**Effect of Integrated Nutrient Management on Yield, Quality and Economics of Linseed (*Linum usitatissimum* L.)**

**Abstract**

A Field experiment was conducted during the *Rabi season* of 2023-24 at crop research centre of ITM University Gwalior, (M.P.) India, to evaluate the “Effect of Integrated Nutrient Management on Yield, Quality and Economics of Linseed”. The experiment followed a Randomized block design (RBD) with three replications. The experiment consisting of ten treatments combinations *viz.*, Control, RDF NPKS (60:40:30:40 kg ha-1 ), N (60 kg ha-1), NP (60:40 kg ha-1 ), NPK (60:40:30 kg ha-1 ), N (60 kg ha-1) + 5 t ha-1 FYM, NP (60:40 kg ha-1) + 5 t ha-1FYM, N (60 kg ha-1) + 2 t ha-1 Vermicompost, NP (60:40 kg ha-1 ) + 2 t ha-1 Vermicompost and N (60 kg ha-1 ) + 5 t ha-1FYM + 1 t ha-1Vermicompost. The soil of the experimental field was slightly alkaline in nature having pH 8.3, EC 0.35 dSm-1, low in organic carbon (0.35 %), available nitrogen (211 kg ha-1) and medium in available phosphorus (13.0 kg ha-1) and Potassium (247 kg ha-1). The results revealed that the application of 60kgN ha-1 with the 5 t ha-1 FYM and 1 t ha-1Vermicompost recorded higher yield and quality parameters of the linseed crop. Among the treatment, the highest net return (₹42644) and benefit cost ratio (1.71) was recorded with the treatment of T10 (60kgN ha-1 with the 5t ha-1 FYM and 1 t ha-1Vermicompost).

 **Keywords:** Economics, INM, linseed, oil content, protein content and yield.

**Introduction**

Linseed, also called flaxseed, is one of the most useful and valuable crops grown around the world. It has been used for a long time to make oil and fiber, and it has many different uses in industries and for nutrition. Today, linseed is grown in more than 30 countries, either as a main crop or for small-scale farming. This shows how well it can grow in different weather and land conditions. According to FAOSTAT (2020), the total area where linseed is grown is about 3. 27 million hectares, and the yearly production is around 3. 18 million tonnes with an average yield of 975. 10 kg per hectare. In India, linseed is an important oilseed crop, covering about 320,000 hectares, producing 174,000 tonnes each year, but with a lower average yield of 543. 80 kg per hectare. This suggests that there is a need for better farming methods, better use of nutrients, and more sustainable ways of growing linseed to increase its production. Linseed provides both edible and non-edible oils. The industrial oil from linseed is used in many products like paint, varnish, soap, ink, linoleum, and treatments for leather, textiles, and wood (Sarmah et al., 2024). It is also used in animal care products, floor treatments, and even in some scientific equipment. Edible linseed oil is rich in alpha-linolenic acid (ALA), a type of omega-3 fatty acid that helps with heart health and has anti-inflammatory effects. Because of these uses, linseed is very important for both health and industry. In recent years, there has been a growing interest in moving away from heavy use of chemical-based farming towards more sustainable and organic methods.

In the past, farmers used organic manure like farmyard manure (FYM), poultry manure, and compost as the main source of nutrients. But with the use of chemical fertilizers becoming common, these organic sources were mostly left aside because they were harder to use and released nutrients more slowly. However, growing concerns about soil damage, loss of soil fertility, pollution, and health risks from chemical residues have brought back interest in organic manures. Organic manures are now seen as very beneficial. Unlike chemical fertilizers that mainly give one or two nutrients, organic sources provide a wide range of nutrients, improve soil carbon levels, and enhance the physical, chemical, and biological structure of the soil. Using organic materials like FYM, poultry manure, and vermicompost not only gives plants the nutrients they need but also strengthens soil structure, improves air and water movement, and reduces soil compaction. These improvements make the soil more fertile and support better root growth, especially for crops like linseed. Using the right amount of nitrogen-based fertilizers along with organic manures can greatly improve how well plants use nutrients and increase crop production. Nitrogen is very important for growing leaves and roots, which in turn helps the plant use nutrients better and grow more. Therefore, combining organic and inorganic fertilizers through integrated nutrient management can help improve linseed yields, soil health, and the long-term productivity of farming.

**Materials and Methods -**

The field experiment took place during the *Rabi* season in 2023-24 at the Crop Research Center-1 (CRC-1) of ITM University in Gwalior, Madhya Pradesh, India. The location is at a latitude of 26 degrees 13 minutes North and longitude of 78 degrees 19 minutes East, and it is 211. 52 meters above sea level. The study was set up using a Randomized Block Design with ten different treatment groups, each tested three times to make sure the results are reliable. The ten treatments were: T1 - Control, T2 - Recommended Dose of Fertilizer (RDF) with NPKS at 60:40:30:40 kg/hectare, T3 - Nitrogen at 60 kg/hectare, T4 - Nitrogen and Phosphorus at 60:40 kg/hectare, T5 - NPK at 60:40:30 kg/hectare, T6 - Nitrogen at 60 kg/hectare+5 tonnes of FYM/hectare, T7 - Nitrogen and Phosphorus at 60:40 kg/hectare+5 tonnes of FYM/hectare, T8 - Nitrogen at 60 kg/hectare+2 tonnes of Vermicompost/hectare, T9 - Nitrogen and Phosphorus at 60:40 kg/hectare+2 tonnes of Vermicompost/hectare, and T10 - Nitrogen at 60 kg/hectare+ 5 tonnes of FYM and 1 tonne of Vermicompost/hectare. The soil at the experimental site was slightly alkaline with a pH of 8.3 and an electrical conductivity (EC) of 0. 35 dS/m. It had low levels of organic carbon (0. 35%) and available nitrogen (211 kg/hectare), but medium levels of available phosphorus (13. 0 kg/hectare) and potassium (247 kg/hectare). During the crop season, the temperature ranged from a minimum of 5. 3°C to 15. 4°C and a maximum of 15. 6°C to 33. 6°C. Each main plot was 5×4 m and net plot was 4.4×2.8m.

At the time of sowing, a base application of 80 kg of nitrogen, 26. 2 kg of phosphorus, 33. 3 kg of potassium, and sulphur was given. The nutrients were provided using urea, di-ammonium phosphate (DAP), and muriate of potash (MOP). Half of the nitrogen, along with the full amount of phosphorus and potassium, was applied at the time of sowing. The remaining nitrogen was applied as a top dressing 30 days after sowing, after the first irrigation. Linseed was sown on October 30th, with a row spacing of 25 cm and a seed rate of 30 kg/hectare.

**Results and Discussion**

***Yield and Harvest Index***

The results revealed (Table 1) that the application of N (60 kg ha⁻¹) + 5 t ha⁻¹ FYM + 1 t ha⁻¹ vermicompost recorded the highest grain yield (890.77 kg ha⁻¹), which was significantly superior to all other treatments. This was followed by NP (60:40 kg ha⁻¹) + 2 t ha⁻¹ vermicompost (845.44 kg ha⁻¹) and N (60 kg ha⁻¹) + 2 t ha⁻¹ vermicompost (742.03 kg ha⁻¹), which were at par with each other but significantly higher than the RDF and chemical fertilizer alone treatments. Among the chemical fertilizer combinations, NPKS (60:40:30:40 kg ha⁻¹) recorded a moderate yield of 631.80 kg ha⁻¹, which was at par with NPK and NP treatments but significantly superior to N alone (560.77 kg ha⁻¹) and control (450.29 kg ha⁻¹).

Similarly, the maximum stover yield (2026.93 kg ha⁻¹) and biological yield (2917.70 kg ha⁻¹) were also observed with N + FYM + vermicompost, which was significantly higher than all other treatments. The next best treatments were NP + vermicompost (1929.06 and 2774.50 kg ha⁻¹) and N + vermicompost (1703.77 and 2445.80 kg ha⁻¹), which were at par with each other and significantly better than treatments without organic inputs.

**Table 1:** Effect of integrated nutrient application on yield of linseed

|  |  |  |
| --- | --- | --- |
| **Treatment** | **Yield (Kg ha-1)** | **Harvest index (%)** |
| **Grain** | **Stover** | **Biological** |
| Control | 450.29 | 1188.02 | 1638.31 | 27.47 |
| NPKS (60:40:30:40 kg ha-1) | 631.80 | 1453.60 | 2085.40 | 30.27 |
| N (60 kg ha-1) | 560.77 | 1309.39 | 1870.16 | 29.98 |
| NP (60:40 kg ha-1) | 593.48 | 1377.94 | 1971.42 | 30.09 |
| NPK (60:40:30 kg ha-1) | 614.29 | 1417.15 | 2031.44 | 30.23 |
| N (60 kg ha-1) + 5 t ha-1FYM | 693.89 | 1597.18 | 2291.07 | 30.28 |
| NP (60:40 kg ha-1) + 5 t ha-1FYM | 719.58 | 1653.08 | 2372.66 | 30.32 |
| N (60 kg ha-1) + 2 t ha-1Vermi | 742.03 | 1703.77 | 2445.80 | 30.34 |
| NP (60:40 kg ha-1) + 2 t ha-1Vermi | 845.44 | 1929.06 | 2774.50 | 30.50 |
| N (60 kg ha-1) + 5 t ha-1FYM + 1 t ha-1 Vermicompost | 890.77 | 2026.93 | 2917.70 | 30.53 |
| SE(m)± | 33.24 | 77.90 | 111.04 | 0.12 |
| CD (P=0.05) | 98.77 | 231.48 | 329.93 | - |

The harvest index ranged from 27.47% (control) to 30.53% (N + FYM + vermicompost); however, all nutrient management treatments were at par with each other in terms of harvest index but significantly superior to the control, indicating more efficient partitioning of biomass toward grain production under integrated nutrient management.

FYM with vermicompost directly increased crop yields either by acceleration of respiratory process, by increasing cell permeability, hormone growth action or combination of all he processes *viz*., release of nutrients, increasing availability of nutrients and improving soil physical, chemical and biological properties. The present findings agree with those of Rasool *et al*. (2013), Dubey *et al.* (2015), and Alam *et al*. (2021), who reported that the application of farmyard manure (FYM) significantly enhances linseed yield by improving soil fertility, microbial activity, and nutrient availability. The integrated application of organic and inorganic sources has been found to sustain higher productivity by stimulating enzymatic functions and facilitating the synthesis of essential coenzymes, which are dependent on micronutrients such as sulphur and boron, as well as macronutrients like nitrogen, phosphorus, and potassium (NPK), as demonstrated by Kumar *et al*. (2020) and Meena *et al*. (2022).

Furthermore, the results are supported by Yadav *et al*. (2023), who highlighted the pivotal role of integrated nutrient management (INM) in enhancing crop yield, maintaining soil health, and ensuring long-term sustainability in oilseed-based cropping systems. The positive impact of organic amendments was evident not only in improving the nutrient status of plants but also in promoting robust root development, enhancing soil moisture retention, and ultimately contributing to a higher harvest index and superior yield performance.

***Quality and Economics***

The data on quality parameters (Table 2) revealed that the highest protein content (20.35%) and oil content (40.53%) were recorded with the application of N (60 kg ha⁻¹) + 5 t ha⁻¹ FYM + 1 t ha⁻¹ vermicompost, which was significantly superior to most other treatments. This was followed closely by NP + 2 t ha⁻¹ vermicompost, which recorded protein (20.34%) and oil content (40.52%), and both were at par with the highest treatment. All integrated treatments showed a significant improvement in quality attributes compared to the control (18.32% protein and 37.50% oil). Treatments involving only chemical fertilizers (N, NP, NPK, and NPKS) also showed moderate improvement in protein and oil content but were significantly inferior to integrated nutrient treatments.

The improvement in oil content may be due to the enhanced synthesis of sulphur-containing amino acids and activation of key enzymes which are involved in fatty acid biosynthesis, especially thiokinase, which facilitates the conversion of acetyl-CoA to malonyl-CoA which is a critical step in oil formation. The increased availability of sulphur and nitrogen and improved soil microbial activity may be due to application of FYM and vermicompost, which might have contributed to these biochemical enhancements. FYM and vermicompost not only improved the nutrient status but also enhanced soil structure, microbial biomass, and enzymatic activities which support oil and protein accumulation in the seed.

These findings agree with Akbari *et al.* (2011) and Parmar *et al.* (2020), who have reported improved oil and protein content in linseed with integrated application of inorganic and organic nutrient sources. Similarly, Kaushal and Umrao (2020) and Singh *et al.* (2020) also highlighted the positive effect of organic sources like FYM and vermicompost on enhancing seed quality parameters through improved nutrient uptake and metabolic efficiency. Recent studies by Alam *et al.* (2021) and Yadav *et al.* (2023) further supported these results, highlighting that integrated nutrient management improves nitrogen assimilation and sulphur metabolism, which are closely related to protein synthesis and oil biosynthesis pathways. Also, enhanced root development and soil microbial interactions under INM facilitate better nutrient mobilization, which ultimately result in improved quality parameters such as oil and protein content in oilseed crops like linseed.

**Table 2: Effect of integrated nutrient application on protein content, oil content and economics of linseed**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Treatment** | **Content (%)** | **Cost of cultivation****(**₹ ha-1**)** | **Gross return****(**₹ ha-1**)** | **Net return****(**₹ ha-1**)** | **B. C ratio** |
| **Protein** | **Oil** |
| **Control** | 18.32 | 37.50 | 21709.5 | 35333.5 | 13624.0 | 0.63 |
| **NPKS (60:40:30:40 kg ha-1)** | 20.19 | 40.29 | 27132.5 | 48083.2 | 20950.7 | 0.77 |
| **N (60 kg ha-1)** | 19.99 | 39.98 | 22490.7 | 42811.9 | 20321.2 | 0.90 |
| **NP (60:40 kg ha-1)** | 20.06 | 40.10 | 24487.1 | 45254.4 | 20767.3 | 0.85 |
| **NPK (60:40:30 kg ha-1)** | 20.15 | 40.23 | 25134.5 | 46777.4 | 21642.9 | 0.86 |
| **N (60 kg ha-1) + 5 t ha-1FYM** | 20.19 | 40.28 | 23490.7 | 52813.7 | 29322.9 | 1.25 |
| **NP (60:40 kg ha-1) + 5 t ha-1FYM** | 20.21 | 40.32 | 25487.1 | 54746.4 | 29259.2 | 1.15 |
| **N (60 kg ha-1) + 2 t ha-1Vermi** | 20.23 | 40.34 | 23990.7 | 56448.2 | 32457.4 | 1.35 |
| **NP (60:40 kg ha-1) + 2 t ha-1Vermi** | 20.34 | 40.52 | 25987.1 | 64229.8 | 38242.7 | 1.47 |
| **N (60 kg ha-1) + 5 t ha-1FYM + 1 t ha-1 Vermicompost** | 20.35 | 40.53 | 24990.7 | 67634.7 | 42644.0 | 1.71 |
| **SE(m)±** | 0.35 | 1.06 | - | - | - | - |
| **CD (P=0.05)** | 1.04 | 3.18 | - | - | - | - |

In terms of economics, the maximum gross return (₹67634.7 ha⁻¹), net return (₹42644.0 ha⁻¹), and benefit-cost ratio (1.71) were achieved under N + FYM + vermicompost, which was significantly superior to all other treatments. The next best economic performance was observed in NP + vermicompost, with net return of ₹38242.7 ha⁻¹ and B:C ratio of 1.47, which was at par with N + vermicompost (₹32457.4 ha⁻¹, 1.35 B:C ratio). Sole chemical fertilizer applications resulted in lower economic returns, with NPKS yielding a net return of ₹20950.7 ha⁻¹ and B:C ratio of 0.77, whereas the control recorded the lowest net return (₹13624.0 ha⁻¹) and B:C ratio (0.63). These results clearly indicate that integrated nutrient management involving the combined use of organic and inorganic sources not only enhances grain quality but also improves profitability and cost-efficiency in linseed cultivation.

The superior economic returns of T10 and T9 treatments may be due to enhanced yield potential which might be due to improved soil fertility, nutrient availability, and microbial activity. The combined application of RDF with FYM and vermicompost might have enhanced the synchrony between nutrient release and crop demand, which may have resulted in better nutrient uptake and higher productivity. Additionally, the slow and sustained release of nutrients through FYM and vermicompost not only reduced the need for additional fertilizer inputs but also reduced nutrient losses, thereby improving input use efficiency and profits. These findings are corroborated by Singh *et al.* (2020) and Kaushal and Umrao (2020) who reported that integrating organic and inorganic inputs in linseed-based cropping systems led to higher net returns and B:C ratios. Furthermore, Parmar *et al.* (2020) also observed that the addition of organic manures greatly enhances soil health and crop productivity, thereby increasing economic returns. Recent studies by Meena *et al.* (2022), Yadav *et al.* (2023) and Sarmah *et al*. (2024) also emphasized that integrated nutrient management practices not only improve crop performance but also enhance profitability by reducing reliance on expensive chemical fertilizers but also improve resource-use efficiency.

**Conclusion:**

Application of 60 kg of nitrogen/hectare along with 5 tonnes of farmyard manure and 1 tonne of vermicompost/hectare improves the yield of linseed, oil content, and economic returns. These results are similar to those achieved with 60 kg nitrogen and 40 kg phosphorus/hectare, combined with 2 tonnes of vermicompost. This shows that combining organic and inorganic nutrient sources effectively boosts the financial returns from linseed cultivation. Such an approach is essential for maintaining high yields in sandy loam soils in the north-eastern region of India, especially during the rabi season, which is becoming a profitable time for growing linseed.

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