Growth, Development and Phenology of Linseed as influenced by different Organic Amendments

Commented [o1]: Title may be modified (if yield data is included) Effect of different organic ammendments on growth and yield attributes of Linseed [(*Linum usitatissimum* (L.)]

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, CSK HPKV, 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. The treatment consists of T_1-FYM to supply 33 % of recommended N; T_2-Neem cake to supply 33 % of recommended N; T3-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) replicated three time in Randomized Block Design. It was found that the 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}). At harvest 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}) was recorded under 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}). Similarly, 100 % RDN (50% VC+ 50% FYM) (T_{10}) had lowest days taken to 50 % flowering and Days taken to physiological maturity.

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Key words: Crop growth rate, dry matter, phenology, linseed, organic amendments, relative growth rate

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 (Sharma et al. 2024).

Linseed (*Linum usitatissimum*) 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). 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. Thus, the study was carried out to study the Growth, Development and Phenology of Linseed as influenced by different organic Amendments

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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 (Table 1) 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.

Table 1. Initial soil physical and chemical parameters of the experimental site

Particulars	Content	Method employed
A. Physical properties		
Sand (%)	34.96	
Silt (%)	38.10	International pipette method (Piper 1966)
Clay (%)	26.94	
Texture		Silty clay loam
B. Chemical properties		
pH	5.95	Glass electrode pH meter (Jackson 1973)
N	236	Alkaline permanganate method (Subbiah and Asija 1956)
P	24.7	$NaHCO_3$ method (Olsen et al. 1954)
K	145.4	Ammonium acetate extraction method (AOAC 1970)
S	17.2	Turbidimetric method (Chesin and yien 1950)
OC	7.70	Dichromate oxidation of organic matter (Jackson 1973)

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Table 2. Treatment details

Symbol	Treatment details
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)

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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, 90, 120, 150 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.

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 70^{o}C till constant weight was achieved. The dry matter thus recorded was converted into gram per square meter.

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.

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).

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

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.

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.

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RESULTS AND DISCUSSION

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 3. 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. 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. Similar results were also reported by Reddy et al. (2023), Mude et al. (2023) and kaur et al. (2024).

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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 4). Dry matter accumulation was significantly affected by

Table 3. 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

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Table 4. 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

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. These results are in concurrence with the findings of Naik and Panda (2023) and Singh et al. (2024).

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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 5). 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. Similar results were also reported by Kumari et al. (2021), Badkul et al. (2022), Singh et al. (2024a) and Naik et al. (2024).

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Table 5. 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

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 6). 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. Similar results were also reported by Kumari et al. 2021, Badkul et al. 2022 and Naik et al. (2024).

Table 6. 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

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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 7. 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.

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Days taken to physiological maturity

Nutrient management through organic sources significantly affected days taken to physiological maturity have been given in Table 7. 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. A similar finding was reported by Reddy et al. (2023) and Dalla Roza et al. (2024).

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Table 7. 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

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

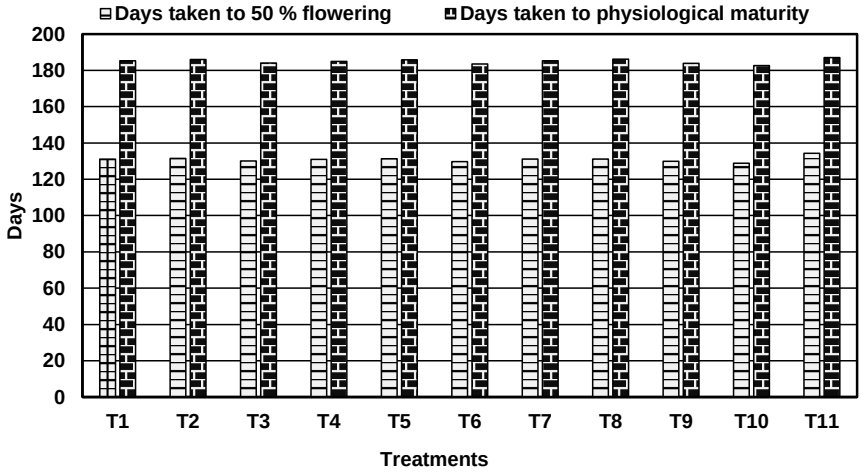

Figure 1. Effect of organic nutrient management on phenological stages of linseed

CONCLUSION

Based on the result of one year experimentation, it can be concluded that the application of 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, 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.

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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.

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