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

www.agronomyjournals.com
2024; 7(4): 168-172
Received: 24-01-2024
Accepted: 28-02-2024

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Studies on moisture conservation practices in linseed (*Linum usitatissimum* L.)

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DOI: https://doi.org/10.33545/2618060X.2024.v7.i4c.554

Abstract
A field experiment was conducted during *Rabi* season of 2020-2021 at Experimental Farm, of Agronomy Section, at College of Agriculture, Latur to determine the Studies on the moisture conservation practices in linseed. The soil of experimental plot was clay in texture, neutral in soil reaction having pH (7.02) with chemical composition such as available nitrogen (231 kg ha^{-1}), slightly low in available phosphorous (8.57 kg ha^{-1}) and very high in available potassium (580 kg ha^{-1}). It was well drained and favorable for optimum crop growth. The gross monetary return was significantly influenced due to different treatments. Significantly the highest gross monetary return of ₹ 85,888 ha^{-1} was obtained with the application of soybean straw mulching at 5 t ha^{-1}.
The experiment was laid out in Randomized Block Design with Eight treatments. The treatments were T_1: No mulching, T_2: Soybean straw mulching at 5 t ha^{-1}, T_3: Spreading of FYM at 5 t ha^{-1} as a mulch, T_4: Incorporation of FYM in soil at 5 t ha^{-1}, T_5: Dust mulching at 30 DAS & Hand weeding, T_6: Dust mulching at 30 DAS, Hand weeding & Hoeing at 45 DAS, T_7: Dust mulching at 30 DAS & Hoeing, T_8: Dust mulching at 30 DAS & Hoeing at 45 DAS. The gross and Net plot size of each experimental unit was 5.4 m x 4.5 m and 4.5 m x 3.6 m, respectively. Sowing was done on 09-November-2021 by dibbling method with seed rate of 20 kg ha^{-1}. The recommended dose of fertilizer for linseed crop was 40:20:20: kg NPK ha^{-1}.
The result showed that application of Soybean straw mulching at 5 t/ ha^{-1} (T_2) was found most effective for increasing growth and productivity of linseed. Among the different treatments, application of Soybean straw mulching at 5 t/ ha^{-1} was found beneficial in increasing growth, yield attributing characters and seed yield of linseed than No mulching alone or combination with Spreading of FYM at 5 t ha^{-1} as mulch respectively.
Application of Soybean straw mulching at 5 t ha^{-1} (T_2) was superior in respect of gross and net monetary returns and followed by T_3 & T_4. Similarly higher B:C ratio (2.29) was recorded with the application of Soybean straw mulching (T_2).

Keywords: Linseed, soybean straw, FYM, yield attributes

Introduction
Linseed (*Linum usitatissimum* L.) is an important *Rabi* oilseed crop belonging to the family Linaceae. It is originated from Mediterranean region and Southwest Africa. The name Linum originated from *lin* or thread and the species name *usitatissimum* is a Latin word meaning most useful. It has been grown from ancient time for getting fiber (flex) and for its seed which is rich in oil. It is known as Agasi (Kannada), Jawas or Alashi in (Marathi), Alsi in (Hindi) and Ousahalu in (Telugu). The Genus *Linum* has over 200 species of *Linum usitatissimum* L. It is widely cultivated for economically important species. It has somatic chromosome number 2n=30 and varies from 18 to 86 in other species. There is two morphologically different cultivated species of linseed are recognized, mainly for flax and seed. The flax type of linseed is commercially grown for extraction of fibre, whereas the linseed is mainly used for extraction of oil from there seed.
The divers agro-ecological condition in India is favorable for growing oilseeds. Oil and fat occupy an important role in human life. They form essential and integral part of our daily diet, oilseed have also medicinal and therapeutic values.

The oilseeds are good source of energy for human body.

It is the third largest natural fibre producing crop and one of the fifth major oilseed crop in the world. It is grown under rain fed and irrigated situation. It contains 35 to 47 percent oil and 11 to 32 percent protein. The oil extracted from linseed is mainly used in paint industries as a medium for oil paint, pad ink and printing ink etc. In India the paint and allied industries are the major consumer of linseed oil accounting to 70 percent of the total consumption.

In a germination of seed, primary tap-root develops from seed in which grow to words down producing numerous small lateral roots. Stem is either erect or procumbent, depending on the fiber of linseed varieties. The plant height normally varies between 40 to 70 cm. Leaves are linear to lanceolate, smooth, tapering to a blunt apex and green to bluish green. Inflorescences are carymbose, with a single flower born terminally on the pedicel in a multiple flower panicle. Tolerance to biotic and abiotic stress is a most important characteristic of linseed crop. Due to this property of linseed survival and cultivation of linseed is prevailing in wide range of tropical, sub-tropical and temperate regions.

Linseed contains 35-70% linolenic acid, (omega-3 fatty acid) this factor is reduces blood cholesterol concentration of cardiovascular tissue and benefited by affecting prostaglandins and lleukotrien related to blood clotting and inflammatory disorder in blood like rheumatoid arthritis. Linseed has a natural source of lignin which is anti-carcinogenic properties and also provide protection against certain form of cancer due to estrogenic and anti-estrogenic activities happen inside the body.

Among the oilseed crops linseed is an important crop in the world cultivated over an area of 22.70 lakh hectare with a high production of 22.39 lakh tons and productivity is 985 kg ha-^{1}. In India, linseed is mainly grown in central part of the country, like Madhya Pradesh, Eastern Maharashtra, Bihar and Uttar Pradesh. It also grown in a small extent in Karnataka, Odisha, Rajasthan, West Bengal and Andhra Pradesh. Total cultivated area of linseed in India is about 0.017 Mha over a total production of 0.09 MT and productivity is 575 kg ha-¹ (Anonymous, 2020) [2, 3]. In Maharashtra total area under linseed cultivation is about 7000 ha-^{1} with an annual production of 2.7 thousand tons. The average productivity of linseed in Maharashtra is about 380 kg ha-¹. It is below world and national average. The area under linseed in Latur district is about 1.75 hundred ha-^{1}, with total production is 0.7 hundred tones in per hectare productivity of 387.5 kg ha-¹ (Anonymous, 2020) [2, 3].

The national average productivity of linseed is very low as compared to the world. Low productivity of linseed among the many reasons, that is an inadequate and imbalanced fertilization are the major factor. The major implementation of the lower national average productivity have been the area of production under major linseed producing states of India in that basically lies under irrigated input starved and poor crop management conditions. The cultivation of low yielding linseed cultivar under input starved conditions are the major obstacles in low productivity of national level. To increase the productivity of linseed, use of balanced fertilization by the application of chemical fertilizer along with organic manure is a great importance. Integration of inorganic fertilizer with organic manure will not only help to sustain the crop productivity but also effective for keeping good soil health and improving the nutrient use efficiency.

To enhance the productivity of linseed use of mulch can increase the yield, water use efficiency, profitability and simultaneously decreasing weed problems reported that Beneficial effect of rice straw mulch is a protective layer of organic material that is spread on the top of soil to check moisture loss from the soil by preventing evaporation from soil and decreasing water loss from plant, Prevent weed growth, Improve the soil condition, Provide home for earthworm and natural enemies found in the soil, Mulch helps to regulate soil temperature by shading in summer thus keeping it cool and help insulate it in the winter from chilling wind. Mulching improves nutrients and water retention in soil, encourages favorable soil microbial activity and worms, and suppresses weed growth.

Therefore in view of the above facts the present field experiment entitled studies on moisture conservation practices in linseed (*Linum usitatissimum* L.) was undertaken to find out the effect of moisture conservation practices in linseed at experimental farm, Department of Agronomy, College of Agriculture, Latur during *Rabi* season 2021 with the following objectives:

1. To find out suitable moisture conservation practices in linseed grown under rain fed situation.
2. To study the effect of moisture conservation practices on growth and yield of linseed.
3. To study the economics of moisture conservation practices in linseed.

Materials and Methods

The experiment was conducted during *Rabi* season of 2020-2021 at Experimental Farm of Agronomy section, College of Agriculture, Latur. To study "Studies on moisture conservation practices in Linseed (*Linum usitatissimum* L.)" was laid out in Randomized Block Design with three replications. The experiment consisted of eight treatments.

T_1: No mulching T_2: Soybean straw mulching at 5 t/ha T_3: Spreading of FYM at 5 t/ha, as a mulch, T_4: Incorporation of FYM in soil at 5 t/ha, T_5: Dust mulching at 30 DAS and Hand weeding, T_6: Dust mulching at 30 DAS, Hand weeding and hoeing at 45 DAS, T_7: Dust mulching at 30 DAS & Hoeing, T_8: Dust mulching at 30 DAS & Hoeing at 45 DAS.

The experimental unit was gross plot size of each Gross-5.40 x 4.50 m2 Net plot-4.50 x 3.60 m2 respectively. The Linseed cultivar LS-93 sowing was done by drilling method on 13th Nov. at spacing 30 x 5 cm row and between the plants. The RDF 40:20:20 NPK kg ha^{-1} was applied, half dose of nitrogen along with full dose of phosphorous and potash was applied as basal dose and reaming dose of nitrogen was applied at 30DAS. Seed rate 20 kg ha^{-1} Year of experiment (Season): *Rabi* 2020 Source of fertilizer Urea and DAP. The crop was harvested on 30/01/2021.

Harvest index indicates the efficiency of plant material to convert the photosynthate in to the economic yield and it is worked out as.

$$\text{Harvest Index (\%)} = \frac{\text{Economic yield (kg ha-}^{1}\text{)}}{\text{Biological yield of respective plot (kg ha-}^{1}\text{)}} \text{ X } 100$$

The benefit cost ratio was calculated on the basis of formula given below

$$\text{B: C ratio} = \frac{\text{Gross monetary returns (ha-}^{1}\text{)}}{\text{Cost of cultivation (ha-}^{1}\text{)}}$$

Results and Discussion

Yield attributes

Data on yield contributing character viz. Number of capsules per plant, weight of capsules per plant (g), number of seeds per capsules and weight of seeds per plant (g), test weight (g) are presented in Table 1 and depicted in Fig. 1. From Table 1 it showed that the mean number of capsules per plant, weight of capsule per plant (g), number of seed per capsule, weight of seed per plant (g) and test weight (g) were 69.90, 3.59 (g), 6.45, 2.43 (g), and 7.26 (g) respectively.

Table 1: Number of capsules per plant, weight of capsules per plant (g), number of seeds per capsules and weight of seeds per plant (g), test weight (g) as influenced by different treatments at harvest

Treatments	No. of capsules plant^{-1}	Weight of capsules plant^{-1} (g)	No of seeds capsules^{-1}	Weight of seed plant^{-1} (g)	Test weight (g)
T_1- No mulching	50.80	2.36	4.73	1.56	5.33
T_2- Soybean straw mulching at 5 t/ha^{-1}	82.96	5.37	8.6	2.67	8.66
T_3- Spreading of FYM at 5 t/ha^{-1} as a mulch	81.60	5.15	8.25	2.47	8.55
T_4- Incorporation of FYM in soil at 5 t/ha^{-1}	79.45	4.91	7.82	2.38	8.41
T_5- DustmulchingaT$_3$0DAS & hand weeding	58.20	2.30	5.36	1.81	6.0
T_6- Dust mulching at 30 DAS, Hand weeding and hoeing at 45 DAS	71.82	3.09	5.96	2.17	7.26
T_7- Dust mulching 30 DAS & Hoeing	64.20	2.78	5.60	2.02	6.66
T_8- Dust mulching at 30 DAS & hoeing at 45 DAS	70.15	2.81	5.53	2.05	7.26
SE#	2.96	0.20	0.34	0.094	0.40
CD @ 5%	8.97	0.63	1.03	0.287	1.23
General mean	69.90	3.59	6.45	2.43	7.26

Number of capsules per plant

Data on mean number of capsules plant^{-1} was significantly influenced by various treatments. The mean number of capsules plant^{-1} was 69.90. Significantly the highest number of capsules plant^{-1} (82.96) was produced by the application of soybean straw mulching at 5 t/ha^{-1} (T_2) which was at par with T_3 and found significantly superior over rest of the treatments. Significantly the lowest pod yield plant^{-1} (50.80) was obtained with the treatment (Control) T_1.

Weight of capsules per plant (g)

The data on mean weight of capsules per plant was significantly influenced by various treatments. The mean weight of capsules per plant was 3.59. The higher weight of capsules plant^{-1} (5.37 g) was obtained due to the application of soybean straw mulching at 5 t/ha^{-1} (T_2) which was at par with T_3 and found significantly superior over rest of the treatments.

Significantly the lowest weight of capsules plant^{-1} (2.36 g plant^{-1}) was produced with the treatment T_1.

Number of seeds plant^{-1}

The data on mean number of seeds plant^{-1} was not influenced significantly by various treatments. The mean number of seeds plant^{-1} was 6.45. The maximum number of number of seed plant^{-1} (8.6) was produced by the application of soybean straw mulching at 5 tha^{-1} (T_2) and lowest number of seed plant^{-1} (4.73 plant^{-1}), (Control) T_1.

Seedyieldplant^{-1}(g)

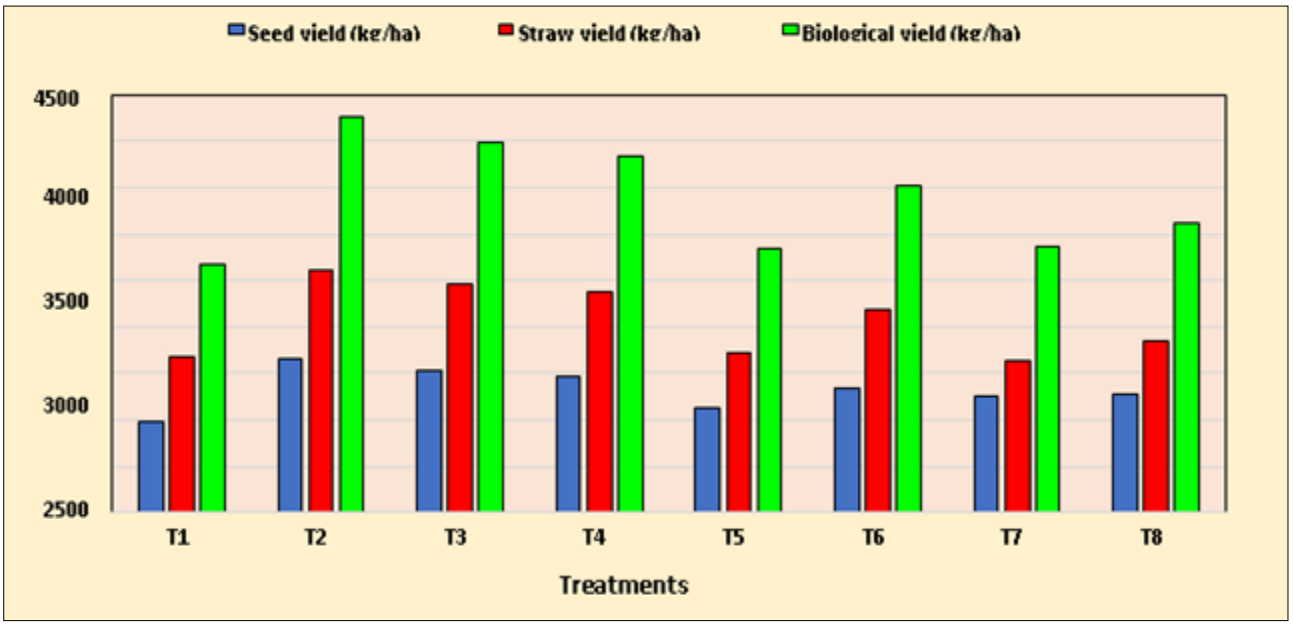
The data on mean weight of seed per plant was influenced significantly by various treatments. The mean number of seed plant^{-1} was 2.43 the maximum weight of seed per plant (2.67 g) was produced by the application of soybean straw mulching at 5 tha^{-1} (T_2) which was at par with T_3 and found significantly superior over rest of the treatments. Significantly the lowest seed yield per plant (1.56 g) was obtained due to Control (T_1).

Test weight (g)

The data on mean test weight (g) was not influenced significantly by various treatments. The mean test weight was (7.26 g). Numerically highest test weight (8.66 g) was observed with the application of soybean straw mulching at 5 t ha^{-1}. (T_2) and lowest test weight observed was 5.33 g due to treatment (Control) T_1.

Table 2: Seed yield (kg ha^{-1}), straw yield (kg ha^{-1}), biological yield (kgha^{-1}) and harvest index (%) as influenced by various treatments at harvest

Treatments	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest Index (%)
T_1- No mulching	974	1675	2682	36.31
T_2- Soybean straw mulching at 5 t ha^{-1}	1651	2622	4274	38.64
T_3- Spreading of FYM at 5 t ha^{-1} as a mulch	1530	2460	3990	38.34
T_4- Incorporation of FYM in soil aT_5 tha-^{1}	1470	2370	3840	38.28
T_5- Dust mulching at 30 DAS & hand weeding	1123	1718	2841	39.52
T_6- Dust mulching at 30 DAS, Hand weeding and hoeing at 45 DAS	1343	2184	3527	38.07
T_7- Dust mulching 30 DAS & Hoeing	1248	1628	2876	43.4
T_8- Dust mulching at 30 DAS &hoeing at 45DAS	1267	1848	3115	40.67
SE#	61.23	102	153	1.63
CD@5%	185.75	309.5	464.67	4.95
General mean	1325.9	2063.2	3393.31	39.15



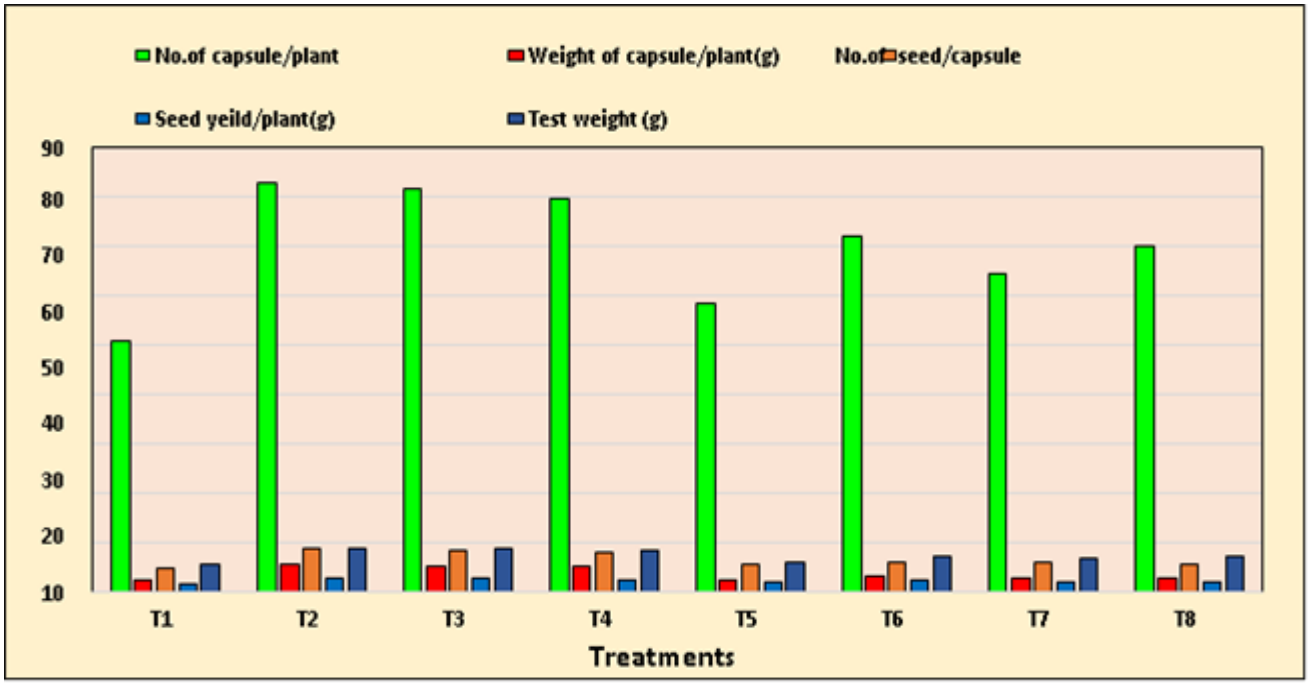


Fig 1: No. of capsules plant^{-1}, Weight of capsules plant^{-1} (g), No. of seed capsules^{-1}, Seed yield plant^{-1} of linseed

The data on mean oil content (%) and oil yield (kg ha^{-1}) is presented in the table 2. and depicted in fig 1. The mean oil content (36.42%) and mean oil yield was (485.78 kg ha^{-1}).

The significant differences were not evident in respect of oil content of linseed seeds due to treatment. However, the highest oil content (39.42%) was observed with the application of soybean straw mulching at 5 tones ha^{-1} (T_2) which was followed by T_3 and T_4. The highest oil yield (650 kg ha^{-1}) was obtained with the application of soybean straw mulching at 5 tons ha^{-1} in (T_2), which was followed by T_3 and T_4 but it was significantly superior over the rest of the treatments. The lowest oil yield (332 kg ha^{-1}) was obtained due to control (T_1).

Which was followed by application of Spreading of FYM at 5 t ha^{-1} as a mulch (412 kg ha^{-1}) and application of Incorporation of FYM in soil at 5 t ha^{-1} (402 kg ha^{-1}). Improvement in oil content and oil yield with micronutrients through FYM might be due to involvement of sulphur directly in oil synthesis. Similar result was observed by Dubey *et al*., (2000) [20] and Yadav *et al*., (2009) [21].

Benefit: Cost ratio

Data in respect of B: C ratios as influenced by various treatments are presented in Table 2. The mean benefit ratio was observed as 1.95. The higher B: C ratio (2.29) was observed with the application of soybean straw mulching at 5 t ha-^{1} (T_2) where as control gave lowest B: C ratio (1.56).

Conclusion

In conclusion, the study elucidates the significant impact of various treatments on yield attributes of linseed. Soybean straw mulching at 5 t/ha-1 (T_2) exhibited the most promising results across multiple parameters including the number and weight of capsules per plant, seed yield, and oil content. This treatment consistently outperformed others, demonstrating its effectiveness in enhancing linseed productivity. Conversely, the control treatment (T_1) consistently yielded the lowest results

across all parameters. Additionally, the application of FYM, particularly spreading and incorporation at 5 t/ha-1, showed notable improvements in seed yield and oil content, attributed to the involvement of sulphur in oil synthesis. The economic analysis revealed that treatments like soybean straw mulching at 5 t/ha-1 offered the highest benefit-to-cost ratio, emphasizing its economic viability. These findings underscore the importance of sustainable agricultural practices, such as mulching and organic amendments, in optimizing linseed yield and economic returns for farmers. Further research could explore the long-term effects and sustainability of these treatments on linseed cultivation.

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