00	2.07	2.03	40.4	41.4	40.9	498	491	494.5	8.53	9.00	8.8
F_6: 13:0:45 @1.0% + $ZnSO_4$@0.5%	42.1	48	45.05	2.07	1.80	1.9	38.4	36.8	37.6	391	510	450.5	8.07	9.07	8.6
F_7: Urea 2% + $ZnSO_4$ @0.5%	55.0	47	51.0	1.80	2.33	2.1	43.5	44.5	44	522	488	505.0	8.33	9.20	8.8
F_8: Control (Water spray)	41.9	40.3	41.1	1.83	1.73	1.78	26.3	27.3	26.8	433	452	442.5	7.73	9.2	8.5
SEm+	1.91	1.59	1.75	0.13	0.20	0.16	1.86	2.56	2.21	28.1	30.89	29.5	0.20	0.14	0.17
CD 5%	5.78	NS	5.36	NS	NS	NS	4.46	4.76	4.63	NS	NS	NS	0.73	0.71	0.72
CV%	7.21	5.89	6.6	11.52	19.30	15.4	11.38	12.48	11.93	9.30	11.53	10.41	4.27	6.68	5.47

0.5% zinc sulphate separately. Kikon *et al*. (2024) reported that linseed growth responded significantly to nitrogen fertilization, which enhanced plant height as well as other growth parameters. This may be due to the foliar sprays reduced nutrient leaching losses and improved nutrient use efficiency. Also, nitrogen and zinc plays important role in photosynthesis, chlorophyll production, pollen function and fertilization hence, more number of capsules per plant was observed, similar result was revealed by Chopra and Badiyala (2016) and Kumar *et al*. (2023) the foliar application of nitrogen and zinc sulphate enhances seed and seed size development.

There are no significant variations were observed in harvest index of linseed among the treatments. The crop growth rate (CGR) (4.91, 4.7,4.3 g $day^{-1}m^{-2}$) at 60-90 DAS was found statistically maximum with the treatment of foliar spray of 2% Urea and 0.5% zinc sulphate separately which was statistically at par with two spray of 1.0% NPK 19:19:19 + 0.5% $ZnSO_4$ and two spray of NPK 19:19:19 @ 1.0% during both the years and pooled analysis and relative growth rate (RGR) of linseed (17.1 g g^{-1} day^{-1}) at 60-90 DAS was found maximum with the treatment of foliar spray of 2% Urea and 0.5% zinc sulphate separately which was statistically at par with two spray of 1.0% NPK 19:19:19 + 0.5% $ZnSO_4$ and two spray of NPK 19:19:19 @ 1.0% during both the years and pooled analysis. CGR and RGR increased might be due to increase in primary branches, secondary branches, dry matter, leaf area and harvest index, which makes better use of light, water and nutrients, as well as increased in vegetative growth produced more photosynthesis and more carbohydrate produced. Similar finding was observed by Kumar *et al.* (2023) and Sarkar and Saha (2005) (Fig 2).

Productivity and profitability

A notably greater yield of linseed (520 kg/ha) was obtained in treatment of foliar spraying of 2% Urea and 0.5% zinc sulphate separately which however found statistically at par with two spray of 1.0% NPK 19:19:19 + 0.5% $ZnSO_4$ (503 kg/ha) and two spray of NPK 19:19:19 @ 1.0% (490 kg/ha), based on two years of pooled results. Similar findings were reported by Kumar *et al.* (2023). The increase in seed yield of linseed after foliar spray of nitrogen, phosphorous, potassium and zinc sulphate might be due to these elements helps in cell division, cell enlargement and synthesis of protein. Zinc also regulates the membrane function and provides resistance to environmental stress in crop plants Moreover, the role of zinc in biomass production is also very important. Zinc plays important role in increasing plant height, number of capsule and branches and seed yield. Therefore, the increases in plant height, may increase the length of fruiting zone which may be because of zinc, which play a role in the biosynthesis of the protein and oil, cell membrane integrity and in plant metabolism (Tahir *et al.* 2014). Application of urea and zinc enhances the lateral shoots, which helps for more capsules. Moreover, zinc maximizes the biosynthesis of growth hormone, starch formation and maturation, so, it ultimately increased the seed weight. Whereas the test weight of linseed (4.92 g) was found statistically maximum with the treatment foliar spraying of 2% Urea and 0.5% zinc sulphate separately which was statistically at par with all the treatments except control. This variation of test weight among treatments might be due to the foliar application of water-soluble fertilizers directly absorb by plant as a result bolder size seed was produce. Similar findings were reported by Sune *et al*. (2006) and Rana *et al*. (2000), the foliar application of zinc on flax increased the test weight. The increase in test weight might be due to zinc that has high phloem mobility from leaves to roots, stem and developing grains (Table 2).

The statistically maximum gross return (Rs. 31230/ha) was observed with the treatment of foliar spraying of 2% Urea and 0.5% zinc sulphate, which was followed by the treatment two spray of 1.0% NPK 19:19:19 + 0.5% $ZnSO_4$

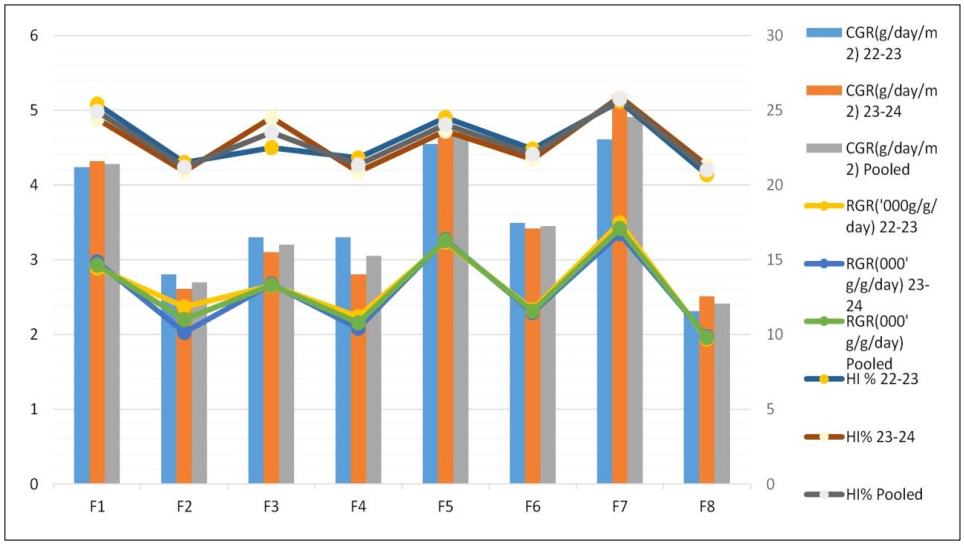


Fig 2: Crop growth rate, relative growth rate and harvest index of linseed affected by water soluble fertilizers.

Table 2: Effect of water-soluble fertilizers on yield and economics of *Utera* linseed.

Treatment	Test weight (g)			Seed yield (kg/ha)			GMR (Rs/ha)			NMR (Rs/ha)			B:C		
	2022-23	2023-2024	Pooled	2022-23	2023-2024	Pooled	2022-23	2023-2024	Pooled	2022-23	2023-2024	Pooled	2022-23	2023-2024	Pooled
F_1: 19:19:19 @ 1.0%	4.12	4.32	4.22	484	496	490.0	29040	29760	29400	18240	18960	18600	1.7	1.8	1.75
F_2: 13:0:45 @1.0%	4.19	4.49	4.34	389	375	382.0	23340	22500	22920	12690	11850	12270	1.2	1.1	1.15
F_3: Urea @2%	4.23	4.33	4.28	481	491	486.0	28860	29460	29160	19660	20260	19960	2.1	2.2	2.15
F_4: $ZnSO_4$ @0.5%	4.47	4.57	4.52	463	474	468.5	27780	28440	28110	17380	18040	17710	1.7	1.7	1.7
F_5: 19:19:19 @1.0% + $ZnSO_4$ @0.5%	4.65	4.90	4.78	491	515	503.0	29460	30900	30180	17760	19200	18480	1.5	1.6	1.55
F_6: 13:0:45 @1.0% + $ZnSO_4$@0.5%	4.25	4.45	4.35	474	481	477.5	28440	28860	28650	16140	16560	16350	1.3	1.3	1.3
F_7: Urea 2% + $ZnSO_4$@0.5%	4.85	4.98	4.92	497	544	520.5	29820	32640	31230	18820	21640	20230	1.7	2.0	1.85
F_8: Control (Water spray)	4.08	4.28	4.18	379	357	368.0	22740	21420	22080	15140	13820	14480	1.9	1.8	1.85
SEm+	0.23	0.18	0.21	14.55	12.53	13.53	1030	1148	1089	703	780	741.5	0.086	0.12	0.1
CD5%	0.74	0.66	0.7	41.15	39.24	40.19	2916	3477	3196.5	2119	2430	2274.5	0.26	0.36	0.31
CV%	8.98	7.18	8.19	6.96	10.19	8.9	18.47	21.20	19.84	17.6	18.4	18.0	7.13	5.69	6.41

and two spray of NPK 19:19:19 @ 1.0%. The lowest gross return of Rs. 22080/ha was observed in the control. Maximum net return (Rs. 20230/ha) was recorded under the treatment of foliar spraying of 2% Urea and 0.5% zinc sulphate, which was followed by the treatment foliar spray of Urea 2%. The lowest net return of Rs. 12270/ha and Rs. 14480/ha were recorded under the treatment NPK 13:0:45 @1.0% and in control (Table 2). Whereas the statistically maximum B:C ratio (2.15) was observed with the treatment NPK 13:0:45 @1.0%, which was statistically at par with the treatments foliar spraying of 2% Urea and 0.5% zinc sulphate and control. 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 (2018) and Kumar *et al*. (2017).

CONCLUSION

The experimental results positively showed that linseed crop when cultivated as relay/utera with paddy responded well to foliar application of water-soluble nutrients and increases the seed yield. Hence, exogenous application of urea @ 2% and zinc sulphate @ 0.5% at vegetative stage (45 DAS) and capsule development stage (75 DAS) is the most suitable and beneficial to increase the production potential of linseed grown as relay crop with rice under the agro-ecological conditions of Assam.

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Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Informed consent

Yes.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

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