E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2024; SP-7(7): 425-428
Received: 11-05-2024
Accepted: 16-06-2024

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Effect of fertilizer level on growth and yield of linseed (*Linum usitatissimum* L.)

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DOI: https://doi.org/10.33545/2618060X.2024.v7.i7Sf.1109

Abstract
The experiment was carried out at Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani during *rabi* season 2020-21. To study the effect of different fertilizer doses in linseed (*Linum usitatissimum* L.) The experiment was laid out in randomized block design with three replication and nine treatments of fertilizer doses such as T_1 : 25:25:00 NPK kg ha^{-1} (RDF), T_2 : 30:30:00 NPK kg ha^{-1}, T_3 : 35:35: 00 NPK kg ha^{-1}, T_4 : 25:25:25 NPK kg ha^{-1}, T_5 : 30:30:00 NPK kg ha^{-1}, T_6 : 35:35: 00 NPK kg ha^{-1}, T_7 : 40:20:20 NPK kg ha^{-1}, T_8 : 50:25:25 NPK kg ha^{-1}, T_9: control. The result of the experiment revealed that among the different treatments 50:25:25 NPK kg ha^{-1} (T_8) recorded the higher growth attributes such as plant height(cm), more number of functional leaves, higher leaf area (dm^2), higher number of branches, higher dry matter accumulation (g), also yield and yield attributes such as weight of seed plant^{-1}, number of pod plant^{-1}, number of seeds plant^{-1}, seed index (g), seed yield kg ha^{-1}, straw yield kg ha^{-1}, harvest index % and but it was comparable with the treatments 40:20:20 NPK kg ha^{-1} (T_7).

Keywords: Linseed, growth attributes, leaf area, harvest index, dry matter accumulation

1. Introduction
Linseed or flax (*linum usitatissimum* L.) belongs to family Linaceae is one of important *rabi* oilseed crop. It contains 35 to 45% oil. The oil cake left, after extraction of oil is a most valuable cake, perhaps the most favorite cattle feed. The oil cake is a good feed for milch cattle as well as poultry and hence price of linseed cake is higher than mustard cake. It is cultivated for the oil extraction from the seed or fiber from the stem. Every part of the linseed plant is utilized commercially either directly or after processing. Linseed oil is used for human consumption and it contains alpha-linolenic acid (ALA), a poly unsaturated fatty acid that has nutritional and health benefits. Apart from ALA, linseed is widely used as nutritional and functional food in the western world due to its high contents of therapeutic health promoting substances such as omega-3 fatty acid, soluble and insoluble fiber, lignin and its suitability to use with bread, breakfast cereals and other food products. Omega-3 fatty acid helps to reduce the risk of cardiovascular disease and cancer. The linseed oil is an important ingredient in the manufacture of paint varnish, printing ink and linoleum. It contains about 5% N, 1.4% P_2O_5 and 1.8% K_2O. The major consumers of linseed oil in India are West Bengal, Maharashtra, Delhi and Uttar Pradesh accounting for 25% of the total consumption in India.

Linseed crop is cultivated over an area of 22.70 lakh ha with a production of 22.39 lakh tonnes and productivity is 986 kg ha^{-1} at world level. In India, it occupies an area of 2.70 lakh ha with a production of 1.25 lakh tonnes and a productivity is 477 kg ha^{-1}. India ranks third in area after Canada and Kazakhstan. India contributes about 14.88% and 6.57% of world's area and production respectively. The major part of linseed growing area lies in the states of Madhya Pradesh, Himachal Pradesh, Chhattisgarh, Uttar Pradesh, Maharashtra, Bihar, Odisha, Jharkhand, Karnataka and Assam accounting for more than 97% of total area (Anonymous, 2016) [1]. The area under linseed in Maharashtra is 10.2 thousand ha, with an annual production of 2.5 thousand tonnes and averages productivity is 243 kg ha^{-1} (Anonymous, 2017) [2].

Low productivity of linseed is due to many factors such as genotype, nutrient management, irrigation management, weed management etc. but nutrient management assume more importance as it directly influence the crop growth and production. Plant nutrition is key input to

increase the productivity. Hence nutrient management assume major importance to improve crop yield.

2. Materials and Methods

The experiment was laid out in field at Experimental farm, Department of Agronomy, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani during *rabi* season 2020-21. The experiment was laid out in Randomized block design with Treatment details: T_1 : 25:25:00 NPK kg ha^{-1} (RDF), T_2 : 30:30:00 NPK kg ha^{-1}, T_3 : 35:35: 00 NPK kg ha^{-1}, T_4 : 25:25:25 NPK kg ha^{-1}, T_5 : 30:30:00 NPK kg ha^{-1}, T_6 : 35:35: 00 NPK kg ha^{-1}, T_7 : 40:20:20 NPK kg ha^{-1}, T_8 : 50:25:25 NPK kg ha^{-1}, T_9: control. For treatment T_7 and T_8 nitrogen applied in two splits of 50% as basal dose and remaining at 30 DAS. For all the remaining treatments entire dose of RDF was applied at the time of sowing. The net plot size was 4.8 m x 4.2 m. Sowing was done on 2nd November, 2020. The spacing of 30 cm x 15 cm was maintained. The recommended cultural practices and plant protection measures were taken.

3. Results and Discussion

3.1 Effect of different fertilizers doses on growth parameters.

The data on mean plant height (cm), mean no of functional leaves, mean leaf area (dm^{-2}), mean no. of branches, and mean dry matter accumulation (g) as influenced by different treatments are presented Table 1.

3.1.1 Plant height (cm)

It was observed that the mean plant height (cm) of linseed plant was increased with successive stages of crop growth. Mean plant height (cm) of linseed crop at 30 DAS was found to be non-significant. At 90 DAS taller plants of linseed crop was recorded with application of 50:25:25 NPK kg ha^{-1} (T_8) (31.50 cm) which was significantly higher than other treatment except for 40:20:20 (T_7) (31.10 cm). Among the remaining treatments 35:35:35 NPK kg ha^{-1} (T_6) (27.23 cm), 30:30:30 NPK kg ha^{-1} (T_5) (26.67), 35:35:00 NPK kg ha^{-1} (T_3) (25.17 cm) and 30:30:00 NPK kg ha^{-1} (T_2) (24.53 cm) were found at par with each other. The lowest plant height was recorded at control plot (T_9) (27.67 cm). The increasing fertility level significantly increased the plant height. Significantly the taller plants, higher stem length and stem weight plant^{-1} was recorded with the application of 150 N kg ha^{-1} than 0 N kg ha^{-1} (Gabiana *et al.*, 2005) [10]. Similar results were reported by Nandanwar *et al.*, (2000) [15] and Gokhale *et al.*, (2008) [11].

Table 1: Mean plant height (cm), mean no of leaves, mean leaf area (dm^{-2}), mean no of branches and mean no of dry matter accumulation (g) of linseed influenced of different treatments.

Tr. No	Treatment details	Plant height (cm)	Number of functional leaves	Leaf area (dm^2)	Number of branches	Dry matter (g)
T_1	25:25:00 kg NPK/ha (RDF)	21.87	34.65	0.23	6.47	5.23
T_2	30:30:00 kg NPK/ha	24.53	40.90	0.27	7.37	6.67
T_3	35:35: 00 kg NPK/ha	25.17	42.56	0.29	7.63	7.33
T_4	25:25:25 kg NPK/ha	22.97	37.80	0.25	6.57	6.23
T_5	30:30:00 kg NPK/ha	26.67	45.63	0.32	7.70	8.23
T_6	35:35: 00 kg NPK/ha	27.23	47.36	0.36	7.80	8.50
T_7	40:20:20 kg NPK/ha	30.10	48.98	0.45	8.93	9.00
T_8	50:25:25 kg NPK/ha	31.50	50.23	0.52	9.23	9.27
T_9	Control	21.67	24.96	0.22	6.35	4.60
SE (m)±		1.14	2.68	0.02	0.31	0.46
C.D. at 5%		3.42	8.07	0.06	0.93	1.39
General mean		25.74	41.45	0.32	7.56	7.23

3.1.2 Number of functional leaves plant^{-1}

The effect of different treatments on number of functional leaves of linseed was (50.23) recorded higher with application of 50:25:25 NPK kg ha^{-1} (T_8) which was significantly higher than other treatment except for 40:20:20 NPK kg ha^{-1} (T_7) (48.98). Among the remaining treatments 35:35:35 NPK kg ha^{-1} (T_6) (47.36), 30:30:30 NPK kg ha^{-1} (T_5) (45.63), 35:35:00 NPK kg ha^{-1} (T_3) (42.56) and 30:30:00 NPK kg ha^{-1} (T_2) (40.90) were found at par with each other to be significant at all growth stages except 30 DAS. With higher fertilizer dose, availability of nutrients especially nitrogen has increased which promoted growth of plants in terms of height and leaves due to rapid cell division and cell elongation. Lowest number of functional leaves per plant was recorded by control (T_9) (24.96) at all growth stages.

3.1.3 Leaf area (dm^2) plant^{-1}

The effect of different treatments on leaf area was observed to be significant at all growth stages. At 90 DAS maximum leaf area (dm^2) plant^{-1} of linseed crop was recorded with application 50:25:25 NPK kg ha^{-1}(T_8) (0.52) which was at par with 40:20:20 NPK kg ha^{-1}(T_7) (0.45). It was also found that 35:35:35 NPK kg ha^{-1}(T_6) (0.36), 30:30:30 NPK kg ha^{-1}(T_5) (0.32), 35:35:00 NPK kg ha^{-1} (T_3) (0.29) and 30:30:00 NPK kg ha^{-1}(T_2) (0.27) were at par with each other. Similar findings were also recorded by Khajani *et al.* (2012) [13]. The lowest leaf area was found at control treatment (T_9) (0.22).

3.1.4 Number of branches plant^{-1}

At 90 DAS maximum number of branches of linseed was recorded with application of 50:25:25 NPK kg ha^{-1}(T_8) (9.23) which was significantly higher than other treatment except for 40:20:20 NPK kg ha^{-1}(T_7) (8.93). It was observed 35:35:35 NPK kg ha^{-1}(T_6) (7.80), 30:30:30 NPK kg ha^{-1} (T_5) (7.70), 35:35:00 NPK kg ha^{-1}(T_3) (7.63) and 30:30:00 NPK kg ha^{-1}(T_2) (7.37) were at par with each other. These findings were in accordance with Khajani *et al.* (2012) [13], Singh *et al.* (2013) [20]. The minimum number branches were recorded by control (T9) (6.35).

3.1.5 Dry matter accumulation plant^{-1}(g)

The dry matter accumulation plant^{-1} (g) was increased continuously with advancement in age of crop. The rate of dry matter accumulation was slow initially up to 30 DAS, very fast between 30 to 75 DAS and thereafter increased at decreased rate up to 90 DAS. At 90 DAS maximum dry matter of linseed crop was recorded with application of 50:20:20 NPK kg ha^{-1} (T_8) (9.27g) which was significantly higher than other treatment

except for 40:20:20 NPK kg ha^{-1}(T_7) (9.00g). It was observed 35:35:35 NPK kg ha^{-1}(T_6) (8.50g), 30:30:30 NPK kg ha^{-1}(T_5) (8.23g), 35:35:00 NPK kg ha^{-1}(T_3) (7.33g) and 30:30:00 NPK kg ha^{-1}(T_2) (6.67g) were at par with each other. The minimum dry matter was recorded by control (T_9) (4.60g) at all growth stages. Similar results were also found by Gokhale *et al.* (2008) [11] and Singh *et al.* (2013) [20].

3.2 Effect of different fertilizer doses on yield attributes and yield of linseed

The data on weight of seed plant-1(g), no of capsule plant-1, no of seed capsule-1, weight of capsule Plant-1(g), weight of seed capsule-1(g), seed yield, and straw yield as influenced by different treatment presented in Table 2.

3.2.1 Weight of seed plant^{-1} (g)

Application of 50:25:25 NPK kg ha^{-1}(T_8) (8.90g) which recorded significantly higher weight of seed plant^{-1} than other treatments except for of 40:20:20 kg NPK ha^{-1} (T_7) (8.28g). Among other treatments i.e., 35:35:35 NPK kg ha^{-1}(T_6) (7.68), 30:30:30 NPK kg ha^{-1}(T_5) (7.44g), 35:35:00 NPK kg ha^{-1}(T_3) (7.01g) and 30:30:00 NPK kg ha^{-1}(T_2) (6.78g) which was found at par with each other. The lowest weight of seed plant^{-1} recorded with control (T_9) (4.34g).

Table 2: Weight of seed plant(g), No. of seed caps^{-1}, Wt. of capsule plant^{-1}, Weight of seed caps^{-1}, seed yield, straw yield linseed influenced by different treatments.

Trt. No.	Treatment details	Weight of seed plant (g)	No. of seed caps^{-1}	Weight of capsule plant^{-1} (g)	Weight of seed caps^{-1} (g)	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1	25:25:00 kg NPK/ha (RDF)	4.94	5.93	2.93	0.05	645	1470
T_2	30:30:00 kg NPK/ha	6.78	6.33	4.17	0.06	781	1785
T_3	35:35: 00 kg NPK/ha	7.01	6.40	4.37	0.06	835	1800
T_4	25:25:25 kg NPK/ha	5.62	6.18	3.50	0.05	695	1510
T_5	30:30:00 kg NPK/ha	7.44	6.50	4.77	0.07	839	1830
T_6	35:35: 00 kg NPK/ha	7.68	6.57	4.90	0.07	862	1873
T_7	40:20:20 kg NPK/ha	8.28	6.63	5.57	0.08	1050	2165
T_8	50:25:25 kg NPK/ha	8.90	6.87	6.07	0.09	1113	2225
T_9	Control	4.34	5.3	1.93	0.04	496	1125
SE (m)±			0.36	0.29	0.25	43	112.8
C.D. at 5%			1.09	NS	0.75	129	339.48
General mean			6.78	6.30	4.24	813	1754

3.2.2 Number of seeds capsule^{-1}(g)

The treatment differences of mean number of seeds capsule^{-1} (g) of Linseed crop due to different treatments were found non-significant.

3.2.3 Weight of capsule plant^{-1}(g)

Application of 50:25:25 NPK kg ha^{-1} (T_8) (6.07g) which recorded significantly higher weight of capsule plant^{-1} than other treatments but was found at par with 40:20:20 NPK kg ha^{-1} (T_7) (5.57g). Among other treatments i.e., 35:35:35 NPK kg ha^{-1} (T_6) (4.90g), 30:30:30 NPK kg ha^{-1} (T_5) (4.77g), 35:35:00 NPK kg ha^{-1} (T_3) (4.37g) and 30:30:00 NPK kg ha^{-1} (T_2) (4.17g) which was found at par with each other. The lowest weight of capsule plant^{-1} recorded with control (T_9) (1.93g). Heavier capsule weight recorded in higher fertilizer dose treatment is due to higher leaf area promoted by availability of nutrients which in turn helps in photosynthesis and dry matter accumulation. Choubey *et al.* (2002) [5] has also reported similar kind of results.

3.2.4 Weight of seeds capsule^{-1} (g)

The treatment differences mean of weight of seeds capsule^{-1} of linseed crop due to application of different fertilizer doses were significant. The mean weight of seeds capsule^{-1} was 0.06 g. The higher weight of seeds capsule^{-1} was obtained due to the application of 50:25:25 NPK kg ha^{-1} (T_8) (0.09 g) and which was at par with application of 40:20:20 NPK kg ha^{-1} (T_7) (0.08g) and found significantly superior over rest of the treatments. Significantly the lowest weight of seeds capsule^{-1} (0.04 g) was produced with the treatment T_9 (Control) also reported similar kind of result.

3.2.5 Linseed seed yield (kg ha^{-1})

The treatments differences of seed yield of linseed crop due to different treatments were found significant. The mean seed yield (kg ha^{-1}) of linseed crop was recorded 813 kg ha^{-1}. Data from Table 2. revealed that application of 50:25:25 NPK kg ha^{-1} (T_8) which was significantly higher seed yield (1113 kg ha^{-1}) higher than other treatment except for application of 40:20:20 NPK kg ha^{-1} (T_7) (1050 kg ha^{-1}). It was observed 35:35:35 NPK kg ha^{-1} (T_6) (862 kg ha^{-1}), 30:30:30 NPK kg ha^{-1} (T_5) (839 kg ha^{-1}), 35:35:00 NPK kg ha^{-1} (T_3) (835 kg ha^{-1}) and 30:30:00 NPK kg ha^{-1} (T_2) (781 kg ha^{-1}) were at par with each other.

The lowest seed yield of linseed obtained with control treatment (T_9) (496 kg ha^{-1}). Higher seed yield recorded in higher fertilizer dose treatment is due to higher leaf area promoted by availability of nutrients which in turn helps in photosynthesis and dry matter accumulation which increases the weight of capsule in plants which in turn resulted in higher seed yield. Similar results were reported by Khajani *et al.* (2012) [13]

3.2.6 Linseed straw yield (kg ha^{-1})

The mean straw yield kg ha^{-1} was 1754 kg ha^{-1}. The straw yield was differed significantly due to different treatments. The highest straw yield (2225 kg ha^{-1}) recorded with application of 50:25:25 NPK kg ha^{-1} (T_8) which was at par with 40:20:20 NPK kg ha^{-1}(T_7) (2165 kg ha^{-1}) and significantly superior over all other treatment. This might be due to the higher growth and photosynthesis which resulted in more dry matter accumulation in treatment receiving higher fertilizer doses. Similar trend of observation was also reported by Delesa and Choferie (2016) [7]. The lowest straw yield (1125 kg ha^{-1}) was observed with treatment T_9 (Control). This treatment was found significantly inferior over rest of the treatments.

4. Conclusion

Single season experiment conducted on linseed crop with different levels NPK kg ha^{-1} of fertilizer doses during *rabi* season 2020-21 concluded that application of 50:25:25 NPK kg ha^{-1} (T_8) recorded higher growth parameters, yield attributes and grain yield having at par values with treatment 40:20:20 NPK kg

ha^{-1} (T_7) and significantly superior over rest of the treatments. Higher benefit: cost ratio was found in 50:25:25 NPK kg ha^{-1} (T_8). On the basis of present investigation, it may be concluded that for getting maximum growth attributes, yield attributes and yield. Application of 50:25:25 NPK kg ha^{-1} (T_8) or 40:20:20 NPK kg ha^{-1} (T_7) to linseed crop is more profitable.

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