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Effect of organic manure and sulphur on growth and yield attributes of linseed (*Linum usitatissimum* L.)

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Abstract
The field experiment was conducted during *Rabi* season of 2023 at Crop Research Farm, Department of Agronomy. The experiment was laid out in a Randomized Block Design with ten treatments which have replicated thrice. The treatment details are as follows T_1 Vermicompost 6 t/ha+ Sulphur 15 kg/ha, T_2 Vermicompost 6 t/ha+ Sulphur 20 kg/ha, T_3 Vermicompost 6 t/ha+ Sulphur 30 kg/ha, T_4 FYM 12t/ha + Sulphur 15 kg/ha, T_5 FYM 12t/ha + Sulphur 20 kg/ha, T_6 FYM 12t/ha + Sulphur 30 kg/ha, T_7 Vermicompost 3t/ha + FYM 6t/ha + Sulphur 15 kg/ha, T_8Vermicompost 3t/ha + FYM 6t/ha + Sulphur 15 kg/ha, T_9Vermicompost 3t/ha + FYM 6t/ha + Sulphur 15 kg/ha and control Plot. The result of experimental plot that the Application of Vermicompost 3 ton/ha +FYM 6 t/ha + 30 kg/ha Sulphur (Treatment 9) recorded significantly Result revealed that the highest plant height (58.00 cm), highest dry weight (3.27 g), capsules per plant (31.87), seeds per capsules (7.67), test weight (11.83 g), seed yield (1194.33kg/ha), Stover yield (2702.67 kg/ha) and oil content (40.18%). Were significantly influenced with application Vermicompost 3 ton/ha +FYM 6 t/ha + Sulphur 30 kg/ha. Higher gross return (INR 148278.33 /ha)**,** higher net return (INR 97278.33/ha) and higher B: C ratio (1.91) were also recorded in treatment -Nine (Vermicompost 3 ton/ha +FYM 6 t/ha + Sulphur 30 kg/ha).

Keywords: Vermicompost, FYM, sulphur, growth, yield and economics

Introduction
Linseed (*Linum usitatissimum* L.) also well-known as flax that is grown in north India, is a crucial Rabi season oil seed crop. It is fitting for temperate climate with cold season. Linseed crop is one of the primitive oil seed crops, among all oilseed crops grown in north India, that cultivated for both oil and fiber purpose. Linseed crop is conventionally grown on marginal and sub-marginal soil with subsidiary use of agricultural inputs in Indian states. The oil contains in linseed crop 34-43% and also utilized in industry such as pulp making, paper, and paint and as fiber. Worldwide, the linseed crop is a noteworthy while its production almost in the world 2.65 million tons from 2.62 million ha area with its standard productivity is 1011kg /ha. However, its national production is 0.10 million tons from 0.28 million ha-1 along with national average productivity of 541 kg/ha (Annual Report, AICRP on linseed, 2019-20). India's have to be ranks 4th in term of total area coverage and 3rd in its total production followed by Canada, Russia, India, China, and USA.

India is the second largest (21.21%) linseed growing country in the world after Canada and production-wise it ranks fourth (8.20%) in the world after Canada (40.51%), China (18.68%), and USA (10.89%). The world linseed average productivity is 852 kg/ha. However, the productivity of linseed in India is lower than the world linseed average productivity and is only 395 kg/ha. Among the *Rabi* oilseed crops in India, linseed happens to occupy the second position i.e., next to rapeseed-mustard in areas as well as production. At present, linseed is cultivated on about 4.36 lakh ha with the contribution of 1.67 lakh tons to the annual oilseed production of the country. Presently, linseed is under cultivation in as many as 16 states of the country *viz*., Madhya Pradesh, Maharashtra, Chhattisgarh, Uttar Pradesh, Jharkhand, Bihar, Orissa, Karnataka, Nagaland, Assam, Jammu and Kashmir, West Bengal, Andhra Pradesh, Himachal Pradesh, Rajasthan and Punjab. Area under linseed cultivation has remained almost static between 2.85 to 2.98 lakh ha (2013-14 to 2015-16).

Productivity of linseed has declined from 541 kg/ha (2014-15) to 442 kg/ha (2015-16).

In India, predominantly linseed crop has to be grown under rainfed condition (63%), its area under uteri cropping system (25%) and irrigated condition (12%) along with marginal inputs. The foremost constraints for its lower national productivity are the all those areas that basically comes under sub-marginal, un-irrigated, input starving and marginal conditions of crop management practices, and its cultivation of traditionally along low yielding old and unimproved local linseed crops cultivars with marginal use of input. He malnourishes situation have to be major difficulty for the low productivity at country level. The use of Sulphur is one of the most important factors in increasing yields. Sulphur plays an important role in the formation of amino acids, synthesis of proteins, chlorophyll and oil (Singh and Singh 2007) [18]. Balanced use of Sulphur commensurate with crop needs and soil nutrient status is indispensable for sustained production of high yield level. Experimental evidences indicate that Sulphur is most essential plant nutrient which is generally lacking in Indian soils. To, fulfill the necessities for Sulphur nutrient, it is necessary to supply these to the hungry soil in concentrated and readily available from i.e. fertilizers. It is also essential to know optimum level of Sulphur. Though many workers have worked on this aspect but requirement of Sulphur vary from soil to soil and place to place. Even agro-climatic conditions have great influence on the Sulphur requirement of a crop. Therefore, it was necessary to find out the most beneficial sources and level of Sulphur from the point of view of yield, nutrient uptake and quality of linseed.

Vermicompost on soil condition and plant growth (Singh *et al*. 2008) [19]. Many studies have reflected the great potential of vermicompost in horticultural and agricultural practices in field or as a substitute in medium for plant growth in greenhouses and nurseries. Various studies have confirmed the beneficial effects of vermicompost on seed germination, seedling growth and plant productivity, but the effect of vermi-compost has been unique and specific on various plant species and varieties, so it becomes utmost important to investigate the genus specific suitability of the vermicom-post before its beneficial effects are predicted for a crop plant. Even the same rate or ratio of vermicompost application has shown different effects on different varieties of same plant.

India is among top five countries producing Linseed, with U.K and Canada being top two countries, and still India imports Linseed. In India, currently Linseed occupies 468.0 thousand ha with productivity of 3490 hectogram's/ ha (www.pdkv.ac.in). Linseed is an oilseed crop grown mainly in Punjab (India) in regions of Gurdaspur, Jaland-har, Hoshiarpur and Ropar. Recent statistics show that Linseed has a production of 0.1 thousand tonnes in Punjab state with average yield of 8.0 quintal per hectare. There is a scope to increase the covered area and yield of cultivating Linseed in India (Table 1) vermicompost on soil condition and plant growth (Singh *et al*. 2008) [19]. Many studies have reflected the great potential of vermicompost in horticultural and agricultural practices in field or as a substitute in medium for plant growth in greenhouses and nurseries. Various studies have confirmed the beneficial effects of vermicompost on seed germination, seedling growth and plant productivity, but the effect of vermi-compost has been unique and specific on various plant species and varieties, so it becomes utmost important to investigate the genus specific suitability of the vermicom-post before its beneficial effects are predicted for a crop plant. Even the same rate or ratio of vermicompost application has shown different effects on different varieties of same plant.

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Material and Methods

During the *Rabi* season of 2023, a field experiment was conducted at the Crop Research Farm of the Department of Agronomy, Sam Higginbottom University of Agriculture Technology And Sciences, Prayagraj, Uttar Pradesh. which is located at 25.24'42'' N latitude, 81.50' 56" E longitude and 98 m altitude above the mean sea level (SL). The soil of experimental plot was sandy loam, having a nearly neutral soil reaction (pH 7.2), electrical conductivity 0.18 ds/m, medium in available nitrogen (178.48 kg/ha) and potassium (233.24 kg/ha), and low in available phosphorous (27.80 kg/ha). The experiment was conducted in a Randomized Block Design consisting of ten treatment combinations and three replications. Fertilizers were applied as band placement, for which 4-5 cm deep furrows were made along the seed rows with a hand hoe. The plot size of each treatment was 3m x 3m. Factors are (Vermicompost 6t/ha, FYM-12t/ha, Vermicompost-3t/ha+FYM-6t/ha and Sulphur (15, 20 and 30 kg/ha). The Linseed crop was sown on 21 November 2023. Harvesting was done by taking $1m^2$ area from each plot. And from it five plants were randomly selected for recording growth and yield parameters. The observations were recorded for plant height(cm), dry weight (g), Crop growth rate, Relative growth rate, number of capsules/plants, number of seed/capsules, test weight(g), seed yield (t/ha) and stover

yield(t/ha) Harvest Index (%), Oil content (%). The observed data was statistically analysed using analysis of variance (ANOVA) as applicable to randomized block design (Gomez and Gomez, 1984) [5].

Results and Discussions

Growth parameters

Plant height: Significantly at 80 DAS, recorded higher plant height (3.27 cm) in treatment-9 with the application of Vermicompost 3 t/ha+ FYM 6 t/ha with Sulphur 30 kg/ha. However, the treatment-3 in which Vermicompost 6 t/ha + Sulphur 30 kg/ha, were found to be statistically at par with treatment-9 Vermicompost 3 t/ha+ FYM 6 t/ha + Sulphur 30 kg/ha. The Use of organic fertilizers such as vermicompost, and FYM. Organic fertilizers not only provide macro- and micronutrients to plants, but also contribute to improving soil health at physical, chemical, and biological levels. Through natural processes like nitrogen fixation and invigorating plant growth by the amalgamation of growth-promoting substances to append nutrients.

Plant dry weight

Similarly at 80 DAS, recorded significantly higher plant dry weight (3.27 g) in treatment-9 with the application of Vermicompost 3 t/ha+ FYM 6 t/ha with Sulphur 30 kg/ha. However, the treatment-3 Vermicompost 6 t/ha + Sulphur 30 kg/ha. However, were statistically at par with treatment-9 Vermicompost 3 t/ha+ FYM 6 t/ha + Sulphur 30 kg/ha. The substantial function that Sulphur plays in cell proliferation and differentiation, root elongation, which reflects into increased nutrient absorption, and photosynthate generation, which reflects into increased dry matter production, may all contribute to higher dry matter accumulation caused by sulfur. Lawania *et al*. (2015) [11]. Sulphur help in chlorophyll formation and encourages vegetative plant growth. It also increases root growth increase in dry matter per plant with application of sulphur might be due to increase in metabolic activity reported by (Jagtap *et al.,* 2003) [7].

Yield attributes

Number of Capsules/plants

At harvest, Treatment-9 with the application of Vermicompost 3 t/ha+ FYM 6 t/ha with Sulphur 30 kg/ha was recorded significant and maximum number of capsules/plant (31.87) which was superior over all other treatments. However, the treatment-3 Vermicompost 6 t/ha + Sulphur 30 kg/ha was found to be statistically at par with the treatment-9 Vermicompost 3 t/ha+ FYM 6 t/ha + Sulphur 30 kg/ha.

Number of seeds/capsules

At harvest, Treatment-9 with the application of Vermicompost 3 t/ha+ FYM 6 t/ha with Sulphur 30 kg/ha was recorded significant and maximum number of seeds/capsules (7.33) which was superior over all other treatments. However, the treatment-3 Vermicompost 6 t/ha + Sulphur 30 kg/ha and treatment-7 Vermicompost 3 t/ha+ FYM 6 t/ha + Sulphur 15 kg/ha was found to be statistically at par with the treatment-9 Vermicompost 3 t/ha+ FYM 6 t/ha + Sulphur 30 kg/ha. Significant increase in number of seeds/capsules.

Test weight (g)

At harvest, Treatment-9 with the application of Vermicompost 3 t/ha+ FYM 6 t/ha with Sulphur 30 kg/ha was recorded significantly highest test weight (11.83 g) which was superior over all other treatments. However, the treatment-3 Vermicompost 6 t/ha + Sulphur 30 kg/ha, were found to be statistically at par with the treatment-9 Vermicompost 3 t/ha+ FYM 6 t/ha with Sulphur 30 kg/ha.

Seed yield (kg/ha)

At harvest, Treatment-9 with the application of Vermicompost 3 t/ha+ FYM 6 t/ha with Sulphur 30 kg/ha was recorded significantly higher Seed yield (1276.33 kg/ha) which was superior over all other treatments. However, the treatment-3 Vermicompost 6 t/ha + Sulphur 30 kg/ha, were found to be statistically at par with the treatment-9 Vermicompost 3 t/ha+ FYM 6 t/ha + Sulphur 30 kg/ha.

Stover yield (kg/ha)

At harvest, Treatment-9 with the application of Vermicompost 3 t/ha+ FYM 6 t/ha with Sulphur 30 kg/ha was recorded significantly higher stover yield (2702.67 kg/ha) which was superior over all other treatments. However, the treatment-3 Vermicompost 6 t/ha + Sulphur 30 kg/ha, was found to be statistically at par with treatment-9 Vermicompost 3 t/ha+ FYM 6 t/ha + Sulphur 30 kg/ha.

Harvest index (%)

At harvest, highest harvest index (30.64%) was recorded in treatment-9 with the application of Vermicompost 3 t/ha+ FYM 6 t/ha with Sulphur 30 kg/ha, though there was significant difference among the treatments.

Oil Content (%)

At harvest, higher in oil content (40.18%) was observed in application treatment-9 (vermicompost 3 t/ha + FYM 6 t/ha + Sulphur 30 kg/ha). However, treatment 4 (37.48) was found to be statistically at par with treatment 9 (Vermicompost 3 t/ha+ FYM 6 t/ha + Sulphur 30 kg/ha).

Economics

The data on the economics of different treatments the maximum gross return (INR.148278.33./ha), net return (INR.97278.33 /ha) and benefit-cost ratio (1.90) was recorded treatment-9 with the application (vermicompost 3 t/ha + FYM 6 t/ha + Sulphur 30 kg/ha)and the minimum gross return (INR.114658.33 /ha), net return (INR.70186.67 /ha) and benefit-cost ratio (1.25) was observed in the treatment-1 with the application of Vermicompost- 6 t/ha + Sulphur-15 kg/ha.

Table 1: Influence of organic manures and Sulphur on yield attributes of linseed

S. No.	Treatments combinations	Plant Height (80 DAS)	Plant Dry weight (80 DAS)	No of Capsules/ plant	No of seed/capsules	Test weight	Seed Yield (kg/ha)	Oil Content (%)
1	Vermicompost- 6 t/ha + Sulphur- 15 kg/ha	51.63	2.70	29.60	6.67	11.48	1064.00	38.01
2	Vermicompost- 6 t/ha + Sulphur - 20 kg/ha	51.90	2.79	29.73	6.87	11.50	1077.00	38.05
3	Vermicompost- 6t/ha + Sulphur - 30 kg/ha	52.00	2.81	30.07	7.03	11.58	1093.67	38.32
4	FYM – 12 t/ha + Sulphur- 15 kg/ha	49.23	2.27	24.20	5.53	11.20	951.67	37.48
5	FYM – 12 t/ha + Sulphur - 20 kg/ha	50.37	2.55	26.27	6.27	11.29	977.33	37.89
6	FYM – 12 t/ha + Sulphur - 30 kg/ha	51.30	2.63	28.40	6.27	11.30	1026.33	38.01
7	Vermicompost-3 t/ha + FYM - 6 t/ha +Sulphur- 15 kg/ha	52.60	2.81	30.20	7.10	11.81	1109.67	38.52
8	Vermicompost-3 t/ha + FYM – 6 t/ha + Sulphur - 20 kg/ha	53.70	2.93	30.47	7.33	11.81	1196.33	39.07
9	Vermicompost- 3 t/ha + FYM – 6 t/ha + Sulphur - 30 kg/ha	58.00	3.27	31.87	7.67	11.83	1276.33	40.18
	Control	45.03	2.00	23.47	5.33	10.93	604.33	37.67
F - Test		S	S	S	S	NS	S	NS
SEm(+)		1.83	0.18	0.54	0.19	0.37	17.20	0.51
CD (P= 0.05)		5.45	0.55	1.63	0.57	--	51.57	--

Table 2: Effect of organic manure and sulphur level on economics of linseed

S. No.	Treatments combinations	Cost of cultivation (INR/ha)	Gross returns (INR/ha)	Net returns (INR/ha)	Benefit-cost ratio (B:C)
1	Vermicompost- 6 t/ha + Sulphur- 15 kg/ha	56250	126436.67	70186.67	1.25
2	Vermicompost- 6 t/ha + Sulphur - 20 kg/ha	56500	127878.33	71378.33	1.26
3	Vermicompost- 6t/ha + Sulphur - 30 kg/ha	57000	129924.00	72924.00	1.28
4	FYM – 12 t/ha + Sulphur- 15 kg/ha	44250	114658.33	70408.33	1.59
5	FYM – 12 t/ha + Sulphur - 20 kg/ha	44500	117130.00	72630.00	1.63
6	FYM – 12 t/ha + Sulphur - 30 kg/ha	45000	121971.67	76971.67	1.71
7	Vermicompost-3 t/ha + FYM - 6 t/ha + Sulphur- 15 kg/ha	50250	131758.33	81508.33	1.62
8	Vermicompost-3 t/ha + FYM – 6 t/ha + Sulphur - 20 kg/ha	50500	140085.00	89585.00	1.77
9	Vermicompost- 3 t/ha + FYM – 6 t/ha + Sulphur - 30 kg/ha	51000	148278.33	97278.33	1.90
10	Control	27300	74876.65	48576.65	1.74

Conclusion

From the results, it is concluded that application of application of Vermicompost 3 t/ha + FYM 6 t/ha + Sulphur 30 kg/ha (Treatment 9) Linseed has recorded highest seed yield, gross return, net return and benefit cost ratio.

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