International Journal of Advanced Biochemistry Research 2025; SP-9(12): 871-874

International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2025): 5.29
IJABR 2025; SP-9(12): 871-874
www.biochemjournal.com
Received: 04-09-2025
Accepted: 07-10-2025

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Effect of date of sowing and Sulphur on growth and yield of linseed (*Linum usitatissimum* L.)

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DOI: https://www.doi.org/10.33545/26174693.2025.v9.i12Sk.6624

Abstract

The field experiment titled, "Effect of Date of Sowing and Sulphur on growth and yield of Linseed (*Linum usitatissimum* L.) was conducted during *Rabi* season of 2024 at Crop Research Farm, Department of Agronomy, Naini Agriculture Institute, Sam Higginbottom University of Agriculture, Technology and Science, Prayagraj (U.P.) India. To study effect of different Date of sowing and Sulphur levels on growth and yield of Linseed. The soil of experimental plot was sandy loamy in texture, nearly neutral in soil reaction (pH 7.3), low in Organic carbon (0.458%) and available medium Nitrogen 239.5 kg/ha, Phosphorus 27.4 kg/ha and Potassium 243.8 kg/ha. Treatments consisted of 3 levels of Sulphur (20, 30 and 40 kg/ha) and different date of sowing along with RDF (50:30:20 kg NPK/ha). This experiment was laid out in a Randomized Block Design with ten treatments which have replicated thrice. The results revealed that significantly higher growth attributes of Linseed at 80 DAS *viz.*, plant height (58.74 cm), number of branches (7.80) dry weight (5.67 g), Capsule /plant (72.16), seed/Capsule (9.03), test weight (6.65), grain yield (1440.20 kg/ha) and stover yield (1860.67 kg/ha) were recorded in T_7 (10 December + Sulphur 20 kg/ha) compared to other treatments. and Maximum gross return (INR 95030.92/ha), net return (INR 64952.92/ha) and B:C ratio (2.16) were also recorded in T_7 (10 December + Sulphur 20 kg/ha)**.** it concluded that application of Date of Sowing and Sulphur perform better growth and yield of Linseed has recorded highest test weight, grain yield, stover yield, gross return, net return and benefit cost ratio and as well as it is economically profitable.

Keywords: Economics, growth, lentil, date of sowing, sulphur and yield

Introduction

Linseed (*Linum usitatissimum* L.) is one of the most important oil seed crops in India. It is self- pollinating flax crop include linen, linum, and tisi. India ranks first in terms of area under linseed cultivation and third in production in world. It is primarily cultivated worldwide for its multifunctional oil and fiber. Flax, also known as Linum Linseed, is a valuable crop with a wide range of uses. It is an annual herbaceous plant that belongs to the *Linaceae* family. Flax seeds are known to contain chemical compounds with specific biological activity and functional properties, such as soluble dietary fibers, lignins, proteins, carbohydrates, and polyunsaturated fatty acids (PUFA) omega-3 family, as well as water-holding and fat-absorption capacities, thermal stability, emulsifying qualities, and electrostatic charge density Chaurasiya *et al*. (2024) [2]. It contains 41% fat, 20% protein, 28% total dietary fiber, 7.7% moisture, and 3.4% ash the mineral-rich residue that remains after samples are burned. As the oil content of the seed rises, the protein content falls. Its oil is used to create hardwood, oil cloth, varnish, and paint. oil with a low oleic acid content and a high conjugated linoleic acid content. Nonetheless, it is useful to humans, and its fiber has been valued for millennia in the production of rough webbing and cotton. Linseed is grown on 5.25 lakh ha in India, with a total production of 2.12 lakh tones and an annual production of 403 kg/ha (Singh *et al*. 2022) [15]. The climate conditions that are ideal for growth are those that are characterized as being moderate and cold throughout the year. The temperature ranges that are the lowest and highest are 10 degrees Celsius and 38 degrees Celsius, respectively. It is therefore the principal growth season for linseed, which occurs during the months of October and November, depending on the amount of soil moisture. By planting the crop at an earlier stage, it is possible to prevent the spread of diseases such as rust, linseed bud fly, and powdery mildew in various areas.

The maturation of the crop might take anywhere from 110 to 120 days, depending on the variety. It is detrimental to both productivity and quality if there is a drought and very high temperatures during the early and seed filling phases Singh *et al*. (2022) [15].

An essential factor in assessing the quality of oil extracted from these crops is Sulphur (S). It is necessary for the synthesis of vitamins, proteins, and chlorophyll. One of the primary causes of the Sulphur deficiency in Indian soils is the use of fertilizers devoid of Sulphur. Sulphur encourages vegetative development and is a component of chlorophyll. The synthesis of certain amino acids and oils requires Sulphur. Since Sulphur is a component of amino acids (cysteine, cysteine, and methionine), it is necessary for protein creation. It is linked to both the synthesis of oils and the production of chlorophyll. Depending on improving development and plant part, linseed crop Sulphur uptake and genetic mutation vary. Application of Sulphur improved yield and quality (Patil *et al.* 2017) [9].

According to experimental data, the two most important plant nutrients that are typically deficient in Indian soil are phosphorous and Sulphur. Because phosphorous is comparatively mobile in plants, it can be transported to areas where new development is occurring. As a result, older leaves of certain plants may exhibit signs of dark to blue-green hue. Additionally, Sulphur is linked to oilseed quality and blooming. Among other nutrients, phosphorus and Sulphur are crucial for enhancing the quantity and quality of linseed Jimo *et al*. (2017) [5].

Due to the low phosphorus and Sulphur content of the soil, a significant portion of the planted area linseed needs fertilizer to produce a satisfactory crop. Phosphorus promotes the growth and development of roots in seedlings. It also encourages the growth of seeds and fruit. Sulphur encourages vegetative development and is a component of chlorophyll. The synthesis of certain amino acids and oils requires Sulphur was reported by Singh *et al*. (2022) [15].

Materials and Method

An experiment entitled on Effect of Date of sowing and Sulphur on growth and yield of Linseed (*Linum usitatissiumum* L.) was conducted during *Rabi* season of 2024. A field experiment was conducted in alluvial soil at the Department of Agronomy at Crop Research Farm, Naini Agriculture Institute, Sam Higginbottom University of Agriculture, Technology and Science, Prayagraj (U.P.) India. The soil of experimental plot was sandy loamy in texture, nearly neutral in soil reaction (pH 7.3), low in Organic carbon (0.458%) and available medium Nitrogen 239.5 kg/ha, Phosphorus 27.4 kg/ha and Potassium 243.8 kg/ha. Treatments consisted of 3 levels of Sulphur (20, 30 and 40 kg/ha) and different date of sowing along with RDF (50:30:20 kg NPK/ha).

Linseed (SHUATS Alsi - 2) were planted on December 12, 2024, with a 30 cm × 10 cm spacing. Using a hand hoe, furrows 4-5 cm deep were dug along the seed rows in order to apply organic manure as a spreading method. Once germination occurred, the gaps were closed by transplanting ten days following sowing. Seedlings were removed where needed to keep the space between plants at 30 cm by 10 cm. Intercultural operations were conducted at intervals of 25 to 45 days in order to decrease crop density and weed competition. The crop was harvested on March 29th, 2025. Plant growth characteristics, including plant height (cm) and dry weight (g/plant), were measured at regular intervals from germination until harvest. At harvest, yield attributes such as Capsules/plant, seeds/ Capsules, test weight (g), seed yield (kg/ha), stover yield (kg/ha), and harvest index (%) were measured at 20, 40, 60 and 80 DAS. Analysis of variance (ANOVA), as it relates to randomized block design, was used to statistically examine the observed data of ten treatments (Gomez and Gomez, 1984 and Mohan *et al.* (2024) [3, 8]. and Prayagraj has subtropical and semiarid climatic conditions, with both extremes of temperature, i.e. summer and winter. It would be hot which commences in the month of February and with draws by the end of October. The meteorological data including the weekly average of the maximum and minimum temperature, relative humidity, and rainfall recorded at the Agro- meteorological Observatory unit, School of Forestry and Environmental Sciences, SHUATS, during the cropping period.

Results and Discussions

Growth parameter

The data of growth parameter are presented in Table 1. show Effect of Phosphorus and Sulphur on growth and Yield of Linseed. the application of T_7 (10 Dec. and Sulphur at 20 kg/ha) in T_7 was recorded the maximum plant height (58.74 cm) was significantly higher than all other treatments. On the other hand, T_1 (30 November + Sulphur 20 kg/ha) had the lowest plant height (47.66 cm). The early growth of seedlings may be caused by the application of Phosphorus which boosts growth and development capacity and produces growth-promoting hormones like IAA, trace elements, vitamins, amino acids, antibiotics, and micronutrients it's essential for the synthesis and function of several key plant hormones and plays a vital role in plant growth and development. Phosphorus, primarily in the form of phosphate (Pi), is a crucial component in energy transfer (ATP), DNA/RNA, and cell membranes. It also influences the production of hormones like abscisic acid (ABA) and indoleacetic acid (IAA), and impacts stomatal behaviors and root development, ultimately affecting a plant's response to stress reported by Patil *et al.* (2017) [9]. the application of (10 December + Sulphur 20 kg/ha) in T_7 resulted the highest plant dry weight (5.94 g) was observed at 80 DAS and T_1 (30 November+ Sulphur 20 kg/ha) had the lowest plant dry weight (4.52 g). Plant dry weight increased significantly due to excess growth and development of plant which may be the result of growth-promoting hormones of hormones like abscisic acid (ABA) and indoleacetic acid (IAA), and impacts stomatal behaviour and root development in phosphorus that increase the activation of cell division and cell elongation in the axillary buds. Sulphur help in chlorophyll formation and encourages vegetative plant growth. It also increases root growth. It is necessary for the synthesis of vitamins, proteins, and chlorophyll.

One of the primary causes of the Sulphur deficiency in Indian soils is the use of fertilizers devoid of Sulphur reported by Singh *et al.* (2022) [15] and Kushwaha *et al.* (2019) [7].

Yield attributes

Number of Capsules per Plant

The data presented in Table 2 Sowed the result related to yield-attributing characters. The maximum number of capsules per plant (72.16) was recorded in T_7 (10 Dec. and Sulphur at 20 kg/ha), which was significantly superior to all other treatments. It was followed by T_6 (5 December sowing and Sulphur at 40 kg/ha, 68.28 capsules/plant) and T_8 (10 December sowing and Sulphur at 30 kg/ha, 66.27 capsules/plant. It might be due to the fact that P and S found to be increased the photosynthates, which accumulated into seeds consequently increasing test weight. Sulphur is closely associated with seed containing constituents such as greater accumulation of sulphur containing amino acids, higher synthesis of proteins and glucosides, related to the higher test weight of seeds (Singh *et al.* and Singh *et al.* 2022) [9]. Sulphur applied topically had a major impact on Linseed. It is necessary for the synthesis of vitamins, proteins, and chlorophyll and increases in growth, development and yield, including test weight, number of seeds per Capsules, and number of capsules per plant. It increases in flowering reproduction stage for formation of capsules in plant which increase the seed quality and quantity Kumar *et al.* (2018) [6].

Number of Seeds per Capsule

The maximum number of seeds per capsule (9.03) was recorded in T_7 (10 Dec. and Sulphur at 20 kg/ha), which was significantly superior over all other treatments. It was followed by T_6 (5 December sowing and sulphur at 40 kg/ha, 8.68 seeds/capsule) and T_8 (10 December sowing and sulphur at 30 kg/ha, (8.47 seeds/capsule). Sulphur applied topically had a major impact on Linseed. It is necessary for the synthesis of vitamins, proteins, and chlorophyll and increases in growth, development and yield, including test weight, number of seeds per Capsules, and number of capsules per plant. It increases in flowering reproduction stage for formation of capsules in plant which increase the seed quality and quantity Kumar *et al.* (2018) [6].

Test Weight (g)

The maximum test weight (6.55 g) was recorded in T_7 (10 Dec. and Sulphur at 20 kg/ha), which was significantly superior over all other treatments. It was followed by T_6 (5 December sowing and sulphur at 40 kg/ha, 6.42 g) and T_8 (10 December sowing and sulphur at 30 kg/ha, 6.30 g). These treatments were found statistically at par with each other. The lowest test weight (5.72 g) was recorded in T_1 (30 November sowing and sulphur at 20 kg/ha).The higher test weight under optimum sowing time (10 December) with higher sulphur application (20 kg/ha) might be due to better nutrient absorption, enhanced metabolic activity, and effective translocation of assimilates to developing seeds, resulting in bold and well-filled grains. Sulphur also plays a vital role in oil and protein synthesis, contributing to seed development and density. Similar findings were reported by Patil *et al.* (2018) [9] and Dawar *et al.*

Grain yield

According to the statistical data in Table 2, The maximum seed yield (995.97 kg/ha) was obtained in T_7 (10 Dec. and Sulphur at 20 kg/ha), which was significantly superior to all other treatments. It was closely followed by T_6 (5 December sowing and sulphur at 40 kg/ha, 950.51 kg/ha) and T_8 (10 December sowing and sulphur at 30 kg/ha, 920.58 kg/ha). These treatments remained statistically at par with each other. The minimum seed yield (720.81 kg/ha) was observed in T_1 (30 November sowing and sulphur at 20 kg/ha). The activation of cell division and cell elongation in the axillary buds, which promotes an increased number of Capsules, seeds, and grain yield, may be the result of growth-promoting hormones present in Phosphorus. It might be due to the fact that P and S found to be increased the photosynthates, which accumulated into seeds consequently increasing test weight. Sulphur is closely associated with seed containing constituents such as greater accumulation of sulphur containing amino acids, higher synthesis of proteins and glucosides, related to the higher test weight of seeds. The application can lead to significant improvements in plant growth, yield components, and overall grain production. It's important to assess soil nutrient levels and consult with agricultural experts to determine the appropriate fertilization strategies for specific crops and growing conditions. (Kumar *et al.* 2018 and Parmar *et al.* 2020) [6, 10].

Stover yield

According to the results in Table 2, The maximum straw yield (3160.74 kg/ha) was obtained in T_7 (10 Dec. and Sulphur at 20 kg/ha), which was significantly superior over all other treatments. It was followed by T_6 (5 December sowing and sulphur at 40 kg/ha, 3020.45 kg/ha) and T_8 (10 December sowing and sulphur at 30 kg/ha, 2950.33 kg/ha). These treatments were found statistically at par with each other. The lowest straw yield (2420.48 kg/ha) was observed in T_1 (30 November sowing and sulphur at 20 kg/ha).The stover output increased significantly after Phosphorus along with Sulphur were applied this could be because of better growth in terms of plant height, seedling emergence, and dry matter buildup, all of which increase photosynthetic efficiency Raja *et al*. (2021) [12]. Superior vegetative development results from increased photosynthetic accumulation in vegetative components, which raises stover production. Phosphorus boosts growth and development capacity and produces growth-promoting hormones like IAA, trace elements, vitamins, amino acids, antibiotics, and micronutrients it's essential for the synthesis and function of several key plant hormones Kumar *et al.* (2018) [6] and Rahil *et al*. (2021) [11].

Harvest index

Data presented in table 2 showed that the maximum harvest index (30.58%) was recorded in T_7 (10 Dec. and Sulphur at 20 kg/ha), which was significantly superior to all other treatments. It was followed by T_6 (5 December sowing and sulphur at 40 kg/ha, 29.20%) and T_8 (10 December sowing and sulphur at 30 kg/ha, 28.43%). The higher harvest index under later sowing (10 December) with higher sulphur application (20 kg/ha) may be attributed to improved partitioning efficiency, where a greater proportion of assimilates was translocated to the economic sink (seeds) rather than vegetative parts. Sulphur, being an essential element for protein and enzyme synthesis, supported better seed filling, while optimum sowing time provided favourable temperature and photoperiod conditions during the reproductive phase. This synergistic effect of timely sowing and higher sulphur dose ensured maximum conversion of biomass into economic yield. Similar results were also reported by Gethe *et al.* and Singh *et al.* (2022) [9].

Economics

Gross returns, net returns, and benefit-cost (B:C) ratio of linseed under different sowing dates and sulphur levels have been presented in Table 3

Cost of cultivation (INR/ha)
The maximum cost of cultivation (46,700 INR/ha) was recorded in T_3 (30 Nov. and Sulphur at 40 kg/ha), T_6 (5 Dec. and Sulphur at 40 kg/ha) and T_7 (10 Dec. and Sulphur at 20 kg/ha), whereas the minimum cost (23,350 INR/ha) was observed in T_1 (30 Nov. and Sulphur at 20 kg/ha), T_4 (5 Dec. and Sulphur at 20 kg/ha) and T_7 (10 Dec. and Sulphur at 20 kg/ha).

Gross returns (INR/ha)
The highest gross return (30,874 INR/ha) was obtained in T_7 (10 Dec. and Sulphur at 20 kg/ha), followed by T_8 (10 Dec. and Sulphur at 30 kg/ha, 28,495 INR/ha) and T_6 (5 Dec. and Sulphur at 40 kg/ha, 25,984 INR/ha). The lowest gross return (14,658 INR/ha) was recorded in T_1 (30 Nov. and Sulphur at 20 kg/ha).

Net returns (INR/ha)
The maximum net return (22,132 INR/ha) was recorded in T_7 (10 Dec. and Sulphur at 20 kg/ha), followed by T_8 (18,632 INR/ha) and T_6 (5 December and Sulphur at 40 kg/ha, (17,654 INR/ha). The minimum net return (10,472 INR/ha) was observed in T_1 (30 Nov. and Sulphur at 20 kg/ha).

Benefit-cost ratio (B:C)
The highest B:C ratio (1.61) was attained in T_7 (10 Dec. and Sulphur at 20 kg/ha), while the lowest (1.20) was recorded in T_1 (30 Nov. and Sulphur at 20 kg/ha).The economics of linseed production was significantly influenced by both sowing date and sulphur application. Higher levels of sulphur (20 kg/ha) combined with delayed sowing (10 December) promoted better vegetative growth, increased seed and straw yield, and improved gross and net returns. Consequently, this combination also achieved the highest B:C ratio. These results are in agreement with previous findings where proper nutrient management and spacing enhanced yield and profitability (Dawar *et al.*, and Jadhav *et al.*

Conclusion
On the basis of one year experimentation, it concludes that with the application of date of sowing 10 December along with Sulphur 20 kg/ha performed better in growth and yield of Greengram has recorded highest test weight, grain yield, stover yield, net return and benefit cost ratio and as well as economically profitable.

Acknowledgement
I am grateful to my advisor and chairman as well as all of the faculty members of Department of Agronomy, NAI for their unwavering support and advice throughout the entire experimental research study.

Competing Interests
Authors have declared that no competing interests exits.

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