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Effect of Different Organic Ammendments on Growth and Yield Attributes of Linseed [*Linum usitatissimum* (L.)]

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted during *Rabi* 2023-24 at the experimental farm of the model Organic Farm Department of Organic Agriculture and Natural Farming, Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur, Kangra, Himachal Pradesh. The experiment consisting of eleven treatment combinations which was laid out in Randomized Block Design with three replications. Surbhi variety of the linseed was used in the experiment. It was found that among the different treatments higher plant height (66.0 cm) at harvest, dry matter accumulation (371.2 gm^{-2}), higher crop growth rate (3.24 g m^{-2} day^{-1}) at 150 DAS, the lowest days taken to 50% flowering

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and Days taken to physiological maturity, seed yield (11.16 q ha^{-1}) and straw yield of (27.51 q ha^{-1}) was recorded with the application of 50% FYM + 50% vermicompost to supply 100% of recommended N (T_{10}). Whereas, the lowest plant height (44.9 cm), dry matter accumulation (252.1 gm^{-2}), lowest crop growth rate of 2.20 g m^{-2} day^{-1} seed yield (7.26 q ha^{-1}) and straw yield (19.00 q ha^{-1}) in absolute control (T_{11}).

Keywords: Crop growth rate; dry matter; linseed; organic amendments; phenology; relative growth rate.

1. INTRODUCTION

India becomes self-sufficient in staples like wheat and rice, as increased food production increased after the Green Revolution in India. However, the dependence on chemical inputs led to degradation of natural resources (soil and water) and reduction in biodiversity (Eliazer Nelson et al., 2019). As sustainable agriculture gains momentum, the research on organic nutrient amendments has intensified, focusing primarily on optimizing nutrient supply to enhance crop production (Parewa et al., 2021; Sharma et al., 2024). From 1960s and 2000s wheat and rice production increased from approximately 10 million tons to over 75 million tons for wheat and from 35 million tons to 100 million tons for rice. The increase in the production ensured food security, also the environmental challenges prompted a shift towards sustainable agricultural practices (Eliazer Nelson et al., 2019).

Linseed [(*Linum usitatissimum* (L.)]is an important oilseed crop known for its high levels of omega-3 fatty acids and fiber content, diversely used in cosmetics, health foods and other industries (Kaur et al., 2023). India produces 1.5–1.8 million tons of linseed annually, with Madhya Pradesh, Uttar Pradesh, and Chhattisgarh being the leading states. However, production and productivity have been constrained by imbalanced nutrient management and declining soil health (Anonymous, 2024). By using organic inputs as combinations of farmyard manure (FYM), neem cake, vermiwash and cow urine by which helps in restoring the soil biodiversity and nutrient cycle, leads to sustainable yield, improved oil quality and less environmental impact. This study examines the effects of various organic treatments on linseed growth and yield, includes different combinations of farmyard manure (FYM), neem cake, vermiwash, and cow urine (Piper, 1966). Thus, the present investigation was carried out to study the growth, development and phenology of linseed as influenced by different organic amendments.

2. MATERIALS AND METHODS

A field experiment was carried out during *rabi* season 2023-24 at the experimental farm of the model Organic Farm Department of Organic Agriculture and Natural Farming, CSK HPKV, Palampur, Kangra, Himachal Pradesh. The experiment consisting of eleven treatment combinations was laid out in Randomized Block Design with three replications. Surbhi variety of the linseed was used in the experiment. The physical properties and chemical properties indicated that the soil of the experimental site was silty clay loam in texture, acidic in reaction and low in available nitrogen and medium in available phosphorus and potassium. The initial soil physical and chemical parameters of the experimental site suggested that the soil physical properties Sand (34.96%), Silt (38.10%), Clay (26.94%) and texture of soil was Silty clay loam. The soil chemical analysis reveals that the soil pH with 5.95 (glass electrode pH meter (Jackson, 1973)); the available N was 236 kg ha^{-1} (alkaline permanganate method (Subbiah & Asija, 1956)), the available P at 24.7 kg ha^{-1} (NaHCO3 method (Olsen et al., 1954), available K at 145.4 kg ha^{-1} (Ammonium acetate extraction method (AOAC, 1970)), avaliable S at 17.2 (Turbidimetric method (Chesin & Yien, 1950)) and the organic carbon at 7.70 (Dichromate oxidation of organic matter (Jackson, 1973).

The treatment details are T_1- FYM to supply 33% of recommended N;T_2- Neem cake to supply 33% of recommended N;T_3-FYM to supply 33% of recommended N + neem cake to supply 33% of recommended N;T_4-FYM to supply 33% of recommended N + foliar spray of vermiwash (10%) at branching, flowering and capsule development stage;T_5-Neem cake to supply 33% of recommended N + foliar spray of vermiwash (10%) at branching, flowering and capsule development stage;T_6-FYM to supply 33% of recommended N + neem cake to supply 33% of recommended N + foliar spray of vermiwash (10%) at branching, flowering and capsule development stage;T_7-FYM to supply 33% of recommended N + foliar spray of cow urine (2.5%) at branching, flowering and capsule development stage;T_8-Neem cake to supply 33% of recommended N + foliar spray of cow urine (2.5%) at branching, flowering and capsule development stage;T_9-FYM to supply 33% of recommended N + neem cake to supply 33% of recommended N + foliar spray of cow urine (2.5%) at branching, flowering and capsule development stage;T_{10}-50% FYM + 50% vermicompost to supply 100% of recommended N;T_{11}-Absolute control (No manure or cake application).

2.1 Plant Height

From each plot, five plants were chosen at random and tagged. These tagged plants were measured in height from the ground to the top of the main stalk branch. At 60, 60, 90, 120, 150, 180 days after sowing (DAS) and at crop's physiological maturity harvest, observations were recorded. To get the mean plant height in cm, the average of five plants was calculated.

2.2 Dry Matter Accumulation

The plant samples from 0.25 m row length in the sampling row next to the border row were cut close to the ground surface at 30, 60, 90, 120, 150 DAS and at harvest of the crop. These samples were dried in the oven at 70ºC till constant weight was achieved. The dry matter thus recorded was converted into gram per square meter.

2.3 Crop Growth Rate (g m^{-2} day^{-1})

Crop growth rate (CGR) expresses the gain in dry matter production of the crop per unit land area per unit time and is expressed as gram per meter square per day (g m^{-2} day^{-1}). It is calculated according to the formula given by Watson (1952).

$$CGR = \frac{1}{P} \times \frac{W_2 - W_1}{T_2 - T_1}$$

Where, W_2 and W_1 are dry weights at two sampling times T_2 and T_1 respectively.

2.4 Relative Growth Rate (mg g^{-1} day^{-1})

The relative growth rate (RGR) represents the rate of increase in dry weight per unit of plant dry weight and is expressed as mg m^{-2} day^{-1} (Blackman, 1919).

$$RGR = \frac{\ln W_2 - \ln W_1}{t_2 - t_1}$$

2.5 Days Taken to 50% Flowering

The experimental plots were visited on every alternate day after the initiation of flowering. Ten plants were randomly selected and the dates on which all these plants showed flowering were recorded and used for calculating the number of days taken from sowing to flowering.

2.6 Days Taken to Physiological Maturity

When stems of all 10 randomly selected plants turned yellow and capsules were ripened, the crop was considered to attain maturity and the days from sowing to maturity were counted and recorded as the number of days taken to physiological maturity.

2.7 Seed Yield (q ha^{-1})

The crop was harvested from each net plot and was threshed gently by beating with wooden roller at maturity. The seed yield per hectare was converted by multiplying the net plot yield by factor 33.67.

2.8 Straw Yield (q ha^{-1})

After threshing, the stalks were sun-dried and weighed. The recorded weight per plot was converted to kilogram per hectare by multiplying the net plot yield by factor 33.67.

2.9 Statistical Analysis

The data obtained were subjected to suitable statistical analyses as per Gomez & Gomez (1984).

3. RESULTS AND DISCUSSION

3.1 Plant Height (cm)

The results on the effect of nutrient management through organic sources on plant height (30, 60, 90, 120, 150, 180 DAS and at harvest) are presented in Table 1. Plant height was significantly affected by nutrient management through organic sources from 30 DAS onwards and up to harvest. Significantly higher plant height (66.0 cm) was recorded at harvest with the application of 50% FYM + 50% vermicompost to supply 100% of recommended N (T_{10}) whereas, the lowest plant height (44.9 cm) at harvest was recorded under absolute control (T_{11}). The increase in height with the application of 50% FYM + 50% vermicompost might be due to boost of nitrogen through these nutrient sources that have stimulated cell division and cell expansion which resulted in better plant height (Reddy et al., 2023). These organic nutrient sources might have acted as a nutrient reservoir which upon decomposition releases nutrients slowly for the entire crop growth leading to higher plant height (Mude et al., 2023 and Kaur et al., 2024).

3.2 Dry Matter Accumulation (g m^{-2})

Data on dry matter accumulation plant^{-1} have been recorded monthly (60, 90, 120, 150 DAS) and at harvest (Table 2). Dry matter accumulation was significantly affected by nutrient management through organic sources from 60 DAS onwards and up to harvest. The significantly highest dry matter accumulation (371.2 gm^{-2}) was recorded at harvest with the application of 50% FYM + 50% vermicompost to supply 100% of recommended N (T_{10}) whereas, the lowest dry matter accumulation (252.1 gm^{-2}) at harvest was recorded under absolute control (T_{11}). This might be due to adequate major nutrients might have helped in harvesting of solar energy as reflected by increased dry matter accumulation. Increase in dry matter accumulation in treatment T_{10} (application of 50% FYM + 50% vermicompost to supply 100% of recommended N) might be due to application of vermicompost and FYM supplied all essential nutrients, growth hormones and enzymes to plant, which favours rapid cell division and elongation and ultimately results into more development of plant and higher dry matter accumulation (Naik & Panda, 2023). These results are in concurrence with the findings of and Singh et al. (2024).

3.3 Crop Growth Rate (g m^{-2} day^{-1})

The Crop Growth Rate (CGR) was observed in the linseed after sowing to till harvest during *Rabi* 2023-24 (Table 3). Initially at 60 DAS the highest crop growth rate was with the application of 50% FYM + 50% vermicompost to supply 100% of recommended N (T_{10}) at 1.48 g m^{-2} day^{-1} whereas, the lowest crop growth rate of 1.00 g m^{-2} day^{-1} in absolute control (T_{11}). At 150 DAS, the significantly higher crop growth rate of 3.24 g m^{-2} day^{-1} observed with the application of 50% FYM + 50% vermicompost to supply 100% of recommended N (T_{10}) whereas, the lowest crop growth rate of 2.20 g m^{-2} day^{-1} in absolute control (T_{11}). The decomposition of organic inputs, attributed to enhances nutrient availability to plants, contributed to enhanced nutrient uptake and boosted growth rate. The application of vermicompost and farmyard manure attributed the supply of essential nutrients, improved soil structure, and enhanced microbial activity (Kumari et al., 2021; and Badkul et al., 2022). Similarly, Singh et al. (2024a) and Naik et al. (2024) suggested that organic farming resulted in improved the CGR with multiple copping system.

3.4 Relative Growth Rate (mg g^{-1} day^{-1})

The Relative Growth Rate (RGR) was observed in the linseed after sowing to till harvest during *Rabi* 2023-24 (Table 4). A significant variation in relative growth rate was observed in the linseed under different stages of crop growth. At 60-90 DAS relative growth rate ranges from 18.36 mg g^{-1} day^{-1} to 18.39 mg g^{-1} day^{-1}. At 90-120 DAS relative growth rate ranges from 6.89 mg g^{-1} day^{-1} to 6.98 mg g^{-1} day^{-1}. At 120-150 DAS relative growth rate ranges from 4.69 mg g^{-1} day^{-1} to 4.82 mg g^{-1} day^{-1}. The application of various organic inputs contributed to improved nutrient availability and uptake during the vegetative growth phase. Also, as similar results with multiple cropping system under organic farming and natural farming resulted in enhanced RGR (Kumari et al., 2021; Badkul et al., 2022 and Naik et al., 2024).

3.5 Days Taken to 50% Flowering

The data on the effect of nutrient management through organic sources on days taken to 50% flowering of linseed have been given in Table 5. Nutrient management through organic sources significantly affected days taken to 50% flowering. Among different organic treatments, 100% RDN (50% VC+ 50% FYM) (T_{10}) had lowest days for flowering which remained statistically at par with T_9 and T_3. As enhanced nutrient availability resulted in completion of vegetative phase early thus, attributed to less days taken to 50% flowering. A similar finding was reported by Kumawat et al. (2021).

Table 1. Effect of organic nutrient management on plant height (cm) of linseed at different stages of observation

Treatments	30 DAS	60 DAS	90 DAS	120 DAS	150 DAS	180 DAS	At harvest
T_1: 1/3 RDN FYM	11.5	17.0	22.7	41.2	48.5	60.6	60.6
T_2: 1/3 RDN Neem cake	11.0	16.5	22.0	40.1	47.1	58.9	58.9
T_3: T1+T2	12.0	17.5	23.3	42.3	49.8	62.3	62.3
T_4: T1+FS VW*	11.9	17.4	23.3	42.3	49.8	62.2	62.2
T_5: T2+FS VW*	11.5	17.0	22.7	41.2	48.5	60.6	60.6
T_6: T3+FS VW*	12.2	17.7	23.6	43.0	50.6	63.2	63.2
T_7: T1+FS Cow*	11.9	17.4	23.1	42.1	49.5	61.9	61.9
T_8: T2+FS Cow*	11.5	17.0	22.6	41.2	48.4	60.5	60.5
T_9: T3+FS Cow*	12.1	17.6	23.5	42.9	50.4	63.0	63.0
T_{10}: 100 % RDN (50% VC+ 50% FYM)	13.0	18.5	24.7	44.9	52.8	66.0	66.0
Absolute control	7.1	12.6	16.8	30.5	35.9	44.9	44.9
SEm (±)	0.2	0.2	0.3	0.5	0.7	0.8	0.8
LSD (P=0.05)	0.7	0.7	0.9	1.6	2.0	2.4	2.4

**Foliar spray at branching, flowering and capsule development stage*
RDN=Recommended nitrogen dose, VW=Vermiwash, FYM=Farmyard manure, VC=Vermicompost, DAS = Days after sowing, FS=Foliar spray

Table 2. Effect of organic nutrient management on dry matter accumulation (g m^{-2}) of linseed at different stages of observation

Treatments	60 DAS	90 DAS	120 DAS	150 DAS	At harvest
T_1: 1/3 RDN FYM	34.4	122.5	197.2	272.6	291.8
T_2: 1/3 RDN Neem cake	33.5	119.3	192.1	265.5	281.1
T_3: T1+T2	38.3	136.2	218.2	301.7	320.5
T_4: T1+FS VW*	36.6	130.0	209.4	289.5	306.4
T_5: T2+FS VW*	34.5	122.5	197.3	272.7	288.7
T_6: T3+FS VW*	40.7	144.4	233.9	326.5	345.7
T_7: T1+FS Cow*	36.0	127.9	206.0	284.8	301.5
T_8: T2+FS Cow*	33.8	120.1	193.4	267.4	283.1
T_9: T3+FS Cow*	39.7	141.1	227.2	314.2	332.6
T_{10}: 100 % RDN (50% VC+ 50% FYM)	44.3	157.4	254.5	351.8	371.2
Absolute control	30.1	107.0	172.2	238.1	252.1
SEm (±)	1.2	3.6	5.6	7.7	8.0
LSD (P=0.05)	3.4	10.7	16.5	22.8	23.7

**Foliar spray at branching, flowering and capsule development stage*
RDN=Recommended nitrogen dose, VW=Vermiwash, FYM=Farmyard manure, VC=Vermicompost, FS=Foliar spray

Table 3. Effect of organic nutrient management on crop growth rate (g m^{-2} day^{-1}) of linseed at different stages of observation

Treatments	60 DAS	90 DAS	120 DAS	150 DAS
T_1: 1/3 RDN FYM	1.15	2.94	2.49	2.51
T_2: 1/3 RDN Neem cake	1.12	2.86	2.43	2.45
T_3: T1+T2	1.28	3.26	2.73	2.78
T_4: T1+FS VW*	1.22	3.11	2.65	2.67
T_5: T2+FS VW*	1.15	2.93	2.49	2.51
T_6: T3+FS VW*	1.36	3.46	2.98	3.09
T_7: T1+FS Cow*	1.20	3.06	2.60	2.63
T_8: T2+FS Cow*	1.13	2.88	2.44	2.47
T_9: T3+FS Cow*	1.32	3.38	2.87	2.90
T_{10}: 100% RDN (50% VC+ 50% FYM)	1.48	3.77	3.24	3.24
Absolute control	1.00	2.56	2.17	2.20
SEm (±)	0.02	0.07	0.14	0.18
LSD (P=0.05)	0.50	0.20	0.43	0.53

**Foliar spray at branching, flowering and capsule development stage*
RDN=Recommended nitrogen dose, VW=Vermiwash, FYM=Farmyard manure, VC=Vermicompost, FS=Foliar spray

Table 4. Effect of organic nutrient management on relative growth rate (mg g^{-1} day^{-1}) of linseed at different stages of observation

Treatments	90 DAS	120 DAS	150 DAS
T_1: 1/3 RDN FYM	18.39	6.89	4.69
T_2: 1/3 RDN Neem cake	18.39	6.89	4.69
T_3: T1+T2	18.36	6.83	4.69
T_4: T1+FS VW*	18.35	6.91	4.69
T_5: T2+FS VW*	18.35	6.89	4.69
T_6: T3+FS VW*	18.33	6.98	4.82
T_7: T1+FS Cow*	18.35	6.91	4.68
T_8: T2+FS Cow*	18.35	6.89	4.70
T_9: T3+FS Cow*	18.36	6.90	4.69
T_{10}: 100% RDN (50% VC+ 50% FYM)	18.35	6.95	4.69
Absolute control	18.36	6.89	4.69
SEm (±)	0.29	0.35	0.31
LSD (P=0.05)	0.86	1.06	0.93

**Foliar spray at branching, flowering and capsule development stage*
RDN=Recommended nitrogen dose, VW=Vermiwash, FYM=Farmyard manure, VC=Vermicompost, FS=Foliar spray

Table 5. Effect of organic nutrient management on phenological stages of linseed

Treatments	Days taken to 50% flowering	Days taken to physiological maturity
T_1: 1/3 RDN FYM	131.1	185.3
T_2: 1/3 RDN Neem cake	131.5	186.0
T_3: T1+T2	130.0	184.1
T_4: T1+FS VW*	130.9	185.0
T_5: T2+FS VW*	131.4	185.8
T_6: T3+FS VW*	129.7	183.6
T_7: T1+FS Cow*	131.1	185.3
T_8: T2+FS Cow*	131.2	186.2
T_9: T3+FS Cow*	129.9	183.9
T_{10}: 100% RDN (50% VC+ 50% FYM)	128.9	182.7
T_{11}: Absolute control	134.4	187.0
SEm (±)	0.4	0.5
LSD (P=0.05)	1.2	1.5

**Foliar spray at branching, flowering and capsule development stage*
RDN=Recommended nitrogen dose, VW=Vermiwash, FYM=Farmyard manure, VC=Vermicompost, FS=Foliar spray

Table 6. Effect of organic nutrient management on yield of linseed

Treatments	Seed Yield (q ha^{-1})	Straw Yield (q ha^{-1})
T_1: 1/3 RDN FYM	8.51	21.88
T_2: 1/3 RDN Neem cake	8.16	21.12
T_3: T1+T2	9.51	23.87
T_4: T1+FS VW*	8.96	22.96
T_5: T2+FS VW*	8.41	21.66
T_6: T3+FS VW*	10.31	25.91
T_7: T1+FS Cow*	8.81	22.65
T_8: T2+FS Cow*	8.26	21.22
T_9: T3+FS Cow*	9.86	24.78
T_{10}: 100% RDN (50% VC+ 50% FYM)	11.16	27.51
T_{11}: Absolute control	7.26	19.00
SEm (±)	32.6	54.7
LSD (P=0.05)	96.1	161.5

**Foliar spray at branching, flowering and capsule development stage*
RDN=Recommended nitrogen dose, VW=Vermiwash, FYM=Farmyard manure, VC=Vermicompost, FS=Foliar spray

3.6 Days Taken to Physiological Maturity

Nutrient management through organic sources significantly affected days taken to physiological maturity have been given in Table 5. Among different organic treatments, 100% RDN (50% VC+ 50% FYM) (T_{10}) had lowest days for physiological maturity which remained statistically at par with T_3, T_6 and T_9. This may be due to improved nutrient availability during critical growth stages and the subsequent translocation of nutrients, which ultimately influences pod formation, leading to an increase in the number of seeds capsule^{-1} and seed weight (Reddy et al., 2023 and Dalla Roza et al., 2024).

3.7 Seed and Straw Yield (q ha^{-1})

The data on the seed and straw yield as affected by nutrient management through organic sources have been presented in Table 6. Seed and straw yield was significantly affected by nutrient management through organic sources. The significantly highest seed yield (11.16 q ha^{-1}) and straw yield (27.51 q ha^{-1}) were obtained with the application of 50% FYM + 50% vermicompost to supply 100% of recommended N (T_{10}) which was at par with T_6. Whereas, the lowest seed yield (7.26 q ha^{-1}) and straw yield (19.00 q ha^{-1}) were obtained under absolute control (T_{11}). Slow release of nutrients and enhanced nutrient uptake by linseed attributed to increase in the seed and straw yield. As combination of organic source of nutrients like vermicompost and FYM resulted in improved organic matter, microbial population (Kumari et al., 2021; Kumawat et al., 2021; Badkul et al., 2022 and Mude et al., 2023).

4. CONCLUSION

Based on the result of one year experimentation, it can be concluded that the application of 50% FYM + 50% vermicompost to supply 100% of recommended N (T_{10}) resulted in significantly enhanced the plant height, dry matter accumulation, crop growth rate, days taken to 50% flowering and days taken to physiological maturity, seed and straw yield (q ha^{-1}), compared to absolute control. The application of organic amendments not only resulted in improved soil health but also resulted in increase in dry matter accumulation, enhanced nutrient uptake.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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