Eco. Env. & Cons. 30 (4) : 2024; pp. (1850-1853)
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ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2024.v30i04.064

Effect of Nitrogen and Sulphur Levels on Productivity and Profitability of Linseed (*Linum usitatissimum* L.)

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(Received 26 May, 2024; Accepted 1 August, 2024)

ABSTRACT

The field experiment was conducted during the *Rabi* season of 2023-24 at the Crop Research Centre, School of Agriculture, ITM University, Gwalior, (M.P.) to investigate the effect of nitrogen and sulphur levels on productivity and profitability of linseed. The experiment consists of three levels of nitrogen (40, 80, and 120 kg N ha^{-1}) and three levels of sulphur (30, 40, and 50 kg S ha^{-1}), and absolute control was laid out in a factorial randomized block design with three replications. The results revealed that the application of 120 kg N ha^{-1} recorded significantly higher number of bolls plant^{-1}, number of seeds boll^{-1}, test weight, seed yield, straw yield, biological yield and harvest index, being *at par* with 80 kg N ha^{-1} and followed by 40 kg N ha^{-1}. Among the sulphur levels, the application of 50 kg S ha^{-1} recorded significantly higher number of bolls plant^{-1}, number of seeds boll^{-1}, test weight, seed yield, straw yield, biological yield and harvest index, being *at par* with 40 kg S ha^{-1} and followed by 30 kg S ha^{-1}. Among all the treatment combinations, T_6- 80 kg N and 40 kg S ha^{-1} (N_2S_2) recorded maximum value of gross return, net return and benefit-cost ratio.

Key words: *Linseed, Nitrogen, Sulphur, Yield, Net return and Benefit-Cost ratio.*

Introduction

Oil seed crops are vital to the national economy, providing essential dietary oils and raw materials for various industries. India, the fourth largest oilseed producer globally, covers 20.8% of the total area and accounts for 10% of global production. In 2020-21, India produced 365.65 lakh tons of oilseeds, a 10% increase from the previous year (Anonymous, 2022-23). Linseed (*Linum usitatissimum* L.), also known as flax, is a member of the genus *Linum* in the family *Linaceae*. It is known as *Agasi* or *Akshi* in Kannada, *Jawas* or *Alashi* in Marathi, *Alsi* in Hindi, and *Ousahalu* in Telugu. It is one of the oldest cultivated crops grown for seeds and fibre, which is used for the manufacturing of linen. It is commonly cultivated worldwide for flax, while in India it is cultivated for oil. Linseed is one of the rabi oilseed crops of India. Linseed, or flax, is the fourth most important oilseed crop in India due to its diverse uses and special qualities. Grown for both seed and fibre, linseed contains 33-47% oil used in food and various industries such as paint, varnishes, and printing ink (Lawania *et al.*, 2015). It is rich in omega-3 fatty acids, particularly alpha-linolenic acid, beneficial for inflammatory diseases, heart conditions, and arthritis, and contains lignans, which aid in cancer prevention (Budwig, 1994). Post oil extraction, the remaining oil cake is a valuable feed for animals and can also be used as organic manure, containing 5.0% nitrogen, 1.5% phosphorus, and 1.8% potassium. Linseed straw, rich in bast fibres, is used in manufacturing paper, textiles, fibreboard, rope, and insulation materials (Matheson, 1976; Wood, 1997).

The world has 4.53 million hectares of cultivated linseed area, with a production of 3.97 million tonnes and a productivity of 876.6 kg ha^{-1}. (Anonymous, 2022). In India, linseed is cultivated on about

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0.228 million hectares, contributing 0.161million tonnes to the annual oilseed production of the country. The average productivity of linseed in India is 682.86 kg ha^{-1}. Madhya Pradesh has the largest growing area (0.077 million hectares) and production (0.057 million tonnes) with 740 kg ha^{-1} productivity. The highest productivity was achieved in the state of Jammu and Kashmir (2480 kg ha^{-1}) (Anonymous, 2022-23). Nitrogen is a structural component of chlorophyll and protein; therefore, the supply of nitrogen is beneficial for growth, carbohydrates, and protein metabolism (Lawania *et al*., 2015). An adequate supply of nitrogen is associated with vigorous vegetative growth and a dark green colour. It promotes cell division and cell enlargement, resulting in more leaf area and thus ensuring better growth, development, plant vigor, and yield (Patel *et al.*, 2017). Sulphur is the fourth major nutrient after nitrogen, phosphorus, and potassium. Sulphur-containing amino acids, namely cystine, cysteine, and methionine, make up one of the most essential factors for plant growth and development (Parmar *et al.,* 2020). Considering these facts in view, a field experiment entitled "Effect of Nitrogen and Sulphur Levels on Productivity and Profitability of Linseed (*Linum usitatissimum* L.)" has been proposed to be conducted at the Crop Research Centre, School of Agriculture, ITM University, Gwalior (M.P.) in the ensuing *rabi* season of 2023–24.

Materials and Methods

The experiment was conducted at Crop Research Centre, School of Agriculture, ITM University Gwalior (M.P.) during the *Rabi* season of 2023-24. The soil of the experimental field is sandy loam in texture with a pH of 7.9 and the soil medium is low in organic carbon (0.30%). ITM University is situated geographically at 26°14′N latitude and 78°14′E longitude. It falls under the cliffs plateau and subtropical climate zone of Madhya Pradesh. The linseed variety used for the study was Jawahar Linseed Sagar-79 (JLS-79), released by CVRC, New Delhi, in 2016 through AICRP for cultivation under irrigated situations in the whole of Madhya Pradesh. Urea was used as a source of nitrogen fertilizer and gypsum as sulphur fertilizer. The treatment consisted of three levels of nitrogen (40, 80 and 120 kg N ha^{-1}), and three levels of sulphur (30, 40 and 50 kg S ha^{-1}), and one absolute control. The experiment was laid out in a randomized block design (RBD) in a factorial arrangement replicated three times. The field layout was prepared, and the treatments were assigned to each experimental plot randomly within a block plot spacing 30 cm × 10 cm. Linseed seed was sown in rows at the recommended rate of 30 kg ha^{-1} on the prepared fine seed bed on November 7, 2023. Nitrogen fertilizer in the form of urea was applied at the specified rates in two equal parts, i.e., half was applied at the time of sowing and the remaining half was top-dressed just at the start of the flowering stage. Sulphur was applied in the form of gypsum at the specified rates at sowing. All the broad leaf and grass weeds were removed by hand weeding at 30-35 DAS. Harvesting started on at March 7, 2024. During harvesting, the yield attributes of linseed was recorded i.e., the number of bolls plant^{-1} and the number of seeds boll^{-1}. After threshing and drying, seed yield, straw yield, biological yield, and 1000 grain weight per plot were recorded, and the harvest index was calculated as follows:

$$\text{Harvest index (\%)} = \frac{\textit{Economicyield}}{\textit{Totalbiologicalyield}} \times 100$$

Moreover, the cost of cultivation, gross return, net return, and benefit-cost ratio were calculated. 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 significant difference values were computed for 5 percent probability of error.

Results and Discussion

Yield attributes and yield

The data revealed that the significantly higher number of bolls plant^{-1} (70.00), number of seeds boll^{-1} (8.19), test weight (7.74 g), seed yield (852.63 kg ha^{-1}), straw yield (1617.00 kg ha^{-1}), biological yield (2469.63 kg ha^{-1}), and harvest index (34.58 %) were recorded with 120 kg N ha^{-1}, which was found to be *at par* with 80 kg N ha^{-1} and followed by 40 kg N ha^{-1} due to the enhanced nitrogen availability supporting better plant growth and development. Whereas the minimum number of bolls plant^{-1} (34.61), number of seeds boll^{-1} (6.79), test weight (7.00 g), seed yield (493.68 kg ha^{-1}), straw yield (1026.78 kg ha^{-1}), biological yield (1520.46 kg ha^{-1}), and harvest index (32.87 %) were recorded under absolute control (0 kg N ha^{-1}) due to the nitrogen deficiency limiting essential physiological processes and growth. Similar findings were also reported by Awasthi *et al.*

(2011), Patel *et al.* (2017), Parmar *et al.* (2020), Solo *et al.* (2021), Patel *et al.* (2022), Patel *et al.* (2023) and Rajput *et al.* (2023).

The data from Table 1 and 2 showed that the significantly higher number of bolls plant^{-1} (69.11), number of seeds boll^{-1} (8.16), test weight (7.71 g), seed yield (850.81 kg ha^{-1}), straw yield (1614.68 kg ha^{-1}), biological yield (2465.49 kg ha^{-1}), and harvest index (34.56 %) were recorded with 50 kg S ha^{-1}, which was found to be *at par* with 40 kg S ha^{-1} and followed by 30 kg S ha^{-1} due to optimal sulphur availability, enhancing enzyme activity, protein synthesis and chlorophyll formation. Whereas the minimum number of bolls plant^{-1}, number of seeds boll^{-1}, test weight, seed yield, straw yield, biological yield, and harvest index were recorded under absolute control (0 kg S ha^{-1}) due to the sulphur deficiency limiting vital physiological processes and growth. Similar findings were also reported by Jimo and Singh (2017), Parmar *et al.* (2020), Vyas *et al.* (2020), Solo *et al.* (2021), Pawar *et al.* (2023) and Rajput *et al.* (2023).

Table 1. Effect of different levels of nitrogen and sulphur on yield attributes of linseed

Treatments	Yield attributes		
	No. of bolls plant^{-1}	No. of seeds boll^{-1}	Test weight (g)
Absolute control	34.61	6.79	7.00
A. Nitrogen Levels (kg ha^{-1})			
N_1- 40 kg ha^{-1}	55.47	7.31	7.56
N_2- 80 kg ha^{-1}	68.85	8.09	7.62
N_3- 120 kg ha^{-1}	70.00	8.19	7.74
SEm±	1.97	0.21	0.22
CD (P=0.05)	5.87	0.64	NS
B. Sulphur Levels (kg ha^{-1})			
S_1- 30 kg ha^{-1}	57.03	7.34	7.60
S_2- 40 kg ha^{-1}	68.17	8.09	7.61
S_3- 50 kg ha^{-1}	69.11	8.16	7.71
SEm±	1.97	0.21	0.22
CD (P=0.05)	5.87	0.64	NS
Interaction (N×S)			
SEm±	3.42	0.37	0.37
CD (P=0.05)	NS	NS	NS

Economics

The data from Table 3 indicated that the maximum cost of cultivation was recorded in the treatment combination of T_{10}- 120 kg N ha^{-1} + 50 kg S ha^{-1} (₹ 25169.30), and the minimum cost of cultivation was recorded in the treatment combination of T_{1}- 0 kg N ha^{-1} + 0 kg S ha^{-1} (₹ 22219.40). The maximum gross return (₹ 75668.46), net return (₹ 51297.46), and benefit-cost ratio (2.10 re^{-1} invested) were recorded in the treatment combination of T_6- 80 kg N ha^{-1} + 40 kg S ha^{-1}. Whereas the minimum gross return (₹ 40106.26), net return (₹ 17886.86), and benefit-cost ratio (0.81 re^{-1} invested) were recorded in the treatment combination of T_{1}- 0 kg N ha^{-1} + 0 kg S ha^{-1}. Similar findings were also reported by Parmar *et al.* (2020) and Patel *et al.* (2022).

Interaction effect

The interaction effect between different levels of ni-

Table 2. Effect of different levels of nitrogen and sulphur on yield of linseed:

Treatments	Yield (kg ha^{-1})			Harvest index (%)
	Seed	Straw	Biological	
Absolute control	493.68	1026.78	1520.46	32.87
A. Nitrogen Levels (kg ha^{-1})				
N_1- 40 kg ha^{-1}	678.31	1309.92	1988.23	34.32
N_2- 80 kg ha^{-1}	843.58	1605.46	2449.04	34.39
N_3- 120 kg ha^{-1}	852.63	1617.00	2469.63	34.58
SEm±	21.27	52.92	59.31	-
CD (P=0.05)	63.19	157.24	176.22	-
B. Sulphur Levels (kg ha^{-1})				
S_1- 30 kg ha^{-1}	680.97	1312.93	1993.90	34.25
S_2- 40 kg ha^{-1}	842.73	1604.78	2447.51	34.48
S_3- 50 kg ha^{-1}	850.81	1614.68	2465.49	34.56
SEm±	21.27	52.92	59.31	-
CD (P=0.05)	63.19	157.24	176.22	-
Interaction (N×S)				
SEm±	36.84	91.67	102.73	-
CD (P=0.05)	NS	NS	NS	-

Table 3. Effect of different levels of nitrogen and sulphur on economics of linseed

Treatments	Cost of cultivation (₹ ha^{-1})	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	B-C ratio
T_1- 0 kg N ha^{-1} + 0 kg S ha^{-1}	22219.40	40106.26	17886.86	0.81
T_2- 40 kg N ha^{-1} + 30 kg S ha^{-1}	23572.70	45706.22	22133.52	0.94
T_3- 40 kg N ha^{-1} + 40 kg S ha^{-1}	23849.40	57314.39	33464.99	1.40
T_4- 40 kg N ha^{-1} + 50 kg S ha^{-1}	24127.70	61388.94	37261.24	1.54
T_5- 80 kg N ha^{-1} + 30 kg S ha^{-1}	24093.50	59227.64	35134.14	1.46
T_6- 80 kg N ha^{-1} + 40 kg S ha^{-1}	24371.00	75668.46	51297.46	2.10
T_7- 80 kg N ha^{-1} + 50 kg S ha^{-1}	24648.50	69357.47	44708.97	1.81
T_8- 120 kg N ha^{-1} + 30 kg S ha^{-1}	24614.30	60101.87	35487.57	1.44
T_9- 120 kg N ha^{-1} + 40 kg S ha^{-1}	24891.80	71075.51	46183.71	1.86
T_{10}- 120 kg N ha^{-1} + 50 kg S ha^{-1}	25169.30	75218.02	50048.72	1.99

trogen and sulphur on the number of bolls $plant^{-1}$, number of seeds $boll^{-1}$, test weight, seed yield, straw yield, biological yield, and harvest index was found to be non-significant.

Conclusion

On the basis of the results obtained in this study, it was concluded that the application of 120 kg N ha^{-1} and 50 kg S ha^{-1} recorded significantly higher yield attributes and yield of linseed, which was found to be *at par* with the application of 80 kg N ha^{-1} and 40 kg S ha^{-1}. However, the combined application of 80 kg N ha^{-1} and 40 kg S ha^{-1} recorded the maximum net return and benefit-cost ratio.

Conflict of Interest- None

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