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Integrated nutrient management in linseed (*Linum usitatissimum* L.)

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Abstract
The present experiment entitled on "Integrated nutrient management" on growth, yield and quantity of linseed (*Linum usitatissimum* L.) was conducted at the instructional farm of department of Agronomy, faculty of Agriculture Science and Technology, AKS University Satna, (M.P.) during the Rabi season of 2022. The investigation was aimed to assess the productivity of linseed under the application of different integrated nutrient management and their subsequent effect on plant growth parameters, yield as well as economics and quality of the produce. A set of twelve integrated nutrient management treatment were tested in randomized block design with3 replication. All the fertilizers and nutrients were applied as per the treatments. Other agronomic practices were performed in all the treatment as per recommended package of practices. Based upon the experiment, it is conducted the application of 100% RDF prove best treatment. Among the INM treatment, application of 100% nitrogen through poultry manure recorded the maximum and significantly higher grain yield (15.92 q/ha) gross return (95408.00Rs/ha), net return (72461.00 Rs/ha) and highest B: C ratio of 3:16:1.

Keywords: Integrated nutrient management, linseed, growth, yield, quality

Introduction
Linseed (*Linum usitatissimum* L.) is one of the most versatile and useful crops also known as flaxseed. It is cultivated in more than 30 countries as a commercial or subsistence crop. The current worldwide acreage of linseed is 3.27 million hectares with a total annual production of 3.18 million tonnes and productivity of 975.10 kg/ha. India holds fifth rank in area with 320 thousand hectares with annual production of 174 thousand tonnes and productivity of 543.80 kg/ha (FAOSTAT, 2020) [2]. Linseed plant is an abundant source of both edible and nonedible oil. Industrial oil is an important ingredient for paint, varnish, and stain manufacturing. It is used in soaps, inks and the production of linoleum. It's also used in the animal care products, earthen floors, animal feed, industrial lubricant, leather treatment, oil cloth, particle detectors, textiles, wood preservation, seasoning of cookware. Edible linseed oil is used for human consumption and contains alpha-linolenic acid (ALA), a polyunsaturated fatty acid that provides nutritional and health benefits.

The utilization of organic manures as a nutrient source has been in use since the beginning of established agriculture, but after the induction of prevalent utilization of inorganic fertilizers, the bulky organic manures were deemed as a second alternative of nutrients. In order to safeguard the environment and health of soil-plant-human from further degradation, again we should choose for less use of chemical fertilizers and shift from chemical to biological agriculture to nourish the crop. Subsequently, to sustain the agriculture and soil fruitfulness, organic manures and various other organic materials got importance as constituents of plant nutrient management. Bulky organic manures provide most of the essential plant nutrients (instead to one or two nutrients by chemical fertilizers) beside enhancing the soil carbon stock and improving soil physical and biological conditions. In this respect, the use of FYM, poultry manure, vermicomposting as an organic source is an imperative tool which is of increasing interest of farmers and governmental bodies due to its amazing crop advantages. Organic manures promoted the strong health promoter which helps to fulfil our basic object of reducing the usage of inorganic fertilizers, restoring organic matter in soil, enhancing nutrient use efficiency and maintaining soil quality while improving the crop yield and production economics. Addition of FYM, poultry manure and vermicompost to the soil system also improves the physical conditions including soil structure, porosity, reduces compaction & crusting and overall increases water holding capacity of the soil.

Besides, proper supply of nitrogenous fertilizers is also needed as it affects the root development, resulting in improved crop yield and nutrient use pattern in linseed.

The results of a large number of experiments on organic manures and fertilizers conducted across the country revealed that neither chemical fertilizer nor organic sources alone can sustain the soil productivity under highly intensive cropping systems. The integrated nutrient management (INM) has assumed greater significance in the recent past. Work on INM, as a whole is very less. Besides, the prohibitive cost of chemical fertilizers often compels to use organic manures. Therefore, INM involving inorganic and organic sources has potential to improve soil fertility on sustainable basis, since it supplies almost all the nutrients besides increasing nutrient use efficiency and improving physio- chemical properties of soil. Hence, there is need to study the effect of combined use of organic and inorganic nitrogenous sources on productivity in linseed.

Materials and Methods

The present experiment was conducted during the Rabi season of 2021- 22 at the Student Instructional field, department of Agronomy, Faculty of Agriculture, AKS University, Sher ganj, Satna (M.P.). Mean temperature and humidity ranged from 10.20 ºC (min) to 45.0 ºC (max) and 87.00% (morning) to 75.00% (evening), respectively. The soil of experimental field was silty clay loam with low level of organic carbon (0.35%), available nitrogen (150.4 kg ha^{-1}), available phosphorus (17.2 kg ha^{-1}) and medium level of available potassium (280.00k gha^{-1}) having 7.8pH and 0.14ds/m EC.

Experiment was carried out at the Research Farm, Faculty of Agriculture, AKS University, Sherganj, Satna (M.P.) during Kharif season 2021-22. The experiment was conducted in randomize block design with three replications. different Fertility levels *viz*., RDF (NPK @ 50: 20: 40 kg/ha) – T1, 100% nitrogen through FYM – T2, 100% nitrogen through vermicompost –T3, 100% nitrogen through poultry manure - T4, 75% nitrogen through FYM + 25% nitrogen through vermicompost – T5, 75% nitrogen through vermicompost + 25% nitrogen through poultry manure – T6, 75% nitrogen through poultry manure + 25% nitrogen through FYM – T7, 50% nitrogen through FYM + 50% nitrogen through poultry manure – T8, 50% nitrogen through vermicompost + 50% nitrogen through poultry manure – T9, 50% nitrogen through FYM + 50% nitrogen through vermicompost – T10, 50% nitrogen through FYM + 25% nitrogen through vermicompost + 25% nitrogen through poultry manure – T11 & 25% nitrogen through FYM + 25% nitrogen through vermicompost + 50% nitrogen through poultry manure – T12. The gross and net plot size was 5 m x 3 m, respectively. The experimental plots were fertilizers as per recommended dose.

The seed of linseed, JL-66 variety was obtained from JNKVV, Jabalpur. The linseed variety was sown as per treatments. As per treatment the crop was sown using seed rate of 30 kg/ ha. Seeds were treated with Bavistin before sowing the seeds to control the seed borne disease. In order to obtain uniform plant height stand, seeds were weighed for each plot separately in small packets for sowing. Sowing was done manually in furrows 30.0 cm x 5.0 cm apart. The crop was sown on 25th October 2021. Sowing was done followed by pre sowing irrigation and then sowing was done as per treatment has retained optimum moisture content. Pre-sowing irrigation was given 7-10 days before sowing. The crop was irrigated two times. The seeds were sown manually at about 5 cm depth followed by irrigation.

Results and Discussion

The result shows that plant height, number of branches per plant, number of capsule/plant , number of Seed/ capsule, test weight of seed , grain and Stover yield, harvest Index, oil content was influenced significantly due to INM. The highest plant height (57.04 cm) was recorded under the application of treatment, T1 (100% RDF @ 50:40:20 kg NPK/ha) which was significantly better than T2 (43.00 cm), while the crop was fertilize with 100% nitrogen through FYM. Among the INM treatments, application of 100% nitrogen through poultry manure (T4, 54.75 cm) was found significantly better than T3 (100% nitrogen through vermicompost) of 54.41 cm which was on par with 50% vermicompost + 50% poultry manure (T9) of 53.39 cm and 75% nitrogen through vermicompost + 25% poultry manure (T6, 52.79 cm).

An examination of data showed positive effect of different levels of INM treatments application on number of branches per plant of Linseed. The highest number of branches per plant (8.67) was recorded under the application of treatment, T1 (100% RDF @ 50:40:20 kg NPK/ha) which was significantly better than T2 (3.93), while the crop was fertilize with 100% nitrogen through FYM. Among the INM treatments, application of 100% nitrogen through poultry manure (T4, 6.33) was found significantly better than T3 (100% nitrogen through vermicompost) of 6.20 which was on par with 50% vermicompost + 50% poultry manure (T9) of 6.07 and 75% nitrogen through vermicompost + 25% poultry manure (T6, 5.93). Plant height and number of branches showed marked variation due to the combined Application of inorganic fertilizers and organic manure i.e. vermicomposting, FYM, poultry Manure. The treatment of 100% Nitrogen through poultry manure showed significant improvement in plant height, number of branches as compared to remaining practices. The basal application of chemical fertilizers meets the nutritional requirement of crop for proper establishment and growth during the initial period. At subsequent stages poultry manure ensures the proper supply of macro-and micro-nutrients, vitamins and plant growth promoting hormones which have positive effect on plant growth and development. The increased plant height and branches might be due to the involvement of nutrients in cell wall development and cell differentiation which resulted in elongation of shoot and root in plants. The maximum height and branches might be due to more functional leaves and associated increased light interception and enhanced photosynthetic rate, which ultimately resulted in higher leaf area index. Similar results were obtained by Meena *et al.* (2020) [3] who had reported that an appropriate supply of nutrients through organic and inorganic sources increased the growth attributes of linseed through active photosynthesis. The results are in agreement with the findings of Murali *et al.* (2018) [4] and Dubey *et al*. (2020) [5]. These results corroborate with those of many workers, *viz*., Reddy and Singh (2018) [6], Sunil *et al.* (2018a) [7], Kumar and Sood (2020) [8], Kaushal and Umrao (2020) [9], Meena *et al.* (2020) [3] *Linum usitatissimum* and Nautiyal *et al.* (2021) [10].

Based on application of 100% RDF @ 50: 40: 20 kg NPK/ha produced significantly highest number of capsules per plant of linseed. The highest number of capsules per plant (60.73) was recorded under the application of treatment, T1 (100% RDF @ 50: 40: 20 kg NPK/ha) which was significantly better than T2 (46.33), while the crop was fertilize with 100% nitrogen

through FYM. Among the INM treatments, application of 100% nitrogen through poultry manure (T4, 57.60) was found significantly better than T3 (100% nitrogen through vermicompost) of 55.13 which was on par with 50% vermicompost + 50% poultry manure (T9) of 54.80 and 75% nitrogen through vermicompost + 25% poultry manure (T6, 54.13).

The highest number of seeds per capsules (8.80) was recorded under the application of treatment, T1 (100% RDF @ 50: 40: 20 kg NPK/ha) which was significantly better than T2 (3.60), while the crop was fertilize with 100% nitrogen through FYM. Among the INM treatments, application of 100% nitrogen through poultry manure (T4, 7.20) was found significantly better than T3 (100% nitrogen through vermicompost) of 6.53 which was on par with 50% vermicompost + 50% poultry manure (T9) of 6.20 and 75% nitrogen through vermicompost + 25% poultry manure (T6, 5.40).

Based on application of 100% RDF @ 50: 40: 20 kg NPK/ha produced significantly highest test weight of linseed. The highest test weight (7.62 g) was recorded under the application of treatment, T1 (100% RDF @ 50: 40: 20 kg NPK/ha) which was significantly better than T2 (5.09 g), while the crop was fertilize with 100% nitrogen through FYM. Among the INM treatments, application of 100% nitrogen through poultry manure (T4, 7.41 g) was found significantly better than T3 (100% nitrogen through vermicompost) of 7.16 g which was on par With 50% vermicompost + 50% poultry manure (T9) of 6.87 g and 75% nitrogen through vermicompost + 25% poultry manure (T6, 6.34 g).

Based on application of 100% RDF @ 50: 40: 20 kg NPK/ha produced significantly highest seed yield per hectare of linseed. The highest seed yield per hectare (16.53 q/ha) was recorded under the application of treatment, T1 (100% RDF @ 50: 40: 20 kg NPK/ha) which was significantly better than T2 (8.53 q/ha), while the crop was fertilize with 100% nitrogen through FYM. Among the INM treatments, application of 100% nitrogen through poultry manure (T4, 15.92 q/ha) was found significantly better than T3 (100% nitrogen through vermicompost) of 14.64 q/ha which was on par with 50% vermicompost + 50% poultry manure (T9) of 14.58 q/ha and 75% nitrogen through vermicompost + 25% poultry manure (T6, 12.69 q/ha).

The highest stover yield per hectare (31.03 q/ha) was recorded under the application of treatment, T1 (100% RDF @ 50: 40: 20 kg NPK/ha) which was significantly better than T2 (19.06 q/ha), while the crop was fertilize with 100% nitrogen through FYM. Among the INM treatments, application of 100% nitrogen through poultry manure (T4, 30.91 q/ha) was found significantly better than T3 (100% nitrogen through vermicompost) of 30.88 q/ha which was on par with 50% vermicompost + 50% poultry manure (T9) of 30.67 q/ha and 75% nitrogen through vermicompost + 25% poultry manure (T6, 30.28 q/ha).

The highest harvest index (34.76%) was recorded under the application of treatment, T1 (100% RDF @ 50: 40: 20 kg NPK/ha) which was significantly better than T7 (29.14%), while the crop was fertilize with 75% Nitrogen through Poultry Manure + 25% FYM. Among the INM treatments, application of 100% nitrogen through poultry manure(T4, 34.00%) was found significantly better than T10 (50% FYM + 50% Vermicompost) of 33.42% which was on par with 75% Nitrogen through FYM + 25% Vermicompost (T5) of 32.74% and 50% Vermicompost + 50% Poultry Manure (T9, 32.23%).

The highest oil content (39.97%) was recorded under the application of treatment, T1 (100% RDF @ 50: 40: 20 kg NPK/ha) which was significantly better than T2 (36.95%), while the crop was fertilize with 100% nitrogen through FYM. Among the INM treatments, application of 100% nitrogen through poultry manure (T4, 39.72%) was found significantly better than T3 (100% nitrogen through vermicompost) of 39.68% which was on par with 50% vermicompost + 50% poultry manure (T9) of 39.35% and 75% nitrogen through vermicompost + 25% poultry manure (T6, 39.25%).

The highest net monetary return (₹74832.00 Rs/ha) was recorded under the application of treatment, T1 (100% RDF @ 50: 40: 20 kg NPK/ha) which was significantly better than T2 (₹27249.00 Rs/ha), while the crop was fertilize with 100% nitrogen through FYM. Among the INM treatments, application of 100% nitrogen through poultry manure (T4, ₹72461.00 Rs/ha) was found significantly better than T9 (50% Vermicompost + 50% Poultry Manure) of ₹64278.00 Rs/ha which was on par with 100% Nitrogen through Vermicompost (T3) of ₹64192.00 Rs/ha and 75% nitrogen through vermicompost + 25% poultry manure (T6, ₹53074.00 Rs/ha).W

The highest B: C ratio (3.16:1) was recorded under the application of treatment, T4 (100% nitrogen through poultry manure) which was significantly better than T2 (1.13:1), while the crop was fertilize with 100% nitrogen through FYM. Among the INM treatments, application of 100% RDF @ 50: 40: 20 kg NPK/ha (T1, 3.10:1) was found significantly better than T9 (50% Vermicompost + 50% Poultry Manure) of 2.75:1which was on par with 100% Nitrogen through Vermicompost (T3) of 2.70:1 and 75% nitrogen through vermicompost + 25% poultry manure (T6,2.25:1).

Summary and Conclusion

Based upon this experiment it is concluded that among the INM treatment, application ofthe 100% nitrogen through poultry manure recorded the significantly higher seed yield (15.92q/ha), maximum gross returns (95408.00Rs/ ha), net returns (₹72461.00Rs/ ha) and

Highest B: C ratio of 3.16:1. Hence, application of these nutrient can be adopted in semi-arid

Eastern plain zone of Madhya Pradesh. Hence, it can be concluded that application of 100% nitrogen through poultry manure recorded B: C ratio >3, can be used as remunerative strategies. However, these results are only indicative and require further experimentation to arrive at more consistent and final conclusion Tobe passed on to growers.

Table 1: Integrated nutrient management on growth, yield and quality of Linseed (*Linum usitatissimum* L.)

Treatment	Plant height (cm)	Number of branches / Plant	No. of capsule /plant	No. of Seed/ capsule	test weight of seed	Grain yield per hectare (q/ha)	Stover Yield per hectare (q/ha)	Harvest Index (%)	Oil content (%)
RDF (NPK @ 20: 50: 20 kg/ha)	57.04	8.67	60.73	8.80	7.62	16.53	31.03	34.76	39.97
100% nitrogen through FYM	43.00	3.93	46.33	3.60	5.09	8.53	19.06	30.91	36.95
100% nitrogen through vermicompost	54.41	6.20	55.13	6.53	7.16	14.64	30.88	32.17	39.68
100% nitrogen through PM	54.75	6.33	57.60	7.20	7.41	15.92	30.91	34.00	39.72
75% nitrogen through FYM + 25% nitrogen through vermicompost	43.15	4.67	48.47	3.87	5.10	9.42	19.32	32.74	37.33
75% nitrogen through vermicompost + 25% nitrogen through PM	52.79	5.93	54.13	5.40	6.34	12.69	30.28	29.54	39.25
75% nitrogen through PM + 25% nitrogen through FYM	51.72	5.80	53.53	5.13	6.31	11.83	28.77	29.14	38.89
50% nitrogen through FYM + 50% nitrogen through poultry manure	51.23	5.40	52.53	4.40	6.01	11.31	25.53	30.68	38.42
50% nitrogen through vermicompost + 50% nitrogen through PM	53.39	6.07	54.80	6.20	6.87	14.58	30.67	32.23	39.35
50% nitrogen through FYM + 50% nitrogen through vermicompost	48.04	4.93	49.20	4.13	5.46	10.22	20.39	33.42	37.59
50% nitrogen through FYM + 25% nitrogen through vermicompost + 25% nitrogen through poultry manure	50.02	5.00	49.93	4.27	5.98	10.72	22.80	32.04	37.74
25% nitrogen through FYM + 25% nitrogen through vermicompost + 50% nitrogen through poultry manure	51.38	5.67	52.87	4.80	6.16	11.64	29.67	30.19	38.56
S. Em±	0.65	0.39	0.95	0.42	0.34	0.28	0.67	0.85	0.64
C.D. (P=0.05)	1.89	1.14	2.75	1.23	0.99	0.81	1.96	2.46	1.87

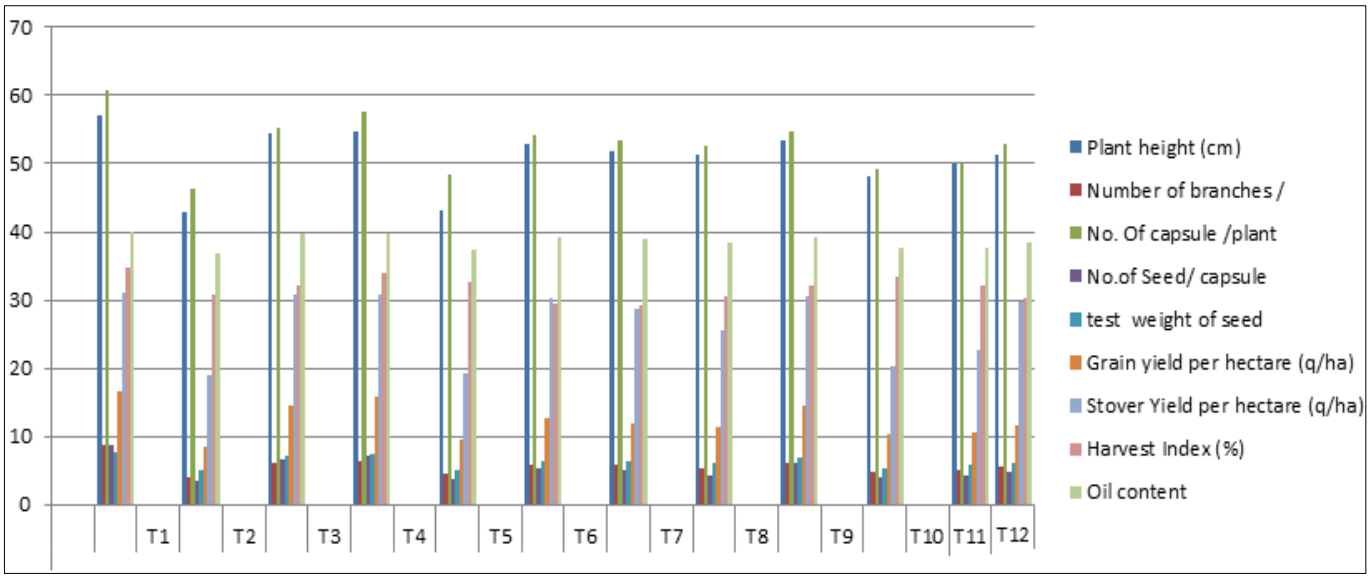

Fig 1: Integrated nutrient management on growth, yield and quality of Linseed (*Linum usitatissimum* L.)

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