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EFFECT OF SOIL APPLICATION AND FOLIAR APPLICATION OF NUTRIENTS ON GROWTH AND YIELD OF LINSEED IN SOYBEAN–LINSEED CROPPING SEQUENCE

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ABSTRACT

A field experiment was carried out in the *Rabi* season of 2022-2023. The experiment aims to improve linseed production by optimizing fertilizer management strategies and determining effective nutrient application methods. It examines the impact of different fertilizer dose levels and foliar nutrient application on growth, physiological characteristics and productivity features of linseed ensuring environmental sustainability. Additionally, the findings provide important information about how farmers can modify their fertilization methods according to regional circumstances. The experiment was carried out in split plot design, the experiment was conducted with three levels of fertilizer applied to the soil in the main plots: 0% RDF (S_1), 50% RDF (S_2), and 100% RDF (S_3) and six distinct nutrients were applied as foliar application to the subplots at pre-flowering and capsule development stage i.e., F_1 water spray; F_2: 0.5% nano-urea; F_3: 2% urea; F_4: 2% DAP; F_5: 2% NPK (18:18:18); and F_6: 2% seaweed sap and it was replicated thrice. The study found that soil application of 100% RDF and nutrient management with two foliar sprays of 2% NPK (18:18:18) at the pre-flowering and capsule developmental stages significantly improved growth characteristics like plant height and dry matter accumulation, physiological traits like crop growth rate and yield attributes like primary branches, capsules per plant, seeds per capsule, and 1000-seed weight, and. Moreover, improvement in production and productivity as indicated by harvest index, grain yield, and straw yield. The interaction between the levels of fertilizers as soil application and foliar application found to be non- significant for the above-mentioned characters.

Key words : Foliar application, Soil application, Linseed, Dry matter accumulation, NPK(18:18:18).

Introduction

India is the world's fifth-largest producer of linseed, accounting for about 3.18% of global production (NITI Aayog, 2024). Oilseeds play a significant role in India's agricultural economy. In Indian languages, flax seed (*Linum usitatissimum*), also called Alsi, Jawas, Aksebija and so on, blooms blue or white and produces tiny, flat seeds with a range of colors from reddish brown to golden yellow. It is the most significant oilseed crop in India, which ranks second in terms of area and production among the several oilseed crops cultivated in the nation, after rapeseed-mustard (*Rabi*) in the winter. Linseed is an essential crop for the production of fiber, oil and food products. In most linseed-producing states, it is mostly farmed under input-starved conditions under rainfed (63%), utera (25%) and irrigated (17%) environments under input-starved conditions Kumar (2024). Moreover, it is a medicinal plant that is high in dietary fiber (28%), protein (20%), oil (41%), moisture (7.7%), and ashes (3.3%). According to Kumar (2018), it contains a high proportion of important fatty acids, including 75% polyunsaturated fatty acids, 57% alphalinolenic acid, an omega-3 fatty acid, 16% linoleic acid and omega-6 fatty acid.

Foliar spray of nutrients is the fastest way to boost up crop growth because the nutrient application is uniform and readily available at the initial and critical stage of the plant, the crop responds to nutrient application immediately, thereby reduce the requirement of fertilizers (Zayed *et al.,* 2011). Enhancing plant inherent mechanisms, plant cell homeostasis, water relations, and production during abiotic stresses is better achieved by foliar spray rather than by soil application. To maximize crop productivity, Crop- and growth-specific foliar sprays are essential (Pasala *et al*., 2022). Applying fertilizer as a foliar spray produced effective absorption and is the cost-effective method of fertilization to produce high-quality produce and increased productivity, particularly when plant organs compete for carbohydrates and nutrient uptake from the soil is limited (Singh *et al*., 2018).

Compared to the global average, the average linseed productivity in the country is extremely low. However, the main cause is unbalanced and insufficient fertilization. Linseed productivity must be increased through balanced fertilization using chemical fertilizer along with foliar application of water-soluble fertilizers are essential for increasing crop production. Previous endeavors have been undertaken to investigate how fertilizer application in the soil affects the linseed vegetative and reproductive attributes. However, little information is available regarding the combined effects of fertilizer application in the soil and foliar nutrient spraying. Therefore, this study was conducted to evaluate the impact of varying fertilizer levels and foliar nutrient applications on growth, physiological characteristics, production and productivity features of linseed. Foliar spray of 2% DAP at flowering and capsule development recorded significantly higher seed and straw yield (Mamdi *et al*. 2023 and Dehury *et al*. (2024). Soil application of 100% nitrogen and supplemental nitrogen management with foliar application of two sprays of nano-urea @ 3 ml/lit at flowering stage and capsule developmental stage was found to record significantly highest seed and straw yield, BC ratio, plant height, dry matter accumulation and oil yield (Kumar, *et al*., 2023) two times foliar sprays of NPK 19:19:19 @ 1.0% + $ZnSO_4$ @ 0.5% at flowering and capsule development stage along with recommended dose of fertilizer (RDF) recorded highest seeds/capsule (7.98), test weight (5.56 g), seed yield (996.98 kg/ha).

Materials and Methods

A field experiment was conducted at Agronomical Research Farm of Birsa Agricultural University, Kanke, Ranchi (23°317'N, 85°19'E, 625 m above mean sea-level) during the *rabi* seasons of 2022-2023 under Ph.D. research program. This location receives 1397.7 mm of rainfall annually on average (average over 50 years), with almost 85% of that amount falling between June to September, the four monsoon months, the climate of site is sub-humid with hot summer and cold winter. The mean annual maximum and minimum temperatures are 26.5°C and 10.8°C, respectively. It received a total of 100.2 mm rainfall received during cropping period from Nov to March of 2022-23. Initial status of soil (0–15 cm) of experimental field was sandy loam in texture (60.84% sand, 22.77% silt and 16.39% clay), acidic in reaction (pH 5.56), low in available nitrogen (218.63 kg/ha) and medium in organic carbon (5.91g/kg), medium in available phosphorus (15.75 kg/ha) and in potassium (178.32 kg/ha). The experiment was laid out in a Split Plot design with 3 replications.

In the main plots three levels of fertilizer applied to the soil: 0% RDF (S_1), 50% RDF (S_2), and 100% RDF (S_3) and six distinct nutrients were applied as foliar application to the subplots at pre-flowering and pod commencement stage i.e., F_1 water spray; F_2: 0.5% nano urea; F_3: 2% urea; F_4: 2% DAP; F_5: 2% NPK (18:18:18); and F_6: 2% seaweed sap. Linseed variety "Priyam", suitable for rainfed conditions was seeded directly using 20 kg seed per ha in rows spaced at 30 cm on 21th November 2022 after basal application of fertilizer. Crop received recommended dose of fertilizer was 40:30:20:20 (N: P_2O_5: K_2O: S kg/ha) was applied through urea, di-ammonium phosphate muriate of potash and gypsum respectively and were applied uniformly to all the plots, all fertilizer were applied in a single dose i.e. basal application. The size of each plot was 5.4 m x 4.3 m. Intercultural operations were done as and when required. Crop was harvested at physiological maturity and plot-wise seed and straw yield in kg/m^2 was recorded. The biometric observation was taken from 5 randomly selected plants of each plot. The plant dry weight destructive sampling procedure was followed and three linseed plants were uprooted from 2nd row at either side of plots from ground level and were dried, first in sun and then in an oven at 65 ± 5°C till reached a constant weight. Dry weight obtained was converted into g/plant. Physiological characteristics, such as growth rate was documented as

Crop growth rate (CGR) is the increase in dry weight of a plant per unit time, expressed in gram per day per plant (g/day/plant) and was calculated by adopting the formulae as suggested by Watson (1952). It was determined in time interval between 90 DAS - maturity of linseed crop by using formula:

$$CGR\left(g/m^2/day\right)=\frac{W2-W1}{t2-t1}\times\frac{1}{A}$$

Where, W1 and W2 represent the dry weight of the plant at the beginning and end of the time interval t1 and t2, respectively and A is unit area occupied by plants (m^2)

Similarly, the yield –attributing characteristics of linseed, such as the harvest index, were determined using the given formula:

$$\text{Harvest Index (\%)} = \frac{\text{Economical yield (grain yield)}}{\text{Biological yield (grain + straw yield)}} \times 100$$

Harvest index (HI) was calculated as the per cent ratio of economic yield to biological yield using the formula suggested by Singh and Stoskopt (1971).

Statistical analysis

The data recorded for different characteristics were subjected to statistical analysis by adopting the method of analysis of variance (ANOVA) as described by Gomez and Gomez (1984). The significance of comparison was tested. The significant difference values were computed for a 5 percent probability of error. Wherever the variance ratio (F value) was found significant, critical difference (CD) values were computed for the comparison among the treatment means.

Results and Discussion

Plant height

As the crop developed, plant height grew gradually. According to data analysis, plant height increased with crop age, however this was particularly apparent at the harvest stage. The data found on plant height recorded and analyzed is presented in Table 1. Plant height was found significantly greater height with the application of S_3 -100% RDF (52.21 cm) which was significantly superior to of S_2- 75% RDF (45.94 cm). The plant height was found to be lowest with S_1- 0% RDF (35.75 cm) at maturity. It could be because the plants have access to a balanced and adequate supply of nutrients, which improves almost every growth characteristic when fertilizer is applied at a higher level. Similar result were also noticed by Devedee *et al*. (2019), Gaikwad *et al.* (2020). These results are in conformity with those reported by Meena *et al*. (2023). The interaction varying fertilizer levels and different foliar nutrient applications on plant height was also found non-significant.

Among in terms of different foliar application where the crop were treated at pre flowering and capsule formation stage showed significant effects on plant height, the two sprays of F5- 2% NPK (18:18:18) calculated significantly taller (48.36 cm) and had followed by F2- 0.5% Nano urea (47.68 cm) and application of F6- 2% seaweed sap (46.28 cm) and the minimum plant height was observed with the application of water spray (F1).The probable reason may be due to the use of complex fertilizer i.e. NPK 18:18:18 that contains equal percentages of nitrogen, phosphorus, and potassium and could readily absorbed by leaves. These nutrients play vital roles in various physiological processes of plant, from vegetative growth to reproductive activities. The equal proportion of nutrients in 18:18:18 NPK fertilizer makes it an ideal choice for promoting robust plant growth, flower formation, and bearing of flowers. Due to balanced application of NPK which enhanced cell division, cell multiplication and tissue differentiation, which may have increased the nutrient uptake and chlorophyll content. Which contribute overall growth and development of plants by reducing nutrient losses, enhancing nutrient use efficiency which ultimately increased plant height. Similar result was also reported by Mousa *et al*. (2010) and Singh *et al*. (2020).

Dry matter accumulation

The buildup of dry matter serves as a gauge for crop growth rate and biomass production. As the crop developed, the dry matter accumulation of linseed increased steadily and peaked at harvest (Table 1 and Fig. 1). Result reveled that higher level of fertilizer i.e. application of 100% RDF significantly influenced dry matter accumulation at 90 DAS and at harvest (11.90 and 14.21 g/plant, respectively) over 75% RDF. Lowest dry matter accumulation was found with 0% RDF (5.25 and 5.89 g/plant respectively). This might be owing to efficient utilization of nutrients which helped in better and vigorous vegetative growth. These results are in conformity with those reported by Meena *et al.* (2011). Higher fertility levels made nutrients more available and easier for plants to absorb, which led to more vegetative growth. This increased plant height because of increased cell division, enlargement, and elongation from improved photosynthesis, which improved the interception, absorption, and utilization of radiant energy and ultimately increased the accumulation of dry matter. This view is in cognizance with finding of Duhan (2013), Nataraja *et al.* (2021) and Sheoran *et al.* (2017). The increase in dry matter accumulation with incremental levels of RDF has also been reported by Dwivedi and Dwivedi (2005), Singh *et al*. (2013).

Similarly, with respect to different foliar application, 2% NPK (18:18:18) exerted significantly influence on the dry matter accumulation (9.91 and 11.78 g/plant,

Table 1 : Effect of soil application of different levels of fertilizer and foliar application of nutrients on growth and physiological characteristics of linseed in soybean linseed sequence during rabi season 2022- 2023.

A: Soil application of nutrients	Primary branches per plant	Capsule per plant (No.)	Seed per Capsule (No.)	1000 seed weight (g)	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest index (%)
S1: 0 % RDF	3.21	5.25	6.69	7.37	671	1352	33.07
S2: 50 % RDF	4.06	9.32	7.06	7.63	1231	2387	33.94
S3: 100 % RDF	4.99	11.90	7.34	7.87	1593	2925	35.25
SEm ±	0.12	0.14	0.20	0.16	26.7	55.3	0.56
CD (P=0.05)	0.42	0.49	NS	NS	96.99	201.22	NS
B: Foliar application of nutrients							
F1: Water spray	3.42	7.21	6.91	7.52	930	1849	33.28
F2: 0.5% Nano urea	4.50	9.79	7.10	7.73	1311	2431	34.63
F3: 2% Urea	3.97	8.42	6.98	7.55	1081	2116	33.39
F4: 2% DAP	3.95	8.31	6.95	7.53	1075	2110	33.34
F5: 2% NPK (18:18:18)	4.64	9.91	7.22	7.75	1374	2515	35.33
F6: 2% Seaweed sap	4.03	9.29	7.02	7.66	1218	2308	34.55
SEm ±	0.17	0.33	0.21	0.20	46.7	88.0	0.91
CD (P=0.05)	0.50	0.95	NS	NS	134.8	254.3	NS
CV (%)	12.62	11.20	9.10	7.85	12.02	11.89	8.03
Interaction (A x B)							
SEm ±	0.29	0.57	0.37	0.35	8.09	15.25	1.58
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS

respectively) at 90 and at harvest. Moreover 0.5% nano urea and 2% seaweed sap also caused significant improvement in dry matter production. While, the lowest dry matter accumulation was observed with treatment F1 i.e., water spray. Increased dry matter production is due to availability of these balanced proportion of macronutrients by the foliar fertilization to the crop at appropriate vegetative stage which resulted in better crop growth and photosynthetic activity which has led to better supply of photosynthates ultimately resulted in higher dry matter production per plant. These results are in conformity with the findings of Bhayal *et al.* (2022) and Parasuraman *et al*. (2008)

Crop growth rate

The crop growth rate (CGR) determines the exponential growth of any crop (Table 1). Linseed moves into its maturation phase after ninety days. As the plant dries out, the seeds develop inside the pods. Now that the plant's energy is being directed toward seed filling and ripening, the growth rate has substantially slowed. The plant will be almost ready for harvest after ninety days. During 90 DAS-at harvest, significant variation was observed regarding crop growth rate (CGR). Among soil applications of different levels of fertilizer; 100% RDF had a significant maximum CGR (5.10 $g/m^2/day$) and among foliar sprays, the significantly highest CGR (4.12 $g/m^2/day$) was attributed to the application of 2% NPK (19:19:19) over application of F1- water spray (2.86 $g/m^2/day$) irrespective of fertilizer sprays, estimation (Table 1). Applying the full RDF ensures that the crop receives an optimal supply of all essential nutrients. This leads to better root development, stronger vegetative growth, more efficient photosynthesis and enhanced accumulation of dry matter during growth period that finally increased the crop growth rate. These results corroborated with the findings of Arancon *et al.* (2006), Dass *et al*. (2022) and Vishwakarma (2023). Similarly, the significant increase in CGR due to combined NPK fertilizer nutrition through application of 2% NPK (18:18:18) might be owing to better availability of nutrients and effective conversion of macronutrients at the site of photosynthesis and have maximum photosynthate accumulation towards the dry matter accumulation through continued photosynthesis, led to significant improvement in CGR .Similar result was

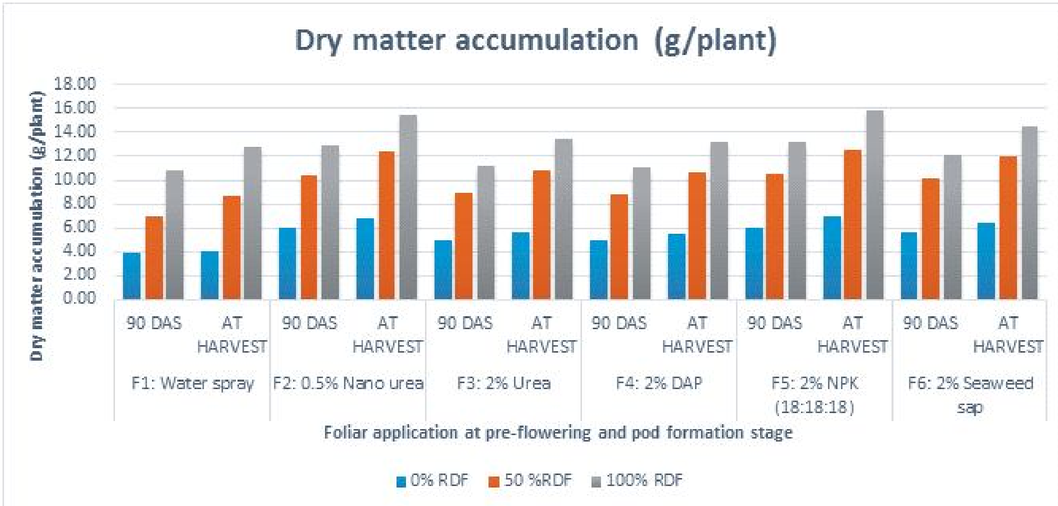

Fig. 1 : Effect of soil application of different levels of fertilizer and foliar application of nutrients on dry matter accumulation by linseed at 90 DAS and at harvest in soybean linseed sequence.

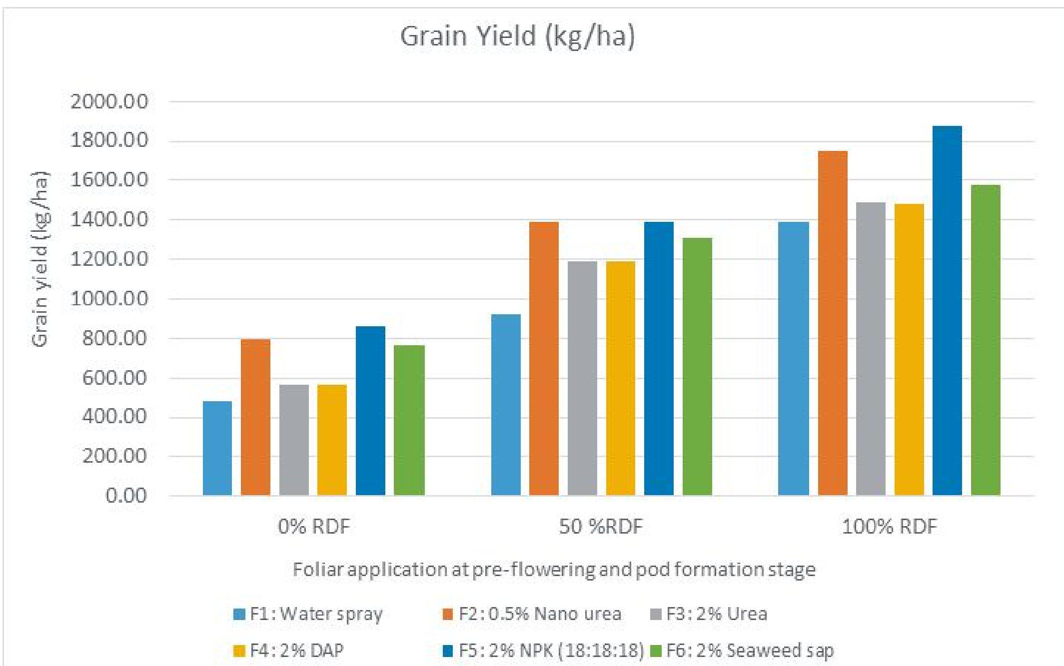

Fig. 2 : Effect of soil application of different levels of fertilizer and foliar application of nutrients on grain yield of linseed in soybean linseed sequence.

reported in different crops in cluster frontline demonstration were documented by Singh *et al*. (2014) in onion, Das *et al*. (2023) in rice and Banerjee *et al*. (2021) in pea.

Yield attributes

A perusal of data presented in Table 2 revealed a significant difference in yield attributing character with the enhancement in fertilization levels. Application of 100% RDF was found significant superiority in terms of number of primary branches per plant (4.99), capsule per plant (11.90) but failed to cause significant variation in number of seed per capsule. The highest number of seed per capsule (7.34) and 1000 seed weight (7.87) was recorded over lower levels of fertilizers i.e. 0% RDF. This might due to higher dose of fertility level helps in facilitated greater crop growth and consequently result in higher linseed production. The positive response of higher level of improvement in crop growth, enabled the plant to absorb more nutrient and moisture which empowered the plant to manufacture more quantity of photosynthetic accumulate there in sink. This results are in conformity by Malik *et al.* (2008) and Gaikwad *et al.* (2020).

Among different foliar application of 2% NPK

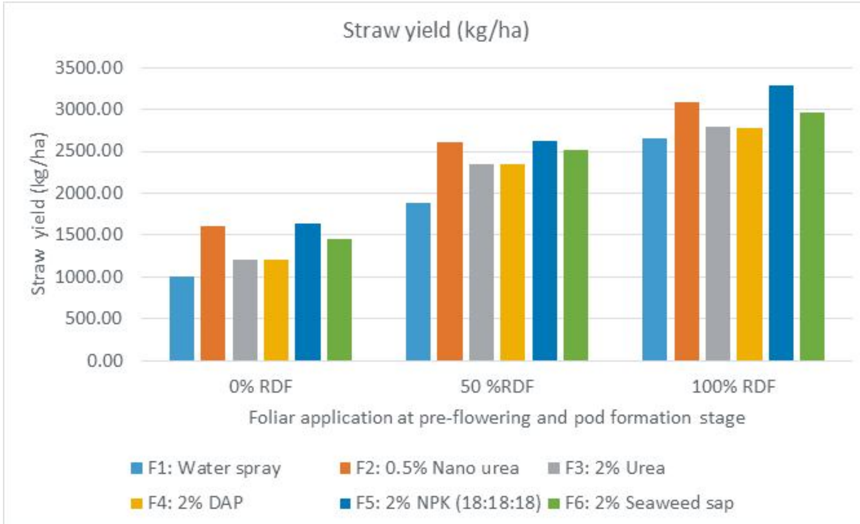

Fig. 3 : Effect of soil application of different levels of fertilizer and foliar application of nutrients on straw yield of linseed.

(18:18:18) found significantly better in increasing yield contributing characters like primary branches per plant (4.64), capsule per plant (9.91). Additionally maximum number of seed per capsule (7.75) was recorded and found at par with F2- 0.5% nano-urea and F3- 2% seaweed sap. This could have stemmed from the balanced application of NPK, which improved tissue differentiation, cell division and multiplication. This, in turn, led to an increase in plant height and branching, as well as an increase in yield attributes, such as the number of capsules per plant, the number of seeds per capsule, and 1000-seed weight. The results of the present investigation corroborate the findings of Meena *et al*. (2011) and Gupta *et al*. (2017). However, 1000-seed weight remained unaffected by fertilizer level and foliar application of nutrient.

Yield

Table 2 shows that grain yield (1593 kg/ha), straw yield (2925 kg/ha) of linseed were significantly influenced by the application of 100% RDF, compared to the various fertilizer levels. These yields were found to be comparable to those obtained with the application of 50% RDF (Figs. 2 and 3, respectively). The lowest grain yield (671 kg/ ha), straw yield (1352 kg/ha) was observed with application of 0% RDF. However, harvest index was found to be non-significant. The increase in grain yield might be due to remarkable improvement in the yield attributes viz. no. of capsules/plant, no. of seeds/ capsule and seeds weight/plant with higher level of fertilizer application also had profound effect of straw yield this could be attributed to the increased plant height, branching and dry matter accumulation with increasing levels of fertilizer application. Similar results were also supported by Gokhale *et al.* (2008) and Bhanwariya *et al*. (2013).

The yield was shown to be significantly impacted by the foliar application of fertilizers. Application of 2% NPK (18:18:18) recorded significantly highest grain (1374 kg/ ha) and straw yield (2515 kg/ha) though it was statistically at par with 0.5% nano urea. However, the treatment followed by the water spray had the lowest grain and straw yield (930 kg/ha and 1849 kg/ha). Despite this, the harvest index was found to have no significant effect. This might be due to a balanced dose of fertilizer application increased uptake of nutrients and effective translocation of nutrients from sink to reproductive area of crop which ultimately owning to increase in dry matter accumulation, number of branches per plant, capsule per plant, seed per capsule and seed weight, which led to increased grain and straw yield as reported by Paikra *et al*. (2018). Furthermore, this integrative treatment facilitated/enabled plants to uptake the required amounts of NPK nutrients avoiding nutrients deficiency and significantly increased growth and productivity, physiological and biochemical attributes, which ultimately enhanced grain and straw production, as reported by Hemida *et al.* (2023). The result is agreement with findings by Lakshmy *et al*. (2020), Dandge *et al.* (2018) who recorded higher seed and straw yield (1599 and 2131 kg/ ha respectively) with the application of 2% 19:19:19 (NPK) + RDF at pod initiation stage.

Interaction effect

The interaction effect between the level of fertilizer applied as soil application and foliar application of various nutrients was found to be non-significant at all stages of linseed crop growth. Likewise, the combined influence of fertilizer levels through soil and foliar applications on growth, yield attributes and yield indices (such as plant height, dry matter accumulation, crop growth rate, primary

Table 2 : Effect of soil application of different levels of fertilizer and foliar application of nutrients on yield and morphological characteristics of linseed in soybean linseed sequence during rabi season 2022- 2023.

A: Soil application of nutrients	Plant height(cm)	Dry matter /plant(g)	Dry matter /plant(g)	CGR (g/m²/day)
	At harvest	90 DAS	At harvest	90 DAS- At harvest
S1: 0 % RDF	35.75	5.25	5.89	1.41
S2: 50 % RDF	45.94	9.32	11.15	4.03
S3: 100 % RDF	52.21	11.90	14.21	5.10
SEm±	0.39	0.14	0.12	0.12
CD (P=0.05)	1.42	0.49	0.45	0.43
B: Foliar application of nutrients				
F1: Water spray	39.07	7.21	8.51	2.86
F2: 0.5% Nano urea	47.68	9.79	11.55	3.87
F3: 2% Urea	43.57	8.42	9.93	3.32
F4: 2% DAP	42.83	8.31	9.78	3.24
F5: 2% NPK (18:18:18)	48.36	9.91	11.78	4.12
F6: 2% Seaweed sap	46.28	9.29	10.96	3.66
SEm±	1.38	0.33	0.283	0.22
CD (P=0.05)	3.97	0.95	0.819	0.63
CV (%)	9.25	11.20	8.16	18.69
Interaction (A x B)				
SEm±	2.38	0.57	0.49	0.38
CD (P=0.05)	NS	NS	NS	NS

branches, capsules per plant, seeds per capsule, 1000-seed weight, grain yield, straw yield, and harvest index) was also determined to be non-significant.

Conclusion

The study found that higher fertilizer levels, *i.e.* 100% RDF (40 N: 30 P_2O_5:20 K_2O:20 S kg/ha) improved linseed growth characteristics and productivity and foliar applications, particularly 2% NPK (18:18:18), promoted plant growth, physiological traits, and yield due to the supply of readily available balanced nutrients, which enhanced metabolic processes. This highlights the importance of precise nutrient management strategies in optimizing linseed production and productivity.

References

Arancon, N.Q., Edwards C.A. and Bierman P. (2006). Influences of vermicomposts on field strawberries: effects on soil microbial and chemical properties. *Bioresource Technology*, **97**, 831-840.

Banerjee, P., Venugopalan V.K., Gaber A., Nath R., Chakraborty P.K., Alsanie W.F., Raafat B.M. and Hossain A. (2022). Seed Priming and Foliar Application of Nutrients Influence the Productivity of Relay Grass Pea (*Lathyrus sativus* L.) through Accelerating the Photosynthetically Active Radiation (PAR) use Efficiency. *Agronomy*, **12**, 1125. https://doi.org/10.3390/agronomy12051125.

Bhanwariya, B.,, Ram M., Kumawat N. and Kumar R. (2013). Influence of Fertilizer Levels and Biofertilizers on Growth and Yield of Linseed (*Linum usitatissimum* L.) under Rainfed condition of South Gujarat. *Madras Agric. J.*, **100(4-6)**, 403-406.

Bhayal, L., Aakash, Jain M.P., Bhayal D. and Menna K. (2022). Impact of foliar spray of NPK and Zn on soybean for growth, Yield, Quality, Energetics and Carbon footprint under Dryland condition at Indore. *Legume Res.*, **45(2)**, 174-181.

Dandge, M.S., Ingle Y.V., Peshattiwar P.D. and Dikey H.H. (2018). Effect of foliar nutrition on soybean productivity. *Int. J. Chem. Stud.*, **6(1)**, 1290-1292.

Dehury, C., Alam M.P., Kumari M., Pandey S.K., Bhagat B., Kar S.P., Bharti P and Kumari N. (2024). Effect of foliar spray of nano urea on growth parameters, quality attributes and yield of linseed. *Int. J. Res. Agron.*, **7(7)**, 186-190.

Das, P., Mohabhoi D., Garnayak L.M. and Mohapatra B.K. (2023). Growth and yield of linseed varieties under different establishment methods and foliar nutrition in rice fallow. *The Pharma Innov. J.*, **12(3)**, 4046-4049.2

Dass, A., Rajanna G.A., Babu S., Lal S.K., Choudhary A.K., Singh R., Rathore S.S., Kaur R., Dhar S. and Singh T. (2022). Foliar Application of Macro- and Micronutrients Improves the Productivity, Economic Returns, and Resource-Use Efficiency of Soybean in a Semiarid Climate. *Sustainability*, **14**, 5825. https://doi.org/ 10.3390/su14105825.

Devedee, A.K, Singh R.K., Meena R.N. and Choudhary K. (2019). Effect of moisture conservation on growth and yield of linseed under varying fertility levels. *J. Crop and Weed*, **15(1)**, 198-200.

Duhan, B.S. (2013). Effect of integrated nutrient management on yield and nutrient uptake by sorghum (*Sorghum bicolor* L.). *Forge Res.*, **39**, 156-158.

Dwivedi, R.K. and Dwivedi B.S. (2005). Nutrient management of utera linseed (*Linum usitatissimum* L.) under rice-based cropping system and residual soil moisture. *Res. Crops*, **6**, 29-31.

Gaikwad, S.R., Suryavanshi V.P., Bhusari S.A. and Misal A.M. (2020). Effect of fertilizers on growth and yield of linseed (*Linum usitatissimum* L.) varieties. *The Pharma Innov. J.*, **9(10**), 127-131.

Gokhale, D.N., Wadhvane S.V., Kalegore N.K., Khalge M.L. and Shaikh F.G. (2008). Response of linseed to row spacing and phosphorus levels under irrigated condition. *J. Oilseeds Res.*, **25**, 94-95.

Gomez, K.A. and Gomez A.A. (1984). *Statistical procedures for agricultural research*. A Wiley - Interscience Publication, John Wiley and Sons, New York.

Gupta, M., Kour S., Gupta V., Bharat R. and Sharma C. (2017). Effect of different doses of fertilizers on yield and NPK uptake of linseed (*Linum usitatissimum* L.). *Bangladesh J. Bot.*, **46(2)**, 575-581.

Hemida, K.A., Eloufeyb A.Z.A., Hassanc G.M., Ashraf N., El-Sadekd M.M.R. and Abdelfattahe M.A. (2023). Integrative NPK soil and foliar application improves growth, yield, antioxidant and nutritional status of *Capsicum annuum* L. in sandy soils under semi-arid condition. *J. Plant Nutr.*, **46(6)**, 1091–1107. https://doi.org/10.1080/01904167.2022.2046060

Kumar, A., Choudhary A.K., Nirala R.B.P and Shekhar P. (2023). Effect of nutrient management through exogenous application of water-soluble fertilizers on yield and economics of linseed (*Linum usitatissimum* L.) under utera condition, **12(3)**, 3205-3208.

Kumar, A., Kumar R. and Nirala R.B.P. (2024). Genetic variability, correlation and path coefficient analysis of linseed (*linum usitatissimum* l.) in Bihar, India. *Plant Archives*, **24(2)**, 2018-2014.

Kumar, S., Singh J.K. and Vishwakarma A. (2018). Importance of linseed crops in agricultural sustainability. *Int. J. Curr. Microbiol. App. Sci.*, **7(12)**, 1198-1207.

Lakshmy, M.P., Engrala A.E., Gadi Y. and Singh A.K. (2020). Response of Soybean (*Glycine max* L. Merrill) to Foliar Application of Nutrients. *Int. J. Curr. Microbiol. App. Sci.*, **9(4**), 494-500.

Malik, Y.P., Hussain K. and Alam K. (2008). Impact of spacings and fertilizer application on linseed and infestation of budfly, Dasyneura lini Barnes. *J Oilseeds Res.*, **25(1)**, 106 107.

Mamdi, S.J., Mirza I.A.B., Tandle S.S., Deshmukh S.B. and Shingod P.L. (2023). Yield and economics of linseed (*Linum usitatissimum* L.) as influenced by foliar application of nutrients. *Int. J. Adv. Biochem. Res.*, **7(2S)**, 571-573. DOI:10.33545/26174693.2023.v7.i2Sh.269.

Meena, R.L, Singh T.K., Kumar R., Singh A.K. and Om H. (2011). Production performance of Linseed (*Linum usitatissimum* L.) to fertility levels and seed rates in dryland conditions of eastern Uttar Pradesh. *Ind. J. Soil Conser.*, **3**, 230-235.

Meena, R.N., Singh R.K., Srivastava V.K. and Choudhary K. (2023). Growth and Nutrient Uptake of Indian Mustard as influenced by Residual effect of Green Leaf Manuring and Nitrogen Fertilization. *Biological Forum-An Int. J.*, **13(4)**, 271-274.

Mousa, M.A., ElKady E.A. and Zedan Z.S. (2010). Effect of nitrogen fertilizers and some micro-nutrients on flax yield and chemical composition characters. *J. Plant Prod.*, **5**, 713-720.

Nataraja, T.H., Naika R., Shankarappa S.K., Reddy K.V., Shaimaa A.M., Abdelmohsen A.M., Al-Harbi F.F., Zin El-Abedin T.K., Elansary H.O. and Abdelbacki A.M.M. (2021). Productivity of Paddies as influenced by varied Rates of Recommended Nutrients in Conjunction with Biofertilizers in Local Landraces. *Agronomy*, **11**, 1165. https://doi.org/10.3390/agronomy11061165.

Paikra, I.R. and Lakpale R. (2018). Effect of foliar nutrition on productivity and profitability of soybean (*Glycine max*). *Indian J. Agron.*, **63(4)**, 535-537.

Parasuraman, P. (2008). Studies on integrated nutrient requirement of hybrid maize (*Zea mays* L.) under irrigated conditions. *Madras Agric. J.*, **92(1&3)**, 89-94.

Pasala, R., Kulasekaran R., Pandey B.B., Manikanta C.H.L.N., Gopika K., Daniel P.S.J., Elthury S. and Yadav P. (2022). Chapter 14 - Recent advances in micronutrient foliar spray for enhancing crop productivity and managing abiotic stress tolerance. *Plant Nutrition and Food Security in the Era of Climate Change*, 377-398.

Singh, A., Singh D., Verma V.K., Pyare R. and Hussain M.F. (2020). Studies on the effect of zinc and boron on growth and yield of linseed (*Linum usitatissimum* L.) under limited irrigation. *Int. J. Chem. Stud.*, **5**, 1964-1966.

Singh, A.K., Singh C.S., Singh A.K. and Karmakar S. (2018). Soybean productivity as influenced by foliar application of nutrients. *J Pharmacogn Phytochem.*, **7(1S)**, 413-415.

Singh, I.D. and Stockoph N.C. (1971). Harvest index in cereals. *Agron. J.*, **63**, 224-226.

Sheoran, R.S., Satpal, Tokas J., Duhan B.S. and Jindal Y. (2017). Potential fodder productivity, quality and relative economics of multi-cut oat genotypes under different levels of nitrogen. *Forage Res.*, **43(3)**, 227-230.

Singh, B.V. and Rakesh Singh (2014). Effect of sources of nutrients on physiological growth parameters and yield of onion varieties. *Annals Plant Soil Res.*, **16(4)**, 362-366.

Singh, D.N., Bohra J.S. and Singh J.S. (2013). Influence of NPK, S and variety on growth, yield a n d quality of irrigated linseed (*Linum usitatissimum*). *Indian J. Agril. Sci.*, **3**, 456-458.

Vishwakarma, M., Kulhare P.S., Tagore G.S. and Gontia A.S. (2023). Growth Response of Wheat as affected by different Nutrient Sources and NPK Levels under Vertisols. *Int. J. Plant Soil Sci.*, **35(21)**, 835-845.

Watson, D.J. (1952). Physiological basis of varieties in yield. *Adv. Agron.*, **4**, 101-145.

Zayed, A., Salem M. and Sharkawy M. (2011). Effect of different micronutrient treatments on rice (*Oryza sativa* L.) growth and yield under saline soil conditions. *World J Agric. Sci.*, **7(2)**, 179-184.